



Deliverable D 3.1

List of operational KPIs, analysis of the users' satisfaction and methodology as a whole, C-REL

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1. Executive Summary

Since the main aim of the IP4MaaS project (S2R-OC-IP4-01-2020, GA 101015492) is to design, execute, monitor and assess the Shift2Rail IP4 demonstrations by liaising between CFMs, TSPs and users, it will be necessary to determine the indicators that will allow evaluating if the tool adds value to the already existing webs and other services TSPs provide to the travellers.

Deliverable D3.1 List of operational KPIs, analysis of the users' satisfaction and methodology as a whole, C-REL provides the preliminary information for a consistent monitoring of IP4 solutions in real environments and a market acceptance analysis through the assessment of needs and expectations of current and future travellers and TSPs when using IP4 solutions.

After setting the terminology of the IP4MaaS project in comparison with other IP4 projects, a provisional list of relevant Key Performance Indicators (KPIs) to be considered in the assessment of each demonstration is defined by considering CFMs recommendations, indicators from other projects such as Shift2MaaS and other literature review technical documents.

In addition to the KPIs, this deliverable introduces the methodology, the User Satisfaction Index (USI) survey to determine the indexes (one per each TSP and one for travellers) and the efficiency formula.

A statistical approach about the significance of the results is also considered to identify the number of travellers to be involved through the user engagement strategy per each functionality “j” and a specific TSP “k”, what will serve as input data for “D4.4. User engagement strategy per each demonstrator” (M15).

This C-REL deliverable will be an initial version to allow an appropriate planning and monitoring of demonstrations (WP4) and the coordination and start of demonstrations (WP5). This deliverable will be updated in D3.2 which is a F-REL version (M17) to feed the performance of demonstrations (WP5) and the performance assessment (WP6).

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
CFM	Calls for Members
EU	European Union
GA	Grant Agreement
IP4	Innovation Programme 4
IT	Information Technology
KPI	Key Performance Indicator
LBE	Location Based Experiences
MAAP	Multi-Annual Action Plan
S2R JU	Shift2Rail Joint Undertaking
TSP	Transport Service Providers
WP	Work Package
WPL	Work package leader



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5. Background

The present document constitutes the Deliverable D3.1 “List of operational KPIs, analysis of the users’ satisfaction and methodology as a whole, C-REL” in the framework of the WP3, Task 3.1 and Task 3.2 of IP4MaaS project (S2R-OC-IP4-01-2020, GA 101015492).

This deliverable will set, as a starting point, the terminology list that is used in this project, summarizing the concepts from the previous IP4 projects. Those new concepts introduced by the IP4MaaS project will be differentiated and special attention will be paid to those topics with a different meaning in comparison with the other IP4 projects (MaaSive, RIDE2RAIL and COHESIVE).

This deliverable, as C-REL version, will establish the methodological framework to obtain the selection of the KPIs to be used for the evaluation of demonstrations that will be held in WP5 (Task 5.2 Barcelona demonstration, Task 5.3 Padua demonstration, Task 5.4 Athens demonstration, Task 5.5 Osijek demonstration, Task 5.6 Liberec demonstration and Task 5.7 Warsaw demonstration). The final list of operational KPIs will be included in D3.2 “List of operational KPIs, analysis of the users’ satisfaction and methodology as a whole, F-REL” (M17) and D3.3 “Final version of the methodological framework for future projects” (M28).

After explaining the methodology to define the list of KPIs in all the demonstration scenarios and providing one as an example, this deliverable indicates the methodology to perform the user satisfaction index (USI) questionnaires that will be asked to the users to evaluate their satisfaction with the IP4 solution¹ and also deeply explain how the efficiency will be calculated for each user profile and the technological innovation.

¹ IP4 solution refers to the Information technology solution, which includes different modules or functionalities, that is being developed by previous projects in Shift2Rail Innovation Program 4 (IP4), which include ATTRACTIVE, CO-ACTIVE, MaaSive, and CONNECTIVE projects..

6. Objective/Aim

This document has been prepared by IP4MaaS WP3 to provide a comprehensive framework for further set the final list of KPIs that will allow evaluating the IP4MaaS tool in each of the 6 demonstration sites.

This document has the following objectives:

- Identify and define exactly each term and concept that will be used in the IP4MaaS project,
- Set the methodology to select the operational KPIs to be used for the evaluation of the IP4 solution in the 6 demonstration sites in the project,
- Introduce a provisional set of KPIs,
- Set the methodology to define the User Satisfaction Index (USI) questionnaires per each demonstration scenario,
- Define and indicate how the efficiency of the IP4 solution, for a specific IP4 functionality when it is used by a TSP and a traveller with a specific profile, will be calculated in the IP4MaaS project.

7. Terminology

The IP4MaaS project belongs to Innovation Program 4 (IP4) that is itself part of Shift2Rail (S2R). It continues and complements the work accomplished within other previous IP4 projects such as ATTRACKTIVE, CO-ACTIVE, MaaSive, and CONNECTIVE that developed (and are developing) a technical framework of sophisticated Information Technology (IT) building blocks that can be flexibly combined in multiple configurations into solutions that adapt naturally to multiple scenarios.

As a starting point, this Section summarizes the concepts used in the IP4MaaS project, taking into account all the terms already defined in the previous IP4 projects (MaaSive² (MaaSive Project, 2020), Cohesive³ (COHESIVE project, 2020) and Ride2Rail⁴ (Ride2Rail project, 2020)).

In the framework of this methodological WP3, the complete glossary of terms and definitions introduced by IP4 projects (Cohesive, MaaSive, Ride2Rail) has been reviewed and completed with new concepts introduced by IP4MaaS. This task of updating the glossary and introducing concepts of IP4MaaS will continue being executed during the Task 3.1, in a collaborative way with other initiatives (Ride2Rail, ExtenSive, ...) in order to avoid contradictions in the terminology. Table 1 formulates definitions of the most relevant key concepts that are used within this project and that have been introduced in the complete glossary of IP4 projects managed by Calls for Members (CFMs).

² <https://projects.shift2rail.org/download.aspx?id=2fb2f4be-77f2-42b9-a001-397a630eb401>

³ Deliverable D3.3 from https://projects.shift2rail.org/s2r_ip4_n.aspx?p=COHESIVE

⁴ Deliverable D2.4 from https://projects.shift2rail.org/s2r_ip4_n.aspx?p=S2R_RIDE2RAIL

TERM	IP4MaaS DESCRIPTION	MaaSive DESCRIPTION	Ride2Rail DESCRIPTION	COHESIVE DESCRIPTION
AS-IS User Journey Map	Expands a user journey considering a specific travel solution and describing the travel experiences characterizing it ahead of introducing IP4 solutions. An AS-IS user journey map focuses on existing problems and areas of potential improvement.	-	-	-
Demonstration Scenario	It is the intersection of a functionality provided by IP4 solutions (technology innovation) and a given travel service provider (TSP). It will be defined by selecting a specific travel experience enabled by IP4 solutions within a TO-BE user journey map.	-	-	-
Demonstration Site	Several transport solutions available for customers in a location.	-	-	-
Efficiency	Metric on how IP4 solutions are matching the needs and expectations of travellers and TSPs, from the perspective of an aggregated analysis and per	-	-	-

	each group of travellers in an intersectional analysis.			
High-level User Journey	Describes a typology of user journeys considering a group of itineraries involving the same Travel Service Providers and similar target users in a demonstration site. A High-level User Journey is identified by a title, it is described by high-level information and exemplified by specific user journeys.	-	-	-
Itinerary	An itinerary defines the Departure and Arrival places and associated Departure and Arrival times used for the realization of a travel. It also includes the names of the marketing and/or operating TSPs managing the different itinerary legs. An itinerary is a set of non-overlapping journeys.	An itinerary defines the Departure and Arrival places and associated Departure and Arrival times used for the realization of a travel. It also includes the names of the marketing and/or operating TSPs managing the different itinerary legs. An itinerary is a set of non-overlapping journeys.	-	-
Journey	A Journey defines the Departure and Arrival places and associated Departure and Arrival times used for the realization of a travel (see Trip). Within Shift2Rail, a journey is	A Journey defines the Departure and Arrival places and associated Departure and Arrival times used for the realization of a travel (see Trip). Within Shift2Rail, a	-	-

	considered as Door-to-door.	journey is considered as Door-to-door.		
Journey Planner	A Service that takes a mobility request and returns potential Trips for which Offers may be attached by an offer-building process.	A Service that takes a mobility request and returns potential Trips for which Offers may be attached by an offer-building process.	-	-
Leg	A synonym for the term “Travel Episode”.	-	A synonym for the term “Travel Episode”.	-
Persona	Personas are fictionalized characters representing a specific user group. In user-centred design, they are created to fully understand the needs of the group they represent. The definition of a persona is usually complemented by the definition of one or more Scenarios depicting their typical use of the system to be designed.	Personas are fictionalized characters representing a specific user group. In user-centred design, they are created to fully understand the needs of the group they represent. The definition of a persona is usually complemented by the definition of one or more Scenarios depicting their typical use of the system to be designed.	-	Personas create reliable and realistic representations of key audience segments for reference (Usability.gov, 2019a). The creation of personas helps designers and the project team understand the end user’s needs, experiences, behaviours and goals. They clarify that different people have different needs and expectations and can be used to support ideation and the creation of a user experience for target user groups (Interaction Design Foundation, 2019).
Profile vector	A set of socio-demographic characteristics and their ranges with significant differences on needs and expectations when	-	-	User/Traveller profile: A user/traveller profile is a representation of a group/segment of users/travellers. A profile of

	facing IP4 solutions.			users may have been grouped together based on similarities across their demographics, needs, pain-points, goals and/or behaviours.
TO-BE User Journey Map	Revise an AS-IS user journey map describing how the travel experiences currently characterizing the user journey can be enhanced introducing IP4 solutions.	-	-	-
Travel	Generic term without any technical assumptions, referring to the combination of services provided to a customer between a physical origin and a physical destination. Travel includes transport (on-board vehicles), as well as possible transfers between modes, possibly services which are offered during the trip, and possibly non-transport services which are proposed at either end of the trip from A to B.	Generic term without any technical assumptions, referring to the combination of services provided to a customer between a physical origin and a physical destination. Travel includes transport (on-board vehicles), as well as possible transfers between modes, possibly services which are offered during the trip, and possibly non-transport services which are proposed at either end of the trip from A to B.	-	-
Travel Experience	Represents a user experience during a travel associated to specific functionalities of	-	-	-

	services provided by a TSP and/or IP4.			
Travel Episode	Part of a Trip, characterized by Departure at the Travel Episode Start Point and Arrival at the Travel Episode End Point, consisting of an ordered sequence of Route Links operated with the same vehicle.	Part of a Trip, characterized by Departure at the Travel Episode Start Point and Arrival at the Travel Episode End Point, consisting of an ordered sequence of Route Links operated with the same vehicle.	-	-
Travel Expert	The technical entity that renders services related to the planning, booking and purchase of transport services. This may involve access to one or more specific TSPs as well as to entities which specialise in certain travel-related information (e.g. ATPCO for air fares or an automated journey planner) which assists in the building of an offer. This entity may be deployed by a TSP or distributors thus relying on a TSP fare products and prices services.	The technical entity that renders services related to the planning, booking and purchase of transport services. This may involve access to one or more specific TSPs as well as to entities which specialise in certain travel-related information (e.g. ATPCO for air fares or an automated journey planner) which assists in the building of an offer. This entity may be deployed by a TSP or distributors thus relying on a TSP fare products and prices services.	-	-

Travel Service Provider (TSP)	An organization providing access to travel-related services (e.g. planning, booking and ticketing, trip tracking) to the public, without necessarily being the actual provider of the physical transport services themselves. This could include also travel experiences at stations and vehicles and much more.	An organization providing access to travel-related services (e.g. planning, booking and ticketing, trip tracking) to the public, without necessarily being the actual provider of the physical transport services themselves. This could include also travel experiences at stations and vehicles and much more.	-	-
Travel Solution	Solution provided to the customer answering its travel needs in the form of Trips and Offers as the result of the Travel Shopping process.	-	-	-
Trip	A set of linked travel episode of an itinerary.	A set of linked travel episode of an itinerary.	-	-
Use Case	Intersection of a demonstration scenario with a profile vector.	-	-	Description of how a user will perform a task, from the specific user's point of view. Each use case is represented as a sequence of simple steps, beginning with a user goal and ending when the goal is fulfilled. (A) = Profile + journey purpose; (B) = TSP)

<p>User</p>	<p>The user is the generic actor involved in the Shift2Rail environment. Using the Personal Application on the internet-enabled device, they register and could make a mobility request, selects an Offer to create their trip and potentially pays for the booking(s).</p>	<p>The user is the generic actor involved in the Shift2Rail environment. Using the Personal Application on the internet-enabled device, they register and could make a mobility request, select an Offer to create their trip and potentially pays for the booking(s).</p>	<p>-</p>	<p>-</p>
<p>User Journey</p>	<p>An itinerary considering a specific origin and destination in a demonstration site. Represents a scenario in which a user may interact with services and products of one or more TSPs to perform the considered itinerary.</p>	<p>-</p>	<p>-</p>	<p>A user journey is a series of steps which represent a scenario in which a user might interact with the service or product being designed. They can be used to demonstrate how users are or might interact with the service or product being developed. A user journey will draw on a user's goals, motivation, pain-points, [needs], their overall character and the main tasks they want to achieve (The UX Review, 2013). In this case, the user journey can be for both travellers and transport service providers (= Traveller + journey purpose = Use Cases for Travellers)</p>

USI (User satisfaction index)	Average score about the satisfaction surveys collected from IP4 functionalities' users (travellers and TSPs).	-	-	-
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Table 1. Glossary of the most relevant terms in the IP4MaaS project and comparison with the terminology of other IP4 projects

Among these concepts there are some that are new terms introduced in the IP4MaaS project (Section 7.1) and others that are adapted with a different meaning than in the other IP4 projects (Section 7.2).

7.1. New terms introduced in the IP4MaaS

The new concepts from Table 1 introduced in the IP4MaaS project that were not previously considered are the following:

- AS-IS User Journey Map
- Demonstration Scenario
- Demonstration Site
- Efficiency
- High-level User Journey
- TO-BE User Journey Map
- Travel Experience
- USI (User satisfaction index)

7.2. Adapted terms in the IP4Maas from other IP4 projects

In addition to the new terms, the following concepts are adapted from other already included in previous IP4 projects.

Persona

- Definition in IP4MaaS (also in **MaaSive**): Personas are fictionalized characters representing a specific user group. In user-centred design, they are created to fully understand the needs of the group they represent. The definition of a persona is usually complemented by the definition of one or more scenarios depicting their typical use of the system to be designed.
- Definition in **COHESIVE**: Personas create reliable and realistic representations of key audience segments for reference (Usability.gov, 2019a). The creation of personas helps designers and the project team understand the end user's needs, experiences, behaviours and goals. They clarify that different people have different needs and expectations and can be used to support ideation and the creation of a user experience for target user groups.

Profile vector

- Definition in **IP4MaaS**: A set of socio-demographic characteristics and their ranges with significant differences on needs and expectations when facing IP4 solutions.
- Definition in **COHESIVE** as *User/Traveller profile*: A user/traveller profile is a representation of a group/segment of users/travellers. A profile of users may have been grouped together based on similarities across their demographics, needs, pain-points, goals and/or behaviours.

Use Case

- Definition in **IP4MaaS**: Intersection of a demonstration scenario with a profile vector.
- Definition in **COHESIVE**: Description of how a user will perform a task, from the specific user's point of view. Each use case is represented as a sequence of simple steps, beginning with a user goal and ending when the goal is fulfilled. (A) = Profile + journey purpose; B) = TSP)

User Journey

- Definition in **IP4MaaS**: An itinerary considering a specific origin and destination in a demonstration site. Represents a scenario in which a user may interact with services and products of one or more TSPs to perform the considered itinerary.
- Definition in **COHESIVE**: A user journey is a series of steps which represent a scenario in which a user might interact with the service or product being designed. They can be used to demonstrate how users are or might interact with the service or product being developed. A user journey will draw on a user's goals, motivation, pain-points, [needs], their overall character and the main tasks they want to achieve. In this case, the user journey can be for both travellers and transport service providers

8. Methodology to identify “Operational KPIs”

Before starting this section, the concept **Operational KPI** is defined as a quantitative and objective operational indicator that **measures the gain or benefit** of a functionality provided by a specific IP4 Tool for a specific TSP and for a specific user profile.

This deliverable tries to provide an initial list of operational KPIs by considering CFMs recommendations, KPIs from other IP4 projects (Shift2MaaS project, 2020) and other indicators coming from Shift2Rail technical reports.

The D4.1 in Shift2Maas (Shift2MaaS project, 2020) has listed several KPIs for the evaluation,

from a strategic, technical and exploitation point of view, of demonstrations where some IP4 functionalities are used. The IP4MaaS project is taking from this list those KPIs valid to measure the gain or benefit of IP4 functionalities offered by TSPs from an operational or performance point of view. Some others KPIs listed by Shift2MaaS are considered in the USI surveys as they are related to the measurement of the satisfaction by the user when using the IP4 functionality.

Table 2 explains the integration between KPIs identified and handled in Shift2MaaS and the list of KPIs and USI surveys introduced by IP4MaaS, given the two different methodological approaches of both projects:

Shift2MaaS – KPIs are introduced for the evaluation of demonstrations in 3 levels: Strategic, Technical and Exploitation	IP4MaaS – KPIs and USI surveys are introduced to assess the performance and satisfaction of IP4 functionalities by users.
Quantitative and objective KPIs: They can be classified in 2 subcategories:	
A- Linked to operational or performance benefits of IP4 functionalities	Considered as operational KPIs , jointly with other valuable KPIs not introduced by Shift2MaaS, for an automatic assessment applying machine learning techniques (Bayesian Networks)
B- Not directly linked to operational benefits of IP4 functionalities	Not considered in IP4MaaS
Qualitative and subjective KPIs: They can be classified in 2 subcategories	
A- Linked to the satisfaction with the IP4 functionalities by users	Considered as questions in the USI surveys
B- Not directly linked to the satisfaction with IP4 functionalities by users	Not considered in IP4MaaS

Table 2. Differences between KPIs listed in Shift2MaaS and Operational KPIs listed in IP4MaaS.

Per each of the 6 demonstration sites “D” defined in the project, several User Journeys “i” were defined with a different travel solution to go from an origin to a destination through the combination of several means of transport (TSP “k”). A provisional list of KPIs will be proposed based on the technological capabilities of the TSP “k” for the integration of an IP4 functionality “j” (see Figure 1).

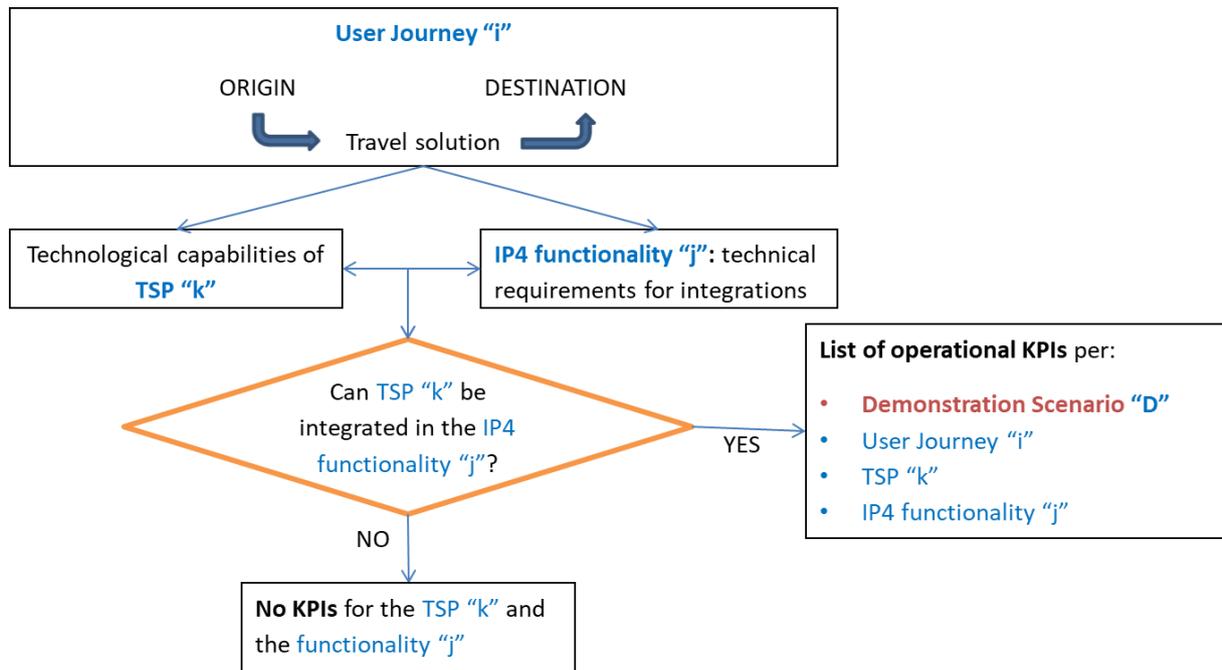


Figure 1. Flowchart to define KPIs

Several means will be used to set the final list of operational KPIs in the deliverable D3.2 “List of operational KPIs, analysis of the users’ satisfaction and methodology as a whole, F-REL” (M17) that will be used to measure the gain or benefit of the intermodality enabled by IP4MaaS.

Each KPI will be measured in a specific unit, and it will be converted in a dimensionless KPI, with a value between 0 and 1, by dividing per the maximum value measured for this KPI linked to a specific functionality among all the demonstration sites, all the User Journeys and all the TSPs. The KPI will be defined in a mean that the higher the better, so a dimensionless value close to 1 will always be better than a dimensionless value close to 0.

The comparison between KPIs will be only possible for a specific functionality “j”, and these dimensionless KPIs will allow us to raise the next kind of assertions:

- **Case 1:** “The functionality “j” is working better for the TSP “k₁” than for the TSP “k₂” in the same Demo site and in the same User Journey (origin-destination)”, or
- **Case 2:** “The functionality “j” is working better for the TSP “k₁” belonging to the Demo site “D₁” in the User Journey “i₁” than for the TSP “k₂” belonging to the Demo site “D₂” in the User Journey “i₂”, or
- **Case 3:** “The functionality “j” is working better for the TSP “k₁” belonging to the Demo site “D₁” in the User Journey “i₁” than for the TSP “k₁” belonging to the Demo site “D₁” in the User Journey “i₂”.

The next table clarifies better this concept:

		Demo site "D"	TSP "K"	User Journey "I"	Measurements of the KPI "I" (in a specific Unit)	Dimensionless KPI "I"
Functionality "j"	Case 1	Warsaw	1	1	20	0.40 (=20/70)
		Warsaw	2	1	50	0.71 (=50/70)
	Case 2	Warsaw	1	1	70	1.00
		Athens	2	2	40	0.57
	Case 3	Warsaw	1	1	30	0.43
		Warsaw	1	2	10	0.14

Table 3. Cases to compare KPIs

Where:

- **Yellow** box is the maximum value for the KPI "I" and the functionality "j" measured among all the demo sites, all the TSPs and all the User journeys.
- **Green** boxes are the ones changing in the Case 1.
- **Blue** boxes are the ones changing in the Case 2.
- **Purple** boxes are the ones changing in the Case 3.

8.1. List of KPIs according to the services offered per each TSP and CFMs' recommendations

The TSP were asked, in an online Google Form survey, to identify which functionalities they offer in their current services that will be ready to be integrated in the IP4 ecosystem.

Although the information provided by the TSPs is included in the "IP4MaaS D2.1. Technology survey C-REL", Table 4 summarizes the last state about functionalities that each TSP partner offers. These functionalities are the starting point to define the provisional list of KPIs and they are in a continuous evolution as they depend, as depicted in the Figure 1, on the technological capabilities of TSPs and the requirements for integration established by CFMs, which are being managed and coordinated in the WP2 (M1-M17).

DEMO SITE	Partner Name:	JOURNEY PLANNING	NETWORK DATA	FARES	BOOKING	ISSUING	VALIDATION	INSPECTION	TRIP TRACKING (POSITIONS)	TRIP TRACKING (DELAYS)	ANCILLARY SERVICES
Barcelona	TMB	YES	YES	No	No	No	No	No	YES ^(*)	YES ^(*)	No
	SOCIAL CAR										
	BUSUP	No	YES	No	No	No	No	No	YES	No	No
Padua	TRENITALIA (FST)	YES	YES	No	YES	No	No	No	YES	No	YES
	BUSITALIA (FST)	YES	YES	No	YES	No	No	No	YES	No	YES
Athens	OASA	No	YES	No	No	No	YES	YES	No	No	No
	TrainOSE	No	No	No	No	No	No	No	No	No	No
	TAXIWAY								No		
	BRAINBOX								No		
	WELCOME PICKUPS										
Osijek	MIRAKLIO	No	No	No	No	No	No	No	No	No	No
	GPP	No	No	YES	No	No	No	No	YES	No ^(**)	No
Liberec	DYVOLVE										
	ČSAD Liberec (CRWS)	YES	YES	YES	No	YES	YES	YES	YES	YES	No
	ARRIVA vlaky (CRWS)	YES	YES	YES	No	YES	YES	YES	YES	YES	No
Warsaw	MZA	No	No	No	No	No	No	No	No	No	No
	ZTM WARSAW	No	YES	YES	No	YES	YES	No	No	No	No
	TRAM WARSAW	No	YES	No	No	No	No	No	YES	No	No

(*)TMB provides a service to forecast ETA of their fleet (bus/metro): not a real trip tracking but close to it

(**)Delays are provided in the form of a JSON document (gpp_zastoji.json) of the currently active delays. This document is generated in the folder on the GPP web server but there is no service to retrieve it.

Table 4. Summary of the functionalities and Network data from the TSP survey

According to Table 4, each TSP should consider the KPIs linked to their available functionalities. To define them, the CFMs were asked to provide a list with the most relevant KPI to evaluate the IP4 functionalities (see Table 5).

KPI	IP4 FUNCTIONALITY	UNITS
Number of real-time information provided	Journey Planning	Number of information per day
Number of involved TSPs in the trip (multimodality)	Journey Planning	Number per day
Number of different ticket systems merged in only one (QR)	Booking	Number of tickets included in one QR per day
Total number of Ticket(s) purchased	Validations and Inspection	Number of tickets validated per day
Number of real-time information provided to help users during their travel	Trip Tracking	Number of information provided in the Trip tracking functionality per day
Number of connections to the navigation pre/during trip	Trip Tracking	Number of entries to the functionality per day
Number of ancillary services	Ancillary Services	Number per day
Number of supports in case of disruption	Alternatives calculation	Number of helps when a disruption happened per day

Table 5. List of the provisional KPIs per functionalities identified by CFMs

8.2. KPIs from Shift2MaaS project

Moreover, the work reported in Shift2MaaS D4.1 “KPIs Definitions” (Shift2MaaS project, 2020) was taken into consideration. KPIs considered in the Shift2MaaS project cover three different levels:

- **Strategic Level:** high-level KPI extracted from Shift2Rail Multi-Annual Action Plan (MAAP);
- **Technical Level:** KPI defined by Shift2MaaS to measure technical aspects related to IP4 technologies. Each KPI is associated with a specific IP4 functionality (e.g., journey planning, issuing);
- **Exploitation Level:** KPIs defined to measure the impact of Shift2MaaS demonstrations.

Table 6 identify the KPIs coming from the Shift2MaaS project that will also be used in the IP4MaaS.

KPI	IP4 FUNCTIONALITY	UNITS
TSP web-services acting as JP integrated into the IP4 ecosystem	Journey Planning	Number of TSP integrated
Successful proposal of multimodal travel solution	Journey Planning	Number of multimodal travel solutions shown per day
Number of users adopting IF assets	Journey Planning	Number of users per day
Available travel solutions for customers (due to the integration of transport modes)	Journey Planning	Number of travel solutions shown per day
TSP web-services for issuing process integrated into the IP4 ecosystem	Issuing	Number of TSP integrated
Successful issuing of multimodal travel solutions	Issuing	Number of issues per day
Validation systems integrated	Validation	Number of validation systems integrated
TSP locations (stations, platforms) available for navigation	Trip Tracking	Number of TSP locations
Successful delivery of notifications on the status of a planned trip	Trip Tracking	Number of successful notifications per day
TSP web-service integrated for shopping of ancillary services	Ancillary services	Number of TSP integrated
Shopping of ancillary services through the integration of a static list of available services	Ancillary services	Number of items bought from the list per day
Service offerings to travellers (in case of disruption)	Alternatives calculation	Number of services per day

Table 6. List of the provisional KPIs gathered from the Shift2MaaS project.

8.3. KPIs from the literature review

Additionally, to the KPIs gathered from the Shift2MaaS and provided by the CFMs, the next step was to collect general KPIs from the literature review. These KPIs complete the initial list of KPIs (Table 5 and Table 6). For the literature review, several Shift2Rail papers and technical reports were analysed to gather more KPIs that were applicable to compare the scenario before and after implementing the tool that will support the intermodality.

Table 7 is a scoping review table in which the keywords and number of papers linked are summarized.

Keyword	Database	Year*	Number of results
Rail intermodal indicator	Scopus Web of science	2017	3
Sustainability transportation system	Scopus Web of science	2006	9
Shift2Rail indicator	Webpages ⁵	2017	6
European Rail Research	Webpages ⁶	2007	2

Table 7. Scoping review. * Year refers to the year of the most recent document.

Intermodality facilities should connect passengers and also strive for a comfortable, safe, and efficient movement of passengers between various modes of transportation (Pelangi, Situmorang, Levara, & Taki, 2021).

Urban transport planning includes scientific and technical knowledge to actions in urban space. In recent years a lot of smart technologies have been promoted for urban problems solving (Yatskiv & Budilovich, 2017). In the context of increasing urbanization, it is essential to find innovative methods to manage urban living systems and to establish a standard method for assessing the environmental performance of cities and their infrastructures (Maranghi et al., 2020).

Cities and urban communities can play a crucial role in the global work of improving sustainability (Wolfram, Frantzeskaki, & Maschmeyer, 2016).

Sustainable transportation has been object of many research, amongst which those dealing with the impact of land use, including social aspects and quality of life (Scheiner, 2006), optimization of city logistics and mobility (Ahmadi-Javid & Hooshangi-Tabrizi, 2015; Anand, Yang, Van Duin, & Tavasszy, 2012), optimization of infrastructure (Khadaroo & Seetanah, 2007), economic efficiency (Litman, 2016), behavioural factors influencing voluntary reduction of car use (Bamberg, Fujii, Friman, & Gärling, 2011), etc. (Ngossaha, Ngouna, Archimède, & Nlong, 2017).

⁵ <https://shift2rail.org/publications/annual-activity-reports/>
<https://shift2rail.org/publications/multi-annual-action-plan/>
https://shift2rail.org/wp-content/uploads/2021/06/Shift2Rail-Master-Plan_approved-by-S2R-GB.pdf

⁶ <https://www.vialibre-ffe.com/PDF/errac07.pdf>
<https://errac.org/publications/rail-strategic-research-and-innovation-agenda-december-2020/>

Table 8 shows a provisional list of KPIs coming from the literature review and their source that complement the ones provided by the CFMs and listed in Table 5.

KPI	SOURCE	FUNCT. LINKED TO	UNITS
% increase the capacity of railway segments to meet increased demand for passenger	(Shift2Rail, 2020)	General	% of tickets offered with and without the Tool per user journey and per day
% decrease in unreliability and late arrivals	(Shift2Rail, 2020)	Trip Tracking	% of delays with and without the Tool per user journey and per day
Number of people older than 65 that ask for reserved seats	(European Rail Research Advisory Council, 2007)	Issuing	Number per user journey and per day
Ratio between claims for security reasons before and after the IP4 Tool	(European Rail Research Advisory Council, 2007)	General	Ratio per user journey and per day
Increase the capacity for a given infrastructure, by increasing the number of trains (control and command), while increasing the number of seats per train (rolling stock) and reducing the LCC (of the rolling stock and infrastructure).	(Shift2Rail Joint Undertaking, 2019)	General	Number of seats per user journey, per TSP and per day
Increase the number of passengers (occupied seats) by providing them with better reliability and quality of service, including one-stop shopping and seamless travel, and through better integration of rail into the overall mobility ecosystem.	(Shift2Rail Joint Undertaking, 2019)	General	Number of passengers per user journey per day
Ratio of attractiveness of the rail services for passengers with the IP4 tool and without (Increase the attractiveness of rail services for passengers)	(The European Rail Research Advisory Council, 2020)	Journey Planning	Number of passengers per user journey per day
Time reduction with the IP4 tool	(The European Rail Research Advisory Council, 2020)	Journey Planning	Minutes saved per user journey with the Tool per day
Cost reduction with the IP4 tool	(The European Rail Research Advisory Council, 2020)	Fares	Money saved per user journey with

	Council, 2020)		the Tool per day
Reduction of walking time due to the IP4 tool helps in choosing the shorter way.	(The European Rail Research Advisory Council, 2020)	Journey Planning	Minutes saved per user journey with the Tool per day
Reduction of waiting time due to the IP4 tool indicates the timing of the different means of transport per each trip.	(The European Rail Research Advisory Council, 2020)	Journey Planning	Minutes saved per user journey with the Tool per day
Number of ticketing and booking per month.	(The European Rail Research Advisory Council, 2020)	Booking	Number of tickets per user journey per month
Reducing carbon emissions, noise and air pollution	(The European Rail Research Advisory Council, 2020)	Journey Planning	Number of carbon emissions reduced per day using the Tool

Table 8. KPIs gathered from the literature review

8.4. Provisional list of KPIs for the demonstration sites

The addition of the KPIs coming from the CFMs of Table 5, the ones in Table 6 coming from the Shift2Rail project and the ones in Table 8 coming from the literature review will provide the provisional list of KPI in this deliverable C-REL version that will be used for measuring in the first demonstration phase during 2022 based on the functionalities shown in Table 4.

The F-REL list of KPIs which will be measured in the second demonstration phase with the new functionalities developed in the recent IP4 projects such as Extensive will be included in the D3.2 (M17)

All the KPIs will be dimensionless handled to calculate the Efficiency as detailed in Section 10 by dividing between the maximum value belonging to this specific KPI, getting a dimensionless value between 0 and 1 (see Section 8).

9. User Satisfaction

The quality of the public transportation service system is closely related to passenger satisfaction through service quality assessment (Pelangi et al., 2021). It is necessary to face a situation where an attribute may have different evaluation values in the aspect of multimodal transport evaluation (Han, Wan, & Zhou, 2020).

In contrast to the KPI definition, the **User satisfaction index (USI)** quantitatively, but subjectively, **measures the utility** that a functionality provided by a specific IP4 tool offers to a specific TSP and to a user with a specific profile. One USI will be generated to evaluate the travellers' satisfaction level with the TSP involved and one more USI will be collected for TSP.

There will be 2 types of USIs:

1. **USI questionnaire for Travellers** with the following two sections:
 - Part A: Questions about needs and expectations (see Annex 1, section 14.2). This questionnaire includes a specific section with questions for all profiles, and a second section with profile-based questions, which only will be answered by those users that in the socio-demographic questionnaire select this option.
 - Part B: Socio-demographic questionnaire for travellers that will support the analysis of satisfaction per profile ("r") (see section 15, Annex 2).
2. **USI questionnaire for TSPs**. This questionnaire only has Part A (see Annex 1, section 14.1)

Outputs of the WP2 have been used for the preparation of both USI questionnaires.

"USI questionnaire for Travellers – Part A" and "USI questionnaire for TSPs" are designed in a Likert scale (Misra & Panda, 2017) where 1 is a low level of satisfaction and 5 is a high level of satisfaction. The USI questionnaire document asks about all the functionalities "j" and all the TSPs "k" offering this functionality to the travellers. However, the satisfaction index will be calculated for a specific functionality "j", a specific TSP "k" and a specific profile of traveller "r" by filtering the related questions in the "USI questionnaire for TSPs" (Annex 1. Section 14.1) and in the "USI questionnaire for Travellers – Part A" (Annex 1. Section 14.2).

Two different USI indicators will be calculated:

- 1) One for the obtainment of the index regarding the **TSP' satisfaction** about the integration of the IP4 functionality.
- 2) And another for the obtainment of index regarding the **travellers' satisfaction** with the IP4 functionalities offered each TSP. This index can be calculated for all travellers, or for a specific selected profile.

These two USI indicators will be further used in the Efficiency formula (see Section 10, from Eq. 3 to Eq. 6)

Evaluation of USI responses can be done in different ways, aggregating, analysing the frequency of responses, calculating the mean, the median or the mode, performing X^2 test, Mann-Whitney U test, etc. Some experts have also indicated that if there is an adequate sample size (at least 5–

10 observations per group) and if the data are normally distributed (or nearly normal), parametric tests can be used with Likert scale ordinal data (Sullivan & Artino, 2013). The use of the mean is acceptable when the sample follows a normal distribution. If the sample finally obtained does not follow this normal distribution, instead of the mean it will be used the median (Boone & Boone, 2012). In addition, the aim of equations 1 and 2 is to obtain an overall satisfaction value that can be easily understandable. Therefore, it has been selected the use of the mean instead of, for example only the sum. Moreover, the division by 5 (e.g. in equation 1) is applied since we want to give at the end a normalised value between 0 and 1 that is easier to understand than a value from $1 \times n$ questions to $5 \times n$ questions. In addition, by defining USI indicators in this way, both will get a value between 0 and 1 which can be directly introduced in the formula to calculate the Efficiency (Section 10, from Eq. 3 to Eq. 6).

The **satisfaction index of a TSP “k” regarding the integration of the IP4 functionality “j”** ($USI_{TSP_{jk}}$) can be seen in Eq. 1.

$$USI_{TSP_{jk}} = \frac{\sum_{v=1}^{n_j} Score_{question_v}}{n_j \cdot 5} \quad (\text{Eq. 1})$$

Being, $Score_{question_v}$, the score to the question number “v”, and “ n_j ” the number of questions in the USI questionnaire belonging to a specific functionality “j” offered by the TSP “k”. A 5 appears dividing in order to normalize and obtain a value between 0 and 1 due to the answer to each question has a value between 1 (representing the minimum satisfaction) to 5 (representing the maximum satisfaction).

The **obtainment of the satisfaction index of travellers**, for all of them or for a specific profile, with the IP4 functionalities offered by each TSP can be seen in Eq.2. This equation calculates the average of the scores of questions corresponding to a specific functionality “j” offered by a TSP “k” for a selected profile “r”, and it is normalized by dividing by 5. When the profiles selected does not have a specific question in the questionnaire then the term “ n_{2jk} ” will be 0, but when a profile has an associated question, then the scores to these questions will be also considered, and “ n_{2jk} ” will be the number of questions associated to this profile and associated to the functionality “j” offered by the TSP “k”.

$$USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}} Score_{question_{wv}}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}) \cdot 5} \quad (\text{Eq. 2})$$

Being:

$Score_{question_{wv}}$ = the score to the question “v” by the respondent “w”.

n_{1jk} = number of questions applicable to all the profiles measuring the satisfaction with the functionality “j” offered by the TSP “k”.

n_{2jk} = number of questions applicable only to the profile “r” measuring the satisfaction with the functionality “j” offered by the TSP “k”.

m_{rjk} = number of respondents to the USI questionnaire belonging to the profile “r”

measuring the satisfaction with the functionality “j” offered by the TSP “k”.

In order to better understand Eq. 2 it has taken as an example the evaluation of the satisfaction index of travellers to the functionality “Booking”. The questions number 4, 5, 6 and 11 shown in the “USI questionnaire for Travellers – Part A” (Annex 1, section 14.2) refer to this functionality (see Table 11), functionality that is evaluated for a TSP “k”. The next considerations apply in this example:

- 1) Questions 4, 5 and 6 are applicable to all the profiles measuring the satisfaction with the functionality “Booking” offered by the TSP “k”, then $n_{1jk}=3$.
- 2) There is only one question associated to a specific profile. Question 11 measures the satisfaction with the functionality “Booking” offered by the TSP “k” by the specific profile “Low incomes”. Therefore $n_{2jk}=1$.
- 3) For this example it is considered that we have 3 respondents of the USI questionnaire belonging to the profile “Low incomes” measuring the satisfaction with the functionality “Booking” offered by the TSP “k”. In this case $m_{rjk}=3$.

The responses for each question and respondent are shown in Table 9.

	Respondent 1	Respondent 2	Respondent 3
Question 4	1	5	3
Question 5	5	3	2
Question 6	3	4	1
Question 11	4	2	4
Total score	13	14	10

Table 9. Example of dataset with the responses to the questions of the USI for travellers associated to the “Booking” functionality and for the profile “Low incomes”.

The Eq.2 provides:

$$USI_{Traveller_{Low\ incomes, Ticketing, k}} = \frac{\sum_{m_{rjk}=1}^3 \sum_{v=1}^{10+2} Score\ question_{wv}}{3 \cdot (3 + 1) \cdot 5} = \frac{13 + 14 + 10}{60} = 0,62$$

9.1. USI questionnaire for TSPs

This USI questionnaire is based on a template filled by TSPs in the Task 2.3 and reported in D2.2 Demonstration requirements and scenarios, C-REL (IP4MaaS project, 2021). Table 10 summarizes the USI questionnaire for TSP (see full USI questionnaire for TSP in Annex 1):

Need & Expectation	Linked Functionality	Nº of question in the USI for TSP
Planner integrating services from different TSPs	Journey Planning	Q1
Plan journeys and notify colleagues/friends about them to possibly share a portion of the trip with the objective of reducing the number of private vehicles.	Journey Planning	Q2
Mobility packages that integrate all TSPs	Mobility packages	Q3
Issuing of online tickets that can be validated/inspected through an application (no paper-based ticket)	Issuing	Q4 Q5
Re-accommodation flow re-planning how to reach a bus stop with an available shared ride using PT.	Alternatives calculation	Q6
Trip tracking on planned journeys with live notifications	Trip tracking	Q7
Navigation during the trip, especially in the interchanges between legs	Navigation	Q8
Information/Experiences for tourists.	Location Based Experiences (LBE)	Q9
Other	-	Q10

Table 10. USI questionnaire for TSPs based on their needs & expectations

9.2. USI questionnaire for Travellers

The “Part A – Questions about Needs & Expectations” was prepared on the basis of the “AS-IS template” (IP4MaaS project, 2021) filled by TSPs according to their experience regarding groups of travellers with special needs and expectations.

The “Part B – Socio-demographic questionnaire” (see section 15, Annex 2) is based on the one used in the DIAMOND project (Revealing fair and actionable knowledge from data to support women’s inclusion in transport systems. Grant Agreement Nº 824326) (DIAMOND Project, 2020).

Table 11 summarizes Part A. See the full USI questionnaire for Travellers in the Annex 1.

Need & Expectation	Linked Functionality	Nº of question in the USI for travellers	Profile linked to
User Journey functionality satisfaction	Journey Planning	Q3	All
Booking functionality satisfaction	Booking	Q4 – Q6	All
Alternatives calculation functionality satisfaction	Alternatives calculation	Q7	All
Navigation functionality	Navigation	Q8 – Q9	All

satisfaction			
Location Based Experience functionality satisfaction	LBE	Q10	All
Special discount fees	Booking	Q11	Low incomes Students Workers Unemployed people Retired people People travelling with dependents
Services offered to accompany and help disabled people from an origin to a destination	Journey Planning	Q12	Disabled people

Table 11. USI questionnaire for Travellers based on their Needs & Expectations

10. Efficiency

All this quantitative data (operational KPIs and USIs) is handled together within the concept “**Efficiency**”, which is an integrated and universal indicator to measure how a specific IP4 functionality “j” is working in the field.

Below it is described how to calculate this universal indicator and how to apply it in different ways:

- **Efficiency of a functionality “j” offered by a specific TSP “k” and used by a specific profile “r”.**

The efficiency of a specific functionality “j” applied by a TSP “k” for matching needs and expectations of a specific profile of travellers “r” will be measured by making use of the monitored operational dimensionless KPIs evaluated as a value between 0 and 1 (see Section 8) and the User Satisfaction Indexes (from TPSs and Travellers) gathered through the surveys (see Section 9 and Annex 1). This efficiency will be calculated by using Eq.3

$$Efficiency_{rjk} = \frac{\sum_{n=1}^N KPI_{nTSPjk} + USI_{TSPjk} + USI_{Traveller_rjk}}{N+1+1} \quad (\text{Eq. 3})$$

Being: “N” the number of operational dimensionless KPIs linked to the functionality “j” offered by the TSP “k”. KPI_{nTSPjk} the value of the KPI “n” belonging to the functionality “j” offered by the TSP “k”.

- **Efficiency of a functionality “j” used by a specific profile “r”**

Eq. 4 gives the expression to calculate the efficiency of a functionality “j” used by travellers

belonging to a specific profile “r”, when all TSPs offering it are considered. The calculation of this efficiency can be particularized for a specific profile of travellers “r” or considering all the data.

$$Efficiency_{functionality\ j_r} = \frac{\sum_{k=1}^M \sum_{n=1}^N KPI_{nTSP_{jk}} + \sum_{k=1}^M USI_{TSP_{jk}} + \sum_{k=1}^M USI_{Traveller_{rjk}}}{N+2M} \quad (Eq. 4)$$

Being: “M” the number of TSPs offering the functionality “j”.

- **Efficiency of a functionality “j” offered by a specific TSP “k” and used by a vector profile “p” with several socio-demographic characteristics “r_i”.**

Eq. 3 can also be applied to a **profile vector p = (r₁, r₂ ... r_n)**, considering different socio-demographic characteristics (age, gender...) by multiplying all the efficiencies calculated through Eq. 3 per each of the profiles of travellers “r” considered:

$$Efficiency_{pjk} = \prod_{r_1}^{r_n} Efficiency_{r_ijk} \quad (Eq. 5)$$

This would be the efficiency of the functionality “j” offered by the TSP “k” for the travellers belonging to the vector profile “p”, or what is the same belonging to the socio-demographic characteristics: r₁, r₂ ... r_n

- **Efficiency of a functionality “j” used by travellers belonging to a vector profile “p” with several socio-demographic characteristics “r_i”.**

And, this efficiency applied to a specific **profile vector p = (r₁, r₂ ... r_n)** could be also calculated over the contracted efficiency obtained by the Eq. 4:

$$Efficiency_{functionality\ j_p} = \prod_{r_1}^{r_n} Efficiency_{functionality\ j_{r_i}} \quad (Eq. 6)$$

In all the cases, the Efficiency will be a value between 0 and 1, and for comparison between TSPs “k”, Functionalities “j”, profiles “r” or vector profiles “p”, the higher the better.

11. Representativeness of the sample

Due to the fact that the Efficiency will be calculated for a specific functionality “j”, offered by a TSP “k” regarding travellers belonging to a profile “p”, with several socio-demographic characteristics r_i (see Section 10), this calculation will need a representative number of travellers, given that TSPs and functionalities are fixed by framework conditions.

This section will identify the number of travellers to be involved through the user engagement strategy which will be defined in D4.4 per each functionality “j” and a specific TSP “k”.

Representativeness of the sample for the aggregated analysis

An aggregated analysis is that for which profiles of travellers “r” or vector profiles “p” are not considered.

Survey Monkey’s sample size calculator⁷ was used to calculate the representative sample for this aggregated analysis. Considering a 0.5 size effect, a 95% confidence level and 80% power of the test, the number of respondents to be achieved (N_T) are 385. Rounding this value up, there should be achieved **400 respondents per each Demo site** for the “USI questionnaire for Travellers – Part A” (for all the profiles “r”, all the functionalities “j” and all the TSPs “k” involved in the “Demo site”). The mathematical model underlying the Survey Monkey’s sample calculator is detailed in Annex 3.

These 400 respondents will be selected randomly without any kind of bias in order to be sure that they are a representative sample of all kind of users’ population per each demo site. Initially, all travellers from different profiles “r” using functionalities “j” offered by TSPs “k” involved in each “Demo Site” (D) will be invited to test these IP4 functionalities in the field and to fill the User Satisfaction questionnaire according to their own experience. The invitation will be launched to all travellers and consequently the sample selection will be done under a random criterion.

Representativeness of the sample for specific profiles

In addition to the aggregated analysis, this section defines how to calculate the representative sample size for a specific profile.

The minimum number of respondents belonging to a specific profile “p” (N_P) can be obtained by multiplying the significant sample size (N_T) for the aggregated analysis per the proportion of people pertaining to a specific profile “p” ($\%_P$), which is calculated as the multiplication of the proportion of people belonging to each specific socio-demographic characteristic “r_i” ($\%_{r_i}$) (see Eq. 7). Table 12 shows the proportion of people belonging to each specific socio-demographic characteristic “r_i” based on data from Eurostat of 2018.

$$N_P = N_T \cdot \%_P = N_T \cdot \prod_{r_i} \%_{r_i} \quad (\text{Eq. 7})$$

For example, the required number of respondents to the “USI questionnaire for Travellers – Part A” gathered for women, between 25-65 years old and with any disability, measuring the satisfaction of a specific functionality “j” offered by a specific TSP “k”, would be:

$$N_{(\text{Women},25-65,\text{disability})} = 400 \times 0.51 \times 0.53 \times 0.176 = 19$$

⁷ <https://es.surveymonkey.com/mp/sample-size-calculator/>

Characteristic of the PI		Probability EU-28 (% p_i)
Age⁸	Age<25 years	0.26
	25<Age<65	0.53
	Age>65 years	0.22
Gender⁹	Male	0.49
	Female	0.51
	Other	No data
Disability¹⁰	With disability	0.176
Economic level	Average salary ¹¹	31833 €
	%Low wage earners ¹²	17.19

Table 12. Table of probabilities for the intersectional analysis.

This calculation about the representative sample size for specific profiles will not be done for those socio-demographic characteristics different to the ones listed in Table 12, as these percentages are not available nowadays in Eurostat.

Initially, all the users of the TSPs will be invited to test the IP4 functionalities in the field and to fill the User Satisfaction questionnaire according to their experiences. The invitation will be opened to all the users and consequently the sample selection will be done under the random criterion.

In theory, by opening the invitation to all the users, the sample achieved should have a socio-demographic distribution according to the European distribution given by Eurostat. However, if the IP4 functionalities would be tested in a biased demo site, this socio-demographic distribution of the sample could be misaligned with the socio-demographic distribution of Europe. To avoid this, regular analysis of the sample taking part in the testing process will be conducted in order to identify lacks in the sample size per specific profiles and the participation in the testing process of these underrepresented profiles will be encouraged.

⁸ Source: Eurostat. Population: Structure indicators [demo_pjanind]. Data from 2018.

⁹ Source: Eurostat. Population on 1 January by age and sex [demo_pjan]. Data from 2018.

¹⁰ Source: Eurostat. Population by sex, age and disability status [hlth_dpeh005]. Data from 2012.

¹¹ Wages and salaries (excluding apprentices) per employee in full-time equivalents, per year for companies with 10 employees or more in the transportation and storage sector. Data source: Labour cost, wages and salaries, direct remuneration (excluding apprentices) by NACE Rev. 2 activity) - LCS surveys 2008, 2012 and 2016 [lc_ncost_r2]

¹² Low wage earners are defined as employees who earn two thirds or less of national median gross hourly earnings. Data source: Eurostat. Low-wage earners as a proportion of all employees (excluding apprentices) by sex for companies with 10 employees or more [earn_ses_pub1s]. Data from 2014.

12. Conclusions

To achieve the main goal of the IP4MaaS project of designing, executing, monitoring and assessing the Shift2Rail IP4 demonstrations by liaising between CFMs, TSPs and users, several indicators will be needed so as to define the satisfaction and utility of the IP4MaaS tools to increase and facilitate the intermodality.

This deliverable *D3.1 List of operational KPIs, analysis of the users' satisfaction and methodology as a whole*, C-REL describes:

- Terms used in the IP4MaaS, differentiating those adapted from other IP4 projects and those newly introduced in this project,
- The methodology to define the list of KPIs to measure the gain or benefit of a functionality provided by a specific IP4 Tool in a specific TSP and for a specific user profile,
- Provisional list of KPIs for a specific demonstration site,
- The User satisfaction index to measure the utility, from the users and TSPs perspective, that a functionality provided by a specific IP4 tool offers to a specific TSP and to a user with a specific profile and
- The Efficiency of a specific technology innovation.

This document is a C-REL version that will be updated and completed in the deliverable “*D3.2. List of operational KPIs, analysis of the users' satisfaction and methodology as a whole, F-REL*” in M17.

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14. Annex 1: USI surveys

14.1. USI questionnaire for TSPs

1. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with integration of your services in the IP4 Journey Planning

1	2	3	4	5
<input type="checkbox"/>				

2. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the integration of the car sharing / ride sharing / car-pooling in the Journey Planning

1	2	3	4	5
<input type="checkbox"/>				

3. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the mobility packages that integrate products offered by all the TSPs involved

1	2	3	4	5
<input type="checkbox"/>				

4. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the integration of the issuing functionality that allows online tickets to be validated through the IP4MaaS application

1	2	3	4	5
<input type="checkbox"/>				

5. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the possibility to print the ticket in a paper format

1	2	3	4	5
<input type="checkbox"/>				

6. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the integration of the Alternatives calculation functionality in the case of disruption

1	2	3	4	5
<input type="checkbox"/>				

7. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the integration of the trip tracking functionality to provide alive notifications during the trip

1	2	3	4	5
<input type="checkbox"/>				

8. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the integration of the navigation functionality during the trip, especially in the interchanges between different means of transport

1	2	3	4	5
<input type="checkbox"/>				

9. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the Location based experience functionality

1	2	3	4	5
<input type="checkbox"/>				

10. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the increasing in number of travellers by using the IP4MaaS Travel Companion

1	2	3	4	5
<input type="checkbox"/>				

14.2. USI questionnaire for travellers

Questions for ALL profiles:

1. Identify your user journey:

2. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the different services offered by the TSPs involved in the trip to go from the origin to the destination

1	2	3	4	5
<input type="checkbox"/>				

3. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the journey planning offered by the Travel Companion

1	2	3	4	5
<input type="checkbox"/>				

4. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the different tickets/subscriptions to incentive the usage of Public Transport and sharing mobility services?

1	2	3	4	5
<input type="checkbox"/>				

5. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the possibility of purchasing a multimodal ticket that allow you to travel from the origin to the destination

1	2	3	4	5
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

6. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the issuing of online tickets that can be validated through the Tool

1	2	3	4	5
<input type="checkbox"/>				

7. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the re-accommodation

1	2	3	4	5
<input type="checkbox"/>				

8. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the navigation functionality during the trip

1	2	3	4	5
<input type="checkbox"/>				

9. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the navigation functionality during the trip, especially in the interchanges between different means of transport

1	2	3	4	5
<input type="checkbox"/>				

10. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the Location based experience functionality

1	2	3	4	5
<input type="checkbox"/>				

Questions for SPECIFIC profiles:

11. PROFILE: student, unemployed, retired people, people accompanying passengers with special needs. On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the special fees and discounts for

specific groups of people such as students, unemployed people, retired people, people accompanying passengers with special needs.

1	2	3	4	5
<input type="checkbox"/>				

12. PROFILE: Disabled (Person on a wheelchair, with reduced mobility, with visual impairment, hearing impaired, other). On a scale from 1 to 5 (strongly disagree, disagree, partly disagree, agree and strongly agree), evaluate your satisfaction level with the services TSPs provide to accompany and help for disable people during the trip

1	2	3	4	5
<input type="checkbox"/>				

15. Annex 2: Socio-demographic questionnaire for the travellers USI survey

1. Do you consider yourself to live in a:

- a. Rural environment
- b. An urban environment
- c. Suburban environment
- d. Abroad/tourist

2. What age bracket are you?

- a. 18-24 years
- b. 25-64 years
- c. 65 years or more
- d. Prefer not to answer

3. What is your average yearly income?

- a. Less than 11,999 €
- b. 12,000-40,999 €
- c. More than 41,000 €
- d. Prefer not to answer

4. Do you travel on a weekly basis with a dependent person?

- a. No
- b. Preschool age children (under 5 years)
- c. School age children (5-16 years)
- d. Elderly relative
- e. Disabled person
- f. Prefer not to answer

5. What is your professional status?

- a. Non-paid work
- b. Paid work
- c. Student
- d. Keeping house/house maker Home maker
- e. Retired
- f. Unemployed
- g. Prefer not to answer

6. Do you currently have an illness, impairment or disability which affects how you travel that has an expected duration of 12 months or more?

- a. No
- b. Person on a wheelchair
- c. Person with reduced mobility
- d. Person with visual impairment
- e. People hearing impaired
- f. Other
- g. Prefer not to answer

7. Do you identify as:

- a. Male
- b. Female
- c. Other
- d. Prefer not to answer

8. Are you familiar with the technology?

- a. Yes
- b. No

16. Annex 3: Representativeness of the sample size for the aggregated analysis

The significant sample size or minimum number of responses to obtain results with a level of confidence α can be represented as N_T . For this calculation it is applied the Null Hypothesis test where:

a) The null hypothesis (H_0) and the alternative hypothesis (H_1), being:

H_0 : The mean or mode of the population (μ_0 or m_0) is equal to the mean or mode of the sample (μ or m) ($\mu = \mu_0$ or $m = m_0$)

H_1 : The mean or mode of the population is different to the mean or mode of the sample ($\mu = \mu_1 \neq \mu_0$ or $m = m_1 \neq m_0$)

- b) The confidence level $(1-\alpha)$ is defined as how much sure you are about considering true the null hypothesis (H_0). Usual values of confidence level range from 90-95%, what corresponds to levels of significance α of 0.1 to 0.05. α is the probability to reject the null hypothesis when it is true ($\mu = \mu_0$): It is called error type I.
- c) The power of the test defined as $(1 - \beta)$. Being β the probability of accepting the null hypothesis when it is not true ($\mu = \mu_1$): It is called error type 2. When the power increases, the probability of a type II error decreases.
- d) The standard deviation of the population (σ).
- e) Expected effect size: $\delta = \frac{\mu_0 - \mu_1}{\sigma_{tested\ population}} = \frac{\mu_0 - \mu_1}{\sqrt{p \cdot (1-p) \cdot N_T}}$ which is the accepted deviation between the means (or modes) by the decision makers in order to accept or reject the null hypothesis.

After this, it is considered a normal distribution with a mean (μ), or mode (m), and a standard deviation of the total population (σ):

- α =significance level= Probability of error type I=Probability to reject the null hypothesis when it is true ($\mu = \mu_0$)
- β =Probability of error type II=Probability to accept the null hypothesis when it is not true ($\mu = \mu_1$)

These expressions can be formulated, by normalizing to a standard normal distribution with $\mu=0$ and $\sigma=1$, according to Eq. 8a and Eq. 8b

$$\alpha = P(\bar{X} > a(\alpha) \quad \text{when } \mu = \mu_0) = P\left[\frac{\bar{X} - \mu_0}{\sigma} = Z > \frac{a(\alpha) - \mu_0}{\sigma} = \mathbf{Z}_\alpha\right] \quad (\text{Eq. 8a})$$

$$\beta = P(\bar{X} < a(\beta) \quad \text{when } \mu = \mu_1) = P\left[\frac{\bar{X} - \mu_1}{\sigma} = Z < \frac{a(\beta) - \mu_1}{\sigma} = \mathbf{Z}_\beta\right] \quad (\text{Eq. 8b})$$

Being \bar{X} the mean (or the mode) of the tested sample (N_T).

From Eq. 8a and Eq. 8b:

$$a(\alpha) = Z_\alpha \sigma + \mu_0 \quad (\text{Eq. 8c})$$

$$a(\beta) = Z_\beta \sigma + \mu_1 \quad (\text{Eq. 8d})$$

Replacing $\mu_1 = \mu_0 + \delta$ and $\sigma^2 = \sqrt{p \cdot (1-p) N_T}$ in the Eq. 8d, and doing $a(\alpha) = a(\beta)$, the representative sample (N_T) for this confidence level $(1- \alpha)$, power of the test $(1- \beta)$ and acceptable effect size is:

$$N_{Tij}^* = \frac{(z_\alpha + z_\beta)^2 \cdot \sigma^2}{p(1-p) \cdot \delta^2} \quad (\text{Eq. 7})$$

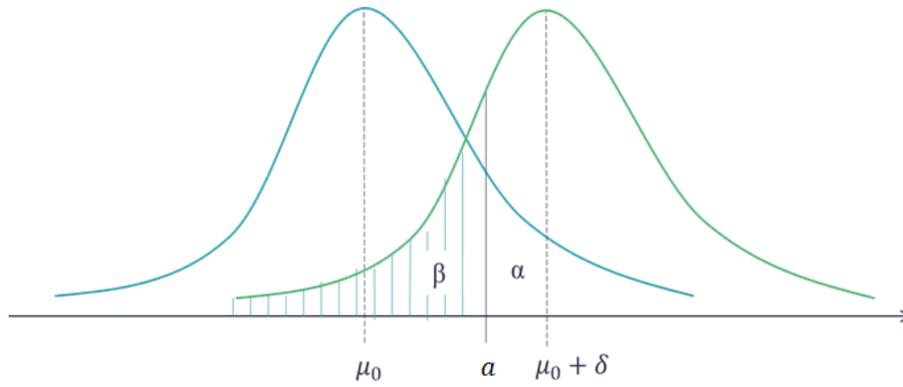


Figure 2. Representation of the regions for error type I (α) and II (β).