Zero Emission off-peak Urban deliverieS

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Document information

Additional author(s) and contributing partners

Name	Organisation
Shary Heuninckx	MOBI-VUB
Philippe Lebeau	MOBI-VUB
Jonas Haustraete	Colruyt Group
Pieter Leonard	Colruyt Group
Rami Darwish	KTH
Romain Rumpler	KTH
Siddharth Venkataraman	KTH
Volker Kraft	Fraunhofer IML
Daniela Kirsch	Fraunhufer IML
Amnir Hadachi	University of Tartu
Mozhgan Pourmoradnasseri	University of Tartu

Purpose of this document

This documents describes the results of and the work performed in Task A2002 “Inventory and CBA [Cost-Benefit Analysis] of information sources and MTSMTs [i.e., models / evaluation tools] to derive indicators” for and make decisions about ZEUS operations. In particular, the document present the methodology used for the pragmatic selection of cost-effective models and their inputs and outputs in the context of evaluation criteria and KPIs as well as evaluation scenarios in a Multi-Actor Multi-Criteria Analysis (MAMCA) process. The document also serves as an internal guide in the remainder of the project as it outlines the semantic dependences and functional relationship between individual models, their inputs, and outputs.

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Abbreviations

CBA	Cost-Benefit Analysis
CO_2	Carbon Dioxide
dB	Decibel
GIS	Geographical Information System
GPS	Global Positioning System
KPI	Key performance indicator
LOD	Level of Detail
LSP	Logistics Service Provider
MAMCA	Multi-Actor Multi-Criteria Analysis
MTSMT	Measurements Techniques and Simulation and Modelling Tools
NO_x	Nitrogen Oxides
OSM	OpenStreetMap
WP	Work Package

1. Introduction and objectives

Task description

Based on the output of early bird 2019 pre-study (knowledge of competences and experiences of partner and a set of preliminary indicators along a number of relevant dimensions, e.g. emissions (e.g., noise, GHG, particles), traffic/congestion, safety, logistics, urban space, business models, etc.):

- Through paper study, qualitative sensitivity analysis and workshops, 1) identify interdependencies between-, 2) rank- and 3) select information (e.g. operations vs ambient noise, other emissions, traffic / congestion, logistics flows / routes, structure of built environment, business models, etc.) that are needed to evaluate the indicators
- Create a set refined indicators based on the information identified
- Create an inventory of existing sources for- as well as existing Measurements Techniques and Simulation and Modelling Tools (MTSMTs)at partners that can derive the selected information
- Cost-Benefit Analysis (CBA) of level of detail and quality of the existing and derivable information

Objective

In comparison to Task 1.1 and 1.2 of WP1 of the ZEUS Early Bird Project in 2019, the objective of Task 2.1 in WP2 is to refine and further specify (as necessary) stakeholder objectives, criteria, and evaluation scenarios, provide further details about the information and data inputs and outputs and modelling options of individual models, and propose a comprehensive evaluation framework that links the models to support a Multi-Actor Multi-Criteria Analysis of ZEUS scenarios with stakeholders. Additionally, this document is to serve as an internal guide in the remainder of the project as it outlines the semantic dependences and functional relationship between individual models, their inputs, and outputs.

Relation to other tasks

DEL01 (D1.1) and DEL02 (D1.2) in WP1 in the Early Bird Project in 2019 provide an "Overview on addressed use cases, stakeholders, objectives, criteria and weights" and a "Selection of suitable tools and models for measurement and evaluation".

In relation to DEL01 (D1.1) in 2019, DEL02 in WP2 of the Innovation Project in 2020:

1) defines additional potential stakeholder objectives,
2) differentiates criteria as "contextual elements that are important input for the models" to evaluate relevant scenarios from objectives which are "something that stakeholders strive for", and
3) in addition to the generic use cases presented in D1.1 (i.e., maneuvering and loading/unloading) defines four stakeholder evaluation scenario "themes" in which variables/variations are used to define 24 basic scenarios as combinations of these variables and presents the selected five scenarios that are to be validated and evaluated with stakeholders for the Colruyt case study.

In relation to DEL02 (D1.2) in 2019, DEL02 in WP2 of the Innovation Project in 2020:

1) based on the overview description of the models presented in D1.2, the herein defined and extended stakeholder objectives, criteria and established scenario themes, proposes a comprehensive ZEUS evaluation framework that establish the input-output links / interactions between the individual models, and
2) further details the information and data needs and the model specification of evaluation models including options (if possible)

As such, DEL02 in WP2 of the Innovation Project in 2020 lays the ground work and road map for the model implementation, integration, deployment and use for the rest of the project.

2. Methodology for pragmatic analysis of evaluation models for MAMCA of ZEUS operations

Overview of methodology

The methodology applied to reach the objective of Task 2.1 was performed in a number, not necessarily sequential steps primarily by reviewing previous project deliverables and documents and through a number of online meetings between the partners that have the expertise in the respective models. The steps were as follows:

- Review the inventory of evaluation tools available at the partners
- Create a comprehensive ZEUS evaluation framework that links model inputs and outputs to KPIs for the evaluation of scenarios with stakeholders through the MAMCA process
- Review, clarify and revise stakeholder objectives and criteria for vehicle manoeuvring and loading / unloading operations in / phases of ZEUS
- Gain a common understanding of the MAMCA process in general and in the context of the ZEUS evaluations
- Define a scenario frameworks relevant for ZEUS and select a subset of the scenarios for initial evaluation with stakeholders for the Colruyt case study
- Gain a common understanding about options for evaluation models and their inputs and outputs in the in the context of the ZEUS evaluation framework

The subsections sections below describe in sequence the details of these steps and their results. An exception to this is the results of the model / evaluation tool information collection (specifications and options) which are presented in Section 4.

Evaluation tools

The aim of WP2 of the ZEUS project is to select, deploy, calibrate, integrate and refine and Measurements Techniques and Simulation and Modelling Tools (MTSMTs) in use cases (vehicle manoeuvring, loading/unloading, and combined) to provide multi actor multi criteria decision support for large-scale implementations of the ZEUS measure / operations to allow the transferability of the concept to new cities by estimating its impacts at unmeasured locations and times.

The ZEUS partners have in prior work developed methods and models in the following areas:

- Transport efficiency modelling and logistics change impact assessment
- Noise measurements, simulation and modelling
- Traffic-, congestion- and population density and mobility measurements and modelling
- Emissions estimation and modelling
- Build environment information acquisition and modelling through remote sensing and GIS
- Business model analysis and business cost / revenue indicators
- Urban freight measure (macro) modelling
- Multi-criteria decision making process and tools

WP2 will deploy, calibrate, integrate and refine these tools in a Multi-Actor Multi-Criteria Analysis (MAMCA) tools to facilitate discussions and decisions making regarding ZEUS scenarios between different stakeholders / actors.

Interrelations between models and evaluation tools in a comprehensive ZEUS evaluation framework

To establish a comprehensive evaluation framework for ZEUS is not a simple task. While the ZEUS partners were confident that from the start of the project that they possess the necessary knowledge and in-house models and tools to perform comprehensive evaluations, a framework needs to be established that link models and their inputs and outputs to one another. To establish such a framework necessitates a clear common understanding of the goal, the inner-working, the inputs and outputs of the models. To establish such a model for the MAMCA process, a “back-casting” approach was taken. This approach proceeds from a clear understanding or stakeholder objectives and criteria, to definitions of scenarios for ZEUS solutions, to KPIs for scenario evaluations, to finally the inner- and inter-workings of models in terms of their input and output options. To further complicate matters, such a framework as it is in the case of the ZEUS evaluation framework often includes feedback loops. Consequently, the comprehensive ZEUS evaluation framework depicted in Figure 1 was not derived as the “second” step of the overall methodology of Task 2.1, but rather has evolved throughout all the steps. The final version of the frameworks is shown in Figure 1, where inputs and outputs are denoted with arrows pointing to and pointing from models and thereof derived KPIs.

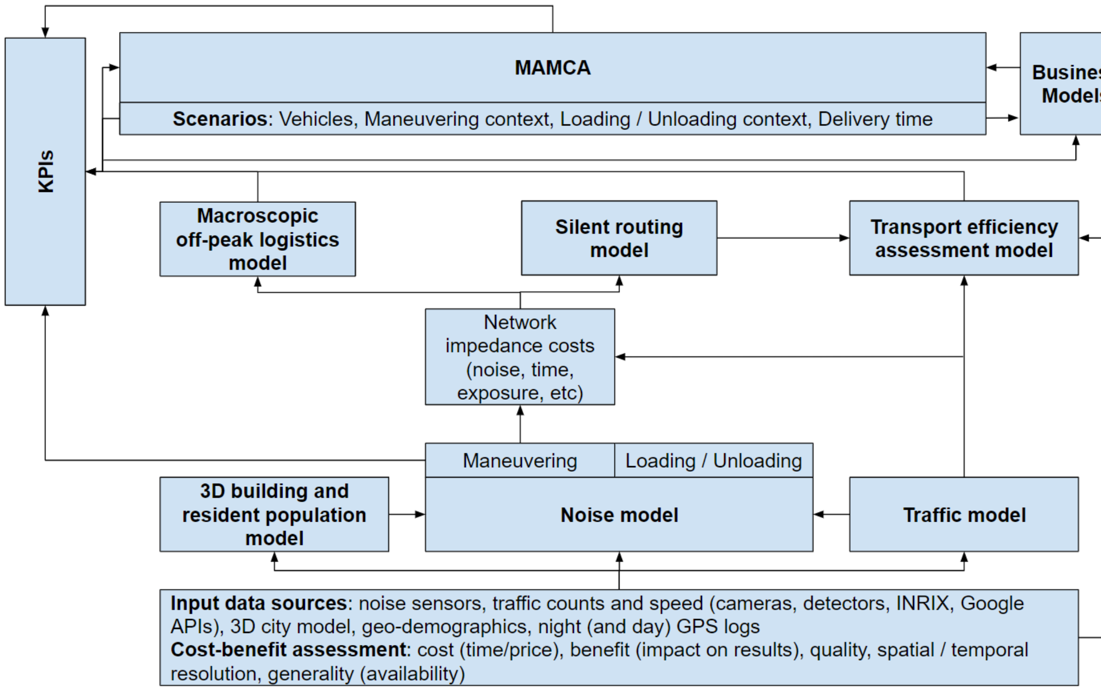

Figure 1: Comprehensive ZEUS evaluation framework

Objectives and criteria for vehicle manoeuvring and loading/unloading operations in / phases of ZEUS

The operations in / phases of ZEUS can be broadly divided into two: 1) the delivery or transport of goods from the depot to the delivery point (aka. "*vehicle manoeuvring*") and 2) the loading and unloading of goods at the delivery point (aka. "*loading/unloading*"). In a two-day workshop of WP1 of the ZEUS project, based on experiences from previous projects, researchers and experts from different stakeholder groups have derived relevant generic criteria/objectives for the ZEUS operations for each of the key stakeholders as:

Objectives	City	Vehicle/driver	Transport Comp.	Retailer/store
Noise reduction	X	X	X	X
Emissions reduction (CO2, PM, NOx)	X	X	X	X
Public opinion (satisfaction vs. complaints)	X	X	X	X
Access to city / store		X	X	X
Safety of driver / store / goods / vehicle	X	X	X	X
Security of driver / store / goods / vehicle		X	X	X
Availability of support during off-peak time		X	X	X

Time (duration of tour, delivery time)		X	X	
Efficiency of operations	X	X	X	

Table 1: Objectives identified in WP1 of Task 1.1 of the ZEUS Early Bird Project via a workshop with stakeholders and experts

Based on the expertise in stakeholder engagement processes for logistics, MOBI-VUB has built up over the years, some extra objectives can be added to the list above that might be relevant for the different stakeholders:

Additional potential objectives
Profitable operations
High-level service
Employee satisfaction
Low cost deliveries
Disturbance of urban daily life (visual nuisance + congestion)
Network optimization
Reliability
Flexibility

Table 2: Additional objectives provided by partners based on prior relevant stakeholder engagements

A survey will be sent out to the relevant stakeholders in which they can indicate what objectives are relevant for them (a weight that indicates the importance of each of the selected objectives will be accounted later).

The selected objectives will be used to determine what proposed solution (scenario) is the best one for each of the stakeholders. To do this, every objective needs to be linked to one or more of the developed models or to a different calculation/assessment method. That way, it can be modelled/calculated how a scenario "scores" on each of the objectives.

The modelling makes it possible to visualize the different effects a scenario will generate (e.g. on noise production, on emissions production, on accessibility of the city…), and the objective selection in MAMCA makes it possible to visualize which of these effects should be more defining than others in the end decision.

An example: The modelling shows that scenario A generates a reduction in emissions, but no improvement in noise production while scenario B has a positive effect on the noise reduction but no effect on emissions. The objectives selection can then show which of the objectives (noise reduction or emissions reduction) is deemed most important by the stakeholders, so a decision on which scenario to implement can be made.

In the workshop of WP1 mentioned above the stakeholders also defined some criteria they deemed important for the loading/unloading phase, depicted in the table below. These are not objectives, since they are not something to strive to, but they are contextual elements that are important input for the models.

For example: noise reduction is something you want to achieve, and hence an objective. The criteria 'loading equipment', 'distance to closest neighbour' etc. mentioned below will be used as input data for the models to "calculate" how big the noise reduction actually will be.

Criteria	Stakeholder
Distance to closest neighbour	City + Industry
Infrastructure (and loading & unloading mode)	City + Industry
Loading equipment (RTI, trailer, …)	Industry
Legal noise level / area type	City + Industry
Density (population)	City + Industry
Background noise	City
Road Safety	City

Table 3: Criteria defined by stakeholders for the loading/unloading use case in the workshop in WP1 during the ZEUS Early Bird Project

Multi-Actor Multi-Criteria Analysis (MAMCA) process

To aid the discussions and decision making, by engaging the stakeholders, the MAMCA methodology is used. The 4 most important action steps from MAMCA (before the results) for the ZEUS project are depicted in the figure below.

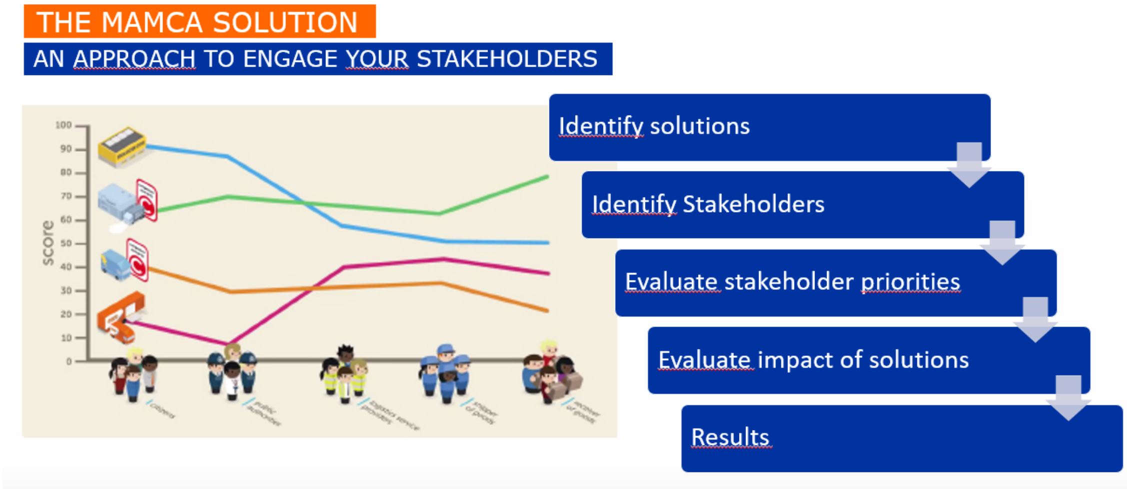

Figure 2: MAMCA process

The aims, phases, questions and action steps in the general MAMCA can be described as follows:

1. **Identify solutions = Scenario building** = What questions do we want answered?
   → Create different scenarios where the questions are the variables
2. **Identify stakeholder = Selection of relevant stakeholders** = Whose opinion should be taken into account to make a final decision?
   → Define who are the relevant stakeholders
3. **Evaluate stakeholder priorities = Stakeholder objectives determination** = What are the concerns of the relevant stakeholders?
   → Send out a survey to see what the objectives of the different stakeholders are
   → Then use the online MAMCA tool to let them indicate the importance (weight) of each of their chosen objectives
4. **Evaluate impact of solutions = Evaluation modeling** = How does each scenario comply with the concerns of the stakeholders?
   → Determine for each chosen objective how it can be quantified (what indicators and which of the developed models can do this, and what data is needed?)
   → Enter the data of each scenario into the models => you get a score for the scenarios on the objectives
   → Enter the score of each scenario on each objective into the MAMCA tool, to create a visualization of which scenario complies best to the wishes of each stakeholder

Scenarios

According to the proposal the ZEUS project goal is the following:

Envisaged testing will demonstrate that optimizations are possible to reach stakeholders' (e.g. city, citizens, retailers and logistic companies) expectations:

- the benefit of an optimized delivery route from a “logistics centre” directly to a retail point located in the city centre → noise measurement and traffic optimization;
- the benefit of electric heavy duty-vehicles being either a plug-in hybrid or a full electric vehicle → reduction of noise and emissions; and
- the benefit of silent transport operations including driving, manoeuvring and loading/unloading activities) and logistic infrastructures → noise reduction and alternatives in logistic operation.

These are project objectives that can be rephrased into questions for which an answered should be provided with the help of the ZEUS project outcome (the modelling and the MAMCA methodology):

1. What delivery route to the retail point should we take?
2. What type of vehicle should be used?
3. Should silent equipment be installed?
4. What delivery times should be used?

In turn, each of these questions has various potential ‘solutions’ (or ‘variables’), respectively (simplified; different types of ‘subvariables’ or variations are possible):

1. Route with the least people impacted (but longer) vs. shortest route (with much people impacted)
2. Diesel vs. electric vehicles (hybrid will be in between)
3. Silent equipment vs. regular equipment
4. Different delivery times: 7h-21h vs. 22h-6h vs. 21h-22h and 6h-7h

By combining these variables in different ways, you create scenarios. There are 24 potential combinations, hence 24 potential main scenarios in the general model. By evaluating each of these scenarios (see step 4 of the relevant MAMCA action steps), it can be determined which combination of variables/solutions complies best with the wishes and questions of the stakeholders.

These 24 scenarios are relevant in the case where all of the 4 questions defined above are on the table and need an answer. In most of the specific city cases where the general model can be used some decisions will already have been made, which leaves open less questions (and hence less potential scenarios to evaluate).

For example, when the decision is already made to work with EV and silent equipment, you only want to figure out what type of route is best to use and what delivery times. This leaves you with 6 potential scenarios. In this project 1 specific user case (a Colruyt retail shop in the Brussels area) will be developed in detail.

In a first scenario exercise that was done other questions (with their respective variables) than the ones mentioned above were also put on the table:

5. What is the type of docking bay infrastructure (street side vs. basement/covered bay vs. uncovered bay)?
6. What is the relationship to the neighbouring housing (attached to a house vs. on a commercial / industrial site vs. across the street/façade exposure)?

Whereas the variables mentioned before are elements you can change and decide upon in the short term in the test sites (routing, vehicle type, equipment and (un)loading time) they can make up scenario variables. The last two types are context elements that can't be changed in the short term in the test sites but who influence decisions. Therefore, these will be taken into account in some form in the evaluation modelling because they make up the specific circumstances or made part of a scenario variable to test the influence of a specific context.

Colruyt case study

For the 2 pilot cases from Belgian retailer Colruyt for which a MAMCA exercise will be performed, the number of scenarios is narrowed down according to their goal. Only variables 3 and 4 of the above list are relevant because Colruyt already uses a route optimization system, and will have to work with EV in the city centres in the future because of regulations.

Within the ZEUS project Colruyt wants to test what the effect of silent equipment in different contexts is, and what the effect of the extension of the delivery window is on the stakeholder acceptance. Therefore, the following 5 scenarios were composed:

1. Business as usual: deliveries 7h-21h with regular equipment (and existing bay infrastructure)
2. Deliveries 7h-22h with silent equipment and uncovered bay infrastructure
3. Deliveries 7h-22h with silent equipment and basement / covered bay infrastructure
4. Deliveries 7h-0h with silent equipment and uncovered bay infrastructure
5. Deliveries 7h-0h with silent equipment and basement / covered bay infrastructure

Model / evaluation tool information collection

To reach a common understanding about modelling options and to enable the pragmatic selection of cost-effective models and their inputs and outputs in the context of evaluation criteria and KPIs as well as evaluation scenarios in a Multi-Actor Multi-Criteria Analysis (MAMCA) process, partners with respective modelling expertise and in-house models were asked to provide more information about model options and respective model inputs and outputs options using the form below:

Model / evaluation tool information collection form

Considering:

- the ZEUS objectives,
- the initially collected stakeholder criteria / objectives,
- the interrelations between models and evaluation tools in a comprehensive ZEUS evaluation framework,
- the scenario variables and scenarios, and
- the MAMCA process

provide information regarding model options and related model inputs and outputs options.

1. **Input information to model**: Describe the information needed (i.e., input information) of the model. Classify information as “mandatory” and “optional”.
2. **Input data source options**: Generic description of potential data sources for the input information. E.g., noise sensors, traffic counts and speed (cameras, detectors, INRIX, Google APIs), 3D city model, geo-demographics, night (and day) GPS logs etc.
3. **Output information from model** (in the context of 1) the evaluation framework, i.e., other model input needs, 2) the possible and feasible KPIs to measure the stakeholders’ objectives / criteria, and 3) the scenarios).
4. **Output data from the model**: Describe the raw data of the model’s output.
5. **KPIs**: Describe possible KPIs [with units and object of analysis, e.g., street segment, road network, route, vehicles, delivery location, district, etc.] that are linked to the stakeholder objectives / criteria.
6. **Model internals**: Short description of the model so that it becomes clear how input data in general is converted to output data.

Instructions: To allow the cost-benefit assessment of possible options please try to reflect in the above descriptions on: cost (time/price or data or model development), benefit (impact on results), quality (data or modelling results), spatial / temporal resolution (of data and model), generality (availability of data at pilot cities and general). In case there are more than one possible option for a model input, outputs, and internals please indicate the options and highlight the option that seems most reasonable for the ZEUS project.

3. Results of model / evaluation tool information collection (specifications and options)

This section presents the results of the Model / evaluation tool information collection step of the methodology. Where multiple modelling-, input-, or output options are possible and a pragmatic selection of one option over the others according to the instructions provided is possible, the more reasonable option for the ZEUS project is highlighted in **bold**.

3D building and resident population model

Input information to model

- Spatial distribution of residential buildings [mandatory]
- Spatial distribution of resident population [mandatory]

Input data source options

There are several options regarding the spatial distribution of building and their residents:

- Buildings:
  - Option 1: 2D GIS data can capture the location and spatial distribution of buildings either as address points of polygons of the perimeter of the buildings. For noise propagation models it is likely that models can benefit from the polygon representation more as such a representation can more accurately model the propagation path of the source noise. 2D polygon representations are usually collected via building permits and registers by national land survey institutions. Under the INSPIRE directive the national land survey institutions or cities makes these freely available via open online geodata portals, e.g., https://dataportalen.stockholm.se/dataportalen/ or https://zeus.slu.se/. OpenStreetMap (OSM) is an open and freely available Volunteered Geographic Information (VGI) system and database product that also contains 2D polygon representation of buildings. In both of these data sources, usually some attributes of the geographic data can be used to distinguish between residential and non-residential buildings. However, the quality of distinguishability is questionable and is difficult to verify.
  - Option 2: Height and 3D form aspects of the buildings can be captured in so called 2.5D and 3D city models: https://en.wikipedia.org/wiki/3D_city_models. Increasing Level of Detail (LOD) models capture and increasing information about the buildings but for the purposes of the nose propagation LOD 0 and LOD 1 building models that either capture the high of the building (2.5D) or also the height and form of the buildings as essentially blocks (3D) are sufficient. These lower LOD city models are usually acquired through remote sensing technologies such as satellite image processing, photogrammetric areal image processing, or airborne laser scanning. Such 2.5D and 3D city models are usually freely available for metropolitan regions and is available for the participating pilot cities.
- Population: Residency is always registered at the address point level but due to privacy considerations such data needs to be anonymized. Possible anonymization techniques that are in use are:
  - Suppression whereby for enumeration units (e.g., address points, administrative districts etc.) with less than a threshold number of registrations the registered number is not reported / is supressed.
  - Perturbation whereby for enumeration units with less than a threshold number of registrations a random value is added the registered number, i.e., the value is perturbed. In theory locations can also be perturbed but this is less feasible when many freely available and easily linkable information (e.g., Google Maps) is available that can easily pinpoint the perturbations.
  - Generalization instead of exact number of registrations per enumeration unit ranges reported.
  - Aggregation whereby registrations for enumeration units are aggregated / grouped in some fashion so that for each group the sum of the registrations is above a threshold number of registrations. The aggregation / grouping of enumeration units is often spatial in nature.

- Option 1: Resident population is available at the address point level with some anonymization, e.g., suppression. This is the case in Stockholm where the City of Stockholm provides such data for exclusive use within the ZEUS project.
- Option 2: Resident population is aggregated to various administrative districts of different size for different purposes, e.g., voting districts, postal code areas, school districts, city parts / districts. The sources of such aggregated population are various and are usually with the organizations that aggregated the based population register data for the respective purposes. Often central statistical agencies provide such aggregations as a data product for a nominal fee, e.g., Statistics Sweden provides such data at the 50m grid cell level for around €1000.

Output information from model

A spatial representation of the buildings and the number of residents in these buildings according to the representation.

Output data from the model

The output data is a function of the spatial representation of the output information from the model. Option 1: In the object-based representation, buildings are represented as points or polygons with or without building height or as 2.5D or 3D objects.

Option 2: In the field-based representation, building information is aggregated based on the buildings' location into rectangular grid cells as a continuous field, where the grid cells can record the average / maximum / minimum height of buildings in the grid cells.

In either the object-based representations or the field-based representation, resident population can be assigned to each enumeration unit, i.e., building or grid cells.

The two representations entail different levels of simplification of reality which inevitably results in inaccuracies but can also entail less complex model implementations for noise propagation. The choice of output must be decided based on application requirements and the options and complexity of the modelling internals of the noise propagation model.

KPIs

This model does not produce direct KPIs in the ZEUS evaluation frameworks. Rather, it produces relevant input to the noise model, where it is used to evaluate the populations exposure the noise produced by the ZEUS operations, i.e., part of the estimated perceived emission impact of the ZEUS operations.

Model internals

The model is essentially a spatial interpolation model that distributes / assigns the population data from its enumeration unit, e.g., address point or administrative district, to the output enumeration unit of building information, i.e., 2D/3D points, polygons, volumes or grid cells based on the intersection between the enumeration units in question and if needed an assumption about the spatial distribution of the population, for example, assuming that the population is uniformly distributed in its enumeration units.

Noise model

Input information to model

- GIS data of road network [mandatory]
- GIS data of building geometry in 2D [mandatory]
- GIS data of building geometry in 3D [optional]
- Meso-level traffic data (time of day based vehicles count per traffic lane for each vehicle category) [mandatory]
- Micro-level traffic data (position/speed, vehicle category) [optional]
- Micro-level traffic data of delivery vehicles (position/speed at high temporal resolution) [mandatory]
- Population density distribution (spatial resolution: per building if 3D building geometry data is unavailable, per street/locality if 3D building data is available) [mandatory]
- Noise measurement calibration points [mandatory]
- Long-term (several months) noise monitoring at delivery locations [mandatory]

Input data source options

- GIS data of road network
  - **Option 1**: OpenStreetMap
  - Option 2: Google Maps
  - Option 3: City administration
- GIS data of building
  - **Option 1**: OpenStreetMap
  - Option 2: Google Maps
- Traffic data
  - **Option 1**: Simulations by TARTU
  - Option 2: Traffic and speed counters
- GPS logs for the selected delivery vehicles
  - **Option 1**: Delivery-responsible logistics company
  - Option 2: Truck manufacturer
- Population density information
  - **Option 1**: City Administration
  - Option 2: From the 3D building and resident population model if such processing is needed
- Noise measurements on selected vehicles and delivery locations
  - In-house noise monitoring solutions from KTH

Output information from model

- Manoeuvring – weighted impact calculated from number of people affected along the driving route and the dB exceedance over background noise levels
- Loading/Unloading - weighted impact calculated from number of people affected near the delivery location and the dB exceedance over background noise levels

Output data from the model

- Absolute and relative noise levels at relevant receiver positions along the driving route and around the delivery location

KPIs

- Absolute and relative noise levels to be converted into a suitable KPI, unit connected to overall societal cost.
- Manoeuvring – (number of people exposed * dB exceeded over threshold) per route
- Loading/Unloading - (number of people exposed * dB exceeded over threshold) per delivery instance

Model internals

- For the model associated with manoeuvring-related cost, modelling of noise emissions from micro-level traffic data, in order to make an estimate of time-dependent background noise level, and contributions from individual actors
- For the model associated with loading/unloading-related cost, exceedance assessment of delivery noise against the existing background noise level, in order to assign a societal cost model to the associated delivery events

Traffic model

Input information to model

The input information for modelling and simulation of urban traffic can be divided into two groups:

- Network
- Traffic information

The following network information is required:

- Geographical network boundaries [mandatory]
- Information on road segments, such as one-way/two-way [mandatory], max speed, … [optional]
- Traffic lights locations [mandatory]
- Traffic light protocols [optional]

However, it is possible to have an estimate of the max speed and traffic lights' protocol, but having this information helps the model to be more accurate.

The following traffic information is necessary for micro-level traffic simulation and modelling, in each road segment.

- Traffic count [mandatory]
- Average speed [mandatory]

Input data source options

The model can import the network from OpenStreetMap, but this data cannot be validated with high certainty at low cost.

Any data on the traffic count can be acquired by the model. The data sources can be cameras, inductive loops, etc., which is usually available for every European city.

The count can be obtained in several ways and different spatiotemporal resolutions. It has to be clear that the traffic count belongs to which road segment and in what time window the count has taken place.

If the count is available in more road segments and more frequent in time, the result of the model will be more close to reality.

Additional data sources [optional]:

- More details, such as vehicle types, help the simulation to be more accurate
- Other data sources such as mobile data can be used in the calibration

Output information from model

The output can be delivered in both macro-level and micro-level. The model can simulate the traffic changes, according to the changes in the input data, for instance, the changes in the delivery times.

Output data from the model

The output of our model will be used as an input for modelling the noise and according to the required requirement. Outputs can be produced ad microscopic and macroscopic scales:

- The microscopic output contains each car's route and details such as the car position and speed in each time step.
- The macroscopic output contains the number of cars passed from each road segment, in the chosen time window, and the average speed in the segment.

It is also possible to compute the travel time for specific routes.

KPIs

- Travel time for each route
- Speed distribution per road segment
- Traffic density per road segment
- Travelled distance for particular cars (for example delivery cars)

Model internals

The simulation is done using SUMO, which is an open-source software tool for the microsimulation of urban traffic.

SUMO gives the possibility to provide the traffic forecast and recognize traffic variations on the route changes for the delivery vehicles, upon accurate input data.

Silent routing model

Input information to model

- Restrictions (streets, noise emissions, environment) [mandatory]
- Penalty costs [mandatory]
- Process of street/noise/environment restrictions [mandatory]

Input data source options

- Properties of trucks
  - Average velocity of trucks on different street types at different times
  - Average velocities of trucks at diff. times
  - Velocity deviations at diff. times
- Velocity on street types
- Distance between different cities/places/stores to be considered
- Driving time between different cities/places/stores to be considered

Output information from model

- Optimal route between different cities/places/stores regarding noise emissions and efficiency
- Relation between driving time/distance and external costs through noise emissions

Output data from the model

- Driving time changes through routing with restrictions in comparison to driving without restrictions
- Distance changes through routing with restrictions in comparison to driving without restrictions

KPIs

- Change in driving time
- Change in distance

Model internals

The model is originally an algorithm that controls the traffic of inland ports in order to reduce the noise emissions in the affected areas. Based on the input of restrictions and penalty costs, this algorithm generates an optimal truck routing to and from the considered cities, places or stores by securing the efficiency of truck traffic. This algorithm was developed for the routing of the ports of Cologne, Bonn, Duisburg, Dortmund and Aachen and can be transferred to other cities or places.

Macroscopic off-peak logistics model

Input information to model

- Total population per cell [mandatory]
- Population density per cell [mandatory]
- Number of employees contributing to social insurance [optional]
- Total retail sales per cell [mandatory]
- Social cultural population structure: age, household structure, household income [optional]
- Geodata (shape files of single districts) [optional]
- Type of land use [mandatory]

Input data source options

- Statistical data of the cities
- Traffic counts for delivery traffic
- Transport data of the companies

Output information from model

The model provides analysis on impacts of different kind of measures, e.g. off-peak delivery, in urban context in a mathematical manner. I.e. factors like transport volumes, vehicle mixes, environmental factors, etc. are calculated to describe these impacts.

Output data from the model

- Effects and potential of cells for off-peak delivery
- Designation of environmental impacts
- Showing the effects of changes in vehicle use, transport volume, etc.

KPIs

The model shows the changes fort he defined scenario in comparison to the base scenario, including following KPIs:

Changes in

- Tonne-kilometres
- Number of vehicles
- Number of tours
- CO2, NOx, etc.

Model internals

The Urban Freight Measure Model examines the development and impacts of urban freight transports of different kinds and from different segments in relation to measures in urban context. This can be applied to different types of cities and with different forecast horizons – depending on applicable data. Whilst analysing impacts in cities and conurbation areas, a variety of development scenarios (e.q., changes of delivery volumes and traffic streams, reduction potentials for CO2, NOx) can be generated and their impact and potential are assessed.

One of the measures to be analysed is off-peak delivery, so that the changes and the potential for the selected city can be considered.

Transport efficiency assessment model

Input information to model

- Type of target and reference vehicle including its characteristics in terms of energy efficiency / usage and emissions [mandatory]
- Historical GPS log of the target delivery vehicle under ZEUS operations [mandatory]
- Historical traffic conditions (i.e., speed) on the road segments along an alternative / reference delivery route typically during time periods outside of ZEUS operations, i.e., non-off-peak [mandatory]

Input data source options

- Vehicle type and characteristics from vehicle manufacturer
- Historical GPS log of target delivery vehicles under ZEUS operations from LSPs that is usually available from fleet management system portals.
- Historical traffic conditions along an alternative / reference delivery route:
  - Option 1: In case the exact same deliveries are performed in non-off-peak periods the GPS logs of these deliveries can be considered as alternative / reference routes. These GPS logs implicitly contain the traffic conditions along the delivery route.
  - **Option 2**: Traffic conditions can be simulated by the traffic model of TARTU on each road segment of an alternative / reference route for desired historical non-off-peak periods. Depending on the location, time point, and frequency of the exact traffic measurements the accuracy and variation in the simulated traffic conditions is varying.
  - **Option 3**: Exact or average historical traffic conditions as well as alternative / reference routes can be obtained from real-time traffic conditions and routing services like Google Maps via Google Routes API at a cost, typically a few euro-cents per route.

Output information from model

Relative statistics about delivery accuracy at loading/unloading points and resource efficiency in between delivery points during manoeuvring based on the historical GPS logs of the target off-peak deliver compared to the historical deliveries along a given alternative / reference routes during given non-off-peak periods.

Output data from the model

Relative statistics (KPIs) about transport efficiency along target off-peak delivery routes compared to given alternative / reference delivery routes during given non-off-peak periods.

KPIs

- Delivery accuracy at delivery points, i.e., loading / unloading locations: mean and deviation from scheduled delivery time
- Resource efficiency in between delivery points during manoeuvring: mean and deviation of travel times, distances, related emissions and energy consumption

Model internals

The model essentially compares spatial-, temporal- and spatio-temporal aspects of relevant parts of GPS logs of historical target delivery routes and historical alternative / reference delivery routes and based on the differences and the target and reference vehicles types and characteristics calculates relevant transport efficiency KPIs.

Business models

Input information to model

For each scenario, the [mandatory] data needed for the business model, are:

- the offering /value proposition including the type of truck, loading/unloading material, showing how value is offered to the final customer segment.
- Key activities, required to create and deliver the silent offering
- key resources, required to create and deliver the silent offering
- key partners required to create and deliver the silent offering
- Cost Indicators that point to the main cost drivers for each scenarios
- Revenue indicators, showing

Input data source options

The potential data sources are:

- Output from other models which may indicate costs, effects on activities, drivers or inhibitors for value creation or delivery
- Interviews with project personnel
- Documents, reports

Output information from model

The output of the model, will evaluate the differences between the scenarios from a business model perspective, related to how value will be created and captured, this includes efficiency, profitability, etc.

Output data from the model

Qualitative description evaluating the scenarios in terms of desirability, feasibility, and viability.

KPIs

- Profitability which is linked to viability in terms of costs and revenue indicators

- Desirability, this refers to the value proposed and how it will be delivered to which customer segment.
- Feasibility, linked to key activities, key resources and key partners in terms of each scenario

Model internals

The data will be collected on business model canvas, then The interaction of the data blocs will be evaluated in interaction to show how the building blocks of business model work together. Then a score will be set to each scenario in terms of the three main KPIs.

4. Conclusions & Outlook

Conclusions

Building on the results of the ZEUS Early Bird Project in 2019, the work in Task 2.1 continued the work for integrated the individual evaluation models and tools of partners into a comprehensive ZEUS evaluation framework. During this work, stakeholder objectives and criteria were expanded and clarified, a scenario framework containing 24 scenarios based on four scenario themes were constructed, information about options for models and their inputs and outputs were collected and analysed, and finally based on the above a comprehensive ZEUS evaluation framework was derived that allows the MAMCA of ZEUS operations with stakeholders.

Outlook

As it is stated above the work here is the foundation for the integration of the individual models for a MAMCA of ZEUS operations with stakeholders. As such, this deliverable will serve as an internal guide in the remainder of the project as it outlines the semantic dependences and functional relationship between individual models, their inputs, and outputs. It will help the ZEUS partners to finalize the model integration and calibrations in WP2, which are to be deployed in the field test in WP3 and WP4.

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Project partners:

#	Partner	Partner Full Name	EIT Urban Mobility ID
1	TRATON	TRATON SE	P0044
2	FRAUNHOFER	Fraunhofer Society for the Advancement of Applied Research	P0027
3	MUNICH	City of Munich	P0018
4	KTH	KTH Royal Institute of Technology	P0030
5	STOCKHOLM	City of Stockholm	P0020
6	COLRUYT	Colruyt Group	P0021
7	TARTU	University of Tartu	P0085
8	MOL	MOL Hungarian Oil and Gas PLC	P0031
9	AMB	Barcelona Metropolitan Area	P0053
10	BARCELONA	Barcelona City Council	P0007
11	MOBI-VUB	Mobility, Logistics & Automotive Technology Research Centre – Vrije Universiteit Brussel	

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