UPPER

TES_05: To enhance the information provided through adapted services for different groups of passengers

Description of the measure and main outcomes expected

Thessaloniki's measure 05 builds on a previously existing multimodal trip planner, which was integrating information for car-sharing, bike-sharing, scooter-sharing and walking. A generic utility function was used for route planning. Under this measure, public transport information is being integrated as well and the route planning is being based on user preferences (instead of a generic utility function). The updated multimodal trip planner has also been integrated into the existing MaaS application (eMaaS), with the aim to increase intermodal trips that include public transport and minimize user's travel disutility when combining different modes.

Preparation of the measure

1. Case description

In Thessaloniki, a pilot MaaS system was launched in 2023, aiming to promote multimodality[1]. The system constitutes of 5 shared mobility hubs, where e-cars, e-bikes and e-scooters are available. For further extending the spatial coverage of the system and covering additional origins-destinations, virtual stations were developed, where only e-bikes are available. As such, e-bikes can act as a first/last-mile solution and connect additional (popular) areas with the shared mobility hubs (Figure 1). As a functionality of the MaaS app, a multimodal trip planner was developed for assisting users in taking optimal decisions about their trips. A main inefficiency of this multimodal trip planner was that public transport was not incorporated in the proposed multimodal solutions, due to lack of data (GTFS). This inefficiency is being bridged through the updated/enhanced multimodal trip planner that has been developed as part of the UPPER project.

[1] https://emaasproject.gr/

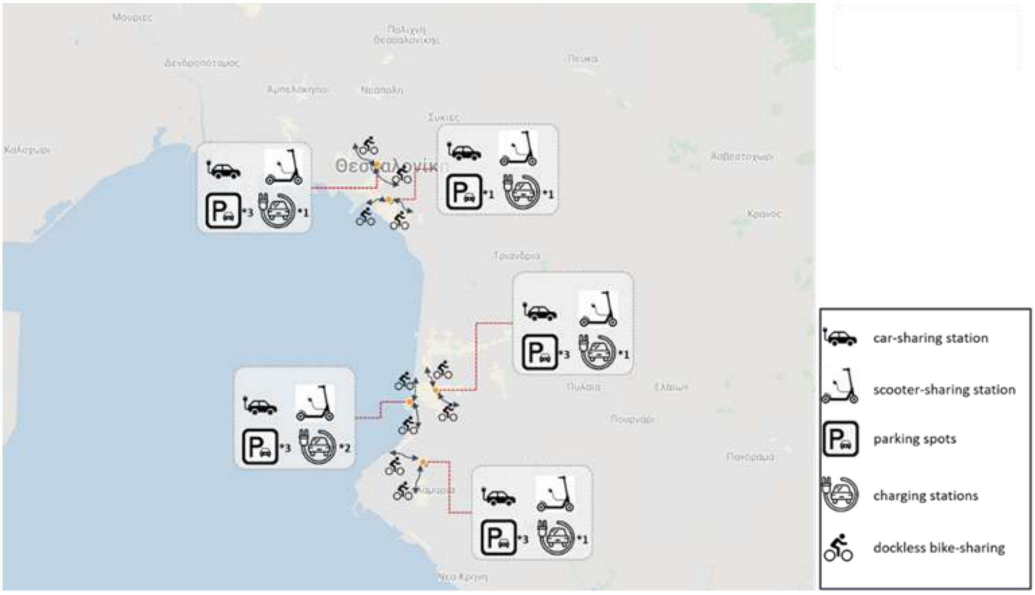

Figure 1. Thessaloniki's MaaS operational model.

2. Technical specifications and architecture

The architecture of the updated/enhanced multimodal trip planner is presented in Figure 2. As it is shown, CERTH/HIT as the developer of the multimodal trip planner communicates through APIs with the MaaS provider for three purposes: a) receiving real-time information about the availability of shared modes (along with their location), b) receiving the trip requests that are being made by the users through the MaaS app, c) sending the multimodal solutions for providing them to the users through the MaaS app. These connections were already developed for the purposes of the previously existing multimodal trip planner. However, some modifications were made for: a) ensuring that the users id is being sent to CERTH/HIT (this is required for the individualization process), b) ensuring that CERTH/HIT will receive the information about specific modes that the user wants to exclude from the proposed multimodal solutions, c) incorporating public transport in the proposed solutions that are sent to the MaaS provider and in turn are provided to the user. Except for these modifications, in the framework of the UPPER project a connection between CERTH/HIT and the public transport authority was established, which was totally missing in the previously existing multimodal trip planner. This connection ensures that CERTH/HIT receives updated GTFS information for the public buses.

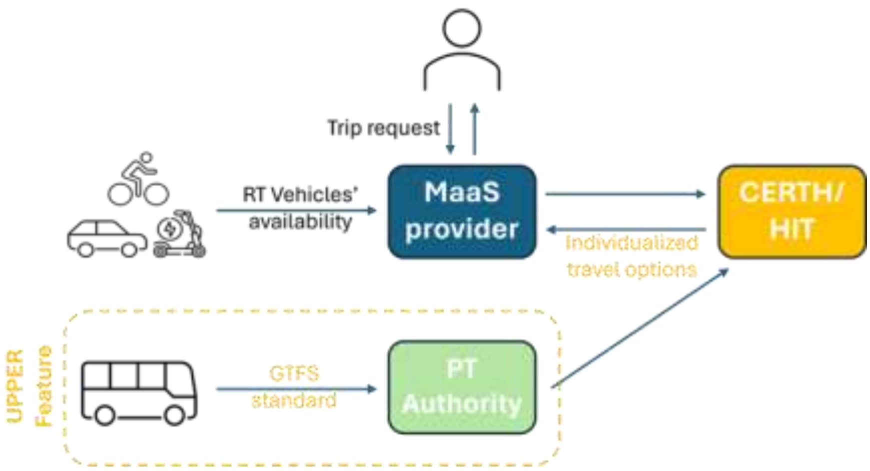

Figure 2. Architecture of the updated/enhance multimodal trip planner.

3. Algorithm for individualized trip planner

The already existing MaaS app was integrating a multimodal trip planner, which was developed by CERTH, and combined car-sharing, bike-sharing, scooter-sharing and walking, in an optimal way. For solving the multimodal trip planning problem, the first step was to identify the various alternative unimodal and multimodal solutions that can be reasonable from users' perspective. Considering the spatial allocation of the shared mobility hubs and the bike-sharing stations, 12 alternative solutions were identified, as presented in Figure 3.

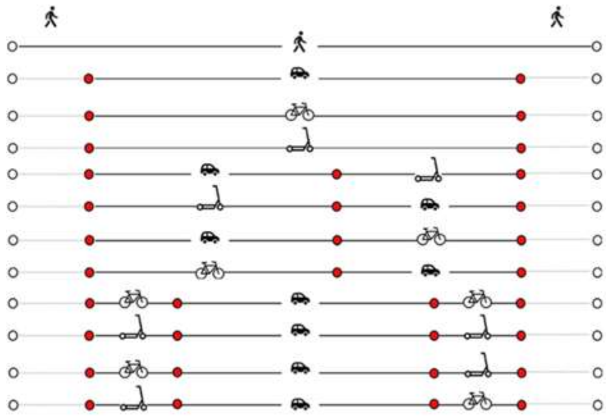

Figure 3. Representation of the 12 alternative solutions (previously existing multimodal trip planner).

The second step was to define the criteria, based on which the various alternatives will be assessed for providing to the user the optimal one or a ranking of the alternatives. For this prioritization task, 3 criteria were defined, namely travel time, travel cost and number of transfers between different transport modes. The calculation of travel time was made with the aid of the OpenTripPlanner (OTP)[2], which is an open-source software capable for providing passenger information and transportation network analysis. Travel cost was calculated considering the travel times and the cost of using the various modes in Thessaloniki's MaaS system.

Since the different criteria are measured in different units, a way to combine the different criteria in a single utility function is needed. For doing so, a stated preference (SP) approach was followed. A very short survey was designed, consisting only of 4 different SP scenarios. In each scenario, the respondents had to select between two different trips. The trips were different with regards to the travel cost, the travel time with the different modes and consequently the number of transfers between the modes. The four SP scenarios are presented in Table 1.

Table 1. Stated preference scenarios for defining a generic utility function.

Trip 1	Trip 2
Trip duration with shared car: 35 minutes	Trip duration with shared bike: 8 minutes + Trip duration with shared scooter: 15 minutes
Trip total cost: 3.5 €	Trip total cost: 5 €
☐	☐
Trip 1	**Trip 2**
Trip duration with shared bike: 15 minutes	Trip duration with shared scooter: 8 minutes
Trip total cost: 2.5 €	Trip total cost: 3.5 €
☐	☐
Trip 1	**Trip 2**
Trip duration with shared car: 35 minutes	Trip duration with shared scooter: 15 minutes
Trip total cost: 2.5 €	Trip total cost: 3.5 €

2 https://www.opentripplanner.org/

☐	☐
Trip 1	**Trip 2**
Trip duration with shared car: 35 minutes + Trip duration with shared bike: 8 minutes	Trip duration with shared car: 15 minutes + Trip duration with shared bike: 8 minutes + Trip duration with shared scooter: 8 minutes
Trip total cost: 3.5 €	Trip total cost: 3.5 €
☐	☐

Based on the responses a simple binary logistic regression model was developed for estimating the impact that the various criteria have on the choice of respondents. The results of the binary logistic regression model led to the following utility function.

$$GC = -0.18 \times ttc - 0.236 \times ttb - 0.37 \times tts - 0.275 \times ttw - 1.073 \times c - 3.925 \times nt \quad (1)$$

where:

- tt_c, tt_b, tt_s, tt_w is the travel time with shared car, bike, scooter and walk respectively,
- c is the total cost of trip,
- nt is the number of transfers between different modes.

Within UPPER, the already existing multimodal trip planner was updated/enhanced in two main directions: a) integration of public transport in the proposed solutions, b) individualization of the proposed solutions based on users' historic trips. The addition of public bus services results in an increase of the alternative solutions that need to be examined. More specifically, 23 possible solutions are now identified, as presented in Figure 4. Moreover, the utility function (equation 1) should also include a parameter and a variable related to the travel time with public transport. Based on the findings of a recent study that conducted in the city of Thessaloniki and models the willingness to use a shared scooter instead of public transport, the parameter of the "travel time with public transport" variable can be derived (Nikiforiadis et al., 2023). More specifically, the parameters identified by the referenced study, along with the already identified parameter for the "travel time with scooter" variable, are being used to estimate the parameter for the "travel time with public transport" variable. As such, the utility function now takes the following form.

$$GC = -0.18 \times tt_c - 0.236 \times tt_b - 0.37 \times tt_s - 0.275 \times tt_w - 0.314 \times tt_{pt} - 1.073 \times c - 3.925 \times nt \quad (2)$$

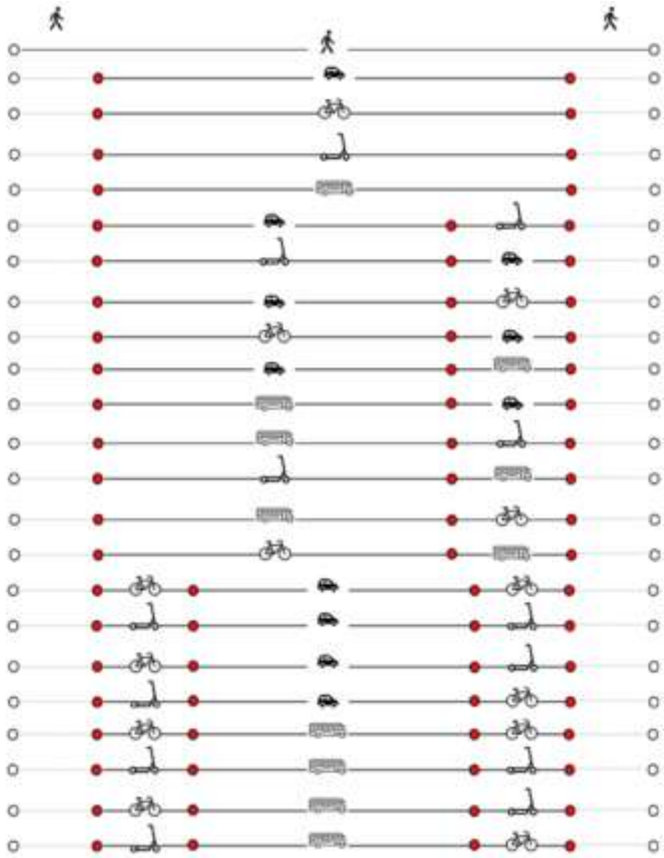

Figure 4. Representation of the 23 alternative solutions (updated multimodal trip planner).

The new form of the utility function, as well as the initial one, is generic (i.e. the same for all users). For incorporating individual preferences in the utility function, a mechanism is being proposed that will consider for each user his/her historic trips, as they are gathered by the eMaaS app. Considering that the eMaaS app records only the trips that the user made through shared car, bike and scooter, the adaptation of the utility function can only be made with regards to the specific modes. As a result, an adaptation factor is being added in the function of each one of the three modes and the final form of the utility function is the following.

$$GCi = -0.18 \times f_{ci} \times tt_c - 0.236 \times f_{bi} \times tt_b - 0.37 \times f_{si} \times tt_s - 0.275 \times tt_w - 0.314 \times tt_{pt} - 1.073 \times c - 3.925 \times nt \quad (3)$$

The adaptation factors (fc, fb, fs) are being computed separately for each user i and they are dynamically changing as the user makes new trips. The three adaptation factors are computed using the following steps.

Step 1: calculate adaptation factors for each separate historic trip

i) if it is a car trip:

$f_{c1} = \frac{t_b}{t_c}$, if $\frac{t_b}{t_c} > 1$ then cap fc1 to 1 (4)

$f_{c2} = \frac{t_s}{t_c}$, if $\frac{t_s}{t_c} > 1$ then cap fc2 to 1 (5)

ii) if it is a bike trip:

$f_{b1} = \frac{t_c}{t_b}$, if $\frac{t_c}{t_b} > 1$ then cap fb1 to 1 (6)

$f_{b2} = \frac{t_s}{t_b}$, if $\frac{t_s}{t_b} > 1$ then cap fb2 to 1 (7)

iii) if it is a scooter trip:

$f_{s1} = \frac{t_c}{t_s}$, if $\frac{t_c}{t_s} > 1$ then cap fs1 to 1 (8)

$f_{s2} = \frac{t_b}{t_s}$, if $\frac{t_b}{t_s} > 1$ then cap fs2 to 1 (9)

where *tc, tb, ts* correspond to the travel time that is needed with car, bike and scooter for a trip from the origin to the destination of the specific historic trip.

Step 2: calculate adaptation factors for each user

$$f_{ci} = \frac{\sum_{j=1}^{n}(fc1j + fc2j)}{n} \quad (10)$$

$$f_{bi} = \frac{\sum_{j=1}^{n}(fb1j + fb2j)}{n} \quad (11)$$

$$f_{si} = \frac{\sum_{j=1}^{n}(fs1j + fs2j)}{n} \quad (12)$$

where n is the number of trips that the user i carried out with the specific mode.

4. Integration into existing MaaS app

In the case of Thessaloniki's MaaS system, the multimodal trip planner service made available to the users both as a stand-alone web app and as an integrated feature in an already existing MaaS app (Figure 5). The multimodal trip planner results are presented with the aid of a map and the service provides not only the optimal trip, but also alternative solutions that are not exceeding specific thresholds. In this way, the user can easily compare and select among the solutions. Moreover, checkboxes have been added allowing users to exclude specific mode(s) from the proposed multimodal solutions.

Figure 5. Multimodal trip planner user interface in MaaS app.

Challenges & Mitigations

The main challenge that was identified during the development of this measure is the need for optimizing the programming code, since the individualization approach requires a lot of computations for each trip request (the number of computations is increasing as the number of user's historic trips is increasing), which could result in a delayed response of the service and in turn in an undesired user experience.

Next steps towards implementation

The updated multimodal trip planner has already been integrated in the MaaS app and it is already operational. Within the next months, continuous testing will be performed for optimizing the programming code and providing the best possible user experience. Also, as an additional next step, the GTFS for the metro system will be sought (when the metro becomes operational) for integrating metro in the proposed multimodal solutions too. After the testing period, users will be recruited to run the demonstration.