



nuMIDAS

Deliverable 5.4

Transferability guidelines



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Editor(s) / main author(s)	Valerio Paruscio (POLIEDRA) Valerio Mazzeschi (POLIEDRA)
Contributing authors	TML MAPTM CERTH FACTUAL CTU AMB INFO AMAT LEUVEN
Reviewer(s)	Sven Maerivoet (TML)
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Acronyms

ANPR	Automated Number Plate Recognition
C-ITS	Connected and Intelligent Transportation Systems
EC	European Commission
GA	Grant agreement
ITS	Intelligent Transportation Systems
KPI	Key Performance Indicator
MaaS	Mobility-as-a-service
MFD	Macroscopic fundamental diagram
NIL	Nuclei di Identità Locale (Local Identity Neighbourhoods)
nuMIDAS	New Mobility Data and Solutions Toolkit
OD	Origin/Destination
UC	Use Case
WP	Work package



1 Executive summary

Deliverable 5.4 gathers the work done within task 5.3 to provide the necessary information to enable users to use the platform correctly. Furthermore, these guidelines also include the list of data that a city must have in order to implement one of the use cases developed by the project.

From a technical point of view, such deliverable can be thought of as both a user manual for users of the dashboard and to indicate to cities that would like to use the outputs of the project what the basic requirements are for implementing one or more co-designed use cases. The concept of transferability, through the approach of transferability for design, was used from the very beginning of the project and in particular, for the development of the use cases. In order to achieve greater dissemination and utilisation of the results of this project (and especially the dashboard), these guidelines are intended to provide, in a synthetic way, the basic knowledge for each use case.

For each of them, the main features (challenges addressed, data required, input parameters) of the tool co-designed with the representatives of the pilot cities were summarised in the introduction, together with the major objectives that the tool aims to achieve. Subsequently, the steps that a user has to execute in order to be able to enter his or her input data and start the calculation. In addition, information was also provided within the report concerning the interpretation of the results both in the form of graphs or maps and in the form of KPIs.

Finally, possible new implementations have also been included in the “next steps” section. These implementations may concern both the part purely related to the algorithm (e.g., the possibility of calculating new KPIs, taking into account more complex calculation and estimation models) and related to the usability of certain functions on the dashboard (i.e. visualisation of several simultaneous scenarios, possibility of interacting more with the maps).



2 Introduction

2.1 About nuMIDAS

The mobility ecosystem is rapidly evolving, whereby we see the rise of new stakeholders and services. Examples of these are the presence of connected and automated vehicles, a large group of organisations that rally to establish various forms of shared mobility, with the pinnacle being all of these incorporated into a large MaaS ecosystem. As these new forms of mobility offerings start to appear within cities, so do new ways in which data are being generated, collected, and stored. Analysing this (Big) data with suitable (artificial intelligence) techniques becomes more paramount, as it leads to insights in the performance of certain mobility solutions and is able to highlight (mobility) needs of citizens in a broader context, in addition to a rise in new risks and various socio-economic impacts.

Successfully integrating all these disruptive technologies and solutions with the designs of policy makers remains a challenge at current. let alone being able to analyse, monitor, and assess mobility solutions and their potential socio-economic impacts.

nuMIDAS, the New Mobility Data & Solutions Toolkit, bridges this (knowledge) gap, by providing insights into what methodological tools, databases, and models are required, and how existing ones need to be adapted or augmented with new data. To this end, it starts from insights obtained through (market) research and stakeholders, as well as quantitative modelling. A wider applicability of the project's results across the whole EU is guaranteed as all the research is validated within a selection of case studies in pilot cities, with varying characteristics, thereby giving more credibility to these results. Finally, through an iterative approach, nuMIDAS creates a tangible and readily available toolkit that can be deployed elsewhere, including a set of transferability guidelines, thus thereby contributing to the further adoption and exploitation of the project's results.

nuMIDAS, the New Mobility Data and Solutions Toolkit, started at the beginning of 2021 under the Horizon 2020 programme and its is being developed by a European Consortium, composed of 9 partners from 6 countries: Belgium, Czech Republic, Greece, Italy, The Netherlands, and Spain.

The project builds on a distributed selection of case studies in pilot cities to provide a geographic coverage of the EU. The four pilot cities are: Barcelona (Spain), Milano (Italy), Leuven (Belgium), and Thessaloniki (Greece).

2.2 Purpose of this document

With the purpose of widespread the results of the projects to other cities, this deliverable is structured as a handbook that describes the data that are required in order to use the tools, tools' characteristics, and the features of the dashboard. This handbook is designed for all users of the dashboard. In particular, it refers to the decision makers of the pilot cities and the technicians supporting them. However, the deliverable is also a useful reference for all potential future users of the dashboard in order to provide them with the correct information for using the platform.

Since the definition of the different use cases, a design for transferability approach was used. In particular, during the discussions among the partners, high attention was paid to co-design the algorithm so that the structure could be adaptable also with other dataset from other cities.



Moreover, an “internal transferability” was done during the project time. Indeed, some city’s representatives from the project pilot cities evaluated, during the usability tests (D5.1), not only the tools concerning their city, but also the other tools, with the aim to have fist feedbacks from people that were not completely involved in the tool co-designing phase.

2.3 Structure of this document

In the first part of this deliverable, the quick start instructions regarding the use of the dashboard are described. Specifically, guidance concerning how to login into the website, add a new city in the dashboard menu, add a new user of the use cases is provided.

Hereafter, in the third part, per each use case are described:

- Introduction: a brief explanation of the reasons for defining the tool for the individual use case. In addition, the goals that the co-designed algorithm achieves are also defined.
- Data requirement: list and description of the data that are required both for the implementation of the tool and for its proper functioning.
- Usage Procedure: outlining and describing the steps that are needed in order to run calculations in the dashboard.
- Interpretation of the results: description of the results that emerge and their explanation
- Next steps: the discuss what steps need to be taken to deploy for another city.

Finally, conclusions regarding the possible applications of this guidelines are reported in the last part of this deliverable.



3 Quick start instructions

This section describes the steps to access to the dashboard and to manage the sections concerning both the cities in which the tools are to be implemented and the possible roles that each registered account can assume within the dashboard.

Specifically, instructions are given for accessing the platform (login) and for entering and editing the following sections of the dashboard:

- How to add toolkit users
- How to add city
- City members
- Toolkit use cases.

Login

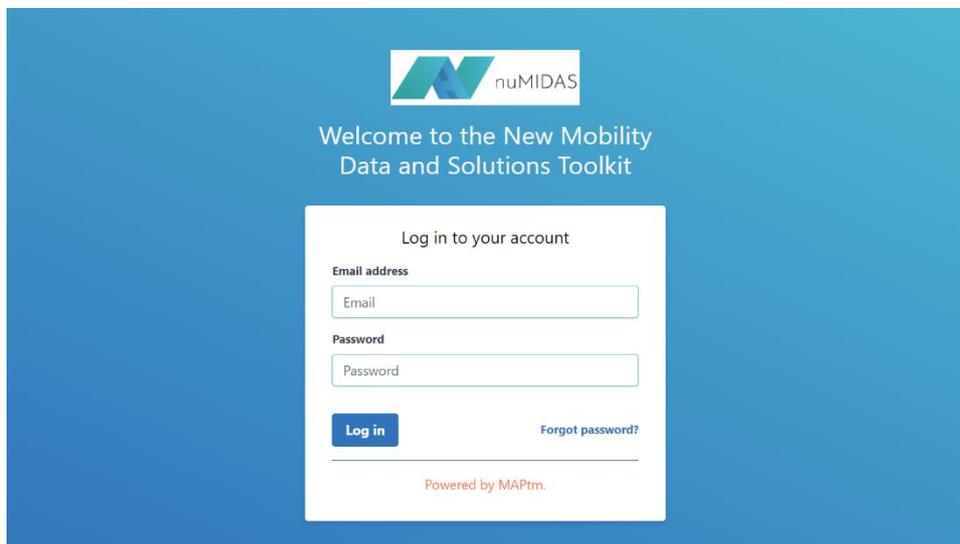


Figure 1: Login home page.

Login is done by entering e-mail and password. A system administrator will provide a password for the first access to the platform. Thereafter, the owner of the invited account has the option of changing the password provided for the first login to a personal password (see the section “how to add users”).

How to add toolkit users

In the settings section, you can add a new user. In fact, in the top right-hand corner there is a 'Create new user' button.

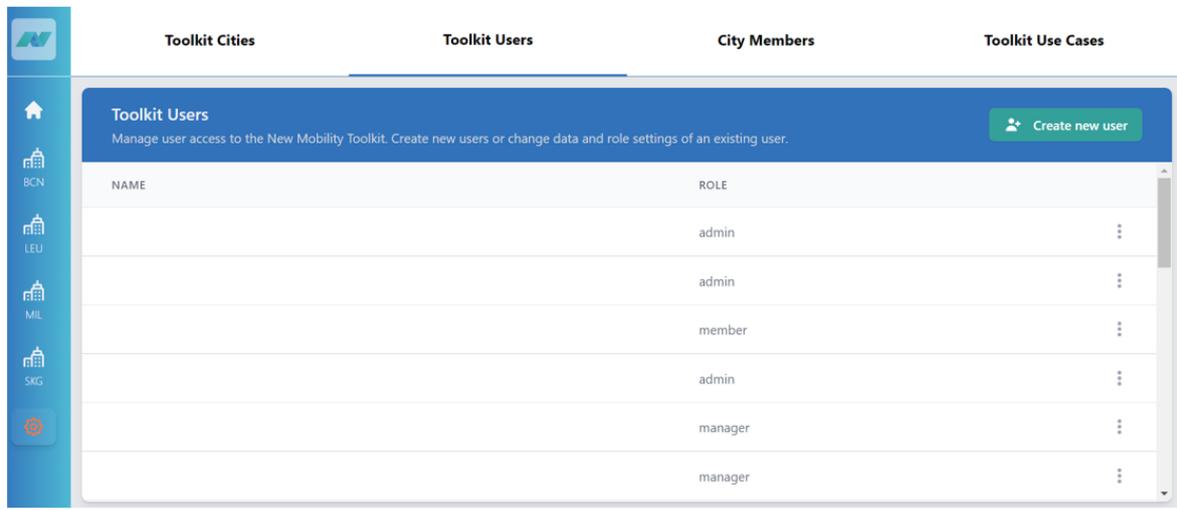


Figure 2: Toolkit users' section.

Once this is clicked, a new box opens in which the user's first name, last name and full name can be entered. In addition, it is required to specify which role the new user will assume. Specifically, there are three roles

- General Administrator: She/He has full editing rights in all sections of the dashboard.
- City Manager: She/He has the right to add new users and add new cities
- Project Member: She/He is only allowed to see the section and results of the city or cities with which it has been associated.

Moreover, it is required to enter the new user's e-mail address and a provisional password, which the new member will then change once he/she has logged in for the first time.



Create new user

Use the form below to create a new user.

First name: Last name:

Full name:

User role:

- General administrator
All rights for creating new users and cities.
- City manager
All rights for configuring new cities and adding city members.
- Project member
Viewing rights to permitted cities.

Email address:

Temporary password:

Password must be at least 8 characters long and contain at least one upper case letter, one lower case letter, one number and one special character.

[Create user](#)

Figure 3: How to add a new user.

How to add city

Only General Administrator and City Manager have the right to insert a new city. Going into details, by entering in the "settings" section (represented by a cogwheel), from the menu on the left, it is possible to access the area concerning the "Toolkit Cities". In this part of the website, a new city can be added to the project dashboard.

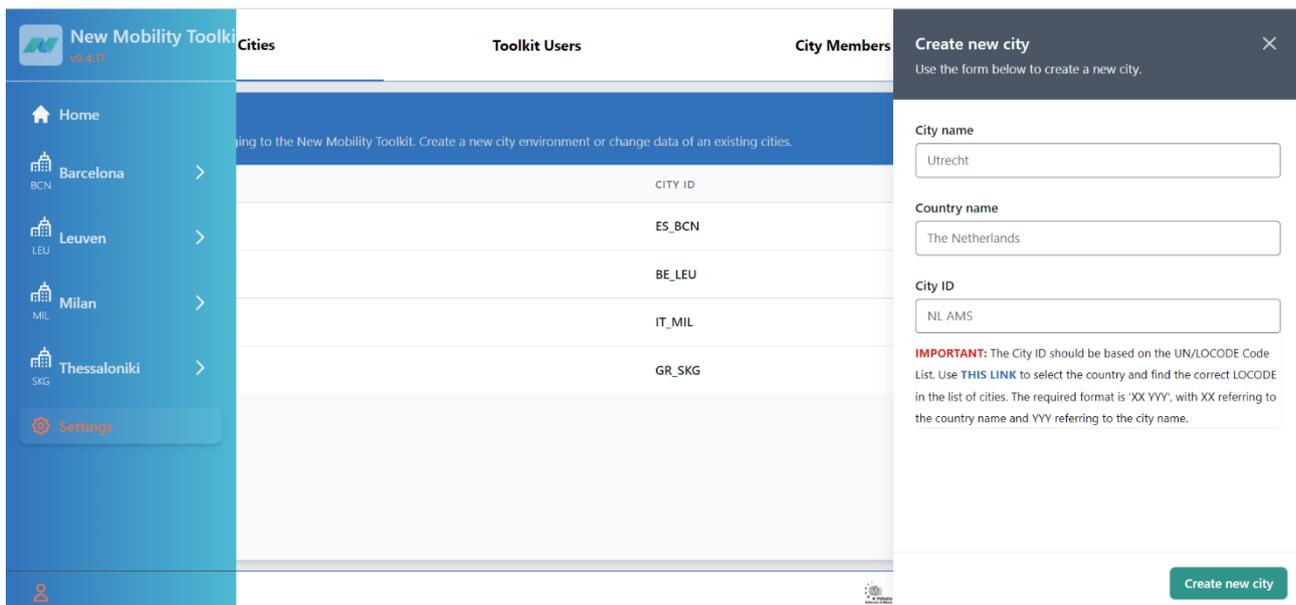
Toolkit Cities	Toolkit Users	City Members	Toolkit Use Cases
Toolkit Cities Manage cities belonging to the New Mobility Toolkit. Create a new city environment or change data of an existing cities. Create new city			
CITY		CITY ID	
Barcelona		ES_BCN	⋮
Leuven		BE_LEU	⋮
Milan		IT_MIL	⋮
Thessaloniki		GR_SKG	⋮

Figure 4: Cities' section.

In the top right-hand corner is the button marked 'Create a new city'. Pressing the button opens a window in which you can enter:

- the full name of the city,
- the full name of the country and the City ID.

In particular, specific coding must be followed for this code, which is shown in the following lines. In fact, the City ID should be based on the UN/LOCODE Code List. The user could use the reference to this link <https://unece.org/trade/cefact/unlocode-code-list-country-and-territory> to select the country and find the correct LOCODE in the list of cities. The required format is 'XX YYY', with XX referring to the country name and YYY referring to the city name.



The screenshot displays the 'New Mobility Toolkit' interface. On the left is a navigation sidebar with options: Home, Barcelona (BCN), Leuven (LEU), Milan (MIL), Thessaloniki (SKG), and Settings. The main content area is titled 'Cities' and contains a table with the following data:

	CITY ID
	ES_BCN
	BE_LEU
	IT_MIL
	GR_SKG

On the right, a 'Create new city' modal is open, containing the following form fields and instructions:

- City name:** Utrecht
- Country name:** The Netherlands
- City ID:** NL_AMS

IMPORTANT: The City ID should be based on the UN/LOCODE Code List. Use [THIS LINK](#) to select the country and find the correct LOCODE in the list of cities. The required format is 'XX YYY', with XX referring to the country name and YYY referring to the city name.

A 'Create new city' button is located at the bottom right of the modal.

Figure 5: How to add a city.

City members

The third item in the settings section offers the possibility of associating to each user registered on the platform the possibility of viewing, managing, editing, and changing, in accordance with her/his level (admin, manager, member), the sections relating to the city or cities to which she/he has access.

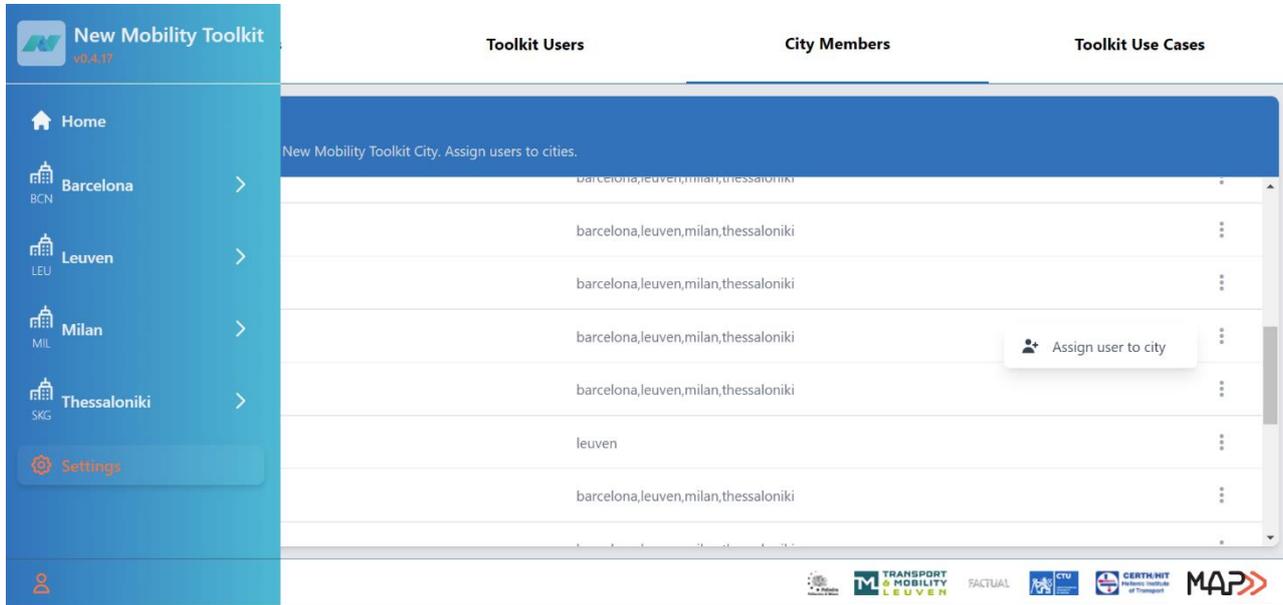


Figure 6: City members' section.

Toolkit Use Cases

Finally, it is also possible to add a new use case to the project dashboard. More precisely, in the 'toolkit use cases' section of the settings, you can find a button at the top of the page labelled 'Create new use case'.

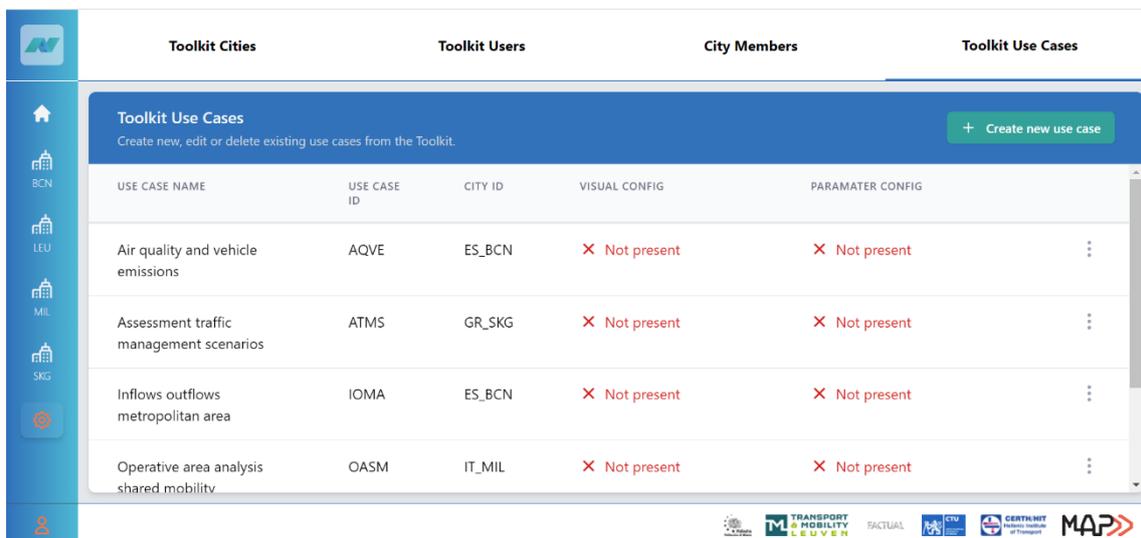


Figure 7: Toolkit use cases' section.



Once pressed, a new subsection opens up in which it is possible to: write the name of the new use case, define a use case acronym, describe the use case in detail in order to provide information to other platform users, and finally associate the use case with one of the cities registered on the platform. Consequently, if the use case concerns a new city, one must first add the new city on the platform and then associate the new use case.

Create new use case ✕

Use the form below to create and assign a new use case.

Use case name	Use case ID
<input type="text" value="Example name"/>	<input type="text" value="ANID"/>

Use case description

Which city or cities would you like to assign this use case to?

<input type="radio"/> Barcelona	<input type="radio"/> Leuven
<input type="radio"/> Milan	<input type="radio"/> Thessaloniki

[Create use case](#)

Figure 8: How to add a use case.



4 Use Case 1: Pre-planning of shared mobility services

4.1 Introduction

Use Case 1 is addressed to all cities offering mobility sharing services. In particular, when pre-planning for sharing mobility implementation, the challenge for these cities is to define an optimal fleet of vehicles to meet user demand on the one hand, and to guarantee a profit for the service operators on the other. In fact, if the fleet is oversized, there would certainly be a greater satisfaction of user demand even though the service operator would then be forced to close down because it would no longer make a profit. If, on the other hand, the fleet is undersized, the operator has a greater profit that would guarantee him to continue his activity at the expense of the users who would not be sufficiently served. Consequently, the tool co-designed for use case 1 can be classified as a decision support tool that solves an optimisation problem. Optimisation concerns, specifically, the size of the fleet, which must be such that it meets demand and is profitable for the service operator. Regarding, decision support, as described in deliverables D3.2 and D4.3, there are two input parameters in the tool concerning the "weight" that the two actors (the service operator and the end user) might have. As the weights for each actor change, the optimisation value changes favouring or disfavouring one of the two actors in the system. Finally, knowing the number regarding the optimal fleet also helps the individual city administrations to define the number of vehicles, for each mode of shared transport, to be included in the tenders that are periodically published.

In conclusion, it is worth pointing out that if a city does not have sharing services, it may still be able to use the tool. In this case, not having historical demand data, a standard daily curve should be used (e.g., the one in Milan).

4.2 Data requirements

The data for UC1 are mainly of two types: one is the data on the modal split of trips made by sharing vehicles, the other is spatial data. Specifically, the first data provides information on the number of trips made by each mode of transport (car-sharing, bike-sharing, kick-scooter, moped), by date and by time slot. The second file is a Shapefile, in which the data (e.g., area of polygons, length of the perimeter of polygons, object identification number) relating to the zones into which the urban territory has been divided are collected.

- **Time series of hourly trips of existing sharing services per mode (if available)**

This table has to include:

- the mode, in the example an integer indicates car sharing, bike sharing, kick-scooters sharing or moped sharing
- the date and time
- the total number of trips within the hour and by the mode.

	Mode bigint	datetime text	trips double precision
61	1	2021-01-03 12:00	171
62	1	2021-01-03 13:00	174
63	1	2021-01-03 14:00	187
64	1	2021-01-03 15:00	244
65	1	2021-01-03 16:00	241
66	1	2021-01-03 17:00	219
67	1	2021-01-03 18:00	158
68	1	2021-01-03 19:00	153
69	1	2021-01-03 20:00	95
70	1	2021-01-03 21:00	66
71	1	2021-01-03 22:00	39
72	1	2021-01-03 23:00	25
73	1	2021-01-04 00:00	8
74	1	2021-01-04 01:00	5
75	1	2021-01-04 02:00	2
76	1	2021-01-04 03:00	1
77	1	2021-01-04 04:00	1
78	1	2021-01-04 05:00	2

Figure 9: Example of time series of hourly trips.

- **City Geo data**

In particular, a shape file of the city divided in sub-zones is useful to retrieve the total area of the scenario to be simulated.

id bigint	id_nil bigint	nil text	shape_leng double precision	shape_area double precision	data bigint	geom text
1	48	RONCHETTO SUL NAVIG...	8723.36871405972	2406306.07896987	326	0106000020E
2	64	TRENNO	3309.9988004761994	489692.08283319284	360	0106000020E
3	67	PORTELLO	3800.750663482093	909602.2187448354	649	0106000020E
6	63	FIGINO	5622.522341274374	1424660.0739678987	599	0106000020E
7	20	LORETO - CASORETTO - ...	5631.442413245651	1747499.4702872867	781	0106000020E
4	81	BOVISASCA	7105.469714553994	1578027.6494128618	328	0106000020E
8	76	QUARTO OGGIARO - VIA...	7138.355679851431	2776872.1958965803	505	0106000020E
9	11	ISOLA	5082.707417608421	1322887.1157650698	393	0106000020E
10	61	QUARTO CAGNINO	4648.169990780246	986354.2126550385	341	0106000020E
35	6	PORTA TICINESE - CONC...	5293.159061792193	1255017.3143643944	317	0106000020E
5	84	PARCO NORD	11741.71700512192	1532331.0035750333	87	0106000020E
11	60	STADIO - IPPODROMI	8277.7341012033	3435177.5065797856	318	0106000020E
46	74	ROSERIO	6789.327807305384	707630.0751857857	522	0106000020E
51	41	GRATOSOGLIO - Q.RE MI...	9810.649561205004	3316447.6607358987	124	0106000020E
53	56	FORZE ARMATE	10211.799908180172	3206782.8217585417	815	0106000020E

Figure 10: Example of City Geo Data.

4.3 Usage procedure

From an operational point of view, the users, after defining the name of the scenario, enters the value of all input parameters that are required:

- Selection of the type of mode to be analysed (bike, moped, kick-scooter, or car-sharing): it is the mode of transport used in the simulations.
- Selection of the type of service to be analysed (station-based or free-floating): this data can only concern bike sharing and car sharing as mopeds and kick scooters are always in free-floating mode.
- Expected daily demand (trips/day): this data concerns the average value of the daily trips made with the selected mode of transport.
- Size of the area of interest (in km²): It is the territorial extension in which the service is active.
- Operating costs per vehicle per minute (in Euros): are the expenses which are related to the maintenance of the car (parking costs, insurance, car maintenance costs). The costs incurred by the provider per minute is an average daily cost, which therefore takes into account both the minutes when the vehicle is in operation and the minutes when it is stationary and parked. However, the actual value of the cost may be difficult to find as the sharing providers are often unwilling to provide this data. Therefore, this input data must be estimated. A reliable estimate is to consider this cost as a percentage of the revenue obtained per minute of rental.
- Expected revenues per minute of rent (in Euros): these are the earnings that the operator of the service obtains and derives from the payment by the user of the rental rates. The value could be the cost the user pays per minute of rental.



- Average user walking speed(km/h): it is the average speed of a pedestrian. In this case, the default value is 3 km/h. This is a prefilled field.
- Mean trip duration (in minutes): it is the average of the vehicle usage time of a certain mode of transport.
- Weighting factors assigned to service operator's and end society's perspectives: the weights are the coefficients that measure the relative importance end-users and operators. The sum of the two weights always equals 1.
- Minimum and maximum value of the fleet size: it is the lowest and highest number of vehicles to be considered as the operational fleet.
- Elastic demand: through this input, the system user decides whether to use a uniformly distributed demand throughout the day, the real demand curve or artificial demand curves that increase or decrease peaks.
- Hourly demand defined by user (in units): This parameter is to be changed if and only if the user decides to use the actual demand curve. Through this input, the user can decide to modify the demand peaks, flattening or emphasising them, but always keeping the daily demand constant
- Profit higher than this value (in Euros): it is the profit threshold above which the simulation is stopped. This input parameter was introduced to reduce the calculation time of the algorithm.

Regarding the average walking speed (km per hour) a default value was chosen. In particular, this value was estimated to be 3.0 km/h, considered as the average speed of a pedestrian in a good state of health and deambulation.

The user can then click on the "create scenario" button and can view the results in the form of graphs and KPIs directly on the home page of the specific use case.

Scenario management

Use the form below to create a new, or select an existing scenario.

Create new scenario

Scenario name

Mode type [?] Service type [?]

Expected daily demand (in units) [?] Area size (in km²) [?]

Operating cost p/vehicle p/minute (in euro's) [?] Expected revenue per minute of rent (in euro's) [?]

Average trip duration (in minutes) [?] Average walking speed (km per hour) [?]

Weighting factor society [?] Weighting factor serviceoperators [?]

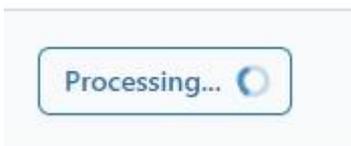
Minimum fleet size (in units) [?] Maximum fleet size (in units) [?]

Elastic demand [?] Hourly demand defined by user (in units) [?]

Profits higher then this value [?]

Figure 11: Scenario management UC1.

Moreover, the user has to refresh the page in order to see the “processing” near the running simulation and wait until the end of the calculation.



Once the simulation calculations are finished, the processing icon gives way to the 'present' icon: at this point, the tool has completed the simulation and the results can be displayed by pressing the 'present' button.



For an explanation and meaning of the results, please refer to the next section “Interpretation of the results.”

4.4 Interpretation of the results

The results of the simulation are visible on the home page of the individual use case. In particular, for use case 1 the outputs are:

- Demand coverage: It is the percentage of the demand that is covered by the service conducted by the optimal fleet size.
- Average walking time: It is the time that it takes a user to reach the closest selected sharing vehicle.
- Average waiting time: It is the time that is needed by the user to arrive at the position of the vehicle.
- Optimal fleet size: Is the combination of the optimal fleet size end users’ perspective and optimal fleet size operators’ perspective. It depends on the weight that is assigned during the creation of the scenario.
- Optimal fleet size from end users' perspective: The number stands for the optimal fleet size in order to have the lowest value both for average walking and waiting time.
- Optimal fleet size operator perspective: It represents the optimal number of vehicles that maximise the providers’ profits.
- Profit service providers: It is the daily profit for a shared mobility provider. This value depends on both the demand and the optimal fleet size.
- One graph.

As an example, a dashboard image of a scenario simulation is shown.



Figure 12: Example of results.

Specifically, the graph has for x-axis the fleet size and for y-axis a scale from 0 (minimum value) to 1 (maximum value). On this graph, three curves are drawn that vary their course as the size of the fleet varies. In particular, they are shown:

- The demand satisfaction curve
- The curve relating to the operator's profits (maximum when close to 1, minimum when close to 0)
- The curve showing the average waiting time (maximum when close to 1, minimum when close to 0).



With regard to the profits of the service operators, it is worth noting that they do not include the entire business model of the company providing the sharing service. For instance, additional sources of income of the operator (i.e. advertising logos on the vehicles) have not been taken into account, nor have other costs that the operators have (i.e. management of the booking and service use platforms). Consequently, the "profits service providers" outputs only take into account the "operational" phase of the service, the purely transport phase that looks at the use of the vehicle as a means of transport for users.

In many simulations that have been conducted, the average waiting time is often a very low value, close to 0. This situation results from the fact that at the optimal fleet value each user has at least one sharing vehicle available. However, how much that vehicle is "really" available is given by the value of the "average walking time". In fact, if this value is low, it means that the vehicle is in the immediate proximity of the user. However, if, on the other hand, the value is high, the available vehicle is far away from the user, who may then choose not to take it. Consequently, important information can be drawn from the walking time and waiting time values as they reveal the real availability of vehicles and therefore the need to increase, if the values are high, or decrease, if the values are low, the availability of vehicles (fleet size) supplied to the user.

4.5 Next steps

Use Case 1 can be replicated in cities that have implemented, or plan to implement, at least one mobility sharing service in their territory. In all cases, thanks to the use of the data used for the pilot city, even cities in which such services are not present can use the tool to explore and analyse hypotheses for the implementation of sharing vehicles. However, if cities wanted to implement the tool, they should be in possession of at least the minimum required data such as the hourly demand curve. However, some cities may not be in possession of certain data required to run the algorithm. For this reason, it might be interesting to provide in the future, in a specific section of the dashboard, a list of standard/default values (e.g., for operating costs and revenues). If a list could not be possible, due to the high variability of these values (dependent on fuel costs, national vehicle taxes) another option is to draw down instructions on how to correctly estimate the values (e.g., demand).

Moreover, during the customisation of the tool for other cities, further improvements could be implemented both in the algorithm and in the dashboard. For example, there is the need to include a more complex cost model per vehicle that takes into account fixed costs (staff, technological infrastructure, etc.) and variable costs (dependent on the number of cars) as well as the possibility of exploiting advantages due to economies of scale. In this way, the cost per vehicle per minute could be closer to the real value, refining the simulations results as a consequence.

From the perspective of visualising the results, an additional information that could be displayed in the dashboard is the fleet utilisation rate. In this way, both the service operator and the decision maker can have the perception of how much fleet is actually used.

In the end, a comparative visualisation of several scenarios, can make the tool even more effective in its role as a decision support tool, as it allows a graphical and simultaneous comparison of two or more scenarios in order to choose which of the is the best solution.



5 Use Case 2: Operative areas analysis shared mobility

5.1 Introduction

The tool for use case 2 resulted from the need of the pilot city of Milan to guarantee access to mobility sharing services also to the population living or working in the peripheral areas of the city where very often, due to low demand, sharing service operators do not implement the service.

The challenge is therefore to ensure the presence of cars, bikes and other shared vehicles in areas that have a very low demand for public or shared mobility and are often referred to as 'market failure areas', in other words, areas where the costs of maintaining the service fail to cover the revenues.

Specifically, the algorithm aims to define new operational areas in which the mobility sharing service can be implemented. In particular, in each area, the algorithm solves an optimisation problem that sees the need to increase the accessibility of the area, thus increasing the number of users who can access the service, but also foreseeing a profit for the operators, such as to support its economic feasibility.

Use Case 2 is closely related to UC1, with which it shares most of the input parameters. However, while UC1 aims to optimise the fleet over all or part of the municipal territory, UC2 focuses on micro-areas, NILs in the case of Milan, and tries to offer a solution or solutions regarding the number of areas where it is optimal to implement the service.

This tool can also be classified as a decision support system tool in that it does not provide a single solution, but allows the comparison of several solutions, called "alternatives" (to which corresponds the addition or non-addition of further zones) from which to choose the solution that the decision maker considers most suitable for the city's situation.

5.2 Data requirements

The data required to perform simulation with this tool are the following. For each table a partial image of the database is provided.

- **Actual availability of sharing services in zones**

The table includes the ID of the zones, their centroids coordinate and the availability (1) or not (0) of each sharing mode.

id bigint	Centroid_X double precision	Centroid_Y double precision	bikeshar double precision	carshar double precision	kscooter double precision	moped double precision
1	1514751.74854	5034499.38621	1	1	1	1
2	1515372.42666	5034798.81615	1	1	1	1
3	1515153.89492	5034172.00328	1	1	1	1
4	1514673.83147	5033893.89721	1	1	1	1
5	1514215.24575	5034096.22691	1	1	1	1
6	1513939.90756	5034466.61709	1	1	1	1
7	1514032.70766	5035150.85801	1	1	1	1
8	1514417.58294	5034824.57961	1	1	1	1
9	1514642.25079	5035275.79321	1	1	1	1
10	1515040.38977	5035197.26846	1	1	1	1

Figure 13: ID zones, centroids, and information about sharing modes.

- **Modal split information**

For each mode this table provides:

- the average length of trips
- the modal split factor
- the maximum and minimum length of trip.

These data were estimated from the historical data. A new city that is willing to use this tool could provide his own data, if available, or otherwise, use the standard data calculated by Milan.

mode text	avg_km double precision	modal_split_factor_static_fixed double precision	max_km double precision	min_km double precision
BIKE SHARING	1.53	0.17	4.59	0
CAR SHARING	8.83	0.24	[null]	4.42
SCOOTER SHARING	4.17	0.4	12.51	0
KISCKSCOOTER	1.37	0.19	4.11	0

Figure 14: Example of historical data.



- **The population of each zone**

	id bigint	population bigint
	1	2962
	2	2477
	3	2059
	4	1366
	5	2253
	6	2029
	7	4476
	8	1705
	9	1791
	10	3143

Figure 15: Population of each zone.

- **The adjacency matrix**

This table shows the connection between all the zones of the city.

If this matrix is not available a pre-processing script is available within the tool to calculate the adjacency matrix from the shape file of the zones.

	a_id bigint	b_id bigint	adj boolean
1	1	1	true
2	1	2	true
3	1	3	true
4	1	4	true
5	1	5	true
6	1	6	true
7	1	7	false
8	1	8	true
9	1	9	false
10	1	10	true

Figure 16: Adjacency matrix.



- **The Origin/Destination matrix**

This data is the highly required by the algorithm and then is mandatory to use the tool in new cities.

	I bigint	J bigint	trips integer
1	1	1	0
2	1	2	104
3	1	3	43
4	1	4	21
5	1	5	66
6	1	6	34
7	1	7	73
8	1	8	30
9	1	9	16
10	1	10	52

Figure 17: O/D matrix.

5.3 Usage procedure

After entering the name of the scenario, the user has to enter the following input parameters, which, as stated above, are almost all the parameters that are already used in the tool for use case 1:

- Selection of the type of mode to be analysed (bike, moped, kick-scooter, or car-sharing): it is the mode of transport used in the simulations.
- Average trip duration (in minutes): it is the average of the vehicle usage time of a certain mode of transport.
- Operating costs per vehicle per minute (in Euros): are the expenses which are related to the maintenance of the car (parking costs, insurance, car maintenance costs).
- Expected revenues per minute of rent (in Euros): these are the earnings that the operator of the service obtains and derives from the payment by the user of the rental rates. The value could be the cost the user pays per minute of rental.
- Weighting factors assigned to service operator's and end society's perspectives: the weights are the coefficients that measure the relative importance end-users and operators. The sum of the two weights always equals 1.



Scenario management

Use the form below to create a new, or select an existing scenario.

Create new scenario

Scenario name

Mode type Average trip duration (in minutes)

bike 0

Operating cost p/vehicle p/minute (in euro's) Expected revenue per minute of rent (in euro's)

0 0

Weighting factor society Weighting factor serviceoperators

0 0

Figure 18: Scenario management UC2.

After entering the input data, the user returns to the Scenario Management section and next to the name of his or her scenario has to click the 'edit' button and then “save and continue” in order to open the “edit mode.” When edit mode is open, a map with the currently served areas in yellow and the currently unserved area in blue is showed on the screen. At this stage, the user has the option of clicking on each area and being able to select it as an area in which to run the simulation (include area), remove this area from the simulation (exclude area) or reset one of the areas to the starting situation (reset area).

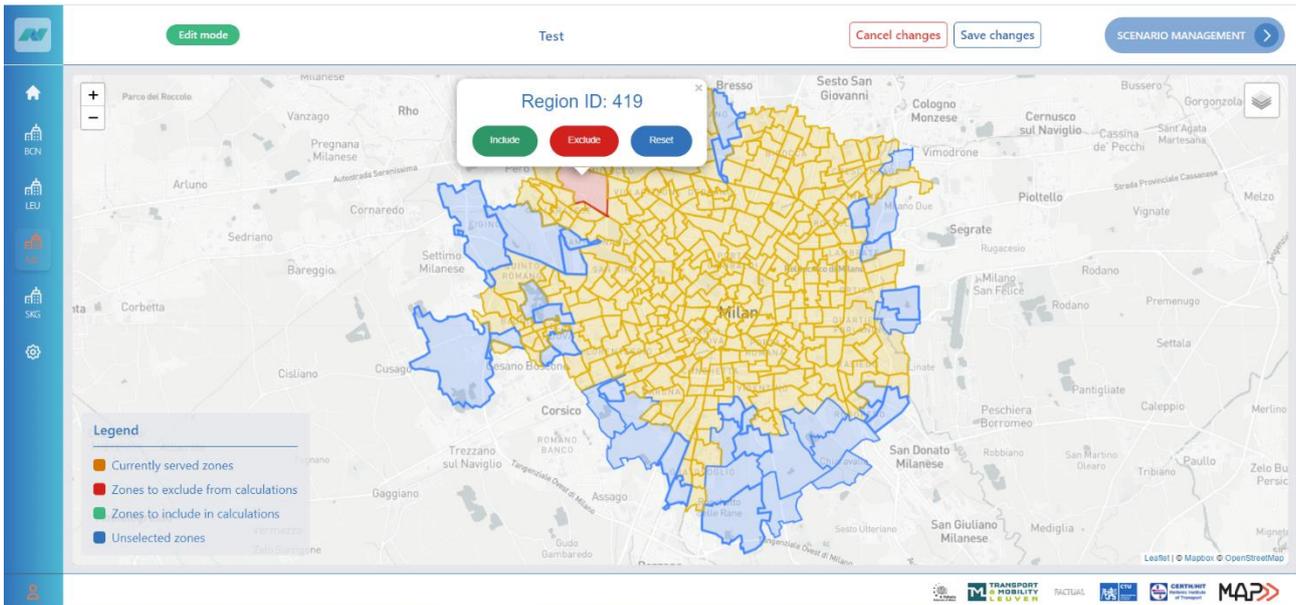


Figure 19: Edit mode.

Once the areas have been defined, the user saves his or her preferences and returns to the scenario management section to start the simulation by clicking on the 'run' button. When the simulation is finished, the dashboard shows the results, which as it is possible to see in the next section consist of a series of alternatives, each with its own KPIs.

5.4 Interpretation of the results

The results of Use Case 2 are mainly of two types, one graphical and one numerical closely related. In fact, at the end of the calculation, a table is shown in which each row corresponds to a different alternative.

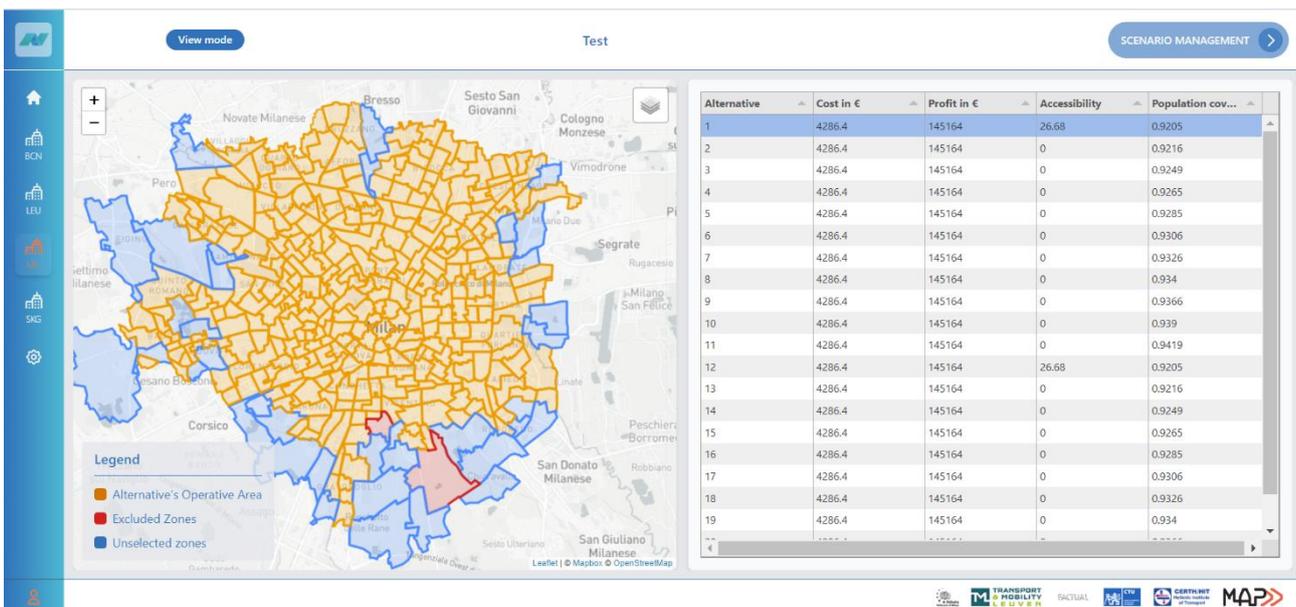


Figure 20: UC2 example of results.



The table of the result includes the following data:

- The ID code of the alternative
- The cost to the service operator for that particular area configuration
- The revenue that the service operator obtains, again with reference to the chosen alternative
- The accessibility, calculated according to Hansen's Accessibility Model
- The percentage of the population covered.

The map changes as the alternatives are chosen from the table. Displaying the alternatives on a map, makes the use of this tool more effective because it highlights which and how many areas are considered as new operational areas for the chosen mode of transport.

In particular, as far as the table is displayed, the first row is the alternative '0', i.e. no area was added to the starting map. The last row, on the other hand, is the alternative in which all potentially addable areas have been taken into account. In between, there are the intermediate solutions.

Being a decision-support tool, there is no 'best' solution, but it is the public decision-maker who, having assessed all scenarios, makes his or her decision based also on his or her own experience and knowledge of the area and the subject matter.

5.5 Next steps

As seen in the UC1 transferability, also in this case standard/default values would be useful, e.g., for operating costs and revenues, or, in alternative, the dashboard could have a section with the instructions on how to estimate the numbers (i.e. demand). Also for this use case, another KPI that could be implemented in future developments with other cities is the fleet utilisation rate, which, as in use case 1, can provide useful information regarding the actual utilisation of vehicles.

A further upgrade that can be made to the tool in the future is to look not only at one operator and one transport mode, but to analyse the sharing mobility system as a whole. In particular, future developments may concern taking into consideration several operators offering the same service in the same area, or perhaps taking into account that on the same area two modes of transport, such as free-floating bikes and scooters may compete with each other.

6 Use Case 3: Air quality and vehicle emissions

6.1 Introduction

The rapid rate of growth of vehicles rises the need of understanding the environmental impacts that caused by the massive usage of private vehicles within urban areas. In most cases, this is reflected by the road congestion and more specifically by the excessive vehicles' starts and stops induced mainly at signalised intersections. On the other hand, promoted concepts, including sustainability, liveability, and quality of life, indicate that there is a clear need to reduce vehicle emissions within urban centres, thus alleviating adverse environmental impacts of traffic (Nešić et al., 2015). To address this environmental issue with regards to air quality, another tool that we planned to be integrated into the nuMIDAS toolkit is responsible for supporting the execution of relevant data analyses based on multi-source data. This is expected to support policy makers towards better planning and assessing enforced policy instruments, such as Low-Emission Zones (LEZ) and Urban Vehicle Access Restrictions (UVAR). The original purpose of the tool was to analyse and correlate various data sources providing information about traffic intensity, weather conditions, air quality, and events. The ultimate purpose would then be to forecast the effect of vehicle traffic and weather on air quality in a short- to medium-term basis (i.e. time horizons covering at maximum the next 10 days).

6.2 Data requirements

There are two types of databases used for UC3. The first group comprises datasets relating to cameras and their acquisitions, while the second concerns data on the composition of the circulating car fleet, with reference to type of vehicle (bus, car, truck).

- **Cameras data**

	id [PK] integer	geom geometry	camera_id text	location_id integer	latitude double precision	longitude double precision	street character varying	zone_id text
1	1	0101000020E6100000...	c40	53	41.36696	2.116407	SCAI-Hospitalet	z10
2	2	0101000020E6100000...	c10	10	41.355719	2.097828	LHC-Av Carrilet - ...	z6
3	3	0101000020E6100000...	c11	11	41.358233	2.102936	LHC-Rambla Just...	z6
4	4	0101000020E6100000...	c1	1	41.4196581	2.2242428	TEST-B10 Sortida...	z1
5	5	0101000020E6100000...	c2	1	41.4196581	2.2242428	TEST-B10 Sortida...	z1
6	6	0101000020E6100000...	c17	17	41.35046	2.114853	LHE-Av America ...	z7
7	7	0101000020E6100000...	c19	19	41.352381	2.1196	LHE-Gran Via - ...	z7
8	8	0101000020E6100000...	c146	162	41.3685361	2.0992778	LHT-C/Pere Peleg...	z109
9	9	0101000020E6100000...	c42	57	41.427598	2.224527	SCAI-Sant Adrià	z14
10	10	0101000020E6100000...	c26	26	41.358208	2.127217	LHE-Gran Via - C...	z7
11	11	0101000020E6100000...	c43	54	41.387209	2.170265	SCAI-Barcelona	z11
12	12	0101000020E6100000...	c237	220	41.4705	2.082528	Rambla del Celler...	z142
13	13	0101000020E6100000...	c4	3	41.422283	2.219967	TEST-B10 Sortida...	z1
14	14	0101000020E6100000...	c5	3	41.422283	2.219967	TEST-B10 Sortida...	z1
15	15	0101000020E6100000...	c3	2	41.36349439	2.05830524	TEST-Panel Sant ...	z2
16	16	0101000020E6100000...	c21	21	41.352806	2.120008	LHE-Gran Via - S...	z7
17	17	0101000020E6100000...	c32	32	41.351714	2.130542	LHE-Carrer Botàn...	z7
18	18	0101000020E6100000...	c31	31	41.360756	2.134097	LHE-Ctra del Prai...	z7
19	19	0101000020E6100000...	c71	86	41.365403	2.12781	LHSTE-Unió	z43
20	20	0101000020E6100000...	c72	87	41.364643	2.127271	LHSTE-Josep A. ...	z43
21	21	0101000020E6100000...	c349	323	41.37397	2.119801	LHPRO-Progrés - ...	z44

Figure 21: Camera data.

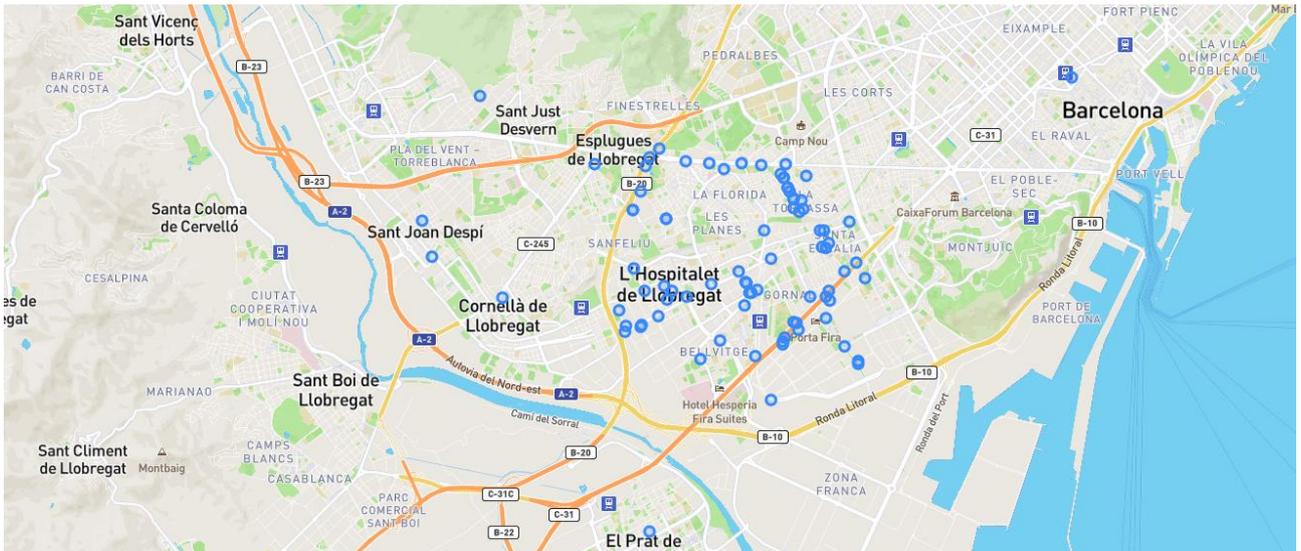


Figure 22: Camera positions.

- Fleet database

	licence_plate text	environmental_badge text	fuel_type text	vehicle_type text
1	kBNk8EJL/G3WH/ticCnuYHyYvqVtsTn86zmFMGDKOvQ	DISTINTIVO C	Gasolina	Touring bus
2	f27F6E8l3xd3nVXIT7lkyIdePjCYgyTjBIPejqvhffg	DISTINTIVO B	Diesel	Truck
3	Oju3Oe9zgko8RRVZyH6XTF7+aghMjJzVikBLsoPg9CU	DISTINTIVO C	Gasolina	Touring bus
4	Oju3Oe9zgko8RRVZyH6XTF7+aghMjJzVikBLsoPg9CU	DISTINTIVO C	Gasolina	Touring bus
5	8AluEB2cRAslIC7Z9H/o0HOjsQIFZ7eJAjaAX9Gd0fs	DISTINTIVO B	Diesel	Touring bus
6	8AluEB2cRAslIC7Z9H/o0HOjsQIFZ7eJAjaAX9Gd0fs	DISTINTIVO B	Diesel	Touring bus
7	2+NZHbOzw1g8KBvPwmFur+QQemVfvStRDSfzd4dphnQ	DISTINTIVO C	Gasolina	Touring bus
8	2+NZHbOzw1g8KBvPwmFur+QQemVfvStRDSfzd4dphnQ	DISTINTIVO C	Gasolina	Touring bus
9	Yn9TBAalTRPILLHEfp4JyUkQW4AiSAvdAJH3NlwJ+Ms	DISTINTIVO B	Diesel	Touring bus
10	SUVCSzypPpPdLYruehJRCMgjC/RRdEJWFQGS6GD00U	DISTINTIVO B	Diesel	Van

Figure 23: Example of fleet database.



6.3 Usage procedure

Once the scenario name has been entered, the user defines the input data required by the dashboard. Specifically, the data to be entered are:

- The period over which the analysis is to be conducted (the start and end day)

Scenario management ×

Use the form below to create a new, or select an existing scenario.

Create new scenario

Scenario name

Test deliverable 5.4

Start date

mm / dd / yyyy

End date

mm / dd / yyyy

Cancel Create scenario

Figure 24: Scenario management UC3.

Once the input parameters have been established and the scenario creation has started, the user must return to the home page of the tool where on the map he/she can choose, manually, the cameras from which to calculate the emissions and display the relevant information.

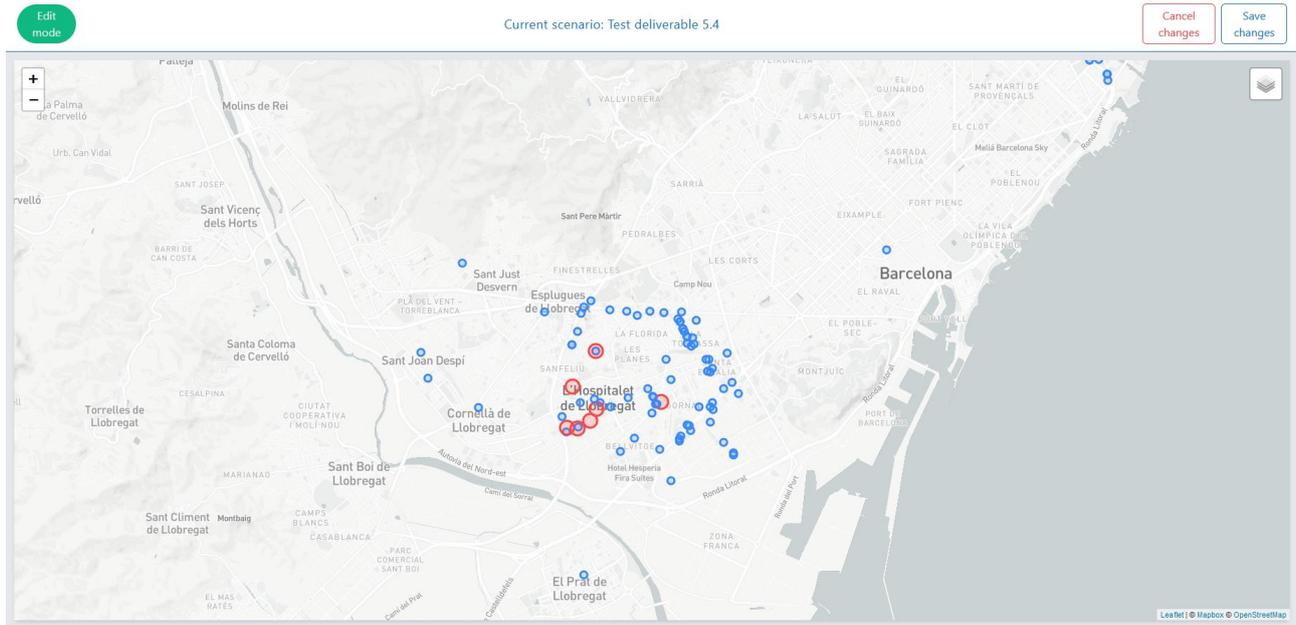


Figure 25: Edit mode.

At the end of the camera selection, the user must click on "Save changes" and return to the scenario creation section to start the calculation using the "run" button. As with other tools, a bar indicates the progress of the calculation while the algorithm is being processed.

Finally, when the 'present' button is pressed, the results of the algorithm are shown on the tool's homepage.

6.4 Interpretation of the results

Once the results are available, they can be queried through the interface. To this end, the user selects a camera from the map, after which the toolkit will show the calculated emissions for traffic. The emissions shown represent averages for a day of 24 hours, taken over the entire specified time period. They are calculated based on the types of vehicles observed by the camera, resulting in emissions of PM_{2.5}, NO_x, and CO₂.



Figure 26: Emission calculation results for a single camera.

6.5 Next steps

Based on the preliminary technical elaboration, we foresee some possible additional features that can be incorporated to make the model more applicable.

In first instance, using real Copert V functions would augment the correctness of the emission estimations. This however entails the use of speed-dependent information in the network, but will automatically give time-of-day dependence. In order to accomplish this, the following inputs need to be available:

- Emission factors for pollutants CO₂, NO_x, and PM_{2.5} (dependent on the type of vehicle and its speed)
- Average speed information corresponding to links in the road network that are associated with the earlier mentioned ANPR cameras

Furthermore, the emission factors are now based on class (i.e. vehicle type) averages. A further refinement can be done by separating out the individual vehicle types. A first approach could be to use:

- Fleet composition



This would allow us to further refine the fleet mix used to calculate the average emission factor. Further details can be obtained by another step, in which each detected vehicle type is used together with a specific speed-dependent emission factor.

At the level of further calculations and comparisons with the real-world recorded emissions by the emission detector stations, we could analyse their correlations by also incorporating:

- Historical records of traffic conditions and/or volumes
- Historical records of weather conditions
- Historical records of events
- Historical air quality-related data
- Meteorological forecasts
- Planned events in the area of interest

7 Use Case 4: Planning for parking

7.1 Introduction

The increasing use of cars over time has created a shortage of roadside parking spaces especially in urban centres. This parking shortage contributes to the increase in vehicle traffic as more cars make longer and longer distances to find a place to park. However, cities are faced with the issue of parking on a daily basis, and the challenge is to understand whether restricting parking policies in one area can produce perturbations that spread to adjacent areas, exacerbating an already difficult situation. Based on a requirement of the pilot city of Leuven, the tool for use case 4 aims to provide the policy maker with a valuable tool that can visualise how a change of certain values in one of the cells into which the city of Leuven has been divided can influence and change the parameters of adjacent cells, providing useful information that allows the best possible decisions to be taken in the planning phase. Nevertheless, in order to apply this tool in a city, it is necessary that the city already has within its database the baseline values (such as the number of parking spaces for each identified cell) from which to start and with which to compare the results of the algorithm. However, in order to also make the tool available to cities that do not have this data, the data from the pilot city of Leuven could be used as a baseline.

7.2 Data requirements

For use case 4, the dataset consists of data on the capacity of on-street parking spaces, the number of on-street parking spaces supplied, parking measurement and data concerning the spatial data of the city (centroids and polygons into which the territory has been divided).

- **On street parking capacity**

	id [PK] integer	fid bigint	ID bigint	Capacity bigint	geom geometry
1	1	1	11290	11	0105000020E61000000100000001020000001C00000042014F5DAAI
2	2	2	11296	7	0105000020E61000000100000001020000001000000042014F5DAAI
3	3	3	11302	11	0105000020E61000000100000001020000002400000042014F5DAAI
4	4	4	11308	10	0105000020E610000001000000010200000014000000AA24EB4372I
5	5	5	11314	10	0105000020E6100000010000000102000000160000006FA2CA678CI
6	6	6	11320	18	0105000020E6100000010000000102000000210000000EC962ED32I
7	7	7	11326	25	0105000020E610000001000000010200000038000000D2F196A30FI
8	8	8	11338	0	0105000020E610000001000000010200000003000000D2F196A30FI
9	9	9	11344	0	0105000020E61000000100000001020000000C00000089F402BBEAI
10	10	10	11350	0	0105000020E61000000100000001020000000B000000248061F00CI
11	11	11	11368	0	0105000020E6100000010000000102000000100000009DF8BC531EI

Figure 27: On street parking capacity data.

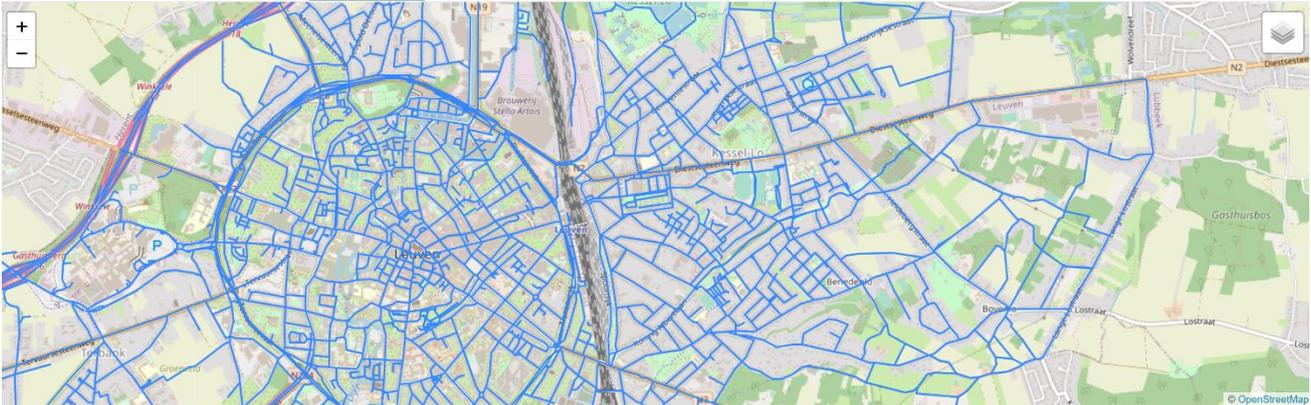


Figure 28: On street parking capacity graph.

- On street parking supply

	fid [PK] bigint	id bigint	Subtype character varying (80)	Number_of_places bigint	WVB_ID bigint	geom geometry
1	1	1	Standaard parkeerplaats	1	30223	0106000020E6100000010000
2	2	2	Standaard parkeerplaats	7	26215	0106000020E6100000010000
3	3	3	Mindervaliden	1	21753749	0106000020E6100000010000
4	4	4	Standaard parkeerplaats	3	26537	0106000020E6100000010000
5	5	5	Standaard parkeerplaats	1	26537	0106000020E6100000010000
6	6	6	Standaard parkeerplaats	3	26429	0106000020E6100000010000
7	7	7	Standaard parkeerplaats	5	26429	0106000020E6100000010000
8	8	8	Standaard parkeerplaats	1	144217	0106000020E6100000010000
9	9	9	Standaard parkeerplaats	2	144217	0106000020E6100000010000
10	10	10	Standaard parkeerplaats	1	144217	0106000020E6100000010000

Figure 29: On street parking supply data.

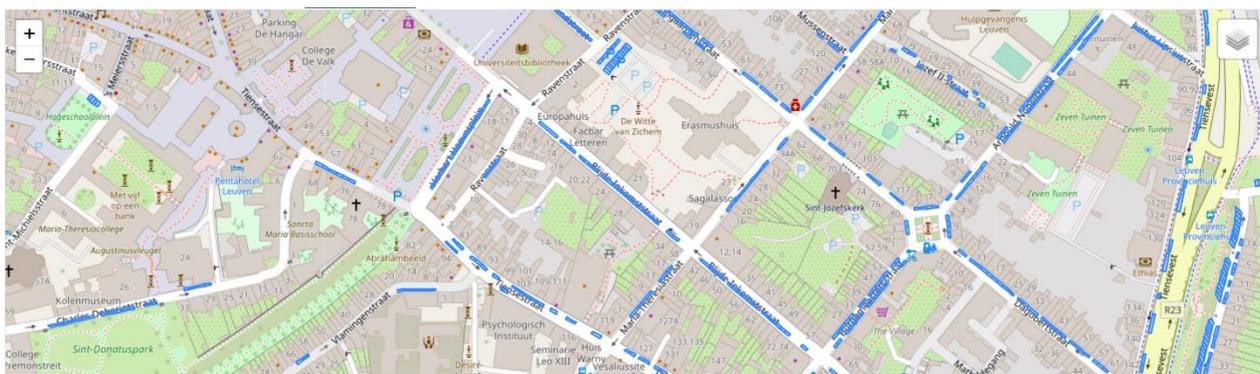


Figure 30: On street parking supply graph.

- Parking measurement

The parking measurement should be separated by time windows (e.g., weekend/working days and day/night).

fid	WVB_ID	Correct_Even	Correct_Odd	Incorrect_Even	Incorrect_Odd	CountTime	Occupancy_Rate	geom
bigint	bigint	integer	integer	integer	integer	character varying (23)	bigint	geometry
1	11326	0	7	0	0	2020-10-03T10:14:43.550	28	0105000020E610000001000000010200
2	11386	0	0	0	0	2020-10-17T10:30:47.779	[null]	0105000020E610000001000000010200
3	11392	0	0	0	0	2020-10-17T10:30:35.221	[null]	0105000020E610000001000000010200
4	11403	0	0	0	0	2020-10-17T10:30:11.194	[null]	0105000020E610000001000000010200
5	11427	0	2	0	0	2020-10-17T10:36:05.940	50	0105000020E610000001000000010200
6	11433	2	4	0	0	2020-10-17T10:36:37.437	75	0105000020E610000001000000010200
7	11463	2	7	0	0	2020-10-17T10:33:47.529	60	0105000020E610000001000000010200
8	11607	0	5	0	0	2020-10-17T10:39:01.462	11	0105000020E610000001000000010200
9	11613	0	2	0	0	2020-10-17T10:37:53.007	40	0105000020E610000001000000010200
10	11625	0	0	0	0	2020-10-17T10:38:02.098	[null]	0105000020E610000001000000010200

Figure 31: Example of parking measurement data.

- Sectors centroids and polygons

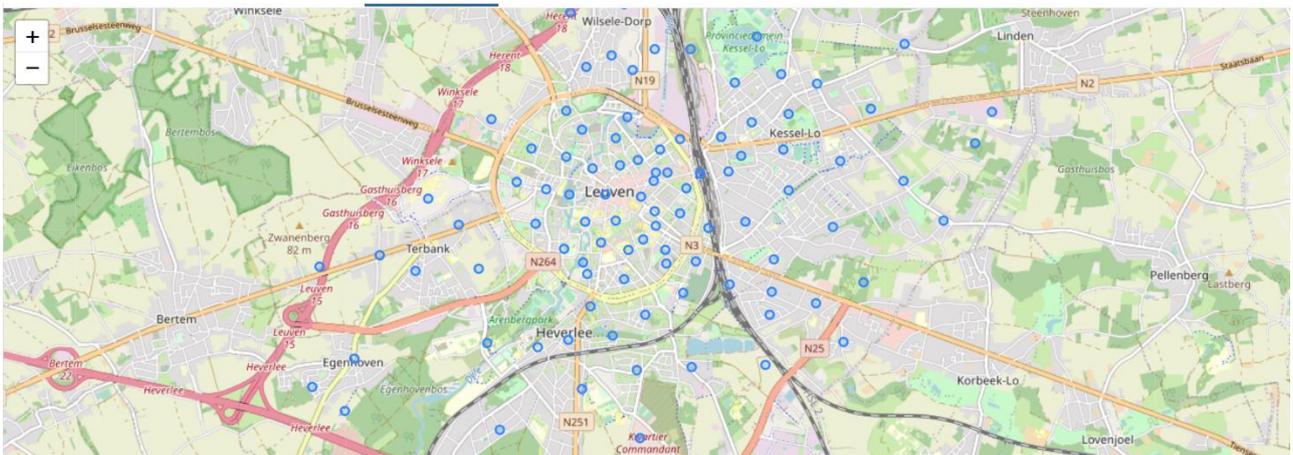


Figure 32: Sector centroids.

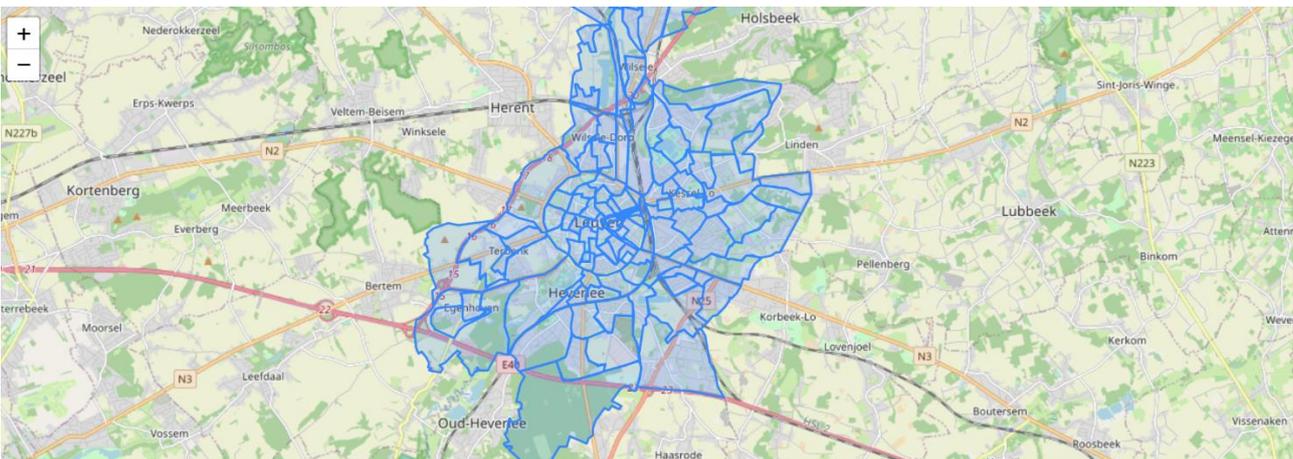


Figure 33: Sector polygons.



7.3 Usage procedure

After entering the name of the scenario, the user must enter the following input parameters:

- Baseline is the set of measurements that are used as a reference. These are data already uploaded to the algorithm database
- Searching speed (in km/h) is the assumed road users' speed when searching for a parking place in km/h
- Average length of a parking space in (m) is the assumed geometrical characteristics of parking places
- Average Spacing Between Parking Places (m) is the assumed geometrical characteristics of parking places
- Expansion level is the policy effect expansion level.

The screenshot shows a 'Scenario management' dialog box with a close button (X) in the top right corner. Below the title bar, there is a subtitle: 'Use the form below to create a new, or select an existing scenario.' The form is titled 'Create new scenario' and contains the following elements:

- Scenario name:** A text input field containing 'SCN001'.
- Baseline:** A dropdown menu with the text 'Select a baseline' and a downward arrow.
- Searching speed in km/h:** A text input field containing '30'.
- Average length of a parking space in (m):** A text input field containing '10'.
- Average Spacing Between Parking Places (m):** A text input field containing '10'.
- Expansion level undefined:** A horizontal slider control with a blue dot in the center.

At the bottom right of the form, there are two buttons: 'Cancel' and 'Create scenario'.

Figure 34: Scenario management UC4.

Once the input parameters have been entered, the user has to press the 'edit' button and return to the map. On the map, he/she will now have to select the cells to which she/he wants to edit and change the baseline value. The user will have to enter the new value in the 'alternate value' cell. For each cell, in order to record the new value, he/she will have to press "submit".

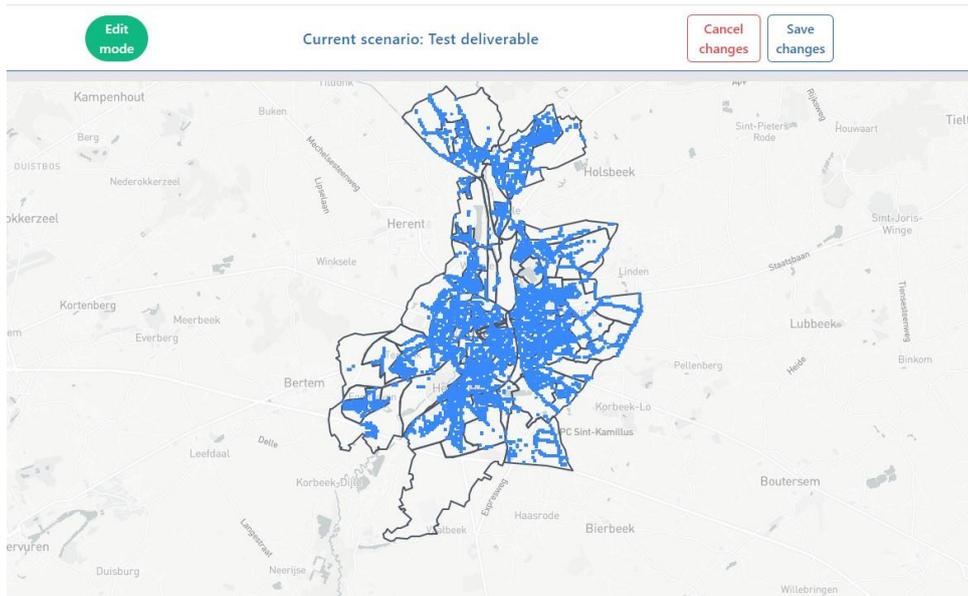


Figure 35: Edit mode-first part.

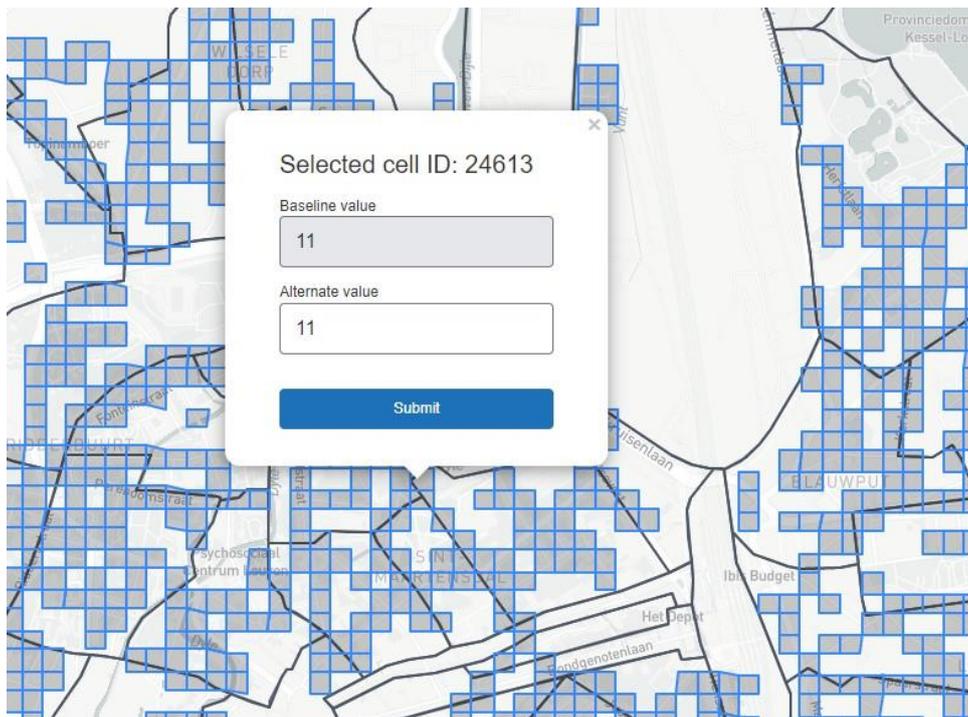


Figure 36: Edit mode-second part.

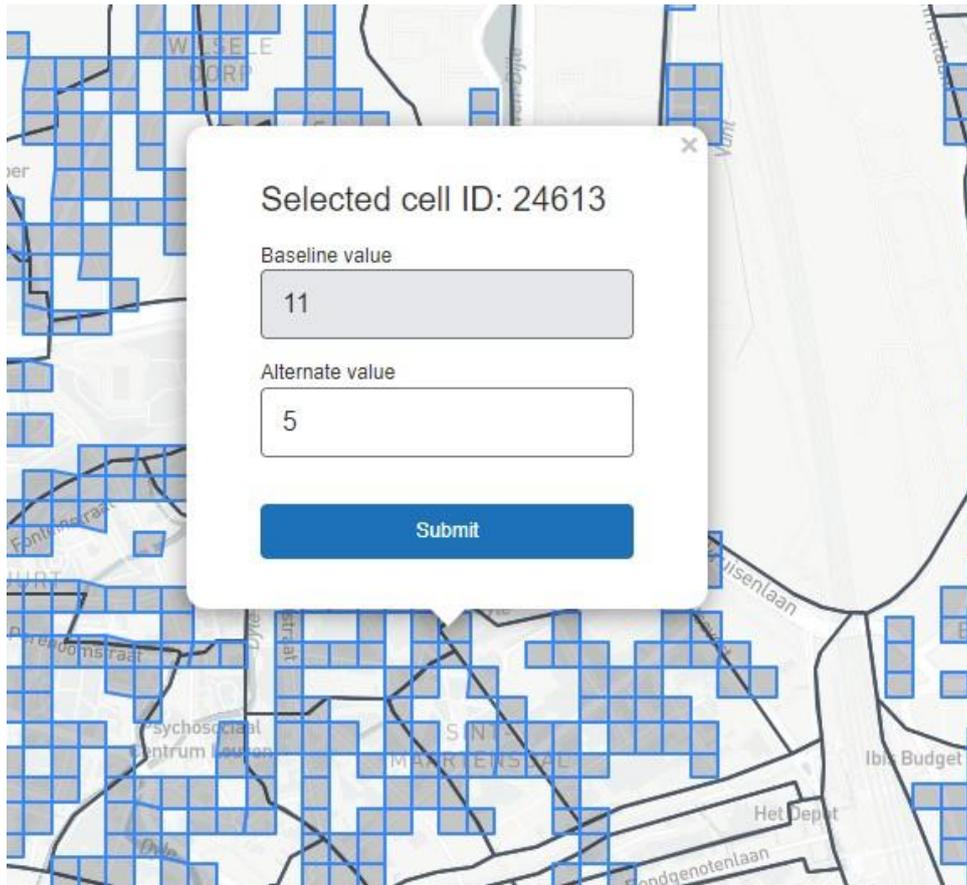


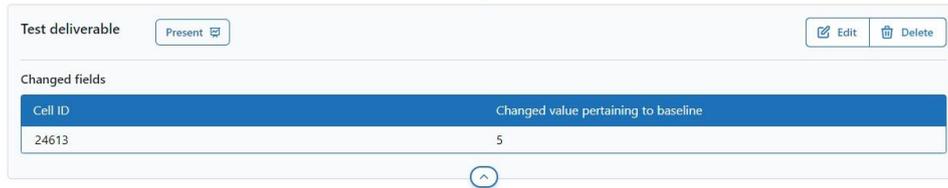
Figure 37: Edit mode-third part.

When the user has edited as many cells as he/she sees fit, the user presses "save changes", return to scenario management, find the scenario called by the name he/she has chosen and press the "run scenario" button.

During the calculation, a bar appears to show what level of calculation completion the tool is at.

7.4 Interpretation of the results

At the end of the calculation, in the section in which the scenarios are stored, clicking on the drop-down menu reveals the list of cells in which the user has changed the baseline to the new value. For example, if the initial value of the baseline was 11 and was changed to 5, the list shows the cell id and the new value of the available parking spaces.



The screenshot shows a web interface for managing test deliverables. At the top, there is a 'Test deliverable' label, a 'Present' button with a checkmark, and 'Edit' and 'Delete' buttons. Below this is a section titled 'Changed fields' containing a table with two columns: 'Cell ID' and 'Changed value pertaining to baseline'. The table has one row with the values '24613' and '5'. A circular refresh icon is located below the table.

Cell ID	Changed value pertaining to baseline
24613	5

Figure 38: Scenario management-modified cell.

Moreover, returning to the home page the map that previously showed all the cells into which the territory of the city of Leuven was divided, now shows only the cells in which the parameters have been changed and the cells that have undergone the resulting perturbations. Thanks to the legend shown in the lower left, it is already visually possible to ascertain the effect that new restrictions or new parking permits have on the analysed cells and adjacent cells. In fact, the colour red and its darker gradations are associated with longer parking search times.

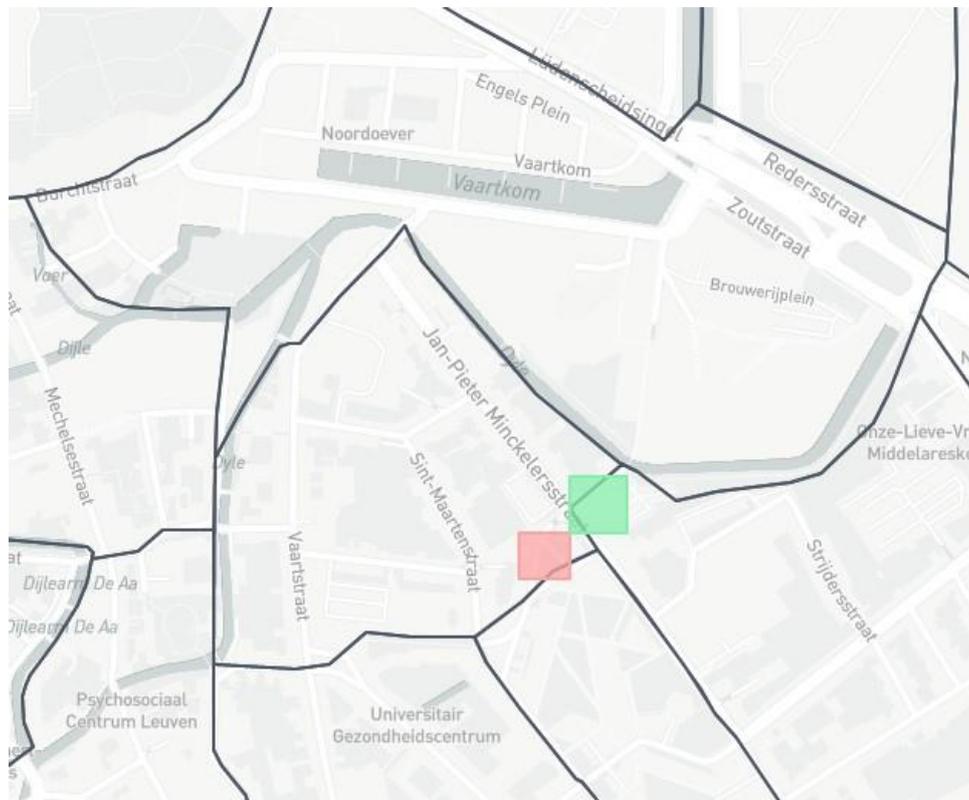


Figure 39: Results on the map.

In particular, for each cell that has undergone the perturbation, clicking on the map provides the following output information:

- Initial searching time
- New searching time
- Difference in searching time
- Average demand
- New average demand
- Available parking spots
- New available parking spots.

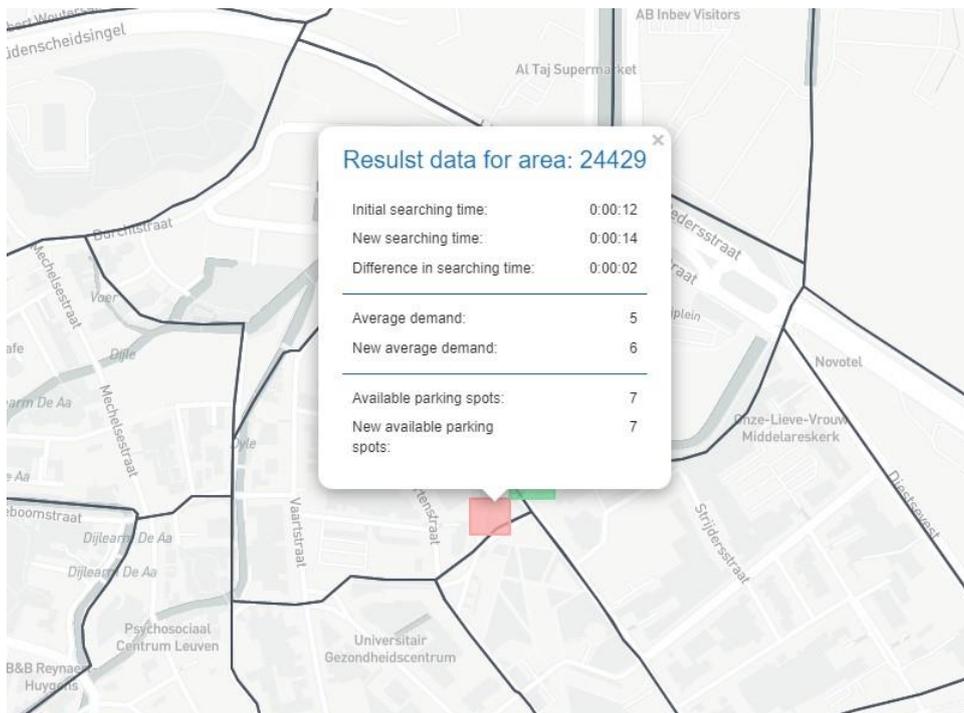


Figure 40: Output parameters.

Specifically, the output “difference in searching time” is the difference between the initial searching time and a new searching time. In particular, in the red cells, the difference is “negative” in the sense that in the area delimited by this cell the searching time increased due to the loss of some places available in the cell adjacent to it.



7.5 Next steps

Cities wishing to implement the tool developed for use case 4 must have data on the number of on-street parking spaces available on each of the streets in their territory. This data is essential to construct a 'baseline' to which to refer when calculating new values. In any case, Leuven baseline could be used by cities that want to use the tool but do not have data regarding parking spots.

Subsequently, also thanks to the work done in other case studies, further KPIs can be implemented, such as: the occupancy rate of spaces, the impact on traffic congestion due to cars driving to find a parking space, and, finally, the changes in revenue that may result from the increase or decrease of paid parking spaces on the road. In particular, occupancy rates can be interesting to analyse and understand which areas are most used by motorists for parking, providing useful information for public decision makers. In addition, the impact on road congestion also provides an estimate of how the entire road traffic system may change when major changes are made in the number of parking spaces. Finally, it might be interesting for the public decision-maker to know the gain lost for the city if paid parking spaces are removed from the roads.

Some improvements could also be made on the dashboard, such as the selection of cells to be analysed. In fact, currently the selection is completely manual, changing cell by cell the value of the available places. In the future, this selection could also be done by drawing an entire area on the map, or by considering the change in all the cells of an entire district.



8 Use Case 5: Inflows and outflows in a metropolitan area

8.1 Introduction

The algorithm developed for Use Case 5 has the main objective of improving the mobility planning process through the acquisition of more information by public decision-makers. For this tool, the data sources are mainly two: data recorded by cameras using the Automated Number Plate Recognition (ANPR) system, and vehicle registration data. In fact, the main output of the tool is a 3D O/D matrix that provides information not only on the vehicle flows between two or more cameras, but also information regarding the type of power supply of the vehicles detected.

For the use of this tool, it is therefore necessary that cities have installed vehicle detection systems on their territories. In the pilot case of the Barcelona metropolitan area, the choice fell on ANPR systems as they were already present in the area. However, the same type of algorithm can be applied to other systems such as the Bluetooth detectors installed in the other pilot city of Thessaloniki. Furthermore, in order for the O/D matrix to be defined as a 3D matrix, it is necessary to associate other types of data with these vehicular traffic detection data, which can, in fact, enrich the knowledge of the current vehicular situation and consequently allow the choice of more or less restrictive mobility policies.

8.2 Data requirements

There are three types of databases used for UC5. The first group comprises datasets relating to cameras and their acquisitions. The second concerns data on the composition of the circulating car fleet, with particular reference to the type of fuel (petrol, diesel, electric) and the type of vehicle (bus, car, truck). Finally, spatial data (shapefiles) relating to the different municipalities that constitute the area under analysis were used.

- **Cameras data**

id [PK] integer	camera_id text	location_id integer	latitude double precision	longitude double precision	street character varying	zone_id text	geom geometry
1	c40	53	41.36696	2.116407	SCAI-Hospitallet	z10	0101000020E61000002B3410C866EE00405778978BF
2	c10	10	41.355719	2.097828	LHC-Av Carrilet – Femades	z6	0101000020E61000009010E50B5AC800406DC83F338
3	c11	11	41.358233	2.102936	LHC-Rambla Just Oliveres	z6	0101000020E610000001A60C1CD0D200408AAC3594I
4	c1	1	41.4196581	2.2242428	TEST-B10 Sortida 26	z1	0101000020E610000062E822CF3FCB014031804B5BB
5	c2	1	41.4196581	2.2242428	TEST-B10 Sortida 26	z1	0101000020E610000062E822CF3FCB014031804B5BB
6	c17	17	41.35046	2.114853	LHE-Av America – Pas sota Gran Via	z7	0101000020E6100000A8C7B60C38EB004030478FDFC
7	c19	19	41.352381	2.1196	LHE-Gran Via – Miguel Hernández	z7	0101000020E610000014D044D8F0F40040AB5D13D21
8	c146	162	41.3685361	2.0992778	LHT-C/Pere Pelegrí – Av. Electricitat (sentit mercat)	z109	0101000020E610000029C0C12852CB00409C72E0302
9	c42	57	41.427598	2.224527	SCAI-Sant Adrià	z14	0101000020E61000004C8DD0CFD4CB0140E2EA0088E
10	c26	26	41.358208	2.127217	LHE-Gran Via – Carrer de la física	z7	0101000020E61000003CF6B3588A04014031957EC2D
11	c43	54	41.387209	2.170265	SCAI-Barcelona	z11	0101000020E61000003F3A75E5835C0140C2DB83109
12	c237	220	41.4705	2.082528	Rambla del Celler/Francesc Moragas	z142	0101000020E6100000C908A87004A900404E6210583
13	c4	3	41.422283	2.219967	TEST-B10 Sortida 27	z1	0101000020E6100000798F90E7EC2014011548D5E0I
14	c5	3	41.422283	2.219967	TEST-B10 Sortida 27	z1	0101000020E6100000798F90E7EC2014011548D5E0I
15	c3	2	41.36349439	2.05830524	TEST-Panel Sant Joan Despi	z2	0101000020E61000002AE2D7BC687700402CAAF2FB
16	c21	21	41.352806	2.120008	LHE-Gran Via – Salvador Espriu	z7	0101000020E610000023111AC1C6F5004092EA38BF2

Figure 41: Camera data.

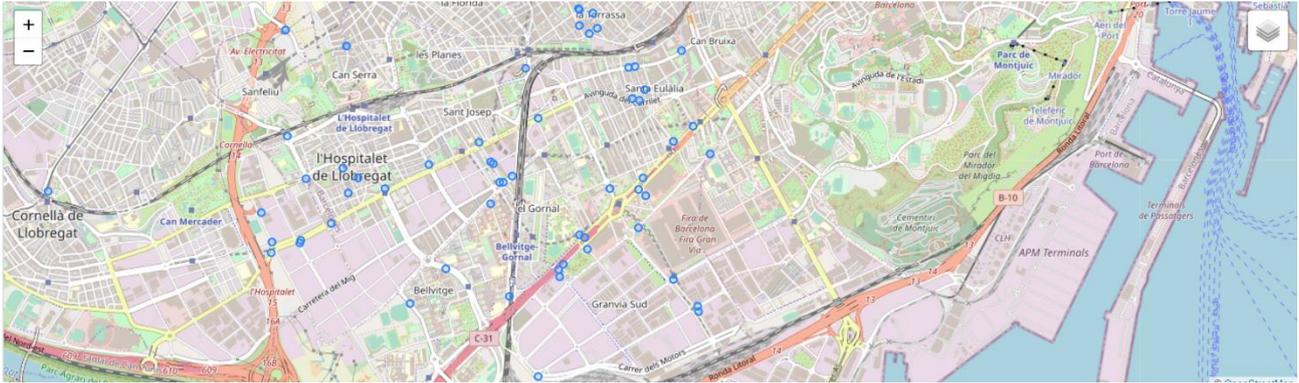


Figure 42: Camera positions.

● Fleet database

	licence_plate text	environmental_badge text	fuel_type text	vehicle_type text
1	kBNk8EJL/G3WH/ticCnuYHyVvqVtsTn86zmFMGDKOvQ	DISTINTIVO C	Gasolina	Touring bus
2	f27F6E8I3xd3nVXiT7lkyIdePjCYgyTjBIPeijqvhffg	DISTINTIVO B	Diesel	Truck
3	Oju3Oe9zgko8RRVZyH6XTF7+aghMjJzVikBLsoPg9CU	DISTINTIVO C	Gasolina	Touring bus
4	Oju3Oe9zgko8RRVZyH6XTF7+aghMjJzVikBLsoPg9CU	DISTINTIVO C	Gasolina	Touring bus
5	8AluEB2cRAsIc7Z9H/o0HOjsQIFZ7eJAjaAX9Gd0fs	DISTINTIVO B	Diesel	Touring bus
6	8AluEB2cRAsIc7Z9H/o0HOjsQIFZ7eJAjaAX9Gd0fs	DISTINTIVO B	Diesel	Touring bus
7	2+NZHbOzw1g8KBvPwmFUr+QqemVfvStRDSfzd4dphnQ	DISTINTIVO C	Gasolina	Touring bus
8	2+NZHbOzw1g8KBvPwmFUr+QqemVfvStRDSfzd4dphnQ	DISTINTIVO C	Gasolina	Touring bus
9	Yn9TBAalTRPtLLHEFP4JyUkQW4AiSAvdAJH3NlwJ+Ms	DISTINTIVO B	Diesel	Touring bus
10	SUVCszyzPpRpdLYruehjRCMgjC/RRdEJWFQGS6GD00U	DISTINTIVO B	Diesel	Van

Figure 43: Example of fleet database.

● Municipalities shape and codes

id [PK] text	objectid integer	inspireid character varying (24)	natocode character varying (11)	nameunit character varying (25)	codnut1 character va	codnut2 character v	codnut3 character	codigoine character varying (5)	shape_leng numeric	shape_area numeric	geom geometry	
1	z1	1782	ES.IGN.SIGLIM34090808015	34090808015	Badalona	ES5	ES51	ES511	08015	0.235523688585512	0.002256856300504	0106000020E6'
2	z12	1890	ES.IGN.SIGLIM34090808123	34090808123	Molins de Rei	ES5	ES51	ES511	08123	0.208493207852106	0.001693037771734	0106000020E6'
3	z23	1973	ES.IGN.SIGLIM34090808205	34090808205	Sant Cugat del Vallès	ES5	ES51	ES511	08205	0.484954315725765	0.005195194242937	0106000020E6'
4	z2	1786	ES.IGN.SIGLIM34090808019	34090808019	Barcelona	ES5	ES51	ES511	08019	1.099813092791118	0.010671165489261	0106000020E6'
5	z3	1787	ES.IGN.SIGLIM34090808020	34090808020	Begues	ES5	ES51	ES511	08020	0.341389227076331	0.005418532047929	0106000020E6'
6	z4	1821	ES.IGN.SIGLIM34090808054	34090808054	Castellbisbal	ES5	ES51	ES511	08054	0.30977926563878	0.003340246399544	0106000020E6'
7	z36	2091	ES.IGN.SIGLIM34090808905	34090808905	La Palma de Cervelló	ES5	ES51	ES511	08905	0.165714942834306	0.000580792303696	0106000020E6'
8	z5	1823	ES.IGN.SIGLIM34090808056	34090808056	Castelldefels	ES5	ES51	ES511	08056	0.165297957825629	0.001390466981575	0106000020E6'
9	z6	1835	ES.IGN.SIGLIM34090808068	34090808068	Cervelló	ES5	ES51	ES511	08068	0.376605527483297	0.002602144059868	0106000020E6'
10	z7	1839	ES.IGN.SIGLIM34090808072	34090808072	Corbera de Llobregat	ES5	ES51	ES511	08072	0.273547768249955	0.00196939511261	0106000020E6'
11	z8	1840	ES.IGN.SIGLIM34090808073	34090808073	Cornellà de Llobregat	ES5	ES51	ES511	08073	0.14411148185436	0.000733748801526	0106000020E6'
12	z9	1844	ES.IGN.SIGLIM34090808077	34090808077	Espulgues de Llobregat	ES5	ES51	ES511	08077	0.097628901246611	0.000490068494669	0106000020E6'
13	z15	1927	ES.IGN.SIGLIM34090808157	34090808157	Pallejà	ES5	ES51	ES511	08157	0.18265482734183	0.000912152140984	0106000020E6'
14	z19	1962	ES.IGN.SIGLIM34090808194	34090808194	Sant Adrià de Besòs	ES5	ES51	ES511	08194	0.095081478256305	0.000410138684814	0106000020E6'
15	z10	1856	ES.IGN.SIGLIM34090808089	34090808089	Gavà	ES5	ES51	ES511	08089	0.33385852220794	0.003331323968516	0106000020E6'

Figure 44: Municipality shape and codes.

Scenario management ✕

Use the form below to create a new, or select an existing scenario.

Edit scenario

Scenario name

Start date

End date

Day(s) of week
 Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Time of day (from)

Time of day (to)

Aggregation period
 5 min 15 min 1 hour

Figure 46: Scenario management UC5.

Once the input parameters have been established and the scenario creation has started, the user must return to the home page of the tool where on the map he/she can choose, manually, the cameras from which to calculate the flows and display the relevant information.

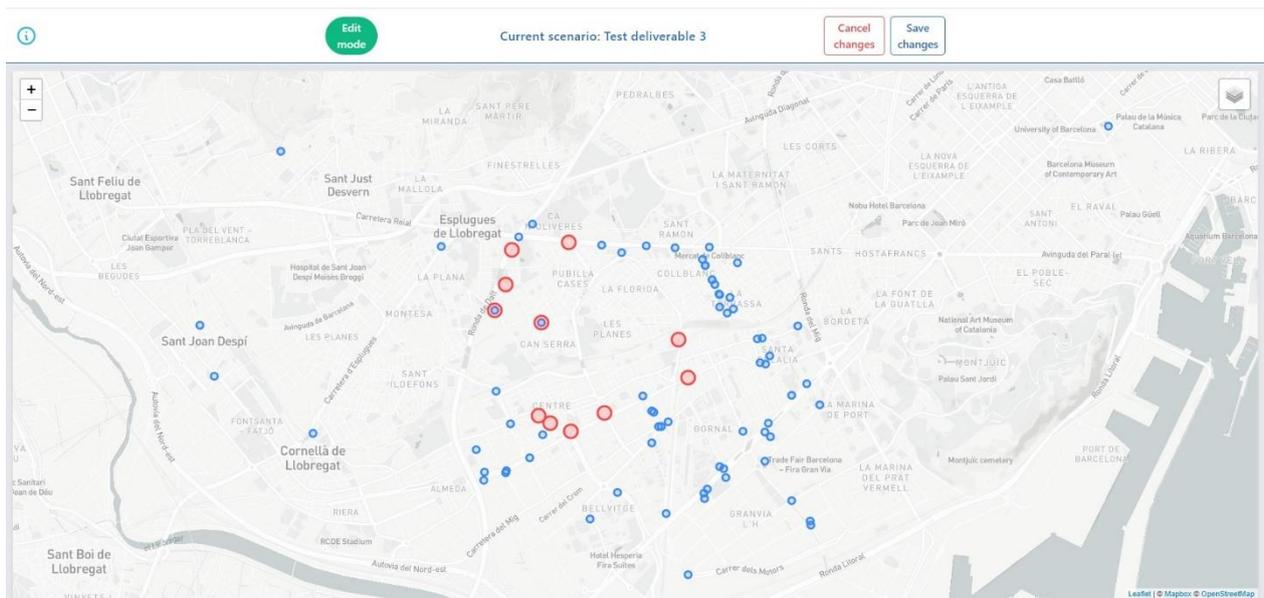


Figure 47: Edit mode.

At the end of the camera selection, the user must click on "Save changes" and return to the scenario creation section to start the calculation using the "run" button. As with other tools, a bar indicates the progress of the

calculation while the algorithm is being processed.

Finally, when the 'present' button is pressed, the results of the algorithm are shown on the tool's homepage.

8.4 Interpretation of the results

The results are displayed in a visualisation that can ideally be divided into four quadrants. By numbering the quadrants starting from the top left and continuing clockwise, it is possible to define that:

1. In quadrant 1, the dashboard shows the O/D matrix resulting from the analysis using the input parameters. This matrix contains all the cameras and related flow data that were taken into account when choosing the input data.
2. In the second quadrant we find the map, in detail, of the cameras analysed. In particular, by clicking on a cell of the table in quadrant 1, the detail map shows the geographical position of the two cameras taken into consideration.
3. In quadrant 3, a graph is shown which has for abscissae the time intervals chosen during the input parameter input phase, and for ordinates the number of passes made in that given time period. The number of passages is associated with a specific criterion which is defined by the user in quadrant 4 and which has been called a filter in the dashboard. If, for example, the chosen criterion is fuel type, the graph shows how many cars running on petrol, diesel, or other fuel, have passed between those two cameras in that time period.
4. The fourth quadrant, smaller than the others, allows filtering of the data shown in the graph in quadrant 3. Specifically, the criteria to choose from are:
 - a. Vehicle type
 - b. Fuel type
 - c. Environmental badge.

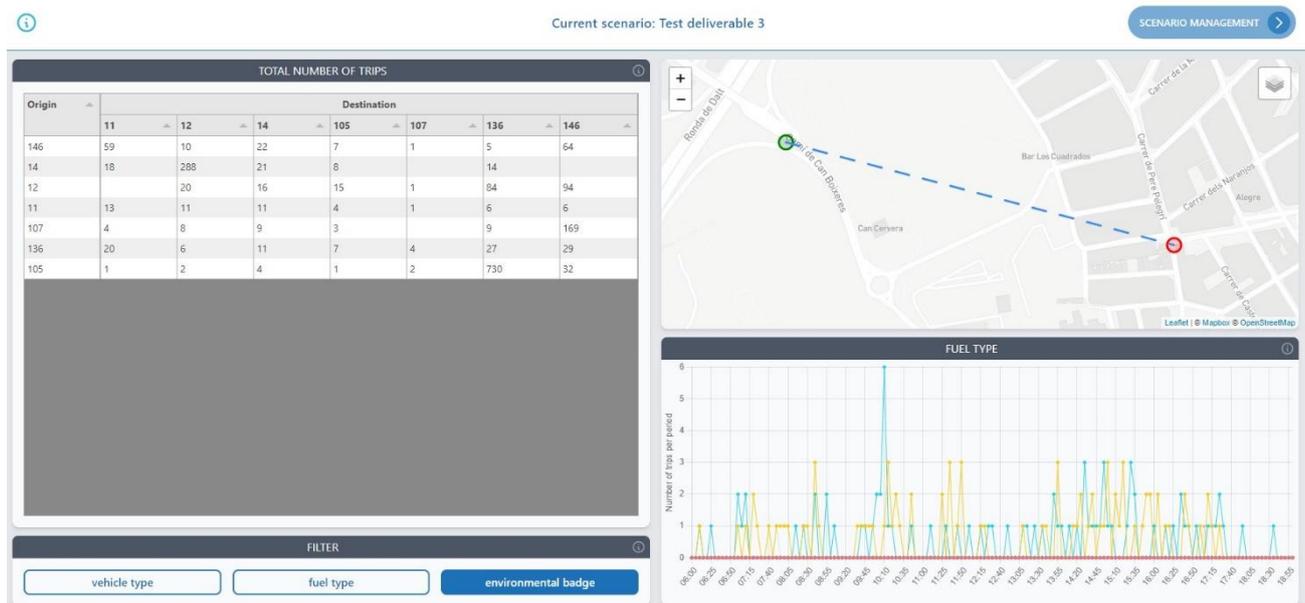


Figure 48: Example of results.



8.5 Next steps

For use case 5, it is essential that cities are equipped with flow detection systems. In the case covered by the project, ANPR type cameras were used as they were the ones provided by the city of Barcelona. However, similar considerations can also be made using data from loop detectors or other types of flow detectors. Moreover, it might be interesting to implement the calculation of the level of service in the path between two selected flow detectors. In particular, the level of service, which is a qualitative scale (from A, free flow to F, breakdown flow) that is used to understand the level of congestion of a road section.



9 Use Case 6: Assessment of traffic management scenarios

9.1 Introduction

Last decades, the rising traffic congestion is a common situation in all large cities induced by the large number of vehicles circulating in the roads. Hence, vehicle emissions are provoked in a high rate and therefore the ambient air quality is even more degraded. Apart from the adverse effect on the environment, there are also other traffic-related impacts, such as the increase of travel delays and vehicular queueing. The most direct approach to reduce traffic congestion is the implementation of traffic management measures dedicated or bundled in the context of traffic management scenarios/strategies that are enabled by intelligent transport system applications, targeting the improvement of road conditions. In that sense, the development and application of traffic management measures typically relies on the knowledge/visibility (ideally in a real-time context) of a transport network, paying increased attention to prevailing traffic conditions. The data that are mainly digested for this purpose by traffic managers and planners can be classified from various perspectives, mainly including their (a) collection source (b) provision timeline, (c) thematic area, and (d) coverage.

The focus of the sixth tool of nuMIDAS toolkit aims to prove the concept of a framework for assessing traffic management scenarios making use of data generated by traffic simulators. In so doing, it provides outputs based on (Macroscopic) Fundamental Diagrams (MFD) and other KPIs utilised in the context of assessing ITS (incl. C-ITS) services and applications. The main purpose in that context is not on defining comprehensive traffic management scenarios, but on providing a mechanism for assessing a set of simpler measures that can later be further parametrised and used for assessing more complex/comprehensive ones.

9.2 Data requirements

There are four types of databases used for UC6. The first group comprises datasets related to corridors and their acquisitions while the second one comprises datasets related to group of corridors and their acquisitions. The third concerns data on the composition of the Macroscopic Fundamental Diagram (MFD) with particular reference to the speed, flow, and occupancy of each scenario of the network. Finally, the fifth group comprises datasets related to edge-based outputs of the algorithm, with particular reference to the CO, CO2, time loss, queueing time, and queueing length of each edge of the network.

- Corridors data

id	geom	osm_id	osm_name	osm_meta	osm_source	osm_target	clazz	flags	source	target	km	kmh	cost	reverse_co	
[PK] bigint	geometry	numeric	character varying (9)	character varying (3)	numeric	numeric	bigint	bigint	bigint	bigint	double precision	bigint	double precision	double precision	
1	89	0105000020E6100000...	4959032	Stathmou	[null]	134738535	1839040684	13	1	57	58	0.1160174	90	0.0012891	1000000
2	119	0105000020E6100000...	13868791	Georgiou_Papan...	[null]	160017887	160019189	15	1	2996	2999	0.033558	50	0.0006712	1000000
3	382	0105000020E6100000...	14296206	Egnatia_1	[null]	137309943	206181779	41	3	265	266	0.0794722	40	0.0019868	1000000
4	2207	0105000020E6100000...	15219512	Ethnikis_Antistasis	[null]	241292229	1746184324	15	1	10654	7226	0.0531123	60	0.0008852	1000000
5	12497	0105000020E6100000...	20395154	Vas.Oligas_1	[null]	568253124	130201188	15	1	16650	11720	0.0127482	50	0.000255	1000000
6	14412	0105000020E6100000...	34122846	Egnatia_2	[null]	5802048518	690660711	15	1	26340	9094	0.0296192	50	0.0005924	1000000
7	25952	0105000020E6100000...	213853701	Vas.Oligas_2	[null]	159969111	159969323	15	1	2919	2921	0.053214	50	0.0010643	1000000
8	33139	0105000020E6100000...	412046197	Leoforos_Nikis_1	[null]	32822561	32822562	15	5	12069	127	0.057132	50	0.0011426	1000000
9	33160	0105000020E6100000...	412046206	Megalou_Alexan...	[null]	32822823	32822824	15	1	235	25515	0.1145947	50	0.0022919	1000000
10	38759	0105000020E6100000...	681808252	Tsimiski	[null]	163169232	163170968	15	1	72	27199	0.0292997	70	0.0004186	1000000

Figure 49: Corridors data.

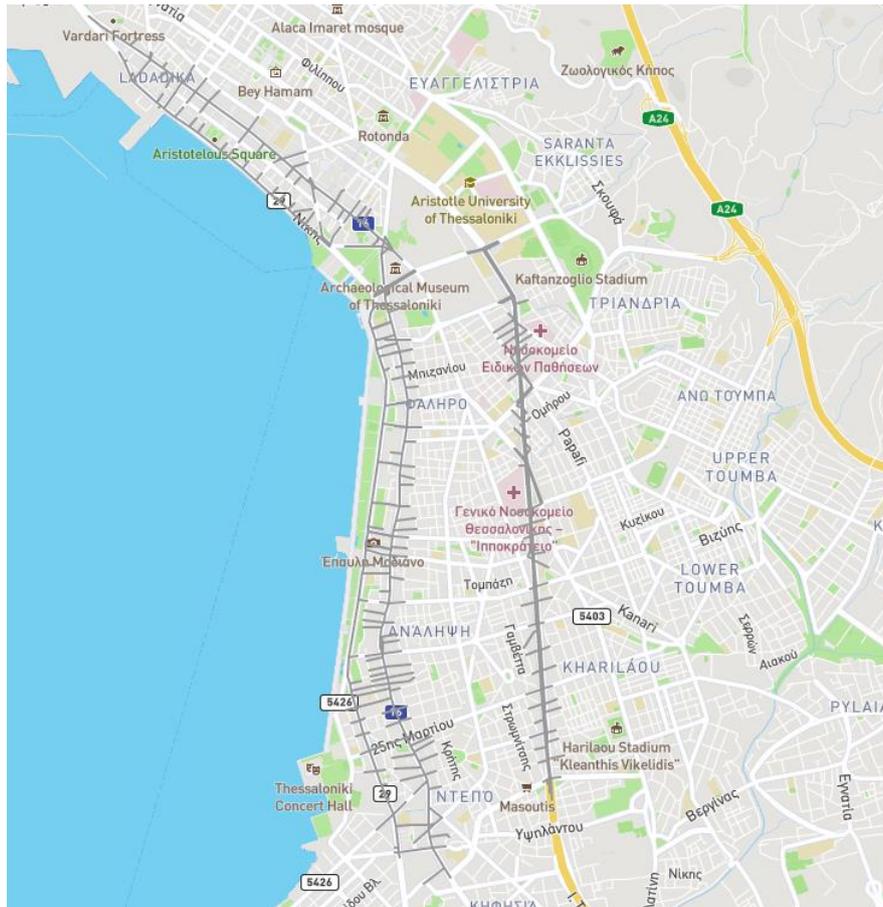


Figure 50: Corridors position.

- Group of corridors data

Data Output							Explain	Messages	Notifications
fid	geom	id	layer	path					
[PK] numeric	geometry	bigint	character varying (2)	character varying (2)					
1	0106000020E6100000...	0	Aerodromio	D:/OneDriveImet...					
2	0106000020E6100000...	0	anatolikos_tomeas	D:/OneDriveImet...					
3	0106000020E6100000...	0	downtown	D:/OneDriveImet...					
4	0106000020E6100000...	0	Dytikos_tomeas	D:/OneDriveImet...					

Figure 51: Group of corridors data.

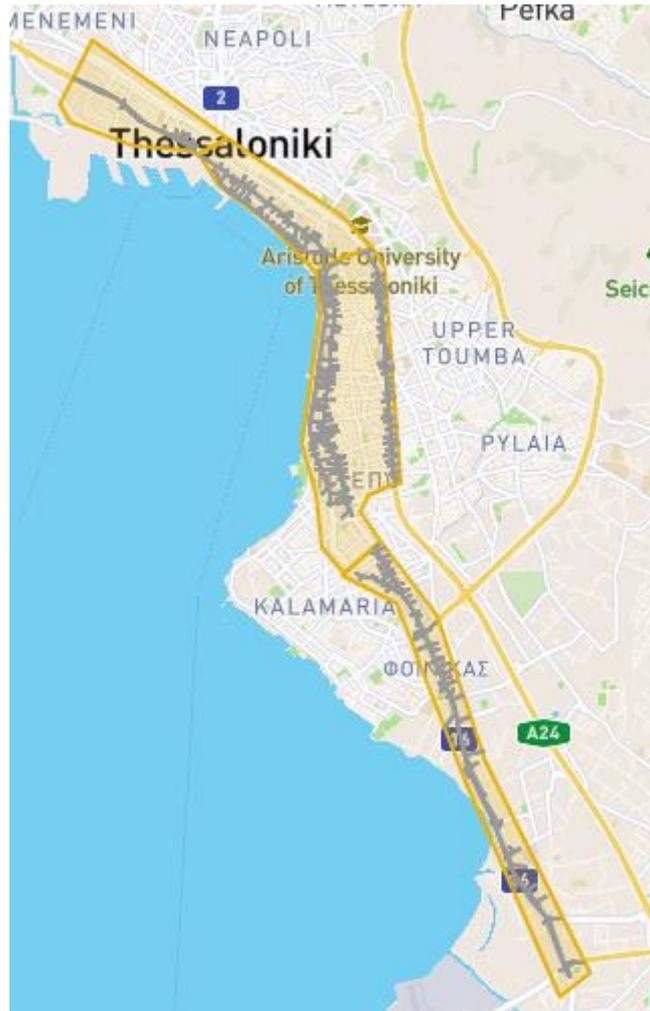


Figure 52: Group of corridors position.

- **Macroscopic Fundamental Diagram database**

Data Output										
	corridor	tls_program	selected_speed	begin_time	edge_det_id	flow	occupancy	speed		
	text	text	integer	json	json	json	json	json		
1	Bas_Olgas_1	New_Tls_Progra...	30	[[28800.0, 28860...	[[["25315", "25315...	[[17.1428571428...	[[1.589999999999...	[[22.6151999999...		
2	Bas_Olgas_1	New_Tls_Progra...	40	[[28800.0, 28860...	[[["25315", "25315...	[[25.7142857142...	[[1.4875, 0.92099...	[[34.9457142857...		
3	Bas_Olgas_1	New_Tls_Progra...	50	[[28800.0, 28860...	[[["25315", "25315...	[[30.0, 34.285714...	[[1.105, 0.882, 1.0...	[[52.6546285714...		
4	Bas_Olgas_1	New_Tls_Progra...	60	[[28800.0, 28860...	[[["25315", "25315...	[[34.2857142857...	[[1.042, 0.792, 1.0...	[[60.4537714285...		
5	Bas_Olgas_1	Old_Tls_Programs	30	[[28800.0, 28860...	[[["25315", "25315...	[[17.1428571428...	[[1.589999999999...	[[22.6151999999...		
6	Bas_Olgas_1	Old_Tls_Programs	40	[[28800.0, 28860...	[[["25315", "25315...	[[17.1428571428...	[[1.506666666666...	[[24.1703999999...		
7	Bas_Olgas_1	Old_Tls_Programs	50	[[28800.0, 28860...	[[["25315", "25315...	[[17.1428571428...	[[1.46, 0.774, 0.81...	[[25.6978285714...		
8	Bas_Olgas_1	Old_Tls_Programs	60	[[28800.0, 28860...	[[["25315", "25315...	[[17.1428571428...	[[1.426666666666...	[[27.2067428571...		
9	Bas_Olgas_2	New_Tls_Progra...	30	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 0.0, 67.5, 75...	[[0.0, 0.0, 2.35083...	[[0.0, 0.0, 22.6367...		
10	Bas_Olgas_2	New_Tls_Progra...	40	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 22.5, 82.5, 5...	[[0.0, 1.33, 2.2600...	[[0.0, 15.1308, 36...		
11	Bas_Olgas_2	New_Tls_Progra...	50	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 45.0, 60.0, 6...	[[0.0, 1.2375, 1.22...	[[0.0, 37.0332, 47...		
12	Bas_Olgas_2	New_Tls_Progra...	60	[[28800.0, 28860...	[[["4683", "4683", "...	[[7.5, 45.0, 60.0, 6...	[[0.64, 1.2675, 1.4...	[[21.1896000000...		
13	Bas_Olgas_2	Old_Tls_Programs	30	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 0.0, 52.5, 75...	[[0.0, 0.0, 2.295, 2...	[[0.0, 0.0, 24.1947...		
14	Bas_Olgas_2	Old_Tls_Programs	40	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 30.0, 67.5, 3...	[[0.0, 1.745, 1.844...	[[0.0, 15.714, 36.5...		
15	Bas_Olgas_2	Old_Tls_Programs	50	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 67.5, 45.0, 4...	[[0.0, 1.5425, 1.87...	[[0.0, 41.5125, 44...		
16	Bas_Olgas_2	Old_Tls_Programs	60	[[28800.0, 28860...	[[["4683", "4683", "...	[[0.0, 67.5, 52.5, 5...	[[0.0, 1.0525, 0.99...	[[0.0, 49.0752000...		
17	Egnatia_1	New_Tls_Progra...	30	[[28800.0, 28860...	[[["39153", "39153...	[[19.2857142857...	[[1.140000000000...	[[27.9172285714...		

Figure 53: Macroscopic Fundamental Diagram database.



Scenario management

Use the form below to create a new, or select an existing scenario.

Edit scenario

Scenario name

Type of Analysis

FD/MFD Traffic Related Statistics

Type of Corridor

Corridor Group Of Corridors (Areas)

Traffic light Programs

Speed Limit

Figure 55: Scenario management UC6.

Once the input parameters have been established and the scenario creation has started, the user must return to the home page of the tool where on the map he/she can choose, manually, the corridor or group of corridors from which to execute the selected type of analysis.

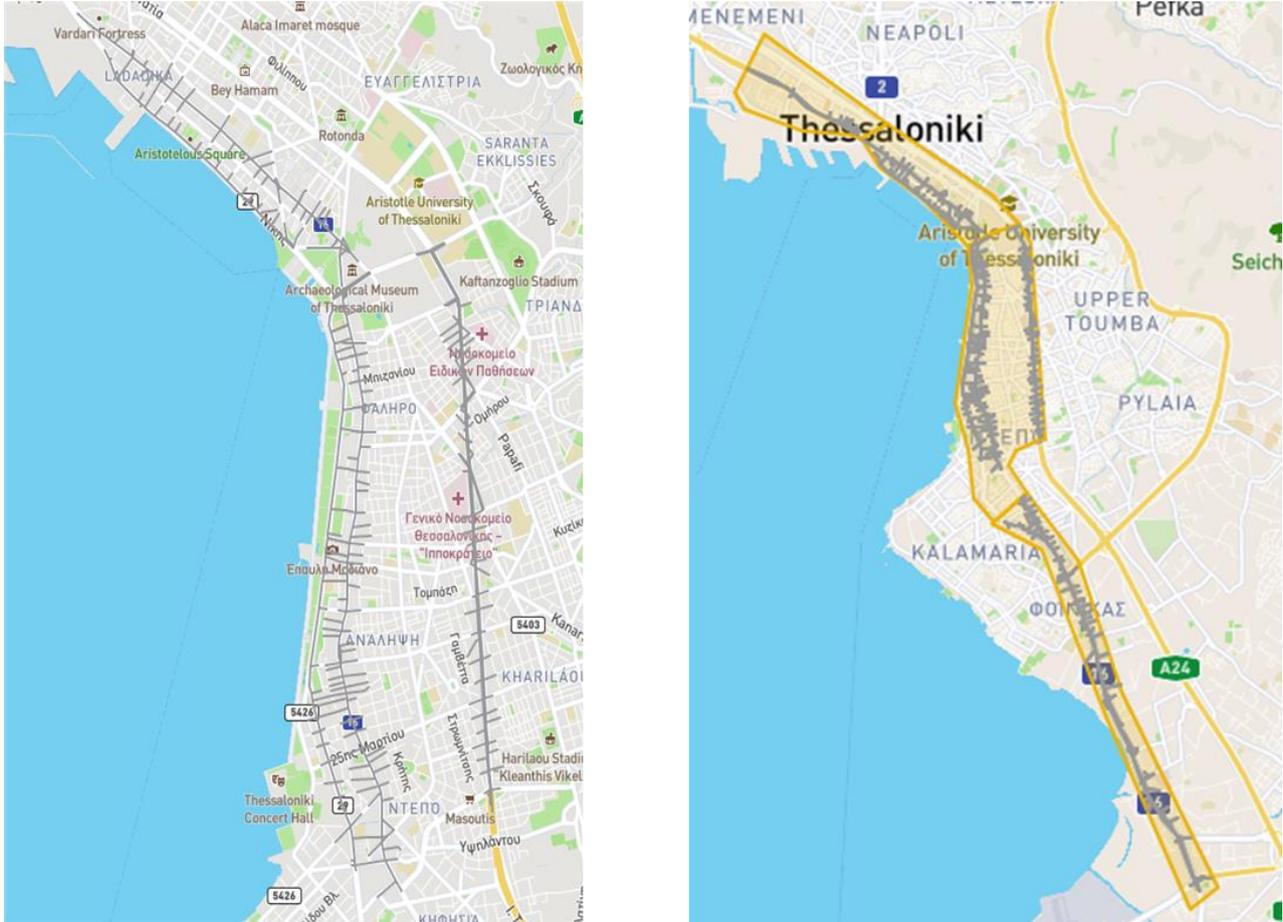


Figure 56: Edit mode.

At the end of the corridor selection, the user must click on “Save changes” and return to the scenario creation section to start the calculation using the “run” button. Similarly with the remaining tools, a bar indicates the progress of the calculation while the algorithm is being processed.

Finally, once the “present” button is pressed, the results of the algorithm are shown on the tool's homepage.

9.4 Interpretation of the results

The results regarding the Macroscopic Fundamental Diagram analysis are displayed in a visualisation that can ideally be divided into two sections. By numbering the sections starting from the left and continuing to the right, it is possible to define that:

1. In section 1, the dashboard displays the map of the corridors as well as of the group of corridors and the selected corridor or group of corridors are coloured blue.
2. In the second section we find the correlation type drop-down menu, the classification parameter drop-down menu, and the checkbox about the inclusion of baseline scenario. Moreover, at this section a scatter plot is used in order to plot the selected correlation type. The possible correlation types are the following:
 - a. Flow vs. Occupancy
 - b. Flow vs. Speed
 - c. Speed vs. Occupancy

The possible classification parameters are the following:

- a) Network loading factor
- b) Simulation time step

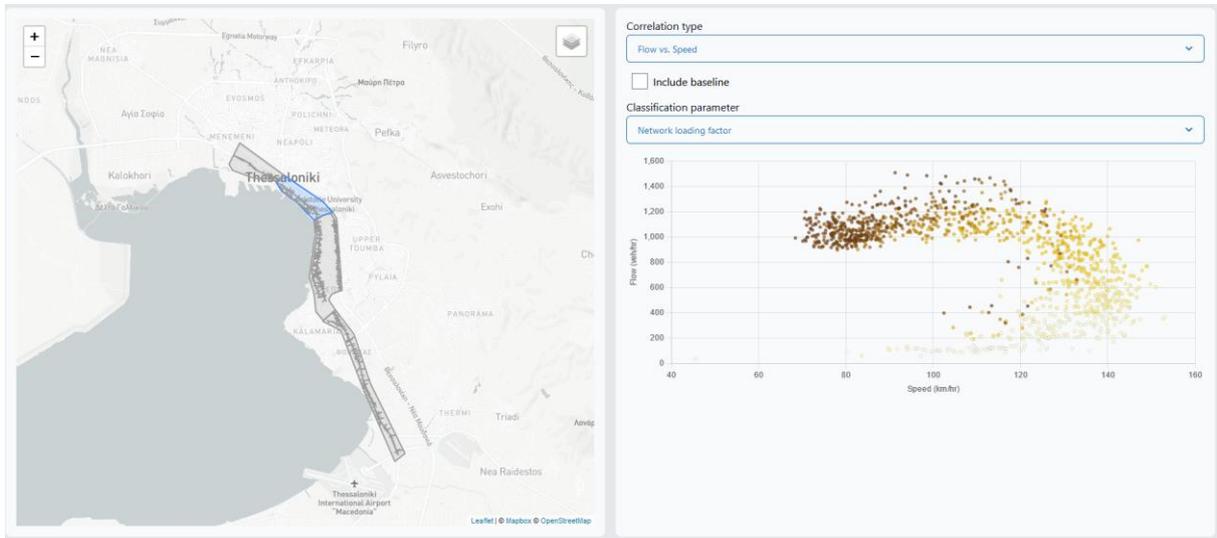


Figure 57: Example of results.

The results regarding the Edge-based analysis are displayed in a visualisation that can ideally be divided into two sections. By numbering the sections starting from the left and continuing to the right (clockwise), it is possible to define that:

1. In section 1, the dashboard displays the map of the edges coloured differently, based on the values that they have.
2. In the second section we find the analysis parameter based on which both the map as well as the graph and the numerical analysis values change. Also, the map included in this section is a bar chart which shows the differences between the baseline scenario and the user defined scenario.

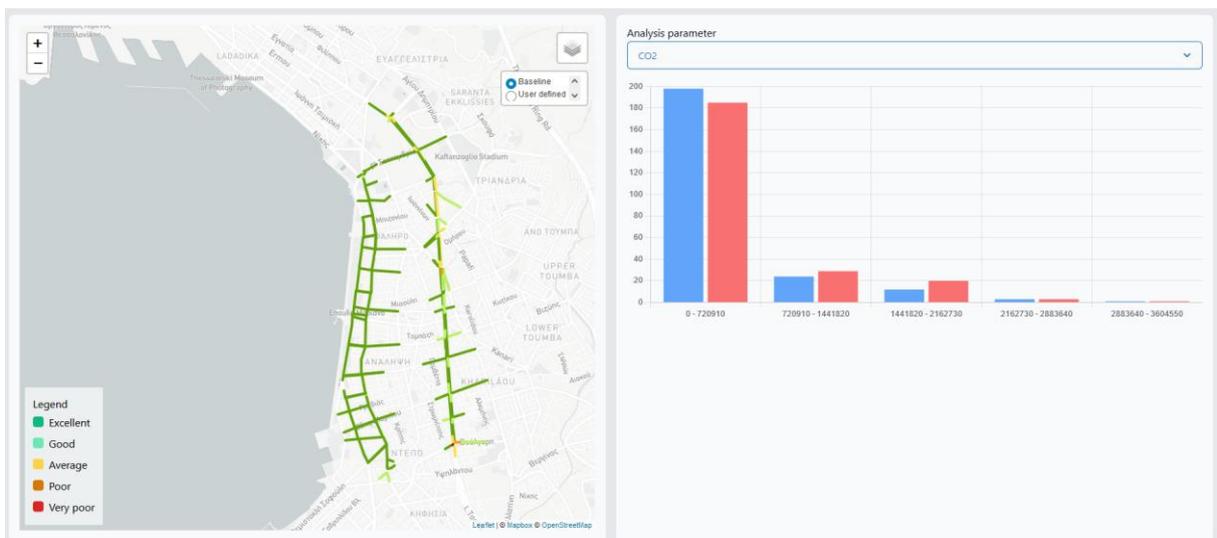


Figure 58: Example of results.



9.5 Next steps

For use case 6, future extensions may involve the provision of the possibility to the users of the toolkit to define a custom traffic management scenario, perform a traffic simulation experiment, and report the already existing KPIs quantified by the outputs of the user-defined simulation experiments. Moreover, future extensions may include the capability of the toolkit to digest real world (dynamic) data and enable the comparison of simulated versus observed traffic characteristics. In summary, there are two dimensions around which use case 6 can be enhanced. The first dimension revolves around the enhancement of its planning/planification capabilities, while the second one revolves around the enhancement of its monitoring capabilities.



10 Conclusions

For a European project, transferability is a fundamental concept. In fact, it is only through the possibility of the dissemination of project results that its impact can have a greater impact on future mobility. Consequently, the guidelines in this deliverable are intended to disseminate both the project results and to extend the use of the dashboard to other cities with a view to exploiting the work done within the project. Therefore, this deliverable, as also described in the introduction can be seen as a "how-to" manual for any person (technician, public decision maker, researcher, etc.) who wants to use the dashboard for both work and research purposes. In this way, the toolkit can be widely used and can remain active for a longer time even once the project is finished.

However, within these transferability guidelines, possible future features or functionalities that could be a 'nice to have' in future versions of the dashboard were also defined. Thus, in addition to describing the work already done, the deliverable outlines possible new steps for updating the toolkit.