



Deliverable D6.4 Final Assessment Report: conclusions about COHESIVE solutions efficiency and impact

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1. Executive Summary

The IP4MaaS Project aimed at demonstrating the benefits of Innovation Programme 4 (IP4) through pilot demonstrators of collective and shared mobility services in six different European countries' cities: Athens, Barcelona, Padua, Liberec, Osijek, and Warsaw. The technologies have been created within IP4 Shift2 Rail Joint Undertaking (S2R JU), developed within the COHESIVE¹ project, and tackled various aspects of traveller experience, meaning the interoperability of Transport Service Providers' (TSPs) services, travel shopping, booking & ticketing, trip tracking, travel companion technologies, and business analytics.

This document constitutes the Deliverable *D6.4 Final Assessment Report: conclusions about COHESIVE solutions efficiency and impact* which aims to summarise the combined outcome of project tasks 6.2 and 6.3 and to deliver conclusions and relevant guidelines for measures aiming at enhancing the performances and the socio-economic impact of COHESIVE solution in a greater influential area.

The document starts with the introductory section, followed by the project background and the overall evaluation objectives of the deliverable (sections 5 and 6).

In Section 7 the assessment methodology, introduced at the beginning of WP6, is summarised to present tools and methods that guided the project evaluation activities.

Section 8 summarises the main evaluation results, reported in detail in *D6.3² Performance and impact assessment*.

Section 9 presents the final assessment with encountered barriers, the contribution of the project to the MaaS development, and the guidelines for future MaaS achievements in the framework of Europe's Rail Joint Undertaking efforts.

¹ https://projects.shift2rail.org/s2r_ip4_n.aspx?p=COHESIVE

² IP4MaaS Project Deliverable D6.3 Performance and impact assessment, <https://zenodo.org/communities/ip4maas/>

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
CFM	Calls for Members
EU	European Union
IP4	Innovation Programme 4
KPI	Key Performance Indicator
MaaS	Mobility as a Service
OC	Open Call
S2R JU	Shift2Rail Joint Undertaking
TC	Travel Companion
TSP	Transport Service Provider
USI	User satisfaction Index
WP	Work Package



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5. Background

The present document constitutes the Deliverable *D6.4 Final Assessment Report: conclusions about COHESIVE solutions efficiency and impact* in the framework of the W6, Task 6.4 of the IP4MaaS project (S2R-OC-IP4-01-2020, GA 101015492).

Innovation Programme 4 (IP4) aim was to build a digital ecosystem to create door-to door travel in a seamless, multimodal and European-wide transport system based on the railways and IP4MaaS addressed the challenge of providing the individual IT solutions developed in IP4 CFM and OC projects, and consolidated by COHESIVE, by combining them into solutions for specific demonstration/pilot scenarios in multiple real environments across Europe according to their respective use cases.

IP4MaaS executed all activities supporting comprehensive demonstrations of technologies developed within IP4 in 6 Demo sites, monitoring progresses and assessing results in terms of effectiveness (achievement of intended goal and KPIs) and user satisfaction (from the point of view of both travellers and TSPs).

WP6 of the project had the objective to assess the performance and impact generated against the overall project objectives, and to evaluate how performance and impact goals set for the demonstrations were met. The assessment relied on inputs provided by the demo execution (WP5) and by the planning phase (WP4, monitoring activities, and WP3³, KPI definition⁴).

A common methodology was defined in Deliverable *D6.1 Assessment Methodology*⁵, tools for performance assessment developed during the project lifetime and presented in Deliverable *D6.2 Tool for performance assessment*⁶, and complete results of performance and impact assessment reported in Deliverable *D6.3 Performance and impact assessment*⁷.

The present deliverable closes the work of WP6, drawing the conclusions and recommendations of the tested solutions.

6. Objective

IP4MaaS WP6 aims to assess the performance and impact generated by the project through COHESIVE demonstrations concerning the overall project objectives and, after setting performance and impacts goals, to evaluate how they are met in the demonstrations.

The purpose of the document is to summarise the combined outcomes of both performance and impact assessments and to report conclusions and recommendations for measures aiming at enhancing the performances and the socio-economic impact of COHESIVE solution in a greater influential area.

³ IP4MaaS Project, Deliverable D3.3 Final version of the methodological framework for future projects, <https://zenodo.org/communities/ip4maas/>

⁴ IP4MaaS Project, D3.2 : List of operational KPIs, analysis of the users' satisfaction and methodology as a whole, F-REL, <https://zenodo.org/record/7566160>

⁵ IP4MaaS Project, Deliverable D6.1 Assessment methodology, <https://zenodo.org/record/8107277>

⁶ IP4MaaS Project, D6.2 Tool for performance assessment, <https://zenodo.org/record/8107313>

⁷ IP4MaaS Project, Deliverable D6.3 Performance and impact assessment, <https://zenodo.org/communities/ip4maas/>

7. Summary of the Assessment methodology

In Deliverable *D6.1 Assessment Methodology* the assessment methodology was defined, and it was based on KPIs to measure and assess socio-economic and mobility impacts of the tested MaaS offers and derived by direct measurements provided by the deployed technical solutions.

The analysed indicators were classified as objective data (collected and provided by CFMs through the means of an Excel file extracted from Cloud wallet-operational KPIs) and subjective data (collected by different methods reflecting the users' opinions – the USIs surveys).

The expected benefits were linked per the project's objectives and classified per potential beneficiary, as reported in the following table.

Table 1. List of expected benefits per project objective

Specific Objective	Expected benefits for end-users and Local Authorities	Expected benefits for TSPs	Expected benefits for the IP4 ecosystem
O1 - Design and develop a demonstration execution scheme tackling the supervision of technical integration and demonstrations' management subjects		Demonstration monitoring through the measurement, analysis, and synthesis of selected KPIs and User Satisfaction Indexes	Technology mapping in WP2, measured by the number of Integrated Technology Demonstrators (ITDs) and System Platform demonstrations
O2 - Execute co-creation and collaboration activities with demonstration stakeholders for demonstration planning and executing and for aligning the opinions of stakeholders on technology usage and integration		Co-creation actions addressing the concerns of stakeholders	Execution of co-creation actions generating information necessary for the project and increase information sharing between demo stakeholders
O3 - Monitor demonstrations of IP4 technologies in 6 different locations involving different transport operators.			Organisation and monitoring of demonstrations of IP4 technologies
O4 - Assess the realized demonstrations to determine the success of their execution and the level of satisfaction of users with the demonstrated technologies	Measurement of the level of user satisfaction with the implemented technology	Measurement of the level of TSP satisfaction with the implemented technology	

Moving from these expected benefits, two assessment methodologies were extensively outlined,

and results reported in previous WP6 deliverables:

- Performance assessment calculated the Effectiveness rate of each use case through a tool developed on purpose, allowing to compare values thanks to a universal metric.
- Impact assessment complemented the previous evaluation by elaborating an Impact indicator assessing socio-economic and environmental impacts per each Demo site.

Some limitations affected the demonstrations and consequently the evaluation activities, and they are commented in section 9. However, the overall assessment methodology and the derived results can be considered relevant to:

- Provide to developers and involved stakeholders' relevant insights for future refinements;
- Provide to the whole research community with a robust assessment methodology for future studies of the evolving MaaS concept.

8. Summary of the Performance and Impact assessment results

In Deliverable *D6.3 Performance and impact assessment*, results of both performance and impact assessment are reported and they are summarised hereafter.

Overall, the IP4MaaS project demonstrated that MaaS schemes are able to increase the capacity of railway segment to meet the increased demand: the 6 demonstrators, the large number of surveyed potential users in the design phase, and the travel experiences performed by users are deeply analysed with a number of indicators and show that:

- Local transport offers were enriched by integrated travel solutions.
- Local stakeholders (TSPs and Public authorities) were provided with additional travel opportunities meeting concrete use case and travel demand.
- IP4 ecosystem was enriched by integrated demonstrators and data, making it more versatile, and able to face diverse environments (urban and rural transports) and new potential business cases.

Besides these positive aspects, problems encountered during the experimentations, led to low user participation and consequent limited statistical representativeness of the data collected. For a number of reasons, reported in detail in WP5 deliverables, the users registered for tests in the demo sites and the share of them responding to questionnaires was (particularly in some demo sites) relatively low, as shown in the following table.

Table 2. Survey quality indicators for IP4MaaS

Demo site	Sample registered users	Net sample (respondents)	Survey response rate
Barcelona	31	11	35%
Athens (phase 1)	140	17	12%
Athens (phase 2)	79	33	41%
Warsaw	244	204	84%
Padua	77	13	17%
Liberec	124	112	90%
Osijek	43	41	95%

However, both performance and impact assessments were conducted according to the defined methodologies and the results are summarised in the next subsections.

8.1. Performance assessment

The Performance assessment toolbox is based on several mathematical data analysis operations

executed sequentially⁸:

1. AHP (Analytic Hierarchy Process);
2. Regression Analysis;
3. Bayesian Network and Bellman shortest path;
4. ANOVA test;
5. USI of travellers, TSPs & Effectiveness.

The assessment methodology and a 5 Modules Toolbox have been presented in D6.3 “Performance and Impact assessment” to assess the Travel Companion APP/IP4 ecosystem more in general.

The toolbox developed and run to carry out the performance assessment was aimed to answer the following research questions:

1. What features of this ecosystem are more relevant for the users?
2. Which features of this ecosystem have the highest Effectiveness based on satisfaction and operational KPIs for all kinds of profiles and specific profiles?
3. What features of this ecosystem show significant differences regarding socio-demographic profiles?

The three questions were synthetically answered by the results of the **top 10 variables of Effectiveness** for all profiles and in all IP4MaaS demo sites and are listed in the following table:

Table 3. The average value of Effectiveness in all demo sites

No.	Variables	Linked to
1	Mobility packages function for low-income profiles	Traveller
2	Asset manager tool	TSP
3	Travel arrangement function for all profiles	Traveller
4	Digital onboarding function for all profiles	Traveller
5	Intermodal fare optimization for low-income profiles	Traveller
6	Intermodal fare optimization for all profiles	Traveller
7	Mobility packages function for all profiles	Traveller
8	Map content function for all profiles	Traveller
9	Guest user function for all profiles	Traveller
10	Smart location function for all profiles	Traveller

In addition, Regarding the **BN analysis**, the following results have been achieved. As is shown in Table 4 the top 3 factors in each demo site are listed in the following table:

⁸ IP4MaaS Project, Deliverable D6.3 Performance and impact assessment, <https://zenodo.org/communities/ip4maas/>

Table 4. Top 3 factors in each IP4MaaS demo site according to BN analysis

Factors	Demo sites					
	Athens	Padua	Warsaw	Liberec	Osijek	Barcelona
Main factor	General satisfaction with intermodal fare optimization for all profiles	Average number of shopped offers with the journey planning function	Providing safe trips with trip sharing function for all profiles	Providing a convenient tool by TC APP for the people who take care of dependent people with travel arrangement function for disabled profiles	Number of TSPs integrated with Journey planning	Average number of shopped offers with the journey planning function
Second Main factor	Cost-saving with intermodal fare optimization for low-income profiles	Giving instant and fast access to TC APP without registration with guest user function for all profiles	General satisfaction with trip sharing function for all profiles	Providing a convenient tool for families, kids, and the elderly to support them while travelling with travel arrangement function for all profiles	Average number of shopped offers with Journey planning	Time-saving with Journey planning function for all profiles
Third main factor	Making traveller's trips more comfortable and providing more accessible routes with journey planning for disabled profiles	The average number of modes involved in the journey with the journey planning function	Willing to pay for trip sharing function for all profiles	Providing convenient and comfortable trips with trip tracking orchestration function for disabled profiles	The average number of modes involved in the journey with Journey planning	Number of mobility packages offered by TSP with Mobility packages function

The performance assessment toolbox has the capability to be used in a future project assessing

different IP4 innovations or functionalities in different demo sites. This toolbox has the potential to be implemented in different circumstances and considers several socio-demographic profiles and evaluates the satisfaction level of both general profiles and specific (sensitive) profiles. The “Performance Assessment Toolbox” and its scripts, codes, modules, and macros have been exclusively and specifically developed and prepared for the IP4MaaS project.

8.2. Impact assessment

The methodology outlined for the Impact assessment allowed to define indicators for socio-economic and environmental impacts that were grouped in 4 classes. The elaborations for the impact indicators per Demo sites are synthetically provided in the following table as percentages, being 100% the maximum desired state:

Table 5. Values of Impact indicators per Socio-economic and environmental classes and per Demo site

	Socio-economic Classes			Environmental Class	Overall Impact indicator
	User Acceptance	Stakeholder Acceptance	Quality Of Service	Multimodality	
Athens	74%	70%	83%	75%	76%
Barcelona	51%	40%	67%	72%	57%
Liberec	77%	100%	86%	63%	81%
Osijek	68%	60%	69%	76%	68%
Padua	76%	70%	77%	62%	72%
Warsaw	69%	67%	68%	74%	70%

9. Commentaries and recommendations

The results shown in the previous section 8 provides meaningful insights to understand if IP4MaaS solutions are suitable to induce **behavioural changes** towards more sustainable transport modes and what can be related **impacts on mobility systems**.

The limitations encountered are analysed in the following as barriers for the MaaS deployed and the positive results as potential opportunities, both leading to the overall guidelines derived from the project experience.

9.1. Barriers encountered during the IP4MaaS experimentations

As already introduced in *Deliverable D6.3 Performance and impact assessment*, the limited user participation impacted in the statistical representativeness of the data collected.

Although the purpose of the IP4MaaS project was not to reach a large sample and derive solid statistics, the problems encountered during the demonstration may lead to relevant considerations: the low number of testers was generated by specific causes that have been analysed in all Demo sites and are reported hereafter, classified per system functionalities:

- Systems integration:
 - A long integration phase is needed to validate trips data and data exchange protocols from all TSPs and to ensure adequate quality of the final product.
 - A long Internal testing phase is needed to reduce bug and functionality problems.
- User experience
 - A long design, development and testing process is needed to ensure an intuitive and effective User Experience, in an app stable and reactive.
 - The validation process for registering mobile apps into the Apple Store and Google Play is complex and necessary to avoid high abandon rates of users not trusting direct app installations via a provided .apk.
 - Compliance with privacy regulations needs to be carefully addressed to avoid communication issues between providers and users and among users willing to have proper interactions during travel experiences.
- Travel solutions
 - Engaging the large majority of TSPs in a city requires technical and commercial efforts and is a prerequisite to ensure the optimal coverage of the services in the local transport system.
 - Planning and routing functionalities require long and deep training to deliver optimal travel solutions.
- Technical and business barriers regarding the sample size for the performance assessment
 - Achieving a sufficient responses sample size for different socio-demographic profiles has a high significance in the results of data analysis for this study. As an example, considering the limited and insufficient number of responses in some demo sites, the participation of specific (sensitive) profiles (low-income people, disabled people, elderly, and women) was quite low, although this was not unexpected due to the difficulties in recruiting sensitive categories of users. The accuracy of the impact in the assessment phase is strictly dependent from the number of users involved in the demos, and from the completion rates

of the questionnaires. *D6.2 Tool for performance assessment* reports some information on the required sample size for each module of Regression analysis, Bayesian Network analysis, and ANOVA test. These sample sizes (for both general and specific profiles), as described in *D6.2 Tool for performance assessment*, allow to have an accurate and more precise outcome in case of data analysis, minimizing the risk of poor/less significant results in the “USI travellers and USI TSPs”.

Addressing these barriers is crucial to deliver a mature and effective solution, able to compete with existing mobility aggregators (being either mere fare integrators or more advanced MaaS providers).

9.2. Contribution of IP4MaaS to MaaS development

The results shown in section 8, complemented by the final reports of demonstration executions elaborated in WP5 clearly demonstrate that, when users are properly engaged, they appreciate the tested solutions.

The peculiarities of MaaS offer, compared to single transport services, seem to be the most appreciated aspect, and IP4MaaS features address specific needs such as:

- Optimise the cost of the transport according to personal requirements (mobility packages, travel arrangements, fare optimisations).
- Optimise the travel experience (digital onboarding, smart location).
- Facilitate operations of TSPs (asset manager).

The class of indicators referring to impact assessment (User Acceptance, Stakeholder Acceptance, Quality of Service, Multimodality) show high values as well in all Demo Sites.

Despite the limited users’ participation, still in line with other pioneering MaaS experiences, these results confirm that the MaaS schemes, and specifically the IP4MaaS tested solutions, address concrete user needs and have the potential to support large MaaS offers at the EU level and to become technical standards for transport service integrations.

A more detailed analysis can be conducted by looking at the Mobility-as-a-Service evolution. IP4MaaS has been a collaborative effort that involved various stakeholders to advance MaaS in Europe and achieve its environmental, societal, and financial benefits. The approach involved iterative real-life testing with the support of experts in technology and business knowledge.

From the results presented above it is possible to derive two opposite considerations:

- Experimentations were successful in terms of effectiveness and perceived impacts and benefits from both end-users and TSPs.
- The participation in the experimentations was in some cases relatively low and this could lead to the assumption that MaaS adoption has still a long and difficult way toward a sustainable penetration in the mobility market.

The reason behind this apparent contradiction resides in the fact that the deployment of MaaS schemes involves several aspects beyond the digitalisation of transport services and these aspects are a prerequisite for the success of such innovative schemes. A study issued by UITP in May 2019 [1] highlighted the **collaboration** as a main enabling factor for MaaS, listed a number of involved

actors (end-users, MaaS integrator, MaaS provider, TSPs, Public authorities), and proposed different models each of them characterised by peculiarities making them suitable in different environments. Among the proposed models the **Open Platform**, represented in the following figure, seems to have more similarities with IP4 Ecosystem.

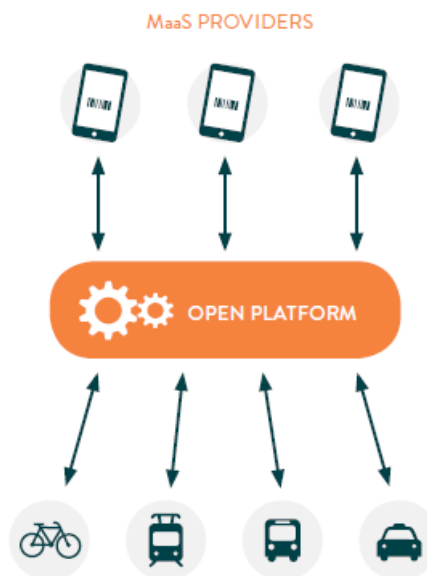


Figure 1. The MaaS Open Platform model (source UITP READY FOR MAAS?)

The MaaS Open Platform model is based on the definition and establishment of rules by a central actor (usually this can be the Public Authority, interested to reach societal goals through transport optimisation), which serves as a central infrastructure on which market actors can build a MaaS solution. Some consideration can be drawn:

- **Strengths:**
 - Central (eventually public) coordination ensures clear conditions and neutrality;
 - Competition among MaaS operators is focused on customer service;
 - The model requires the sharing of APIs by all mobility operators;
 - There is a perception that a customer-oriented service is being offered through an innovative and balanced platform;
 - Local mobility operators are less reluctant to be integrated.
- **Weaknesses:**
 - Investors are not well defined; if a public subsidy is needed, this needs to be carefully designed in order to avoid market distortions;
 - The local character of the platform may prevail, and the EU standardisation could be penalised;
 - Larger international operators may choose not to join the ecosystem if this is not in line with their business strategies.

IP4MaaS was focused on executing and evaluating well-defined use cases liaising CFMs (and IP4 solutions) with TSPs in real environments. The MaaS Open Platform model, matching with the IP4 ecosystem, needs, therefore additional efforts to increase technical maturity and achieve operational readiness in order to be fully accomplished. These efforts were out of the project scope and are the evidence of the limitations encountered project's demonstration that, however, instead of limiting the validity of project results, constitutes the starting point for drawing recommendations for future actions of IP4 towards MaaS second generation.

9.3. IP4MaaS guidelines for future MaaS achievements

The outcomes of the project's results and related evaluations, along with the considerations above reported, lead to the delivery of relevant conclusions and recommendations for the future of Europe's Rail Joint Undertaking efforts in contributing to defining and deploying European rail-focused MaaS offers able to compete with this evolving market:

1. To make MaaS paradigm a reality and reap benefits for citizens and enterprises it is needed to build and maintain a **Community of practice**. IP4MaaS demonstrated that collaborative efforts brought by technical companies (CFMs and project developers), Academy, TSPs, Public Authorities and specialised consultant companies led to defining a framework for design, development, testing and evaluation of complex actions that, besides the deployment of services, support the travellers' behavioural change.
2. The MaaS community works around the principle to have the user at the centre of offer development. Making transport more accessible and sustainable for all, and reducing private mobility modes and negative externalities are the **MaaS societal objectives** that improve inclusion and social cohesion. IP4MaaS evaluation demonstrated that these objectives are highly considered by end-users and should be key aspects when designing transport offers.
3. The prerequisite for successful MaaS offers is a clear **Data sharing policy**: services, tariffs and mobility packages can effectively address user needs if they are built on open and balanced access to information in the MaaS ecosystem. IP4MaaS defined standards for data sharing at the EU level by successfully integrating heterogenous transport systems and several different operators.
4. Among all possible MaaS models, IP4MaaS tested and demonstrated, in real-field conditions, the feasibility and effectiveness of the **Open Backend platform** that becomes a reference model when a centralised environment acts as an aggregator around shared interests, that are represented by the realisation of a digital ecosystem for door-to-door travel in a seamless, multimodal and European-wide transport system based on the railways.
5. The identified Open Backend platform requires as key actor the **MaaS aggregator**, which is the orchestrator ensuring MaaS functioning by coordinating partners' relationships, by ensuring that principles and rules are well-applied and by facilitating data and services intermediation. IP4MaaS demonstrated that the IP4 community, working around CFMs, whose effort is prosecuted in Europe's Rail Joint Undertaking may have a role beyond the research project lifetime and can build stable collaborations looking for a subject/organisation undertaking this pivotal role for future railways promotion.



6. MaaS communities are evolving ecosystems in a very competitive market. Besides the focused Europe's Rail Joint Undertaking objectives to deliver, via an integrated system approach, a high-capacity, flexible, multimodal, sustainable, reliable and integrated EU railway network for European passengers, the **Open approach** is a requirement to be met to avoid monopolies or exclusivities and incentivise service evolution to always address user needs.

10. Conclusions

This deliverable presented the Final assessment report of the IP4MaaS project by proposing conclusions about COHESIVE solutions efficiency and impact.

The work of WP6 has been summarised by reporting the findings of the assessment methodology and the results of both performance and impact assessments.

Outcomes presented in previous Deliverable *D6.3 Performance and impact assessment* allowed to draw relevant conclusions in terms of overall evaluation: encountered barriers during demonstration actions and contributions of IP4MaaS use cases to MaaS development have been presented.

Finally, the document presented IP4MaaS guidelines for future MaaS achievement; in particular the Open Backend platform has been identified as a suitable model for future Europe's Rail Joint Undertaking developments and related guidelines for comprehensive MaaS paradigm deployment have been outlined.



11. References

1. UITP - Ready for MaaS? Easier mobility for citizens and better data for cities – available at <https://www.uitp.org/publications/ready-for-maaS-easier-mobility-for-citizens-and-better-data-for-cities/>