D1.4 FINAL SUMMARY REPORT OF THE PROJECT

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Consortium of partners

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UNION INTERNATIONALE DES TRANSPORTS PUBLICS (UITP)	Belgium
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OLTIS GROUP	Czech Republic
FSTECH	Italy
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1. EXECUTIVE SUMMARY

This deliverable aims to present the summary of the work done within the RIDE2RAIL project. The project aims to integrate multiple (public/private/social) data sets and existing transport platforms for promoting an effective Ride Sharing practice of citizens, making it a complementary transport mode that extends public transport networks. The integration between the Ride Sharing practice, along with a relevant critical mass of users, and the public transport network delivers a crowd-based mobility network and is achieved by the RIDE2RAIL framework for intelligent mobility that integrates and harmonises real-time and diverse information about public transport, Ride Sharing and crowdsourcing in a social ecosystem facilitating the comparison and the choice between multiple options/services classified by a set of criteria including environmental impact, travel time, comfort, cost thus facilitating the individual, more positive, convenience of the travel experience.
All relevant achievements are well described in this document, providing a wide overview of the project developments, mainly focusing on two aspect: the research and developments of innovative software components and tools, and their utilization in the demonstration sites.

RIDE2RAIL designed, developed and tested in 4 real demonstrators (Padua, Brno, Athens, Helsinki) a set of software components for the S2R IP4 ecosystem, including an advanced Travel Companion and the crowd-based Transport Service Provider that fosters combined flexible and regular multimodal mobility with an easy personalisation in diverse existing environments, thus facilitating the market uptake. The advanced Travel Companion is an enriched version of the Shift2Rail Travel Companion, integrated with components developed by RIDE2RAIL partners.

Demonstrating these new solutions, especially those from the research and innovation programmes, is a very important step towards the achievement of the project's ambitious objective of making it easier the combination of flexible and scheduled transport services, utilizing the ride-sharing as a feeder for public transport, especially in rural and low demand areas. Thus, the demonstrations required to be well-planned and organised and the feedback of potential users collected and analysed for decision-making.
The approach used for managing the RIDE2RAIL project is based on several main pillars:

- Definition of choice criteria for journey planning
- State of the art, analysis and recommendations for a successful ride-sharing in a multimodal journey
- Identification of requirements and specifications for complementary travel expert services in the Shift2Rail IP4 ecosystem
- Definition of algorithms for optimal synchronisation of shared-mobility and mass transit
- Development of RIDE2RAIL components (Offer Categorizer, Offer Matcher and Ranker, Incentive Provider, Agreement Ledger, Crowd Based TSP, Driver Companion)
- Implementation of the demos in four Europe-wide demo sites through identification of the current mobility situation in the demo sites, looking at potential improvements for those locations, creating of an evaluation framework and acquiring the KPIs
- Evaluation and Impact Assessment, carried out per each demo site.

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Employing the successful collaboration, the IP4 solution, represented by the Enhanced Travel Companion (including Crowd Based TSP) and the Driver Companion applications and by functionalities, have been demonstrated in four demo sites, Athens, Helsinki, Brno and Padua. Despite the challenges linked to the post-COVID new mobility patterns and other operational challenges of different nature, these tools have been tested in real-time, with a total of more than 120 testers. To provide quality feedback, a complex evaluation has been made. In particular, the demos have been evaluated according to previously identified KPIs, measured using qualitative and quantitative data from the IP4 ecosystem and the users' feedback collected via questionnaires, in Brno also through daily reports.

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Abbreviations and acronyms

AHP	Analytical Heirarchy Process
AL	Agreement Ledger
AM	Asset Manager
CFM	Calls for Members
CB TSP	Crowd Based Transport Services Provider
DC	Driver Companion
ER	Europe's Rail
GA	Grant Agreement
H2020	Horizon 2020
IP4	Innovation Programme 4
JP	Journey Planner
KPI	Key Performance Indicator
MAAS	Mobility as a Service
OC	Open Call
O-D	Origin-Destination
OMR	Offer Matcher and Ranker
PC	Project coordinator
PM	Project manager
PO	Project Officer
PT	Public Transport (or Public Transit)
QAIC	Quality Assurance and Innovation Committee
S2R JU	Shift2Rail Joint Undertaking
TC	Travel Companion
TSP	Transport Services Provider
WP	Work Package
WPL	Work package leader

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2. BACKGROUND

The present document constitutes the Deliverable D1.4 "Final Summary Report of the Project" in the framework of the WP1 "*Project Management and Coordination, Ethics and Data Management*" and in particular tasks 1.1 *"Administrative, Financial and Strategic Management"*, 1.2 " Technical Management", 1.3 *"Quality Assurance, Innovation Management and Risk Assessment"*, 1.5 "*Concertation with other stakeholders, projects, initiatives and the S2R JU*" of the Ride2Rail project (S2R-OC-IP4-01-2019).

It contributes as well to WP6 Task 6.1 *"Dissemination and communication strategy"* and 6.3 *"Transferability and Recommendations"* helping with delivering of clear Summary of the project work for dissemination purposes.

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3. OBJECTIVES/AIM

This document has been prepared to provide a full review of the project and conclusions to the achievements obtained. The report aims to address the scientific and technical findings of the project and provide a lookback on the S2R IP4 travel services such as personal travel companion, seamless ticketing opportunities, etc., while articulating paths for future research and next steps for commercialisation/ implementation of the product.

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4. RIDE2RAIL INTRODUCTION

4.1.Project Scope and Background

During the last decades, globalisation, mobile and sharing economic trends increased the need for mobility and worldwide the car has a predominant role with a stable share in most countries. In addition, unprecedented urban sprawl and dispersed land-use patterns, such as the large developments of extra-urban housing, dominance of big malls, and the consolidation of service centres into fewer, larger units, strengthened individual mobility behaviours, particularly in rural and low-demand areas, consolidating the car as the most preferred transport mean and correspondingly harming the quality of collective transports.

These factors result in a negative condition for both urban and rural mobility: several statistics show that car occupancy rate for commuting trips in EU countries is about 1.1 persons per vehicle, with related implications on traffic congestion, energy consumption, and environmental impacts.

Mobility policies should therefore deal with attentive urban planning, aimed at reducing the need for travel, when possible, and, as second step, promoting more sustainable transport modes. For the latter, the co-modality approach clearly showed to be largely effective, by bringing more traffic demand to high-capacity transport modes and better exploiting their full potential reducing consequently a share of traffic currently addressed by individual private mobility. Among transport demand management with a co-modal approach, an ever-increasing interest is played by Ride Sharing which recently emerged as an effective practice also thanks to mobile technologies facilitating social and matchmaking mechanisms. This approach should be encouraged by considering it a key factor in reducing the overall distance travelled by private vehicles and a formidable feeder for high-capacity transport services. Despite its significant potential, Ride Sharing has demonstrated limited uptake so far, because of a set of barriers such as insufficient awareness of dedicated services, lack of trust and willingness to ride with strangers, need for flexibility in scheduling to allow and cope with change in plans and uncertainty in reaching agreements on sharing costs

Among these experiences, real-time Ride Sharing technologies are emerging for facilitating instant matching between drivers and passengers with similar itinerates. This technology has been piloted in several cities, but the demand for instant Ride Sharing is still relatively limited because of lack of critical mass.

As widely recognised, Ride Sharing, if properly developed, has the potential to reduce the number of single-occupancy vehicles. The vision of RIDE2RAIL is therefore to exploit intelligent mobility approaches making Ride Sharing an effective feeder for high-capacity transport services in less-densely populated and rural areas. The effects will be to deviate current demand from individual to collective mobility and even to potentially attract new demand (trips not executed), hence improving transport accessibility and reducing “disutilities” for users. The RIDE2RAIL approach is based on an inclusive vision of shared mobility within the transport network, supporting the access to individuals’ travel offers and

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fully exploiting social leverages to make the service highly effective. This service model will make the RIDE2RAIL concept easy replicable at a European level.

RIDE2RAIL's overall objective was to develop an innovative framework for intelligent mobility, facilitating the efficient combination of flexible and scheduled transport services, thus enhancing the performance of the overall mobility system. This framework, consisting in a combined suite of travel offer classifications and software components, was integrated into existing collective and on-demand transport services, connecting and reinforcing the mobility offer especially in rural and low-demand areas, in order to induct the access to high-capacity services (rail, bus and other public transport services) thanks to easy-to-use multimodal and integrated travel planning, booking, issuing, etc.

RIDE2RAIL aimed promoting an effective Ride Sharing practice of citizens, making it a complementary transport mode that extends public transport networks. The integration between the Ride Sharing practice, along with a relevant critical mass of users, and the public transport network delivered a crowd-based mobility network and was achieved by the RIDE2RAIL framework for intelligent mobility integrating and harmonising real-time and diverse information about public transport, Ride Sharing and crowdsourcing in a social ecosystem facilitating the comparison and the choice between multiple options/services classified by a set of criteria including environmental impact, travel time, comfort, cost.

As primary achievement, RIDE2RAIL addressed the current challenges of identifying criteria for multimodal travel planning by addressing the aforementioned existing barriers in Ride Sharing practice, developing travel scenarios and testing related business cases.

The second relevant achievement of RIDE2RAIL has been the design, development and test in 4 real demonstrators Padua, Brno, Athens, Helsinki) of a set of software components for the S2R IP4 ecosystem, including an advanced Travel Companion and the crowd-based Transport Service Provider that foster combined flexible and regular multimodal mobility with an easy personalisation in diverse existing environments, facilitating the market uptake.

Summary of objectives:

- To develop an innovative framework for intelligent mobility, facilitating efficient combination of flexible and scheduled transport services, integrating real-time information about PT & RS
- To create a tool that facilitates the comparison and the choice between multiple options/services classified by a set of criteria (environmental, travel time, comfort, cost, etc)
- To encourage carpooling (and ride sharing acceptance) as complementary for PT
- To enhance the performance of the overall mobility system, reducing road congestion and environmental impact reinforcing the mobility offer in rural and low-demand areas
- To combine travel offer classifications and software components, integrating them into existing collective and on-demand transport services

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- To induct the access to high-capacity services thanks to easy-to-use multimodal and integrated travel planning, booking, issuing and other features
- To design, develop and test in 4 real demonstrators a set of software components for the IP4 ecosystem, including an advanced Travel Companion and the crowd-based Transport Service Provider
- To produce recommendations for replicability

4.2. RIDE2RAIL Structure

The RIDE2RAIL Consortium is based on the close collaboration of the beneficiaries listed in Table 1 and Figure 1.

PARTNER	COUNTRY
UNION INTERNATIONALE DES TRANSPORTS PUBLICS (UITP)	Belgium
FIT CONSULTING	Italy
OLTIS GROUP	Czech Republic
FSTECH	Italy
CEFRIEL	Italy
CERTH	Greece
EURNEX	Germany
EURECAT	Spain
POLIMI	Italy
UNIVERSITY OF NEWCASTLE UPON TYNE	United Kingdom
UNIFE	Belgium
UIC	France
UNIZA	Slovakia
ATTIKO METRO	Greece
INLECOM	Greece
FV-Helsinki	Finland
METROPOLIA	Finland

Table 1: List of RIDE2RAIL partners

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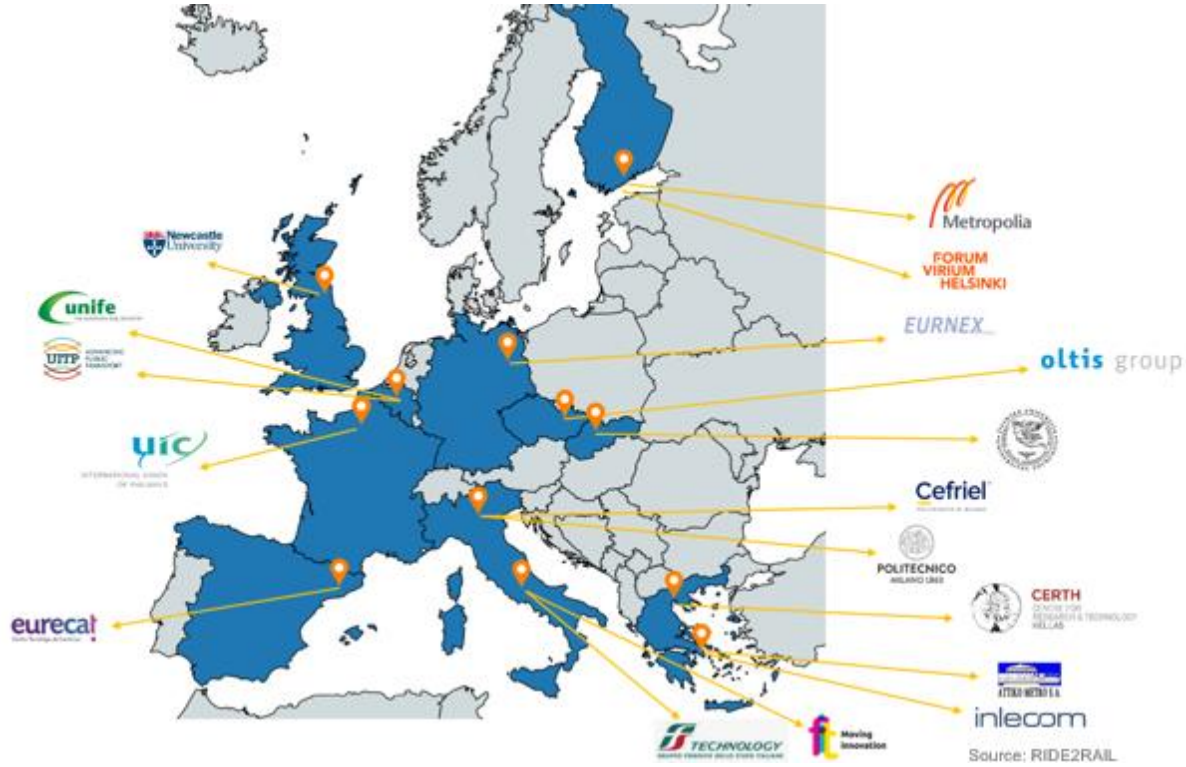

Figure 1: RIDE2RAIL Consortium

The RIDE2RAIL work flow is presented below.

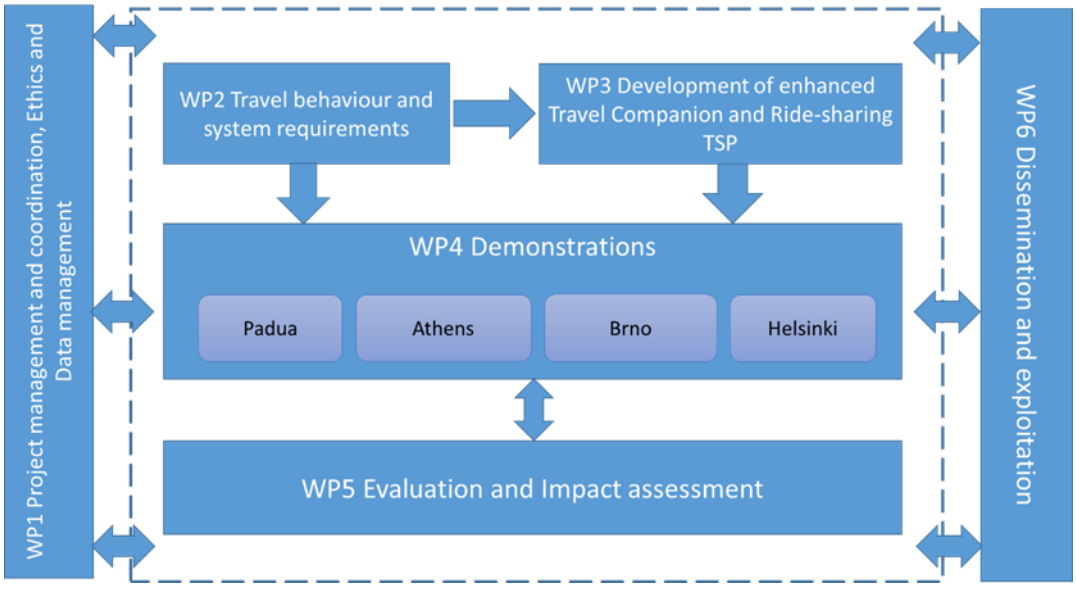

Figure 2: RIDE2RAIL Work Flow

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5. SHIFT2RAIL IP4 ECOSYSTEM

5.1. What is Shift2Rail IP4

The Shift2Rail Joint Undertaking (S2R JU) is a public-private partnership in the rail sector, established under Horizon 2020 programme, to provide a platform for coordinating research and innovation activities in the rail sector. It was established on 7 July 2014, following the entry into force of Council Regulation (EU) No 642/2014 of 16 June 2014 establishing the Shift2Rail Joint Undertaking[1].
The activities of the S2R JU are defined in a strategic Master Plan and represented by five Innovation Programmes: IP1 'Cost-efficient and reliable trains, including high-capacity and high-speed trains', IP2 'Advanced traffic management & control systems', IP3 'Cost-efficient and reliable high-capacity infrastructure', IP4 'IT Solutions for attractive railway services', IP4 'Technologies for sustainable & attractive European freight'.
Europe's Rail Joint Undertaking (EU-Rail)[2] is established by Council Regulation (EU) 2021/2085 of 19 November 2021. It is the new European partnership on rail research and innovation established under the Horizon Europe programme (2020-2027) and the universal successor of the Shift2Rail Joint Undertaking.

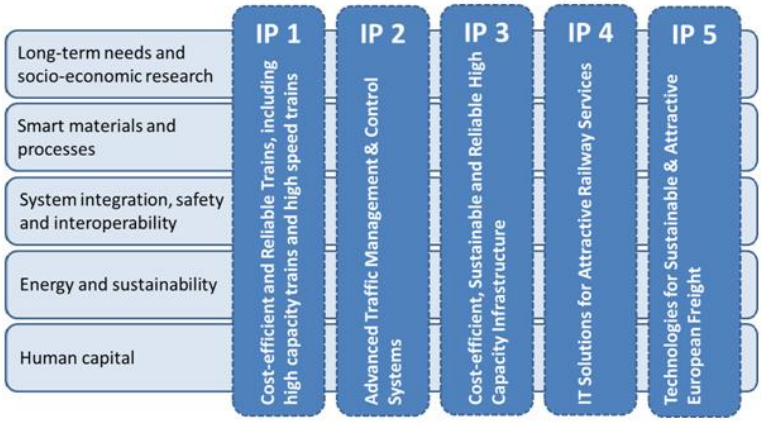

Figure 3: Shift2Rail Innovation programmes and cross-cutting activities (Reference: Shift2Rail website)

[1] https://ec.europa.eu/transport/modes/rail/shift2rail_en
[2] https://rail-research.europa.eu/

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The Innovation Programme 4, also known as IP4, is an initiative by the Shift2Rail Joint Undertaking aiming to facilitate seamless multimodal travel across Europe. As part of IP4, Shift2Rail created a 'Travel Companion' application for the European market that connects rail with other transport modes and provides multimodal travel offer connecting the first and the last mile of long-distance journeys. The main objective is to put the traveller at the centre of solutions' design, ease access to rail services, increasing its attractiveness, and give one-stop-shop access to all multimodal travel services. To achieve this, IP4 is developing an Interoperability Framework including tools and technologies that allow data exchange between different actors of the transport ecosystem, enabling interoperability between new and existing systems.
IP4 is organised around six Technology Demonstrators (TDs). All of these TDs focus on one element of providing a travel application for seamless passenger experience.

Figure 4: Technological Demonstrators of S2R IP4. Source: https://projects.shift2rail.org/s2r_ip_TD.aspx?ip=4

Besides it, there is a specific additional IP4-integrated Technical Demonstrator (iTD4.7) which aims to integrate all developments from other TDs and acts as an orchestrator of all technologies developed within the Programme.

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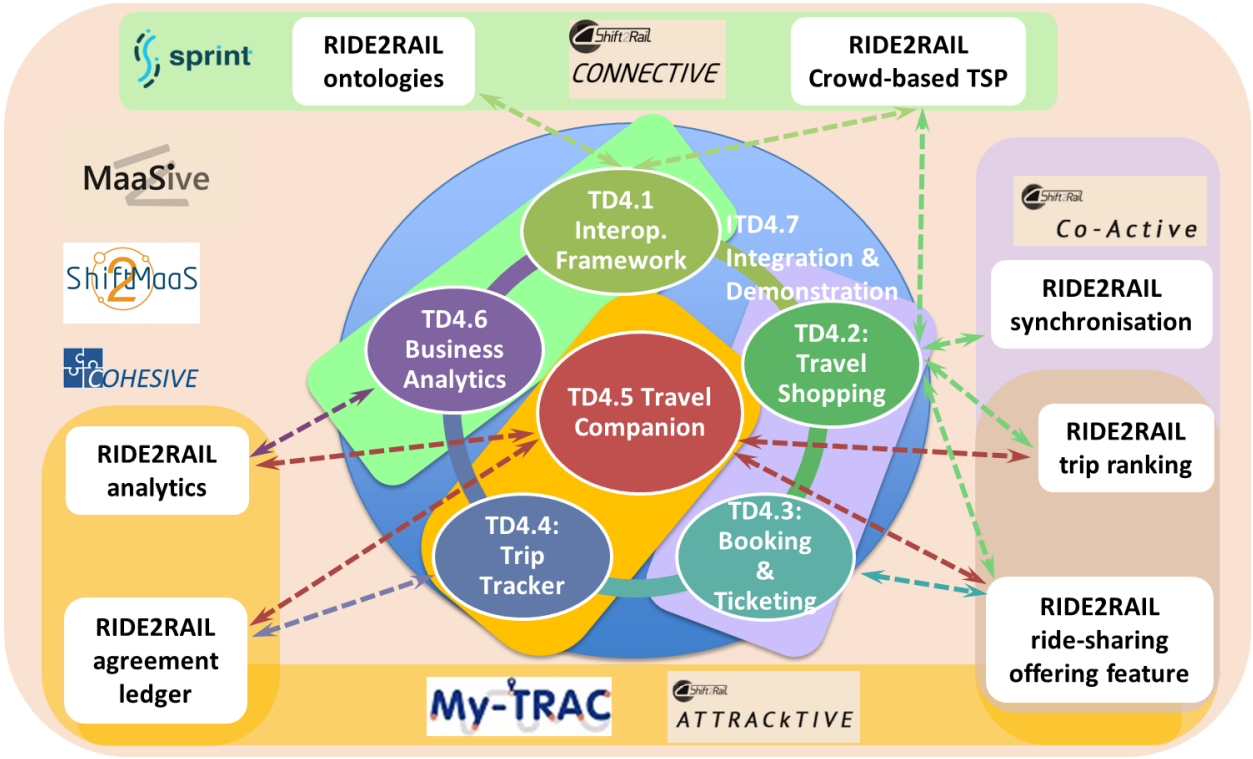

Figure 5: The functionalities developed in the Technological Demonstrators of S2R IP4

The figure above shows how RIDE2RAIL feeds IP4 TDs considering the results of past and concurrent projects:

- The conceptualization of trip categories and user preferences (captured by RIDE2RAIL ontologies) contributes to TD4.1, complementing the work initiated by IT2Rail and refined in the SPRINT and CONNECTIVE projects.
- The design and development of a crowd-based TSP for ride-sharing contributes to TD4.1 and TD4.2 providing a Shift2Rail-compatible TSP, in terms of functionalities and interfaces;
- The definition of algorithms for optimal synchronisation of shared-mobility with rail and mass transit offers contributes to TD4.2.
- The development of the RIDE2RAIL trip ranking contributes to TD4.2 and TD4.5, providing an enhanced feature to support travellers when choosing a multimodal trip combination.
- The design and development of the RIDE2RAIL ride-sharing offering feature enhances the Travel Companion (TD4.5), covering functionalities related to travel shopping (TD4.2) and booking (TD4.3).
- The definition of the RIDE2RAIL agreement ledger supporting the definition of rich and sophisticated agreements between the parties (operators and ride offering parties on the one hand and travellers on the other hand) contributes to the travel

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companion (TD4.5) and the trip tracking (TD4.4) – the latter for what concerns the tracking of shared rides.

- The RIDE2RAIL analytics contributes to both TD4.6 and TD4.5 realizing mechanisms, based on the extended and enriched the conceptual model of traveller preferences and trip choice criteria, for the automated management and update of user data – in particular their preferences – for the improvement of the entire IP4 ecosystem functionalities.

5.2. TDs and IP4 Functionalities

IP4 Functionalities are the technologies of the IP4 projects and are briefly described below. More information could be found on the Shift2Rail website: https://shift2rail.org/research-development/ip4/

TD4.1 – Interoperability Framework aims to seamlessly integrate the legacy systems of the TSPs into the IP4 ecosystem. It enables the digital transformation of the existing service ecosystem and facilitates interoperability among heterogeneous systems (CONNECTIVE, 2018).

TD4.2 - Travel Shopping contains the following scope of the work:

- Journey Planning (JP) calculates multimodal routes from point A to point B. Allows the travellers to plan their trip, by defining the trip in terms of "origin", "destination", and "time".
- Offer Building (OB) calculates multimodal routes from point A to point B including the pricing for that trip.
- CMMP – Contractual Management Market Place – allows TSPs to create and configure multimodal tariffs and rules with different/partner TSPs. The CMMP is linked to the TC and provides the framework for offers from TSPs to be identified by the TC and associated functionalities and subsequently be translated into a legible format and shared with traveller.
- Shop Ancillary services (ANC) provides an opportunity to see any additional services provided by TSPs (e.g., Wi-Fi on board, meal, PRM assistance).

TD4.3 - Booking & Ticketing has developed a wide range of features for the travellers:

- Booking is represented for all online payable parts of an offer. Allow the traveller to book a sea where applicable
- Book Ancillary services (ANC) is a functionality similar to Booking, with the addition of allowing booking of Ancillary Services like Wi-Fi on board, meal, PRM assistance, etc.
- Issuing enables the issuing of an Entitlement / Token / Embodiment.
- Payment enables the traveller to pay for a selected trip.

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- After-Sales enables the traveller to cancel an offer item, or cancel a trip that has already been issued, with the possibility of receiving a refund, including for cancelled or disrupted trips.
- Validation stands for the validation of existing token. It allows the TSP to validate that a ticket has been issued through the Travel Companion.
- Inspection allows the TSP to validate that the traveller is using a valid ticket that has been issued through the Travel Companion and that the token is valid.

TD4.4 - Trip Tracker deals with the functionalities related to trip tracking:

- Trip Tracking provides a real-time information about disruptions/delays on the choice of the traveller. Based on it alternative routes are evaluated in case of the impact on the trip.
- Reaccommodating allows the traveller to find and apply an alternative route in case of a trip disruption.
- Tracking Orchestration analyses real-time data from the partial trip tracking sources and evaluates whether there is an impact on the complete trip for the traveller.
- Partial Trip Tracking (pTT) collects incoming real-time information (i.e., events) from a part of the trip and forwards it to the Tracking Orchestrator.
- mobile pTT allows the travellers to provide feedback about events around them during a journey (incidents, delays, security issues), it also allows the collection of location data from the travellers to automatically understand a possible disruption on the transport network.
- Prognosis Events - pTT receives events from a TSP, and it allows to predict impacts (with a level of certainty) on a transportation service.

TD4.5 - Travel Companion is a travellers' app that is basically represents an interface between the end-users and IP4 functionalities. It includes:

- Location Based Experiences editor is provided for the creation, design, evaluation and publication of location-based experiences by stakeholders.
- Location Based Experiences allows the travellers to have Location Based Experiences and to promote the local businesses. E.g. Suggest shop/cafe during waiting time or suggest a quiz game.
- Cloud wallet provides a secured cloud-based platform to store user account data regarding preferences, electronic payment, travel wallets (e.g. tokens, embodiments), etc. The contents are only visible to the user through the personal application (preferences, my trips, tickets).
- Preference manager allows for travellers' preferences to be managed.
- Identity (Access manager) allows travellers to manage their profile accounts.
- Alerts manager handles alerts that are to be sent to the traveller.

- Navigation provides travellers with guidance instructions for indoor and outdoor locations between interchanges.

TD4.6 - Business Analytics

- Descriptive, Predictive, Prescriptive Analytics enables the production of analytics for the TSPs, through the development of KPIs, along with the creation of predictive algorithms and decision support functions.
- Data Visualization aims to create dashboards through a visualization portal in order to enable the visual presentation of the data.
- Privacy algorithms provides data anonymization algorithms to protect and securely handle sensitive personal data of travellers.

The ones listed above are the most relevant among the tools and functionalities researched and developed within Shift2Rail IP4 projects. For a comprehensive overwiew, we recommend to check the public deliverables of previous or running Shift2Rail IP4 projects (i.e., IT2Rail, ATTRACkTIVE[3], Co-Active[4], CONNECTIVE[5], COHESIVE[6], ExtenSive[7], MaaSive[8], My-TRAC[9], SPRINT[10], Shift2MaaS[11] and ST4RT[12]).

5.3. Collaboration between the projects

IP4 is a long-term programme comprised of different linked projects, and each of them has it is own specific goal. Altogether are working to create this EU-wide multimodal travel experience. The IP4 projects' pool includes projects led by Call-for-Members (CFM) projects consisted of members of S2R JU and so-called open-call projects consisted of external stakeholders from rail and public transport sectors.

CFMs project partners and RIDE2RAIL partners constantly collaborated since the very beginning of the project lifetime, in order to facilitate the integration of TSPs in the IP4 ecosystem, the exchange of technical documentation supporting the understanding of the

[3] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=ATTRACKTIVE
[4] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CO-ACTIVE
[5] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE
[6] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=COHESIVE
[7] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=EXTENSIVE
[8] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=MaaSive
[9] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=MY-TRAC
[10] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=S2R_SPRINT
[11] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=S2R_SHIFT2MAAS
[12] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=s2r_ST4RT

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ecosystem itself and the demo performance and execution. Multiple interactions have been activated in several ways:

- Exchange of material and information via email;
- Formal and informal Collaboration Meetings;
- Invitation to attend and to speak at relevant RIDE2RAIL meetings, events and workshops;
- Bi-lateral calls with targeted partners, to discuss technical and operational aspects of the project;
- Participation to WP calls for demo preparation;
- Support for credentials creation;
- Support for TC and DC Terms of Reference;
- Support for KPI investigation;
- Signature of a COLA-Collaboration Agreement.

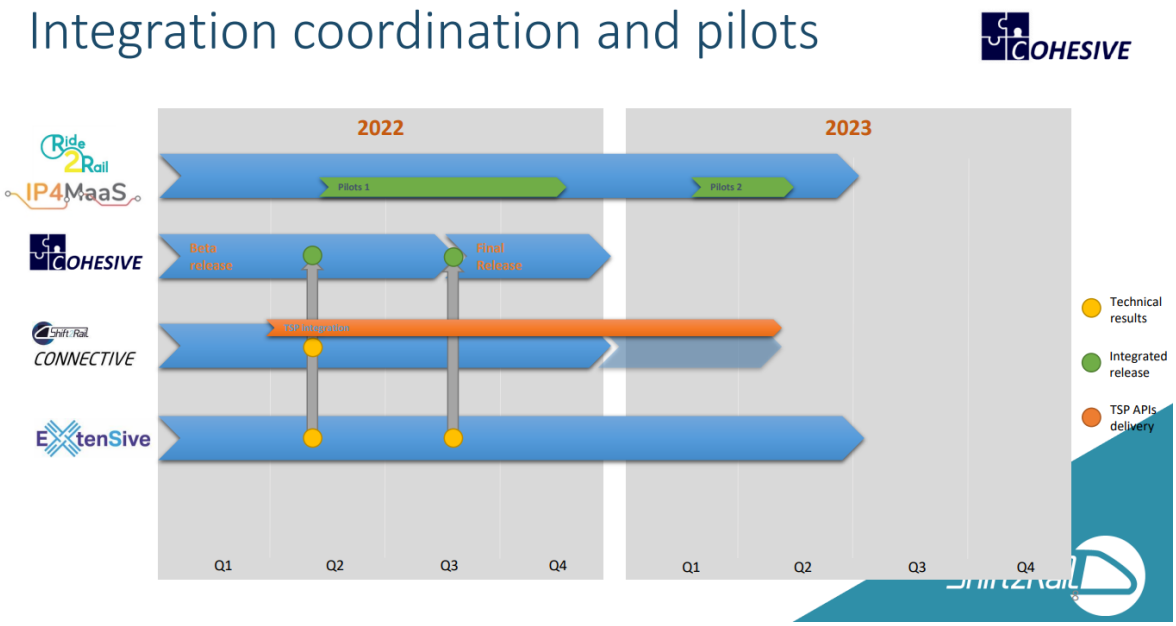

Figure 6: Timeline of demonstrations and interaction with CFMs complementary projects. Courtesy of COHESIVE project[13]

[13] Source: IP4 Advisory Board Meeting (Online), 3 May 2023.

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6. REQUIREMENTS, SCENARIOS AND USE CASES

6.1. Methodology

The project addressed in an integrated way the two following scopes:

1. Choice criteria for travel planning;
2. Ride-sharing in a multi-modal journey context for incorporation in the Shift2Rail IP4 ecosystem.

The overall approach and methodology to be applied by RIDE2RAIL was based on the following principles:

- Leverage the outcomes of previous or running Shift2Rail IP4 projects (i.e., IT2Rail[14], ATTRACkTIVE[15], Co-Active[16], CONNECTIVE[17], COHESIVE[18], ExtenSive[19], MaaSive[20], My-TRAC[21], SPRINT[22], Shift2MaaS[23], and ST4RT[24]) and of previous projects strongly related to the topics of this open call (i.e, SocialCar[25]);
- Develop the RIDE2RAIL solution as a set of software modules and APIs to ease their financial viability and to complement the offer of existing IP4 components (i.e., the Travel Companion);
- Make the modules accessible through the Interoperability Framework and in accordance with the design choices, conceptual models and interoperability guidelines of the entire IP4 ecosystem;

[14] http://www.it2rail.eu/
[15] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=ATTRACKTIVE
[16] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CO-ACTIVE
[17] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE
[18] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=COHESIVE
[19] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=EXTENSIVE
[20] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=MaaSive
[21] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=MY-TRAC
[22] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=S2R_SPRINT
[23] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=S2R_SHIFT2MAAS
[24] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=s2r_ST4RT
[25] https://wayback.archive-it.org/12090/20190615075540/https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-transport/intelligent-transport-systems/socialcar

- Involve users (both travellers and potential ride-sharing service providers) in surveys to profile them, collecting their preferences and choice criteria;
- Demonstrate, validate and evaluate the **RIDE2RAIL** solution in 4 demo sites.

6.2. Scenarios and use cases for demos

To illustrate and exemplify the main functions developed in the RIDE2RAIL project, the following scenario has been created:

Jane lives in Crema, which does not have a railway connection to Milan, she needs to go to Paris for a meeting, and needs to leave very early in the morning. She opens her Shift2Rail Travel Companion (TC) and inserts the information about her trip (date, time, destination, etc.). The TC returns a set of offers, which includes one in which Jane is supposed to join Chris, a fellow inhabitant of Crema, who has entered a car ride in the R2R Crowd-based ride-sharing TSP, which leaves from his home in Crema to Milan. Jane has in the past used ride-sharing services many times, so the system suggests the trip including the shared ride at the top of the list. Jane selects the offer that includes the shared ride offered by Chris, the system informs Chris of Jane's selection, and Chris accepts it, so the system books the trip for Jane. When the time comes, Chris picks Jane up and drives his car to Milan. During the trip, the R2R Crowd-based ride-sharing TSP monitors the trip to detect delays.

The RIDE2RAIL project has defined an expansive set of use cases, which highlight many functions.
The project identified the main actors involved in the RIDE2RAIL ecosystem – e.g., "regular" passengers, drivers, passengers of shared rides, the Shift2Rail ecosystem itself – who take part in the use cases mentioned above.
Some of the most relevant use cases identified that involve these actors include:

- *Select offer with shared ride*, in which a passenger peruses a list of travel offers shown in the TC and selects one that includes, among its legs, a shared ride;
- *Learn passenger preferences*, in which the past behavior of the passenger in tems of offers selected for buying is used to learn the features that are most likely to lead the passenger to buy an offer;
- *Retrieve offers from Crowd-based ride-sharing TSP*, in which the Shift2Rail ecosystem interacts with the Crowd-based ride-sharing TSP to retrieve shared rides that can be included as part of a multi-modal trip;
- *Categorise offers*, in which the RIDE2RAIL system takes as input offers generated by the Sift2Rail ecosystem and associate with each of them a representative category (cheap, comfortable, etc.)
- *Offer single ride*, in which a driver inserts a new shared ride in the Crowd-based ride-sharing TSP, which can then be selected by passengers;
- *Modify offered ride*, in which a driver that has already inserted a ride in the Crowd-based ride-sharing TSP modifies the information related to the ride

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- *Track shared ride*, in which the Crowd-based ride-sharing TSP tracks the position of a vehicle carrying out a shared ride to detect possible delays.

The uses cases defined in the project highlighted the main functions and mechanisms that constitute the core of the RIDE2RAIL ecosystem. From the point of view of the traveller, they include, among others:

- a function to categorize of travel offers, to highlight high-level features (e.g., eco-friendliness) that can help travellers make informed choices when selecting trips;
- mechanisms to incentivize sustainable behaviour in travellers, for example by promoting offers that correspond to sustainable trips;
- mechanisms to automatically learn the preferences of the traveller according to his/her current context;
- a function to rank offers according to the learned preferences of the traveller.

From the point of view of the Crowd-based ride-sharing TSP, instead, the main functions include:

- a function to create shared rides
- a function to book shared rides
- mechanisms to monitor chared rides and detect delays
- functions to manage the information of drivers.

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7. TRAVEL BEHAVIOUR AND SYSTEM REQUIREMENTS

7.1. Definition of Choice Criteria for Journey Planning

In the framework of Task 2.1, two iterations were conducted to define choice criteria for journey planning: the first iteration was carried out through an literature analysis of the state of the art, whose outcome was a preliminary definition of offer categories, user preferences and incentive mechanisms; in the second iteration, Ride2Rail designed, administered, and analysed a survey to validate and check the completeness of the first conceptualization, collecting data from European travellers. The survey was carried out between July and September 2020 and collected answers from a total of 787 users, 609 of which completed the entire survey.

The collected data have been firstly analysed with the objective of ranking the instances proposed in the first iteration (catalogues of offer categories and incentives, preference model) w.r.t. the interest manifested by the respondents and to complement the conceptualization with the new suggested instances. Then, contextual and socio-demographic information of the respondents has been considered to better characterize the target users of a journey planning application in terms of choice criteria and potential interest in incentives.

Concerning offer categories, 10 different instances (i.e., Quick, Short, Reliable, Cheap, Door-to-door, Comfortable, Social, Multitasking, Environmentally Friendly, and Philanthropic) were initially proposed. The results of the survey have shown that the quick, reliable, and cheap categories are the clear favourites among the respondents. On the other hand, social and philanthropic were widely regarded as less important, as factors that are not important in making the final choice.

Concerning user preferences, 9 different instances of travel offer characteristics on which a user may want to express preferences (i.e., transportation company, a time interval for the departure and arrival times, number of transport changes, travel class, seat type, meal inclusion, refundability, live notifications on trip status updates, onboard connectivity) were initially identified and selected. These characteristics were analysed through the survey, asking the respondents to select the ones that they care the most about whenever they're looking for a travel solution. The results of the survey have shown that the factors that are most important to the respondents are being able to pick a specific means of transport, a time interval for the departure and arrival times, and a limit on the amount of transport change. The contextual and socio-demographic analysis complemented these results with several additional findings, among them: (i) all the travellers, except for adults over 50 years old, would like to also have live notifications on trip status updates, (ii) young travellers under 35 years old and women would like to have also onboard connectivity, (iii) users looking for a business trip of medium-long distance would like to specify also the seat type and the travel class, (iv) a family looking for a leisure trip of medium-long distance would also like to specify the seat type and they would like to have a refundable travel solution.

Concerning incentives, the survey aimed to analyse both tangible and intangible incentives. The results of the survey have shown that the highest-rated incentives the ones that provide

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some sort of discount, with the exception of the discounts on complementary services. On the other hand, both the gamification elements and the share of information regarding either the environmental impact or the positive aspects of the trip scored, on average, less than the money-related alternatives. Based on these results, the tangible incentives outscore the intangible ones in almost every form they are presented. The contextual and socio-demographic analysis complemented these results.

The final conceptualization of choice criteria (offer categories and user preferences) and incentive mechanisms, contextualized in IP4 terminology, is represented in the following picture.

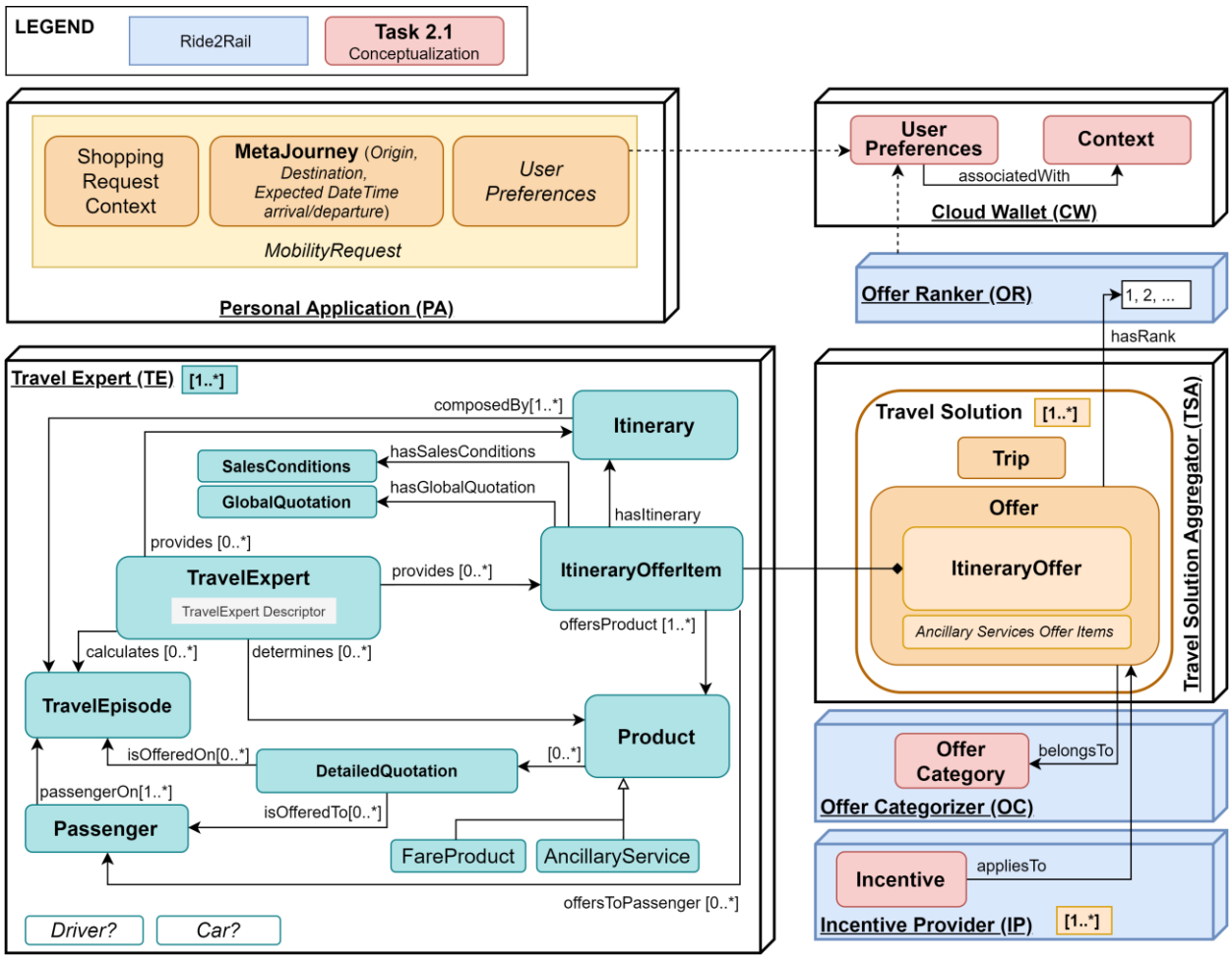

Figure 7 - Ride2Rail final conceptualization of choice criteria and incentives in the context of IP4 Terminology

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7.2. State-of-the-art of ride-sharing in target EU countries and Recommendations and criteria for a successful ride-sharing in the IP4 ecosystem

In the framework of Task 2.2, the partners concluded on the definition that would be sustained throughout the project: "Ride-sharing" refers to the transportation of persons in a motor vehicle when such transportation is incidental to the principal purpose of the driver, which is to reach a destination and not to transport person for any kind of profit (Code of Virginia 1989). In order to conduct a state-of-the-art analysis, 59 ride-sharing providers were identified around the globe, through the review of more than 80 research publications. The main conclusions drawn were:

- Ride-sharing systems are either for-profit or non-profit. Several systems ceased operations due to the low demand, whereas some re-opened under different names and following a different business model.
- Drivers need to be older than 17, in some cases older than 21.
- Paying methods usually entail the use of credit cards; Trips are usually on the spot, 0-2 hours before the actual trip taking place.
- Most systems operate in a specific city or close-by cities.
- Safety is valued and guaranteed through rating and feedback systems as well as through GPS tracking and user's satisfaction to ensure that rides are monitored and completed as planned.
- Potential incentives include: reduction in tolls, loyalty systems, access to HOV lanes, parking spaces, discounts to specific user categories, etc.

When it comes to legal barriers, research showed that Uber and similar services have never started operation in any Country, with at least minor objections occurring from similar services providers, mainly taxi drivers (for unfair competition reasons). Several steps can be taken to avert these objections such as ensuring safety, leaving the sector unregulated and adopting in each case the most suitable pricing model (for profit, non profit, etc).

Following, the main characteristics of ride-sharing travelers and ride-sharing providers were defined. Some of the findings include: Ride-sharing is common among low income commuters, with longer travel distances to work, and limited access to a vehicle; females and younger people are more likely to switch to ride-sharing; attitudes, such as sustainability concerns and security play an important role in choosing ride-sharing services; travel cost and time are important factors. An important finding is also that PT, walking, and cycling are strong alternatives for travelers that avoid traveling alone, reducing the potential market for ride-sharing. The estimates therefore of participation rates must be considered case-specific and decision makers will need to consider whether to open and market the program to all or to focus on solo drivers.
As a final step, the conversational survey was conducted in order to conclude on the recommendations for a succesful ride-sharing system. In total 33 criteria were defined for travellers and 9 criteria for TSPs. Useful insights were provided by using descriptive and bivariate statistics to explore the relationships between individual variables and defined criteria.

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The resulted recommendations were categorized in four groups: Operation, Cost, Travel time and Safety. The analysis showed that, although socio-demographic variables are not correlated with ride-sharing, other criteria were found to be significant in planning of ride-sharing services with public transport. Results are tailored in detail per user type and for TSPs; however, a sample of important recommendations include: the availability of the ride-sharing service through a smartphone application (operation); availability of services in areas that lack or with low frequency of public transport (operation); the reduction of journey cost (cost); the accepted delay time - less than 5 minutes (travel time); the accepted ride-sharing time – 15 minutes (travel time); the ability to check the driver's ID through the application (safety) and the availability of driver's experience to all users (safety) upon request.

7.3. Requirements and specifications for complementary travel expert services in the Shift2Rail IP4 ecosystem

From the use cases summarized in Section **Error! Reference source not found.**, a list of requirements to be fulfilled by the RIDE2RAIL ecosystem have been identified. The requirements have been separated in high/medium/low categories, and they concern the functions recapped in Section **Error! Reference source not found.**.

The RIDE2RAIL project also identified a list of components to be implemented. The most relevant ones are the following:

- *Offer Enricher and Ranker*: this component handles the functions related to the handling of offer categories, incentives, learning of traveller preferences, and ranking of offers. The aforementioned functions are handled by dedicated sub-components of the *OfferEnricherAndRanker*.
- *Driver Companion*: this is the mobile interface used by drivers to manage rides, and in particular create, modify, and delete them.
- *Crowd-based TSP*: this module manages drivers and rides; in particular, is provides an Application Programming Interface (API) that allows clients to create/modify/delete drivers and vehicles, and to create/modify/delete shared rides; it also provides functions that allow clients to search for rides and to book them. This component includes a module focusing on the tracking of shared rides and the detection of delays.
- *Agreement Ledger:* this component stores information about rides in a secure and reliable manner, through the use of a blockchain.

The components mentioned above interact with the Shift2Rail ecosystem in various manners. In particular, the Crowd-based TSP is queried by the Shift2Rail ecosystem to retrieve information about shared rides, to be used in the creation of end-to-end multi-modal travel offers. During the creation of travel offers, and before returning them to the traveller, the Shift2Rail ecosystem also uses the Offer Enricher and Ranker to complete the information about each trip with its category, and to rank the travel offers according to the learned traveller preferences. Finally, the Crowd-based TSP, through its dedicated ride

tracking component, notifies the Shift2Rail ecosystem when delays concerning a shared ride are detected.

All the above are described in the following chapter.

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8. DEVELOPMENT OF ENHANCED TRAVEL COMPANION AND RIDE SHARING TSP

RIDE2RAIL aimed to improve the connection with rural areas reducing the number of single-occupant car trips and facilitating access to rail and public-transport as part of a multi-modal travel experience. RIDE2RAIL built on top of the global vision and technological architecture designed and implemented in the previous and current Shift2Rail IP4 projects. In this sense, the new or extended RIDE2RAIL components perfectly fit with the Shift2Rail ecosystem vision of "IT Solutions for Attractive Railway Services." Specifically, RIDE2RAIL developmed the following modules and their interfaces to the existing IP4 components and functionalities:

- **Crowd-based TSP:** the term "*trip*" is used to indicate a possibly multimodal *itinerary offer*, i.e., the specification of an *itinerary* as an ordered sequence of *travel episodes* which start and end at *stop places* together with its respective *fare* and *sales/post-sales conditions*. The Crowd-based TSP module is oriented to extend the IP4 reach to integrate additional travel service providers from the ride-sharing world. On the one hand, RIDE2RAIL revises the definition of a Shift2Rail-compatible TSP, in terms of functionalities and interfaces (so that new TSPs are seamlessly integrated in the Interoperability Framework, cf. IP4-TD1). To this end, the Crowd-based TSP runs "as a service" to allow travellers to share their car ride providing functionalities for publishing offers, settlement, validation, and trip tracking, through an open source reference implementation of a Crowd-based TSP, based on the results of the SocialCar project, that implements the same trip provision interface of any other TSP. On the other hand, RIDE2RAIL provides the possibility for individual users to offer their riding capability to the ecosystem; to this end, the Crowd-based TSP allows each traveller owning a vehicle to become a TSP, by publishing a ride-share offer, so that this offer can be considered (through the Shopping feature of the Travel Companion) in the trip planning phase for other travellers.
- **Ride-sharing offering feature for any Travel Companion application:** the specific capability described above of an individual traveller to offer a ride to the ecosystem is not only a service offered by the Crowd-based TSP, but also includes the user-application to let the human participant "act" on the system and advertise his/her offering. RIDE2RAIL hence allows travellers to offer the car seats and to manage their offers – e.g., check the validity of the Entitlement/Token generated for the other travellers. This new **Driver Companion** application feature is evaluated both in a stand-alone mode and integrated within a Travel Companion application. RIDE2RAIL provides an enhancement of the TCs developed by the Shift2Rail IP4 projects concerning the integration of the ride-sharing transportation mode.
- **Trip Ranking**: this module ranks the trips considering both descriptive (e.g., travel time, cost, comfort, accessibility) and prescriptive (environmental aspects, traffic restrictions) factors that may influence travellers' choices. In particular, this module provides to a traveller (through the Shopping feature of the Travel Companion, cf. IP4-TD2) a complete rank of the available trips computed considering the matchmaking between the characteristics of each trip and his/her preferences, plus additional information about trip categories. The final aim is to help the traveller with the suggestion of a multimodal trip combination that best fits his/her preferences, having regard to the factors that influence the decisions, while choosing a more

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sustainable travel solution. The Trip Ranking module has the following sub-modules:

- **Trip Categories Estimator**: this module attaches categories to available trips and estimates them w.r.t. trip characteristics. Categories could cover environmental aspects, comfort, specific needs for persons with reduced mobility, traffic conditions and others, based on the analysis performed within the project. **RIDE2RAIL** provides both the conceptualization of the trip categories and the function that annotates a trip offer with its corresponding categories and gives their numerical estimation.
- **User-based Matchmaker**: this module evaluates the matchmaking between the contextual preferences of the traveller and the characteristics of each trip. The term "*contextual preference*" is used to indicate that the same user could have different preferences on the same aspect of the trip in different travel contexts (e.g., a user could prefer a business class trip when he/she is traveling for work and the economy class when travelling for his/her leisure). The result of the matchmaking is the quantitative evaluation of the matching between the user's contextual preferences and each available multimodal trip combination. Monitoring and update of preferences is done through the consideration of behaviours that are retrieved via surveys.

- **Analytics**: this module supports the Trip Ranking providing an updated User Profile containing the full set of his/her contextual preferences. Moreover, the Analytics module monitors travellers' choices to update their profiles in terms of contextual preferences. RIDE2RAIL contributes to the Analytics module by extending and enriching the conceptual model of traveller preferences and trip choice criteria (which is an extension of the pre-existing ontology) and the management of user data for the improvement of the entire IP4 ecosystem functionalities (part of the Business Analytics module, cf. IP4-TD6).
- **Driver Companion app:** the App allows users with the role of Driver, i.e. users who own a car and are willing to share a ride with other people, to offer a ride-share indicating the origin, destination, departure time and number of seats. The user interface allows the driver to select the reference points on the map and obtain the exact toponymy. The ride-sharing offer is then sent to the Crowd based TSP and processed as explained below. The app then allows the driver to receive subscriptions to their offer and therefore be able to confirm the ride, following the appointment at the point of origin and then moving to the destination. The App keeps the history of the trips offered.

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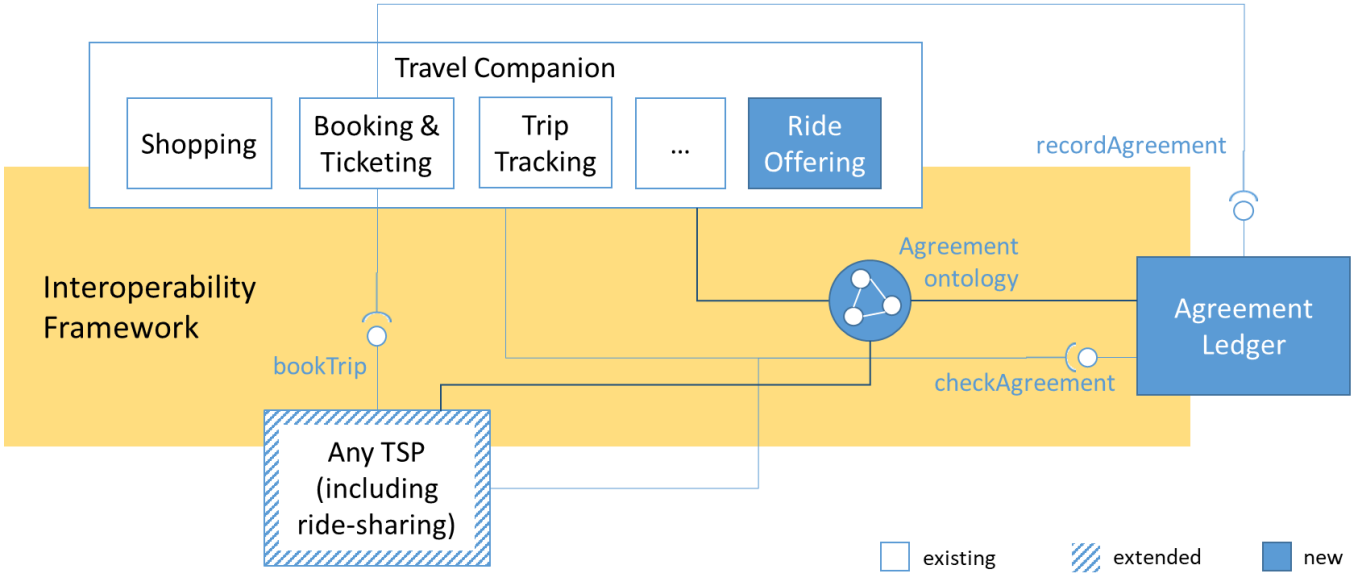

Figure 8: Usage of Blockchain in the RIDE2RAIL solution

RIDE2RAIL used Blockchain technology to overcome existing shortcomings concerning the trust between drivers and passengers. Since traditional rating systems often are not depicting the truth (e.g., a "5 out of 5" experience could just be a normal experience for most people instead of an exceptional one, overshadowing the bad reviews), RIDE2RAIL introduced the application of Distributed Ledger Technology (DLT), and specifically Blockchain technology, towards creating a safe and 'honest' service with bilateral 'contracts/agreements' between the driver and the passengers being formed on the fly (i.e., ad-hoc agreements). With a particular focus on the ride-sharing service, RIDE2RAIL developed the following new module (see its graphical representation in the figure above):

- **Agreement Ledger:** this module supports the definition of rich and sophisticated agreements between the parties (operators and ride offering parties on the one hand and travellers on the other hand). As an example, the agreement could state that a specific travel path has to be followed and, should it not be followed, any extra travel distance outside of the path is not charged. This can be achieved with the help of Ricardian contracts existing in a blockchain operating in conjunction with either IoT sensors on the vehicle or passengers' mobile devices. Ricardian contracts, since their conception in 1996[1], have been used to describe digital processes as a contract at law and as a result they consist in legally-binding contracts to be formulated upon a digital actuation with in-depth and binding terms. Both the smart contracts and concomitant Ricardian contracts are dynamically generated depending on the agreement formed between the parties. For each trip, a Ricardian contract specifies the terms of the agreement and the Blockchain acts as an immutable record of the contract's creation and the digital signatures validating the contract's execution. Payment tracking and any other action regarding the contract will also be recorded on the Blockchain. These new forms of agreements can pave the way for better and more trustworthy transport services to come to life powered by blockchain technology and state-of-the-art cryptography. The terms for the agreements are

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formalized in a dedicated ontology to pave the way for the interoperability of the whole IP4 ecosystem.

- **Incentive provider:** this module pre-evaluates the eligibility of travel offers to be assigned travel incentives before the presentation of the results of the mobility search to a traveller. If a traveller later chooses such a travel offer receives incentives. Thus, the information about the eligibility can be presented to the traveller together with the results of the mobility search to inform the traveller about additional benefits if choosing a travel solution. The evaluation is based on IF-THEN rules. Thus, if a condition is satisfied, the travel offer qualifies to be assigned an incentive. A condition can take into account properties of the travel offer (e.g., used travel modes, travel class, departure time, etc.), past trips of a given traveller (e.g., frequency of trips, actually used travel modes, etc.) and so on. To demonstrate the functionality of this module and to promote ride-sharing, three examples of incentives have been implemented: 10%Discount (price discount of 10%, if at least one ride-sharing leg is included in the travel offer), 20%Discount (price discount of 20%, if at least one ride-sharing leg is included in the travel offer and the traveller has completed at least three ride shares) and FreeSeat (seat class upgrade if at least one other traveller booked at least one of the ride-shares included in the travel offer). To evaluate the eligibility conditions, properties of travel offers are analysed and information about past travel choices is obtained from the Agreement Ledger where it is maintained. The Agreement Ledger implements Ricardian contracts to verify if a user qualify for an incentive.
- **Agreements ontology:** the *Ride2Rail Ontology for Agreements* aims at identifying a set of classes and properties to represent the agreements between parties, implemented through the Agreement Ledger. The ontology guarantees interoperability of the business agreements defined in Ride2Rail considering the relevant domain terminology adopted by IP4. Moreover, it describes the smart contracts in an implementation-independent way. By using the ontology two types of agreements were modelled in Ride2Rail: (i) the *Ride-sharing Booking*, as an agreement between a driver and a passenger, and (ii) the *Incentive*, as an agreement between different parties to grant, according to a set of conditions, a reward that could promote more sustainable transportation alternatives. The *Ride2Rail Ontology for Agreements* reuses and extends the IP4 modular suite of ontologies, considering the relevant domain terminology and the concepts introduced by Ride2Rail, and the OASIS ontology for Ontological Smart Contracts. The ontology is published online at https://w3id.org/ride2rail/terms## (r2r: prefix) following the best practices with respect to permanent identifiers, content negotiation, human- and machine-readable documentation. The RDF dataset, adopting the ontology for the specification of the agreements modelled in Ride2Rail, is published at https://w3id.org/ride2rail/agreements# (ag: prefix).

The figure below describes in detail the ride-sharing process of RIDE2RAIL. The diagram highlights the various software components involved in each step, such as the user interface, database, and the matching algorithm. The process comprises fours steps:

1. A potential driver creates a ride-sharing offer by entering information about the ride (starting and ending locations, date and time, available seats) in the Driver Companion (DC) application. In this step, the DC contact the Crowd-based TSP component which stores the new ride-sharing offer. The event is also registered on the Agreement Ledger.
2. A potential passenger makes a mobility request using the Travel Companion (TC). The request is processed by the Shift2Rail ecosystem, which performs the trip planning to find suitable travel solutions. The computed solutions are sent, in TRIAS format, to the Offer Categorizer (OC) component and then to the Offer Ranker and Matcher (ORM), which, respectively, compute the category scores of each travel offer in the pool and rank the offers that best match the users' preferences. The Offer Matcher and Ranker takes into account the presence of incetives, whose computation also involves the Agreement Ledger. Once the offers are ranked, the answer is sent back to the S2R ecosystem which in turns displays the travel offers to the passenger through the TC app.
3. The passenger selects their favorite travel offers and books it. The booking request is sent to the S2R ecosystem which contacts every TSP involved in the chosen travel offer. If the offer contains a ride-sharing leg then a booking request is sent to the Crowd-based TSP which – according to the availability - confirms the booking. The booking event is registered on the Agreement Ledger. The CbTSP sends to the driver a notification of the booking through a push notification in the DC app.
4. At a later moment, driver and passenger share the ride. When the ride is scheduled to start the trip-tracking component communicates any disruption to the S2R ecosystem. The same component also handles the case of a driver canceling a ride-sharing offer before its start. Any event that is raised by the trip-tracking component is also registered in the Agreement Ledger.

All components represented in the figure below have been designed, implemented and tested to be seamlessly integrated within the IP4 Interoperability Framework and, in particular, by adopting and extending the existing conceptual models and service interfaces. Specifically, RIDE2RAIL enhanced the available IP4 ontologies with further details on travelers' choice criteria and preferences. In order to do that, RIDE2RAIL involved travelers and operators to inform the modeling and design of the respective features, in order to better reflect the actual trip categories, user preferences, and choice criteria. To improve user engagement, RIDE2RAIL collected at the beginning of the project data by means of conversational surveys (i.e., tools to submit surveys to users in a chat-like form so that the

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users experience it as a conversation with another human, rather than an "aseptic" questionnaire, still collecting quantifiable data).

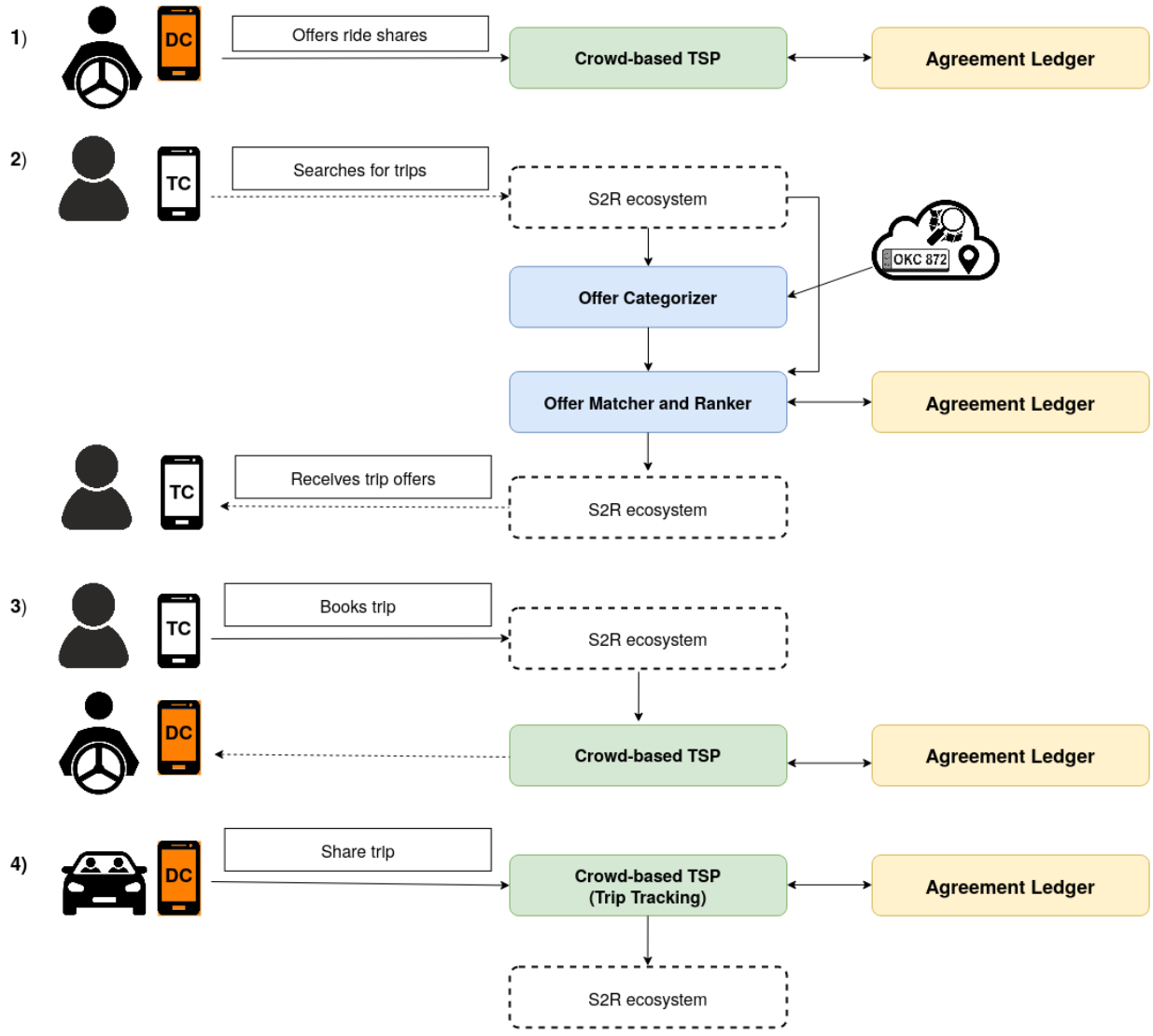

Figure 9: A high-level diagram of the user interactions with the R2R system

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9. ORGANIZATION OF THE DEMOS

The work done on the organization of the demos was devoted to plan specific demonstration activities ensuring that the relevant RIDE2RAIL solutions are tested in an integrated way and for the benefit of local users and mobility services. The demonstration concept and implementation plans for the different demonstrators were coordinated by FIT and developed by local demo teams including technical and operational partners involved.
Every plan was subdivided into three main sections:
1. Activities and Stakeholder: describing the list of activities required to run the demonstration, and the responsible;
2. Demand and targets: describing the potential demand and the target of the demo, as per selected indicators;
3. Potential Risks: identifying and assessing the potential of technical, legal, behavioural and organizational risks that may hinder the smooth implementation and execution of each demo.

Four demos are executed in RIDE2RAIL:

- Athens
- Helsinki
- Brno
- Padua

A brief description for each site is hereby proposed, to best depict the different scenarios of demo implementations (a more extensive overview is provided in the next paragraphs):

ATHENS
The objectives of the demo were: a) to examine and provide input on smart multimodal solutions integrating carpooling (thus increasing both car occupancy and rail ridership), demand-responsive carpool connections with rural Attica parts, integration of carpooling road pathswith the urban rail network in conjunction with a nexus of peripheral urban rail hubs; b) to serve as test site for the platform assessment taking into account new forms of shared mobility; c) to evaluate innovative concepts of multimodality.
The demo area was the 20km-long air-rail corridor between Athens Airport - Doukissis Plakentias (metro station & P+R), along Attiki Odos toll road. Metro and suburban rail serve also 3 intermediate stations in Eastern Attica: Pallini, Kantza, Koropi.

HELSINKI
The Helsinki demo focused on improving access to rail and metro, for the first and last mile of commuter journeys. The demo addressed the mobility needs of people in Helsinki's most Eastern neighborhood Vuosaari, who are not served sufficiently by the current bus lines. The demo focused on on-demand services.
The Vuosaari district covers a large area of 17.07 km² and is geographically the largest district in the city of Helsinki. It has several lowly populated areas. The district does not have

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any train stations, but it is served by two metro stations: Rastila and Vuosaari. The metro stations are served by at least 5 regular bus lines.
The demo included two parts, both focus on reducing single-occupant private car trips:

- Testing the use of an automated shuttle bus in more rural areas, as part of a multi-modal last-mile journey, integrated in relevant travel planning applications;
- Testing the RIDE2RAIL ridesharing platform, as much as possible integrated with existing mobility platforms (e.g. public transport routeplanner).

BRNO
The demo had the purpose to encourage RIDE2RAIL users, such as lonely car drivers, to share the capacity of their cars with other travellers. The demo Area involved the South Moravian region, where there are various local hubs used by daily commuters while traveling to work in the city of Brno (CZ). They often travel by their own private cars from their homes to the closest local transport hub, where they transfer to any of the public transport means. Target users were commuter workers and students.

PADUA
The demo demonstrated RIDE2RAIL functionalities in a real-life environment, a 20 Km area surrounding the city of Padua (Italy) with regular commuter flows from/to suburban and rural areas. The Travel and Driver Companion apps have been made available to a group of persons (in particular students from Ca' Foscari University), testing several functionalities. The demo involved urban and regional mobility service providers in Veneto Region, as well as shared mobility options such as ride sharing in a multi-modal journey context. Target users were commuter workers and students.

9.1. Methodology for the execution of the Demos

In organizing the demos envisaged for the RIDE2RAIL project, the objective was that they were as homogeneous as possible even if carried out in different contexts, places and with different users. The reason for this choice is inherent in the need to carry out measurements that indicate the degree of success of the project in overall terms and not just as a local case study. The partners then proceeded to define the guiding criteria that every demo leader must follow in organizing the demonstration of the use of the services offered by the R2R project. The defined criteria are aimed to clarify and manage:

- activities required to run all demo phases;
- local stakeholders involved, strategy for stakeholders' involvement, and roles in the demo activities;
- risks and risk management for all the demo phases;
- potential demand and targets, with corresponding indicators.

On that base, guidelines were issued to help demo leaders to organize and run demos. Three families of guidelines were created:

- Activities and stakeholders
- Demand targets

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- Potential risks

9.1.1.Actitivities and stakeholders

Regarding activities and stakeholders, the following four guidelines were defined for the execution of the demos:

- Demo Preparation: to plan and provide a checklist of all technical and organisational activities needed for deploying the demonstration execution;
- Demo Implementation: RIDE2RAIL components are technically set up in the demonstrators and the related software tools are customised and integrated in the local services (when needed).
- Demo Execution: following the indications of the implementation plans, the demonstrations is executed in the demo sites;
- Demo Monitoring: in close cooperation with Task 5.1, that proposes KPIs performance indicators and targets. Targets and baseline values form the base for an integrated framework of KPIs allowing for cross-site comparison and assessment. Demo monitoring consists of the following phases, common to all demos:
    - Indicators and KPI validation, for each demo
    - Definition of monitoring tools (questionnaires, reporting and data collection templates, etc.) and provision of a monitoring manual with instructions about features and variables to be monitored

From the guidelines is born the following reference table:

Phase	Actions	Timeframe	Responsible Partner	Other stakeholders involved
1. Preparation				
2. Implementation				
3. Execution				
4. Monitoring				

Table 2: Guideline for project phases

The reference table for activities and stakeholdes leads the demo leaders to design the implementation plan of the demo and helps to manage the execution of activies.

9.1.2. Demand targets

Guidelines were given to set the target of each demo, i.e. the users involved in the demo, the infrastructure and vehicles involved, and the main results expected from the each demonstration. From the potential demand indicated by partners in the project DoA, a fine-tuning data led to target values to set the scope of each demo (e.g., the number of passengers involved and using RIDE2RAIL solutions, the number of trips surveyed, the number of trips attracted to rail or multimodal solutions).

Demo leaders were asked to compile the following table for each indicator targeted.

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Indicator	Potential demand	Target of the demo
...X...		
...Y...		
...Z...		

Table 3: Table filled by demo leaders for measuring indicators

9.1.3. Potential risks

Guidelines to identify a list of risk factors that may occur during each demo phase. Partners responsible for each demo were asked to provide a short description of each risk, and assess the following factors associated to each risk (see D4.1 Implementation plan for details on Risk Priority Number Calculation). A common method to assess the valuation of risks was shared among all demo sites.

Result of that method is the following table, in which each element is detailed, quantified and managed.

Risk	Phase	S (Severity)	O (Occurrence)	ND (No-detactability)	I (Irrecoverability)	Risk Priority Number	Mitigation
...1...							
...2...							
...3...							

Table 4: Methodology for risks quantification

9.2. Summary of conducted Demos

Athens Demo

The demo area in Athens was the 20 km-long corridor between the Athens Airport and the Doukissis Plakentias metro station (with Park and Ride), along Attiki Odos toll motorway. This area comprises territories of five (5) municipalities with low population densities compared to the core centre of the Athens municipality.
Two test sites were foreseen:

- Paid P+R (Park&Ride) with 500 parking spaces (PS) at D. Plakentias, which is located about 12kms from Athens' city centre (i.e., Syntagma square) and

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- free municipal P+R with 300 PS at the Koropi station, which is located 13 kms south of D. Plakentias station.

The overall goal of the demo was to enhance the connection of low-density Attica Region areas to public transport (PT) modes, and specifically to the ATTIKO Metro, through the provision of demand responsive ride-sharing services: travelers going to Athens (north and center) from peri-urban areas, with low frequency of PT services, often use their cars for their trips; ride-sharing services were offered through a dedicated app, for the 1st and/or last leg of the trip. Volunteers for the ultimate demo were recruited by conducting a Stated Preference (SP) experiment. This involved solo parkers and bus feeder users at both test sites to assess ride-sharing acceptance as access/egress mode to rail.
The RIDE2RAIL demo lasted 1 week, from 18th to 22nd July 2022. During the demo period, several functionalities were tested within the "Travel Companion" app and the "Driver Companion" app. More specifically the functionalities integrated in the "Travel Companion" app were: Offer Categorizer, Offer Matcher & Ranker, Agreement Ledger, Incentive provider, Crowd Based TSP.
Following the SP experiment and after having sent the recruting email, more than 100 users stated that they would be willing to participate at the Athens demo; the final number of participants however was significantly lower, probably due to the not favourable period of the demo execution, which coincided with people's summer vacation and a strong heatwave in the city that impacted the mobility patterns in the area. The Athens demo partners, led by the demo leader CERTH, provided specific incentives, in order to persuade identified users to participate in the Athens demo (a voucher of 30€ for groceries for travellers and a 50€ voucher for gasoline for drivers).

The final figures describing the participants at the Athens demo are as follows:

- Number of registered users (travelers): 19
- Number of registered users (drivers): 9
- Number of users that completed the survey: 17

The main conclusions are as follows:
Testing: One week of testing has been considered not sufficient, as at least 2-3 weeks are considered necessary, with all the relevant people (demo team and CFMs supporting the demo preparation/execution) being involved. It is important to receive well in advance the app (already) in a very good working condition. Vacation time must be avoided.
Responsibilities: They need to be clearly identified and made clear to all involved partners. Ideally, a limited number of people composing the "demo core team" needs to be involved, to avoid communication bugs.
Downloading of the app: All APKs should be installed through a single download. One user guide should be provided, giving all the necessary information. Ideally the Terms and Condition should also comprise one and short document.
Translation: The app should be translated in the local language in all its sections/subsections. Translation needs to be done in an efficient way, avoiding out of context translations.

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Operation: Addresses and POIs from other countries need to either be erased or hidden from the TC app. The use of the map was the easiest way to identify an origin or destination. The app sould be improved in order to reduce/minimiza the loading time.
Survey: The survey sent to the user after the completion of the demo needs to be sent immediately after the use of the app; the utilizazion of the code sent by the tester to confirm to demo leader that they completed the survey needs to be described more efficiently. Correct translation of the survey is very important.

All the above inputs have been taken into consideration for the following demos, trying to minimize as much as possible the shortcomings or the complex procedures.

Helsinki Demo

The Helsinki demo consisted of two parts, which both focus on reducing single-occupant private car trips:

(i) Testing the use of an automated shuttle bus (robobus) in more rural areas, as part of a multi-modal last-mile journey, integrated in relevant travel planning applications, carried out in the autumn of 2021 and

(ii) Testing the RIDE2RAIL functionalities, as much as possible integrated with existing mobility platforms (e.g. public transport routeplanner) carried out in October 2022.

The partners of the Ride2Rail project in Helsinki were particularly interested in testing ridesharing as a new mobility habit for users in the capital region of Helsinki.

Activities for the demo were focused in both parts (parts I and II) simultaneously in the beginning of the project and the idea was initially to implement them at the same time. However as there were delays in the production of the applications it was decided to proceed separately with the parts and implement first the robobus demo while also preparing for the second part of the demo which would take place in a later phase of the project.

Helsinki demo area generally consisted of the Helsinki Region Transport's (HSL), the public transport authority of Helsinki Region, area of operation depicted in Figure 1 below. The HSL area consists of Helsinki, Espoo, Vantaa, Kauniainen, Siuntio, Kirkkonummi, Sipoo, Kerava and Tuusula and is divided into four zones, identified by letters A, B, C and D, spreading out from the center of Helsinki.

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Figure 10: Helsinki Region Transport (HSL) area of operation [HSL area and zones 2022].

Part I of the demo was carried out specifically in East of Helsinki in zone B in Vuosaari where the testing of an automated shuttle bus took place in the autumn 2021. Part II, testing the RIDE2RAIL, functionalities, was not limited to a certain specific zone of the HSL area thus the activities of the demo and trips made by recruited test users could take place anywhere on the HSL area.

Goal of the robobus demo was to research how well an automated bus could improve access between the metro station and the neighbourhood as well as offer an opportunity for developing automated shared vehicle solutions in road traffic. In particular the focus of the robobus demo was also to test for the possibility of on demand calls of robobus operation as part of public transport.

Demo Part I - Robobus demo

Demo part I in Ride2Rail focused on testing the robobus (figure below) as part of a multi-modal last-mile journey, integrated in the HSL travel planning application (Reittiopas). This involved an approximately two months long demo where the bus operated on a regular

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route (figure below) in Vuosaari between September 25th and November 17th 2021 for a fixed period of time per day. The bus was integrated in the HSL Reittiopas with line number 90R and was operated on public roads like a normal bus in the area among other traffic. The route was approximately 2 km long, had 7 bus stops and was driven in one direction from Vuosaari metro station to the vicinity of the Aurinkolahti Beach.

Figure 11: Robobus 90R [Laitinen 2021].

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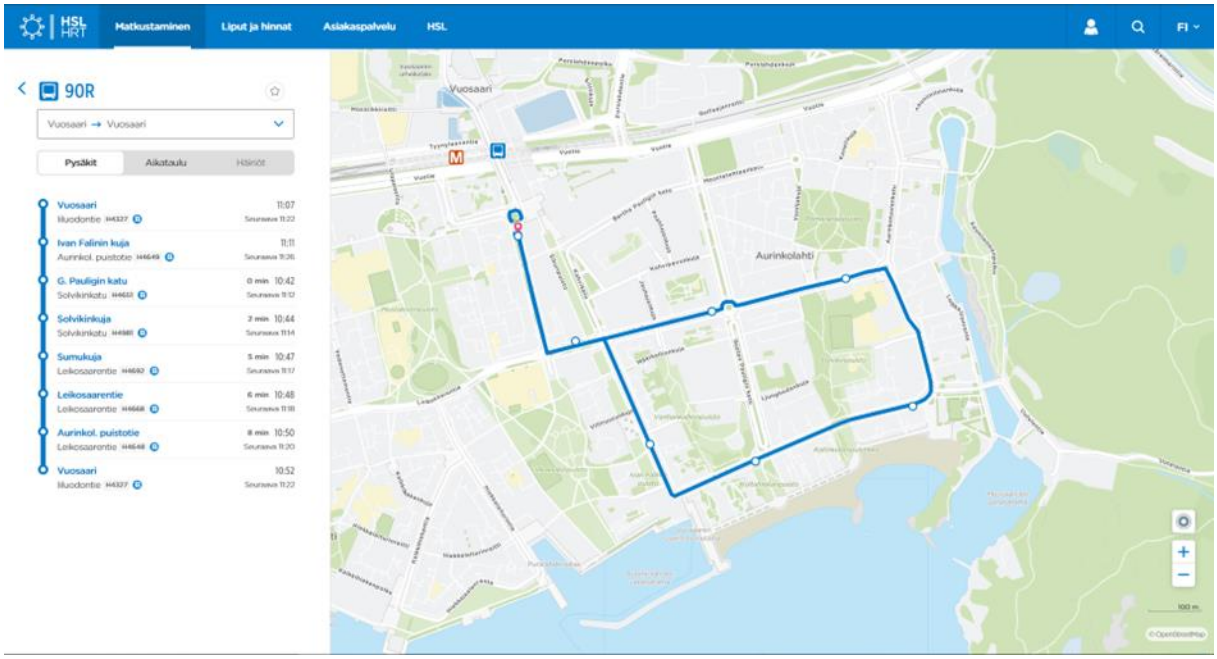

Figure 12: Route of the robobus 90R [Reittiopas 2021].

The bus had seats to accommodate a maximum of six persons plus two folding benches which were basically dedicated for the safety operator. Though the area of the folding benches were also the place where strolls or wheelchairs should be placed leaving very little space for other passengers and the safety operator.

Operation of the robobus started on 25th September on which day also passengers could hop on in the bus. The operation of the robobus gathered vast interest with the total number of passengers being 1112.

During the demo the safety operator had to regularly assist the vehicle in various situations which indicates that the automation should be developed further to operate the vehicle without an onboard safety operator. Design of the vehicle, operational models of the service and related remote functions should be developed further as well. The vehicle should operate at higher speeds and the reliability should be improved. However, it seems that people like the service and feel confident to use it. Though it must be noted that there was still an onboard safety operator which passengers could rely on.

Demo Part II - testing the Ride2Rail applications

The second part of the Helsinki demo was about testing the RIDE2RAIL functionalities, as much as possible integrated with existing mobility platforms (e.g. public transport routeplanner). The main purpose of the demo was to test the ride-sharing functionality created in the Ride2Rail project together with the Travel Companion application.

The applications were tested for two weeks in Helsinki on 3 - 16 October 2022. There were a total of 22 downloads for the TC application and 7 for DC. 17 people answered the survey after testing.

Shift2Rail

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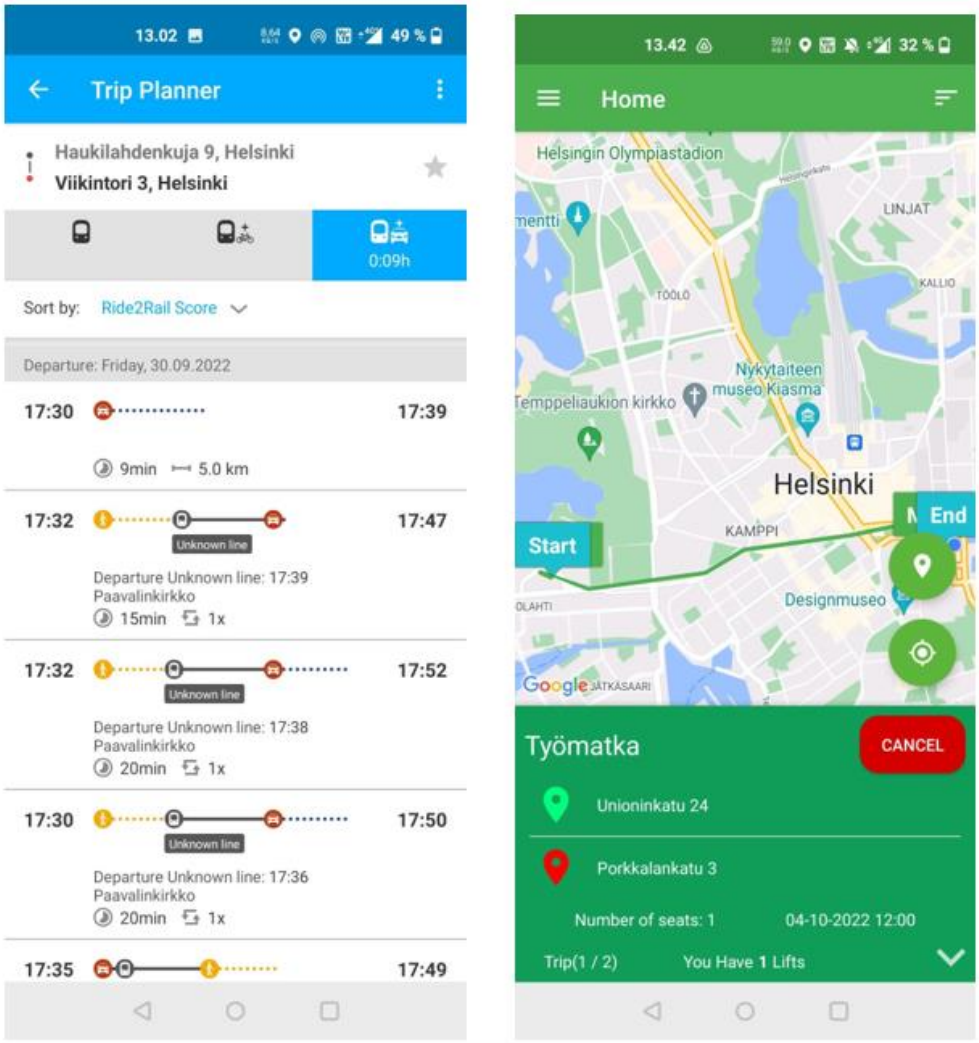

Figure 13: Travel Companion and Driver Companion applications [Ride2Rail, 2022].

The functionalities used in the Helsinki demo were:

- navigation
- journey planner
- trip tracking
- group travelling

As a recommendation, much more emphasis should be placed on user-experience and usability of applications. Also, ride-sharing means a major shift in transport patterns and piloting new solutions for ride-sharing needs a longer demo time compared to the two weeks foreseen in RIDE2RAIL. More time for internal testing would also have been needed, in order to increase the familiarity with the ecosystem itself.

As a result of the demo the following suggestions are proposed to improve the apps:

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- A list of offered rides could be visible somewhere and organised according to the shortest distance and/or time between the start point and end point of the searched trip
- Communication possibility between the driver and passenger
- Possibility to manage preferences of the drivers car, including available seats
- Possibility to cancel a booked ride
- Updating the amount of available seats (taking into account reserved seats)
- Improve the vocabulary of the apps (e.g. cbtsp-tw, gis-car-tsp) to make them more clear to users
- Develop/improve the user interface, in order to make it more intuitive
- Allow users to use their real email addresses for registering on the ecosystem

Brno Demo

The testing of the R2R functionalities and the entire IP4 solution through the Driver Companion and the Travel Companion apps within the Brno demo took place at the beginning of November 2022 in the South Moravian region of the Czech Republic and that in real conditions. The target location for the demo was chosen based on the analysis of the traffic availability, transport flows, and other parameters. Based on the results of the analysis, Znojmo district, from which many residents regularly commute to Brno, was identified as the target location for the demo.

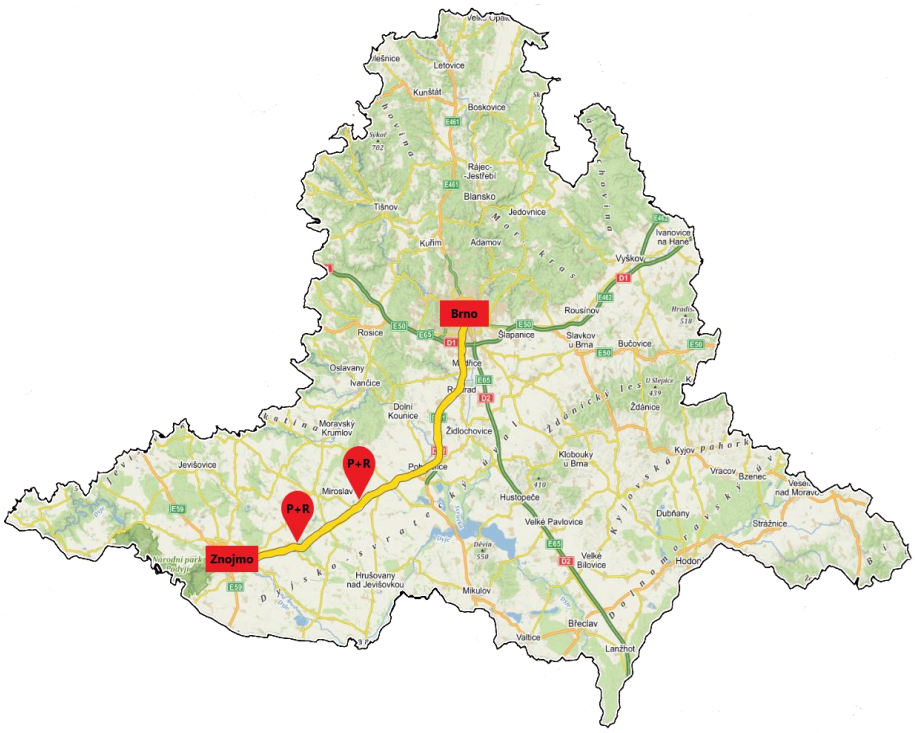

Figure 14 – Demonstration scenario of Brno demo site

Given that in the period before the COVID-19 pandemic, more than 4,000 inhabitants commuted daily between Znojmo district and Brno, even though half of them used a private car for their journeys, the following goals were defined:

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- to motivate commuters who had only travelled by private cars to start travelling by car from their home to a public transport hub (P+R), continuing their trip with public transport;
- to encourage those car drivers travelling alone to share the capacity of their private car with others going in the same direction;
- to reduce traffic and parking congestions and also GHG emissions.

In order to achieve the above objectives, the functionalities of the Travel Companion and the Driver Companion apps were tested to help motivate commuters to change their travel habits. The demo's goal, apart from the smooth execution of the testing and verification of testers' satisfaction with IP4 - R2R solutions, was also to achieve the set KPI values. However, due to the COVID-19 and its consequences, the KPI targets have been reduced to 50%.

For the successful execution of the Brno demo with the achievement of the target KPI values, 11 weeks were set aside for the process. The time frame of the Brno demo was divided into 3 main phases:

- Preparation phase (before the demo execution)
- Execution phase (during the demo execution)
- Evaluation phase (after the demo execution)

Each phase included the specific activities that had to be completed for the proper execution of the demo.

Preparation phase

The entire preparation phase of the Brno demo has been scheduled for 7 weeks and included the following activities:

1. **Addressing possible testers through the identified channels and dissemination of a recruitment questionnaire.** The purpose was to recruit testers by informing residents about the demo and the possibility to participate in it. The particular recruitment tool was a leaflet. The leaflet was distributed in electronic (Figure 15) and paper (Figure 16) version. The electronic version of the leaflet was disseminated in all public transport vehicles in the South Moravian region and through demo partners' social media. The paper leaflet was disseminated at the universities, etc. The leaflet contained a web address and a QR code that guided interested people to fill out the recruitment questionnaire.

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Figure 15 – Electronic version of the leaflet

Figure 16 – Paper version of the leaflet

As part of the Brno demo, a demonstration testing was also performed, in which a few selected testers participated under the supervision of OLTIS and UNIZA. This demonstration

testing was tested according to the demonstration scenario. This means that the participants travelled from Znojmo to Brno with the stops in Lechovice and Miroslav and the journey was planned and executed step by step. Users filled a "demo report" every time they participated to RIDE2RAIL demonstration, providing information on their trip (day/time, O-D, issues emerged, disruptions, comments).

2. **Selection of testers.** Based on the answers to the questionnaire, respondents who met the conditions of participation, were selected and then divided into three categories: passenger, driver, passenger/driver.

3. **Internal testing of the Travel Companion and the Driver Companion apps,** performed according to various scenarios by OLTIS group and UNIZA employees. Identified shortcomings were reported through IssueLog.

4. **Training of testers.** Training of testers was conducted the last week before demo's execution, online. The participating testers were trained on how to use all the tools. General information about the project, Brno demonstration, user guides for both applications, Terms and Conditions, tutorial videos, etc. were distributed.

Execution phase

The demo's execution began on the last day of October 2022 and continued till 11th November 2022. During the execution, the testers of all three roles tested the entire IP4 ecosystem and R2R functionalities in real conditions.

During the demo execution time, the testers filled out daily reports. Two types of daily reports were created, in particular one for passengers and one for drivers. The daily report for passengers collected the daily number of trips, their routes, the approximate travel time, the type of means of transport used and also testers' comments together with information about problems encountered by testers. The daily report for drivers was used to record the trips, where drivers indicated the specific route, capacity of their cars, special requests (no animal). Passengers could also reserve a seat in a selected vehicle.

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Figure 17 – Demonstration testing under supervision of OLTIS + UNIZA, November 2022

The testers were asked to participate in the testing of the demonstration scenario (ride from Znojmo to Brno with the stops on the route) under the supervision of demo partners OLTIS and UNIZA. Some of the testers were willing to participate with their cars and these cars were marked with the R2R poster to better identify them with ensuring GDPR compliance (as per the picture above).

Evaluation phase

Two weeks were set aside for the evaluation phase. This phase started after the demo execution and focused on evaluating the demo outcomes. In particular, this phase consisted of the following activities:

1. **Dissemination and collection of testers' responses to the questionnaire.** Immediately after the end of the demo, the questionnaire was sent to testers to investigate the testers' satisfaction with using the TC and DC apps.
2. **Reimbursement of demo-related costs and distribution of incentives.** After filling out the questionnaire, testers were eligible for incentives (vouchers).
3. **The overall Brno demo evaluation.** The evaluation was based primarily on the basis of the questionnaires and daily reports.

The demo outcomes

The demo testing in Brno was attended by 60 volunteers of various age categories who regularly travelled between the district of Znojmo district and Brno. Of these, 40 were assigned the role of passenger, 5 as driver and 15 as passenger/drivers.

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All testers were filled out the daily reports and participated in the questionnaire. During the Brno pilot, the testers made a total of **1946** journeys of which **76** were shared rides. Most of the trips were made by multiple modes of transport, thanks to the support of multimodal travel solutions. The most used modes of transport were city public transport and private cars. By increasing the occupancy of private cars during the testing, the testers achieved savings of approx. **380** kg of CO_2 and **28** parking spaces.

As a general comment, Travel Companion and the Driver Companion apps were positively evaluated by the testers who indicated that the IP4 and RIDE2RAIL solutions' outcomes as an interesting option to reduce the environmental impacts of transport as well as a possible solution for parking and road congestion problems. RIDE2RAIL solution also encouraged drivers to share the capacity of their vehicles with other passengers, reducing the carbon footprint. Last but not least, the testers highlighted the usefulness of the overall solution and the contribution to the development of transport system.

On the other hand, shortcomings have been collected by the demo team and reported to other partners/CFMs in order to improve the ecosystem for facilitating the future demos preparation and execution.

Padua Demo

The demo in Padua took place in a 20km radius surrounding the urban centre of Padua (Italy) involving urban and regional mobility service providers in Veneto and concerning rail, road and bus, and ridesharing as travelling modes. The demo has focused in urban and suburban area of Padua and surrounding areas, taking place from the 17/04/2023 to 21/04/2023 and focused on commuters belonging to the Padua province and travelling to/from the University of Ca' Foscari, with the main objective to encourage carpooling (and ride sharing acceptance) as complementary for public transport, to improve the efficiency of public transportation services, to encourage car drivers who travel alone to share the capacity of their car with other travellers and to reduce GHG emissions and traffic and parking congestions. The Transport Service Providers (TSPs) involved in the project were BusItalia, which handles road transport, and Trenitalia, which deals with rail transport.

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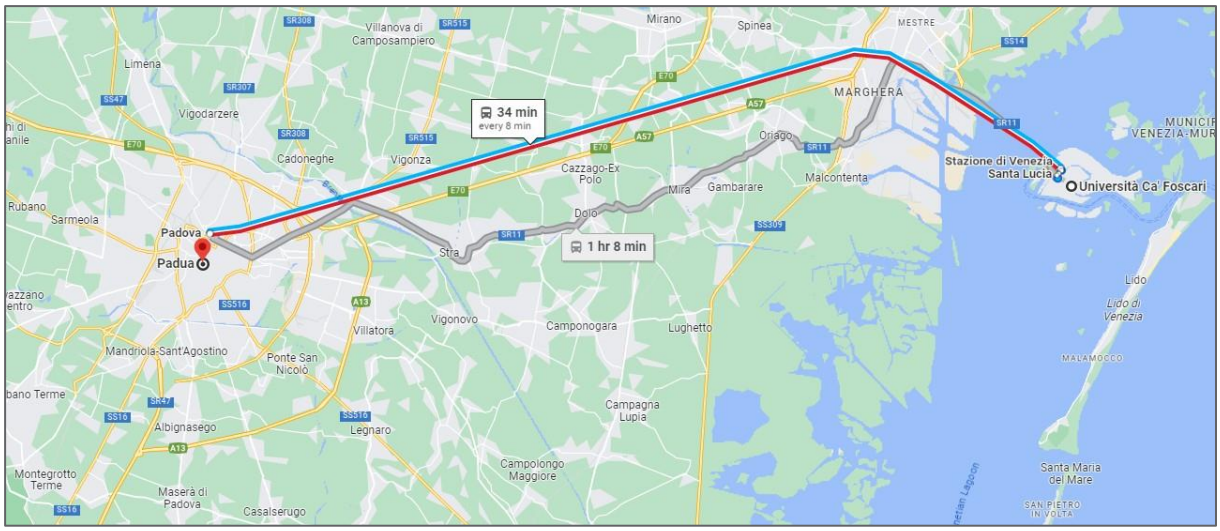

Figure 18: Padua demo site

During the demo, both the Driver and the Travel Companion apps were tested, while the specific functionalities put under the spotlight included Preference & Profile, Trip Planner, Trip Sharing, Navigation, Issuing, Booking, Traveller's Feedback, Guest User, Offering a Ride, View your Journey and Collaborative Space. In order to ensure the largest possible number of testers, a student engagement plan was structured through emails sent by university staff to students' mailboxes, including "Save the date" emails, reminders and an Engagement event on the Padua Demo and the TC and DC apps that took place on 14/04/2023. The goal was to train the Testers so that they could fruitfully tackle the demo. No incentives and/or gifts were provided to Testers so as to encourage participation in the demo. The demo included the testing of demonstration scenario with the support of project partners OLTIS, FIT CONSULTING and CEFRIEL.

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Figure 19 - Cover of the Engagement event

Below, some relevant statistics regarding to the execution phase of the Padua demo are provided.

- Number of app downloads: 79.
  - 77 downloads for the TC application.
  - 2 downloads for the DC application.
- Clicks on distribution link: 79.
  - 77 clicks on TC distribution link for the TC application.
  - 2 clicks on distribution link for DC.
- Number of participants (travellers/drivers, unique users): 9.
- % of rural/suburban trips: 98,56%.
- Surveys completed: 6.
- Number of all rides: 387.
- Number of shared rides: 9.
- Functionalities used: 11.
- Result/Feedback: in general, testers reported that they found the application easy to use and did not encounter any technical issue or particular problems when using it. Some people were very pleased with the application as it facilitated connections to the rural areas of the demo as well as the fact that several travel solutions were available. On the other hand, in some cases there was some redundancy in the questions or disappointment in not being able to purchase a ticket once it had been selected, leading to unnecessary additional steps.

The overall received feedback was quite positive. The Padua demo team, in its interaction with users, could also have the possibility to understand better their feeling about the

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application and the ecosystem, getting some recommendations for improvement (ex using a more easy and less technical vocabulary, make some improvements in the look and feel of the app to make them more appealing, extend the time frame/duration of the demo, improve the way to make the driver “visible” to the traveller using ride-sharing).

An extensive overview and all the relevant informations on RIDE2RAIL demonstrations activities are included in the Deliverables D4.4 Demo Execution Report and D4.5 Demo Monitoring Report (available on RIDE2RAIL website and Zenodo once the deliverable is approved).

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10. EVALUATION AND IMPACT ASSESSMENT

10.1. KPIs for evaluation of functionalities

RIDE2RAIL has used a comprehensive evaluation programme to assess project outcomes. These activities were conducted through live demonstrations with the active usage of travelling participants.

Key to this evaluation process was ensuring that the performance of RIDE2RAIL could be measured in a consistent and reliable manner that reflected the ambitions of the project. To achieve this, a methodology was developed. The methodology was broadly as follows

1) To identify the major areas of impact for RIDE2RAIL as defined in initial project documentation;
2) To identify the key characteristics, or Key Performance Indicators (KPIs) that would track the performance of RIDE2RAIL during demos, and thus inform and measurement of impact;
3) Identify measures and methods to capture data that would give values for these KPIs;
4) Identify further measurements, such as usability scores, that would also support the evaluation of RIDE2RAIL;
5) Deploy measures;
6) Calculate KPI scores;
7) Capture stakeholder priorities for identified impact areas.

A Key Performance Indicator is a measurable value that demonstrates how effectively an organisation or project is achieving main objectives. Organisations use KPIs at multiple levels to evaluate their success at reaching targets. A KPI is usually quantifiable – it can be expressed as a value. More qualitative KPIs (such as trust, user experience and satisfaction) are captured as quantified measures through surveys or questionnaires.

The initial analysis of documents arrived 56 potential measures of performance with RIDE2RAIL. This comprised;

- 29 potential measures from D4.1 demo description tables;
- 12 from site snapshot descriptions in D4.1;
- 15 from DoA and Shift2Rail material.

Criteria for selection involved what data could realistically be collected, which measures were consistent and relevant across all demostration sites, and which would inform the overall project impact.

Based on the analysis and criteria above and through consulation with demonstration site leaders, the following KPIs were defined.

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KPI	DEFINITION	Data Source
KPI#1 Number of RIDE2RAIL app users	Demo site users who download the app and request at least one trip	Eco system
KPI#2 Number of completed RIDE2RAIL app trips	A completed trip made by a demo site app user	Survey
KPI#3 Number of completed multi-occupancy vehicle trips with R2R app	A completed trip made by a demo site app user that involves rideshare	Survey
KPI#4 Number of completed trips involving public transit/rail with R2R app	A completed multi-modal trip	Survey
KPI#5 Number of completed commuter trips with R2R app	A completed trip that is a regular journey (work or education) conducted 4 (including outward or return) or more times a week	Survey
KPI#6 Number of completed rural trips with R2R app	A complete trip where one or both origin and destination is from a rural (or suburban) location	Survey
KPI#7 Number of Ride2Rail app downloads	Number of times app has been downloaded by unique users	Eco system

Table 5: Key Perfomance Indicators identified for RIDE2RAIL

Additionally, two location specific KPIs were identified for Athens and five location specific KPIs were identified for Padua. Further details of the KPI process are prestned in D4.1, available on the RIDE2RAIL website.

In terms of methodology, data was collected using a combination of methods (further details in D5.1):
1) Data derived from the RIDE2RAIL ecosystem – eg location of pickup and dropoff points for journeys
2) Using a post-evaluation with surveys – this would capture qualitative comments and usability data (based on the System Usability Scale – an industry standard scale used worldwide, including Socialcar [see D5.2]).

Versions of the survey, implemented using the GDPR-compliant 'Online Survey' tool, were translated into the local demo languages. As well as data about usage of RIDE2RAIL, and service usability, questions were also asked around which offer criteria were most appropriate for RIDE2RAIL, demographic questions (age, gender, employment) and also participants' previous use of travel services (for Brno and Padua).

Data between the ecosystem and surveys were harmonised and then reviewed with demonstration partners, arriving at the final set of data presented below.

Finally, while Newcastle-Upon-Tyne, UK was not a formal demonstration site, local data was collected to understand the wider appeal of the RIDE2RAIL concept in the Newcastle area.

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10.2. Summary of the evaluations

Data collection required close coordination between demo partners, technical partners (who could advise on the availability of data from the ecosystem) and the main demo coordination partner for WP4.

One significant challenge was that data from the ecosystem represented requested trips, rather than actual trips – it was not possible from ecosystem data alone to ascertain whether the trip had been conducted and completed successfully. This lead to a high level of reliance on data from the RIDE2RAIL surveys. Nonetheless, ecosystem provided useful data and secondary validation, along with a measure of travel requests. This has also been included in the KPI list.

A potential challenge could have been a disconnection between number of users as identified in the ecosystem, and those completing the survey. In practice, there was high concordance between number of users registered to the app and those completing the survey. The only location where this was not achieved was Padua, where response rates and completion of the survey was around 14% due to demonstrations taking place around national holidays. Ecosystem data was captured and included for Padua.

10.2.1. KPI data

Data was captured and harmonised across the demonstration sites. The below table presents the data across the sites. This shows over 2000 journeys were planned using the RIDE2RAIL service, with around 10% conceived as shared journeys. Many of these trips were suburban / rural journeys, and with a high degree of integration with public transit.

KPI	TOTAL	Athens	Helsinki	Brno	Padua
KPI#1 Number of RIDE2RAIL app users	**103**	17	17	60	9
KPI#2 Number of completed RIDE2RAIL app trips	**2364**	26	99	1852	387
KPI#3 Number of completed multi-occupancy vehicle trips with R2R app	**179**	15	68	87	9
KPI#4 Number of completed trips involving public transit/rail with R2R app	**864**	30	58	766	10
KPI#5 Number of completed commuter trips with R2R app	**1949**	39	58	1852	10
KPI#6 Number of completed rural / suburban trips with R2R app	**1695**	13	7	1665	10
KPI#7 Number of Ride2Rail app downloads (driver/traveller)	**37/ 170**	12/ 27	7/ 22	16/ 44	2/ 77
Ecosystem trip requests	**3441**	353	665	2036	387

Table 6: KPI data

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10.2.2. Demographic data

Ride2Rail demonstrations covered a wide range of participants, as identified in the surveys distributed to users during/after the demos. Notably there was good representation across the genders, across age ranges, and across different types of employment. Demographic data is presented in the table below**Error! Reference source not found.**.

		Total	Athens	Helsinki	Brno	Padua
Age	**16-21**	**13**	1	2	9	1
	22 –35	**32**	2	5	20	5
	36–51	**35**	11	9	15	
	52-65	**11**	3	1	7	
	65+	**9**			9	
Occupation	**In work**	**53**	15	15	36	
	Student	**26**	2	1	13	6
	Unemployed	**19**		1	10	
	Retired	**2**			1	
Gender	**Male**	**57**	9	8	36	
	Female	**37**	7	5	23	
	Prefer not to say	**6**	1	4	1	

Table 7 Demographic data collected from surveys

10.2.3. Usability data

Usability was rated by demo participants using the standardized System Usability Scale. The Driver Companion scored 58% and the travel companion scored 57%, both of which indicate good usability for a demonstration application, particularly considering the RIDE2RAIL project TRL level. Usability scores improved with each demo site deployment, suggesting iterative improvements in usability and functionality as the service was refined in response to user feedback. This was the result of the many interactions the consortium had with CFMs in order to learn lessons from the demos performed and use them for improving the tools.

10.2.4. Offer categorisation data

Finally, demo participants were asked to rank which of the 11 criteria were most important for them in RIDE2RAIL. There was strong concordance by demo site, and demographics on the ranking of offer categories – **quick, reliable and cheap offer** categories were ranked as more important than other categories. The table below presents overall ranking scores, where a lower value represents a higher value (best possible = 1; worst possible = 11). Notably, these ranks are very similar to data collected earlier in the project.

	Quick	Reliable	Cheap	Comfortable	Environmental	Door-to-door	Short	Healthy	Multi-tasking	Social	Panoramic
Score	2.4	2.6	3	3.6	4	4.1	4.1	6.5	7.1	7.4	8

Table 8: Ranking of offer categories (from all 4 demos)

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10.3. Summary of the Impact Assessment

Having established the overall performance of the demonstrations, the following stage was to assign impact to the potential of wider rollout of RIDE2RAIL. Based on the oringinal aims of the project, and availability of data through the KPI mechanism, the follwing four impact areas were prioritised

1. Increase PT ridership – the ambition of RIDE2RAIL is to increase the appeal and accessiblity of public transit by providing first and list mile connectivity within a single travel service package (the Travel Companion).
2. Improve rail connectivity – the ambition of RIDE2RAIL is specifically to increase the appeal of rail (metro, light rail and mainline) services by facilitating shared first and last mile travel. While this is a general ambition, it is particularly relevant to suburban and rural areas.
3. Improve environment – by facilitating shared travel, RIDE2RAIL can make better use of the spare capacity available in single occupancy vehicle trips, thus reducing emissions and carbon imact. Furthermore, by encouraging access to rail, RIDE2RAIL can enable travellers to switch to rail and public transit (impact 1 and 2), which are much lower carbon travel options.
4. User satisfaction – finally, by providing a holistic and integrated application environment, and delivering seamless complete journeys, RIDE2RAIL can improve overall user satisfaction.

Data from the KPIs clearly indicates the potential of RIDE2RAIL to support Impact 1 and 2, with a high number of trips generally, and those involving connectivity to rail services. Furthemore, KPI data on number of shared trips indicates successful impact in terms of impact 3, in that around 10% of demonstration journeys were shared. It is important to note that this is in comparison to baseline data from Brno, Padua and (see below) Newcastle, that suggests current levels of organised sharing are very low, and thus indicates how RIDE2RAIL can faciliate the uptake of shared travel.

To calculate which impact areas are most important among RIDE2RAIL involved demo partners, an Analytical Heirarchy Process (AHP) approach has been used. This takes each of the four impacts and asks relevant stakeholders from each demonstration location to make pairwise comparisons of the impact areas. This allows calculations of impact to be weighted and assess how different demo cities prioritize their goals when planning for ride-sharing.

The AHP has recorded data from all four demonstration sites, with over 40 stakeholder responses. Comparison of responses indicates the importance of increasing PT ridership. The figure below recaps the results of this exercise.

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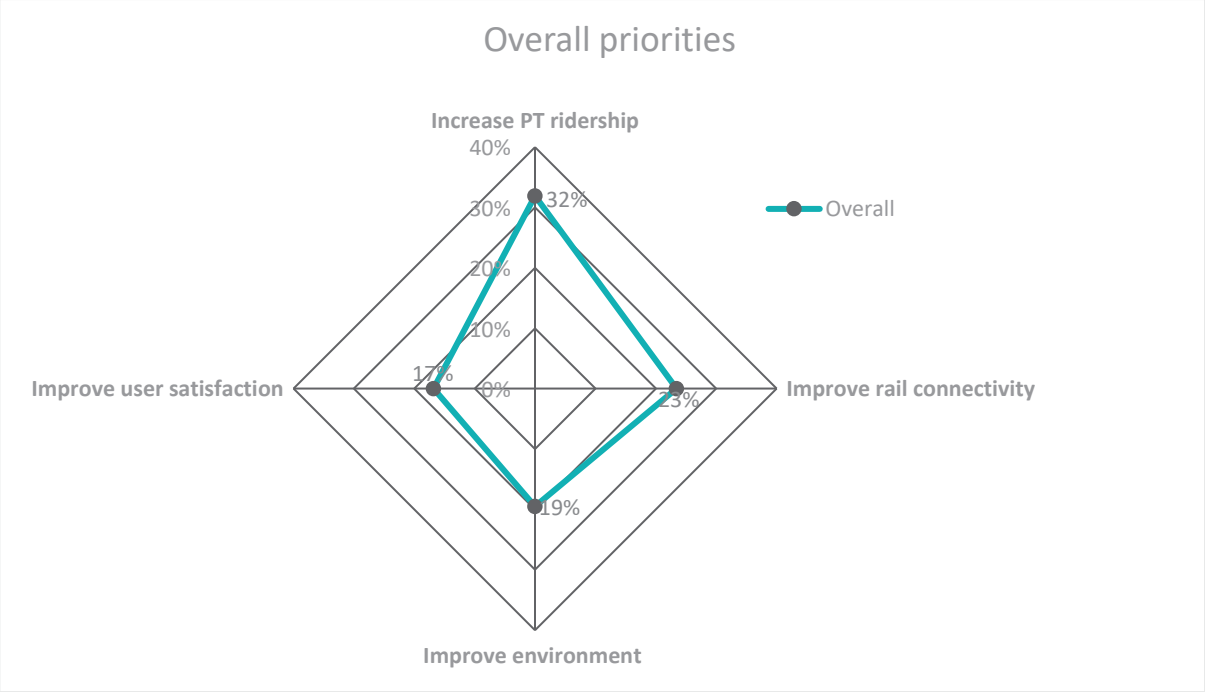

Figure 20: Overall AHP impact comparisons for all demo cities

A cross comparison among demo cities is shown above. The figure illustrates comparatively the priority ranking of each goal regarding the 4 different impact areas. According to the aforementioned, the increase of PT ridership is agreed among all demo cities as number one area of priority when designing ride-sharing schemes. On the other hand, the improvement of the environment and user satisfaction are ranked lowest as the overall result, but it is worth mentioning that in these areas it is observed the greatest variation meaning that cities share different opinions on this issue. In this context, while for Helsinki the improvement of the environment is ranked right after the increase in PT ridership, Athens ranked it in the last position together with the improvement of user satisfaction (a deeper and more extensive analysis is presented in D5.3, available on the project website).

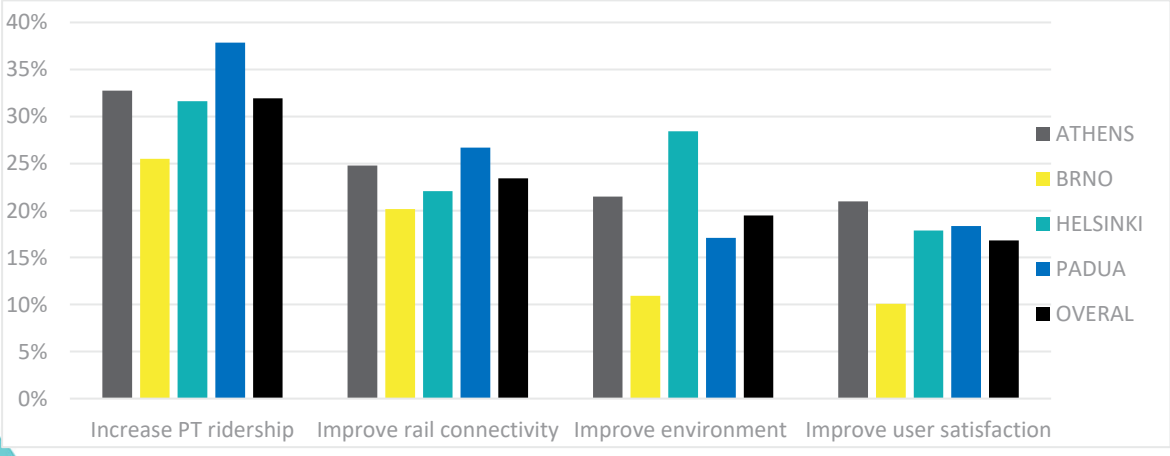

Figure 21: Priorities per priority area among demo cities

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Finally, it is important to understand the wider relevance and appeal of RIDE2RAIL, beyond the demo sites. To assess this, a survey of 400 residents of the Newcastle-upon-Tyne, UK area participated in a survey. This survey presented participants with a textual scenario of one of four shared travel concepts – the RIDE2RAIL concept, describing the potential to request and pay for shared lifts to a local railway / metro station for onward travel to Newcastle city centre; a traditional taxi; paying a friend to give a lift to the station (i.e. non-ticketing, informal lift share); and an autonomous taxi. All participants lived within 10 miles of the current rail / metro service, or within 10 miles of a new rail service opening in 2024. Participants were also asked about their current mode of travel.

For the RIDE2RAIL condition, participants showed a substantial willingness to use the service, with greater acceptance than how often they used regular car share, and comparable to current use of taxi / uber (see figure below). RIDE2RAIL was comparable in acceptance to the taxi scenario, and preferred to the informal shared trip, and the autonomous taxi. This indicates wide acceptance of the RIDE2RAIL concept for connecting with rail (Impact 2) and to increase multiple occupancy vehicle trips, thus reducing emissions (Impact 3).

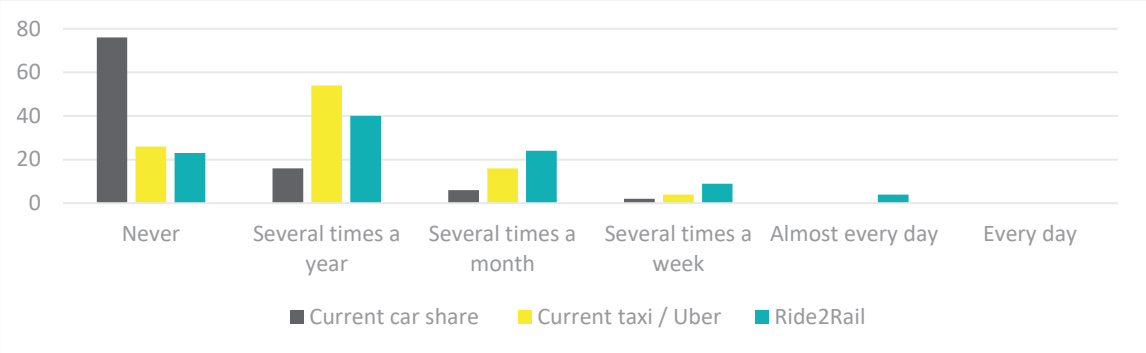

Figure 22: Newcastle comparison survey

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11. DISSEMINATION AND COMMUNICATION

The RIDE2RAIL project aimed to develop an innovative framework for intelligent mobility solutions and to promote an effective ride sharing practice of citizens. To achieve the increased uptake of RIDE2RAIL solutions by relevant stakeholders in Europe and beyond, it was essential to ensure sufficient engagement with all stakeholders and progress/results were widely disseminated to relevant target groups. This has been done by focussing on various aspects:

- Establishing RIDE2RAIL as a brand while disseminating project objecives, raise awareness on topic of car-sharing and public transport, generate interest through various channels including project website, brochure, press articles, anmiation video, newsletters;
- Active involvement of local practitioners and stakeholders: dissemination of demos and their objectives/set-up on website and social media, heavily utilising partners' networks for this. Local dissemination has played an important part in RIDE2RAIL seeing demo audiences were to be targeted locally, in local languages;
- Promote the findings of the project, promote the exploitation of the RIDE2RAIL innovations: through events (both organisation and participation) website, scientific publications, social media articles, newsletters, UITP Project Brief, final leaflet, and other.

As an overview, the following dissemination and communication activities have been conducted throughout the RIDE2RAIL project:

- Setting up/publish the communications and dissemination strategy to outline the activities to be conducted in the project (D6.1 and D6.2);
- Develop a coherent RIDE2RAIL visual identity including logo, graphic charter, templates, and supportive material such as the roll-up;
- Create and maintain the RIDE2RAIL website (www.ride2rail.eu) with events, news and insights (deliverables, publications) develped by the project;
- Create and maintain RIDE2RAIL Twitter (256 followers) and LinkedIn (122 followers) accounts to disseminate project news to a wide array of stakeholders;
- Publications: general project leaflet (in five languages, also printed), factsheet (wrap-up of project results, due in May 2023) and the UITP Project Brief recapping all project results (due in May 2023);
- Sending out 4 E-Newsletters to 104 subscribers;
- Creating one general animation video, shown at various events and conferences (234 views online, YouTube + social media);
- During RIDE2RAIL, partners were constantly encouraged to act as RIDE2RAIL Ambassadors and disseminate the project towards own networks and audiences. This took the form of social media posts, web articles, an animation video, press releases, events, among many others;
- Disseminate project info to press and media outlets, while encouraging partners to publish information on their own websites. 27 articles so far (until mid-April 2023, number will increase afterwards) have been published in six languages;
- Publicaton of 22 Scientitic and Peer-reviewed publications;

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- Creating liasons with other Shift2Rail/Europe's Rail projects, as well as other initiatives on MaaS and public transport (IP4MaaS, ERRAC, TRIPS, ExTensive, COHESIVE etc.) : creating joint events, disseminating material, among others;
- Organization of Final Project Event with accompaning Press Release issued by UITP;
- Development of various dissemination material about demos by local partners: from a demo video to leaflets, to signage material, to stickers, to press articles;
- Organisation and participation in over 50 external conferences, workshops and other events (complete list to be found in dissemination tracker), including:
    - Two Stakeholders' Workshops in February 2020 (online) and May 2022 (Karlsruhe, in line with IT-TRANS Conference);
    - Two editions of IT-TRANS (December 2020 and May 2022);
    - UIC Web Conference on Door2Door (December 2020);
    - 10th International Railway Summit (February 2021, Online)
    - Innovation Meeting event on "Smart and Collaborative Mobility" (May 2021);
    - IEEE International Conference on Artificial Intelligence and Computer Applications (June 2021);
    - International Workshop on Semantics and the Web for Transport" (September 2021);
    - 2 Shift2Rail Innovation Days (December 2021 and 2022);
    - ITS European Congress (May 2022);
    - WCRR World Congress on Rail Research 2022 (June 2022);
    - 30th Symposium on Advanced Database System (June 2022);
    - SEMANTiCS 2022 conference (September 2022);
    - InnoTrans 2022 (September 2022);
    - International Rail Forum & Conference 2022 (October 2022);
    - UIC Training on CRTS (October 2022);
    - TRA Conference (November 2022);
    - RIDE2RAIL Workshop on Transferability (November 2022);
    - 8th ITS Hellas Conference (December 2022);
    - Rail Live Malaga 2022 (December 2022);
    - COHESIVE Final Event (January 2023);
    - RIDE2RAIL Final Event (April 2023);
    - UITP Global Summit Barcelona 2023 (June 2023, RIDE2RAIL will be present with a poster session).

Ensure visibility in various UITP bodies and activities, including Committee meetings such as the UITP RSR Committee, UITP Light Rail Committee, VEI Committee, UITP MENA Conference and Exhibition, and the UITP Asia-Pacific Annual Meeting, inclusion of RIDE2RAIL info in the UITP Activity Report, the UITP Keep it Rail! Campaign, various UITP newsletters (UITP Direct, EU Express, Rail newsletters, Combined Mobility Newsletters), among others.

11.1. Transferability and Exploitation

TRANSFERABILITY

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Taks 6.3 started at M12. The Leader UIC worked on the MS19 "Launch of Open Call For Transferability", in order to foster the replicability of the RIDE2RAIL solutions in other locations. This has been the first step towards the D6.4 Transferability and recommendations handbook, submitted at M41 (April 2023). After the first iteration of the open call (officially launched in July 2021), no positive feebacks have been collected and, according to the calendar, the call was re-opened (but with a broader audience) in October 2021. 100 additional municipalities and potentially interested stakeholders have been involved and UIC, the leader of this task, expects to have candidates by end of 2021. UIC, the leader of this task, has also involved (reopening the call in mid 2022) POLIS, EUROCITIES and MaaS Alliance. Despite this, no candidates have been found. Promotion for the open call was performed on social media and online, and also with direct mailing. An article was drafted on this and posted on the website and disseminated via social media. The open call can be found on the RIDE2RAIL website https://ride2rail.eu/wp-content/uploads/2021/07/Transferability-call-R2R-DescriptionForm-v2.2.pdf

Due to the lack of candidates, the Task Leader UIC decided (in accordance with all Task partners and PO) to organize a Transferability Workshop in Paris (and online) on November 23rd 2022. This specific item was included in the Amendment 2 accepted in November 2022. The Transferability Workshop took place November 23rd afternoon with 40 participants, half at the UIC headquarter in Paris and the other half online, connected via Zoom. All the presentations and the recording of the event are available on the UIC dedicated meeting webpage: https://uic.org/events/ride2rail-transferability-workshop

After the workshop, and exploiting the outcomes of the fruitful discussions that took place in Paris/online, the Task partners worked on the Transferability and Recommendations Handbook, a short report summarizing the above mentioned activities, together with a all-encompassing overview on all demos. Details on recommendations for transferability of RIDE2RAIL results to other potentilly interested stakeholders who want to replicate the project activities in similar or different contexts is included in the document, available on both Zenodo community and RIDE2RAIL website (after its approval). Links to the open-access GitHub page, where all codes for projects' pieces of software are listed, is also provided in the mentioned Handbook, that constitutes D6.4, that will be made available on the project website and on the Zenodo community once approved.

EXPLOITATION

Exploitation (direct or indirect utilisation) of the project results was addressed in Task 6.4. In this task, the consortium, led by OLTIS Group, created an exploitation strategy for the developed project results after the project ends, as well as the actions necessary for sustainable exploitation plans. In order to achieve high adoption levels, this exploitation strategy is based not only on the general evaluated exploitation potential, the RIDE2RAIL project consortium member' s needs, interests and the IPR situation, but also on the feedback of select stakeholders of high significance identified in terms of this task from industry organisations and associations, as well as standardisation bodies by the means of

interactive workshops organised not only for this purpose in T6.2 and T6.3. The exploitation strategy lays out the expected business framework for a commercial application of the project's results by key stakeholders, including specific business cases. As s support to the intended high adoption, the exploitation strategy also covers dissemination and communication, such as branding and the aforementioned involvement of stakeholders, or the project's website, leaflets and social media for the purpose of promoting the project results

Identified potential commercial products stemming from RIDE2RAIL results were updated as the market trends in Europe and around the globe changed after the initial market exploration in T2.2, which evaluated the then market situation around ride sharing globally, including the legal framework concerning ride sharing, and ride sharing users. Project partners chose the Business Model Canvas (BMC) structured into 9 blocks as the means to manage the exploitation strategy.

Whilst establishing exploitable project results and setting out specific business plans, the exploitation strategy identified the projects benefits and target groups. These include for example data availability, increased mobility or adoptability, and transport operators, public authorities, urban planners or retailers respectively. Recognised exploitable results include a conceptual model assessing trip convenience based on several relevant dimensions, a suite of as-a-service software components, by exploiting synergies of existing mobility offers, and a set of validated proof of concepts and business cases envisaging future mobility scenarios. The BMC then describes how project results can be exploited - commercially or otherwise - and potentially by whom.

The basic identified potential revenue streams include advertising, selling of data, and subscription fees. These commercialisation opportunities are commonly used across the globe and are generally platform agnostic. Project partners are intend to exploit the experience gained whilst working on RIDE2RAIL in other European or national projects on similar or adjacent topics.
The RIDE2RAIL Exploitation Strategy is described in Deliverable D6.5, that will be made available on the project website and on the Zenodo community once approved.

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12.CONCLUSIONS

This report aims to address the scientific and technical findings of the RIDE2RAIL project providing a review of the S2R IP4 research activities. An extensive investigation of the work carried out in the project has been completed, with the support of WP Leaders and main technical project partners.

Large space was dedicated to the presentation of the innovative tools developed within RIDE2RAIL and integrated in the IP4 ecosystem with the support of CFM partners. On top of this, RIDE2RAIL also developed a stand-alone application targeted for drivers participating to the demonstration activities, for allowing a successful combination of scheduled and flexible transport services. The enhanced Travel Companion (developed by CFM partners in S2R) and the Driver Companion app (developed by RIDE2RAIL) have been utilized in the 4 demos carried out since July 2022. This document also recaps the activities carried out in each of the RIDE2RAIL demonstrations scenarios, focusing on the objectives, the engagement strategy performed, the activities performed, and their results measured in a qualitative and quantitative way. The performance of the tools utilized in the demos and a more general assessment of the impacts achieved has been also presented in this document (with particular regards to the results of the surveys shared with users, addressing how usable the apps are and how attractive the functionalities have been, with a investigation of the actual impacts obtained by the more than 100 users involved in terms of CO2 reduction, improvement of the mobility in the demo areas, reduction of congestion). A recap of the dissemination and communication activities targeted at giving visibility to RIDE2RAIL and its progresses is also presented, listing some of the most important events and publications. Elements concerning the transferability of projects results, collected during a workshop organized by RIDE2RAIL, are also listed, together with an investigation of the exploitation strategy.

Among the concrete recommendations for improvements of the current version of the IP4 solutions, emerging from the many interactions happened with the demo actors throughout the whole RIDE2RAIL lifetime and reported in several meetings organized in particular after the demos, it is important to note that usability characteristics and user experience are significant indicators enabling the use of a technology by a user for both TSPs and passengers. Concerning technologies related to interoperability and MaaS, integration with European transport services and applying European standards is the key factor of a success. This was partially achieved in the project, with the integration of all the different TSPs of various nature in the IP4 ecosystem. However, this is still far to be reached on a large scale due to the complexity of the integration process and the (in some cases) rigidity of the ecosystem in terms of required/supported standards and data formats, that a TSP needs to fulful to be integrated. In addition to the attractiveness (also measured in terms of maturity of the technology and ability of the ecosystem to provide quick/reliable answers) and user friendliness, passengers find availability of information support, clear guidelines/easy instructions, customisation of services (especially for concrete categories of the public), reliability of provided information, information in their own language critical for an application they would use outside the scope of a research project. RIDE2RAIL tried to address this point with the “Offer Categorizer” and “Offer Matcher and Ranker” components, based on the categories identified at the beginning of the project, through the analysis of more than 1000 conversational surveys from travellers and ride-sharing users.

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Local events also proved to be very important for the demo teams and the users to understand how to use the application, which are the functionalities active in their location (as it was not possible to customize the app for each location), how to actively participate.

Another important aspect is GDPR. Due to GDPR reasons, users could not log in the ecosystem with their real email addresses and had to be duly informed by the demo teams about the privacy policy of the partners collecting their information (even if anonymized/aggregated). Indeed this is a barrier for a large scale deployment, despite IP4 partners are progressing on this aspect.

RIDE2RAIL results, both in terms of number of attracted people and their overall satisfaction level (measured through surveys but also with interaction at demo level) proved once again the great potential the IP4 tools have. The project, boosting the combination of ride-sharing and mass transport, was to be capable of reducing congestion and offering an alternative to solo-car drivers, especially in rural and low demand areas. People, in general, welcomed very well this initiative and were positively attracted by the idea behind the project concept. Despite the tools are not ready for the market (and this was not in the scope of the project) it is clear that Shift2Rail and its successor Europe's Rail have a great baseline to keep working on, imrproving the technical aspects of the ecosystem, facilitating the integration process, enhancing its flexibility, correcting the evidenced issues, finally getting closer to the ambition of having a single EU-wide mobility tool capable of allowing seamless movements inside and across cities. RIDE2RAIL positively contributed to this ambitious plan, by developing tools that enhanced the Travel Companion and by testing these in real conditions, getting direct feedback from real users.

13.REFERENCES

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ST4RT Project website https://projects.shift2rail.org/s2r_ip4_n.aspx?p=s2r_ST4RT

14. APPENDIXES

14.1. List of Public Deliverables

Deliverab.	*Title*	*Nature*	*Dissemination level*	*Leader*	*Delivery date*
WP1					
D1.4	Final Summary Report of the Project	R	PU	UITP	M41
WP2					
D2.1	First conceptualization of choice criteria and incentives	R	PU	CEF	M5
D2.2	State-of-the-art of ride-sharing in target EU countries	R	PU	CERTH	M5
D2.3	First set of requirements and specification for complementary travel expert services	R	PU	POLIMI	M8
D2.4	Final conceptualization of choice criteria and incentives	R	PU	CEF	M10
D2.5	Recommendations and criteria for a successful ride-sharing in the IP4 ecosystem	R	PU	CERTH	M10
D2.6	Final set of requirements and specification for complementary travel expert services	R	PU	POLIMI	M14
WP3					
D3.1	Quantitative estimate of service quality factors	OTHER	PU	EUT	M16
D3.2	Source code of Algorithms for optimal synchronisation of shared-mobility and mass transit	OTHER	PU	EUT	M24
D3.3	Crowd-based Travel Expert Service	OTHER	PU	FSTECH	M30
D3.4	Travel Companion enhancements	OTHER	PU	OLT	M30
D3.5	Ride-Sharing Agreements Ledger Module	OTHER	PU	INLECOM	M30
WP4					
D4.1	Demo implementation plans	R	PU	FIT	M6
D4.2	Monitoring indicators and targets	R	PU	UNEW	M12
D4.3	Monitoring tools	R	PU	FIT	M24
D4.4	Demo execution report	R	PU	FIT	M41
D4.5	Demo monitoring report	R	PU	FIT	M41

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WP5					
D5.1	Performance targets and KPIs	R	PU	UNEW	M24
D5.2	MaaS Assessment Tool	R	PU	UNEW	M24
D5.3	Evaluation and Impact assessment	R	PU	CERTH	M41
WP6					
D6.1	Project visual identity and website	DEC	PU	UITP	M4
D6.3	Leaflet	DEC	PU	UITP	M12
D6.4	Transferability and recommendations handbook	R	PU	UIC	M41
D6.5	Exploitation strategy	R	PU	OLT	M41

All RIDE2RAIL Deliverables are stored in:

- RIDE2RAIL Website: https://ride2rail.eu/resources-library/
- RIDE2RAIL Zenodo Community: https://zenodo.org/communities/ride2rail/?page=1&size=20

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