Italy – Croatia

CROSSFREIGHT

Work Package 3

Activity 3.2

D 3.2.1: CROSSFREIGHT exploitation potential and policy recommendations

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1. Executive summary

This deliverable is aimed at providing the overall exploitation strategy and policy recommendations for the CROSSFREIGHT concept and ICT solutions deployment in the real-word rail operators' market.

Valuable marketing criteria and exploitation plans of the CROSSFREIGHT solutions have been addressed, encompassing the innovative ICT solutions designed, developed and tested by Field Operational Tests (FOTs) at the seven different intermodal and port nodes for an efficient, streamlined and sustainable rail shunting management and operation, benefiting the railway freight transport ecosystem at the 7 nodes.

The 7 pilot actions have been designed by the "Planning" phase, developed and implemented in the test environment within the "Running" phase, and evaluated by Key Performance Indicators (KPIs) within the "Evaluation" phase, determining relevant impacts according to the FESTA methodology defined in WP2.

The assessment of the rail operators' market supporting the digital transaction of shunting activities has been addressed, encompassing the evaluation of comparable ICT tools, potential end-users' clusters among local and regional stakeholders established by the partners for running and evaluating the pilot actions by FOTs. The market analysis encompasses a comparative assessment between each ICT solution developed and tested in the pilot action and relevant IT (software) solutions available in real-life market, enabling to point out potential gaps as well as competitive advantages of the CROSSFREIGHT innovations.

Exploitation plan for each tested innovative solution for the digitalization of rail shunting operations has been also linked with potential national and regional stakeholders for each project's partner as well as with relevant networks and institutions at EU level operating in rail sector (e.g. EU Railway Agency, etc.).

Lastly, policy recommendations for better coordination between transport modes and logistics chain stakeholders for railway shunting management have been provided addressing EUSAIR territory and relevant rail nodes, encompassing Political, Economic, Social, Technological, Legal, and Environmental factors, to be considered as potential barriers or enablers for successful digitalization and collaboration.

2. Methodology

The exploitation strategy of the CROSSFREIGHT Key Exploitable Results (KERs) has been defined outlining an ad-hoc questionnaire which has been submitted to pilot partners enabling them to provide valuable insights and data into potential exploitation pathways for the IT solutions deployed and tested in WP2. The key topics which have been defined for the definition of exploitation and effective scaling up of the tested IT solutions and EUSAIR regional policy recommendations are indicated as follows:

- **Rail shunting systems market size**
  - ICT tools for rail shunting operations available in the current market
  - Main competitors in ICT tool for the digitalization of rail shunting activities
- **Potential end-users' clusters among local/regional stakeholders of pilot actions**
  - Clusters definition and characterization (e.g. shunting operators, rail operators, railway undertakings, MTOs, carriers, terminals, etc.) for each pilot action stakeholders' ecosystem
- **Comparative analysis between CROSSFREIGHT solutions and market-based ICT tools**
  - Competitive advantages of innovative solutions (e.g. unique selling point, filled gaps, etc.)
- **Exploitation strategies for CROSSFREIGHT innovative ICT solutions**
  - Business Model Canvas (BMC) for business modelling of the project's innovative solutions
  - Product Use Cases (its application for the pilot actions by FOTs)
  - Intellectual Property
- **Policy recommendations for stakeholders' collaboration and rail shunting digitalisation**
  - Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) factors
  - Guidelines for supporting policy recommendations leveraging the project's outcomes

3. Rail shunting systems' current market

This section report deals with a benchmarking of logistics automation technologies with the aim of describing ICT systems and applications available in the market for digitalized rail shunting operations.

Below examples of ICT systems and applications available in the market are presented with the aim of providing insights on potential IT solutions to be considered as competitors of CROSSFREIGHT solutions.

Rail Shunting System (RSS) - DBA Group
(https://www.dbagroup.it/en-GB/what-we-do/transport-logistics/software-products/the-port-of-burgas-and-the-aurubis-industrial-site-software-services)

The RSS (Rail Shunting System) software supports Port Rail Ltd. (Port Rail Ltd. is the shunting operator with the most extensive scope of activities in the Gulf of Burgas. It manages the entire flow of goods at Burgas station and to/from its connecting terminals), in the management of the following activities:

- planning, execution and control of shunting based on the available infrastructure and resources, the services required by the connections, incoming rail traffic and planned departures;
- managing service requests (goods information, weighing services, repair services, wagon supply and additional services);
- real-time monitoring of track occupancy status with the indication of the number of wagons present and their position;
- reporting to support invoicing and KPIs;
- registry of locomotives and wagons;
- implementing a mobile app to support activities in the field. This technology controls and monitors all shunting operations, unit/truck damage control, and railway wagons' positioning (uncoupling and coupling) in stations, shunting, and coupling areas in real time.

I-TOS for intermodal rail terminal management- DBA Group
(https://www.dbagroup.it/en-GB/what-we-do/transport-logistics/software-products/itos-for-intermodal-rail-terminal-management)

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The I-TOS (Intermodal-Terminal Operating System) software is addressed for integrated management of logistics processes in Intermodal Transport. I-TOS can be extended with the Vehicle Booking System (VBS) module, which reduces time required for scheduled delivery and goods' collection in precise time slots. It supports Interporto Interminal Quadrante Servizi in Verona in the digitization of the following processes:

- train travel management (composition, recalls, waste management, units and goods transported, Interchange, CIM)
- management of train loading/unloading activities, handling and storage of units
- gate in/out management (vehicle and driver acceptance, Interchange printing, unit exit confirmation)
- management of yard stock and advance notice of arrival
- reporting to support invoicing and KPIs
- wagon records with the registration of the last completed trip.
- support of the main EDIGES messages: S30 (train composition), S10 (trip reservation - booking), S11 (cancellation of trip reservation), S38 (confirmation of arrival and train composition), S40 (UTI pick-up notification), S50 (confirmation of unit picked up by haulier), S25 (confirmation of unit load on a train).
- the mobile app to support the verification of train composition, damage detection of loading units and their positioning in the yard.

Rail Shipment Visibility - KALERIS
(https://kaleris.com/solutions/transportation-management/shipment-visibility/)

Rail Shipment Visibility provides real-time visibility into the status of rail shipments. The solution tracks, traces, and proactively monitors shipments. Integrating dynamic railcar event data with business intelligence reporting from hundreds of railroads provides up-to-date information about your rail inventory and assets. Track Inventory in Real-time anticipates potential problems before they occur and mitigate their impact, reduce delays and variability, improve customer satisfaction, and maintain data integrity. This solution enables visibility across the tracks enabling to achieve the following functions:

- universal web access via laptop, smartphone, or tablet;
- dedicated data management and support team;
- trip and fleet management based on business rules and alerting;
- fleet, lease, detention, demurrage, and unit train reporting and management;
- highly configurable scheduled reporting based on canned and/or customer-specific templates;
- tracks key KPIs: transit/dwell/cycle time, trip analysis, percent under load, etc.

Rail Terminal Operating System - Tideworks Technology
https://tideworks.com/products/#rail-solutions

Rail Terminal Operating System (TOS) operates leverage cutting-edge rail planning technology for on-dock and rail terminals. Intermodal PRO (Rail TOS) solution enables to:

- maximize planning efficiency using automated graphical planning tools that control trains in the yard and moving to and from the gate;
- connect automatically with customer and partner systems using EDI engine and trade booking translator to share billing and other data with necessary parties;
- view data with flexible, user-driven reporting tools enabling custom reports without custom development;
- comply with operating standards in different Regions for hazardous load planning, equipment types and EDI messaging in Europe and beyond

Rail Terminal Operating System - INFORM
https://www.inform-software.com/en/solutions/logistics/intermodal-terminal-logistics

Syncrotess intermodal TOS is the software for optimized load unit handling in intermodal terminals. Tailored to the needs of intermodal transport processes, the system enhances the container handling between rail, road and water. The system manages all transport processes within a terminal, the terminal-specific services and improves yard management. Powered by advanced machine learning algorithms and real-time data analytics, INFORM AI-driven system offers unparalleled efficiency, accuracy, and adaptability in handling complex terminal operations. Among the others, Rail Control provides management of all rails related base data to allow manual train planning using drag and drop functionality.

Autostore TOS – TBA Group
https://tba.group/software/autostore-terminal-operating-system

The Autostore container terminal management system uses a modular, open software architecture that gives you choice and flexibility. It connects directly to business management platform, finance, HR and all your equipment, both automated and manual. It seamlessly integrates all operational processes with business management reporting and finance. It provides a real-time overview of your cargo position plus all the delays, bottlenecks, changes and variances. It enables advanced simulation, tuning and training tools for container terminal optimisation and disruption-free installation. Finally, Autostore TOS enables Dynamic Rail Planning from import, export and transshipment processing to gate operations, yard management, vessel/rail operations and statistical analysis, raising the bar for container logistics control.

Autostore TOS – CIRCLE Group
(https://www.circlegroup.eu/wp-content/uploads/2022/04/Milos-MTO_scheda-suite_sent-ISSC.pdf)

Milos MTO is an innovative modular suite designed to manage all the activities of the multimodal transport operator (MTO) thanks to the integration of commercial, operative and administrative processes, the evaluation of performance and of the related profitability. The modular design of this solution allows indeed to manage every single stage of the multimodal and rail transport process – from the design to the pre-invoicing – configuring flexible and customised solutions; furthermore it is an open and collaborative platform, designed to dialogue with third parties' systems thanks to interoperable standard messages such as EDIFACT/EDIGES as well as to provide native integration with Milos TOS, Milos Global Supply Chain Visibility and Optimisation solutions, for the effective overall transport planning.

4. Exploitation strategies of the CROSSFREIGHT innovative solutions

This chapter presents the exploitation strategy for the innovative tools and solutions which have been developed and tested within the seven different pilot actions of the CROSSFREIGHT project. The tools have been developed or significantly advanced, demonstrating potential for future uptake and replication.

For each ICT tool, a structured analysis has been conducted adopting the Business Model Canvas (BMC) methodology, which served as the basis for drafting corresponding market entry, including customer identification and market opportunities (Customer Segment and Value Proposition), Product Use Cases (factsheet of the pilot action results based on ICT solution), Intellectual Property, and final assessment.

The exploitation strategies for the different innovations tested within the 7 pilot actions are compliant with the overall framework outlined through the shaped questionnaire which was used for data collection.

For each pilot partner, overall exploitation pathway is provided for the CROSSFREIGHT innovations by the identification of addressed functionalities, stakeholder's categories definition and characterization, their competitive advantages in terms of unique selling points as well as filled gaps through the solution comparing AS-IS scenario ("without" innovative solution) and TO BE scenario ("with" innovative solution), business modelling of the developed and tested IT solutions using the well-known BMC, the practical ways the technology was applied assessing its effectiveness and potential for wider implementation (including the description of problem addressed, ICT solution's features and peculiarities, how the digital solution was used in real-world TO-BE scenarios, quantify outcomes and results), Intellectual Property Rights, and finally Political, Economic, Social, Technological, Legal and Environmental factors (drivers and barriers).

4.1 Fondazione ITL – Port of Ravenna

Application (Rail Shunting System software module) for optimizing the planning and execution phase of railway operations in the intermodal node of Ravenna

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The CROSSFREIGHT pilot action focuses on the digitalization and optimization of rail shunting operations within the rail node of Ravenna through the implementation of an interoperable ICT solution designed to improve operational efficiency, coordination, and resource management among the stakeholders operating in the port railway ecosystem. The pilot specifically addresses two core functionalities.

Firstly, the solution enables the digital allocation of rail tracks and operational time slots, supporting more efficient planning and coordination of shunting activities across the Ravenna rail hub.

Secondly, the platform introduces digital communication mechanisms for managing and sharing operational information related to Shunting In/Shunting Out activities and Loading–Unloading times among the involved stakeholders. These functionalities replace traditional manual communication methods and contribute to a more structured, timely, and reliable exchange of operational data.

The pilot action involves several key stakeholders operating within the Ravenna rail and port environment. The main operational actors participating in the testing phase are the shunting operators MERCITALIA Shunting & Terminal and DINAZZANO PO, together with the Port of Ravenna Authority (ADSP MACS). Their involvement is essential for validating the CROSSFREIGHT solution under real operational conditions and ensuring its effective integration within the existing railway and port management ecosystem.

MERCITALIA Shunting & Terminal contributes to the pilot by testing the CROSSFREIGHT software module in an operational environment that accurately reproduces the conditions of the Ravenna rail node. The objective is to verify the software requirements, functionalities, operational stability, and reliability prior to full deployment. Focus was dedicated to supporting shunting activities in the left-side yard "Candiano", ensuring interoperability with the Rail Management System (RMS) operated by the Port Authority.

Similarly, DINAZZANO PO participates in the pilot through the validation of the CROSSFREIGHT solution within the operational environment of the right-side yard "Base e Pesa." The testing activities aim to confirm the readiness of the platform for daily operational use and to ensure seamless interoperability with the existing Rail Management System governing the Ravenna rail node.

The Port of Ravenna Authority (ADSP MACS) plays a strategic coordination and integration role during the pilot implementation. Its contribution focuses on verifying the interoperability of the CROSSFREIGHT solution with the existing Rail Management Platform (RMP), which is already integrated with the Ravenna Port Community System (PCS) and connected to RFI's Integrated Circulation Platform (PIC).

Through the testing phase, the Port Authority supports the validation of data exchange processes and system integration capabilities among the different information systems used by shunting operators and port stakeholders. From an innovation perspective, the CROSSFREIGHT solution introduces several competitive advantages compared with the current operational framework.

One of the key strengths of the system is the implementation of automated movement planning and optimization functionalities capable of supporting the generation of optimized shunting plans. This enables the reduction of idle times, minimization of unnecessary locomotive movements, and improvement of the overall throughput and efficiency of the railway yard operations.

Another significant advantage is the introduction of paperless and streamlined communication processes. Through digital workflows, operational instructions, confirmations, and work orders can be exchanged instantly among stakeholders, reducing the dependency on manual communications such as phone calls and emails while minimizing the risk of misunderstandings and operational errors.

The pilot also contributes to reducing operational costs by optimizing the allocation and utilization of available resources, including locomotives and shunting teams. Improved operational planning and coordination are expected to decrease inefficiencies, reduce fuel consumption, and lower the operational burden associated with manually managed shunting activities.

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The implementation of the CROSSFREIGHT solution addresses several critical gaps identified in the current AS-IS operational scenario of the Ravenna rail node. At present, rail shunting operations are largely managed manually, with operational communications and task assignments exchanged through emails and telephone calls. This approach limits operational visibility, slows decision-making processes, and reduces the ability to optimize resource allocation efficiently. The TO-BE scenario envisioned through the pilot introduces a customized and interoperable software module capable of supporting assisted rail shunting optimization. The new system enables the prioritization of shunting operations, the optimized allocation of locomotives and shunting teams, and the digital sharing of operational data among different stakeholders active within Ravenna node, including shunting operators, terminals, and port authorities.

The CROSSFREIGHT pilot represents an important step toward the modernization and digital transformation of rail shunting operations in Ravenna. By introducing interoperable ICT tools, process automation, and digital collaboration mechanisms, the project aims to improve operational efficiency, strengthen coordination among stakeholders, and establish a scalable and transferable model that could potentially be replicated in other intermodal and port railway nodes, starting with the Bologna freight village which has been selected and engaged for the transferability exercise implemented in the project.

Transferability exercise has been implemented by ITL through the involvement of **Bologna Freight Village (Interporto of Bologna)** for verifying preconditions to potential deployment of RSS successfully developed and tested in the intermodal node of Ravenna with the involvement of AdSP and railways undertakings.

On the 24th of April a meeting was held with Bologna Freight Village regarding the transferability of the ICT solution of Ravenna. Technicians of Bologna were presented with the solution and then asked for feedback. They deemed the ICT tool useful but stated that at this point it could not be applied at Freight Village because it needs to be integrated with shunting management software, but they do not have any currently. It was concluded that the tool has a transferability potential, but the freight village probably does not yet have a technical maturity to adopt it.

Bologna freight village is characterized by a capacity of 8000 trains/year, where tracks and yards are owned by RFI, managed by Terminali Italia, IPBO carries out railway shunting and ITU handling activities.

It performs 20 shunting operations/day by 11 operators using standard Excel modules for shunting planning and management operations. On the other hand, it can be recognised among the actual bottlenecks the unavailability of wagon tracking, real-time communications with railways undertakings and RFI, as well as ICT platform or application active at the node for shunting planning and execution.

Web-based apps for sharing documentation, even offline, with coordination and railways shunting operations personnel are only available. During the meeting with the technicians of the Bologna freight village, it was pointed out the need for shunting operations optimization module for the planning phase (as offered by the RSS module deployed in Ravenna) but, at the same time, with its possible integration with a shunting operations management software. The digital readiness of the Bologna node for railway shunting operations can be considered with large margins for growth, also considering the potential digitalisation investment by the local stakeholders (e.g. railway undertakings, terminal operators, etc.).

Specific requirements indicated by the Bologna freight village for managing the railway shunting operation (such as granular control at the wagon level, etc.) are represented by the following data:

- during the railway shunting planning phase (train number, P/A location and time, shunting start/end time, shunting request with the various types of digitized operation),
- during the shunting management phase (train composition, wagon number and characteristics, RID freight indication, track positioning within the facility, digitized 6A/6B module switches, shunting request with the various types of digitized operation).

Technicians involved in the transferability exercise also indicated the need of measuring specific KPIs to enable improving operational efficiency and process sustainability (e.g. team workload, average length of stay in the station and terminal, % trains served, etc.). The set of KPIs which has been indicated are:

- track allocation and occupancy,
- shift management of operational staff and locomotive use,
- average shunting execution times,
- average length of train stopping in the station and terminal,

- % shunting trains compared to scheduled,
- % trains served on time.

Based upon the described preconditions and digital readiness of the Bologna freight village, the transferability activities is focused on analysing the compatibility between the Ravenna RSS functionalities and the operational requirements of the Bologna node, including optimization of shunting planning processes, track allocation management, locomotive and operational team scheduling, wagon-level operational monitoring, real-time operational communication, and digitalization of operational workflows and documentation. Attention should be dedicated to the integration of the RSS optimization module with future shunting management functionalities requested by the local stakeholders, such as train composition management, RID freight monitoring, digitalized operational forms, and real-time execution monitoring. The exercise also evaluated interoperability with the existing railway ecosystem involving RFI, Terminali Italia, IPBO, Railway Undertakings, and terminal operators, while assessing the scalability of the RSS optimization engine under more complex rail traffic and operational conditions.

The transferability exercise represents an important opportunity to validate the scalability of the Ravenna RSS solution in a more complex intermodal railway environment, supporting the digital transformation of railway shunting operations and establishing a potentially replicable model for other freight and intermodal terminals within the TEN-T network.

Requirements for the successful application of the Ravenna RSS module to the Bologna Freight Village

A key prerequisite for RSS deployment is the availability of reliable and structured operational data.

Bologna freight village should ensure as follows:

- digital availability of train planning data,
- standardized train identifiers,
- wagon composition data,
- track occupancy information,
- locomotive and shunting team availability.

Attention should be dedicated to the harmonization of data formats among stakeholders, data quality validation, and real-time updating of operational information. The introduction of shared operational data standards is essential to support automated planning and dynamic rescheduling functionalities.

Successful deployment requires, among the others, integration with RFI operational systems, communication interfaces with railway undertakings, interoperability with Terminali Italia operational procedures, and coordination with IPBO operational workflows. Additional requirements include API-based data exchange mechanisms, secure communication protocols, and compatibility with future digital platforms adopted by local stakeholders. One of the major gaps identified in Bologna concerns the absence of real-time operational communication among actors. The successful application of RSS requires real-time exchange of shunting requests, operational notifications, train status updates, track occupation status, and execution confirmations. Moreover, the effectiveness of RSS optimization functionalities depends on the digital readiness of the railway node infrastructure and services. Current Bologna operations still rely heavily on Excel-based planning, phone communications, and manual coordination.

RSS implementation therefore requires the transition to digital workflows by the harmonization of operational workflows, standardization of shunting request procedures, digitalization of operational forms (including 6A/6B modules), and structured management of operational events. Finally, being the Bologna operational environment more complex than Ravenna in terms of traffic density, number of operations, and operational interactions, the successful deployment of RSS in Bologna requires scalability of optimization algorithms, ability to manage simultaneous operations, dynamic conflict resolution, and support for real-time replanning. To complete the transferability analysis, strategic and financial commitment needs to be considered as well. Successful transferability requires therefore long-term stakeholder commitment, investment in digital infrastructure, operational support resources, and governance continuity. The willingness of local stakeholders to invest in digitalization, as highlighted during transferability discussions, represents an important enabling factor for successful RSS adoption.

Exploitation strategy of the project's innovative solution of Port of Ravenna

BMC for business modelling of the developed and tested ICT tool is presented below.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr>
<td rowspan="3">Central Adriatic Sea Port Authority (ADSP MACS)

Shunting service operators (the joint venture between Mercitalia Shunting & Terminal and Dinazzano Po)

RFI (Rete Ferroviaria Italiana) providing PIC and being responsible for upgrading the freight yards on both the left and right banks of the Candiano Canal</td>
<td>Optimization algorithm development and customization for ensuring compliance and interoperability

Continuous evolutionary maintenance and adjustment of the optimization algorithms based on operational parameters Ravenna intermodal node

Management of complex information flows (notifications, train lists) among the Railway Undertaking, MTO, Port Terminal, and Shunting Operator

Software validation of in an operational environment, involving the personnel of Mercitalia Shunting & Terminal, Dinazzano Po

Software training activities for personnel</td>
<td rowspan="3">Port-rail seamless integration (24/7 operational) through optimized data-driven planning and execution of rail shunting processes

Enhance operational efficiency enabling to reduce required time for operators for manual planning enabling them concentrating on emergency situations

Intelligent planning to enable offering advanced optimized scheduling for railway shunting, balancing limited resources (tracks, locomotives, personnel) and operational constraints (schedules)

Viable interoperability guaranteeing smooth and standardized integration with existing stakeholder platforms (RMP, operators' management software)</td>
<td>The main channel for delivering value to customers is the direct technical interface (API) with the customers' management platforms rather than a B2C web</td>
<td rowspan="3">Terminal Operators (POLYNT, P.I.R., SAPIR, VERSALIS, MARCEGAGNA, I.F.A., SAPIR, Terminal Container S. Vitale, SETRAMAR, DOCKS Cereali)

Railway Undertakings (Companies requiring train decomposition/formation for long-distance haulage)

Connected Industrial Site (Companies with private rail sidings directly linked to the port network)</td>
</tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr>
<td>The optimization software module as the key digital asset, with specific usage rights granted to the ERIC cluster members

Operational data related to paths, resources, and capacity of the rail assets, managed in real time, as fundamental resource for the shunting operation's optimization algorithm</td>
<td>Direct sales activities

Communication and promoting activities by ADSP MAC

Partnerships with logistics operators</td>
</tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
</table>

Software development costs, including technical and functional requirements analysis, design, development and testing activities Costs for the software maintenance, including evolutionary maintenance activities, potential upgrades and finetuning	Potential revenues may arise from subscription Potential revenues may arise from usage-based models for services provision (e.g. SaaS, evolutionary support, Help Desk, etc.)

The CROSSFREIGHT business model is centered on the digital transformation and optimization of rail shunting operations within the Ravenna intermodal and port logistics ecosystem. The initiative is based on strong cooperation among institutional, railway, logistics, and industrial stakeholders, with the objective of improving operational efficiency, interoperability, and coordination of rail freight activities through the implementation of an advanced ICT solution.

A fundamental role within the business model is played by the ADSP MAC, which acts as the institutional coordinator of the initiative and supports the integration of the solution within the existing Port Community System and Rail Management Platform environment. The operational dimension of the project is strengthened through the involvement of the shunting service operators Mercitalia Shunting & Terminal and Dinazzano Po, which contribute operational expertise and validate the software functionalities under real working conditions within the Ravenna railway yards.

The collaboration with RFI (Rete Ferroviaria Italiana) further supports the initiative through the provision of the Integrated Circulation Platform (PIC) and infrastructure upgrading activities related to the freight yards located on both sides of the Candiano Canal.

The core activities of the project focus on the development, customization, and continuous improvement of optimization algorithms designed to support intelligent rail shunting planning and operational decision-making. The software is specifically developed to ensure compliance with operational requirements and interoperability with existing railway and port management systems. Continuous evolutionary maintenance activities are foreseen in order to adapt the algorithms and functionalities to changing operational parameters and traffic conditions within the Ravenna intermodal node. The solution also supports the management of complex information flows among Railway Undertakings, Multimodal Transport Operators, Port Terminals, and Shunting Operators, enabling the digital exchange of operational notifications, train lists, scheduling information, and resource allocation data.

In addition, operational testing and validation activities are carried out directly in the railway yards with the active participation of personnel from Mercitalia Shunting & Terminal and Dinazzano Po to ensure the platform's stability, reliability, and operational readiness. Dedicated training activities are also organized to facilitate the adoption of the new digital tools and procedures by operational staff.

The value generated by the CROSSFREIGHT solution is primarily linked to the creation of a seamless and integrated port-rail operational environment based on data-driven planning and digital coordination of rail shunting activities. The solution enables a significant improvement in operational efficiency by reducing the time currently required for manual planning and coordination activities, allowing operators to focus on critical operational and emergency situations. Through intelligent planning and optimization functionalities, the platform supports the efficient scheduling of shunting operations by balancing the availability of tracks, locomotives, personnel, and operational time constraints.

Another key element of the value proposition is the capability of the system to ensure interoperability with existing digital platforms, including the Rail Management Platform and the management systems used by the different operators active within the Ravenna logistics ecosystem. This interoperability guarantees standardized and reliable information exchange among stakeholders and supports continuous 24/7 operational coordination between port and rail activities.

The relationship with customers is mainly based on direct technical integration and long-term operational cooperation rather than on traditional business-to-consumer interactions. The primary channel for delivering value is represented by the direct technical interface through APIs, which allow customers to connect their operational management systems directly with the CROSSFREIGHT platform. This approach enables continuous real-time data exchange and operational synchronization among all involved actors. The business model therefore relies on ongoing technical support, software maintenance, interoperability services, and continuous system optimization activities to maintain long-term customer relationships.

The solution targets multiple customer segments operating within the railway freight and intermodal logistics sector. These include terminal operators active within the Port of Ravenna ecosystem, such as POLYNT, P.I.R., SAPIR, VERSALIS, MARCEGAGNA, I.F.A., Terminal Container S. Vitale, SETRAMAR, and

DOCKS Cereali. Additional target customers include Railway Undertakings requiring train composition and decomposition services for long-distance freight transport, as well as industrial sites connected to the port railway network through private rail sidings.

The key resources supporting the business model are represented by the optimization software module itself, which constitutes the core digital asset of the initiative, and by the operational data related to railway paths, infrastructure capacity, locomotives, track occupation, and personnel allocation managed in real time by the platform. These data resources are essential for enabling the optimization algorithms to generate efficient and reliable operational planning scenarios.

The commercialization and dissemination of the solution are supported through direct sales and technical engagement activities addressed to logistics operators, railway undertakings, terminals, and industrial stakeholders. Communication and promotional activities carried out by the Central Adriatic Sea Port Authority (ADSP MAC) further contribute to increasing awareness and adoption potential within the intermodal logistics sector. Strategic partnerships with logistics operators also support the expansion and scalability of the solution beyond the Ravenna rail node.

The main cost elements associated with the business model concern software development and maintenance activities. These include technical and functional analysis, software design, coding, testing, interoperability integration, and validation activities necessary to ensure operational effectiveness and compliance with stakeholder requirements. Additional costs are linked to evolutionary maintenance, software upgrades, optimization of functionalities, and continuous technical support services.

Potential revenue streams are expected to derive from subscription-based access to the platform and from usage-based service models. These may include Software-as-a-Service (SaaS) offerings, interoperability services, software customization, technical support, Help Desk activities, and evolutionary maintenance services provided to operators and logistics stakeholders using the CROSSFREIGHT platform.

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ICT solution*:* The overall objective is to provide a software module for the optimization of the planning and execution phase of railway shunting operations at the Ravenna port hub, through the automation and digitalization of railway operations – Rail Shunting System (RSS) – ensuring effective and efficient allocation of resources, assets, and the execution of the various planned and ongoing operations.

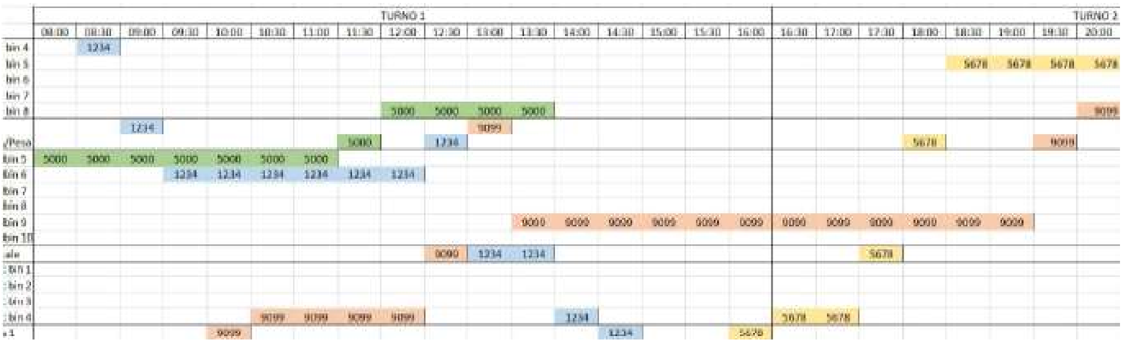
An advanced ICT solution for the optimized scheduling of railway shunting operations in ports was developed and piloted. The solution uses mathematical models and operations research algorithms designed to consider the operational specificities of the port context, providing support for both strategic planning and operational replanning. The developed ICT solution processes data relating to paths, resources, and capacity, generating an optimized output. It was developed to effectively support the three key phases of railway shunting planning, also indirectly aiming to improve logistics, economic and environmental impacts. The system considers three types of scheduling as follows:

1) *Long-term* scheduling, agreed upon every six months, presenting the rough plan based on the periodic train paths and allows for strategic evaluation;
2) *Medium-term* scheduling which is performed weekly based on cancellations and operational train paths (providing a more reliable basis for operational planning and integrates terminal requests);
3) *Short-term* rescheduling which is performed daily or shift by shift representing operational planning that considers terminal-side timetable requests, trains present in the system, and occupied resources.

The software developed supports both the preparation of weekly operational plans through medium-term planning and their dynamic updating through the rescheduling module. The solution consists of an advanced module that processes resource and path data to generate an optimized schedule for railway shunting operations. The system defines the ideal start and end times for operations, considering real operational constraints such as infrastructure availability (tracks, marshalling areas), operational resources (shunting teams, locomotives), pre-established rail routes, and maritime terminal time windows. In this way the scheduling realistically represents the entire process, integrating both the physical and structural limits as well as the managerial and organizational aspects. The generated output can include detailed operational information, such as train location and sequence, shunting schedules, and total number of trains served. An example of the final output in tabular format is represented below where the information provided concerns the day on which the secondary shunting operation is carried out, suggested start and end time for the secondary railway shunting operation, the dwell-time and the rail track at the station, the rail track at terminal and, finally, the deviation from a provided timetable.

	A	B	C	D	E	F	G	H	I	J
1	Id	Treno	Weekday Secondaria	Inizio Secondaria	Fine secondaria	Tempo Stazione	Scostamento TW	Binario Stazione	Parco Terminal	Binario Terminal
2	12	12	Mercoledi	15/06/2022 12:30	15/06/2022 13:30	20.0	0.0	0	Savona	0
3	10	10	Martedi	14/06/2022 18:30	14/06/2022 19:30	99.0	0.0	0	Savona	1
4	2	12345	Lunedi	13/06/2022 12:48	13/06/2022 13:48	338.0	0.0	0	Savona	2
5	14	14	Giovedi	16/06/2022 02:35	16/06/2022 03:35	0.0	0.0	0	Savona	3
6	8	8	Martedi	14/06/2022 07:55	14/06/2022 08:55	0.0	0.0	0	Savona	4
7	0	53120	Martedi	14/06/2022 08:55	14/06/2022 09:55	1518.0	0.0	1	Savona	5
8	4	4	Lunedi	13/06/2022 20:09	13/06/2022 21:09	0.0	0.0	0	Savona	6
9	6	6	Martedi	14/06/2022 03:33	14/06/2022 04:33	0.0	0.0	0	Savona	7
10	13	13	Mercoledi	15/06/2022 19:25	15/06/2022 20:10	120.0	0.0	0	Savona	0
11	3	54131	Mercoledi	15/06/2022 10:45	15/06/2022 11:30	135.0	0.0	1	Savona	1
12	1	54125	Lunedi	13/06/2022 16:03	13/06/2022 16:48	120.0	0.0	0	Savona	2
13	9	9	Martedi	14/06/2022 12:37	14/06/2022 13:22	120.0	0.0	0	Savona	4
14	11	11	Mercoledi	15/06/2022 04:45	15/06/2022 05:30	154.0	0.0	0	Savona	5
15	5	5	Martedi	14/06/2022 02:28	14/06/2022 03:13	170.0	0.0	2	Savona	6
16	15	15	Giovedi	16/06/2022 20:52	16/06/2022 21:37	120.0	0.0	0	Savona	3
17	7	7	Martedi	14/06/2022 07:10	14/06/2022 07:55	203.0	0.0	2	Savona	7

An example of the final output in graphical format provided by the developed solution is presented below in which the occupation of resources by the rolling stock over time is shown, in which for each time interval of the shift, the system shows the position of the train on a stopping track or in a shunting zone.



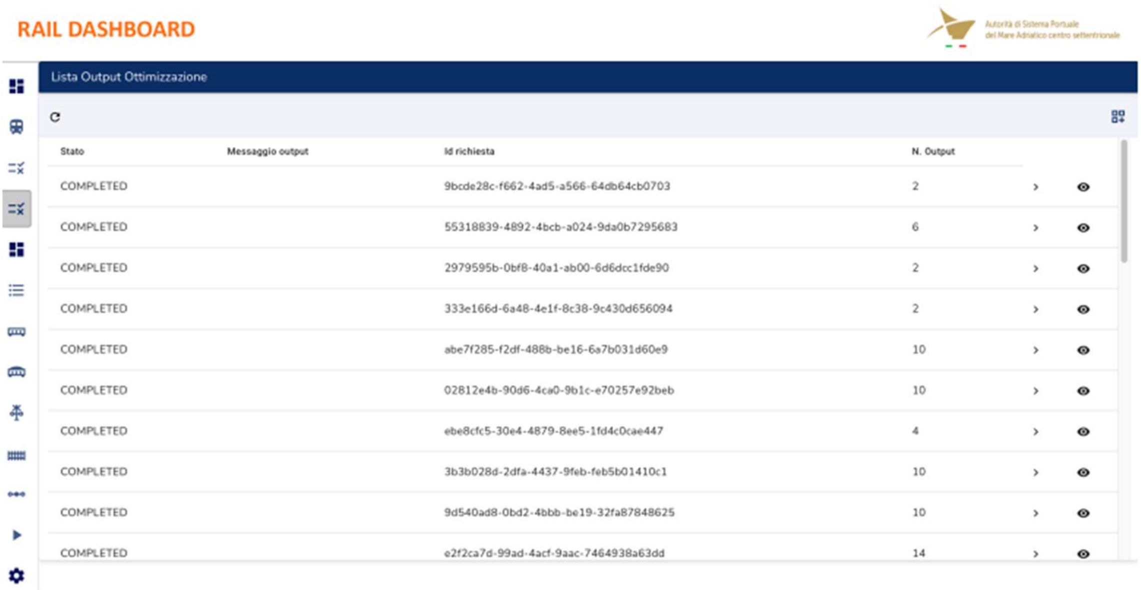
The information flows relating to the various management phases, import and export, include structural exchanges of notifications, events and train lists between the various stakeholders (Railway Company, MTO, Port Terminal and Shunting Operator) and can be collected and managed in a single management platform with which the proposed solution is able to interface and integrate directly with the RMP.

***Use Cases**:* The developed ICT solution was applied in the application test environment by accessing the Train Operations Management page as an integral part of the RMP interface, being the operational tool for planning and processing train data. Users access this section to view a list of trains whose basic data is automatically provided by RFI's PIC (Integrated Traffic Platform) system.

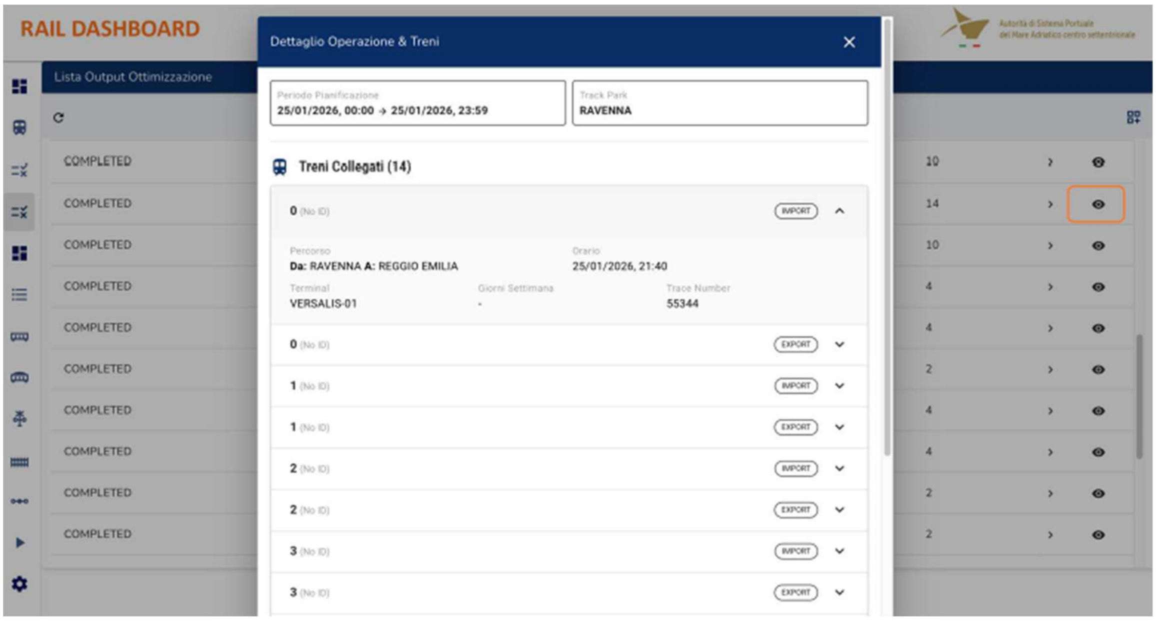
To proceed with the planning, users manually complete the missing information: for each train, they enter the terminal and the corresponding pair. Once the information is complete, users select the specific trains to be included in the planning session and activate the process by pressing the enter key.

The system processes the request and displays a modal (pop-up window) containing detailed planning results. The whole information included in the modal (pop-up window) are as follows: Train track; type; planned arrival/departure date; Origin/Destination; track (indicating the platform where the train will stop); start of operation (time); end of operation (time); location; track (populated if a stop is planned and indicates the track where the train will be temporarily stopped); start of operation, (populated only if more than one operation is planned and indicates the start time of the second operation); end of operation (populated only if more than one operation is planned and indicates the end time of the second operation). This section allows to select the arriving and departing trains for which you wish to proceed with planning. By clicking on the “Plan” button, the “Train Association” form appears, through which it is possible to proceed with the matching of arriving and departing trains and the selection of the terminal to which they belong. The selectable port’s terminals are as follows: Versalis, POLYNT01, MARCEGAGLIA, IFA SRL, Gruppo PIR, Terminal Nord, Terminal Container Ravenna, Setramar, Docks Cereali, PORTO INTERMODALE RAVENNA. To send the shunting planning request, users enter the time range of interest. For each request, it is reported: 1) period, 2) start and end of schedule, 3) number of trains, 4) track type.

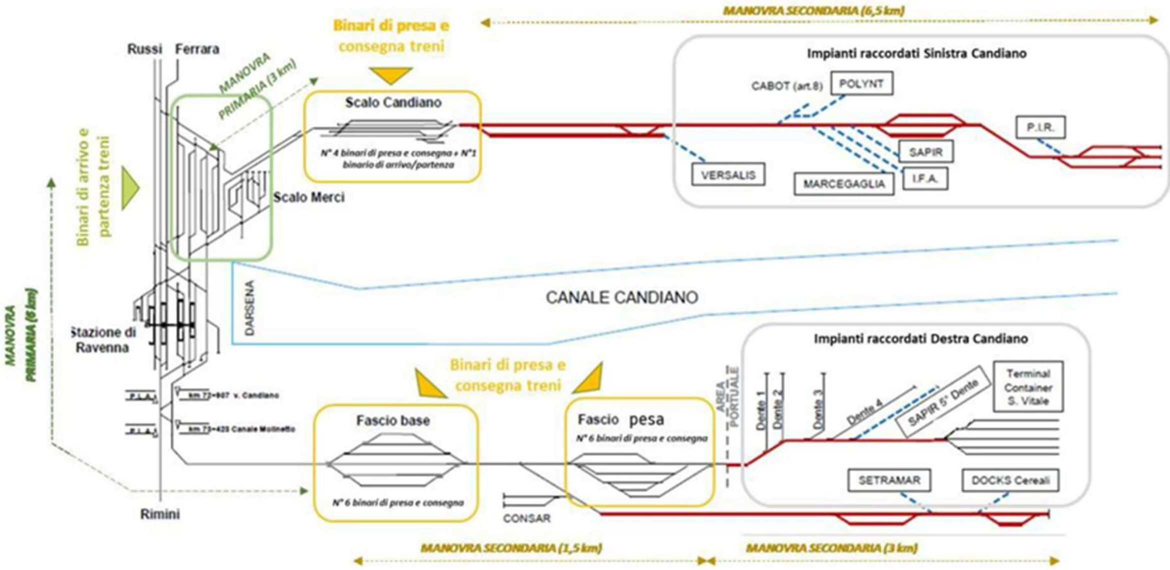
The planning requests is visible and accessible in the "Optimization Output List" section, where data is provided for each request: i) request status, ii) output message, iii) request identifier, iv) number of trains involved in the request.



Finally, it is possible to view the "Operations & Trains Details" mask which shows the details on the planning period, the track park and the trains connected to that specific outcome.



Location: The pilot action took place in the port of Ravenna to manage the railway operation in the Candiano yards (left-side yard "Candiano" and right-side yard "Base e Pesa"). The intermodal node is located near the Ravenna rail station and serves the port area. The railway infrastructure is connected to the national rail network (owned and managed by the national company RFI). At the node there are 11 tracks in total and 10 connected terminal operators served (6 in "Candiano" and 4 in "Base e Pesa" yard).



Participants: Stakeholders which were involved in pilot action are represented by ADSP MAC for enabling interoperability with the RMP, MERCITALIA Shunting & Terminal and DINAZZANO PO as key partners for testing the solution during their operational shunting activities, CIRCLE S.p.A. as technical ICT provider which was selected and assigned by ITL through a public tendering process within CROSSFREIGHT.

Outcomes: To assess the impact of adopting the optimized railway shunting planning system, a series of tests were conducted on various operational scenarios. The objective of the simulations was to compare the performance of the planning process in the previous configuration (AS-IS scenario) with that achievable using the digital rail shunting system developed and tested within the project (TO-BE scenario). The tests were developed considering scenarios characterized by an increasing number of trains to manage, in order to analyze the system's behavior as operational complexity varies. Specifically, three representative case studies were analyzed, with respectively 10, 50, and 114 trains to plan.

The three traffic levels were chosen to cover different rail shunting operating conditions. The 10-train scenario represents a low-traffic scenario, the 50-train scenario represents an intermediate condition, and the 114-train scenario reproduces a highly complex operational configuration, consistent with the traffic levels reported in document M53 (M53 document is a form used in railway shunting operations to record and authorize train or rolling stock movements during shunting operations within stations, yards, or railway facilities, being part of the operational documentation required by railway operating procedures in Italy). The results were analyzed using the defined set of KPIs, with the aim of quantifying the benefits in terms of operational efficiency, infrastructure utilization, and operational resources.

The 10-train scenario

KPI	AS-IS Scenario	TO-BE Scenario
Average terminal dwell time	247.50 min	228 min
Average station dwell time	347 min	568 min
Average parking time in parking zones	-	33.80 min
Secondary inbound operations	-	0
Secondary outbound operations	-	2
Average number of ancillary outbound operations	-	0.33
Average number of ancillary inbound operations	-	0
Trains served	40%	100%
Trains served on eligible pairs	40%	100%
Right backbone team workload	16%	17%
Left backbone team workload	15%	16%

The 50-train scenario

KPI	AS-IS Scenario	TO-BE Scenario
Average terminal dwell time	264.20 min	255.44 min
Average station dwell time	580.46 min	590.72 min
Average parking time in parking zones	-	81.61 min
Secondary inbound operations	-	0
Secondary outbound operations	-	7
Average number of ancillary outbound operations	-	1.17
Average number of ancillary inbound operations	-	0
Trains served	60%	72%
Trains served on eligible pairs	60%	72%
Right backbone team workload	19%	20%
Left backbone team workload	19%	19%

The 114-train scenario

KPI	AS-IS Scenario	TO-BE Scenario
Average terminal dwell time	240.97 min	258.43 min
Average station dwell time	776.38 min	733.04 min
Average parking time in parking zones	-	89.78 min
Secondary inbound operations	-	5
Secondary outbound operations	-	13
Average number of ancillary outbound operations	-	2.17
Average number of ancillary inbound operations	-	0.83
Trains served	63.2%	71.9%
Trains served on eligible pairs	63.2%	71.9%
Right backbone team workload	30%	29%
Left backbone team workload	24%	25%

Definition of IP and Ownership: The ICT solution consists of two modules – the optimization module and the integration module. The optimization module remains the property of the developer and is given to ITL under free usage license. ITL cannot modify the script of this module.

The integration module, developed in the framework of the CROSSFREIGHT project, is the property of ITL who has the right to use, modify and distribute the module. The entire package consisting of optimization and integration modules can be distributed to the members of ERIC cluster for non-profit purposes.

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*

For local and regional stakeholders (e.g. terminal operators, railway companies, and E.R.I.C. cluster), the exploitation strategy focuses on immediate efficiency and return on investment (ROI). "As-a-Service" (SaaS/PaaS) models enable to offer the RSS system via subscription to reduce fixed costs (CAPEX) and transform them into operating costs (OPEX). For an effective exploitation pathway, it is important to demonstrate how digitalization reduces shunting times and the use of locomotives and personnel, improving the capacity of existing tracks (resource optimization). Lastly, the capacity of providing API interfaces (systems integration) connecting to PCS and national railway management systems (PIC), eliminating manual communication via email or telephone, represents a further strength for exploitation.

On June 16th, ITL held an event to present the CROSSFREIGHT project to the ER.I.C. cluster, presenting the developed ICT solution for the automation of railway shunting operations at the Ravenna port hub, through the RSS which can be effectively transferred to other cluster's nodes by relevant customisations.

il 16 giugno abbiamo fatto un evento per presentare il progetto al cluster ER.I.C.

- *Networks and institutions at EU level operating in rail sector:*

The involvement of bodies such as the European Union Agency for Railways (ERA) and Europe's Rail Joint Undertaking is crucial for standardization process. Compliance and interoperability are key issues for the exploitation to relevant networks and institutions at EU level: align the system development and upgrading with the technical specifications for interoperability to facilitate cross-border train movement and reduce technical barriers is crucial for an effective exploitation of the standardised shunting solution.

- *Other relevant EC initiatives and projects:*

Synergies with the Horizon AUTOSUP project dealing with the definition and implementation at feasibility study level of automation-driven technologies for seamless multimodal freight transport and supply chain.

4.2 Adriafer – Port of Trieste

Application for data visibility along the Trieste railway traffic management

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The pilot action focused on the digitalization of rail shunting operations through the implementation and testing of advanced ICT functionalities designed to improve operational efficiency, coordination, and real-time visibility within the rail terminal environment.

The implemented solution enabled the digital communication of Estimated Time of Arrival (ETA) and Estimated Time of Departure (ETD) for freight trains, allowing stakeholders to receive timely and reliable operational updates that support better planning and synchronization of terminal activities. The system also enabled the digital exchange of information related to Shunting In/Shunting Out procedures as well as loading and unloading times, improving coordination between terminals, railway operators, and shunting managers while reducing delays and inefficiencies associated with manual communication processes. In addition, the solution provided real-time tracking of trains during shunting activities, ensuring continuous visibility over train positions and operational progress inside the terminal area.

The pilot action involved multiple categories of stakeholders operating within the rail freight and terminal ecosystem. These included shunting operators, rail operators, railway undertakings, railway transport managers, and terminal operators. The main shunting operator participating in the pilot was ADRIAFER s.r.l., which acted as the shunting manager and sole shunting operator in the Port of Trieste.

Its contribution focused on the execution of shunting operations within the terminal and the operational use of the ICT solution for real-time monitoring and digital communication of operational activities and timings. Various rail freight operators interacting with the terminal also participated in the pilot through the exchange of operational information concerning train movements, ETA/ETD updates, and coordination of terminal and shunting activities via the ICT platform.

CROSSFREIGHT

The railway infrastructure manager RFI participated both as a railway undertaking and as a railway transport manager. Its role included the provision and use of digital operational data related to train arrivals, departures, and train status during terminal operations, as well as the coordination and monitoring of rail activities through the ICT platform to support operational planning and decision-making processes. The pilot was carried out within the operational environments of HHLA PLT, TO DELTA, and TMT, which enabled the testing and validation of digital communication processes and real-time monitoring of shunting and loading/unloading activities under real operating conditions.

The ICT solution developed within the CROSSFREIGHT project demonstrated several competitive advantages. One of the most significant benefits is the provision of end-to-end visibility of yard operations through a unified digital overview of train positions, wagon status, track occupancy, and operational progress. This enables dispatchers and operational managers to make faster, more accurate decisions while improving operational transparency. The solution also contributes to improved punctuality and reduced turnaround times by optimizing workflows and enabling real-time information exchange, resulting in more efficient train assembly, disassembly, and terminal handling operations.

Another important advantage is the modular architecture of the system, which allows operators to gradually adopt functionalities according to operational priorities and infrastructure readiness. Furthermore, the platform supports compliance and traceability through automated reporting, audit trails, and operational data recording, facilitating regulatory compliance, performance analysis, and operational investigations when necessary. The pilot also addressed several operational and technological gaps identified between the current operational environment and the desired future scenario.

One of the primary challenges identified was the underutilization of existing digital infrastructure. Systems such as PCS Sinfomar and Trainshunt already possess the technical capability to exchange operational data related to maneuver requests and customs gate authorizations; however, these functionalities are not fully active within daily operations. The CROSSFREIGHT solution bridges this gap by enabling these digital processes to operate fully in production, thereby realizing their intended operational benefits.

The solution additionally addresses problems related to data fragmentation and manual redundancy. In the current operational environment, users often face disorganized data management and repetitive manual data entry. The new solution introduces an integrated logic connecting the "Train Management" (GTR) and "Port System Circulation" (GCSP) modules, enabling automatic real-time synchronization of information and significantly reducing manual errors. Finally, the project resolves technical synchronization issues related to rolling stock data by implementing an automated wagon database synchronized between the Single Manager (GU) and the Port Community System (PCS). This creates a reliable "single source of truth" for wagon technical information such as tare and length, improving consistency, interoperability, and operational reliability across port rail operations.

Exploitation strategy of the project's innovative solution of Port of Trieste

BMC for business modelling of the developed and tested ICT tool is presented below.

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
The deployment requires a strategic partnership between Adriafer (the railway operator and customer) and Info.era (the technology provider). Key decision makers include the management from Adriafer and the Port Network Authority, who oversee the integrated PCS Sinfomar system.	The core activities for deployment include functional and technical analysis, software realization, and rigorous testing before the field operational test. The value proposition specifically requires the creation of an automated wagon database and the integration of maneuver request states.	The innovative ICT solution delivers value by digitalizing manual rail procedures, specifically allowing for the digital suppression or cancellation of maneuvers. It addresses the requirement for operational efficiency by ensuring real-time data synchronization between the GTR and GCSP modules, satisfying the port community's need to eliminate redundant data entry.	The value reaches users through the seamless integration of new digital states into their existing daily software workflows. The pilot established a shared working group between the provider, the operator, and the port authority to ensure the tools are integrated with user routines through specialized "key user" training.	The primary consumers of the ICT solution are Railway Undertakings like Adriafer and the broader Port Community. The rail node creates specific value for terminal operators and logistics managers who require synchronized wagon and maneuver data.
	Key Resources		Channels	

	Operation relies on the digital infrastructure of the Sinfomar PCS and the Trainshunt system. Essential human resources include senior analysts expert in rail logistics and software programmers.		Customer segments are reached through the Sinfomar and Trainshunt software platforms. These digital interfaces are the most cost-efficient way to integrate new functionalities directly into the intermodal rail node's existing routines.	

Cost Structure	Revenue Streams
The most significant costs are the software engineering man-days required for development. The most expensive activity is the connection between GTR and GCSP modules, followed by the implementation of the automated wagon database.	Costs are covered through the CROSSFREIGHT project funding, with invoicing tied to specific reporting periods. Customers are willing to pay for these services because they reduce manual errors and operational downtime, contributing to the overall financial sustainability of automated port services.

The business model underlying the ICT solution is built around a close collaboration between key industry stakeholders, combining operational expertise in rail logistics with specialized technological development capabilities. The deployment relies primarily on a strategic partnership between ADRIAFER s.r.l., acting as both the railway operator and end user of the system, and Info.era, which provides the technical expertise for software design and implementation. In addition, governance and coordination are supported by decision-makers within the Port Network Authority, which oversees the integration and operation of the PCS Sinfomar. This multi-stakeholder structure ensures that operational requirements, regulatory oversight, and technological development are aligned throughout the implementation process.

The development and deployment of the solution are driven by a set of core technical and operational activities. These include detailed functional and technical analysis of existing processes, software development and realization, and comprehensive testing phases that precede field deployment. A central element of the implementation is the creation of an automated wagon database, designed to ensure consistent and reliable rolling stock data across systems. Another key activity involves the integration of maneuver request states, which enables the digital management of operational rail actions within the port environment. These activities collectively aim to transform previously manual or fragmented processes into fully integrated digital workflows.

The value proposition of the solution lies in its ability to significantly digitalize and streamline traditional rail operations. By introducing digital management of maneuvers, including the possibility to suppress or cancel them electronically, the system reduces reliance on manual procedures and improves operational responsiveness. A key benefit is the synchronization of real-time data between the GTR (Train Management) and GCSP (Port System Circulation) modules, which addresses the long-standing issue of redundant data entry and fragmented information flows. This ensures that all stakeholders operate on a shared, up-to-date dataset, improving coordination and reducing operational inefficiencies across the port rail ecosystem.

Customer relationships are maintained through direct integration of the solution into existing operational workflows, ensuring that users interact with the new functionalities as part of their daily software environment rather than through separate systems. To support this transition, a collaborative working group was established, bringing together the technology provider, the railway operator, and the port authority. Within this framework, “key user” training played a central role in facilitating adoption, ensuring that operational staff were properly supported in using the new tools effectively and consistently within real operational contexts.

The primary customer segments for the solution include railway undertakings such as ADRIAFER s.r.l. and the broader port community, including terminal operators and logistics managers. These stakeholders rely on accurate, real-time synchronization of wagon and maneuver data to coordinate operations efficiently within the intermodal rail node. The solution is particularly valuable in environments where multiple actors depend on shared operational visibility and tightly coordinated scheduling.

The key resources enabling the solution include both digital infrastructure and specialized human expertise. On the technical side, the existing Port Community System (Sinfomar PCS) and Trainshunt platform form the backbone of the system architecture, providing the environment in which new functionalities are deployed. On the human side, the project depends on senior analysts with expertise in rail logistics as well as software developers responsible for implementing and maintaining the system. These combined resources ensure that both operational knowledge and technical capacity are available throughout the development lifecycle. Customer channels are primarily digital, with the solution delivered directly through the Sinfomar and Trainshunt platforms. These systems serve as the main access point for users, allowing new functionalities to be embedded seamlessly into existing operational routines. This approach minimizes disruption and ensures cost-efficient deployment by leveraging tools already familiar to users within the intermodal rail environment.

The cost structure is dominated by software engineering efforts, particularly the man-days required for system development and integration. The most resource-intensive components include the connection between the GTR and GCSP modules and the implementation of the automated wagon database, both of which require complex system alignment and data harmonization. Funding for these activities is primarily provided through the CROSSFREIGHT project framework. Customers are willing to pay for this service because it lies in the expected reduction of manual errors, operational delays, and inefficiencies, ultimately contributing to more sustainable and cost-effective port rail operations.

ICT solution: The implementation involves the development of specialized software modules within the Sinfomar Port Community System (PCS) and the Trainshunt management system. The technology focuses on three main pillars: digital management of maneuver cancellations, real-time synchronization between Train Management (GTR) and Port Circulation (GCSP) modules, and the creation of an automated wagon database for consistent technical data (tare and length) across all platforms.

Use Cases:

- Solution1: Digital Maneuver Management: Shunting requests are now digitally suppressed or cancelled directly within the Sinfomar and Trainshunt systems, eliminating manual communication gaps.
- Solution2: Automated Data Synchronization: Operational "Train" files are automatically updated in real-time across different modules (GTR/GCSP), ensuring that composition data is always current without double data entry.

- Solution3: Automated Technical Validation: The system automatically retrieves and validates technical wagon data from the Single Manager’s database, providing a "single source of truth" for all rail operations

Location: The pilot action took place at the Port of Trieste, specifically focusing on the last-mile rail operations and maneuvers managed by Adriafer.

Participants:

- Adriafer S.r.l.: The Railway Undertaking and Single Manager (GU).
- Info.era S.r.l.: The technology provider and software developer.
- AdSP MAO: The owner of the Sinfomar PCS.
- Port Community: End-users involved in shunting and rail logistics.

Outcomes: The effectiveness of the solution is demonstrated through the following indicators:

- Efficiency Gains: Elimination of "double insertions" of data through automated module logic.
- Operational Recovery: Reactivation of previously implemented but unused digital flows, such as customs gate crossing authorizations and maneuver requests, bringing them into daily production.
- Technical Accuracy: Complete homogenization of wagon technical data (tare/length) between Adriafer and the PCS systems.
- Resource Optimization: The project involved 73 man-days of specialized development to refine user interfaces and database structures for maximum usability.

Definition of IP and Ownership: The intellectual property of the tested digital solution comprises the specific software code, interoperability modules, and functional extensions developed to digitalize railway shunting procedures. It includes the proprietary algorithms used for the automatic synchronization of wagon data between the Trainshunt platform and the PCS Sinfomar, as well as the unique database architecture designed to manage integrated rail and port logistics information.

Additionally, the IP covers the technical specifications, functional designs, and the user interface developed to streamline the communication between rail operators and port stakeholders.

In terms of ownership, the IP structure is divided into Background and Foreground IP. The Background IP, consisting of the pre-existing platforms (Sinfomar and Trainshunt), remains the exclusive property of the technology provider (Info.era/Circle Group) and the respective partners. The Foreground IP, which includes the new interoperability modules, algorithms, and specific digital procedures developed during the CROSSFREIGHT project, is owned by ADRIAFER. These results are managed according to the Interreg Italy-Croatia Partnership Agreement, ensuring that while the core software remains protected, the innovative project-specific outputs are available for the coordination and exploitation of pilot's results.

The solution is built upon the integration of pre-existing third-party and proprietary platforms, namely PCS Sinfomar and Trainshunt, which require specific licensing for continued use. In this collaborative context, the IP strategy ensures that new developments remain compatible with European technical standards such as TAF TSI to allow for cross-border data exchange.

Any extraordinary maintenance or future functional evolutions that exceed the initial pilot scope are managed through separate service agreements. This collaborative framework ensures that while the pilot uses existing infrastructures, the new innovative layers developed specifically for CROSSFREIGHT are protected and clearly attributed to the partners involved in the development.

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*
- Direct Implementation: The solution is being integrated into the daily workflows of port planners and operators in the Port of Trieste to reduce manual interventions and human errors.
- Regional Scaling: The results provide a blueprint for other intermodal nodes facilitating a shift from manual processes to automated digital management.

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- Stakeholder Engagement: The project utilizes a regular interaction model with a large platform of local actors, including port authorities, railway undertakings, and terminal operators, to ensure the solution meets specific operational needs

- *Networks and institutions at EU level operating in rail sector*

The digital solution specifically implements TAF TSI; results are shared with EU-level networks to demonstrate how digital shunting management contributes to the TEN-T policy objectives of improving efficiency and sustainability across cross-border transport corridors.

4.3 AIN – Dry Port of Škrljevo

Application for monitoring and analyzing extraordinary events within the railway system

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The ICT solution tested in the pilot focuses on the digitalization of rail shunting operations, specifically supporting the digital monitoring of train performance in the context of rail accident investigations. The implemented functionality enables improved oversight of operational data relevant to safety analysis and investigative processes, replacing more fragmented and manual approaches previously in use.

The pilot did not directly involve defined external stakeholder clusters during its execution phase. No specific categories of external stakeholders were formally engaged in the running of the pilot, and consequently no structured characterization of such groups in the implementation phase was applicable.

The CROSSFREIGHT solution demonstrates its primary added value through enhanced compliance support and improved traceability for incident and accident investigations. By enabling structured audit trails and automated reporting capabilities, the system strengthens regulatory compliance, facilitates more efficient investigative workflows, and improves the overall capacity for performance analysis in safety-critical contexts. In the pre-implementation scenario, rail traffic monitoring at the Škrljevo node relied on disconnected records and document-based practices, without a centralized digital system capable of providing a unified and comprehensive overview of operational data. This fragmented approach limited transparency and hindered efficient data retrieval and analysis. In contrast, the introduction of the CROSSFREIGHT system has enabled a fully digitalized approach to monitoring, reviewing, and managing relevant operational information. The system consolidates previously dispersed data into a centralized and standardized environment, improving transparency, consistency, and accessibility of information.

In its target configuration, the application functions as an internal digital tool used by the Accident Investigation Body. It supports the management of key data and documentation related to incident and accident notifications, investigations (both on-site and administrative), safety recommendations, and records of open incidents, accidents, and suicide-related cases. While the system allows for structured collection, storage, and processing of these information categories, data input remains largely manual, either entered directly by AIN staff or uploaded in document form. The application is not integrated with external digital platforms and does not exchange data automatically with railway undertakings, infrastructure managers, or other safety-related organizations. As a result, all information is internally managed without automated interfaces or third-party system connectivity.

Exploitation strategy of the project's innovative solution

BMC for business modelling of the developed and tested ICT tool is presented below.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td rowspan="3">• AIN
• IT provider</td><td>Core activities include system development and maintenance, data import and validation, user training, testing (including FOT), user support, access-rights management, and preparation of reports and analytics.</td><td rowspan="3">CROSSFREIGHT delivers a centralized digital platform that replaces fragmented Excel-based records with standardized, traceable, and secure workflows for safety-related railway data. It improves data quality, accelerates reporting, supports investigations, and provides a unified view of all relevant operational and safety information. It satisfies customer needs for transparency, compliance, efficiency, and reliable data management.</td><td>Value is delivered through a stable, secure, and user-friendly digital system. Relationships are based on continuous communication, structured feedback during the pilot, and ongoing technical support. These relationships reduce administrative workload and integrate naturally into existing operational routines.</td><td rowspan="3">AIN Accident investigators</td></tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr><td>Essential resources include the CROSSFREIGHT software platform, the central database with historical and operational data, IT infrastructure, the technical support team, documentation, and trained users.</td><td>The primary channel is the web application accessible through standard browsers. Additional channels include digital documentation, training sessions, and communication with operational staff.</td></tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
</table>

• Key costs include software development, system maintenance, IT infrastructure, data integration, testing, and user training. • The most significant expenses relate to development, security, and long-term system support.	• Costs are covered through institutional and project-based funding

The CROSSFREIGHT solution is based on a digital platform designed to modernize and centralize the management of safety-related railway data. Its core value proposition lies in replacing fragmented, spreadsheet-based and manual record-keeping practices with a standardized, traceable, and secure digital environment. The system enhances data quality, improves the speed and reliability of reporting processes, and supports more effective incident and accident investigations. By providing a unified view of operational and safety information, it addresses key user needs such as transparency, regulatory compliance, operational efficiency, and dependable data management across investigative workflows.

The main stakeholders involved in the exploitation and implementation of the solution include the Accident Investigation Body (AIN) and the IT service provider responsible for system development and technical support. These partners ensure both the operational usability of the platform and its continuous technical evolution. The system's core activities encompass software development and maintenance, structured data import and validation, user training, functional testing (inc. FOTs), user support, access rights management, and the generation of analytical outputs and reports to support investigative work.

The functioning of the system relies on several key resources, including the CROSSFREIGHT software platform itself, a centralized database containing both historical and operational data, the underlying IT infrastructure, and the technical support team responsible for system maintenance and user assistance. In addition, documentation and trained end-users represent an essential operational resource, ensuring the effective and consistent use of the platform in daily investigative activities.

Customer relationships are built on continuous interaction between users and the system support structure, with a strong emphasis on responsiveness, structured feedback collection during pilot activities, and ongoing technical assistance. The solution is designed to integrate smoothly into existing workflows, thereby reducing administrative burden and supporting users in their routine operational and investigative tasks. Access to the system is primarily provided through a web-based application, available via standard internet browsers, ensuring ease of deployment and accessibility. This is complemented by supporting channels such as digital documentation, training sessions, and direct communication with operational staff, which facilitate onboarding and continuous user engagement.

The primary customer segment consists of accident investigators within the Accident Investigation Body (AIN), who use the platform to manage, analyse, and document railway safety incidents and accidents.

The cost structure is driven mainly by software development and ongoing system maintenance, as well as the required IT infrastructure, data integration processes, testing activities, and user training. Significant cost components are associated with ensuring system security, reliability, and long-term sustainability, particularly in relation to continued technical support and platform evolution.

Revenue streams are not based on commercial sales but are instead supported through institutional and project-based funding mechanisms. This funding model ensures the sustainability of the platform within a public-sector and research-driven environment, where the primary objective is operational improvement of safety-related railways data management rather than profit generation.

ICT solution: CROSSFREIGHT is a digital platform designed to replace fragmented Excel-based records with a centralized, standardized, and fully traceable system for managing safety-related railway data. It supports digital entry, review, and analysis of notifications, accidents, investigations, and safety recommendations.

Use Cases: The system was used to import historical data (2022–2025), record new safety events, manage investigation workflows, upload documents, and generate reports. Users tested the platform in real operational conditions, confirming improved visibility, data quality, and workflow consistency.

Location: AIN in office and on site

Participants: AIN investigators

Outcomes: Centralized database replacing multiple Excel files

- Faster access to safety information and investigation records
- Improved data accuracy through standardized fields and validation
- Full traceability via audit logs
- Reduced administrative workload through automated filtering and exports
- Enhanced transparency and consistency in safety-related processes

Definition of IP and Ownership: The intellectual property of the CROSSFREIGHT solution includes the software platform, source code, database structure, user interface design, algorithms, and all documentation created during development. All IP is owned by AIN.

4.4 ERF – Port of Marghera

Application for shunting infrastructure monitoring and observation of elementary subsystems in Venezia Marghera Scalo Railway District

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The pilot action involved testing an ICT-based solution designed to support the digital transformation of rail shunting operations, with particular focus on improving the allocation of railway tracks and time slots and enhancing safety and security management for shunted trains.

The system was applied in a real operational context to evaluate its ability to optimize yard activities, reduce inefficiencies, and support more structured control of movements within railway terminals.

The pilot engaged key stakeholder groups operating within the freight and rail logistics ecosystem, primarily terminal operators and port authority systems. The involvement of these actors was essential to validate the solution under realistic conditions. A terminal operator (Tencara Terminal) participated by testing the system's functionality in a controlled environment, verifying requirements, and assessing whether the platform could effectively integrate new railway elements, support operational measurements, and be feasibly deployed within terminal workflows.

In parallel, collaboration with North Adriatic Sea Port Authority System enabled comprehensive testing using real railway infrastructure, including sidings and their technical characteristics, as well as existing datasets and measurements associated with infrastructure components. This allowed the system to be evaluated against real-world operational complexity and infrastructure conditions.

The innovative solution demonstrated several competitive advantages compared to traditional shunting management approaches. It enables paperless and streamlined communication by replacing manual instructions, radio calls, and paper-based procedures with digital work orders, confirmations, and real-time updates, thereby reducing errors and improving coordination. It is designed to integrate with existing rail infrastructure systems such as yard control platforms, signaling systems, asset management tools, and enterprise resource planning systems, supporting interoperability rather than requiring full system replacement. The solution also contributes to reducing operational costs through automation, which minimizes manual intervention, improves efficiency in train movements, and reduces fuel consumption and equipment wear caused by inefficient operations. In addition, it supports predictive maintenance by collecting and analyzing data from sensors and digital logs, enabling early detection of potential faults in wagons and locomotives, thereby reducing downtime and improving asset reliability. Finally, it enhances compliance and traceability by generating structured audit trails and automated reporting, which support regulatory compliance, incident investigation, and performance monitoring.

From a gap-bridging perspective, one of the main gaps to be filled in the "last mile railway shunting" context is undoubtedly infrastructure maintenance. Railway sidings often use procedures that require manual management of monitoring operations. Furthermore, the lack of structured databases impedes analysis aimed at streamlining the maintenance process. This often leads to "last-minute" interventions that are not only incompatible with scheduled operations but also undoubtedly more costly because they are performed under emergency conditions. “Minosse” was born precisely from the need to monitor railway infrastructure components in a structured, more effective, and efficient way, thus optimizing the various phases of the maintenance process. This not only improves workplace safety and railway operations but also reduces maintenance costs and the unavailability rate of shunting infrastructure.

Exploitation strategy of the project’s innovative solution of Port of Marghera

BMC for business modelling of the developed and tested ICT tool is presented below.

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
North Adriatic Sea Port Authority System (AdSPMAS) Tencara Terminal which operates in Venezia Marghera Scalo Railway District.	Developing of a structured database which contains relevant data of each railway siding elements (just for switches). Monitoring the state of the railway sidings infrastructure.	Monitoring railway infrastructure components in a structured, more effective, and efficient way, thus optimizing the various phases of the maintenance process.	The main way is by using a simple access to the system (by using username and password) or by using API to connect to it.	Terminal Operators and Main Railway Siding Manager

	Performing analysis about the state of each switch. Connecting to SIMA to consider traffic data also. (In collaboration with North Adriatic Sea Port Authority System).	Coordinating railway works with the operations aspects		
	Key Resources		Channels	
	Data about the state of each switch of the railway siding infrastructure. Georeferenced infrastructure		Direct sales activities Communication and Promoting activities by AdSPMAS	

Cost Structure	Revenue Streams
Software development costs, requirements analysis, design, development and testing, including technical and functional activities. Costs for the software maintenance, including evolutionary maintenance activities, potential upgrades and finetuning. Cost for railway siding infrastructure upgrading and modelling	Potential revenue arises from kind of subscription and from how many variables are involved in the modelling

The business model is based on a network of institutional and operational partnerships that support both the development and real-world validation of the solution. Key partners include the North Adriatic Sea Port Authority System (AdSPMAS), which plays a central role in providing access to port and rail infrastructure data, supporting system validation, and facilitating integration within the broader port-rail ecosystem. Another essential partner is Tencara Terminal, located in the Venezia Marghera Scalo Railway District, which contributes operational expertise and enables the testing of the system in an active terminal environment, ensuring that the solution reflects real operational needs and constraints.

The core activities focus on the development and continuous management of a structured digital database that captures detailed information on railway siding infrastructure, with particular attention to switch components. A key operational function is the continuous monitoring of infrastructure conditions, allowing for timely identification of potential issues and supporting more efficient maintenance planning. The system also performs analytical processing on the condition and performance of each switch, enabling data-driven decision-making for maintenance and operations. In addition, the platform integrates external traffic data through connection with SIMA, which enhances situational awareness and allows for a more comprehensive understanding of railway operations in coordination with port authority systems.

The value proposition of the solution lies in its ability to transform infrastructure management into a structured, data-driven, and proactive process. By centralizing and continuously updating information on railway siding components, the system enables more effective monitoring and improves the efficiency of maintenance activities. It supports a shift from reactive to preventive maintenance approaches, reducing operational disruptions and improving overall infrastructure reliability. Furthermore, it enhances coordination between maintenance planning and railway operations, ensuring better alignment between infrastructure availability and traffic management needs.

Customer relationships are established through secure and controlled access to the system, which is provided via authenticated user credentials such as username and password. This ensures that access to sensitive infrastructure data is properly managed and traceable. In addition, the system supports integration through APIs, enabling seamless interoperability with existing digital platforms and operational systems. This allows customers to incorporate the solution into their existing workflows without disrupting established processes.

The primary customer segments consist of terminal operators and railway siding infrastructure managers. These stakeholders are directly involved in the operation, monitoring, and maintenance of rail yard infrastructure and benefit from improved visibility, better planning tools, and enhanced decision-support capabilities. The system is designed to support their operational responsibilities by providing accurate, real-time, and structured information about infrastructure conditions.

Key resources include detailed georeferenced datasets describing railway siding infrastructure and its components, particularly switches. These datasets form the foundation of the system’s modelling and monitoring capabilities, enabling accurate digital representation of physical infrastructure and supporting reliable analysis and decision-making processes. The solution is brought to market through direct sales activities targeting relevant stakeholders within the railway and port logistics sectors.

These activities are complemented by communication and dissemination efforts led by the port authority system, which help promote awareness of the solution and support its adoption across the wider ecosystem of port and rail operators. The cost structure includes expenses related to software development, covering all phases from requirements analysis and system design to implementation, testing, and technical validation. Additional costs are associated with software maintenance, including updates, improvements, and system optimization activities. Further costs arise from the modelling and digital representation of railway siding infrastructure, which is necessary to ensure accurate system configuration and operational alignment.

Revenue is expected to be generated primarily through a subscription-based model, where users pay for access to the platform on a recurring basis. The level of revenue depends on the complexity of the infrastructure being modelled and the number of variables included in each deployment, as these factors influence the level of customization, processing effort, and system configuration required for each client.

ICT solution: The overall objective is to provide a software module for the optimization of railway siding infrastructure maintenance. This ICT solution stores information on the status of railway infrastructure elements and enables real-time analysis through georeferenced representation. The two workstations provided - one "in the field" for monitoring the asset's status and the other "on-site" for global analysis - allow for greater flexibility and reduce the possibility of errors, as the entire process is managed electronically, eliminating the need for repeated manual data entry. The system is modular meaning that, in the event of infrastructure changes, the system can be easily updated by geolocating the new element.

Use Cases: Minosse was created as a module of SIMA, the shunting management system used by the Venezia Marghera Scalo Railway District. The model was created using data from the District's railway network. Each element was modeled with its technical, functional, and geometric characteristics.

Location: The pilot took place on the main railway siding of Venezia Marghera Scalo Railway District.

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Participants: In addition to the North Adriatic Sea Port Authority System, the Tencara Terminal also intervened, allowing us to verify the correct functioning of the system and make optimizations.

Outcomes: During system development, its functionality was tested through field surveys. Obtaining KPIs such as average availability, MTBF, and wear rate for each component was not possible at that stage due to the very long intervals of the monitoring and maintenance process itself; this does not allow for immediate comparisons when maintenance policies are modified.

In quantitative terms, up to 48% improvement in data entry and management was estimated in terms of time savings compared to the previous process (AS-IS) used to monitor the status of the switches.

Definition of IP and Ownership: The ICT solution "Minosse", developed in the framework of the CROSSFREIGHT project, is the property of ERF who has the right to use, modify and distribute the module

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*

For local and regional stakeholders (e.g. terminal operators, Main Siding Operators, etc.), the exploitation strategy focuses on two key aspects: safety during railway shunting operations and streamlining the maintenance process, resulting in lower costs. Using this system, in fact, it is possible to analyze the evolution of infrastructure defects to draw up a maintenance program based on a well-defined policy.

- *Networks and institutions at EU level operating in rail sector:*

Currently, national regulations do not provide a "complete" reference standard for railway sidings in terms of geometry. Standardizing a system like Minosse would allow, in specific operational contexts such as railway sidings, to lay the foundation for standardizing track geometric defects and defining maintenance policies supported by real data, and correlating the various operating variables involved with these data.

- *Other relevant EC initiatives and projects:*

Much remains to be implemented. The system implemented to date still has considerable potential for development, as there are many variables at play. The system therefore lends itself well to potential synergies with other European projects.

4.5 Sangritana – Terminal Saletti

Application for managing and reporting rail traffic along the Fossacesia/Torino di Sangro - Atessa rail infrastructure, with additional functions for the rail traffic management at TISV Terminal Intermodale Saletti Val di Sangro and the relative workshop.

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The ICT solution tested within the pilot action addresses a broad set of functionalities aimed at the digitalization and optimization of rail shunting operations. It enables the digital allocation of locomotives, improving the coordination and efficiency of traction resources within the terminal environment.

It also supports the digital allocation of rail tracks and time slots, contributing to better yard capacity management and reducing conflicts in track usage. In addition, the system allows for the digital communication of Estimated Time of Arrival (ETA) and Estimated Time of Departure (ETD), enhancing operational predictability and planning accuracy among stakeholders. It also facilitates the digital exchange of key operational milestones, including Shunting In and Shunting Out processes, as well as loading and unloading times, ensuring improved transparency and coordination across actors involved.

A further functionality concerns the real-time tracking of trains undergoing shunting operations, providing continuous visibility over train movements within the terminal. It also integrates digital safety and security features, strengthening operational control and reducing risks associated with manual coordination.

The pilot action involved several stakeholder categories representing the main actors in rail and intermodal logistics, including shunting operators, rail operators, multimodal transport operators, carriers, terminal operators, shippers, and freight forwarders. Each group contributed to the testing and validation of the ICT solution in a real operational environment.

The shunting operator involved was Sangritana, which served as the only shunting operator within the compound and played a central role in executing shunting activities. The same organisation also acted as the main rail operator for the tested trains, directly contributing to operational execution and system validation.

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As a multimodal transport operator, Viglienzone participated in the pilot by managing both national and international intermodal train flows connected to the Saletti terminal. It actively used the system to monitor train movements and operational status within the compound.

Within the carrier category, Honda and Viglienzone were involved as key intermodal carriers responsible for intermodal transport units operating in rail traffic towards the Saletti terminal. Their participation enabled continuous monitoring of train operations through the ICT platform.

The terminal operator GN Logistics played a crucial role in the pilot as the operator of the Saletti terminal, contributing significantly to data processing activities and operational data entry, with the involvement of key terminal staff in system implementation.

Shippers such as Amadori and Honda actively participated by monitoring their trains through the system, improving transparency and enhancing the perceived quality and usability of the digital solution.

The freight forwarder Futura Cargo contributed by integrating shipments into the system in connection with existing train operations, supporting a comprehensive and integrated view of the logistics chain.

The CROSSFREIGHT solution introduces several competitive advantages in the field of rail shunting and terminal management. A key advantage is enhanced safety through real-time monitoring, which allows continuous tracking of locomotives, wagons, and personnel, reducing reliance on manual coordination and lowering the risk of human error and collisions. It also enables automated movement planning and optimization, supporting the generation of efficient shunting plans that reduce idle time, limit unnecessary movements, and increase overall yard throughput. The system further provides end-to-end visibility of yard operations, offering a unified digital view of train positions, wagon status, track occupancy, and operational progress, which supports faster and more accurate decision-making.

Another important advantage is paperless and streamlined communication, as digital work orders and instructions replace radio calls, phone communications, and paper-based processes, reducing misunderstandings and improving operational consistency. The solution also contributes to a reduction in operational costs by optimizing resource use, lowering fuel consumption, and decreasing wear and tear caused by inefficient movements. Operational performance is further improved through better punctuality and reduced turnaround times, as digital coordination enables faster train assembly and disassembly and increases terminal efficiency. In addition, the modular architecture allows gradual and flexible adoption of functionalities, supporting scalable implementation based on operational needs.

The CROSSFREIGHT Saletti 4.0 application addresses key gaps between the current operational situation and the envisioned digital future. In the current AS-IS scenario, there is no continuous monitoring of trains, locomotives, wagons, or staff, and operations are largely managed manually, increasing the likelihood of errors and potential safety risks. In the TO-BE scenario, real-time tracking enables constant visibility of all operational assets, significantly improving safety and situational awareness.

Shunting planning in the current system is performed manually, often resulting in queues and inefficiencies, particularly during peak periods along the 12 km single-track regional line. The TO-BE solution introduces automated planning, reducing congestion and improving operational flow.

Today, there is no comprehensive visibility of train positions, wagon status, or track occupancy, meaning that terminal decisions rely heavily on staff experience and fragmented information. The TO-BE system provides full operational visibility, allowing terminal managers to access real-time data on train arrivals, wagon conditions, workshop needs, and track allocation, improving coordination and decision-making.

Communication is currently based on radio, phone calls, and occasional messaging tools, which can lead to misunderstandings and inconsistencies. The TO-BE system replaces these methods with a centralized digital platform for work orders, improving clarity, traceability, and operational reliability.

Operational costs in the AS-IS situation are high due to manual processes, significant labor requirements, and elevated fuel consumption linked to diesel locomotive usage on a non-electrified line, as well as inefficiencies in movement planning. The TO-BE scenario reduces these costs through optimized operations, lowering fuel consumption, labor intensity, and equipment wear.

Performance levels are also currently limited, with low punctuality and extended turnaround times for train assembly and disassembly. The introduction of the digital solution is expected to significantly improve efficiency and on-time performance at the Saletti terminal.

Finally, the existing IT environment is based on rigid, non-modular systems that are costly and difficult to adapt. The CROSSFREIGHT solution introduces a modular architecture that allows incremental implementation, reducing costs and enabling more flexible and scalable deployment.

Exploitation strategy of the project's innovative solution of Terminal Saletti

BMC for business modelling of the developed and tested ICT tool is presented below.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td rowspan="3">Rail Operators
Shunting Operators
Terminal Operators
MTO
Carriers
FLMTO
RIM</td><td>Installing fixed devices;
Completing the software version
Integrating the software solution across the supply chain</td><td rowspan="3">Optimised shunting
Real time tracking for trains
Digital assignment for staff
Increased safety and security for shunted trains
Syncronised timing</td><td>Essential interaction among clients
Transactorial platform</td><td rowspan="3">Rail Operators
Shunting Operators
Terminal Operators
MTO
Carriers
FLMTO
RIM
Consignee
Shipper
Freight Forwarders</td></tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr><td>Devices, both fixed and non-fixed
Software data input interfaces</td><td>ICT channel (direct)
API integration</td></tr>
<tr><th colspan="2">Cost Structure</th><th colspan="3">Revenue Streams</th></tr>
<tr><td colspan="2">Costs connected to the software maintenance and improvement
Costs connected to the hardware purchase and positioning.</td><td colspan="3">Membership Fees paid by the platform users
Usage fees paid by platform users
Rentals fees for devices</td></tr>
</table>

The ICT solution delivers value by enabling the full digitalization of rail and shunting operations, primarily aimed at reducing reliance on manual work and lowering associated operational costs. For rail operators and shunting operators, the system improves efficiency by automating key processes and reducing administrative and coordination burdens. The main value generated for customers is the reduction of manual intervention, improved optimization of operations, and faster execution of rail and terminal activities. The solution addresses several critical customer needs, including automated shunting processes, digital allocation of resources per train, staff rota management, and real-time traffic monitoring. These functionalities directly respond to the need for greater operational control, improved planning accuracy, and enhanced visibility across rail and terminal operations. Therefore, the developed solution satisfies the need for more efficient and coordinated terminal and shunting rail operations.

The successful deployment and operation of the ICT solution depend on the involvement of several key partners, including terminal operators, shunting operators, rail operators, and road operators.

These actors form the core ecosystem required to ensure system functionality and operational integration across the logistics chain. Key suppliers within this model are the respective IT providers supporting each stakeholder, particularly those responsible for system integration, hardware provision, and software maintenance. Decision-making is distributed across these operational actors, with terminal and rail operators playing a central coordination role.

Key activities required for the deployment and operation of the solution include the installation of gateway devices and the deployment of removable tracking devices on locomotives and trains to enable real-time monitoring. The use of the software platform across all operational actors is essential, as without full system adoption the traffic management and tracking functionalities cannot operate effectively.

A critical activity is also the full integration of all stakeholders within the rail supply chain, ensuring that shunting operators, rail operators, road operators, and terminal operators are interconnected within a unified digital environment. Key resources for the deployment and operation of the solution include gateway devices, beacon-based tracking systems, and the full-scale ICT platform beyond the pilot beta version. These resources enable real-time data collection, processing, and operational coordination. Additional integration between existing IT systems is required to ensure interoperability across different stakeholders. No significant additional physical infrastructure is required beyond the deployment of the system and its devices, as the existing terminal infrastructure is sufficient to support implementation.

Customer relationships are established primarily through direct access to the digital platform, where end users can log in and access real-time planning and operational information. The main relationship model is based on continuous data exchange related to rail operations, ensuring constant synchronization between stakeholders. During the pilot phase, direct relationships were established between rail operators, shunting operators, and terminal operators, forming the core operational network. These relationships are essential to the functioning of the business model, as they enable real-time coordination, although they do not represent the most cost-intensive component of the system.

Channels for reaching customer segments are primarily direct, with a strong preference for API-based integration. This approach ensures efficient, automated, and cost-effective data exchange between systems. API connections are considered the most efficient channel due to their scalability and ability to integrate seamlessly into existing operational workflows. The intermodal rail node integrates these channels into customer routines by linking rail-based deliveries with last-mile road operations and shunting activities, ensuring full visibility and coordination across the logistics chain.

Customer segments include rail operators, shunting operators, terminal operators, carriers, MTOs, freight forwarders, and shippers or consignees. The most important customer is the industrial consignee, as this actor ultimately drives demand and represents the final beneficiary of the logistics process.

The cost structure of the business model is primarily driven by the maintenance of sensors and the ICT system itself. These include both hardware upkeep and software maintenance activities required to ensure continuous system functionality. The most significant cost items are tracking devices and ongoing maintenance of the digital platform, particularly the continuous updating and management of operational data. Without regular use and maintenance, system's effectiveness would be significantly reduced.

Revenue streams are expected to be generated through a combination of membership fees and usage-based charges applied to system users. Customers are willing to pay primarily for the value derived from improved information availability and the operational savings enabled by the system. Currently, many customers indirectly bear costs related to inefficiencies and disruptions rather than paying directly for digital solutions that prevent them. In the future, a hybrid payment model combining subscription-based access with pay-per-use components is considered the most appropriate approach. The main revenue source is expected to come from membership fees, supplemented by usage-based revenues generated through platform utilization.

ICT solution: the developed solution combines hardware and software solution. The hardware base for the system would be to use both gateways on the line and beacons to track each wagon and each train.

Use Cases: The pilot managed to track a train and single wagons from the rail station of Fossacesia Torino di Sangro in Italy to the rail terminal of TISV Saletti, by the passage on the rail compound Fossacesia-Atessa-Val di Sangro, managed by Sangritana. The pilot system tracked down all the statuses of the trains, monitoring each step of the operations and each change.

Location: Inland rail terminal of TISV Saletti and rail station of Fossacesia Torino di Sangro

Participants: Sangriana as Rail Operator and Shunting Operator, GN Logistc as Terminal Operator, Honda as MTO/Carrier/Consignee, Viglienzone as MTO/Carrier, Amazori as Consignee.

Outcomes:

- Increased efficiency in monitoring the train statuses,
- cost savings by better resources allocation,
- improved safety.

Definition of IP and Ownership: The IP will not be considered for the pilot action, there are no rights involved. In terms of ownership and collaboration and third-party IP, no IP for the pilot action.

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*

TUA Divisione Ferroviaria, Interporto d'Abruzzo, Walter Tosto, Futura Cargo, Honda, Amadori.

4.6 Port Authority of Sibenik – Port of Sibenik

Optimization Plan for Railway Station Capacity and Loading

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The solution tested in the pilot action supports the digitalization of key rail shunting and operational coordination processes. It enables the digital allocation of rail tracks and time slots, allowing more structured planning of railway yard capacity and reducing operational conflicts. It also supports the digital exchange of ETA and ETD, improving coordination between stakeholders and enabling more accurate planning of arrivals, departures, and resource allocation. In addition, the system facilitates the digital communication of key operational events such as shunting movements (In and Out) as well as loading and unloading times, which improves transparency and operational synchronization among involved parties.

The pilot action involved several stakeholder categories from the rail freight and port logistics ecosystem, including rail operators, railway undertakings, railway transport managers, terminal operators, shippers, and the Port of Šibenik Authority. These stakeholders contributed to the implementation and testing of the ICT solution within the operational environment of the port and railway station system.

Rail operators, including Luka Šibenik and HŽ Cargo, provided essential operational data such as train schedules, train identification numbers, and other planning inputs required for capacity management and monitoring of loading operations through the Excel-based ICT tool.

Railway transport managers, represented by the Port of Šibenik Authority (LUŠ) overseen the pilot implementation, ensuring alignment among stakeholders while supporting the optimization of railway station capacity and cargo handling efficiency.

Terminal operations carried out by Luka Šibenik included the execution of loading and unloading activities as well as participation in the testing of scheduling and monitoring processes developed through Excel templates. In its operational role related to cargo flows, Luka Šibenik also acted as a shipper by providing feedback on cargo handling performance, including loading accuracy and operational delays.

The Port of Šibenik Authority additionally played a central role in developing and implementing the pilot solution, coordinating stakeholder collaboration, and evaluating operational improvements using structured Excel-based tools.

The CROSSFREIGHT solution provides several competitive advantages compared to traditional approaches. It enables automated movement planning and optimization, reducing idle time, unnecessary shunting operations, and improving overall yard throughput.

Communication is significantly improved through paperless and streamlined processes, replacing manual radio communication and paper-based instructions with digital work orders and confirmations, thereby reducing errors and improving traceability. The solution is designed to integrate existing rail infrastructure systems such as yard control systems, signaling, asset management, and ERP platforms, ensuring interoperability and continuity with existing processes. Furthermore, it contributes to improved punctuality and reduced turnaround times through optimized workflows and real-time operational data, enabling faster train assembly and disassembly. Its modular architecture allows gradual adoption of functionalities depending on operational needs and readiness levels.

Before the implementation of the pilot action, railway operations in the Port of Šibenik were primarily based on manual coordination and fragmented data exchange between stakeholders, which limited operational visibility and efficiency. The pilot introduced a simplified ICT solution based on standardized Excel templates used for planning, monitoring, and analyzing railway station capacity and cargo loading and unloading operations. This system enables stakeholders to input train schedules in a structured way, monitor track and platform occupancy, analyze loading efficiency, and visualize operational performance through tables and charts. As a result, coordination between stakeholders has improved and the utilization of existing railway infrastructure has been enhanced. These improvements were achieved without requiring new infrastructure investments, demonstrating how digital tools can increase operational efficiency through better data structuring, transparency, and collaboration.

Exploitation strategy of the project's innovative solution of Port of Sibenik

BMC for business modelling of the developed and tested ICT tool is presented below.

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr>
<td rowspan="3">Port of Šibenik Authority
HŽ Cargo
Luka Šibenik
IT/software providers
Port Authority</td>
<td>Planning train arrivals and departures
Allocating rail tracks and time slots
Monitoring loading and unloading operations
Collecting and managing operational data
Maintaining digital planning tool (Excel-based system)
Coordinating information exchange among stakeholders</td>
<td rowspan="3">Simple digital tool for planning and monitoring railway station capacity and cargo operations
Improves coordination among port and rail stakeholders
Increases transparency of operational data
Enhance efficiency of railway infrastructure use
Supports better planning of train arrivals, departures, and cargo handling
Enables improved decision-making with minimal IT investment</td>
<td>Collaborative, data-sharing based relationships
Continuous coordination between stakeholders
Integrated into daily operational planning routines
Low-cost interaction model using simple digital tools
Focus on reliability, transparency, and cooperation</td>
<td rowspan="3">Port of Šibenik Authority
Railway operators (HŽ Cargo)
Terminal operators (Luka Šibenik)
Cargo operators / logistics stakeholders
Primary users: railway and terminal operators (highest dependency on efficiency)</td>
</tr>
<tr><th>Key Resources</th><th>Channels</th></tr>
<tr>
<td>Excel-based digital planning tool
Operational railway data (schedules, track availability, loading times)
Personnel for operational coordination and planning
Railway and cargo handling infrastructure
Basic IT systems</td>
<td>Shared digital tools (Excel templates)
Direct operational communication between stakeholders
Daily coordination processes in port railway operations
Embedded use within intermodal rail node routines
Cost-efficient, informal digital communication channels</td>
</tr>
<tr><th colspan="3">Cost Structure</th><th colspan="2">Revenue Streams</th></tr>
</table>

Personnel costs for operational coordination and planning	Currently non-commercial (pilot phase focused on efficiency)
Data management and maintenance of digital tool	Future potential: operational analytics services
Minimal ICT development costs (Excel-based solution)	Possible subscription-based access to reports and data
Low infrastructure-related digital costs	Consulting services for replication in other ports
Main cost driver: staff involved in daily operations and coordination	Maintenance and support services for the tool
	No direct revenue generated at pilot stage

The ICT solution developed in the pilot represents a simple, low-cost digital tool designed to support the planning and monitoring of railway station capacity as well as cargo loading and unloading operations within the Port of Šibenik. Its core value lies in improving coordination among stakeholders involved in rail freight operations, increasing the transparency of operational data, and enabling more efficient and structured use of existing railway infrastructure. By supporting better planning of train arrivals, departures, and cargo handling activities, the solution enhances operational decision-making while requiring only minimal investment in new IT systems, relying mainly on widely available digital tools.

The implementation and operation of the solution are based on a collaborative ecosystem of key partners. The Port of Šibenik Authority plays a central coordinating role, overseeing the implementation of the system and ensuring alignment of operational planning activities. Railway operators, particularly HŽ Cargo, together with terminal operators such as Luka Šibenik, contribute essential operational data and actively participate in the coordination of train movements and cargo handling processes. IT and software providers act as supporting partners by enabling the development and maintenance of the digital planning tool, while key decisions regarding operations and system use are taken jointly by the Port Authority management, railway operators, and terminal operators.

The functioning of the solution is supported by a set of core operational activities that include the planning of train arrivals and departures, allocation of rail tracks and time slots, and continuous monitoring of cargo loading and unloading operations. These activities are complemented by the collection and management of operational data, the maintenance of the digital planning tool, and the coordination of information exchange between all involved stakeholders. These processes ensure more structured operational planning, improved transparency of rail activities, and better utilization of port railway infrastructure.

The key resources enabling the system include the Excel-based digital planning tool, reliable operational railway data such as train schedules, track availability, and loading times, as well as personnel responsible for coordinating railway operations. In addition, physical infrastructure such as railway tracks and cargo handling facilities within the port are essential, alongside basic IT equipment such as computers and communication systems that enable data sharing and coordination between stakeholders.

Customer relationships within the system are based on continuous collaboration and operational coordination among stakeholders. Railway operators, terminal operators, and cargo owners benefit from improved information sharing and more predictable operational planning. The relationships are characterized by a cooperative model in which stakeholders jointly contribute data and use shared planning tools, ensuring low operational costs due to the simplicity and accessibility of the ICT solution. These interactions are embedded in daily operational routines, reinforcing long-term coordination practices. Communication and interaction with customer segments are primarily enabled through shared digital tools, particularly Excel-based planning templates, as well as direct operational communication between the Port Authority, railway operators, and terminal operators. These channels are cost-efficient and integrated into existing workflows, ensuring that the digital solution is used as part of standard operational procedures for managing cargo and train movements within the port rail node.

The main customer segments include the Port of Šibenik Authority, railway operators such as HŽ Cargo, and terminal operators such as Luka Šibenik. These stakeholders derive value from improved coordination of train movements, optimized use of railway station capacity, and increased efficiency in cargo handling operations. Railway and terminal operators represent the most critical user groups, as their operational performance is directly linked to the efficiency of rail infrastructure within the port environment.

The cost structure of the solution is relatively limited, as it is based on a simple ICT tool and existing operational resources. The main costs are associated with personnel involved in operational coordination and data management, as well as the ongoing use and maintenance of the digital planning tool. Development costs for the ICT solution are minimal, given its reliance on widely available software such as Excel. The most significant resource-related costs are therefore linked to staff time dedicated to planning, coordination, and operational oversight.

Although the solution is currently non-commercial and focused on improving operational efficiency, several potential revenue streams could be developed in the future if the system is scaled or expanded.

These may include the provision of operational support services and performance analytics by the Port Authority to railway operators and logistics companies, subscription-based access to standardized reports and operational statistics, and consulting services for implementing similar railway optimization tools in other ports or logistics hubs. Additionally, ongoing support, maintenance, and enhancement of the planning tool could be offered as a service. The solution is non-commercial and focused on operational efficiency, but the above models demonstrate the potential for future service-based revenue streams.

ICT solution: The solution implemented in the pilot is an Excel-based digital planning tool designed to support the management of railway station capacity and cargo loading/unloading operations. It allows users to record train schedules, allocate rail tracks and time slots, and monitor operational data related to rail movements and cargo handling processes.

Use Cases: The solution was used to support the planning and coordination of train arrivals and departures, allocation of railway tracks, and monitoring of loading and unloading activities in the port railway station. The digital tool enabled stakeholders to collect and analyse operational data, identify delays, and improve coordination between railway operators, terminal operators, and the port authority.

Location: Port of Šibenik – seaport terminal with rail connection

Participants: Port of Šibenik Authority, HŽ Cargo and Luka Šibenik

Outcomes: The pilot improved transparency of operational data and coordination between stakeholders. The use of the digital planning tool contributed to more efficient scheduling of trains and better utilization of railway infrastructure. The pilot also supported improved monitoring of operational performance and identification of potential operational delays.

The following quantitative KPIs will be used to assess the performance of railway operations:

Train throughput

- Number of trains handled per day or per week.
- Target improvement: increase by 15% compared to baseline operations.

Loading and unloading time

- Average wagon/container handling time (minutes per wagon or per container).
- Target improvement: reduced handling time by 20%.

Platform utilization rate

- Percentage of time the railway platform is actively used for loading/unloading operations.
- Indicator of infrastructure capacity efficiency.
- Train turnaround time
- Time between train arrival and departure from the railway platform.

Operational delay rate

- Number of delayed operations or trains compared to planned schedule.

Loading accuracy / error rate

- Number of operational errors or incorrect cargo handling events.
- These KPIs are visualized using charts, dashboards and tables in Excel, allowing stakeholders to track operational performance, identify bottlenecks and improve planning.

Definition of IP and Ownership: No IP for this ICT solution

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*

Port authorities, railway operators, terminal operators, logistics companies, and cargo owners operating in multimodal transport nodes.

- *Networks and institutions at EU level operating in rail sector*

European Union Agency for Railways (ERA), Network of Representative Bodies (NRBs), RailNetEurope (RNE), and European rail and intermodal transport associations.

- *Other relevant EC initiatives and projects*

Connecting Europe Facility (CEF) EU funding instrument supporting the development of trans-European transport infrastructure (TEN-T) and digital transport systems, EU initiatives supporting digitalization of transport and logistics EU initiative promoting digital data exchange in logistics and transport systems, and other EU projects focused on rail freight and intermodal transport development.

4.7 Transagent – Port of Rjieka

FIS (FREIGHT INFORMATION SYSTEM)

Digitalization of railway operations, clusters and competitive advantages of the project's solution

The pilot action implementation focused on functionalities such as digital allocation of staff, locomotives, tracks, and time slots, as well as real-time train tracking, ETA/ETD communication, and digital coordination of shunting and loading/unloading activities. The pilot involved several stakeholder groups, including rail operators, railway undertakings, terminals, and freight forwarders, with organizations such as Transagent Rail Ltd., HŽ Infrastruktura, and AGCT Rijeka contributing to operational implementation, coordination, data exchange, and workflow validation. The solution's main competitive advantages include end-to-end visibility of yard operations, paperless communication, integration with existing rail infrastructure, improved punctuality and turnaround times, modular architecture, and enhanced compliance and traceability. Compared to the previous AS-IS situation, characterized by fragmented communication and manual processes, the CROSSFREIGHT TO-BE scenario introduces centralized digital coordination, real-time monitoring, and automated information exchange, resulting in greater operational efficiency, transparency, and decision-making capabilities. The developed digital solution can reduce operational costs and improve rail efficiency supporting reduction of emissions and promotes sustainable transport.

Exploitation strategy of the project's innovative solution of Port of Rijeka – Brajdica railway station

BMC for business modelling of the developed and tested ICT tool is presented below.

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
Railway undertakings, infrastructure managers, terminal operators, and IT providers. These stakeholders are essential for system implementation, data exchange, and	Development and maintenance of the ICT system, integration with existing systems, user training, system monitoring, and continuous improvement based on operational feedback.	The system provides real-time visibility of railway operations, improves coordination between stakeholders, reduces manual processes, and enhances efficiency and reliability of rail freight operations. It addresses the need for	Relationships are based on long-term cooperation, operational support, and continuous system improvement. The system integrates into daily operational workflows of users.	Railway undertakings terminal operators infrastructure managers logistics companies freight operators

operational coordination.		digitalization of last-mile rail processes.		
	Key Resources		Channels	
	ICT infrastructure software platform operational data trained personnel technical support		Direct system access (web platform), training sessions, operational support, and stakeholder coordination meetings.	
Cost Structure			Revenue Streams	
Main costs include system development, maintenance, IT infrastructure, training, and integration with existing systems.			-	

ICT solution: The Freight Information System (FIS) is a web-based platform for real-time monitoring and management of railway freight operations.

Use Cases: The system is used for monitoring train movements, managing operational data, and improving communication between stakeholders in real time. It supports coordination of train arrivals, departures, and terminal operations.

Location: Port of Rijeka – Brajdica railway station / AGCT terminal

Participants: Transagent Rail, HŽ Infrastruktura, AGCT terminal operator, railway and logistics stakeholders

Outcomes: Improved operational visibility, reduced communication delays, better coordination, and increased efficiency of rail operations.

Definition of IP and Ownership: The intellectual property includes the software platform, system architecture, databases, and operational logic of the FIS system. Ownership is attributed to Transagent Rail Ltd. and/or the contracted technology provider, depending on contractual agreements. Third-party components may be included and are managed through appropriate licensing agreements. Data ownership remains with operational stakeholders.

Exploitation strategy for the tested ICT solution for digitalization of rail shunting operations being addressed to potential local and regional stakeholders, to relevant networks and institutions at EU level operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF) is indicated below for each analyzed category.

- *Local and regional stakeholders*

Railway undertakings, infrastructure managers, terminal operators, logistics companies

- *Networks and institutions at EU level operating in rail sector*

European Union Agency for Railways (ERA), rail freight corridors, TEN-T network stakeholders

- *Other relevant EC initiatives and projects*

CEF projects, digital transport initiatives, smart logistics platforms

5. Policy recommendations

The CROSSFREIGHT project successfully implemented pilot actions to digitalise port–rail logistics chains demonstrating that the digitalisation of port–rail and last-mile railway operations is a strategic enabler for improving efficiency, interoperability, safety, and sustainability across the Adriatic–Ionian macro-region.

Implemented across seven pilot nodes in Italy and Croatia, the solutions tested confirm strong alignment with EU policy frameworks, including TEN-T priorities, the EUSAIR Strategy (Pillar 2 – "Connecting the Region"), and Green Deal objectives. The implemented IT solutions in the seven pilot port-rail nodes are in line with the revised Action Plan of the EU Macro-Regional Strategy for the Adriatic and Ionian Region (EUSAIR), addressing the Pillar 2 "Connecting the Region" and the Topic "Multi-modal connectivity", to strengthen and interlink sustainable energy and transport networks and services in the Region, reducing bottlenecks and developing necessary regulatory frameworks, emphasizing digital solutions adoption.

Among the cross-cutting topics defined in the **EUSAIR Action Plan**, digitalisation represents a prioritized action to set up the network of digital innovation hubs in the Region, building stronger connections within the network, strengthening the need to increase availability of digital tools for logistics optimization, railways transport real-time monitoring, resource-efficient operations, assets' capacity exploitation, etc.

Wider macro-regional cooperation and capitalization of harmonized digital solutions are encouraged to provide seamless and digitalized railway shunting services at port-rail nodes, benefiting railways system by increased rail transport capacity and safety, interoperable rail infrastructure and services among countries of the Adriatic-Ionian region, including EUSAIR rail nodes and broader TEN-T railways corridors.

Policy recommendations for optimizing port-rail last-mile operations, enhancing interoperability and cooperation among value chain stakeholders, and supporting cross-border multimodal transport efficiency should address actions to overcome current limited IT integration, data and information fragmentation among actors, manual procedures adoption in railway shunting operational processes, etc.

Digital solutions enable to improve visibility of operational processes, enhance communication among stakeholders, reduce manual errors, optimize allocation of shunting and terminal resources, and speed up structured information flow among all railway related actors, including railway infrastructure managers, railway undertakings, shunting operators, intermodal transport operators, inland terminals, rail terminals. CROSSFREIGHT demonstrates that the digitalization of railway shunting operations is a strategic lever for transforming rail–port logistics systems across the Adriatic-Ionian macro-region.

At the strategic level, the main recommendation is the establishment of a **common Adriatic-Ionian framework for digital railway shunting operations**. This framework should define shared principles, interoperable data standards, and minimum digital requirements to ensure consistent coordination across ports, terminals, and rail operators in both advanced and less mature logistics environments.

The aim is not uniform technological adoption, but interoperability between heterogeneous systems and IT platforms. A second key recommendation concerns the development of **integrated rail–port digital ecosystems**. This includes the harmonization of PCS, railway management platforms, and terminal operating systems through API-based interoperability and real-time data exchange, being essential to reduce fragmentation and improve decision-making across stakeholders within the rail-logistics nodes.

The third major policy direction is the transition from manual and reactive operations to **real-time and predictive rail shunting management**. The CROSSFREIGHT pilot actions have shown that digital tools significantly improve shunting planning, resource allocation, and operational visibility. Policy actions should therefore support the adoption of real-time monitoring systems and AI-assisted optimization tools to increase efficiency, reduce delays, and improve infrastructure reliability. A fourth recommendation focuses on **railway safety and traceability digitalization**. The Croatian pilot demonstrates the value of centralized digital systems for accident reporting, investigation, and compliance management.

Policy frameworks should promote interoperable safety-data systems, structured audit trails, and harmonized digital reporting mechanisms to strengthen regulatory oversight and operational resilience.

Another key recommendation is the promotion of scalable and modular digitalization models. The pilots in smaller terminals and regional nodes show that even low-complexity digital tools can deliver significant efficiency gains. Policy design should therefore **support phased digital transition pathways**, enabling gradual adoption of ICT solutions depending on technological readiness and institutional capacity, ensuring inclusiveness across the region. Digital optimization of shunting operations also contributes to reduced fuel consumption, lower emissions, and improved infrastructure utilization. Recommendations emphasize the integration of digital rail operations into broader climate and sustainability strategies, aligning transport digitalization with Green Deal objectives and freight transport modal shift policies.

Governance and institutional coordination represent another essential pillar. CROSSFREIGHT pilots highlight the need for stronger cooperation among railway undertakings, railway infrastructure managers, terminal operators, port authorities, and logistics providers. Policy measures should support the creation of **permanent rail–port coordination mechanisms** to ensure alignment between operational actors and digital systems. Finally, the recommendations underline the importance of financing and transferability.

Since EUSAIR does not have its own financial instruments, implementation must rely on **coordinated use of EU, national, and regional funding sources** such as CEF, Cohesion Policy, Interreg, and Horizon Europe.

Investment strategies should prioritize interoperable, scalable, and replicable IT solutions, particularly for secondary and regional logistics nodes. The analysis of the pilots' results confirms that railway shunting digitalisation is not merely a technical upgrade but a structural transformation of rail–port logistics governance. The main barriers are not technological, but institutional, organisational, and regulatory.

The pilots have confirmed strong technological feasibility through API-based interoperability, modular architecture, and integration with existing port and rail systems. Key challenges include heterogeneous ICT maturity, limited real-time data availability, and integration with legacy systems. The CROSSFREIGHT approach demonstrates scalability across different operational contexts, including smaller rail terminals.

From the legal viewpoint, EU interoperability standards and clear intellectual property frameworks support replication and deployment. However, challenges remain in data governance, cross-border information exchange, and defining responsibilities for data ownership in multi-actor environments.

From the economic viewpoint, digital solutions generate clear operational benefits, including reduced shunting costs, improved resource allocation, and lower fuel consumption. Scalable, modular ICT models (inc. SaaS-based approaches) are suitable for smaller or lower-volume terminals.

From the political viewpoint, EU and macro-regional policies strongly support rail–port digitalisation and multimodal integration. However, fragmented governance structures and inconsistent institutional coordination across regions and countries remain a key barrier. This reinforces the need for a coordinated macro-regional approach to digital rail operations. In conclusion, the CROSSFREIGHT project demonstrates that coordinated digitalisation of rail shunting and port–rail interfaces can significantly enhance the performance, sustainability, and competitiveness of Adriatic–Ionian rail transport system.

Key policy recommendations are summarized as follows:

- Establish a common Adriatic–Ionian framework for digital railway shunting, defining shared principles, interoperable standards, and minimum digital requirements across countries-nodes.
- Develop integrated rail–port digital ecosystems, ensuring interoperability between PCS, terminal systems, and railway platforms through API-based data exchange.
- Harmonize legal and data governance frameworks, ensuring secure, structured, and interoperable data exchange across all stakeholders involved in railway and port ecosystems.
- Support scalable and modular digitalisation pathways, enabling gradual adoption tailored to different levels of technical and institutional readiness.
- Invest in capacity building and establishment of permanent rail–port coordination mechanisms.
- Leverage multi-level funding instruments (e.g. CEF, Cohesion Policy, Interreg, Horizon Europe, etc.) to ensure scalability, replication, and long-term sustainability of railway digitalisation process.

6. Conclusions

The CROSSFREIGHT project has demonstrated the strong potential of interoperable ICT solutions to support the digital transformation of rail shunting operations within intermodal terminals, freight villages, and port railway nodes across the Italy–Croatia cross-border area. Through the implementation and testing of seven pilot actions in different operational contexts, the project validated innovative digital tools capable of improving coordination, operational efficiency, communication processes, and sustainability within railway freight ecosystems. The developed solutions introduced a significant advancement toward the modernization of the processes by enabling interoperable and data-driven operational management. Across the pilot actions, the tested ICT tools demonstrated the capability to support optimized planning of shunting activities, digital management of operational requests, real-time sharing of operational information, monitoring of train and wagon movements, allocation of tracks and resources, predictive maintenance and enhanced coordination among the different chain stakeholders.

The project demonstrated the importance of interoperability between ICT systems already existing within ports, terminals, railway undertakings, and infrastructure managers. The digital transformation of rail shunting operations requires coordinated action among public authorities, railway undertakings, terminal operators, infrastructure managers, and logistics stakeholders. Several pilot actions confirmed that successful digitalization does not only depend on the introduction of innovative software tools, but also on the capability of these systems to exchange data seamlessly through standardized interfaces and harmonized operational procedures. In this perspective, CROSSFREIGHT contributed to strengthening the integration between rail operations and wider logistics and port community systems, supporting more synchronized and resilient freight transport chains. The benchmarking activities described in this deliverable also confirmed that the market for digital rail shunting and terminal operating solutions is rapidly evolving, with increasing demand for automation, real-time operational visibility, AI-supported planning, and integration among transport modes. In this context, CROSSFREIGHT solutions position themselves as valuable and innovative contributions capable of addressing operational gaps that are still present in many railway and intermodal nodes, particularly in medium-sized ports and freight terminals where digital transformation processes are ongoing.

The ICT applications developed and validated throughout the project showed strong potential for future deployment beyond the pilot sites thanks to their modularity, interoperability, and adaptability to different railway operational contexts. The solutions tested in Ravenna, Trieste, Škrljevo, Marghera, Terminal Saletti, Šibenik, and Rijeka demonstrated the capability to support key operational processes.

A major exploitation opportunity lies in the increasing demand for digital railway and terminal management solutions within European freight transport corridors and TEN-T intermodal nodes: many railway and port environments still rely on fragmented communication systems, spreadsheet-based planning, and manual coordination procedures. The CROSSFREIGHT solutions address these gaps by enabling automated planning functionalities, paperless workflows, interoperable data sharing, and improved operational visibility, generating measurable benefits in terms of efficiency, resource optimization, and reduction of operational delays. The transferability exercises conducted confirmed that the solutions could be replicated in additional freight villages, ports, and railway terminals, provided that minimum digital readiness conditions and stakeholder coordination mechanisms are ensured.

From a commercial and operational perspective, the ICT tools tested in the seven pilot actions have the potential to be exploited through partnerships among railway undertakings, terminal operators, port authorities, infrastructure managers, and technology providers. Their modular architecture enables gradual implementation according to local operational needs and investment capacities, facilitating adoption even in intermodal nodes that are still in early stages of digital transformation.

CROSSFREIGHT also contributes to broader European transport and sustainability objectives: the optimization and digitalization of rail shunting operations can play a significant role in supporting greener, safer, and more sustainable freight transport systems within TEN-T network and the EUSAIR area. Achieved results provide a strong foundation for future scaling-up activities for railway digitalization, supporting efficient and sustainable railway freight operations at regional, national, and European levels.

7. Annexes

Exploitation questionnaire

Purpose of the document – partners' questionnaire for CROSSFREIGHT exploitation analysis

This activity is aimed at providing the overall exploitation strategy and policy recommendations for the CROSSFREIGHT concept and solutions deployment in the real-word rail operators' market. Exploitation plans of the CROSSFREIGHT solutions will be addressed, encompassing the innovative ICT tools designed, developed and tested by Field Operational Tests (FOTs) at the 7 intermodal rail nodes according to the FESTA methodology defined in WP2. The assessment of the **rail operators' market** supporting the digital transition of shunting activities will be addressed by collecting relevant data by following questionnaire, which encompasses the evaluation of market size and potential end-users' clusters among local and regional stakeholders established by the project partners for running and evaluating the pilot actions. Exploitation plan for each tested innovative ICT solution for the digitalization of rail shunting operations will be also linked with potential national and regional stakeholders for each project's partner as well as with relevant networks and institutions at EU level operating in rail sector (e.g. EU Railway Agency, etc.). To define the exploitation strategy of the CROSSFREIGHT **Key Exploitable Results (KERs)**, an ad-hoc questionnaire is provided to be submitted to the project's partners enabling them to provide valuable insights on potential exploitation pathways for the ICT solutions deployed and tested in WP2 by FOTs.

The questionnaire is structured in 5 sections as follows:

- **Section 1: Digitalization of rail shunting operations (functionalities)**
- **Section 2: Potential end-users' clusters definition and characterization**
- **Section 3: Competitive advantages of the project's innovative solution**
- **Section 4: Exploitation strategies for the project's innovative solution**
- **Section 5: Stakeholders' collaboration and the project's innovative solution implementation**

Section 1. Digitalization of rail shunting operations

1.1 – Addressed functionalities
Please indicate functionalities addressed by the ICT solution tested in the pilot action

☐ Digital allocation of staff

☐ Digital allocation of locomotives

☐ Digital allocation of rail tracks and time slots

☐ Digital communication of Estimated Tima of Arrival (ETA) and Estimated Time of Departure (ETD)

☐ Digital communication of Shunting In - Shunting Out, Loading-Unloading times with stakeholders

☐ Digital real-time tracking of all trains is being shunted

☐ Digital safety and security solutions for shunted trains

☐ Digital monitoring of the performance of trains for rail accidents' investigations

Section 2. Potential end-users' clusters definition and characterization

2.1 – Cluster definition

Please indicate stakeholder's categories which have been involved in the pilot action

☐ Shunting operators

☐ Rail operators

☐ Railway undertaking

☐ Railway transport managers

☐ Multimodal Transport Operators (MTOs)

☐ Carriers

☐ Terminals

☐ Shippers

☐ Freight Forwarders

☐ Other (specify):_______________

2.2 – Cluster characterization

*Please specify the **name** of the indicated stakeholder's categories involved in the pilot action and the respective **contribution** within the "running" phase of the pilot through the ICT solution implementation*

☐ **Shunting operators**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Rail operators**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Railway undertaking**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Railway transport managers**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Multimodal Transport Operators (MTOs)**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Carriers**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Terminals**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Shippers**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Freight Forwarders**

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

☐ **Other (specify)**:_______________

- Name of the organisation involved in the pilot action: ______________________
- Contribution of the organisation involve in the pilot action: __________________

Section 3. Competitive advantages of the project's innovative solution

3.1 – The unique selling points of the CROSSFREIGHT solution

Please describe the competitive advantages of the ICT innovative solution implemented by the pilot action

☐ **Enhanced Safety Through Real-Time Monitoring**

(Continuous tracking of locomotives, wagons, and staff reduces human error and prevents collisions)

☐ **Automated Movement Planning & Optimization**

(ICT rail shunting system can automatically generate optimal shunting plans, minimizing idle time, reducing unnecessary movements, and improving yard throughput)

☐ **End-to-End Visibility of Yard Operations**

(ICT rail shunting system provides a single digital view of train positions, wagon status, track occupancy, and operational progress—helping dispatchers make faster, more accurate decisions)

☐ **Paperless, Streamlined Communication**

(Digital work orders, instructions, and confirmations replace radio calls and paper forms, allowing instant updates and reducing errors)

☐ **Integration with Existing Rail Infrastructure**

Modern digital shunting systems connect seamlessly with: Yard control systems, Signaling, Asset management, ERP

☐ **Reduction in Operational Costs**

(Automation reduces manual labor requirements, fuel consumption, and wear-and-tear from inefficient movement, leading to measurable cost savings)

☐ **Improved Punctuality and Turnaround Times**

(Optimized workflows and real-time data allow faster train assembly and disassembly, improving terminal efficiency and on-time performance)

☐ **Predictive Maintenance Support**

(Sensors and digital logs capture wagon and locomotive condition, enabling early detection of faults and reducing downtime)

☐ **Modular Architecture**

(Modular components allow operators to adopt the technology gradually)

☐ **Compliance and Traceability**

(Audit trails, and automated reporting support regulatory compliance, incident investigations, and performance analysis)

3.2 – Qualify gaps between CROSSFREIGHT innovation (TO-BE) and existing situation (AS-IS)

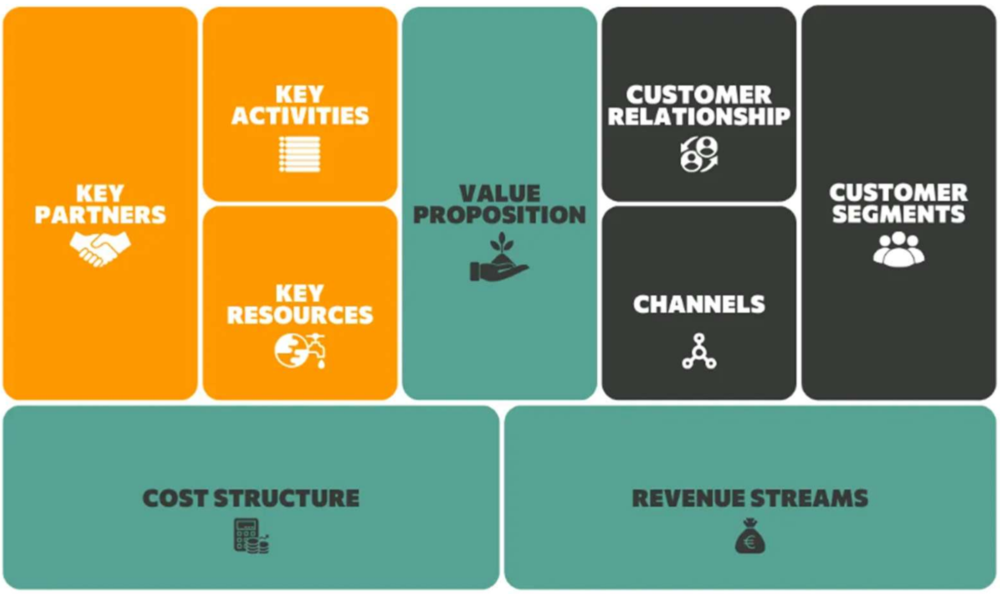
Which are the filled gaps by the CROSSFREIGHT solution comparing AS-IS and TO-BE scenarios?

Section 4. Exploitation strategy of the project's innovative solution

4.1 – Business Model Canvas (BMC)

Please provide information based on the results of the pilot action regarding:

- *Business Model Canvas (BMC) for business modelling of the developed and tested ICT tools*



1) Value Propositions

- What is the value to the consumers of offered innovative ICT solution?
- What value does it deliver to the customer?
- Which one of the customer's needs and requirements are addressing?
- Which customer's needs are satisfying?

2) Key Partners

- How are key partners for the deployment and operation of the innovative ICT solution?

- Who are the partners required? Who are key suppliers? Who are key decision makers?

3) Key Activities

- Which are key activities for the deployment and operation of the innovative ICT solution?
- What key activities do Value Propositions require?

4) Key resources

- Which are key resources for the deployment and operation of the innovative ICT solution?
- What key resources do Value Propositions require?
- What are the resources and infrastructure/equipment required?

5) Customer Relationships

- How does the value reach the consumers?
- What type of relationship does each of Customer Segments expect to establish and maintain with operation of the innovative ICT solution?
- Which ones have the pilot action established?
- How are they integrated with the rest of business model? How costly are they?

6) Channels

- Through which Channels does the Customer Segments want to be reached?
- Which ones are most cost-efficient?
- How is the intermodal rail node integrating them with customer routines?

7) Customer Segments

- Who are the consumers of the innovative ICT solution?
- For whom is the rail node creating value? Who is the rail node most important customers?

8) Cost Structure

- What are the most important costs inherent business model of the innovative ICT tool?
- What are the cost items to offer the value?
- Which Key Resources and Key Activities are most expensive?

9) Revenue Streams

- What are the sources to cover the costs of the value?
- For what value is the rail node's customers willing to pay?
- For what do customers currently pay?
- How would customers prefer to pay?
- How much does each Revenue Stream contribute to overall revenues of automation services?

4.2 – Product Use Cases (factsheet of the pilot action based on the implementation of the ICT solution)

Please provide information based on the results of the pilot action regarding:

- *Product Use Cases (brief description of its application for the pilot actions)*

Factsheet of pilot action for CROSSFREIGHT innovative solution should detail the specific Use Case (UC), which is the practical ways the technology for the digitalization of the shunting operations was applied, and results of the pilot to assess its effectiveness and potential for wider implementation. Key components of such a factsheet should include a description of the problem addressed, ICT solution features, how the digital solution was used in real-world scenarios (the UC), quantify/qualify outcomes and final results.

***ICT solution**: Provide a summary of the technology implemented*

***Use Cases**: Describe the specific, real-world applications of the solution*

***Location:** Where the pilot took place (e.g. port, inland rail terminal, dry port, seaport terminal, etc.)*

***Participants**: Who was involved (e.g. users, organizations, stakeholders)*

***Outcomes**: Quantifiable data - KPIs - on performance (e.g. efficiency gains, cost savings, safety, etc.)*

4.3 – Intellectual Property (IPR)

Please provide information based on the results of the pilot action regarding:

- *Intellectual Property Rights (IPR)*

Intellectual Property Rights (IPR) for the innovative ICT solutions include sections for defining ownership, protecting different types of IP like software and patents, and outlining an IP strategy with specific goals and operational details. Key elements involve a clear statement of who owns the IP, how it will be managed and protected through formal and informal methods (e.g., copyright, patents, trademarks, trade secrets).

***Definition of IP**: Clearly state what constitutes intellectual property of the tested digital solution, including software, code, algorithms, databases, design, and hardware components.*

***Ownership**: Specify who owns the IP.*

***Collaboration and third-party IP**: Address how IP will be handled in collaborative projects or when using third-party components, including requirements for licensing and joint ownership agreements.*

Section 5. Stakeholders' collaboration and the project's innovative solution implementation

5.1 – PESTLE analysis

Please provide information on Political, Economic, Social, Technological, Legal, and Environmental factors which influence (drivers or barriers) scaling and exploitation of the ICT solution in other multimodal nodes

Political
Please describe external forces driven by government and politics
Economic
Please describe external forces driven by the economy
Societal
Please describe external forces driven by workforce and social dynamic
Technological
Please describe external forces driven by technology
Legal
Please describe external forces driven by the law or regulation
Environmental
Please describe external forces driven by the environment

*5.2 – Exploitation strategy for each tested innovative ICT solution for the digitalization of rail shunting operations being addressed to potential **national and regional stakeholders** for each project's partner, to relevant **networks and institutions at EU level** operating in rail sector (e.g. European Railway Agency, Network of Representative Bodies - NRBs, etc.), and to other EC initiatives and projects (including CEF).*

Please indicate (select all that apply):

☐ National and regional stakeholders: ____

☐ Networks and institutions at EU level operating in rail sector: _____________________________________

☐ Other relevant EC initiatives and projects: ____