Deliverable D 5.3

Impact assessment, scalability assessment and user handbook

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Executive Summary

The ESEP4Freight project has developed and validated a Web Platform to foster the uptake of intermodal and rail freight transport in Europe. The platform provides shippers, operators, and logistics stakeholders with transparent access to data on terminals, timetables, routes, costs, and contractual frameworks, thus supporting informed decision-making towards sustainable and cost-efficient transport solutions.

This deliverable (D5.3) integrates three core elements: the impact assessment, the scalability analysis, and the user handbook. The impact assessment confirms that the project has broadly achieved its Key Assessment Indicators (KAIs) and Expected Results (ERs). Stakeholder engagement was high, all core modules were delivered and validated, and the tools demonstrated strong potential to contribute to the European Green Deal objectives by facilitating modal shift and enabling external cost estimation.

The scalability analysis identified opportunities for future improvements, including extended data coverage, enriched terminal information, enhanced usability, and potential integration of other modes such as inland waterways and short-sea shipping. Recommendations also include the integration of real train path data, more realistic first/last mile modelling, and the development of APIs to ensure interoperability with third-party systems.

The user handbook complements the technical developments, providing guidance for users of the platform and ensuring accessibility. Together, these results demonstrate that ESEP4Freight has successfully laid the foundation for a trusted and scalable digital environment to promote intermodal rail freight solutions in Europe.

Abbreviations and acronyms

Abbreviation / Acronym	Description
API	Application Programming Interface
CIP	RNE Customer Information Platform
CLNI	Strasbourg Convention on the Limitation of Liability in Inland Navigation
CMNI	Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway
CMR	Convention on the Contract for the International Carriage of Goods by Road
CTO	Combined Transport Operator
DG MOVE	Directorate-General for Mobility and Transport (European Commission)
EC	European Commission
EO	Expected Outcome
ER	Expected Result
ESEP4Freight	European Shift Enabler Portal for Freight
EU	European Union
EU-RAIL	Europe's Rail Joint Undertaking
GA	Grant Agreement
GTC-CIM	General Terms and Conditions of Carriage for International Freight Traffic by Rail
HGV	Heavy Goods Vehicle
ICT	Information and Communication Technology
IM	Infrastructure Manager
IoT	Internet of Things
KAI	Key Assessment Indicator
KPI	Key Performance Indicator
LSP	Logistics Service Provider
MTO	Multimodal Transport Operator
NUTS	Nomenclature of Units for Territorial Statistics
PoD	Proof of Delivery
RDM	Reference Data Model
RINF	Register of Infrastructure
SG	Stakeholder Group
SMEs	Small and Medium-sized Enterprises
TMS	Transport Management System
TG	Target Group
TO	Terminal Operator
UIC	International Union of Railways
WP	Work Package
WTT	Well-to-Tank

1 Background

The present document constitutes the Deliverable D5.3 “Impact assessment, scalability assessment and user handbook” in the in the project European Shift Enabler Portal for Freight (ESEP4Freight). Funding body is the EU-RAIL in the call HORIZON-ER-JU-2022-02.

In the future European mobility system, rail freight plays a key role in making a significant contribution to achieving the goals of the European Green Deal. The fastest and most efficient way to decarbonize freight transport is to shift freight to rail. To achieve this shift, the overall competitiveness of rail in the transport market should be improved. To strengthen the role of rail freight in the transport market, it is necessary to attract the attention of freight customers. An approach to increase the awareness of rail freight is to provide customers with high-quality and open information about the possibilities of rail freight transport and the associated benefits of intermodal rail freight.

The objective of the ESEP4Freight project is therefore to provide freight customers with an overview of the available intermodal rail freight services in Europe. This will be supported by the creation of a Web Platform based on an existing map developed by SGKV, along with the identification of freight flows with a higher potential for transport by rail. The Web Platform will include an interactive map with different modules such as an external costs calculator, a schedule viewer, a route viewer, a contract toolbox and a match making tool.

This deliverable come with the end of the project and has three different parts: the first part consists of assessing the impact of the Web Platform and the project. The second part focusses on analysing the scalability of the Web Platform, assessing possible future improvements. The third and final part is the User Handbook of the Web Platform and has been used as basis for the preparation of the user handbook integrated in the Web Platform.

2 Objective

This document comprises the output of Task 5.3 and it is divided in three main sections: Impact Assessment, Scalability, and User Handbook.

The Impact Assessment was guided by three sets of indicators. Key Assessment Indicator (KAIs), Expected results (ER) and Expected Outcomes (EO). The indicators were identified during the Grant Agreement and have been refined, when needed during the project in the Task 5.3

The Scalability has been assessed in close collaboration with WP4 and the Stakeholder Group (SG). A selection of stakeholders has assessed the Web Platform and has shared their impressions with us. This has been used as basis to identify possible improvements and update of the Web Platform in the future.

Finally, the User Handbook has been a joint effort from the whole consortium to facilitate the use of the Web Platform and thus to ensure its transferability. Despite the Web Platform has been designed to maximize its usability, the user handbook intends to provide additional information to user about its functioning and the assumptions made during its development.

3 Impact assessment

The impact assessment of the project has been based on the Key Assessment Indicators (KAIs) from section 1.1 of the GA and the other indicators included in the proposal such as the Expected Results (ER) and the Expected Outcomes (EO).

3.1 Key assessment indicators (KAI)

The purpose of this section is to define the framework that will be used to assess the overall impact and effectiveness of the ESEP4Freight project. This preliminary structure is based on the Key KAIs outlined in the Grant Agreement and referenced in Section 1.1 of this deliverable, together with other indicators such as the Expected Outcomes described in the project proposal.

KAIs are strategic indicators designed to assess the long-term contribution of the project to its stated objectives and broader EU policy goals. Unlike Key Performance Indicators (KPIs), which focus on operational performance, KAIs are used to evaluate systemic impact, stakeholder engagement, and the scalability and usability of the project's results.

The identified KAIs include are presented in Table 1.

Table 1. Identified KPIs

KAI	Description	Target	Assessment
KAI.1	Number of users reached via the Web Platform (various user types)	≥ 1,500 by project end	On track – the Web Platform was publicly launched on 23th September. It is expected that the Web Platform reached 1500 users by the end of October
KAI.2	Stakeholder engagement in pilots and validation activities	≥ 75% of invited stakeholders participating	Achieved – more than 75% of invited stakeholders actively participated in different physical and online activities in WP1, WP2 and WP4 validation.
KAI.3	Number of mapped rail freight corridors and services	≥ 50 services mapped	Achieved – broad coverage of European services
KAI.4	Functional coverage of the platform (modules delivered and usable)	External costs calculator[1], contract toolbox, schedule viewer, matchmaking all operational	Achieved – all modules delivered and validated.

[1] Originally CO_2 calculator

KAI.5	Interoperability with third-party systems (APIs, open access)	≥ 1 external system connected via API	Not achieved – several reasons. See the paragraph below the table for further information
KAI.6	Stakeholder satisfaction and willingness to adopt	≥ 75% express interest in using tools post-project	Partially achieved – overall ratings 3–4/5, SMEs show high willingness, larger operators cautious.
KAI.7	Contribution to EU modal shift and Green Deal goals	Qualitative increase in rail freight intention	Achieved qualitatively – positive feedback confirms awareness raised and modal shift potential.

The development of an API was not pursued because much of the platform's data either comes directly from public sources (e.g. rail infrastructure, corridors) or is already available in research publications, while other datasets belong to private operators and require specific permissions for open access. Permissions would have required negotiations with a wide range of stakeholders and the lack of time and resources has limited this possibility. The web platform already provides access to the documents resulting from the contract analysis, and in particular, offers open access to the General Contract Terms skeleton, which was prepared explicitly during the project. In addition, for security reasons the platform does not allow external updates without administrator control, and there was insufficient time to design a safe environment for system-to-system interaction.

KAI shows that the ESEP4Freight project is broadly on track to meet its strategic objectives. Stakeholder engagement levels are high, with more than three quarters of invited actors actively participating in pilot activities. Functional coverage has been achieved, as all core modules were delivered and validated during WP4. While satisfaction levels vary across user groups – with SMEs reporting higher immediate value and larger operators highlighting the need for further integration – overall ratings are consistently positive (3–4 out of 5). Coverage of terminals and services is sufficient, though not yet complete, and transparency of data sources remains a point for improvement. Importantly, the project has demonstrated its potential to contribute to EU modal shift and Green Deal goals by raising awareness of intermodal options and enabling external costs savings estimation. These results confirm the robustness of the ESEP4Freight approach while also pointing to areas where further refinement will maximise long-term impact.

3.2 Expected results (ER#)

In addition to the KAIs, the Table 2. summarises the main Expected Results (ERs) of the project, as defined in the Grant Agreement. These results represent the key technical and operational outputs that ESEP4Freight aims to deliver. Each ER corresponds to a specific tool, recommendation or service to be developed and validated during the project. Together, they support the achievement of the overall objectives and enable the assessment of the project's impact.

Table 2. Expected results of the ESEP4Freight project defined in the Grant Agreement

ER ID	Title / Tool	Expected Outcome / Result	Assessment
ER#1	Interactive Map	Visualisation of rail freight services and corridors across Europe	Delivered.
ER#2	CO_2 Calculator	Estimation of emissions savings when using rail vs. road	Delivered. Expanded to external cost calculator.
ER#3	Schedule Viewer	Timetable data viewer for intermodal services	Delivered
ER#4	Digital Contract Templates	Ready-to-use contractual modules for combined transport	Delivered
ER#5	Matchmaking Tool	Tool for connecting users and services in rail freight	Delivered. Modified to stakeholder directory.
ER#6	Recommendations for contract standardisation	Set of best practices and legal clauses for harmonisation	Delivered
ER#7	Contract Toolbox	Online environment to manage and generate harmonised transport contracts	Delivered

The assessment of the Expected Results confirms that all major project outputs have been successfully delivered and validated. The interactive map, the external cost calculator, schedule viewer, and contract toolbox are operational and have been tested in pilot activities. Future developments of the Web Platform that may enable to improve the Web Platform have been summarised in Section 4.

3.3 Expected outcomes (EO#)

In order to demonstrate that the project objectives have been met, a set of KPIs for the EO# has been defined. These KPIs are directly linked to the measurable outcomes and expected results. They will be assessed by the end of the project to provide clear and quantifiable evidence of success and impact. According to the Grant Agreement, the two EO are the following:

- **EO#1** To support the easy usage of rail freight and multimodal services and a seamless switch towards rail through harmonised or even standardised models transport agreements and contracts, taking into account digitalisation and automation innovations as possible upcoming enablers to release new added value services in the rail freight market, making the modal shift more attractive and cost effective to end users.

- **EO#2** To provide easy access to static information about network access points and general rail services available, to effectively support the information and dissemination of today's EU rail freight network with its available nodes and commercial routes as well as to identify the supply chain flows most suitable for rail transport from both a CO2 and business perspectives**.**

The KPIs listed below in Table 3 assess the quantification of each EO.

Table 3. Key functionalities and expected results of the ESEP4Freight project

EO#	KPI	Timing	Target	Assessment
EO#1	Validation of recommendations (ER#6, ER#7)	End of project	≥ 90% validated by all TGs	Achieved – both recommendations and the Contract Toolbox were validated by stakeholders; functionality confirmed, though broader dissemination remains desirable.
EO#1	Validation of Contract Toolbox	End of project	≥ 75%	Achieved – Contract Toolbox validated by stakeholders above 75%, confirming functionality and potential for uptake.
EO#1	Validation of tools (ER#1, ER#2, ER#3, ER#5)	End of project	≥ 75% each	Achieved – validation surveys confirmed >75% positive feedback for all tools; some usability and timetable issues identified but did not prevent overall validation.
EO#1	External costs[2] saving estimation via ER#2	End of project	≥ 10% on selected routes	Achieved – the external cost calculator demonstrated savings well above the 10% threshold on tested routes.
EO#1	Increased rail freight intention	End of project	≥ 80% (according to feedback from SG)	Partially achieved – SMEs and smaller operators confirmed increased interest in rail freight; larger operators recognised potential but adoption for daily operations remains limited.

[2] Originally CO2 calculator

EO#2	Policy uptake (Number of reports or documents referencing project recommendations)	1 year after project end	≥ 3	To be confirmed (likely) – recommendations issued are indirectly already part of different previous documents so it is expected that they will be replicated with small differences in future documents
EO#2	Contract Toolbox users	1 year after project end	≥ 1,500	To be confirmed (likely) – toolbox validated and functional; uptake confirmed among stakeholders but total user base remains slightly below target.
EO#2	ER#2, ER#3, ER#5 users	1 year after project end	≥ 2,000	To be confirmed (likely) – tools demonstrated usefulness and validated by pilots so it is expected that the target is reached
EO#2	ER#1 (interactive map) users	1 year after project end	≥ 5,000	To be confirmed (likely) – tools demonstrated usefulness and validated by pilots so it is expected that the target is reached
EO#2	Stakeholders in ER#5	1 year after project end	≥ 500	To be confirmed (unlikely) – stakeholder directory validated, but actual stakeholder numbers fell short of the 500 target. It is unlikely that the directory increases until 500 references due to the existence of similar tools in the market

The overall assessment of the EOs confirms that ESEP4Freight has largely delivered on its objectives. Most validation-related targets (EO1) were achieved: the core tools and recommendations were positively validated by more than 75% of stakeholders, and the external costs calculator demonstrated savings above the 10% threshold on selected routes. Stakeholders, especially SMEs, confirmed increased awareness and intention to use rail freight, though larger operators remain more cautious in terms of daily adoption.

Regarding sustainability and uptake (EO2), the targets are to be reached in one year after completion of the project so no actual assessment is currently possible. However, the target estimations showed in the previous table yielded positive results. All targets related to EO2 are expected to meet their targets except the stakeholder directory as 500 references is considered as too ambitious.

Overall, the project has proven effective in validating innovative digital solutions for intermodal transport, with strong contributions to modal shift objectives, while also identifying areas where further effort will maximise long-term uptake and impact.

4 Scalability

This section focusses on the identification of additional data and possible upgrades and modules to expand the platform in the future. This topic has been addressed in the Chapter 5 of D4.1 (Plehm & Borgogna, 2025) based on the data from the SG consultation and the test of the Web Platform. A summary of the potential improvements identified can be found below.

- Availability and Data Coverage
  - Data reliability & consistency: Standardize and complete terminal/service datasets.
  - Enriched terminal information: Include performance indicators (train frequency, capacity, services offered).
  - Extended scope: Represent non-craneable units, pre-/post-haulage providers, and additional modes (inland waterways, short-sea shipping).
- Awareness & Value-Added Services
  - Dynamic timetables: Provide complete, up-to-date schedules.
  - Integrated booking & cost tools: Enable bookings, cost estimates, and CO_2/WTT savings.
  - Transparency: Publish methodologies for external cost calculations.
- Functional Capabilities
  - Advanced search & routing: More intuitive fields, reset options, and clearer route sections.
  - Connection reliability: Ensure displayed routes match actual timetables.
  - Filters & indicators: e.g., semi-trailer compatibility, realistic first/last mile data (via Google Maps/OSM).
  - API & interoperability: Facilitate integration with TMS/digital freight platforms.
- Usability & User Experience
  - Improved navigation: Clearer route display, compressed layouts, terminal legends, and quick access to contact details.
  - Interactive maps: Pop-ups, reset function, intuitive origin/destination selection.
  - Multilingual support: Broaden accessibility.
  - Source visibility: Show data origins to strengthen trust.
  - Professional support: Manuals, guides, and context-sensitive help.
- Strategic & Operational Impact
  - User segmentation:
    - Large operators: use platform for exploring new chains.
    - Small operators: rely on platform for daily operations and awareness.
  - Scenario testing: Validate complex multimodal chains for robustness.
  - Trust & adoption: Showing real train paths, reliability, and punctuality data will build confidence.
  - Enhanced external costs: Include dimensions like energy source, noise, safety, and congestion.

5 User handbook

5.1 Interactive map

5.1.1 Description and how to

The Interactive map is focused on displaying information about intermodal terminals and helping to find routes to connect them primarily by rail.

5.1.2 Reference values used and other relevant information

- Openstreet map (Openstreet map, 2025)
- Graphhopper (Openstreet map, 2025)

5.2 Terminal selection

5.2.1 Description and how to

The initial view of the web platform features an interactive map displaying points of various colours, each representing different intermodal terminals. Each colour corresponds to a specific type of terminal, which is explained on the left vertical bar under the "Terminal Types" label.

Different filters can be applied to select the terminals on the map:

- Terminal name
- Terminal type: to select terminals by their type
- Infrastructure characteristics:
    - Open 24/7: it is a checkbox to select the terminals that are open 24/7
    - Loading units: to filter terminals by the type of loading unit they admit
    - Services: to filter terminals by the type of services
    - Equipment: to filter terminals by the type of equipment they have available

Filters within each group are applied as a union ('or'), while combinations between different groups are applied as an intersection ('and').

By clicking on a point to select a terminal, a pop-up menu will appear, with different options depending on the terminal's connectivity.

- First, for all terminals, a checkbox is shown to add the terminal for the comparison functionality (to be detailed later)
- Also, for all the terminals, the 'See details' button gives access to the form to show the terminal information (to be detailed later)
- For those terminals that have timetables associated with:
    - The 'See schedule' button gives access to the details of the timetables.
    - Two checkboxes give the option to add the terminal as the origin or destination of a route (to be explained later).
    - In the rare case that a terminal is the origin but not the destination (the destination but not the origin) of the timetables related to it, the corresponding 'Add as destination' ('Add as origin') checkbox will not be displayed.
- For those terminals without timetables, the text 'No available schedule' replaces the 'See schedule' button.

When you click on a point on the map (not a terminal), a pop-up menu appears with:

- Two checkboxes to give you the option to add the point as the origin or the destination of the route (to be explained later)
- The 'Show nearby terminals with connections' button. When you click on the button, the terminals with connections within a 200.0 km radius from the selected point are highlighted in purple.
- A trash button will appear in the top left corner of the map to refresh the screen after clicking on the 'Show nearby terminals with connections' button.

5.3 Terminals information

5.3.1 Description and how to

From the interactive map terminal pop-up menu, when clicking on the ‘See details’ menu, you can access the terminal information. The information is grouped into different categories:

- Basic information: terminal type, UIRR code, and opening hours.
- Terminal operator and contact information.
- Adress

- Characteristics of loading tracks
- Type of loading units accepted
- List of available services
- List of available equipment

The back button will return to the point where the details were called (interactive map terminal pop-up, schedule details, corridors details)

5.3.2 Reference values used and other relevant information

Data collected from:

- Intermodal map (SGKV, 2025)
- UIRR Terminals code (UIRR, 2025)
- UIC RICS Codification (UIC, 2025)

5.4 Terminal comparison

5.4.1 Description and how to

You can access the terminal comparison from the menu under "Terminal Comparison" or through the interactive map by selecting different terminals and adding them to the terminal comparison feature.

From the 'Terminal comparison' functionality, you can search terminals by name, UIRR code, or apply a filter by modality or loading units type.

For each terminal, a card will be displayed with the following information:

- UIRR code
- Modality
- Type of loading units the terminal admits
- List of available services
- List of available equipment

The location of each terminal is depicted on the right side of the map, where there is a correspondence between the card tag colour and the colour of the point on the map.

A maximum of 6 terminals can be selected.

5.5 Schedules

5.5.1 Description and how to

From the interactive map terminal pop-up menu, clicking on the 'See schedule' (when it is available for the terminal selected), you can access the timetable details.

First, a general view of all the connections is shown. The table shows the list of connections available from or to the terminal:

- Terminal origin
- Terminal destination
- Name of multimodal operator (MTO)
- Mode of transport (Rail, Barge, Sea)
- Details

The data is organized as follows: first, the connections where the terminal is the origin, followed by the connections where the terminal is the destination.

When you click on a row in the list, the corresponding connection will be displayed on the map. The red point indicates the origin, while the green point indicates the destination.

By clicking on 'Details' for each row, you can view more information related to the connection.

- Origin
- Destination
- MTO details
- The list of available closing time/pickup time/Clearance gauge per day
- Mode of transport

For the barge schedules' characteristics, the details pertain only to the main destination, but other available destinations are included as additional information (in brackets).

5.5.2 Reference values used and other relevant information

Data collection:

- SGKV Intermodal Map Database for Intermodal Terminals: https://www.intermodal-map.com
- EiFa project schedule template to collect and harmonise schedules of CT-Operators (SGKV; PTV Group, 2022)
- UIRR Codes to identify CT Terminals: https://www.cdm.uirr.com/code-data-management

- RINF - Register of Infrastructure for European rail network with relevant additional information: https://data-interop.era.europa.eu/dataset-explorer
- UIC RICS Codification: https://www.cit-rail.org/media/files/appendix_circular_letter_10_2021_list_of_codes_2021-05-17.pdf (UIC, 2025)

5.6 Route with External Costs Estimation

5.6.1 Description and how to

The route calculation is based on available timetables and primarily focuses on non-road routes. Roads are only utilized for first and last-mile connections or for intermediate connections to facilitate other modes of transportation.

Several fields are used in the route calculation, but only the origin and destination are mandatory. The remaining fields are optional and come with default values. To calculate a route, simply enter the required fields and click the 'Search' button.

There are different ways to introduce the origin and destination of the desired route:

1) You can select a terminal with connections on the map by clicking on its corresponding point. Then you can add the terminal as the origin or destination of the route from the interactive map terminal pop-up.
2) You can click on a point on the map and add it as the origin or destination of the route.
3) You can click on a point on the map and click on the 'Show nearby terminals with connections' button. Then you can select one of the terminals highlighted following point 1). It is important to note that in this case, the origin (destination) point is the one you have clicked on initially, and the connection will use the terminal selected.
4) You can introduce the address directly in the origin or destination field.

The rest of the fields are optional:

- *Departure date from*: you can introduce the date from to start the route calculation. By default, the route starts the day after the current day. The route will start as soon as possible after the selected date.
- *Fix departure date:* when this check box is marked, the route will start precisely on the date introduced in the previous field (Departure date from). By default, the check box is blank.
- *Loading unit*: You can select between different types of loading units. This field conditions the timetable to the availability of transporting this type of unit. By default, the value is 'Container/Swap body up to 20ft'

- *Number of loading units:* to estimate the weight of the load. It has an impact on the external costs calculation. By default, the value is 1.
- *Total weight transported in tons:* Instead of introducing the number of loading units, the weight can be introduced directly. When this field has a value greater than zero, it is used instead of the number of loading units. It has an impact on the external costs calculation. By default, its value is zero.
- *First/Last mile maximum distance*: between 100km and 500km. To limit the results to those that are focused on alternative transport modes to road transport. By default, the value is 300 km.
- *Sort results by*: distance/travel time/External costs. By default, the value is distance.

After introducing the values in the fields and clicking on the 'Search' button, a list of available routes will be displayed (with a maximum of 5). First, a general overview of all the routes is given. The results show the following information for each route:

- Clicking on a row, the route is depicted on the map, with different colours for each mode (following the legend on the top right corner of the map)
- A block for the multimodal transport route, with the travel time, distance in kilometres and the total external cost associated with the multimodal route.
- Also, for the multimodal transport, a summary of the share for each mode of the distance covered and the external costs is provided.
- The next block shows the total external costs of the route, whether it was covered only by road.
- Then the main information of the route:
    - Origin and the route starting time
    - Destination and the route ending time
    - The list of MTOs in charge of the route
    - The 'Details' button gives more details of the route.

After clicking on the 'Details' button, a new screen appears, with the details of the route:

- At the top, a map displaying the route.
- Two blocks on the top under the map with the decomposition of the total external costs, one block for the multimodal transport (in grey) and the other block for the only-road route (in orange)
- The details for each leg that comprises the route:

- The travel time, distance, mode of transportation and MTO for the leg
- The origin and starting time, and the destination and ending time for the leg
- The total external costs and their decomposition corresponding to the leg
- Different colours to represent each mode of transport: green for rail, orange for road, purple for barge, blue for short-sea shipping
- The grey framework highlights the relationship between the total external costs of each leg and the total external costs for multimodal transport (the total external cost for multimodal transport is the sum of the total external costs of all legs)
- Clicking on each leg highlights it on the map

5.6.2 Reference values used and other relevant information

Data Collection:

- Openstreet map (Openstreet map, 2025)
- Graphhopper (Graphhopper, 2025)
- RINF – Register of Infrastructure (RINF Register of Infrastructure, 2025)
- RNE Customer Information Platform (RNE Customer Information Portal, 2025)
- FERRMED – Data from the Study of Traffic and Modal Shiftt Optimisation in the EU (Ferrmed, 2025)
- Handbook on the external costs of transport (CE Delft, DG MOVE, 2020)

Main element of the route calculation:

- The route calculation is based on the shortest path algorithm applied to a directed graph.
- The direct graph has two levels: a lower level with high granularity, which permits drawing the route on the map following the tracks, and an upper level made from the timetables to calculate the optimal routes.
- The lower-level directed graph uses the operational points and the section of lines obtained from RINF.
- The upper-level directed graph represents the terminals as nodes, with the connections between them defined by the timetables as arcs. An expanded graph is created, where each terminal includes new nodes that represent the origins and destinations according to the timetables. There is a single connection for each triplet origin/destination/MTO, although this connection may allow for multiple departures.

- Extra road connections between terminals have been created when the road connection is lower than 500km. It helps to find alternative routes in areas with many terminals.
- Figure 1 shows an example. Black points represent the terminal A, B and C. White points represent the extra nodes for the origin/destination of each timetable. Orange connections represent the road arcs when available.

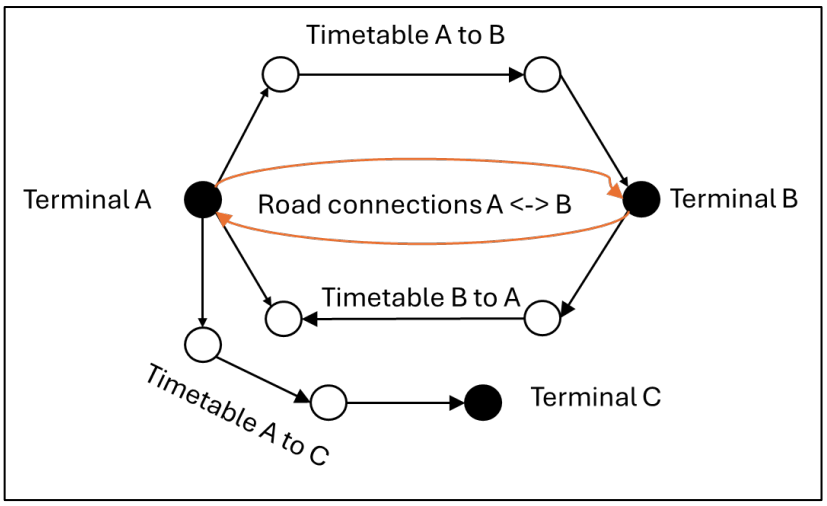

Figure 1. Expanded graph example

- Each terminal has correspondence with one and only one node from the lower-level graph (obtained from the UIR RICS Codification or by geographical coordinates).
- A shortest path algorithm is applied between all the terminal connections using the lower-level directed graph to define the track path that represents the resulting routes on the interactive map. Figure 2 shows the track path between two terminals.

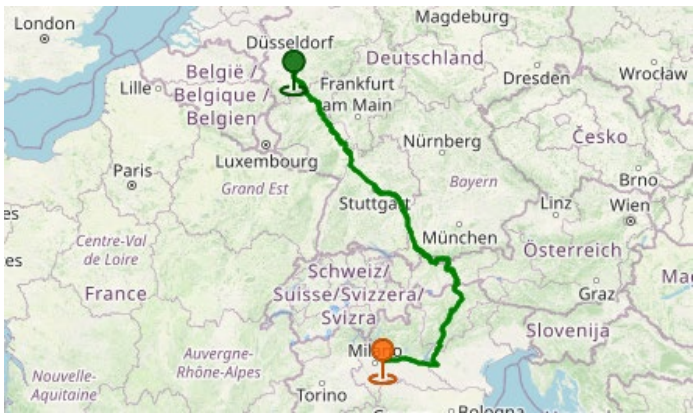

Figure 2. Rail track path example between two terminals

How the route calculation has been implemented:

- First, a list of potential origin-destination pairs is generated based on whether the origin or destination has fixed terminals or not.
- From this list, possible paths are created using the shortest path algorithm applied to the upper-level expanded graph. Initially, only rail connections are considered, followed by a second step that includes road connections.
- Next, the list of potential paths is refined by merging consecutive road connections into a single leg and removing duplicates. Then the paths are initially sorted by to the number of legs and the specific criteria: distance or travel time. For external cost sorting criteria, distance is used since external costs are directly related to the distance, and they are only calculated after obtaining the complete data for the route.
- The top paths from this list form the final selection, with a maximum of five paths being chosen.
- A final selection is required to remove those paths that show a weird solution (too long connections using multiple terminals or road connections), keeping at least one path, the best one after sorting the paths by distance, travel time, and external costs. From the best solution, paths with a total distance greater than 50% of the total distance of the best solution, a travel time greater than 5 times the travel time of the best solution, or multimodal external costs exceeding the external costs of the "only road route" are removed. Both 50% for distance and 5 times are parameters that were agreed upon, taking into account previous results.
- Obtaining the data for each path:
    - Starting date/time for each leg:
        - For the first leg, the date is displayed on the screen.
        - For each subsequent leg, the starting date/time is calculated based on the end date/time of the previous leg, with an additional margin depending on the transition between modes of transport:
            - Transitioning from road to train: 0 hours
            - Transitioning from train to road: 0 hours
            - Transitioning from train to train: 6 hours of handling time is added.
    - The end date/time of each leg is determined by the starting date/time and the mode of transport:
        - If the mode of transport is road, the average speed is applied based on the distance using the following rules:

- For a distance of less than 20 km, the average speed is 25 km/h
- For a distance of less than 50 km, the average speed is 50 km/h
- For a distance greater than 50 km, the average speed is 70 km/h

▪ If the mode of transport is train:

- all schedules connecting the origin and destination of the leg are retrieved from the corresponding arc's schedule, considering the indicated loading unit type on the screen.
- The closest schedule after or equal to the starting date/time is selected.

o Updating the first mile start/end date, when the first mile is covered by road and the "Fix Departure Date" checkbox is left blank:

▪ The end date/time of the first mile leg is updated to match the start date/time of the next leg. The start date/time of the first mile is recalculated by subtracting the travel time from the new end date/time.

o Travel time:

▪ per leg: Travel time is calculated as the end date/time minus the start date/time.

▪ per path: Total travel time is calculated as the last leg's end date/time minus the first leg's start date/time. This encompasses the travel time for each leg and the waiting time between legs.

o Distance:

▪ Per leg:

- For road, it is calculated using Graphhopper.
- For the other modes, it is calculated using the lower-level network directed graph

▪ Per path: the sum of the distance of each leg.

o External costs:

▪ The weight is obtained from data entered on the screen. The number of loading units is converted to weight following these rules:

- Container up to 20 ft: 20.12 t
- Container up to 40 ft: 18.79 t

        - Semitrailer: 25.99 t
    - For road transport, it is assumed a Heavy Goods Vehicle (HGV) is used, while for trains, an electrified train is assumed.
    - The parameters required to calculate external costs include the mode of transport, weight, and distance.
- Only road calculations:
    - Distance is determined using the shortest road distance between the origin and destination.
    - External costs are calculated based on the same criteria as those applied for road legs.

The External Cost Calculator is a JavaScript module designed for use in the map-based web application ESEP4Freight. It estimates the environmental and societal costs of freight transport operations in €-cents based on average external cost factors provided in the EU Handbook on External Costs.

The module supports multiple transport modes and provides both relative (per distance and weight) and total yearly cost outputs as structured JSON objects.

The calculator uses fixed values from the EU Handbook on External Costs (CE Delft, DG MOVE, 2020). These are applied per tonne-kilometre (tkm) or vehicle-kilometre (vkm) depending on the cost type.

Cost categories include:

- Accidents
- Air pollution
- Climate change
- Noise
- Congestion
- Well-to-tank (WTT) emissions
- Habitat damage

The data used in this module can be found in the EU Handbook.

For the calculation of the rail routing, only electrified track sections according to the RINF data were used for the main leg. The background is that otherwise, the selection of the shortest route would often include small non-electrified branch lines that are not actually used in practice. This approach enables a much more realistic routing, which serves as the basis for the calculation of external costs.

5.7 Stakeholders' directory

5.7.1 Description and how to

Contact directory of intermodal actors from different regions of Europe to facilitate matchmaking.

For each stakeholder, the following data is shared:

- Name of the stakeholder
- Web site
- Type of stakeholder
- For road operators, it also displays their address and the list of main intermodal terminals they are related to

A filter by name or type can be applied to select the list of stakeholders.

5.7.2 Reference values used and other relevant information

The initial identification of stakeholders was carried out based on comprehensive desk research by SGKV.

Any company interested in being part of the stakeholders' directory should contact the web platform responsible using the provided contact form to request their inclusion in the database.

5.8 Contract toolbox

5.8.1 Description and input collection

A template was created to collect information about the legal and policy framework ruling contractual relations within the intermodal transport sector. This includes for example Combined Transport Operators (CTOs), Terminal Operators (TOs), Logistics Service Providers (LSPs) or even shippers. A SWOT analysis and a catalogue of digital platforms for document exchange were also developed, leading to draft specification for smart contracts and contracts harmonisation opportunities.

An analysis of European projects related to smart contracts and blockchain was also performed and provided ground for specification definition to ensure compatibility with the ESEP4freight platform.

For each document, the following data is displayed:

- Name of the document
- Date of the document

- Application and scope
- Type of the document: General, General Terms and Conditions for intermodal operators and customers, General Terms and Conditions for terminals
- Category of the document: Convention, General Framework agreement, Framework services agreement, General Terms and Conditions
- The 'Open' button to download the document

A filter by name, type, category, date or scope can be applied to select the list of documents.

5.8.2 Reference values used and other relevant information

The following international conventions were identified as relevant under WP2.

- CIM (uniform rules concerning the contract of international carriage of goods by rail)
- General Terms and Conditions of Carriage for International Freight Traffic by Rail (GTC-CIM)
- Convention on the Contract for the International Carriage of Goods by Road (CMR)
- United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea (Rotterdam Rules)
- Strasbourg Convention on the Limitation of Liability in Inland Navigation (CLNI)
- Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway (CMNI)

An analysis of the UIRR's sectorial convention was performed and compared to a sample of CTO's terms and conditions (T&C) currently in force. These T&C rule the relationship between CTOs and LSPs

- Sectorial convention: UIRR General Terms and Conditions (1999)
- Combined transport Operator terms and conditions:
    - Adria Kombi
    - Alpe Adria
    - Ambrogio Trasporti
    - Baltic Rail
    - CargoBeamer
    - Hupac

- Kombiverkehr
- Mercitalia Intermodal
- Metrans
- Naviland Cargo
- Novatrans
- Samskip

A collection of the terms and conditions of LSPs related to their contractual relationship with shippers and their agreement with intermodal operators has also been performed:

- Gruber Logistics,
- BASF
- DHL Spain
- Zalando
- Condognotto
- Other companies whose testimonies were collected by EURNEX and Tenalach.

5.9 Corridors and traffic flows

5.9.1 Description and how to

Main European rail corridors (TEN-T) and their main infrastructure specifications are showed in the map. Freight volumes between major origin and destination nodes, and an outlook for high potential routes for modal shift

5.9.1.1 Corridors

The main European rail corridors (TEN-T) and their specifications are outlined. In the left side menu, you can find a list of these corridors under the 'Corridors' tab. Each corridor is associated with a specific colour that is represented on the map, while the main intermodal terminals along each corridor are indicated by a green circle.

Different filters can be applied to the results displayed in the map:

- Nominal track gauge
- Infrastructure manager

- TEN-T Classification
- Semi-trailers profile
- Swap-bodies profile

Filters within each group are applied as a union ('or'), while combinations between different groups are applied as an intersection ('and').

Clicking on a section of line in the map shows the section of line details, grouped by categories:

- Name of the section of line
- The list of corridors the section of line belongs to
- Country and responsible IM
- TENT-T Classification
- Main track characteristics:
    - Length of the section of line, in kilometres
    - Number of tracks
    - Gradient
    - Track gauge
- Freight transport characteristics:
    - Maximum train length
    - Maximum speed
    - Gauging
    - Profile for swap bodies
    - Profile for semitrailers
- Traction:
    - Electrification system,
    - Type of current
- Signalling system
- ETCS levels

Clicking on a terminal shows the terminal details (see Terminal information)

5.9.1.2 Rail freight traffic flow per regions

The rail freight traffic flow per regions is represented in the map after selecting the data:

- *Scenario*: choose one from the list
- *Import/Export*: choose one of the options
- *Volume cluster*: choose which volume clusters you want to represent on the map. By default, all clusters are selected

Once you select the Scenario and Import/Export options, the results will be displayed on the map. Different grades represent various clusters. The blue colour indicates import rail traffic flows, while the green colour represents export rail traffic flows.

When you click on a coloured region, a pop-up window appears showing the rail freight transport volume details for the selected area. By clicking on the 'Show import regions' ('Show export regions') button, you can highlight the regions that are the origin (destination) of import (export) rail freight transport.

Additionally, the chart option allows you to visualize the same data in a traditional chart format.

5.9.1.3 Freight transport per country – potential growth

The map shows the results of the work detailed in D1.1 Section 7.3 Potential of shifting freight to rail.

Different filters can be applied:

- Country: by default, all countries are selected.
- Type of goods: by default, all types of goods are selected. Putting the pointer on the question mark gives more detail about the type of goods.
- Current/potential: one option or both options can be selected. When both options are selected, the results show the sum of both.

The map illustrates the countries included in the study. Different color gradients indicate the volume measured in ton-km, as shown in the legend in the top right corner. The bubbles represent the volume in thousands of ton-km for each country and types of goods selected. By clicking on a bubble, you can view the total ton-km for each type of goods, along with their share relative to the overall volume displayed on the bubble

Additionally, the chart option allows you to visualize the same data in a traditional chart format.

5.9.2 Reference values used and other relevant information

5.9.2.1 Corridors

Data collection

- RINF – Register of Infrastructure (RINF Register of Infrastructure, 2025)
- RNE Customer Information Platform (RNE Customer Information Portal, 2025)
- FERRMED – Data from the Study of Traffic and Modal Shift Optimisation in the EU (Ferrmed, 2025)

5.9.2.2 Rail freight flows per regions

Rail freight traffic flow per region is estimated by implementing k-medoid clustering models for freight flows between NUTS level 2 and European statistical regions from 2005 to 2020. The extracted data from Eurostat for clustering comprised missing volumes. Developed clustering models are based on three scenarios of handling the missing volumes between regions.

- **Scenario Zero**: in this scenario, missing volumes are imputed as zero values. Scenario zero is the scenario that considers the lowest level of rail freight transportation in Europe.

- **Scenario Median**: in this scenario, missing volumes are imputed as the median of the volumes transported between NUTS level 2 and statistical regions for the specific year. The scenario median is the most realistic scenario in depicting the current rail freight status in Europe.

- **Scenario Random Forest Algorithm**: in this scenario, missing volumes are predicted from the patterns found in the non-missing volumes. Therefore, this scenario assumes higher transportation volumes. The results from scenario random forest regression may be the most optimistic ones and may not entirely depict the status of the European rail freight transport because the missing volumes are mostly predicted as ``what could be the transported volume.''

In the tables below, the minimum and maximum flow in each cluster is represented by the medoid, which is the central point of the cluster. Other flows in each cluster may experience higher or lower volumes from 2005 to 2020 because clustering considers the overall patterns in the dataset, but the medoid remains the point of reference for representation and clarity on the platform. Therefore, the legends in the platform are based on the medoids' range. Using the import/export tab in the web platform, the users can select a region and see the other regions that import or export to that region.

Table 4. Scenario Zero

Medoid NUTS O-D	NUTS code	Minimum Volume in Medoid (ton)	Maximum volume in Medoid (ton)	Cluster
Región de Murcia - Galicia	"ES62"-"ES11"	0	0	1
Śląskie - Střední Morava	"PL22"-"CZ07"	0	81,489	2
Thüringen - Düsseldorf	"DEG0"-"DEA1"	168,789	364,440	3
Cataluña - Cataluña	"ES51"-"ES51"	873,557	1,578,857	4
Moravskoslezsko - Moravskoslezsko	"CZ08"-"CZ08"	5,344,105	9,253,825	5

Table 5. Scenario Median

Medoid NUTS O-D	NUTS code	Minimum volume in Medoid (ton)	Maximum volume in Medoid (ton)	Cluster
Moravskoslezsko - Bursa, Eskişehir, Bilecik	"CZ08"-"TR41"	2,889	5,768	1
Észak-Magyarország - Bratislavský kraj	"HU31"-"SK01"	4,131	80,072	2
Hamburg - Oberpfalz	"DE60"-"DE23"	125371	272,282	3
Hamburg - Oberbayern	"DE60"-"DE21"	609,804	1,157,041	4
Severozápad - Severozápad	"CZ04"-"CZ04"	3,926,738	7,826,780	5

Table 6. Scenario Random Forest Algorithm

Medoid NUTS O-D	NUTS code	Minimum volume in Medoid (ton)	Maximum volume in Medoid (ton)	Cluster
Észak-Magyarország - Kärnten	"HU31"-"AT21"	3,242	4,611	1
Prov. Limburg (BE) - Zeeland	"BE22"-"NL34"	70,617	117,740	2
Zahodna Slovenija - Západné Slovensko	"SI04"-"SK02"	345,210	410,144	3
Veneto - Köln	"ITH3"-"DEA2"	1,256,887	1,511,127	4
Śląskie - Zachodniopomorskie	"PL22"-"PL42"	4,882,679	8,057,735	5

5.9.2.3 Freight transport per country – potential growth

To identify and estimate the potential of shifting road transport to rail within EU official data from Eurostat for rail and road transport for 2022 was analysed. Goods transported by road were classified by distance, i.e. 50 km, 50 to 149 km, 149 to 499 km and 500 km or more. The data was linear interpolated using equation to estimate the potential shift of over 300 km of goods transported by road to rail. More information can be found in (Djordjevic, 2024)

5.10 Smart Contract Demo

5.10.1 Description and how to

The demo walks through a real-world shipment from Äänekoski (Finland) to Alicante (Spain) across truck, ship, rail, and final-mile legs, showing how each handover becomes a signed, immutable proof-of-delivery on a shared ledger to replace e-mails and paper stamps with verifiable evidence. This design ensures every custody transfer is captured at the moment it occurs and can later be audited in a public explorer, building trust among shippers, forwarders, terminals, and carriers without third-party trust brokers.

- Start screen: launch the Esep4Freight Blockchain Demo to follow the shipment journey and see how the ledger records each hand-off and proof-of-delivery across modes.
- Delivery order: the shipper submits consignee, container ID, origin/destination, cargo details, ETA, and chosen forwarder to initiate the chain in a familiar workflow before any blockchain event occurs.
- Booking legs: the forwarder books the first and last truck legs as standard transport actions, intentionally triggering no blockchain writes at booking time to avoid clutter and keep the ledger focused on custody events, not planning data.

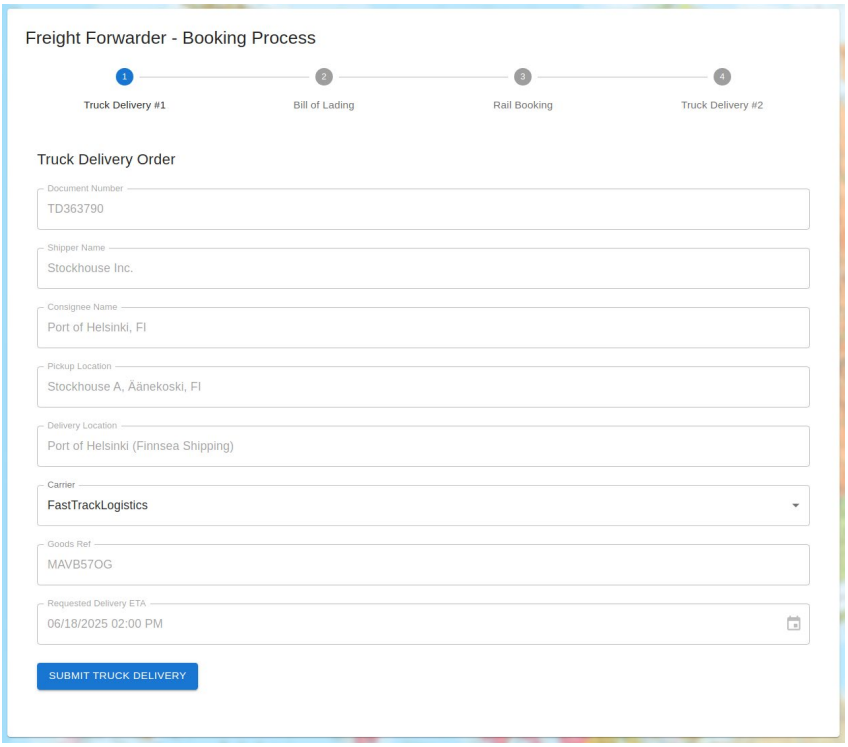

Figure 3. Summary of the booking leg of the smart contract pilot

- Transport dashboard: a multi-leg dashboard activates each leg in sequence and summarizes container details and proofs as they are created, providing operational clarity while the ledger becomes the evidence trail.
- Handover and PoD: at the start of every leg, the receiver confirms who hands over/accepts, container ID, seal status, notes, and signature, and "Accept Goods" writes the proof-of-delivery to the blockchain to establish a tamper-proof hand-off record before movement continues.

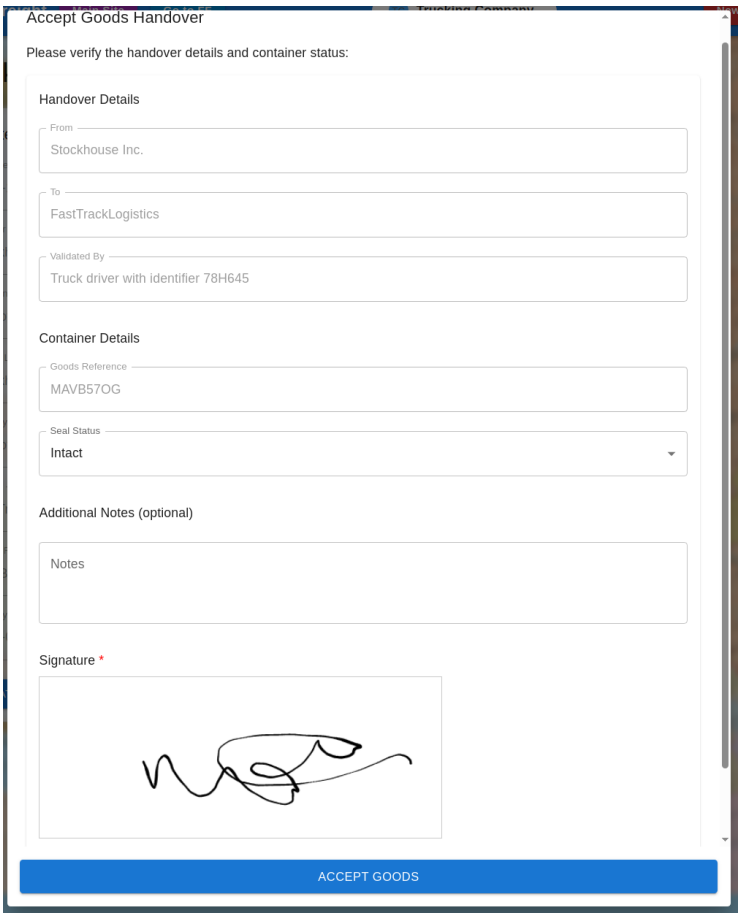

Figure 4. Handover and Proof of Delivery of the smart contract pilot

- Truck in-transit: carriers can update the e-CMR, simulate the journey, and post status pings; routine telematics remain off-chain by design, while the custody events remain on-chain to balance scalability with evidentiary value.

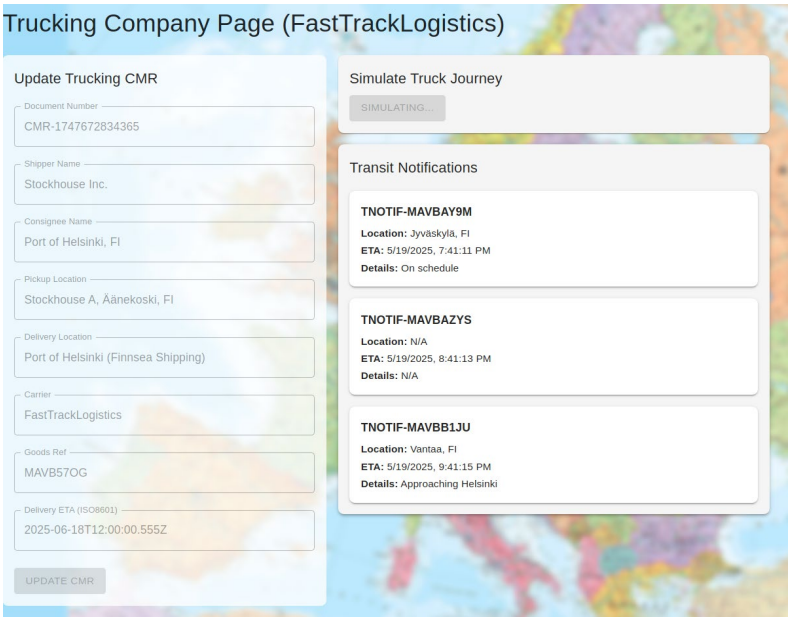

Figure 5. Simulation track journey of the smart contract pilot

- Ocean operations: the shipping line confirms maritime fees, simulates voyage events, and records discharge conditions; no new blockchain transaction is generated here because custody does not change, preserving the ledger for material transfer and critical evidence.
- Document hash anchoring: when “Download B/L” is clicked, the Bill of Lading is generated and its cryptographic hash and transaction ID are stamped on-chain so any party can later verify the document’s integrity and timestamp without sharing the file itself.

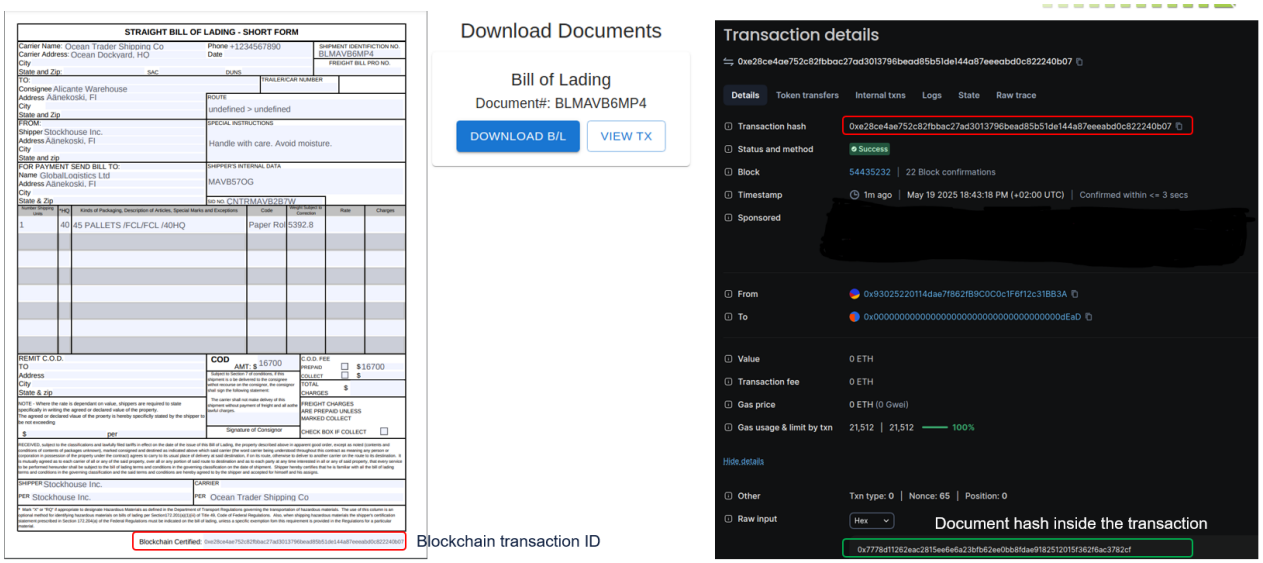

Figure 6. Bill of Lading and cryptographic hash of the smart contract pilot

- Final PoD: at destination, the receiver submits the last proof with optional photo, seal remarks, and signature, which closes the shipment's on-chain evidence and aligns the leg-by-leg record with the operational summaries.
- Timeline and verification: the end-to-end timeline lists every handover with roles and seal status, and selecting "Blockchain Proof" opens a public explorer that shows transaction success, timestamp, block number, and raw input fields to independently verify the record.

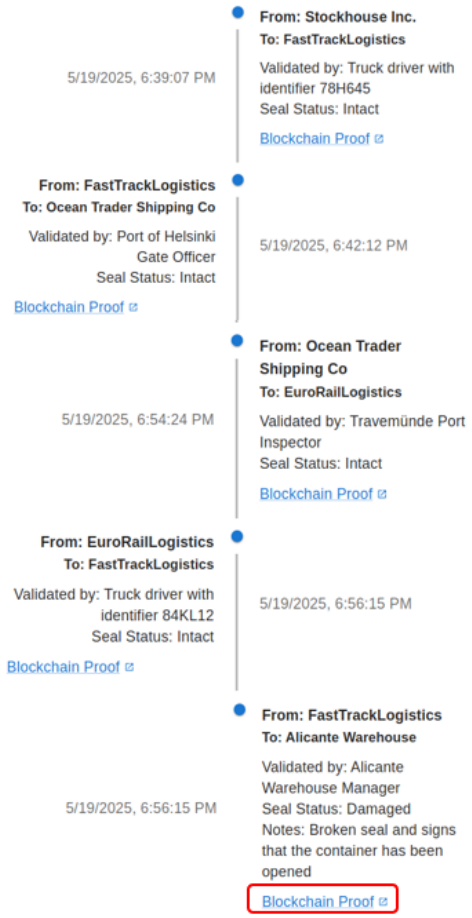

Figure 7. Timeline and verification smart contract pilot

5.10.2 Design choices and rationale

The demo deliberately anchors only material events—namely leg handovers as proofs of delivery and the certification of key transport documents—on the shared ledger to keep the on-chain record concise, legally meaningful, and directly tied to custody changes and document integrity rather than to mutable planning edits or operational chatter. This separation between planning workflows and evidentiary records is reflected in the guided, leg-by-leg dashboard where operational steps proceed in sequence, while the act of accepting goods triggers the immutable write that establishes non-repudiation for each handover before the shipment advances to the next carrier or mode.

To ensure document integrity and time-stamping without exposing sensitive content, the demo hashes the Bill of Lading and anchors this cryptographic digest within a blockchain transaction that surfaces a transaction identifier for later verification, allowing parties to prove a document has not been altered and existed at a given moment without storing the document itself on-chain. The same principle applies to essential proof-of-delivery inputs, where embedding the minimal, relevant data needed for independent verification provides a durable audit trail while keeping confidential operational details off the public ledger and within the respective operational systems.

Public verification is a first-class aspect of the experience: each recorded event and certified document presents a "Blockchain Proof" link that opens an explorer view exposing the transaction's success status, timestamp, block number, and the anchored inputs so that any stakeholder can independently validate the evidence without relying on a central repository or an intermediary's testimony. This design shortens dispute resolution cycles by making the same immutable facts available to all parties and transforms what would otherwise be back-and-forth email reconciliation into a shared source of truth backed by cryptographic guarantees and a transparent audit path.

The overall approach is framed as a proof of concept based on eFTI and blockchain, demonstrating how digital transport information and digital evidence can interoperate across actors and systems while remaining understandable to operational users and inspectable by technical stakeholders through the explorer views and transaction metadata. The "Smart Contracts proof of concept current status" framing clarifies scope and maturity boundaries, indicating which touchpoints and documents are covered across modes and roles so the audience can relate the demo's evidentiary focus to familiar processes and systems in a realistic end-to-end journey.

5.10.3 Reference values used and other relevant information

- Shipment path: Äänekoski (FI) to Alicante (ES), with first truck leg to Port of Helsinki, sea leg, rail segment to Barcelona terminal, and final-mile truck to consignee.
- Roles and systems: Freight forwarder, road carriers, shipping line, railway operator, intermodal terminal; Port Community System, TMS, Railway Operator System, Terminal Operating System are shown to reflect realistic IT boundaries.
- Documents and evidences: Delivery Order, e-CMR, CIM reference in flow, Release Order, Bill of Lading, maritime fee components, and per-leg PoD with signatures and seal checks.
- Blockchain artifacts: Transaction IDs, block numbers, timestamps, and embedded hashed inputs for PoD and B/L; explorer view exposes raw input fields for independent verification.

5.11 About us

- User handbook: an HTML version of this handbook,
- Frequently asked questions.
- Terms and conditions.
- Contact form: to contact with the web platform responsible. To solve doubts, to inform about issues or suggest improvements, to share your data and include your company, terminal, etc in the web platform database.
- Other project outputs: a link to the web project site and the project deliverables

From ESEP4Freight logo: a link to the project web site

6 Conclusions

Deliverable D5.3 consolidates the final outcomes of the ESEP4Freight project through the impact assessment, scalability analysis, and user handbook. The impact assessment shows that the project delivered on its main objectives: the platform was launched with all planned modules, validated with stakeholders, and confirmed to raise awareness of intermodal opportunities. The results indicate a tangible contribution to modal shift objectives, particularly among SMEs and smaller operators.

The scalability analysis highlights that the platform can evolve further by expanding coverage, improving reliability of data, and integrating additional modes and functionalities. Critical next steps include interoperability through APIs, enhanced external cost calculations, and real-time data integration to build long-term trust and usability.

The user handbook provides clear, structured instructions for using the platform and ensures transparency on data sources and methodologies. This strengthens user confidence and facilitates the transfer of results to target groups.

Overall, the project has demonstrated the feasibility and added value of a neutral, open-access digital platform for intermodal rail freight services. While some limitations (such as API development and long-term integration with large operators' systems) remain, ESEP4Freight has established a strong foundation for future adoption, scalability, and policy impact.

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