Deliverable 4.2
Overview of emissions and air quality use cases

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Editor(s) / main author(s)	Eglantina Dani (FACTUAL) Carola Vega (FACTUAL)
Contributing authors	TML MAPTM CERTH CTU POLIEDRA AMB INFO AMAT LEUVEN
Reviewer(s)	Magdalena Hyksova (CTU) Andre Maia Pereira (CTU)
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v1.0	31/12/2022	Final version	Sven Maerivoet (TML)

Table of contents

List of figures

List of tables

1 Executive summary

This deliverable presents the results of UC3 (Air quality analysis and forecasting). For the use case, we provide a short description, the required input data, how the use case is set up and deployed, some usage guidelines, and finally the results.

For UC3 we show the application of a number of scenario's. First, we let the toolkit calculate PM2.5, NOx, and CO_2 emissions for a set of cameras for a single day (21 March 2021). The results show how the increase in traffic led to an increase in emissions, dependent on the time of day. Similarly, we extend the date range from 28 March 2021 to 5 July 2021, whereby the calculated emissions now represent hourly averages for a day of 24 hours, taken over the entire specified time period. Currently, the toolkit makes all emissions graphs exhibit the same trends (but they have different absolute values). The reason is that they are all solely based on the number (and types) of vehicles detected, while assuming a fixed average speed. In a future version, this can be further diversified by incorporating the actual observed/measured speeds of the vehicles at each camera location.

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.

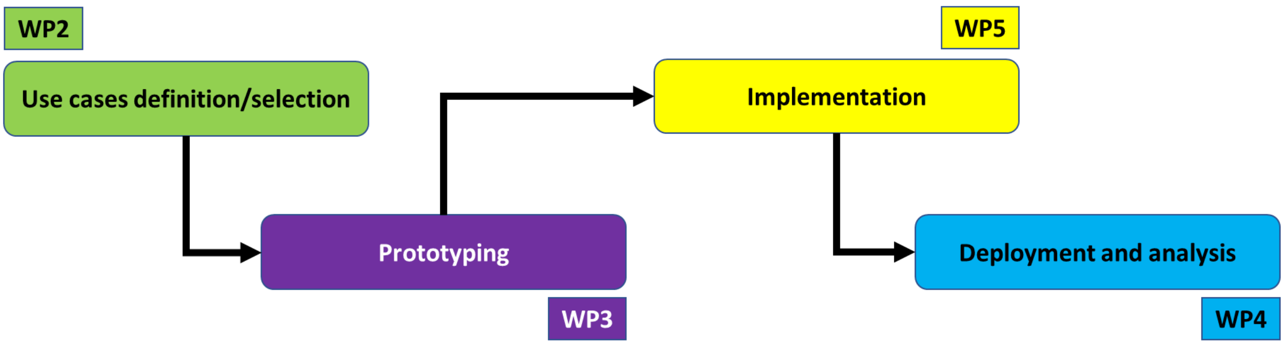
The project builds on a distributed selection of case studies in pilot cities to provide a geographic coverage of the EU. The four pilot cities are: Barcelona (Spain), Milan (Italy), Leuven (Belgium), and Thessaloniki (Greece).

2.2 Purpose of this document

A critical expectation for this project was to be able to draw conclusions and formulate recommendations that are relevant across the whole EU, and not just for selected locations. To this end, this project built on a distributed selection of case studies in pilot cities to provide a geographic coverage of the EU, with each pilot city an active partner in the consortium as well as being accompanied by a local core partner:

- The city of Barcelona (AMB INFORMACIO) in Spain, supported by FACTUAL.
- The municipality of Milano (AMAT) in Italy, supported by POLIEDRA.
- The city of Leuven (LEUVEN) in Belgium, supported by TML.

The use cases that were considered by each of these pilot cities were used to further validate our research, i.e. we used the proposed new variables and KPIs from WP2 as well as the methods and tools from WP3. The toolkit (in the form of a dashboard) from WP5 was used to incorporate the previously defined methods and tools, and thus providing researchers, planners, and policy makers a visualisation of the results as highlighted in their case studies.



The six selected uses cases were prototyped in WP3, and finally ended up being implemented in WP5 and deployed in WP4. Whereas WP3 worked with more proof-of-concept data, the results from working with the actual data from the pilot cities in WP5 is reported in the set of WP4 deliverables:

- **D4.1: Overview of traffic operations use cases**
  - UC4 (Planning for parking)
  - UC5 (Inflows and outflows in a metropolitan area)
  - UC6 (Assessment of traffic management scenarios)
- **D4.2: Overview of emissions and air quality use cases**
  - UC3 (Air quality analysis and forecasting)
- **D4.3: Overview of dynamic mobility operations use cases**
  - UC1 (Pre-planning of shared mobility services)
  - UC2 (Operative areas analysis)

The aim of the current Deliverable D4.2 is to describe in detail the backgrounds, setups, deployments, and results for Use Case 3 concerning the analysis of emissions in the city of Barcelona

2.3 Structure of this document

This deliverable contains the results of UC3 (Air quality analysis and forecasting) in Chapter 3. For the use case, we provide a short description, the required input data, how the use case is set up and deployed, some usage guidelines, and finally the results.

2.4 Acronyms

ANPR	Automated Number Plate Recognition
EC	European Commission
GA	Grant agreement
LEZ	Low-emission zone
MaaS	Mobility-as-a-service
nuMIDAS	New Mobility Data and Solutions Toolkit
UC	Use case
WP	Work package

3 Air quality analysis and forecasting (use case 3)

3.1 Description

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). Currently, the tool for UC3 takes the number and type of vehicles and their assumed average speed into account. The former are obtained via the ANPR cameras, whereas the latter are reflected in the emission factors used to calculate the emissions.

3.2 Input data

- Table with camera information regarding the position (latitude, longitude), name of the street and zone to which each camera belongs.
- Table with information per each pseudo anonymized license plate of vehicles travelling along the city of Barcelona about the fuel type, vehicle type and environmental badge.

3.3 Setup and deployment

In this section, the structure of the database is shown. In order to clearly describe the structure, for each file that makes up the database, the file name has been defined, what it refers to and what fields and data type make up the file. In addition, a brief description of the contents of the files and the acronyms in them has been provided.

Table 1: Structure of the camera database.

Name	Title	Fields	Data type
"ES_BCN"."AQVE_in_camerasNumidas"	Table which contains information about the position of the cameras and the zones they belong.	"id" "geom" "camera_id" "location_id" "latitude" "longitude" "street" "zone_id"	integer geometry text integer double precision double precision character varying text

This table contains all the cameras thar are available for the city of Barcelona as well as the position (latitude and longitude) and the name of the street. Also, the cameras are grouped into different zones ("zone_id" column) based on their location.

Table 2: Structure of the fleet database.

Name	Title	Fields	Data type
"ES_BCN"."IOMA_fleet_database"	Table which contains information about the vehicles that travel along the Barcelona city.	"licence_plate" "environmental_badge" "fuel_type" "vehicle_type"	text text text text

This table contains specific information for each vehicle based on its licence plate. The licence plates, for GDPR reasons, are pseudo anonymised. For each licence plate, specific information is available: environmental badge of the vehicle, fuel type of the vehicle, and vehicle type.

Table 3: Structure of the time series camera data.

Name	Title	Fields	Data type
"ES_BCN"."AQVE _out_week_XXX _XX_XX"	Number of tables which contain information per camera detections per 5-minute interval for each week for almost 1 year (March 2021- February 2022)	"timestamps" "from_camera" "vehicle_type_info"	Timestamp without time zone bigint text

The above table provides a sample for the pre-calculated data regarding the camera pairs. There are as many tables as the weeks between 28 March 2021 to 5 February 2022. Each table provides information per 5-minute interval for all the camera pairs. For each camera pair, the total number of vehicles is calculated and then a distribution of them is made based on the fuel type, environmental badge and vehicle type. All these tables are used in order to provide the user of the tool with the needed information based on the selected camera pairs and datetimes.

3.4 Usage guidelines

The data that are required in order for the algorithm to work properly, are the following:

- Start date: is the date based on which the tool will start to retrieve data from the database.
- End date: is the date up to which the tool will end the process of retrieving data from the database.

At the end of the calculation process, the tool provides a map representation to the user. Specifically, the map shows only the selected cameras. For these cameras the output parameters are the following:

- For each camera a graph which shows the values about $PM_{2.5}$, CO_2 and NO_x per hour of the day are provided.
- Map where the position of the selected cameras is shown.

3.5 Results

As an example, we let the toolkit calculate PM2.5, NOx, and CO_2 emissions for a set of cameras for a single day (21 March 2021). The results are shown in the following figure. We can see how the increase in traffic leads to an increase in emissions, dependent on the time of day. The fact that all three graphs currently exhibit the same trends (but have different absolute values) is because they are all solely based on the number (and types) of vehicles detected, while assuming a fixed average speed.

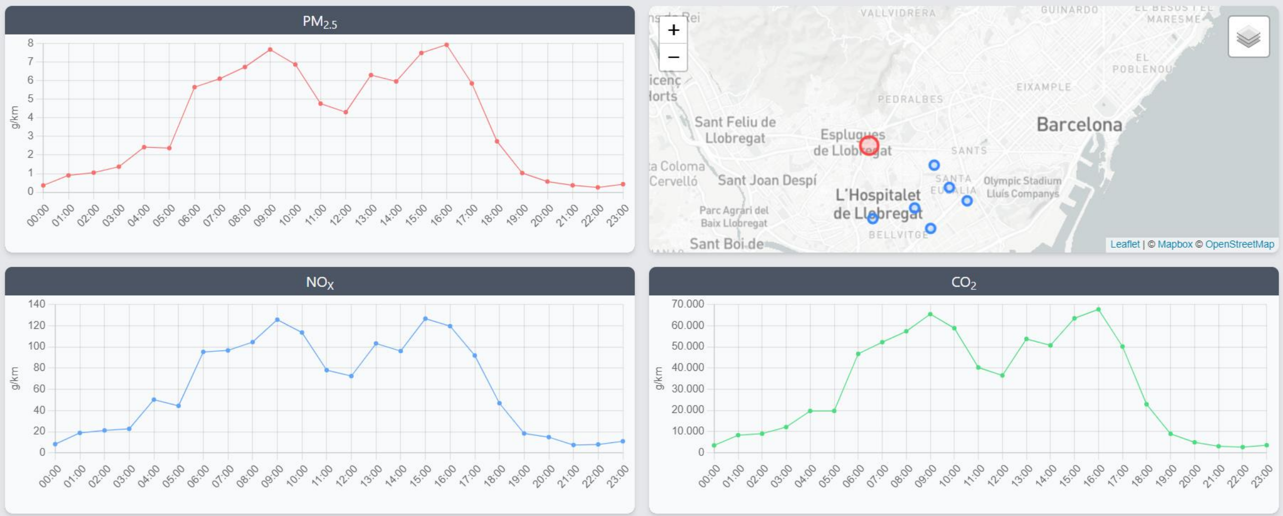


Figure 1: Results for the UC3 emissions calculations for a set of cameras for 21 March 2021.

A similar scenario is shown in Figure 2, where we now extend the date range from 28 March 2021 to 5 July 2021. The emissions here represent hourly averages for a day of 24 hours, taken over the entire specified time period.

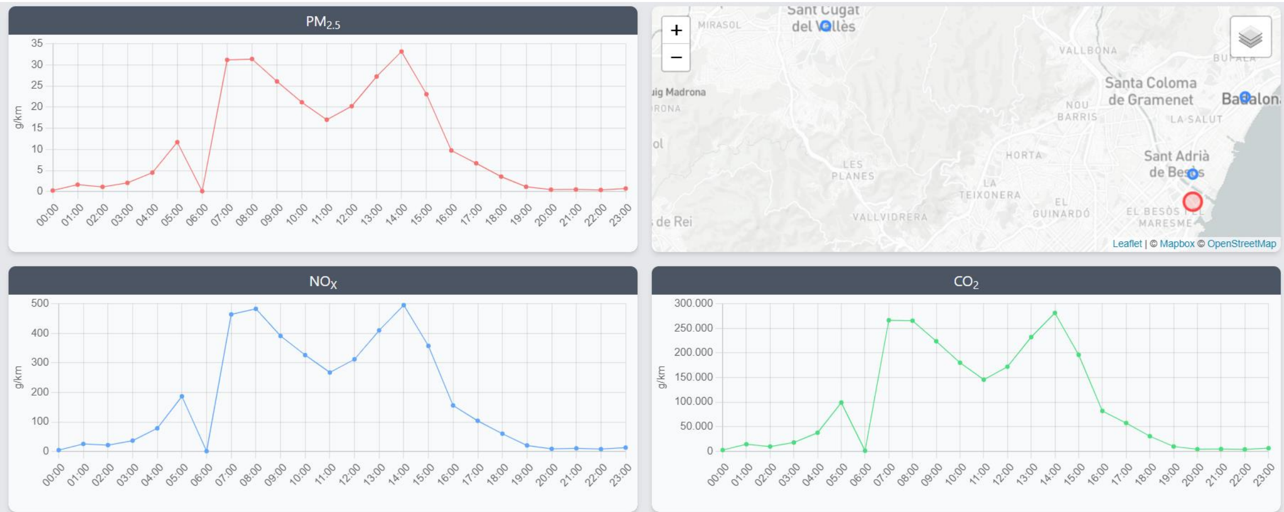


Figure 2: Results for the UC3 emissions calculations for a set of cameras for an extended date range.

4 Conclusions

This deliverable presented the results of UC3 (Air quality analysis and forecasting). For the use case, we provided a short description, the required input data, how the use case is set up and deployed, some usage guidelines, and finally the results.

For UC3 we showed the application of a number of scenario's. First, we let the toolkit calculate PM2.5, NOx, and CO_2 emissions for a set of cameras for a single day (21 March 2021). The results showed how the increase in traffic led to an increase in emissions, dependent on the time of day. Similarly, we extended the date range from 28 March 2021 to 5 July 2021, whereby the calculated emissions now represent hourly averages for a day of 24 hours, taken over the entire specified time period. Currently, the toolkit makes all emissions graphs exhibit the same trends (but they have different absolute values). The reason is that they are all solely based on the number (and types) of vehicles detected, while assuming a fixed average speed. In a future version, this can be further diversified by incorporating the actual observed/measured speeds of the vehicles at each camera location.