MOMENTUM

Modelling Emerging Transport Solutions for Urban Mobility

This document is a manual for the Level 3 of the Decision Support Toolset developed by Centre for Research & Technology Hellas Hellenic Institute of Transport (CERTH/HIT), under European Project MOMENTUM. This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 815069.

In this manual, all the steps that need to be followed in order to test different scenarios, in Level 3 are described. The nature of the methodological stream of Level 3 is based on the investigation of the transport model of the city examined. Thus, the online version of the DST, needs an off line preparation. The online version of the DST, is focused on the visualization of the produced off line preparation.

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Introduction

To achieve the general objective of MOMENTUM project, is to develop new modelling approaches that are able to ascertain the impact of emerging mobility concepts and solutions. This means that changes required to incorporate emerging mobility solutions into strategic transportation models, both in terms of supply and demand, have to be formulated and explanatory and predictive models have to be constructed. An intermediate modelling approach was formulated, which integrates the principles of agent-based approaches within the traditional four-step approach, providing an opportunity for cities to evaluate and integrate shared mobility systems and form long term planning strategy.

This document is divided in two parts: Data preparation (offline) and Visualization (online). In each part, input data and preparation procedures needed, are described.

Data preparation – offline

Considering the existing literature and the models used by the cities, a new modelling framework is designed to extend the traditional four-step approach, and the same is presented in this section. Existing literature related to modelling of shared mobility generally shows the use of agent and activity-based approaches.

The new proposed framework, continue to use the existing trip generation and trip distribution steps from the traditional four-step approach for OD matrix generation. Following trip distribution, the OD matrix is disaggregated using socio-demographic data to generate synthetic population and destination choice. Based on this synthetic population, the demand for different modes is estimated using mode choice models. The conventional aggregate mode choice models of the cities usually include only conventional modes, and, hence, an updated model that also includes different shared mobility systems is required.

Vehicle route

This model was designed to optimize Demand Responsive Transport (DRT) routes by solving the Dial-A-Ride Problem with Time Windows (DARP-TW). The input to this module consists of a JSON file with information regarding trip requests, travel times, fleet and depot, as well as the set-up of the optimization algorithm. The output consists of another JSON file containing information about the optimised routes and trip requests that cannot be served. This module was developed using the OR-tools library, an open-source software suite developed by Google for solving vehicle routing among other optimisation problems. For its use, in addition to installing the or-tools library, it is also necessary to install the beeprint library. The GitHub link consists of the following five files: (i) inputData.py – data model for input data; (ii) outputData.py – data model for output data; (iii) CVRPTW-PD_final.py – main methods of the software module; (iv) dataInput.json – sample input file; (v) dataOutput.json – sample output file.

Script location: https://github.com/h2020-momentum/MOMENTUM/tree/main/Fleet%20management/Operations/drt

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Citing this model: Jenny Fajardo, Antonio D. Masegosa, Pablo Fernandez (2021), DRT optimisation module - EU H2020 MOMENTUM Project (GA 815069), Software Library, University of Deusto, Spain

Mode choice model

This model is intended to estimate modal split between (i) conventional transport modes as a whole, (ii) bike-sharing, (iii) car-sharing, and (iv) ride-sharing. A CSV file with synthetic population data, trip travel times and sharing vehicle availability are taken as an input and the output is also a CSV file, with mode choice combined with the input data. This model is coded in 'R' language and is available in the GitHub link provided below. It uses the base functions in R and hence, no special package is required for running it. The GitHub link consists of the following three different files: (i) CoefficientValues.csv – Model parameters; (ii) NewModeChoiceModelPrediction.R – Main model script; (iii) InputSampleFile.csv – Sample input file, for understanding the inputs and testing the model.

Script location: https://github.com/h2020-momentum/MOMENTUM/tree/main/Demand/Mode%20choice/New%20mode%20choice%20model%20(logit)

Contact details: Santhanakrishnan Narayanan (santhanakrishnan.narayanan@tum.de), Constantinos Antoniou (c.antoniou@tum.de)

Citing this model: Narayanan, S. and Antoniou, C. (2022). Shared mobility services towards Mobility as a Service (MaaS): What, who and when?

Synthetic population module

The synthetic population module consists of different methods for generating disaggregated demand that is further provided to the mode choice module for the estimation of the modal splits for conventional and shared mobility trips.

The synthetic population module consists of the following models:

- **Synthetic population generation** model for the generation of a synthetic population.
- **Statistical matching** and **Random Forest** methods for enriching the syntheting population with missing attributes.

Within the MOMENTUM project, the open-source PopGen synthesiser (MARG, 2016) is used as a basis for the synthetic population generation. The data requirements are defined by the type of method that is used for the generation of a synthetic population as well as the data availability. Synthetic population generation is based on census data and sample data from travel surveys.

The main inputs for the **synthetic population generation module** are the following and are provided in CSV format:

- Aggregate sociodemographic data (census data) for select attributes
- Samples data of disaggregate data for households and individuals (e.g. travel surveys) with corresponding information for the select attributes
- Geographic areas and zoning system
- Geographic mapping (between multiple zone levels)
- Marginals for household and individual attributes

There may be relevant attributes (especially for the new mobility services) that are not available in both the census and the travel survey data, which is a requirement for the PopGen synthesiser. In such cases, **statistical procedures** are used within MOMENTUM to enrich the synthetic population with additional attributes. For example, a sample from the synthetic population can be combined with data from the household travel surveys for attributes (e.g. if a person holds a driver´s license) that may not be available both in the census and survey samples to include them in the initial population synthesis. The process involves the definition of mutual sociodemographic attributes in the synthetic population and sample surveys (e.g. age, gender, income class), assuming sufficient correlation with the unilateral attributes to attach to the synthetic persons.

This data-driven approaches that enrich the synthetic population generation process are the ones hosted in the repository. Two approaches are developed for the enrichment of the synthetic populations. A **statistical matching** (adopted by Hörl, S. and Balac, M., 2020. Reproducible scenarios for agent-based transport simulation: A case study for Paris and Île-de-France.) and a **Random Forest** model.

The input files for the statistical matching and random forest methods are:

- Synthetic population
- Travel survey data with the additional attributes to be added in the basic synthetic population

The format of the input and output files is CSV.

Script location: https://github.com/h2020-momentum/MOMENTUM/tree/main/Demand/Synthetic%20population%20generation

Contact details: Athina Tympakianaki (athina.tympakianaki@aimsun.com), Jordi Casas (jordi.casas@aimsun.com)

Citing this model:

PopGen: MARG (2016). *PopGen: Synthetic Population Generator*. Mobility Analytics Research Group. http://www.mobilityanalytics.org/popgen.html.

Statistical matching: Hörl, S. and Balac, M., 2020. Reproducible scenarios for agent-based transport simulation: A case study for Paris and Île-de-France.

Shared Service Simulation Platform (Aimsun Ride)

The Aimsun Ride simulation platform (Aimsun, 2020) for shared mobility services is an advanced tool that enables the deployment and assessment of various scenarios related to new shared mobility applications (e.g., DRT, car-sharing, ride-sharing, bike-sharing and micro-mobility systems). The Aimsun Ride framework is integrated in the commercial software Aimsun Next, hence, this module is not available in the repository.

The main input information for the shared-mobility services simulation platform Aimsun Ride is related to:

i) Transport network information and service areas,
ii) Individual trip requests
iii) Operator and fleet characteristics

The **network** information to be imported into the Aimsun Next software includes:

- **Network supply** (road network graph, geometric characteristics, road sections capacities). Possibility to import JSON/SHP/Map formats.
- **Network travel times.** Utilization of free-flow, simulated or historical/external travel times (e.g., from other simulation software or ground truth travel time measurements)
- **Network fidelity for the simulations.** Flexibility to simulate with multiple resolutions (microscopic, mesoscopic, macroscopic or hybrid models) for large-scale networks
- Definition of the **service area** and **stops/stations locations** (GIS formats)

The **requests** file has a collection of fields related to the requested trips to be executed during the simulation and can include can include several user-defined fields that are, in turn, provided to the operator as additional attributes:

- **Origin and destination** locations
- **Time** of the request
- **Constraints** (e.g. accessibility, walking distance thresholds, departure or arrival time windows)

The **operator** file includes information related to the specific service that is being evaluated as well as the fleet specifications:

- Vehicle **type** (e.g. bus, van, taxi)
- Fleet **size**
- Fleet **capacity**
- **Location** and **number** of stops or stations

The request´s and operator´s files are provided in JSON format.

After an execution, the simulation platform produces a file with all the events executed as well as an optional recording file to visualize the simulation. The events file is a binary file that can be exported to JSON format, which will contain a list of events with information for the different event types that have been executed (either for a request or a vehicle in the fleet). This information is related to the state of a request or a vehicle executing it, the position and used capacity of vehicles, the path chosen.

Example of **Key Performance Indicators**

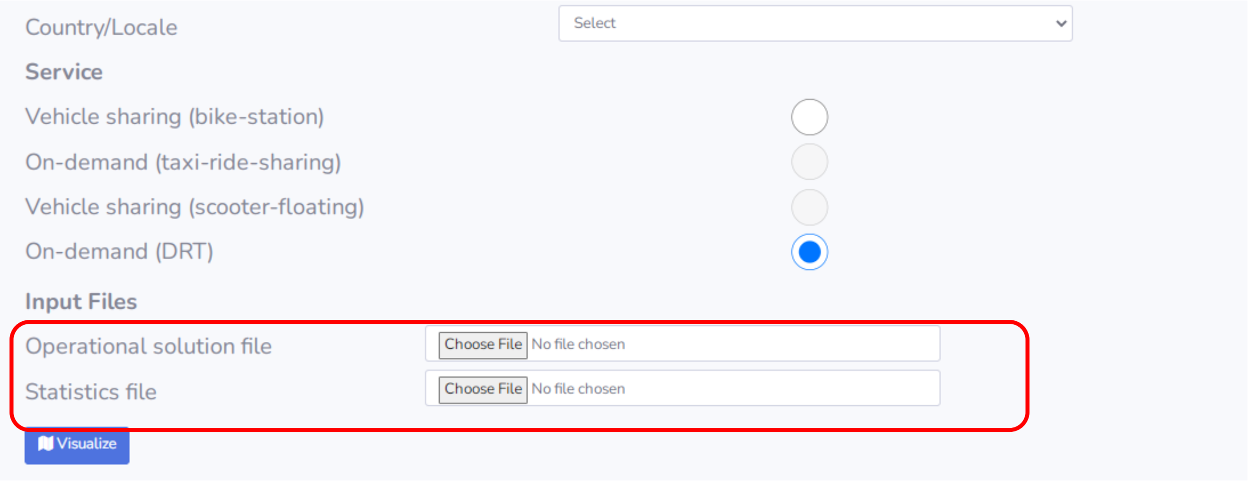
- Trip time
- Trip distances
- Waiting times
- Number of cancelled trip plans
- Vehicle utilization

Contact details: Athina Tympakianaki (athina.tympakianaki@aimsun.com), Jordi Casas (jordi.casas@aimsun.com)
Citing this model: Aimsun (2020). *Aimsun Next 20 User´s Manual.* Aimsun Next Version 20.0.2, Barcelona, Spain.

Visualization – online

Once the previous steps are finished, users can import the produced json files to the online version of the Decision Support Toolset. The available services that can be tested in this Level, include the following services described in the screenshot below.

The input data for Level 3, user need to upload json files exported from previous steps. For DRT sevice, user need to inport In the simulation data file user need to import the json exprotred from the Aimsun Ride (Operational solution file) , while on the statistics input soloution file, user need to import the exportred json file from the “vehicle route” step. For the bike sharing system, user need to import only the json file produced from the Aimsun ride assignment



Country/Locale: Select

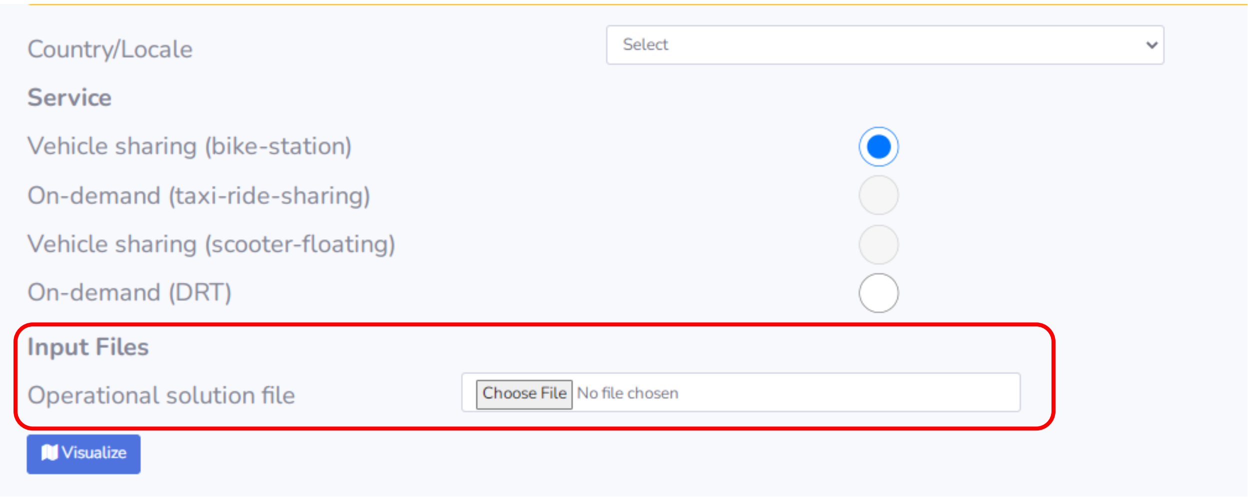
Service

- Vehicle sharing (bike-station) ○
- On-demand (taxi-ride-sharing) ○
- Vehicle sharing (scooter-floating) ○
- On-demand (DRT) ●

Input Files

- Operational solution file: Choose File No file chosen
- Statistics file: Choose File No file chosen

Figure 1: DRT input data



Country/Locale: Select

Service

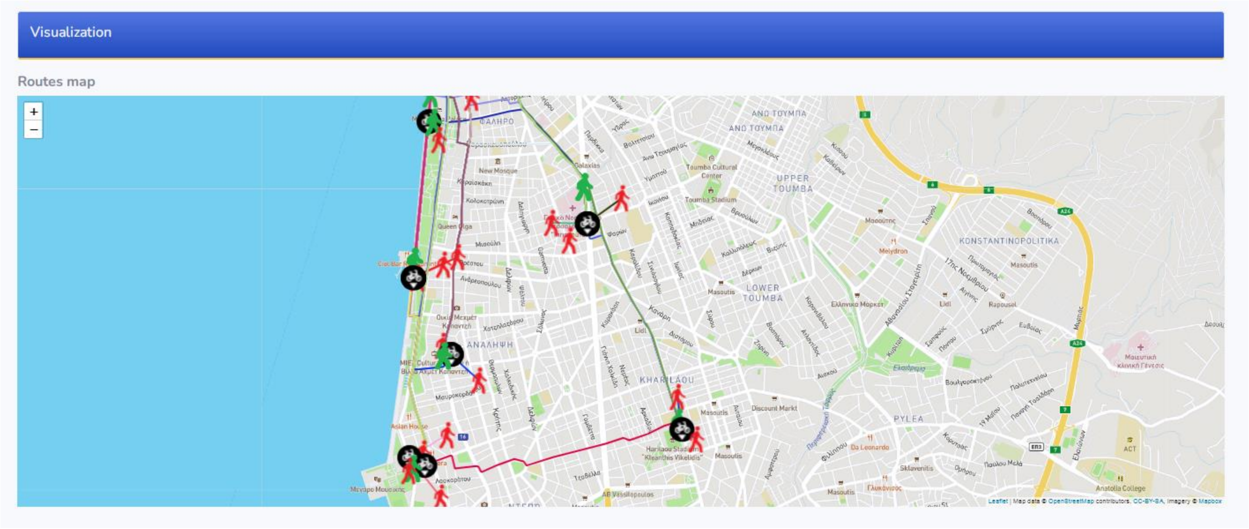
- Vehicle sharing (bike-station) ●
- On-demand (taxi-ride-sharing) ○
- Vehicle sharing (scooter-floating) ○
- On-demand (DRT) ○

Input Files

- Operational solution file: Choose File No file chosen

Figure 2: Bikesharing input data

Once all files are imported, then user need to press the visualization button. Then results of the tool will be available. Result are divided in two sections: the visualization map and the operational information of the examined service.

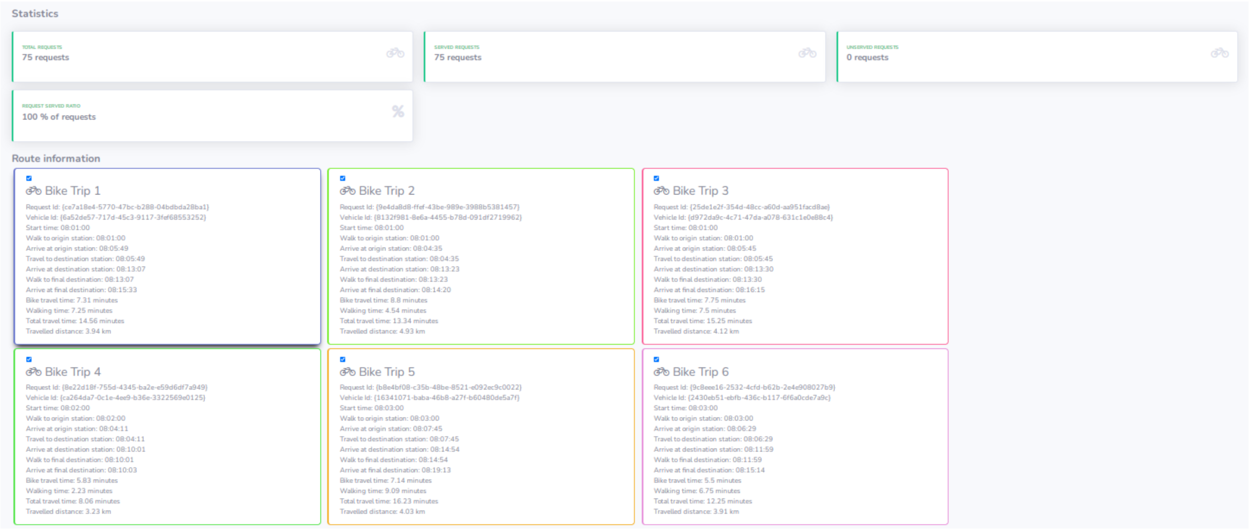


Visualization

Routes map

Figure 3: Bike sharing routes

In the second part of the results, statistics and KPIs produced, are presented in the DST.



Statistics

TOTAL REQUESTS
75 requests

SERVED REQUESTS
75 requests

UNSERVED REQUESTS
0 requests

REQUEST SERVED RATIO
100 % of requests

Route information

☑ Bike Trip 1
Request Id: {ce7a18e4-5770-47bc-b288-04bdbda28ba1}
Vehicle Id: {6a52de57-717d-45c3-9117-3fef68553252}
Start time: 08:01:00
Walk to origin station: 08:01:00
Arrive at origin station: 08:05:49
Travel to destination station: 08:05:49
Arrive at destination station: 08:13:07
Walk to final destination: 08:13:07
Arrive at final destination: 08:15:33
Bike travel time: 7.31 minutes
Walking time: 7.25 minutes
Total travel time: 14.56 minutes
Travelled distance: 3.94 km

☑ Bike Trip 2
Request Id: {9e4da8d8-ffef-43be-989e-3988b5381457}
Vehicle Id: {8132f981-8e6a-4455-b78d-091df2719962}
Start time: 08:01:00
Walk to origin station: 08:01:00
Arrive at origin station: 08:04:35
Travel to destination station: 08:04:35
Arrive at destination station: 08:13:23
Walk to final destination: 08:13:23
Arrive at final destination: 08:14:20
Bike travel time: 8.8 minutes
Walking time: 4.54 minutes
Total travel time: 13.34 minutes
Travelled distance: 4.93 km

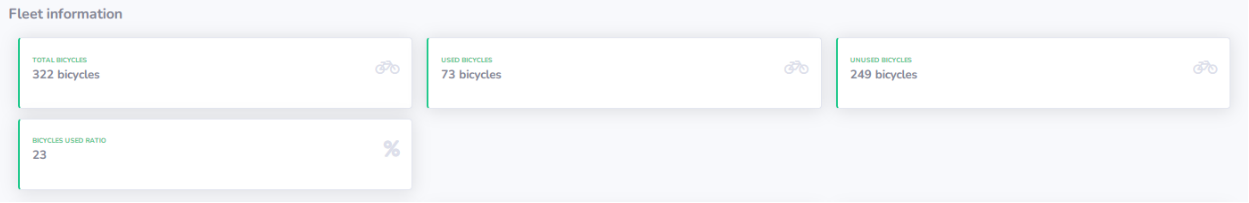
☑ Bike Trip 3
Request Id: {25de1e2f-354d-48cc-a60d-aa951facd8ae}
Vehicle Id: {d972da9c-4c71-47da-a078-631c1e0e88c4}
Start time: 08:01:00
Walk to origin station: 08:01:00
Arrive at origin station: 08:05:45
Travel to destination station: 08:05:45
Arrive at destination station: 08:13:30
Walk to final destination: 08:13:30
Arrive at final destination: 08:16:15
Bike travel time: 7.75 minutes
Walking time: 7.5 minutes
Total travel time: 15.25 minutes
Travelled distance: 4.12 km

☑ Bike Trip 4
Request Id: {8e22d18f-755d-4345-ba2e-e59d6df7a949}
Vehicle Id: {ca264da7-0c1e-4ee9-b36e-3322569e0125}
Start time: 08:02:00
Walk to origin station: 08:02:00
Arrive at origin station: 08:04:11
Travel to destination station: 08:04:11
Arrive at destination station: 08:10:01
Walk to final destination: 08:10:01
Arrive at final destination: 08:10:03
Bike travel time: 5.83 minutes
Walking time: 2.23 minutes
Total travel time: 8.06 minutes
Travelled distance: 3.23 km

☑ Bike Trip 5
Request Id: {b8e4bf08-c35b-48be-8521-e092ec9c0022}
Vehicle Id: {16341071-baba-46b8-a27f-b60480de5a7f}
Start time: 08:03:00
Walk to origin station: 08:03:00
Arrive at origin station: 08:07:45
Travel to destination station: 08:07:45
Arrive at destination station: 08:14:54
Walk to final destination: 08:14:54
Arrive at final destination: 08:19:13
Bike travel time: 7.14 minutes
Walking time: 9.09 minutes
Total travel time: 16.23 minutes
Travelled distance: 4.03 km

☑ Bike Trip 6
Request Id: {9c8eee16-2532-4cfd-b62b-2e4e908027b9}
Vehicle Id: {2430eb51-ebfb-436c-b117-6f6a0cde7a9c}
Start time: 08:03:00
Walk to origin station: 08:03:00
Arrive at origin station: 08:06:29
Travel to destination station: 08:06:29
Arrive at destination station: 08:11:59
Walk to final destination: 08:11:59
Arrive at final destination: 08:15:14
Bike travel time: 5.5 minutes
Walking time: 6.75 minutes
Total travel time: 12.25 minutes
Travelled distance: 3.91 km

Figure 4: Statistics for each bike route



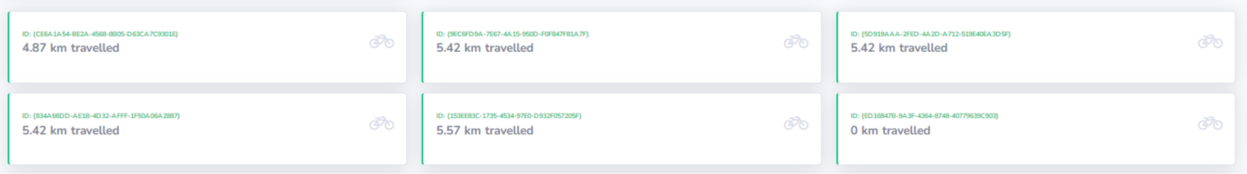
Fleet information

TOTAL BICYCLES
322 bicycles

USED BICYCLES
73 bicycles

UNUSED BICYCLES
249 bicycles

BICYCLES USED RATIO
23



ID: {CE6A1A54-BE2A-4568-8B05-D63CA7C9301E}
4.87 km travelled

ID: {9EC6FD9A-7E67-4A15-950D-F0F847F81A7F}
5.42 km travelled

ID: {5D919AAA-2FED-4A2D-A712-519E40EA3D5F}
5.42 km travelled

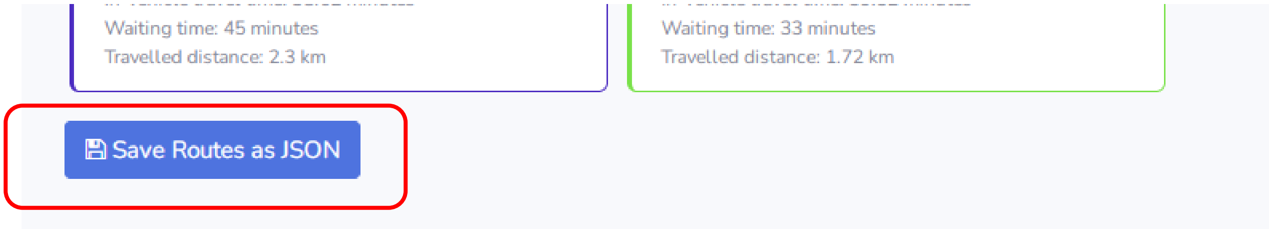
ID: {834A66DD-AE1B-4D32-AFFF-1F50A06A2887}
5.42 km travelled

ID: {153EE83C-1735-4534-97E0-D932F057205F}
5.57 km travelled

ID: {ED16847B-9A3F-4364-8748-40779639C903}
0 km travelled

Figure 5: Fleet Information

At the end of the produced results, users can extract the results. the format selected to be exported is jason. The resan why this format was selected, aims to produce an flexible way to further usage of the exported results.



Waiting time: 45 minutes
Travelled distance: 2.3 km

Waiting time: 33 minutes
Travelled distance: 1.72 km

Figure 6: Button to save JSON with results

Supported coordinate systems

Thessaloniki

```
+proj=merc +lon_0=0 +k=1 +x_0=0 +y_0=0 +a=6371000 +b=6371000 +units=m +no_defs
```

Madrid

```
PROJCS["WGS_1984_UTM_Zone_30N",GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["WGS_1984",6378137,298.257223563]],PRIMEM["Greenwich",0],UNIT["Degree",0.017453292519943295]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000],PARAMETER["False_Northing",0],PARAMETER["Central_Meridian",-3],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0],UNIT["Meter",1]]
```

Regensburg

```
PROJCS["DHDN / 3-degree Gauss-Kruger zone 4 (E-N)",GEOGCS["DHDN",DATUM["Deutsches_Hauptdreiecksnetz",SPHEROID["Bessel 1841",6377397.155,299.1528128,AUTHORITY["EPSG","7004"]],TOWGS84[598.1,73.7,418.2,0.202,0.045,-2.455,6.7],AUTHORITY["EPSG","6314"]],PRIMEM["Greenwich",0,AUTHORITY["EPSG","8901"]],UNIT["degree",0.0174532925199433,AUTHORITY["EPSG","9122"]],AUTHORITY["EPSG","4314"]],PROJECTION["Transverse_Mercator"],PARAMETER["latitude_of_origin",0],PARAMETER["central_meridian",12],PARAMETER["scale_factor",1],PARAMETER["false_easting",4500000],PARAMETER["false_northing",0],UNIT["metre",1,AUTHORITY["EPSG","9001"]],AXIS["Easting",EAST],AXIS["Northing",NORTH],AUTHORITY["EPSG","5678"]]
```