My-TRAC

My TRAvel Companion.

Deliverable D6.3

Roadmap for application improvements and extension

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Executive Summary

This document presents the potential improvements to implement for further development of the My-Trac application, based on the analysis of the pilot phase II. During the pilot phase II, the partners have executed users' focus groups, usability testing, and an extensive assessment of the models integrated in the application. Additionally, all the changes in the different application components after Pilot Phase I, have been reported in each WP respective Deliverable, i.e., the changes regarding the HMI that emerged from Pilot Phase I have been reported in D4.4. During Pilot Phase II, we faced specific travel restrictions due to the Covid-19 crisis that prevented us from testing the application as planned in a real environment. Instead, some of the features of the app were assessed in virtual experiments, such as the validation of the route choice model. The results of the analysis of the Pilot Phase I and Pilot Phase II are reported in the deliverable D6.2. This document builds upon deliverable D6.2 and suggests ameliorations to improve the user's experience, the usability of the application, and the models integrated in the app.

The improvements based on the user's experience were determined based on the analysis of the usability testing, and of the user's study focus group. Some improvements relate to the set-up of the application (account creation, log in…) before use and could be fixed without affecting the design. Some others relate to the intuitiveness of the application: the interface provides too much information and confuses the user, understanding the navigation is not straightforward. The latter ones would require more work.

The activity recommendation was tested with a stated-choice experiment, where participants had to use virtually the application. This virtual experiment helped identifying improvements on the recommendation system and on the activity prediction mechanism. The recommendation system could be improved by providing more visual information on the different points of interest, enabling filtering of activities, and better profiling the user. The activity prediction mechanism could be improved by creating more activity categories, and integrating other data in the analysis, such as the user's calendar.

Concerning the route choice model, the prediction power could be increased by adding more explanatory variables, such as the transit mode. Moreover, the parameters of the model allow to determine how a user perceives each component of the trip (for instance the in-vehicle time, or the walking time) which could be used to determine a personalized itinerary, using a personalized Open TripP lanner request.

The mode choice and time of departure models could be improved by adding variables that account for parameters affecting decision. For instance, the two models could integrate a parameter representing the change in the travellers' habits due a pandemic such as the Covid-19.

To increase the engagement of Transport Service Providers (TSPs) and reinforce the value chain between TSPs, users and the application, the operators' portal (OP) will be improved. First, the OP will allow operators to share the vehicles' location in real-time, allowing the users to track the actual position of the vehicles on a map. Second, an API will be developed to automate communication and data exchange between the OP and the TSPs (currently, the interface between the two is manual).

Abbreviations and Acronyms

API	Application Programming Interface
EC	European Commission
GPS	Global Position System
GDPR	General Data Protection Regulation
GTFS	General Transit Feed Specification
HMI	Human-Machine Interface
IoT	Internet-of-things
OP	Operator's portal
OSS	Open Source Software
OTP	OpenTripPlanner
PC	Project Coordinator
POI	Point of Interest
PT	Public Transport
MaaS	Mobility as a Service
UEQ	User Experience Questionnaire
RP	Revealed Preference
SP	Stated Preference
SUS	System Usability Scale
TRL	Technology Readiness Level
TSP	Transport Service Provider
UI	User Interface
UX	User Experience
WP	Work Package

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

WP6 consists in the design, the execution and the analysis of pilots for testing the My-TRAC application in a realistic environment. The design of the pilots, and the pilots' execution plan are described in deliverable D6.1, while deliverable D6.2 focuses on the execution and results of the pilots both for Phase I and Phase II. The current document (deliverable D6.3) explores the potential improvements for further development of the application, covering the following scope:

- Measurement of models' accuracy
- Guidelines for system improvement in terms of models' performance
- Guidelines to improve user experience in terms of interface usability and adaptability in each of the different functionalities
- Additional insights into passenger choice behaviour.

The My-TRAC application and the My-TRAC operator's portal were tested during pilot Phase I and pilot Phase II to evaluate, the usability of the application, the accuracy of the models, as well as the usefulness of the operator's portal. This allowed to steer the development of the app and to address potential issues arising when using the app in a real environment. Unfortunately, the Covid-19 crisis impacted substantially the execution of the pilots and the dissemination of the application amongst travellers, due to travel restrictions and lockdown measures. The consortium partners set up a contingency plan to adapt to the situation (see deliverable D6.1), and the execution of the pilots is described in deliverable D6.2. The contingency plan allowed evaluating the application in depth, and determining the most relevant improvements for developing the application further. This deliverable presents these improvements based on the evaluation performed and reported in deliverable D6.2.

After this introduction, the second section of this deliverable focuses on the recommendations to improve the user's experience with the application. During pilot Phase I and pilot Phase II, two usability tests were performed, where participants were asked to perform actions with the application, in order to evaluate its usability. The results of pilot Phase I usability testing as well as the recommendations for improvements based on these comments are reported in D6.2. Additionally, in D6.2 the results from the pilot Phase II usability tests are also reported, but not the improvements based on these results. Based on the results of the pilot Phase II usability testing, this document presents recommendations to improve further the usability and the user experience of the app beyond the project. During pilot Phase I and pilot Phase II, the user control groups (pilot I), and the user study focus groups (pilot II) gathered feedback from users of the application. The main observations from the users' feedback are summarized in deliverable D6.2, and the related suggestions for improvements are discussed in this deliverable.

The third section of the deliverable explores potential improvements for the models integrated in the My-TRAC app. The validation of these models is described in deliverable D6.2, while deliverable D6.3 suggests potential improvements that could increase the accuracy of the models, and strengthen the integration of the models in the app.

2 POTENTIAL IMPROVEMENTS BASED ON THE USERS' FEEDBACK

2.1 USABILITY TESTING RELATED RECOMMENDATIONS

My-TRAC usability tests were performed during both pilot Phase I and pilot Phase II. The methodology, the hypothesis as well as the execution details for both phases are reported in D6.1 in detail. Additionally, the results of both Pilot Phase I and Pilot Phase II, are reported in D6.2. The proposals for the update of the app based on the users' comments from the pilot Phase I are also reported in D6.2. Herein, we will provide some guidance on next steps regarding a future update of the app's UI, beyond My-TRAC project, to elevate the user experience (UX) and its usability, based on the results of the pilot Phase II.

2.1.1 DECREASE THE SIZE OF THE LOG-IN QUESTIONNAIRE

The majority of the users at the usability tests (both in pilot Phase I and also in pilot Phase II) were disappointed with the extended size of the log in questionnaire. During the pilot Phase I most of the user commented negatively the extended length of the log in questionnaire and some of them even considered it as a barrier to use the application in real life. Considering the importance of these answers in order to make our models work and achieve providing the user with personalised feedback, we tried to shrink the questionnaire to the minimum for the pilot Phase II. Again, even if the comments were not so intense, they still existed. So we have to reconsider how and when will we get this info from the users without increasing so much their workload in tasks where no effort should be put, like log in. One suggestion is to have the questionnaire divided into two Sections; Section A and Section B. Section A would have the basic questions (5 tops) and will be given to the user during log in. Then there will be Section B with the questions that are needed for the personalisation. The user will be asked at that point if he/ she is willing to answer these questions now, or at a later stage of using the app, informing him/ her that they will not have personalised info if they never answer these questions. In that way it will be at the user's preference when to answer these questions. The respective wireframes from D4.4 are presented below.

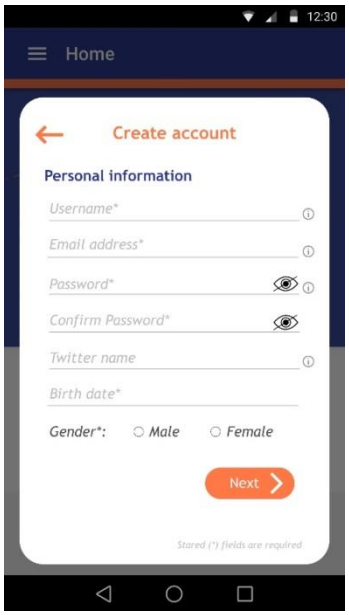

Figure 1: Personal info tab.

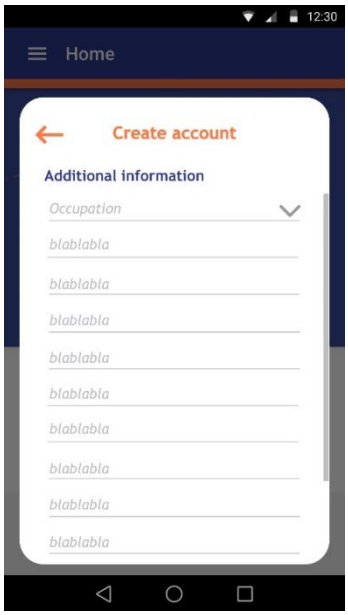

Figure 2: Additional info tab.

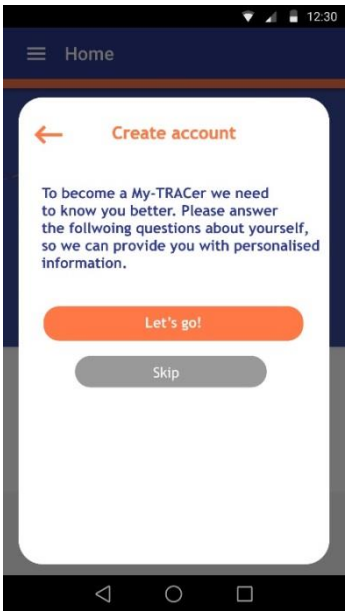

Figure 3: Additional questionnaire tab.

2.1.2 SIMPLIFY THE TERMS AND CONDITIONS ACCEPTANCE

Most of the users, especially during the pilot Phase II, had difficulties on finding how to accept the terms and conditions and could not realise this sub-task without assistance. We should simplify this task, by adding a tick box like the one in the following figure that the users should click to accept.

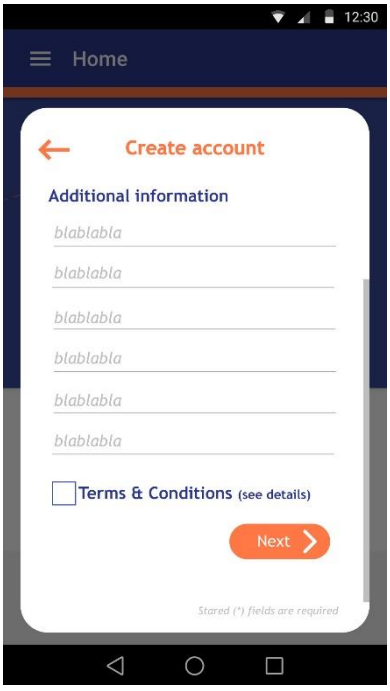

Figure 4: Terms and conditions proposal.

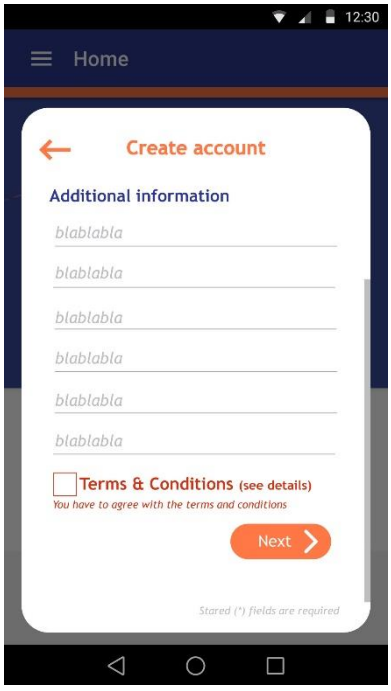

Figure 5: Terms and conditions not checked.

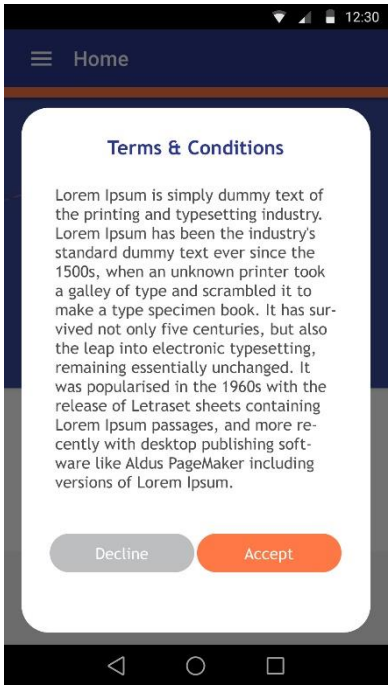

Figure 6: Terms and conditions details.

2.1.3 CREATE AN ACCOUNT CODE EMAIL COLOURS

Some users could not read the mail text in the email that was sent to them including the verification code for creating an account. Likewise in the figure that follows, the email should be in white font with black or blue (My-TRAC logo's blue) colour letters.

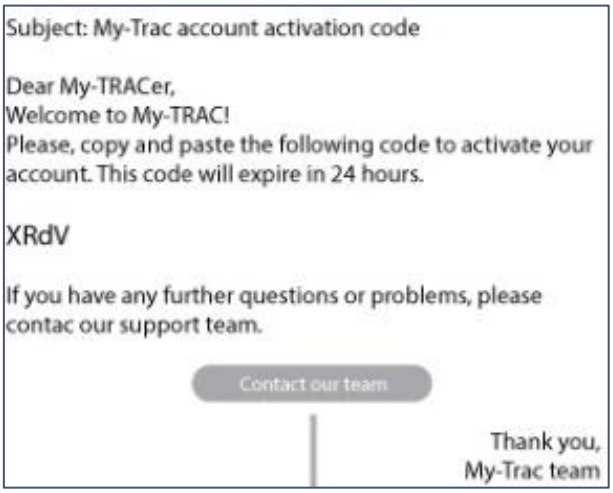

Figure 7: Verification code email colours.

2.1.4 SIMPLIFY THE PERSONALISED PROPOSAL REPRESENTATION

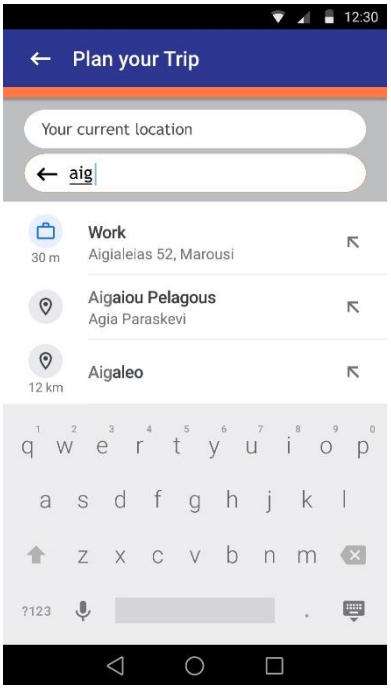

Figure 8: Route request by giving a destination.

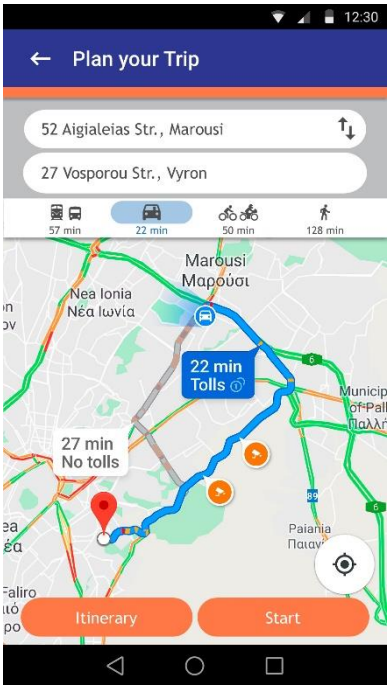

Figure 9: Suggested route and mode by My-TRAC models.

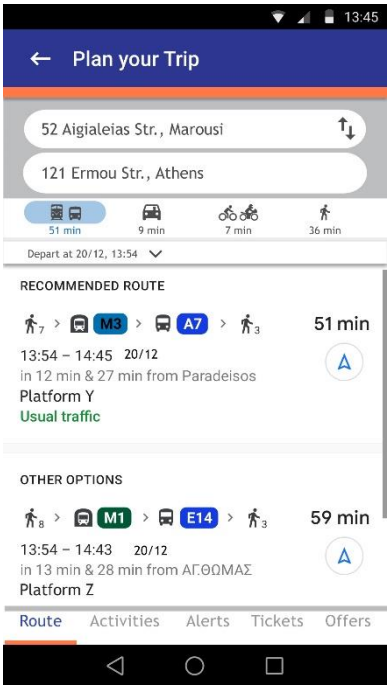

Figure 10: Alternative route and mode details selected by the user.

One of the main guidelines of the affective and persuasive design that we follow in My-TRAC is to have a UI that is simple and transparent. This means that the user should not be aware of all the models that run to the back end of the app; he/ she should just be presented with their outcome. The majority of the users

in the usability testing did not understand the personalised route icon and they were confused with the sequence of the actions realised to select the most suited route and mode for them. The proposal is to hide all this information. The user should see as an outcome of the route request only the route that is considered as the most appropriate to his/ her preferences. So the personalisation button should be omitted. Then the user of course will have the possibility to see the rest of the routes found by the system, as presented in the above figures.

2.1.5 THE NAVIGATION VISUALISATION SHOULD BE MORE CLEAR

Many users did not understand what was going on when the navigations started. The navigation should be given to the user with a clear visualisation on the map, like the one presented at the following figure.

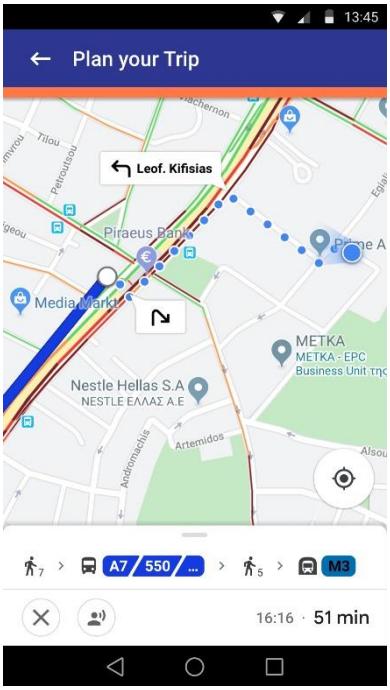

Figure 11: Navigation visualisation proposal.

2.1.6 LOG-OUT ACCESSIBILITY

Most of the users, especially those with low technical literacy, had difficulty to find how to log out, since there is no button available in the main screen of the application. Considering that there is actually no reason to log out often, this comment has not been thought as major issue. Nevertheless, we could add a log out option when pressing the three dots at the top right ankle of the major screen of the application, under the help.

2.2 RECOMMENDATIONS FROM THE STUDY FOCUS GROUPS

2.2.1 INTRODUCTION

The purpose of the study focus groups was to collect feedback from the users of the improved My-TRAC app, during the second pilot phase. For the pilot sites where control focus groups were also organized during the first pilot phase (Athens, Lisbon), a qualitative comparison of user feedback during pilot phases I and II has been performed. For the other two pilot sites (Barcelona and Netherlands), the focus group feedback obtained from pilot phase II participation is compared with user attitudes towards post phase II app functionalities. Each study focus group consisted of 5 to 10 participants. For more detailed information on the study focus group methodology, as well as the main findings of each focus group session, please refer to deliverables D6.1 and D6.2.

In the following subsections, the key recommendations received by the participants of study focus groups in all 4 sites are discussed.

2.2.2 REAL-TIME NAVIGATION

Various users mentioned the value of having real-time navigation provided to the users when using the app. More importantly, it was often mentioned that, when in trip navigation mode, the map point indicating the user's location on the map did not work properly. Additionally, compared to other similar apps (e.g., Google Maps), navigation directions were not available, rendering the app less useful than its counterparts/competitors in the context of navigation. Such a feature is deemed essential especially for private vehicle, biking and walking trips. Adding this feature to the app would significantly improve its reliability and its stance among other similar apps, it would complete the app, and it would make it more competitive in a commercial context.

2.2.3 FUTURE TRIP PLANNING

Various participants mentioned their need to be able to plan trips into the future. During the second pilot phase, users were only able to plan their trip on the fly, based on the transportation service provided at the moment of planning. However, multiple users commented on the usefulness of a future trip planning app feature. Such a feature would allow users to plan their travel ahead of time, using future travel service information, especially with respect to public transit trips. Including this feature in the app is expected to increase its competitiveness, especially given the fact that all similar, commercially successful apps provide such a feature to their users.

2.2.4 ADDITIONAL POINTS OF INTEREST

A recurring suggestion during all study focus groups was with respect to the points of interest. More specifically, users suggested that the list includes additional categories of points of interest, along with supplementary information related to the POI (e.g., type of business, business hours, contact information). On that note, numerous participants also suggested including a feature that would allow

them to filter the POIs based on category, or other criteria. Improving the POI functionality would undoubtedly enhance the app altogether and would discourage users from switching to other apps (e.g., browser, Google Maps) in order to retrieve said information.

2.2.5 ADDITIONAL COMMENTS ON FEATURE IMPROVEMENT

In addition to the main improvements analysed in the previous subsections, a few additional recommendations were discussed during the study focus groups. First, some users mentioned the need for the app to provide a detailed illustration of the surrounding infrastructure; this is particularly important for public transit trips in dense urban environments, where the location of a public transit station may not be accurately indicated on the map (especially, if other stations are in the vicinity, and it is not clear to the user towards which station they should walk).Additionally, several users mentioned the lack of proper explanation for certain app features (e.g., how often and when the app refreshes, what is the rating provided to each alternative, etc.), and emphasized the need for a concise user guide that would explain those app features that are not necessarily straightforward. Another suggestion was reducing the length of the questionnaire, and potentially asking the user to complete the questionnaire after they have had some time to interact with the app and evaluate its usefulness. With respect to group travel, several users suggested that the app includes a social component, allowing them to interact with their friends (e.g., messaging). Last but not least, with respect to social market, users did not make any particular recommendation, since it was only demoed to them, and they did not have the chance to properly test it themselves. As it was pointed out in the D6.2, My-TRAC does not have an agreement with a provider such as a travel operator or a shop in order to be able to provide to the user real products through the social market. In general, users expressed a positive attitude towards the inclusion of this functionality and the possibility to exchange points to get discounts etc., although they also declared that they would not just use the application because of that.

Overall, the consensus has been that, prior to branching out to additional functionalities and features, it should be ensured that the existing functionalities are developed to perfection, without glitches and unintuitive behavior.

3 RECOMMENDATION RELATED TO THE MODELS

3.1 ACTIVITY RECOMMENDATION MODEL

In this section, the recommendations proposed for the improvement of the evaluated activity and recommendation models are described. Additionally, a small description of the virtual experiment and of the evaluation results is also provided.

3.1.1 INTRODUCTION

As discussed in deliverable D6.2, the activity models and the recommendation system were tested using a stated-choice experiment with 50 participants. The experiment took place in Greece and was conducted online. The online experiment was selected as an option due to the Covid-19 situation, because under these circumstances the live pilots were threatened with the lack of participants and thus lack of data. Due to the Covid-19 situation, the testing of both models was biased because travelling habits and the daily behaviour of users had changed radically.

The scope of the experiment was to allow users use the My-TRAC application as they would use it before the lockdown and the restrictions forced due to Covid-19 crisis, and receive recommendations for POIs that they could visit when taking a certain trip, in order to retrieve the data required for the models' evaluation. The feedback retrieved from the experiment was used for the evaluation and validation of both the recommendation system's model and the Activity Prediction mechanism. Apart from the main experiment's core, which is described in detail in D6.2, a questionnaire aiming to measure user's experience was also used. This questionnaire had an online version and was sent to the participants of the virtual experiment in order to fill it in when they had finished with the experiment.

The results of the experiment described in D6.2 showed a positive impression of the users with the recommendation system. More specifically, users were mostly satisfied with the recommendations provided by the recommendation system and the activity types predicted. Regarding the general user's experience, it was measured using the System Usability Scale (SUS) and User Experience Questionnaire (UEQ) scales used for measuring perceptions of usability and user experience in a simple and immediate way. In both scales, the experiment's participants were satisfied from the functionalities of the recommendation system, as they have tested each one of them through the experiment. The scales with excellent impression were attractiveness, efficiency, and intuitive use, quality of content, trustworthiness of content, trust, perspicuity, dependability, stimulation and novelty. The scales that are defined as good are the visual aesthetics, were improvement on the data presentation in the My-TRAC application can be implemented. Additional analysis and information about the results are available in D6.2.

Based on the results of the evaluation, improvements and future extensions that could be made on both the models, the Activity Prediction mechanism and the recommendation system are described in this section.

3.1.2 IMPROVEMENTS ON THE RECOMMENDATION SYSTEM

The recommendation system implemented and described in D3.3 aims at providing personalized recommendations of POIs that a user could visit on a certain itinerary. This system includes not only the main recommendation model, responsible for predicting the best POIs that a user could visit, but also a filtering mechanism which is responsible to filter the recommendation system's output without changing the core recommendation system's algorithm. This filtering mechanism, as described in D3.5, takes into consideration the output of the Activity Prediction module, introduced and described in D2.2, and the GPS coordinates of the destination of user's trip and filters the recommended POIs. The scope of this mechanism is to provide personalized suggestions to the users, in order to increase user satisfaction, enhance their online experience and increase the popularity of the application. This recommendation system has been also extended as described in D5.4 aiming to support group recommendations. In this section, the improvements proposed concern the recommendation system in general, either if it provides personalized or group recommendations.

One first improvement, resulted from the evaluation results, concerns the update of the visual aesthetics of the list where the POIs are provided (i.e., "Activities" tab within the My-TRAC application). This list could be enhanced with additional information, such as the contact details of a POI or if a POI is accessible from people with disabilities. Alongside, this interface could be more attractive to the user, by including images of the POI, if they are available, or an image depicting the rating predicted by the recommendation system for each POI. In this way users will have more information available helping them deciding the POI that they will visit, giving thus an advantage in the recommendation system and the application.

A second improvement concerns the filtering mechanism included in the recommendation system. Currently this filtering mechanism uses both the Activity Prediction mechanism's output and the calculation of the distance between the POI and the user in all cases. In a future improvement, the users should be able to handle this filtering through the application. The users should be able to select from the application id they want the POIs to be filtered using the Activity Prediction mechanism and the range in which the POIs recommended should be included (e.g. the recommended POIs should be in range of 5km close to the user). Additionally, the users should be able to filter the amenities of the POIs recommended in real time through the application, allowing them to view POIs from several amenities and select the one that better fits their preferences. This addition aims to increase user satisfaction and make not only the recommendation system a more valuable asset for the users, increasing also user experience.

From technical perspective, the recommendation system could be extended and evaluated using additional information as input concerning the user's profile. Currently, the recommendation system's core algorithm receives as input information demographic information about the users (e.g. gender, occupation, age) and the preferences of the users through the ratings they provide via the My-TRAC application. The proposed extension includes the extension of the list of inputs in the recommendation system's core algorithm aiming to include more information about the user, such as the POI's amenities that they like mostly to visit (i.e., cinemas, restaurants, etc.) and information about the times that they have visited a POI. For the support of such an addition, extensions on the application's side in order to be able to retrieve such data should be implemented. These additional inputs might lead to more personalized recommendations and to increased user satisfaction.

3.1.3 IMPROVEMENTS ON THE ACTIVITY PREDICTION MECHANISM

Currently, to predict the user's anticipated activity, the Activity Prediction mechanism takes into consideration a set of parameters. These parameters are:

- User's demographic attributes (i.e., gender, age, marital status, occupation)
- System parameters (i.e., day and month of prediction)
- Sequences of daily activities performed by a user. For each sequence, the information needed is:
    - Activity type
    - Activity's duration.

For the creation of a user's sequence of daily activities, information about the activity type a user performs daily need to be available and on an hourly basis.

Currently, the user has the ability to provide feedback for the predicted activity type and correct it only when s/he creates a trip. The user can provide feedback for the predicted activity and correct it through the evaluation window described in D2.5, which is integrated in My-TRAC application. However, the user does not have the ability to provide feedback for the other activities predicted in the rest of the day aiming to fill in the user's daily schedule.

An improvement of the Activity Prediction mechanism would be the retrieval of live feedback of the activity type a user performs hourly through an additional interface or mechanism. Aiming to increase the accuracy of the model's prediction of the user's anticipated activity, an additional source of information concerning the user's daily schedule could be used in order to provide to the model the activity type a user performs on an hourly basis. This source could be either another application (e.g. calendar), or a mechanism who will ask for feedback from the user throughout the day. This information could be used not only for the creation of the user's daily program that would be inserted into the model, but also could be used as a correction plan in order to correct the output of the Activity Prediction mechanism and update the user's daily schedule. With this improvement, the Activity Prediction mechanism can be dynamic and follow the user's updated daily routine in order for the Activity Prediction mechanism to be used under any circumstance.

Apart from the aforementioned improvement, the Activity Prediction mechanism could be extended in order to support the prediction of additional categories of activities than the ones currently included. In this context, the user should also be able to enter his/her own categories of activities through an interface without restriction. This extension aims to allow users better select activities and insert the exact activity type they perform, in order to create a more personalized mechanism, where the system will be able to predict the anticipated activity type from the activity categories each user defines for him/herself.

3.2 ROUTE CHOICE MODEL

3.2.1 INTRODUCTION

As discussed in deliverable D6.2, the route choice model was tested using a virtual (stated choice) experiment where 500 participants were asked 15 questions where they had to pick their preferred itinerary over a set of itineraries. Due to the Covid-19 situation, not enough data was collected through the app, and the virtual experiment was an alternative way of gathering sufficient data for testing the route choice model. After testing it, one could say that the route choice model is valid: the explanatory variables are relevant, and the model can predict the user's choice to a certain extent.

In the My-TRAC app, the route choice model is calibrated per individual, meaning that the recommendations provided by the model are personalised. However, in the validation of the route choice model described in deliverable D6.2, the model was calibrated on the population sample instead of being calibrated for each individual, and the personalisation feature of the route choice model was therefore not tested. Calibrating the model at the individual level requires sufficient number of observations per individual, while only 15 questions were asked per individual during the virtual experiment.

The personalisation feature implemented in the app still needs to be tested. It should improve significantly the predicting power of the model: instead of predicting the user's choice based on the choices of all users (assuming that the user behaves as the average), the model predicts the user's choices based on the user's previous decisions. Testing the performance of the personalisation feature would be the first step of the further development of the route choice model embedded in the My-TRAC app. If the personalisation feature is effective, several improvements could be implemented to increase even more the predicting power of the model, such as including more explanatory variables in the model, or personalising the OpenTripPlanner request depending on the user's preferences. These improvements are further discussed in the following subsections.

3.2.2 IMPROVE THE MODEL'S PERFORMANCE BY ADDING MORE EXPLANATORY VARIABLES

Currently, to predict the traveller's choice, the route choice model considers the in-vehicle time, the walking time, the waiting time, and the number of transfers. Other trip attributes can affect the user's choice, and including these attributes in the model could improve the accuracy of the model's predictions if done properly. For instance, the model could potentially integrate the transit mode (train, bus…), or the weather conditions in the modelling.

The route choice model does not differentiate trips regarding transit mode, while this information is displayed to the user in the app, and it can have an impact on the user's choice. For instance, some users might prefer taking the train than the bus, and modelling these preferences could improve the model's predictive power. The effect can be constant (intrinsic to the mode), if the impact of the transit mode on the behaviour does not depend on anything else. It can also interact with another variable (for instance if in-vehicle time by bus is not perceived the same as the in-vehicle time by train). In the first situation, the effect is modelled by a constant, while in the second situation, the in-vehicle time parameter is estimated for both the bus and the train. Equation 1 shows a model where using a specific mode *k* is represented by

the binary variable δ_k (for instance δ_{Train} is 1 if the train is taken, 0 otherwise). In this example, the in-vehicle time impedance depends on the transit mode (there is one parameter for the in-vehicle time for each possible mode), the number of transfers and the waiting time impedance do not depend on the transit mode, and the train has an intrinsic impact on the traveller's choice. Before integrating such feature in the model, one should determine whether the mode indeed has an impact on the traveller's choice, and the impact should be assessed in detail before integration.

$$V_{example} = \alpha_{Train} \cdot \delta_{Train} + \beta_{transfers} \cdot N_{transfers} + \beta_{wait} \cdot t_{wait} + \sum_k \delta_k \cdot \beta_{in-veh,k} \cdot t_{in-veh} \qquad \textbf{Equation 1}$$

The weather can also affect the traveller's behaviour [1] [2]. For instance, if the weather is rainy or cold, the traveller could penalise more the walking time than in a sunny and warm day. One can represent this effect by using the method described in the paragraph above where the walking time impedance would depend on the weather.

The transit mode and the weather are examples of variables that could potentially improve the model's predictions. One could think of other variables to integrate in the route choice model. The procedure would be to continuously track the model's performance, identify potential flaws in the output, and improving the model accordingly. For instance, if bus itineraries are systematically undervalued by the traveller compared to train itineraries with similar characteristics, one could see if a constant penalising travelling by bus improves the model's performance. However, adding a new variable is cumbersome since the analyst should also perform significance tests on the estimators, and find the most suited functional form for the model. Adding inappropriate variables could affect negatively the model's predicting power.

3.2.3 PERSONALISING THE OPENTRIPPLANNER REQUEST

The routing algorithm in the My-TRAC app relies on the OpenTripPlanner open-source project [3], which allows to specify how the traveller perceives the different characteristics of trips (walking time, waiting time…), and suggests itineraries accordingly. When a traveller asks for itineraries between a starting and a destination point, the My-TRAC app casts an OpenTripPlanner request, with parameters[1] (such as starting and destination location), and OpenTripPlanner returns a set of itineraries that best fit the request. The list of parameters is exhaustive, and some could be used to personalise the request based on the user's preferences. For instance, the parameter walkReluctance indicates how long is the walking time perceived compared to the in-vehicle time. If this parameter is set to 2, one minute of walking time is considered twice longer when the fastest path is determined by OpenTripPlanner. This allows to represent the travel time perceived by the user, opposite to the actual travel time.

Fortunately, the route choice model can assess the perception of the different trip components (in-vehicle time, walking time, waiting time, and number of transfers) by the user, by expressing the walking time, the waiting time and the number of transfers in equivalent in-vehicle time. For instance, in deliverable D6.2, the results from the model's validation show that, on average, users are willing to

[1]The list of parameters can be found at http://dev.opentripplanner.org/apidoc/1.0.0/resource_PlannerResource.html

perform an extra transfer if it reduces the in-vehicle time by 10 minutes (assuming that the waiting and walking times remain the same); one transfer is therefore equivalent to an extra 10 minutes of in-vehicle time. Similarly, one could use the model to find how much in-vehicle time is equivalent to one minute of walking time, or to one minute of waiting time. These values could then be added to the OpenTripPlanner request as walkReluctance, waitReluctance and transferPenalty[2] (see Table 1). The routing algorithm in OpenTripPlanner would then suggest the fastest itineraries in terms of perceived travel time, instead of actual travel time.

Table 1: Description of three OpenTripPlanner parameters that could be used to better represent the perceived travel time.

Parameter in OpenTripPlanner	Description
walkReluctance	How much longer is perceived one minute of walking time compared to one minute of in-vehicle time.
waitReluctance	How much longer is perceived one minute of waiting time compared to one minute of in-vehicle time.
transferPenalty	The burden of performing one transfer, in in-vehicle time unit.

Let's suppose that the walkReluctance and the waitReluctance parameters are set to 2 and 1 respectively, while the transfer penalty is set to 5 minutes. The perceived travel time can be computed using Equation 2. Then, if two itineraries A and B are possible to go from the starting point to the destination point (see Table 2), itinerary B with a smaller perceived travel time will be displayed before than itinerary A, even though itinerary A is faster in terms of actual travel time. The fact that the traveller has to transfer once makes itinerary A less interesting for them, according to the OpenTripPlanner parameters taken in this example.

$$t_{perceived} = Reluct_{walk} \cdot t_{walk} + Reluct_{wait} \cdot t_{wait} + t_{in-veh} + Penalty_{transfer} \cdot N_{transfers} \quad \textbf{Equation 2}$$

Table 2: Example of two itineraries with different trip components

Itinerary	Walking time	Waiting time	In-vehicle time	Number of transfers	Actual travel time	Perceived travel time
A	5	2	22	1	27	40
B	5	2	25	0	32	37

3.3 TIME OF DEPARTURE AND MODE CHOICE MODELS

[2] More info on http://dev.opentripplanner.org/apidoc/1.0.0/resource_PlannerResource.html

3.3.1 Evaluating the Mode choice and Time of Departure Choice Models

This section summarizes the evaluation process of the choice models with the given revealed-choice live pilot input. As explained, the data input was not adequate for achieving the goals of the evaluation, since the minimum requirements (see D6.2) were not met by the end of the second phase of the live pilots. The structure and formulation of the models per se are described in more detail in deliverables D2.3 and D2.5.

The live pilot experiment aimed to collect revealed choice data across all pilot sites for the Mode Choice and Time of Departure Choice models to evaluate the models in the following ways:

- Validate (or reject) the assumptions made regarding the explanatory variables that were used for each country's model.
- Verify the accuracy of the models and assess their predictive precision.
- Re-calibrate the models by appending the RP data of the pilots to the SP dataset of the survey.

Both models used are multinomial logit models (MNL), meaning that they are using logistic regression methods to capture the effect that the explanatory variables have on the dependent variable. The existing design of the models contains parameters that are either related to the socioeconomic profile of the decision-maker (e.g. age, gender, income), or related to the trip characteristics in each given situation (duration, distance, purpose). Each variable partakes into the estimation of the utility of each option for the given instance for the given user. Ultimately, the option that is estimated to maximize the utility of the proposed mode or time of departure is presented to the user, based on the weights of the models and the values of the variables.

Given this approach, the existence of a pandemic can be represented as one additional variable that affects decision making. The modelling question that arises is how one can insert it into the models to comprehend, formulate and ultimately predict user behaviour under these circumstances. Does COVID-19 equally affect public transport and car use? Are these effects complementary, or is the motorbike and bicycle use also affected? Is the decision for time of departure affected by the pandemic? To what extent are these choices affected from the pandemic?

Researchers have begun to address these questions in an attempt to grasp the effect of the pandemic on the way that people travel. A study in Sweden conducted some initial exploratory analysis on the effect of COVID-19 on public transport, where the effect of the pandemic can be seen to have a crushing effect on the use of public transport, regardless of the fact that Sweden [4] followed a controversial strategy of minimal preventive measures against the pandemic and no forced lockdowns. The sudden drop in public transport use can be seen in Figure 12 in relation to the outbreak of the first cases in March 2020.

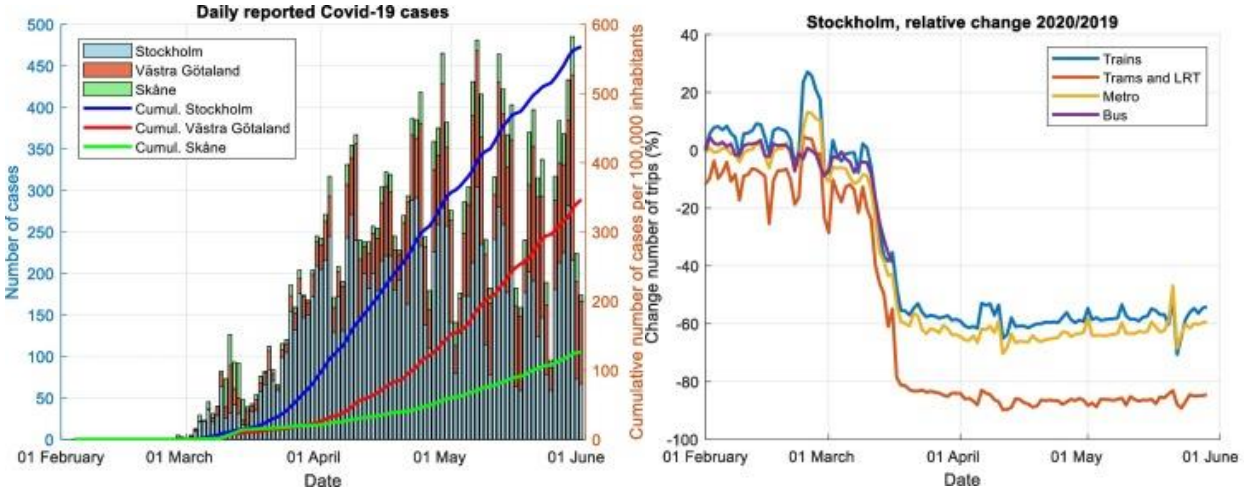

Figure 12: The effect of COVID-19 in Sweden.

The three pilot sites of the live pilots, Athens, Barcelona, Lisbon, imposed significantly harder restrictions and that led to a similarly dramatic decrease of public transport use. In order to capture the onset of the effects of COVID-19 on public transport, the My-TRAC models could be reworked to include a parameter that encapsulates the effect of COVID-19. Given the fact that the data collection precedes the reformulation of the models, selecting a binary variable for the existence of COVID-19 or not should be able to explain the entirety of the effect. A proposed structure of the Mode Choice model is presented in Equation 3, Equation 4, and Equation 5 depicting the utility functions associated with the three modes.

$$V_{CAR} = \beta_0 + \sum_{i=1}^{n} \beta_i \cdot a_i + \beta_{n+1} \cdot Covid \qquad \textbf{Equation 3}$$

$$V_{PT} = \beta_0 + \sum_{i=1}^{m} \beta_i \cdot a_i + \beta_{m+1} \cdot Covid \qquad \textbf{Equation 4}$$

$$V_{MOTO} = \beta_0 + \sum_{i=1}^{k} \beta_i \cdot a_i + \beta_{k+1} \cdot Covid \qquad \textbf{Equation 5}$$

As the study suggests, the travel patterns of the citizens of Stockholm changed rapidly and remained at this stable reduced state for the months following the outbreak. Therefore, a binary value representing the presence or not of the pandemic appears to be a valid enough way of capturing the effect within a variable. Unfortunately for the case of My-TRAC, the very low volume of trips that was collected during the live pilot phase is not adequate to allow such a re-formulation of the models. It would be very interesting to capture this phenomenon if a richer dataset were to be available for the analysis.

Variations of this formulation might prove to be also interesting from a modelling perspective. Asking the users' perception of the danger and their personal level of concern regarding the pandemic would provide an extra dimension of personalisation, specifically regarding the pandemic. These perceptions can similarly be included into the models which will then be able to partially attribute the travel choices of travellers to the pandemic.

3.3.2 FUTURE CONSIDERATIONS

My-TRAC has been built to grasp the preferences and expectations of the users. The focus is not only on maximizing the utility of each choice for the user, but also to maximize the happiness of making the best subjective choice at the given moment. The subjective element of the My-TRAC recommendations is in core of the logic and formulation of the models. The inclusion of questions that aim to extract the individual perspectives of the user will allow the models to be in line with the disposition of providing personalised recommendations. The user should willingly share his/her stance towards travel preferences, towards grave issues such as the COVID pandemic, and also feedback on how good a recommendation was. That way the models will be able to produce more accurate recommendations and make one step closer to the goal of happiness optimization.

The implementation of a reformulation for the models, as described in section 3.3.1, enables the personalisation of the recommendations and would manifest in many ways; i) first and foremost, the model is built to provide recommendations according to who is performing the trip based on the personal traits and preferences of the user ii) secondly, the trip characteristics affect the outcome of the models leading to a different suggestion per each separate trip, iii) additionally, the algorithm gradually adapts the recommendations to each user once there are multiple revealed choices for the user through the personalisation mechanism that is described in D2.5, iv) with the last addition of the COVID perception variable, the outcome of the models will be fine-tuned by the perceived influence of the virus on the choices made by the user, v) the trip suggestions are optimized for the maximization of the subjective happiness of the traveller.

In conclusion, the mode choice and time of departure choice models can provide recommendations based on parameters which are adaptable and expandable to potential future changes. Adding variables that account for parameters that affect decision-making is a process that is required if the models are to remain relevant and up to date. The structure of the My-TRAC platform facilitates this approach as it has been created following a building-block concept, meaning that individual components can be updated separately while the app remains live. That opportunity enables a potential workflow of periodic updates to the individual modules whenever that is needed. This brings in focus the fact that modelling human behaviour is a challenging endeavour and the mathematical and computational means for predicting it are tools that need to be sharpened frequently. The ever-changing landscape of potential external barriers and the restrictions that affect the choices of travellers need to be monitored and subsequently transferred into concepts which will lead to a continuous improvement of the My-TRAC services.

4 IMPROVEMENTS OF THE OPERATORS' PORTAL

4.1 ADDITION OF STATIC GTFS CREATION/MANAGEMENT TOOLS

My-TRAC wants to increase engagement with Transport Service Providers (TSPs) and reinforce the value chain between TSPs, users and the application. To achieve that, certain tools can be created in the scope of allowing the creation and management of GTFS data, as determined through the focus groups. Integrating those tools on Operators' Portal (OP) will make it a data hub that interconnects the TSPs with the user-facing information even more; TSPs can either upload their GTFS data on OP or create them anew and those data can be consumed by the application.

The extension can be based on open source technologies (e.g., see https://github.com/cbick/gtfs_SQL_importer or https://github.com/BlinkTagInc/node-gtfs). Most GTFS open source tools appear stagnant in terms of development, some being updated years ago, increasing the programming requirements for creating said tools. Thus, the contribution made to the open source community in the scope of developing/updating such tools will be significant.

4.2 ADDITION OF REAL-TIME GTFS CREATION/MANAGEMENT TOOLS

The OP already contains tools to upload real-time GTFS data for 2 categories (Trip Updates and Service Alerts) and will be extended to include a third category, which is live Vehicle Positions. In this category, live locations of vehicles are uploaded in a specific GTFS format, allowing the user to track the actual position of the bus on a map. In addition, live vehicle positions can be used to provide analytics, such as time of arrival estimation. Those analytics can be:

- Estimation of time-of-arrival. In the GTFS format, the update of the vehicle positions can be done through Trip Updates, yet the process is highly verbose, requiring many manually inserted fields to have information. With the vehicle position data at hand, the time of arrival of a vehicle to the next stops can be estimated instead, automating the creation of Trip Updates, or even Service Alerts.

- Estimation of network characteristics. Through analytics, an estimation of the network characteristics can be made, such as, estimating traffic flow (density, average speed, flow) and estimating network issues (e.g., road blockage). This can benefit the TSP in terms of improving its planning activities and also other 3rd parties that operate on the area (e.g., MaaS, travellers, traffic management centres).

The process of retrieving live vehicle position, however, is not an easy one. It will require either the creation of an app that tracks the position of the bus (e.g., used by drivers or by travellers [crowdsourcing]) or the integration of currently installed live vehicle position tracking to the OP (since, usually TSPs install positioning devices on vehicles). My-TRAC will examine all avenues first, from a business standpoint and second, from a technical standpoint, to determine the most efficient path to follow.

4.3 APIs FOR DATA EXCHANGE

All processes of data creation in the OP are currently manual, requiring the user to login to the platform and insert the data in forms. This process was commented on by TSPs during the focus groups, proposing instead the use of APIs for data sent to OP. With that method, the TSPs would integrate the OP API in their services and allow the sending of data in an automated fashion. This process is not simple, since the data format needs to be studied (create a data structure for the APIs that is user friendly and efficient), learning material for TSPs will have to be produced (in order to gain knowledge on how to use the APIs), while the OP will need to be adapted to receive inputs from APIs (tackling security, erroneous data formats and have high fault tolerance and robustness in service provision).

Irrelevant of the difficulties though, creating a robust and reliable API system for the OP will allow it to tap into the IoT domain and obtain information from new sources that will lead to better service provision and a unique value proposition for the TSPs.

In addition to the above, which discusses only the TSP to OP data flow, the opposite flow, from OP to TSPs is also interesting. Two categories of APIs can be created in that regard; first, exchange aggregated data on user choices essentially replacing the current "download data" functionality and second but most interesting, send GTFS data to the operators in the form of exploring the GTFS dataset (similar to https://www.navitia.io/ which resembles more of a Living Lab than a data hub the way OP is envisioned to become).

5 ROADMAP FOR POTENTIAL IMPROVEMENTS EXPANDING USERS' FEEDBACK

The following section considers the recommendations of the users and the results of pilot post-analysis and details suggestions that incorporate technical aspects to have improvement in the whole My-TRAC ecosystem. These recommendations are based on D6.2 onsite results from both phases of the pilots and on the suggestions proposed at the sections above. Therefore, we list the suggested improvements per functionality based on the functionalities of the My-TRAC's final version (v6) (Table 3). When we are discussing of improvements and suggestions for a functionality immediately, we need to know the effect and the relationship of this functionality and suggested change with the system, as most of the functionalities are not isolated. Moreover, we are discussing for changes that will have a significant impact on the My-TRAC ecosystem and not for resolving bugs. So, a change might cause a chain reaction of changes in the flow of My-TRAC. The extent of this reaction depends on the change suggested.

Table 3: My-TRAC functionalities of final version

Traveller's registration
Trip creation
Detection of changes and disruptions on a route during a trip
Activities' proposition
Activities' proposition in groups
Navigation
Using My-TRAC app in a country other than home-country
Communication with MaaS and 3rd party services
Traveller's feedback and recommendations (My-TRAC rating system)
Group creation, Group modification: Adding a new member, Group modification: Remove a member, Group deletion, group itinerary creation
Erase traveller's profile
Request personal data
UI/UX personalization
Points and rewards system
Booking and ticketing
Occupancy prediction

5.1 General improvements of My-TRAC system

Although, My-TRAC's architecture permits adoptability and scalability, it is currently working only for android mobility systems, hence a general suggestion would be to advance the mobile technologies and allow the usage of My-TRAC at iOS users. Furthermore, My-TRAC as it has evolved directed its focus on commuters and public transport users; its personalization models (time of departure and route choice) are focusing on Public Transport. Therefore, My-TRAC suggestions towards PT are more elaborated than towards other means such as car or moto. Additionally, My-TRAC recommendations are working better for its pilots' sites as the models were created for these sites and we have better quality of data for My-TRAC's pilot locations (e.g., GTFS, PoIs etc). To that end, a general improvement should be towards improving the functionalities that are related to these aspects. Finally, not only from the results of the pilots but from our point of view My-TRAC has strong capabilities of being a travel companion used by users for planning reasons and not so much for conducting the trip as its strong points are the personalization suggestions for both itineraries and activities recommendations, group creation and social market. So, a suggested improvement is towards the functionalities that are related to navigation and identification of disruptions.

5.2 Traveller's registration

Taking into account the remarks of the users from the usability tests, control and study groups, registration is a functionality that the user should not face any kind of issues to use My-TRAC as it is the first step to accept and use My-TRAC app. Traveller's registration is connected with the trip creation, activities' proposition, UI/UX personalization, Points and rewards system, Request personal data, Erase traveller's profile.

a. Amount of information requested

My-TRAC is requesting a lot of information at the registration stage and this information serves a lot of functions of research and analysis. Although, My-TRAC has a high TRL (TRL7-8) it is an application and system developed for a RIA project. Towards commercialization My-TRAC should request as less information at the registration phase as possible, or cluster this information based on the input modules that the user will be willing to use. The latter is the idea of having travellers' profiles (i.e., commuter, tourist, business traveller, leisure travellers etc.) in that way the user will indirectly choose which models are the most relevant for him/ her. However, this demands changes in the flow of My-TRAC architecture and a completely new version of the app.

b. Allow user to use My-TRAC without registering

Another suggestion could be to allow user to use My-TRAC without registering, meaning utilize the part which works as a "common" travel companion and then if he wants to create a profile in order to get personalized recommendations.

c. Ability to modify personal information

We realized, especially with the changes of ridership mindset provoked by COVID that an important need of the travellers is to be able to modify their personal information and all the information provided by My-

TRAC at any time. This suggestion calls for changes not only at the front end by also at the back end, as well as to the retrieve my data functionality.

d. Register and sign in with Social media

Due to data privacy reasons, we were advised to permit registration only with an email account and not allowing the access with the usage of social media accounts (e.g., Facebook, LinkedIn, Google). Such type of registration should be aligned with the request of personal data from the user as well as with the sign in at My-TRAC's social market.

e. Terms and conditions

My-TRAC was one of the first projects that has implemented GDPR processes. The terms and conditions are in such a way to obligate the user to open them and read them as much as possible. However, we could change it and allow the user just to click the acceptance of terms and conditions.

5.3 TRIP CREATION

My-TRAC users can create itineraries in different ways either by choosing their mode of transport or via utilizing the personalization models of mode, time of departure and route choice. Trip creation is one of the core functionalities of My-TRAC and is what gives to it an added value. This functionality is related with the travellers' registration, with third party services, with activity recommendation and with the group functionality.

a. Route engines

Incorporate new route engines to have better results in route suggestions.

b. Difference in routing for car and moto

My-TRAC Does not make the distinction between car and moto when computing trip duration

c. Flow of personalization models

Change the flow of personalization models in the application to be more intuitive to the user that means that a redesign of the app should be implemented in that case. Another option is to adjust the wizard to provide more information on the models.

d. Long distance routes

My-TRAC is mainly oriented to serve its pilots therefore long-distance trips or trips between different countries are supported but not at great extent.

5.4 DETECTION OF CHANGES AND DISRUPTIONS ON A ROUTE DURING A TRIP

Currently, My-TRAC application provides changes and disruptions only for Barcelona and although My-TRAC's operators' portal facilitates the creation of real time GTFS data the deployment and the provision of this information to the traveller via the app has not been established. So, a suggested improvement is to finalize and test the communication of My-TRAC platform and operators' portal. Furthermore, My-TRAC could benefit the group creation and feedback feature to crowdsource information on delays and disruptions. In other words, My-TRAC users can provide this information to the system and My-TRAC app

can share this information with other users of the system that might be interested in getting such recommendations.

5.5 ACTIVITIES' PROPOSITION AND ACTIVITIES' PROPOSITION IN GROUPS

It was mentioned from the users and it is a strongly recommended suggestion, to provide more information for the PoIs and to have them clustered in a way. The first point depends on the information and data availability and the second one calls for a change in the database and PoIs libraries. Additionally, the connection of PoIs with Social market will allow the user to get benefits and discounts.

5.6 NAVIGATION

My-TRAC is using two types of navigation provided by the OTP and provided by Google. A proposal of improvement is to implement google navigation not only for reaching PoIs but for any destination. Additionally, indoors navigation in huge transport hubs public transport could be implemented if My-TRAC has an agreement with the respective transport service provider.

5.7 USING MY-TRAC APP IN A COUNTRY OTHER THAN HOME-COUNTRY

This functionality depends on the information availability and it concerns also the scalability and transferability of the application. In technical terms My-TRAC is fully capable to scale and be transferred to other regions. Our suggestion is to start from scale up My-TRAC in at the near regions of the pilot sites including more areas and new TSPs.

5.8 COMMUNICATION WITH MAAS AND 3RD PARTY SERVICES

Although this functionally is developed in a great extent, modifications such as response times can be implemented. Also, a better connection could be established with the MaaS providers in order to facilitate the users to rent a bike or a car without having to registering or even searching for this service.

5.9 GROUP CREATION, GROUP MODIFICATION: ADDING A NEW MEMBER, GROUP MODIFICATION: REMOVE A MEMBER, GROUP DELETION, GROUP ITINERARY CREATION

Concerning the group creation, an extension could be that the user can invite his/her friends by their email or social media account or by their phone number. The latter means that the system needs to read the phone book of the users mobile and send a request. Additionally, it was requested that the users can have an exchange of information more than once and to be able to communicate via a chat. The itinerary creation can be extended in the form that My-TRAC allows the users to have different starting points and only one destination and in some way optimize their itineraries to allow them to travel together as much as possible.

5.10 UI/UX PERSONALIZATION

The UI/UX personalization has a limitation of three skins in the application hence an enhancement would be to find a way to present more than three options to the user.

5.11 POINTS AND REWARDS SYSTEM

A proposal is to extent the points system and allow groups of users to share points or even to allow the user to gain points by the usage of other applications such as Co-APS that has a point system as well. Finally, the possibility of exchanging the points obtained for public transport tickets through the social market is envisaged.

5.12 BOOKING AND TICKETING

An extension will be to be able to perform an actual transaction and having a list of local shops subscribed so the user can benefit from the usage of My-TRAC and get discounts. Moreover, would be to connect the booking and ticketing with Social market so the user of My-TRAC would be able to get a variety of products and services using social market and not by visiting the websites of different providers. Finally, the booking system can be extended and provide recommendations based on the mode choice prediction model or the activity prediction model.

5.13 OCCUPANCY PREDICTION

Ideally a suggestion is to integrate My-TRAC services in Co-APS so the user can have a travel companion with the functionality of crowdsourcing and the functionality of the occupancy prediction.

5.14 PRIORITIZATION OF APP'S IMPROVEMENTS

The previous sections are dedicated to My-TRAC app functionalities' improvements; therefore, this section aims to compile this information and prioritize the improvements based on the importance for the application (criticality) and their implementation complexity. We measure importance/critically on the expected benefits (e.g., additional users, downloads and in general fostering the exploitation and sustainability opportunities.) that these improvements can offer.

Table 4 shows the way of prioritization of these improvements considering the expected additional users that this improvement might provide for the following aspects:

- Potential benefits for exploitation (at a qualitative scale from 1 to 5, with 5 demonstrating the most benefits) which are related with the expected percentage of additional users.
- Meet Market's standards to be as competitive as other existing travel companions. (at a qualitative scale from 1 to 5, with 5 demonstrating the most benefits) (taking into account also the extensive analysis of existing travel companions presented in D7.9: My-TRAC platform exploitation plans).
- Value added to My-TRAC services and utilization of the technologies developed (at a qualitative scale from 1 to 5, with 5 demonstrating the most benefits).
- Urgency: how critical is the improvement for the exploitation at all levels (at a qualitative scale from 1 to 5, with 5 demonstrating the most benefits).
- Complexity (low, medium, high) from the technical point of view. (High=1, Medium/high=2, Medium=3, Low/Medium=4 and Low=5).

The answers of the following table have been based on the insights gained by the My-TRAC's pilots and more precisely by the conclusions extracted from each and every section of this deliverable, to allow us to draft a general roadmap for functionalities improvements. To simplify our work for rank the proposed improvements, we have implemented a scale which have been discussed among My-TRAC partners. The justifications provided aim to complement our rating at a great extent, however in some cases we just reference the relative section.

Furthermore, Table 4 includes information of the constraints that are envisioned to implement these improvements and the partners that can collaborate to solve them. Finally, the information presented in Table 5 and Figure 13 allows us to conclude to tentative ranking of improvements.

Table 4: Prioritization of app improvements

#	Name of Functionality/improvement	Expected percentage of additional users	Benefits for exploitation	Meet standards of Market	Extent value of My-TRAC services	Urgency (must have as soon as possible)	Complexity	Constraints	Type	Partner(s)
1	General improvements My-TRAC for iOs system	50% Almost have of the population uses a smartphone with an ioS system.	5	5 Most of the applications nowadays are supporting both Android and ioS systems.	5 It will allow all types of mobile users to use My-TRAC services	5 It is essential to keep up with such requirements	1 High The system is designed for Android.		Technical, economical	UPC, SPA
2	Traveller's registration	40% The registration process should be easier and more straightforward to the users	1	5 Registration on existing application is an easy process	1 (Registration was created in such a way to facilitate the acquisition of input for the models and research purposes)	5 It is crucial to make that modification as it was mentioned by many users at the usability test and study focus groups	4 Low-Medium		Legal, Technical	UPC, Modellers (CERTH, DUT, AETHON)

3	Trip creation	20% There is a lot of work conducted at the trip creation.	5	3 My-TRAC already exceeds market standard in itineraries proposition.	5 Improvements on this functionality can demonstrate the full potential of the models implemented in My-TRAC	3 It can wait as a lot of work has been implemented in this functionality.	1 High		Technical, economical	UPC, Modellers (CERTH, DUT, AETHON) CFMs projects
4	Detection of changes and disruptions on a route during a trip	60% Existing travel companions are rarely providing such information to their users	5	3 Existing applications provide information on scheduled disruptions.	5 (please see 5.4)	4 It would be nice to implement it relatively soon as it provides and added value to My-TRAC users.	2 Medium high			
5	Activities' proposition and activities'	45% Existing travel companions	4	4 Existing application	4 (please see 5.5)	4 It would be nice to	2 Medium high		Technical, economical	UPC, SPA< CERTH

	proposition in groups	provide information on PoIs but they do not provide personalized recommendations		dedicated to PoIs provide relevant information.		implement it relatively soon as it provides and added value to My-TRAC users.				
6	Navigation	30% It is a core functionality of a travel companion and should be enhanced in My-TRAC even though is provided by a 3rd party such as Google	3	5 Existing applications provide good Navigation, hence My-TRAC needs to be one of them.	4 (please see 5.6)	3 It can wait because although it is a core functionality for a travel companion, it is implemented just needs modifications to be more intuitive	2 Medium high		Technical, economical	UPC, SPA

						for the user.				
7	Using My-TRAC app in a country other than home-country	5% My-TRAC is focusing on commuters and its models are designed for the specific pilots' locations.	2	2 Most of the existing app are dedicated to a location or a certain TSP	4 (please see 5.7)	2 Focus needs to be the countries that My-TRAC already works.	4 Low Medium		Technical, Economical	UPC, SPA, CERTH, AETHON, DUT
8	Communication with MaaS and 3rd party services	It is hard to calculate how many new users can be gained by improving the connection with the 3rd party services as they differ at great extent.	3	3 Existing applications make use of 3rd parties services and My-TRAC can be competitive due its scalability potential provided by	4 My-TRAC is based a lot on 3rd parties services.	1 My-TRAC already is connected with a lot of 3rd parties services.	1 High		Economical	UPC, SPA

				its architecture						
9	Group creation, group modification: adding a new member, group modification: remove a member, group deletion, group itinerary creation	60% We received a lot of positive comments for this functionality from the participants of the study focus groups and also is not a common functionality in existing travel companions.	5	3 There are not a lot of travel companions allowing the group formation and interaction of their users.	5 It will enhance this new functionality	5	3 Medium		Technical, Legal	UPC, SPA
10	UI/UX personalization	30%	3	4 There are not a travel companions providing such a feature.	4 (please 5.10)	3	3 Medium		Technical	UPC, SPA, CERTH
11	Points and rewards system	40%	3	4 There are not a travel companions	3 (please see 5.11)	4	3 Medium		Technical	UPC, SPA, USAL and EXPERIS

				providing such a feature.						
12	Booking and ticketing	40%	4	3 There are a lot of travel companions providing booking and ticketing options but My-TRAC demonstrate a more complete solution.	3 As My-TRAC provides different itineraries should also allow the user to book the relative service in an easy way.	5	2 Medium High		Business Technical Legal	UPC, SPA,
13	Occupancy prediction	25% Occupancy prediction and crowdedness management is crucial due to COVID-19	4	3 Some travel companions started presenting occupancy predictions, My-TRAC with collaboratio	4 My-TRAC focuses on the promotion of PT services, hence occupancy prediction can be a great	4	2 Medium High		Legal	UPC, SPA, AIR institute

				n with Co-APS can provide predictions up to 7 days.	added value at its services					

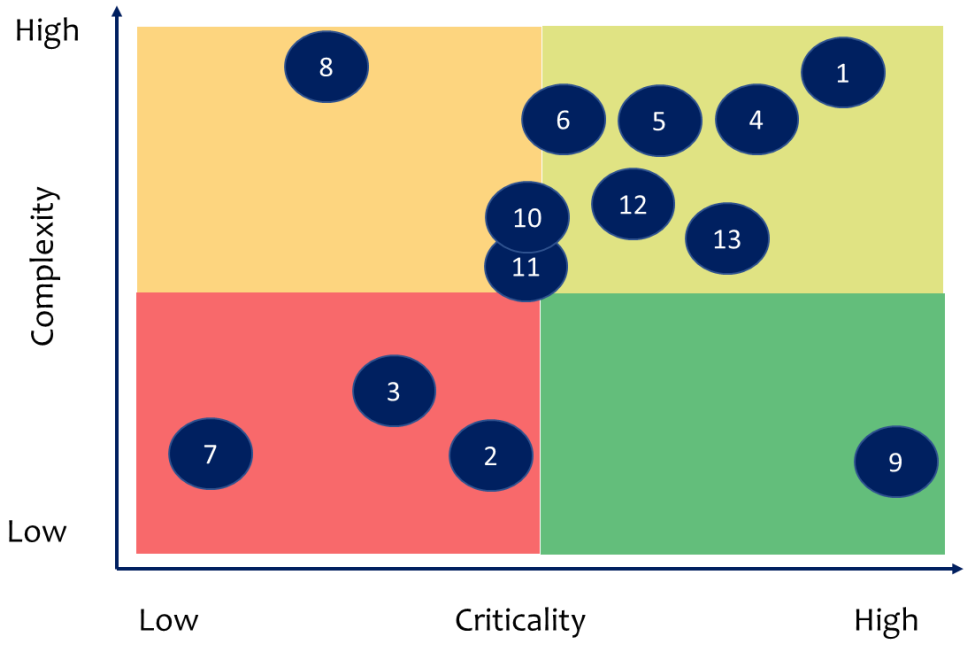

Figure 13: Improvements vs criticality and complexity

The following table (**Table 5**) sums up the "points" given to criticality and complexity of implementation for the foreseen improvements to allow us in a simple way to rate and rank the possible improvements. To that end, **Table 6** presents the ranking of the proposed improvements based on both their criticality and complexity.

Table 5: Proposed improvements criticality and complexity

	Proposed improvement	Criticality	Complexity	Total
1	General improvements My-TRAC for iOs system	20	1	21
2	Traveller's registration	13	4	17
3	Trip creation	15	1	16
4	Detection of changes and disruptions on a route during a trip	17	2	19
5	Activities' proposition and activities' proposition in groups	16	2	18
6	Navigation	15	2	17
7	Using My-TRAC app in a country other than home-country	7	4	11
8	Communication with MaaS and 3rd party services	11	1	12
9	Group creation, group modification: adding a new member, group modification: remove a member, group deletion, group itinerary creation	19	3	22
10	UI/UX personalization	14	3	17
11	Points and rewards system	14	3	17
12	Booking and ticketing	15	2	17
13	Occupancy prediction	16	2	18

Table 6: Ranking of potential improvements.

Proposed development ranking
Group creation, group modification: adding a new member, group modification: remove a member, group deletion, group itinerary creation
General improvements My-TRAC for iOs system
Detection of changes and disruptions on a route during a trip
Occupancy prediction
Activities' proposition and activities' proposition in groups
Traveller's registration
Navigation
Booking and ticketing
UI/UX personalization
Points and rewards system
Communication with MaaS and 3rd party services
Using My-TRAC app in a country other than home-country

6 CONCLUSION

D6.3 completes WP6 by providing a roadmap for improvement and extension of the My-TRAC application after the development of the application by the end of the project. While D6.1 planned the pilot phase and D6.2 summarized the analysis of the pilots' results, D6.3 builds upon D6.2 by suggesting ameliorations of the application, and features to add. The usability testing, the user's study focus group, the assessment of the different models have allowed us to identify a wide range of improvements. In the further development of the application, these improvements should be classified by priority, depending on the value added to the user's experience, the ease of deployment, and the financial cost. The developers should focus first on the improvements suggested by the users in the study focus group and in the usability testing, since they address direct feedback from the users. The improvements should be cost-effective, in the sense that they should be implemented only if the increase in user's experience is worth the technical implementation and the associated financial cost. The improvements related to the integrated models should be deployed in a second time. They do not address critical issues; however, they would help differentiating the My-TRAC application from the other competitors. Finally, the further development of the application should come along a wide dissemination of the functional application, since some of the integrated functionalities (group creation, social market, personalization models) need a critical mass to reach their full potential.

REFERENCES

[1] L. Böcker, M. Dijst and J. Faber, "Weather, transport mode choices and emotional travel experiences," *Transportation Research Part A: Policy and Practice,* pp. 360-373, 2016.

[2] L. Creemers, G. Wets and M. Cools, "Meteorological variation in daily travel behaviour: evidence from revealed preference data from the Netherlands," *Theoretical and Applied Climatology,* pp. 183-194, 2015.

[3] OpenTripPlanner, "Multimodal Trip Planning," 2020. [Online]. Available: https://www.opentripplanner.org/. [Accessed 18 November 2020].

[4] E. Jenelius and M. Cebecauer, "Impacts of COVID-19 on public transport ridership in Sweden: Analysis of ticket validations, sales and passenger counts," *Transportation Research Interdisciplinary Perspectives,* vol. 8, 2020, ISSN.

[5] R. Schakenbos, L. La Paix, S. Nijenstein and K. T. Geurs, "Valuation of a transfer in a multimodal public transport trip," *Transport Policy,* pp. 72-81, 2016.