URBANIZED

MODULAR AND FLEXIBLE SOLUTIONS FOR URBAN-SIZED ZERO-EMISSIONS LAST-MILE DELIVERY & SERVICES VEHICLES

URBANIZED D2.1: Mission profiles, KPIs, assessment plan, List of vehicle requirements, design specifications and shared interfaces

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Executive summary

The URBANIZED project develops and demonstrates the next generation of modular vehicle architectures for urban commercial e-vehicles, satisfying design principles of optimisation and right-sizing vehicles for their mission.

Work package 2 of the URBANIZED project provides the requirements, key performance indicators (KPI) and design specifications on which the design and implementation of the demonstrator vehicle in the project will be based. Furthermore, this work package describes the steps that will be executed for assessing if the developed demonstrator vehicle meets these requirements and specifications. Finally, in this WP the a priori risk assessment on project level is executed. This risk assessment will be updated during the project and the a posteriori results will be presented in M30 with an update of this deliverable.

For the development of the requirements, KPI's and assessment steps, a template has been constructed. This template covers the most relevant requirements' attributes used in requirements engineering and is used by all partners involved in the requirements development in this work package.

The mission profile requirements, describing how the vehicle will be used by the two end users in the project, BPost and Coffee Island, are developed by TNO, together with these end users and other partners of the project. Using a road profile generator tool, customer information about their current delivery vehicles is translated into a road profile, which will be used in combination with ALKE's knowledge of existing customer needs for further design and optimization throughout this project The KPI's that will be used in the project to assess the performance on fleet level are also covered in the mission profile requirements.

Based on the mission profile requirements, the vehicle requirements have been set by Alke together with BPost and Coffee Island, as well as other partners of the project. The vehicle requirements have been aligned with the mission profile requirements such that the resulting vehicle design will meet the expectations of the end users. The vehicle requirements cover the performance and design aspects of the different parts of the vehicle. Furthermore, the vehicle requirements include the KPI's that have been defined in the project on vehicle level. For all vehicle requirements and KPI's, the assessment activities that will be carried out during the project are described also in this document.

From the vehicle level requirements, the design specifications for the vehicle components are derived by Alke together with the partners involved in the component design. These design specifications contain the detailed requirement for the vehicle modules and components, such as the front and rear part of the vehicle, the vehicle drivetrain and the modular cargo body.

Finally, a risk analysis has been executed, where project risks on technical, legal, behavioural and organisational level are analysed. This is done by using the Failure Mode and Effects Analysis (FMEA). For the medium and high-level risks, mitigation steps are defined in order to adequately deal with these risks throughout the project. The risks have been defined and

analysed by the partners who have participated at the requirements identification. In total 169 risks have been identified and mitigation strategies have been proposed for 55 of them, which are of moderate or severe importance.

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1. Introduction

The steadily growing demand related to increasing urbanisation is turning the management of logistics flows in urban areas a more complex process, with higher demand for adaptability and flexibility for the new solutions to contribute to optimise the overall transport capacity, reducing operational costs and negative impacts (health, safety). URBANIZED develops and demonstrates the next generation of modular vehicle architectures for urban commercial e-vehicles, satisfying design principles of optimisation and right-sizing vehicles for their mission, delivering outputs in 3 dimensions:

1) High-performance e-powertrain components and control architectures, through the use of advanced co-design approaches.

2) Interchangeable, plug & play cargo modules for different urban freight transport use case scenarios.

3) Integrated energy and fleet management strategies using data, connectivity and learning algorithms.

URBANIZED follows a holistic design approach working at 3 levels (systems, vehicle, fleet) during the entire project: starting with the definition of specific mission profiles within 2 main pre-selected use cases (last-mile delivery of retail, e-commerce, courier and post; HoReCa (Hotel, Restaurants and Café) and other urban on-demand services), during the optimisation loops of the design process, and until project demonstrations, to be performed both physical and in virtual environments, covering the specific requirements of operators. URBANIZED brings a complementary multidisciplinary consortium of 9 partners from 6 EU countries, involving all relevant actors from the value chain, from academic, to industrial (TIER1, OEMs) and logistics operators. Aiming at broadening dissemination and impact, URBANIZED defines an extended partnership, involving 3 satellite cities (Groningen, Madrid and Bergen) committed to CO2-emissions free logistics in their city centres by 2030 and a high-volume OEM (Ford) highly positioned in the LCV market, all interested in replicability of project results.

This document describes work package 2 of the URBANIZED project. The main goal of this work package is to specify all relevant requirements and specifications for the vehicle system, design process and safety requirements, as well as the mission profiles within the main 2 use cases and their associated to the project risks. The specified requirements are to be used as guidelines for work package 3 and 4, to go from conceptual to detailed design, prototyping and actual testing/demonstration. Moreover, in parallel with the requirements specification, this WP also aims at defining mission profiles and specific related KPIs to be monitored for evaluation and assessment of the developed technologies within the two main use cases, urban and suburban last-mile deliveries and services.

Work package 2 consists of the following three tasks:

Task 2.1 – Identification of vehicle requirements: functional, operational, safety & protocols

This task deals with the collection of functional, operational and safety requirements for the new target EV platform. Collection of data starts from state-of-the-art vehicle supplied by ALKE, to be used as baseline adding expected new features and upgrades for the project. Also, the ICT based topics e.g. cloud connectivity, remote monitoring and communication protocols are mapped, and new features identified. Vehicle requirements cover both, main vehicle chassis with its drivetrain, and the cargo area set-up, with focus on new modular developments, at macro scale (swap bodies), and micro scale (single body partitioning). The functional and ergonomics requirements are also documented for an onboard electric hand-truck module integrated to the based bodies. The results of this tasks are documented in Chapter 4.

Task 2.2 – Definition of specific mission profiles and KPI's within main 2 use cases

Within this task, mission profiles and KPIs are defined by TNO in close collaboration and consultation with partners. This task starts with investigating and specifying baseline scenarios for urban and suburban deliveries and services with support from ALK and end-users (BPost, Coffee island). The baseline scenarios are utilised for defining relevant mission profiles and KPIs for verification and assessment of the developed technologies in this project. Moreover, required data and constraints for developments in other WPs are identified and listed with support from other WP leaders (e.g. VUB, CERTH and BAX for WP3-WP7-WP8). All the aforementioned information is used to formulate a draft plan for the final verification / testing and assessment with focus on which KPI's are evaluated via actual testing and which ones are assessed by virtual simulation. The results of this tasks are documented in Chapter 3.

Task 2.3 – Definition of design specifications and risk analysis

Objective of this task is to define the main design specifications for the new EV platform, including new developed subsystems, cargo area modules and linked extensions like the e-hand-truck module. The newly developed EV shall first meet the requirements for N1 category electric road vehicles. Secondly, it integrates the innovations developed within the project. Thirdly, the vehicle shall have specifications compatible with defined use-cases and scenarios. There is a specific focus on identifying the shared design interfaces to facilitate the coordination of the design process across WP3-WP4-WP5 involving multiple parallel developments. The design specifications are described in Chapter 5.

Dedicated risk analysis, building upon the high-level project assessment in WP1, now focused on the design process, is carried out to avoid unexpected issues and/or not forecasted deviations (see subtask 2.3.1 below)

Subtask 2.3.1: Risk analysis

The aim is to identify early potential problems and/or conflicts that will occur during the implementation of the design process, and assign adequate compensation strategies for them, as well as unpredicted ones that were finally met and solved. A risk assessment of the project vehicle design and development is performed, based on the Failure Mode and Effects Analysis (FMEA) methodology. According to the methodology, the level of severity, occurrence, detectability and recoverability is estimated per risk, resulting to an overall risk

number. Risks are categorized based on their nature, e.g. technical-related ones (dealing with the system or its sub-elements functionalities, their limitations and possible complications), behavioural-related (according to the targeted users – from WP2 – potential unexpected/erroneous actions), legal (in relation to the possible legislative conflicts in various EU countries), etc.; the detailed risks categories are defined during the task. Specific mitigation actions are defined that are appropriate to deal and overpass the potential risks. Risks are identified at the early stage of the project (Month 6) and towards the project end (Month 30), as follows:

• Stage 1, estimation of a priori/foreseen risks, along with mitigation/alternative solutions.

• Stage 2, a posteriori risks analysis, in order to identify actual risks that occurred after the project developments and examine the compensation solutions that were applied.

This document describes the results of stage 1, which can be found in Chapter 6.

The results of work package 2 give input to most of the other work packages in the URBANIZED project.

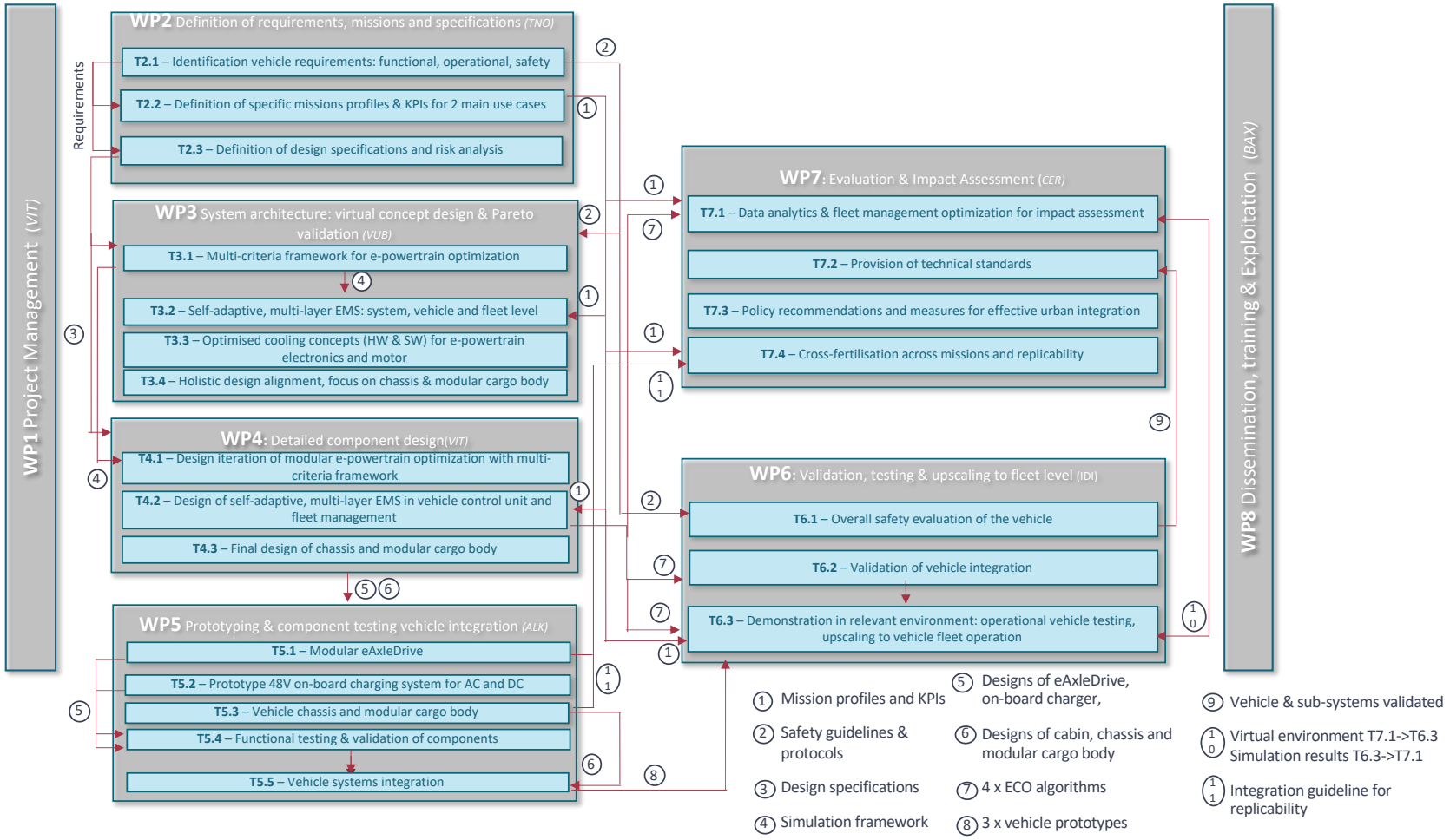

Figure 1: Overview of interconnection between the URBANIZED work packages and the position of WP2 in the project

2.Requirements Approach

2.1 Requirement levels

The requirements approach applied in work package 2 of URBANIZED project follows the V-cycle method. The requirements are part of the left side of the V-cycle as depicted in Figure 2, which describes the design phase of the system. In the requirements, the following levels can be distinguished:

- **Mission profile requirements:** These requirements describe the 'mission' of the vehicle, thus how the vehicle will be used by the end user. The mission profile requirements are elicited together with the end users, BPost and Coffee Island. The mission profile requirements are described in detail in Chapter 3.
- **Vehicle requirements:** These requirements describe the vehicle and its functionality. The vehicle requirements are derived from the mission profile requirements and direct input from the end-users on vehicle functionality that is required for their application. The vehicle requirements are depicted in Chapter 4.
- **Design specifications:** The design specifications contain the detailed vehicle components requirements and are derived from the vehicle requirements. The design specifications are depicted in Chapter 5.

From these 3 levels of requirements, the mission profile requirements are highest in order, since they describe how the vehicle will be used by the end users. Following, the mission profile requirements can be decomposed into vehicle requirements, describing what functionalities, performance and qualities the vehicle should have in order to meet the mission profile requirements. In the following step, these vehicle requirements are further decomposed into component level requirements, the design specifications, which are describing the behaviour and characteristics on the vehicle components, required for fulfilling the vehicle requirements.

After the requirements have been translated into a design strategy, the implementation of the design is realized in the lower part of the V-cycle. Next, the assessment of the design is done in the V-cycle's right-side part. This is carried out by comparing the implemented characteristics and behaviour against the required characteristics and behaviour described in the requirements phase. Such comparison is done for all three levels, starting with the component level and working upwards to the mission profile level.

The Key Performance indicators (KPI) that have been defined in the project Grant Agreement (GA) are set as requirements of a high aggregation level and are of high importance since these reflect the core of the URBANIZED project. The KPI's follow the same requirements structure as the mission and vehicle requirements and can therefore be allocated to the same

levels as defined for these requirements. The KPI's are listed in separate sections for the different levels (section 3.1.1 for KPI's related to mission profile and section 4.1.1 for the KPI's related to the vehicle).

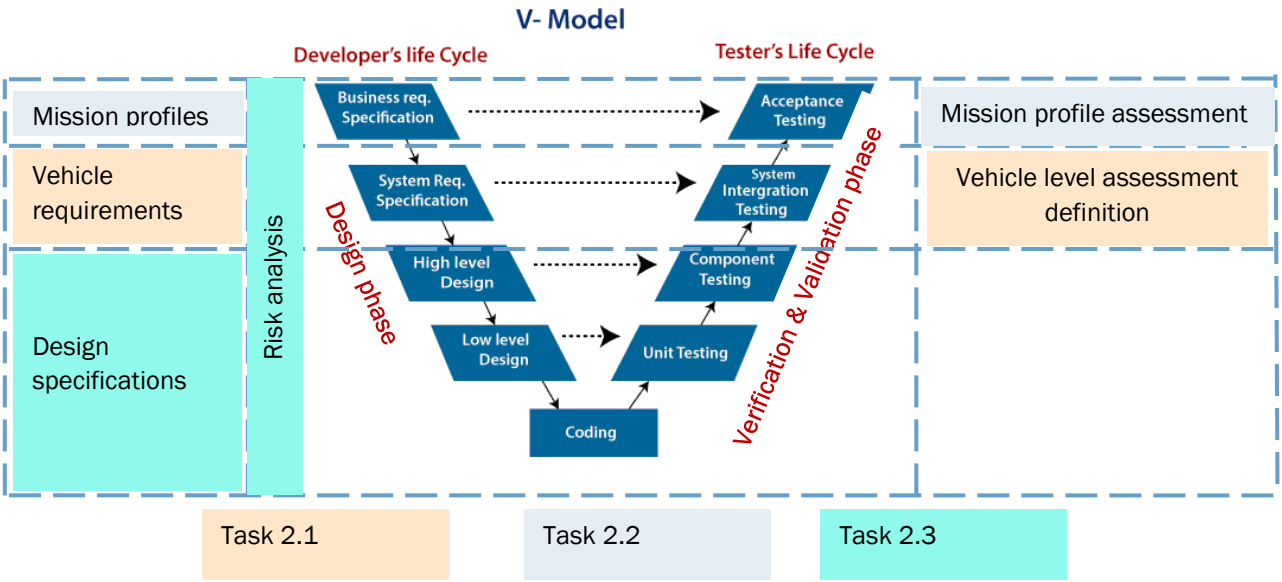

Figure 2: Use of requirements in the V-cycle

2.2 Requirements template

For the alignment of the requirements with the different stakeholders in the project, a requirements template has been defined. This template has been used for all requirements levels by the partners of the project.

The requirements template structure is based on the guidelines for writing requirements as proposed by the international Council on System Engineering (Incose, 2015). These guidelines include a list of attributes, which can be used to help define and maintain the requirements and their intent. This list is not exhaustive and its purpose it to suggest attributes that could be suitable for each project. In URBANIZED, the selection of requirements' attributes that are used in the template is done based on best practices and lessons learned from similar work in previous projects, where the work package partners were involved.

For the requirement definition, the following attributes are included in the template:

- **ID** - For easy reference, every requirement is assigned to a unique ID. This ID contains an abbreviation of the requirements level the requirements are part of, e.g. MP for mission profile, followed by a unique number. The requirements ID is also used as a link between the different requirement levels. Vehicle requirements

can be linked to the parent mission profile requirement from which it is decomposed.

- **Name** - The requirements name gives a short summary of the requirements content and it is useful for easily refer back to a requirement.
- **Description** - This attribute describes the requirement's content in detail. For this description, the SMART approach is used (Specific, Measurable, Achievable, Realistic, Time-bound).
- **Status** - This field is used for tracking the requirements progress throughout the development of the requirements. The following requirements statuses are used:
  - *Draft*: requirement is being worked on
  - *Ready for review*: review can be started by the assigned reviewer
  - *Released*: requirement content is approved and of enough quality. All requirements described in this report have reached the 'Released' status.
- **Priority** - This attribute describes how Important is the requirement to the stakeholder. The following options are possible:
  - *Must have*: The requirement is critical for the success of the project/product and needs to be achieved.
  - *Want to have*: The requirement is not critical for the success but could add value to the project/product.
  - *Descoped*: The requirement is no longer needed by the stakeholder and is therefore out of scope of the project. This status is used instead of simply deleting the requirement to indicate that the requirement has been considered in the project.
- **Rationale** - The rationale gives an explanation why the requirement is needed and other information relevant to better understand the reason for and intent of the requirement.
- **Source** - This attribute describes the source of information on which the requirements content is based. This field can also be used for indicating the stakeholder that gave input to the requirements content.
- **Category** - The following requirement categories are used in the template. These categories can be used for checking completeness of the set of requirements, as typically for most systems all categories should be represented.
  - *States/modes*: The requirement describes the states and modes that the system shall have.
  - *Functional*: The requirement describes the functional behaviour that the system shall have.

- *Performance*: The requirement describes the performance that the system shall have. In most cases, the performance is linked to a system function and the functional and performance requirement are combined.
- *External interface*: The requirement describes an external interface that the system shall have.
- *Environmental*: The requirement describes environmental conditions in which the system shall operate.
- *Resource*: The requirement describes a resource that the system shall make use of.
- *Physical*: The requirement describes a physical characteristic that the system shall have.
- *Other qualities:* The requirements describe any other quality that the system shall have. For example, sustainability.
- *Design:* The requirement describes the design solution that the system shall comply to.

For the review of the requirements, which is part of the requirements definition process, the following attributes have been defined in the template:

- **Reviewer** - This attribute is used for listing the stakeholder that is providing the review comments. This can be used both for assigning a reviewer before the review process start or by the reviewer himself during the review process.
- **Review comments** - This attribute is used for listing the comments that the reviewer has on the content of the requirement. In case that multiple reviewers are providing comments, the reviewer is asked to start the review comment with [*<fill in reviewer name>*].
- **Review status** - This attribute is to be used by the author of the requirement to indicate if he accepts, rejects or accepts with remarks the comments provided by the reviewer. In case of rejecting or accepting with remarks, the reason for rejection or the remark can be provided by the author in the Review comments field. In that case, the author is expected to start the comment with [*<fill in author name>*]

The assessment that will be executed in this project is based on the requirements. Therefore, the attributes for describing the required assessment steps are included in the requirements template. The following assessment attributes are included:

- **Validation Method** - This attribute is used for describing the validation method in high level. Examples of the validation method are simulation, vehicle testing, check list, etc.
- **Validation test** - This attribute is used for describing the validation test in more detail. The validation test description typically contains the test conditions, the required test equipment and the information resulting from the test, required for validating the requirement.
- **Validation responsible** - This attribute is used for listing the project partners that are responsible for executing the test. In case of shared responsibility, all involved partners are to be listed.
- **Validation remarks** - This attribute can be used for documenting remarks on the defined validation steps throughout the project. These remarks can be used for refining the validation definition or to get a better understanding of the validation outcome.
- **Validation status** - This attribute can be used for tracking the validation status of the requirement throughout the project. The following validation status inputs can be used in the template:
    - *Achieved*: The requirements have been achieved, based on the validation test executed on the developed system or component.
    - *Achieved with remarks*: The requirements have been achieved, based on the validation test executed on the developed system or component, but there are remarks related to the validation result. An example of such a remark could be that the system has not been validated throughout its complete operational ambient temperature range. The remark is to be documented in the attribute field 'Validation remarks', see previous item.
    - *Rejected*: The requirement has not been achieved, based on the validation test executed on the developed system or component.

The 'Validation remarks' and 'Validation status' attributes have not been used yet, as at the moment of writing this document, the validation of the requirements has not been executed.

The definition of requirements is an iterative process. It requires constant alignment between the different stakeholders and refinement of the requirements content based on the stakeholder's input. To facilitate this process, a requirements versioning approach has been applied to the requirements documents. The requirements versioning workflow is depicted in Figure 3.

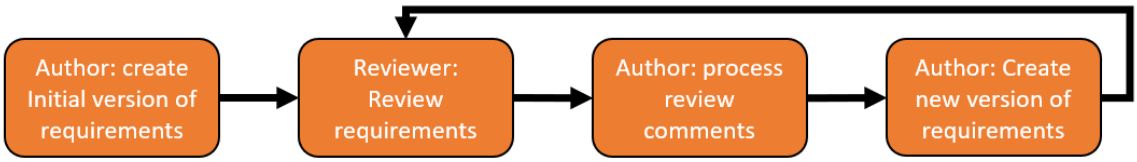

Figure 3: Workflow for requirements versioning

A new version of a set of requirements is developed by creating a new sheet in the requirements Excel document. To keep track of the different versions, a document history sheet is available in the requirements document, where for each new version the relevant information, such as date of release and main updates in the release, are documented.

3. Mission Profile Requirements (MPR)

The Mission profile requirements (MPR) correspond to a series of drive cycles, road conditions, and performance requirements, which capture an average trip that the vehicle encounters during daily operation. Such an average trip, which will be determined based on factors like route length, route time duration, energy consumption on the route, number of stops on the route, etc., is relevant for assessing requirements such as efficiencies, vehicle and fleet-level optimizations and costs. Note that other type of requirements, such as extreme-performance-related requirements (e.g., minimum operational temperature), require worst-case type of tests at vehicle level, which are outside the scope of this project.

Among others, the mission profile captures requirements such as the typical drive cycle (e.g., GPS locations, charging points, stops, environment conditions, traffic flow), performance required for the vehicle to follow daily operation (e.g., driven distance, range), and KPI related requirements (e.g., fleet level load cargo). Each one of the data field of mission profile has a corresponding assessment strategy.

Since the intended use cases focus on different types of deliveries (delivery of packages and fresh products) and different location (Belgium and Greece), the mission profile requirements differ with respect to typical drive cycle per use case.

The complete list of data fields common for both use cases can be found in (TNO, 2021). The specific drive cycles of each use case can be found in (BPost, TNO, 2021) for BPost and in (CERTH (a), 2021) for Coffee Island.

The following section describes in detail the requirements, further divided over several subsections. The section immediately after depicts the assessment plan for these requirements.

3.1 Detailed Requirements

The requirements of the MPR are subdivided in four parts: Key performance indicators, drive cycle definition, performance related requirements, and other requirements. In the tables below, only the fields "Title", "Description", and "Rationale" from the requirements template are shown, due to space limitations. The complete template with all the fields can be found in (TNO, 2021).

3.1.1. MPR: Key Performance indicators (KPI)

The KPIs covered in the MPR document are related to fleet-level requirements. These KPIs are tailored to each use case, since the nature of each use case is different. The source of such KPIs is the URBANIZED project proposal. The KPIs related to the mission profile requirements are shown in Table 1, which is retrieved from (TNO, 2021). The title of these KPIs directly refers to the objectives mentioned in the project Grant Agreement.

Table 1: Key performance indicators on mission profile level

Title	Description	Rationale
OBJ 5 fleet-level cargo load cargo	[BPost] The vehicle shall have an increase in the fleet-level cargo load factor from 70% to up to 95%.	KPI mentioned on project grant agreement. Better planning at fleet level as result of the ECO-charging and ECO-routing algorithms should increase the load factor from 70% to up to 95%.
OBJ 5 fleet-level driven kilometres	[CI] There shall be a fleet-level reduction of daily driven distances by at least 15%.	KPI mentioned on project grant agreement. Better planning at fleet level as result of the ECO-charging and ECO-routing algorithms should reduce the driven distances by at least 15%
OBJ 5 fleet-level idle time	[CI] The vehicle shall show a fleet-level reduction of idle time by at least 20%.	KPI mentioned on project grant agreement. Better planning at fleet level as result of the ECO-charging and ECO-routing algorithms should reduce the idle time by at least 20%

3.1.2.MPR: typical drive-cycle definition

Table 2 shows the input information required for a typical drive-cycle definition. This table only shows an example of the type of information required for such a drive cycle, because the actual one corresponds to datasets too large to be displayed in this format. The complete datasets with the drive cycles can be found in (BPost, TNO, 2021) and (CERTH (a), 2021).

The initial information for creating a typical drive cycle is originated on the end users, e.g., GPS locations of the stops, stop time, etc. However, some of the required information cannot always be made available by the end users: e.g., road slope, temperature profile, etc. Therefore, a Mission Profile Generation tool is created to generate the missing information. In the next subsections, such a tool is described.

Table 2: Typical drive-cycle requirements definition

Title	Description	Rationale
Daily temperature profile	The mission profile shall contain, or be enriched with, the daily temperature as function of date and time (for the specific location of the use case). *<u>Example:</u>* *Month: April* *Time (h) Temperature (C)* *06:00 8* *08:00 11* *10:00 14* *12:00 16* *14:00 17*	The ambient temperature will have an effect on multiple items: - The powertrain energy consumption. - The air conditioning energy consumption. - The cargo module cooling/heating energy consumption. Thereby, the ambient temperature changes during the day may have an influence on the operating schedule of the vehicle/fleet.

	16:00 18 *18:00 17* *20:00 14* *22:00 11*	By specifying the daily temperature profile for every month, the seasonal effects can be taken into account, e.g. study the difference between operational planning in winter vs summer. Suggestion is to specify an average daily temperature profile per month, thus assuming that every day in that month follows the same temperature profile.
GPS information vehicle destinations	The mission profile shall contain GPS information for the vehicle destination, including foreseen stops in between the starting point and the destination. *<u>Example:</u>* *Stop # Location start (lat,lon) Location end (lat,lon)* *1 40.6435552090543, 22.937548130320444 40.62658470804938, 22.948490070819542* *2 40.62658470804938, 22.948490070819542 40.630087914431336, 22.960305009740182*	Based on the GPS information of the vehicle destination, the vehicle route will be calculated and used for creating the vehicle speed profile. The GPS information will also be used for the ECO-routing and ECO-charging functions developed in WP3&4.
Stop time destinations	The mission profile shall contain the stop time for every destination along the defined route. *<u>Example:</u>* *Stop # stop time (min)* *1 10* *2 15*	The vehicle stop time at every destination will be used for segmenting the vehicle speed profile for the defined route.
Road slope profile	The mission profile shall contain, or be enriched with, the road slope profile as function of date and time, and should correspond with the vehicle speed profile.	The road slope has an influence on the required powertrain power and thereby on the vehicle energy consumption.
Cargo mass profile	The mission profile shall contain, or be enriched with, a cargo mass profile as a function of time per day. This cargo mass profile will be based on recorded data. *<u>Examples for deriving cargo mass profile:</u>* *- Determine average cargo starting weight from existing delivery routes and assume that cargo weight is zero at end of route and equally decreases at every delivery stop along the route.*	The cargo mass will impact the overall vehicle weight and thereby the energy consumption of the vehicle. The cargo mass also has an impact on the energy consumption of the cooling/heating of the cargo module (if applicable).

Daily air humidity profile	The mission profile shall contain, or be enriched with, a daily air humidity profile as function of date and time for the specific location of the use case. This can be set up similar as the daily temperature profile. *Example:* *Month: April* *Time (h) Humidity (%)* *06:00 40* *08:00 50*	Air humidity has an impact on the HVAC power consumption and is therefore relevant for the ECO-comfort function developed in the project.
Charger locations	The mission profile shall contain the GPS location of the chargers available for vehicle charging. *Example of locations:* *# Location start (lat,lon)* *1 40.6435552090543, 22.937548130320444* *2 40.62658470804938, 22.948490070819542*	Required for ECO-charging.
Starting time	The mission profile shall contain the starting time of the route. *Example*: Route starting time 08:00 am.	The starting hour of the day has an impact on traffic conditions and thereby, the speed profile.
Day of week	The mission profile shall contain the day of the week on which the delivery route is driven. *Example:* *Delivery day Wednesday and Sunday.*	The day of the week may have an impact on traffic conditions and thereby the vehicle speed profile that will be generated for the route.
Month	The mission profile shall contain the Month in which the delivery route is driven. *Example:* *Delivery months July and February.*	The month of year will determine the vehicle ambient conditions and humidity.

Mission Profile Generation tool

The Mission profile Generation (MPG) tool is a software application that allows to generate (and enrich) mission profile information based on user inputs. It has been developed to assist in the formulation and dimensioning of several mission profile requirements and it will also be used in later stages of the project for simulations and requirements assessment. This approach is selected over using a default drive cycle (i.e., WLTP, SORT etc.) due to the availability of data by the end users and the fact that this approach will serve the development of Eco algorithms, i.e., Eco-charging, that will be developed in the next WPs. Also, due to the nature of the expected routes (frequent stops for parcel/product deliveries), a standard drive

cycle could not accurately capture the expected driving behaviour. An overview of the tool is shown in Figure 4. The tool requires general mission information: e.g., a list of GPS coordinates where the vehicle stops, start time of the mission, stop time per stop, etc. The tool works in two steps: a road-profile generator and a vehicle simulator.

Road-profile generator

This step uses online databases to perform the following actions:

- To get a list of coordinates between the stop lists provided by the user (i.e., a route generator); the coordinates are obtained considering the available roads between the stops and the fastest possible route.
- To create a list of necessary vehicle data along the generated route (i.e., route analysis) that are used as inputs for the vehicle simulator. The data includes weather information, road loads and traffic information, which are required for calculating the energy consumption. Note that the traffic information is generated based on the desired departure time. Likewise, the speed limits are obtained taking into account not only the legal speed limits but also the reduction on speed due to cornering actions, roundabouts, etc.

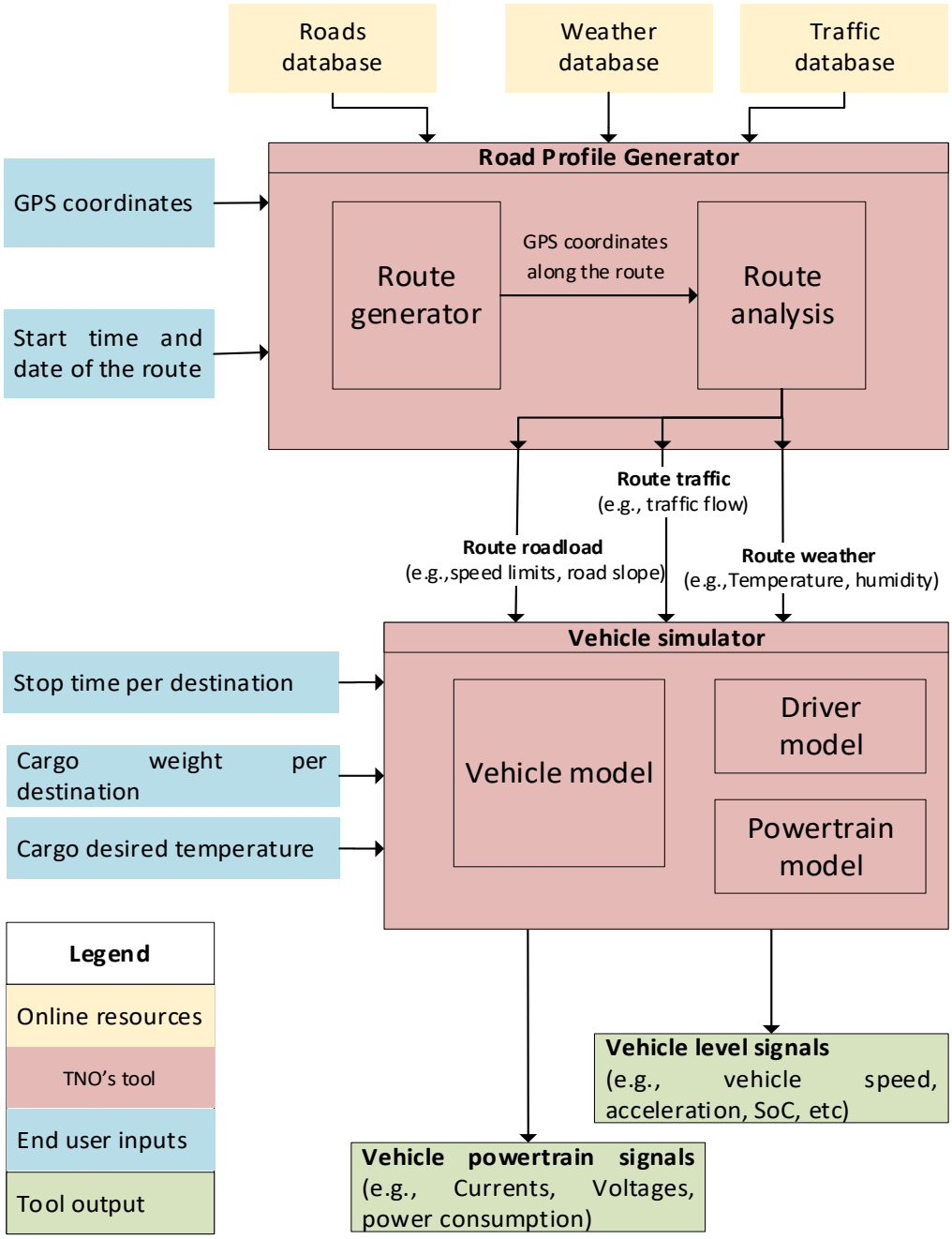

Figure 4: Mission Profile Generation (MPG) tool

Use case results: BPost and Coffee Island

Figure 5 shows an example of the first step of the route-profile generation tool: a complete route generation for the BPost use case. Given the input data (markers denoted by “Stops”), the tool generates a complete trace of coordinates connecting these input points (dash line denoted by “planned route”). The complete trace of coordinates is used to generate a road profile. Examples of the output information are shown in Figure 6 and Figure 7. In Figure 6, note that the generated maximum vehicle speed drops to zero in several points. This is to account for the stops provided by the input data.

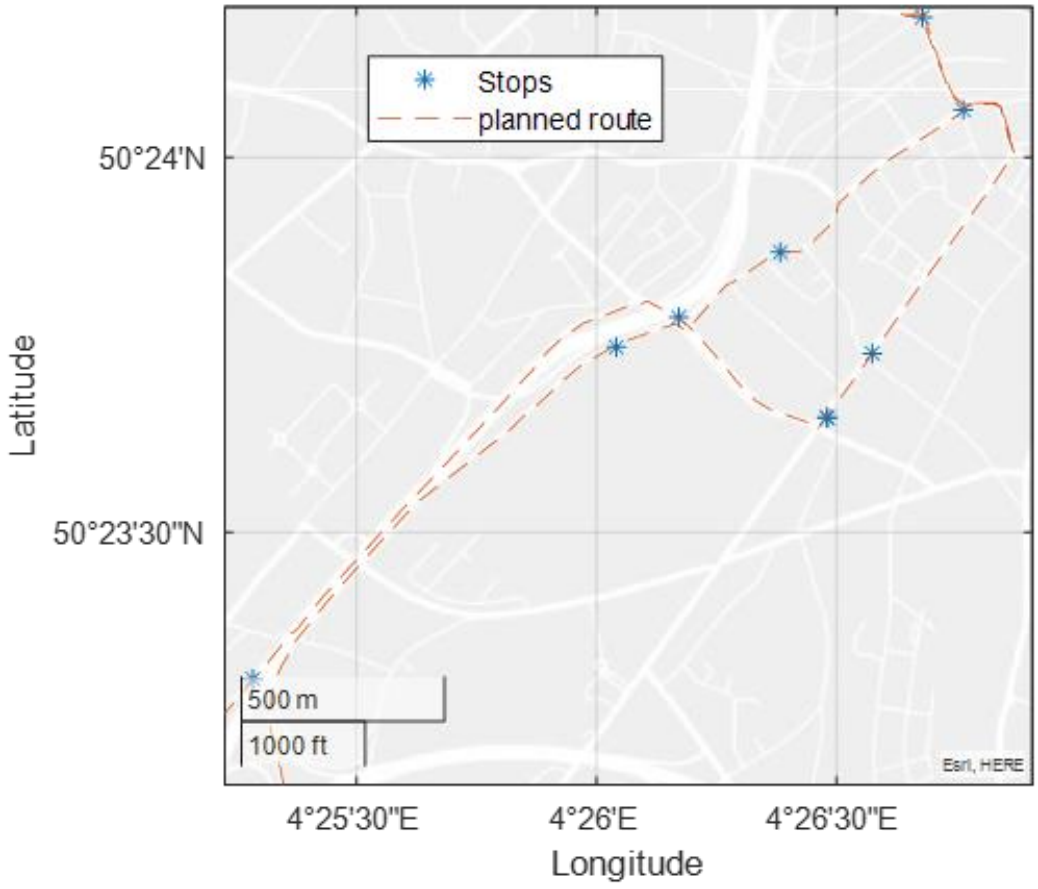

Figure 5: Route generation – Bpost

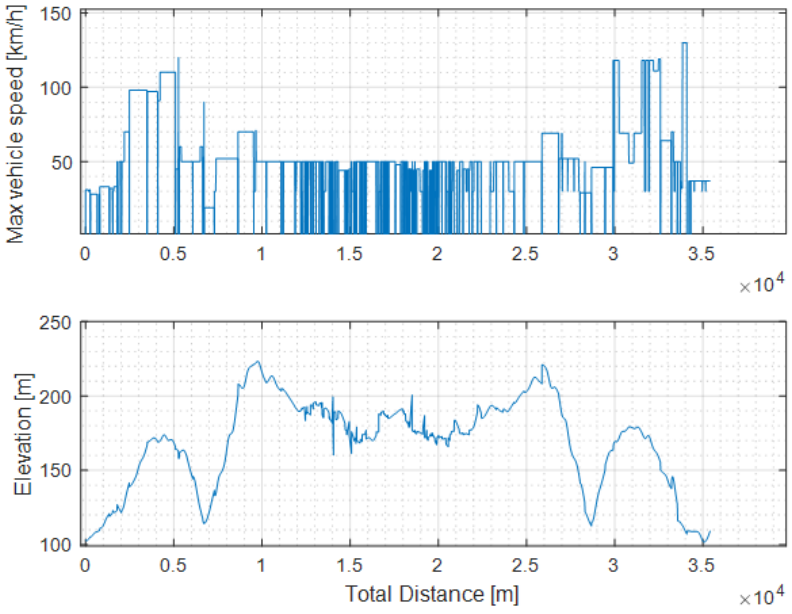

Figure 6: Road information - BPost

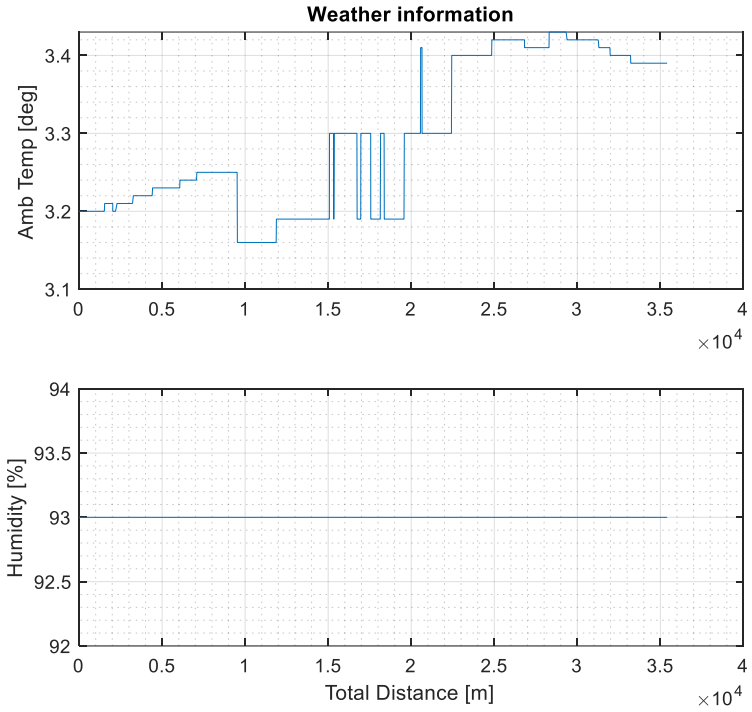

Figure 7: Weather information - BPost

Similarly, the results for the Use Case of Coffee Island are presented from Figure 8 to Figure 10. In this case, two sets of data were provided by Coffee Island for two typical routes that occur on Thursdays and Fridays.

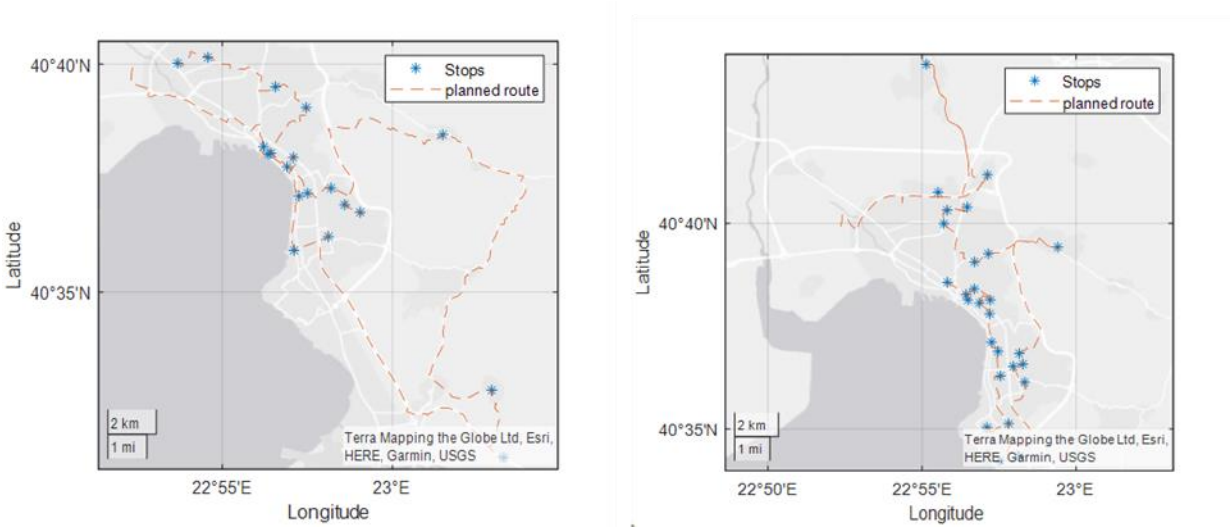

Figure 8: Route generation - Coffee Island

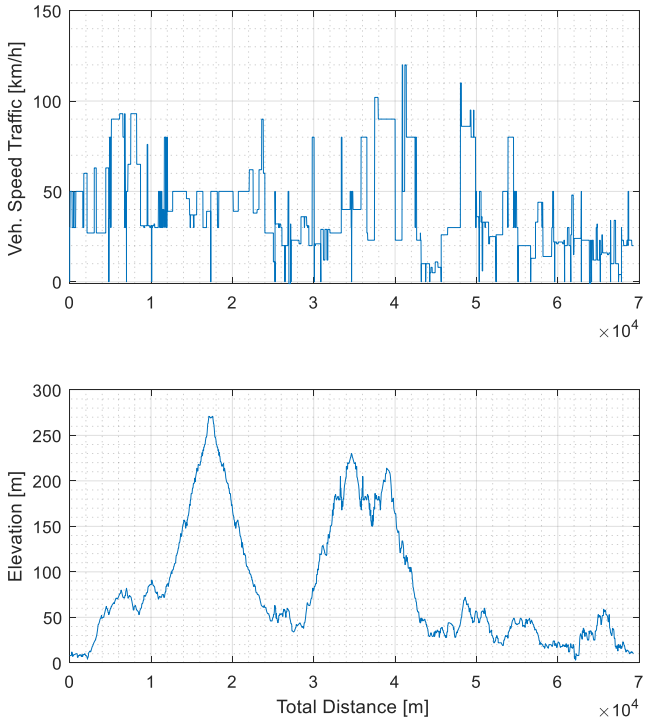

Figure 9: Road information - Coffee Island

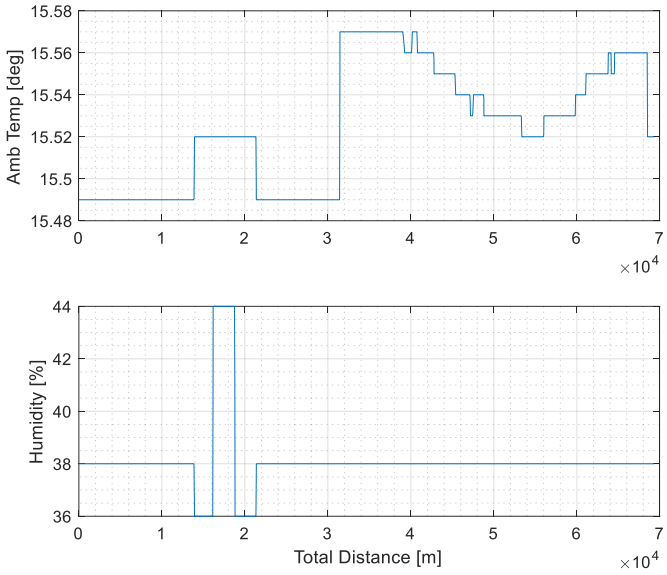

Figure 10: Weather information - Coffee Island

Vehicle simulator

This step uses a detailed vehicle model, a powertrain model and a generic driver model to provide vehicle and powertrain level signals along the desired route. The generation of these signals also takes into account the provided route weather, route road load and route traffic, which are outputs of the route analysis, as shown in Figure 4.

Figure 11 shows some preliminary speed profile generated by the complete tool. Such a speed profile is generated using the 'Max Vehicle speed' data from the Road-profile generator (see for example Figure 6), the (ideal) maximum (de-) acceleration of the vehicle, and the average stop time. The left graph on Figure 11 shows the time dependence of the vehicle speed while the right graph shows the distance dependence of the speed. Notice that the vehicle tries to follow the maximum speed, while making complete stops according to the average stop time. Future iterations of the tool will use the vehicle model in order to provide a more realistic speed profile, which will include average acceleration and deceleration depending on multiple factors such as road inclination and cargo load. .

The predicted vehicle speed, ambient temperature and humidity signals that are created with the mission profile generator and vehicle simulator model will be used as an input to the Energy Management Strategy (EMS) and ECO-function development in WP3 and WP4.

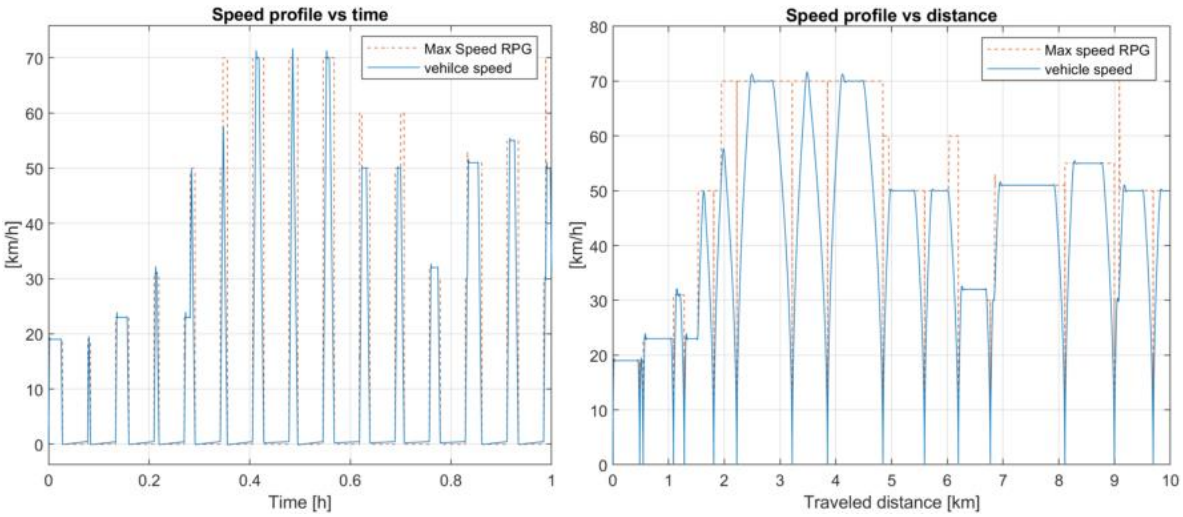

Figure 11: example of total vehicle speed generated with the mission profile generator. RPG stands for Route-Profile Generator

3.1.3.MPR: performance requirements

The performance related requirements of the MPR are meant to guarantee that the vehicle can fulfil the intended usage that the end users will give to the vehicle as well as the typical drive cycle from the previous subsection. The performance related requirements are therefore derived from use case needs (given by BPost and Coffee Island) and what is feasible in the project scope (given by technical partners). The complete description of the performance requirements is available in (TNO, 2021). A summary of the most relevant fields is shown in Table 3.

Table 3: Performance related requirements of MPR

Title	Description	Rationale
Minimum number of delivery routes per day	The vehicle shall be able to drive 1 delivery route per day.	Most of the current vehicles in the fleet only drive one delivery route per day.
Desired number of delivery routes per day	The vehicle shall be able to drive more than 1 delivery routes per day, each route defined by a typical drive cycle and including a charge cycle of at least half an hour between routes.	Some vehicles in current fleet already do more than one route per day, may become more in future.
Range	[BPOST] The vehicle shall attain a driving range of 100 km based on WLTP, which is to be driven per route. [COI] The vehicle shall attain a driving range of 70 km based on indicated driving cycle of each route.	BPost information about current vehicle fleet shows that a range of 100 km covers around 90% of all current delivery routes.

Braking power	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating.	This helps on defining peak braking power in the powertrain. The considered N1 standards are targeting Regulation (EU) 2018/858 (and following ones) of the European Parliament and of the Council of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.
Charging during night	The vehicle shall be fully charged during the night.	This helps on defining nominal power of the on-board charger. Charging during the night does not require fast charging.
Charging in between routes	The vehicle shall be charged in between routes during the day, where intervals of up to half an hour are available.	Charging in between routes will require vehicle fast charging.
Parking on slope	The vehicle shall be capable of parking at road slopes of at least 18% slopes when fully loaded without a trailer attached.	Based on the road slope requirements for driving.
Parking on slope with trailer	The vehicle shall be capable of parking at road slopes of at least 12% slopes when fully loaded with a trailer attached.	Based on the road slope requirements for driving.
Ambient temperature range	The vehicle shall be able to operate in a temperature range of -20°C to 40°C.	Normal performance is based on the vehicle performance requirements in this document. Requires battery preconditioning.
Vehicle acceleration	The vehicle shall have a powertrain able to accelerate on flat regular road, no wind, with 205/65R15 tires: - in low speed from standstill to 50km/h within 15sec at empty weight - in high speed from standstill to 70km/h within 25sec at empty weight.	Vehicle acceleration performance is relevant, the vehicle should be able to follow the other vehicles in urban traffic and not congest the traffic flow. The acceleration performance requirements will give input to the required vehicle wheel torque and thereby the requirements for the powertrain components.
Maximum vehicle speed	The vehicle shall have a powertrain able to deliver a top speed of: - 70km/h on flat road, no wind, in high speed - 50km/h on flat road, no wind, in low speed.	SOTA vehicle has top speed of 44km/h, a higher speed is required to deal with urban environments in a better way during routes to/from satellite hubs where highway circulation can be required. In some countries a minimum speed of about 60-70km/h is needed to be able to drive on specific connection roads and make such vehicles more flexible and useful.
Maximum road slope	The vehicle fully loaded shall deal with at least 18% slopes without trailer.	The vehicle will operate in urban environments mainly. Depending on the region of operation, steep road slopes may occur also in urban environments. The value is based on the N1 type approval standard.

Maximum road slope with trailer	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	The vehicle will operate in urban environments mainly. Depending on the region of operation, steep road slopes may occur also in urban environments. The value is based on the N1 type approval standard.

3.1.4.MPR: other requirements

The final type of MPR, which cannot be classified in any of the previous subsections are shown in Table 4. These requirements help to further specify the type of use that the vehicle will endure during its potential use in the use cases. The full description of the requirements can be found in (TNO, 2021).

Table 4: Mission profile other requirements

Title	Description	Rationale
Type of roads	The vehicle shall be able to drive on all roads classified as secondary or lower, on-road types of road.	This is based on typical roads accessed by the use-case.
Usability	The vehicle shall be able to be used 7 days a week, for 52 weeks a year.	Based on the average use of combustion vehicles a year. This describes the intended frequency of use of the vehicle by the end user. Maintenance of the vehicle is not covered in this.
Public charging and depot	The vehicle shall be able to charge at the BPost/COI depots.	Based on available/intended charging facilities. BPost and COI are not intending to make use of public charging locations.
Target market	[CI] The vehicle shall be able to deliver fresh and non-fresh products from distribution centres to local shops. [BP] The vehicle shall be able to deliver packages to customers.	Cis use case corresponds only to the daily fulfilment of CI shops (more than 300 shops). Types of products differ from fresh food products to non-fresh products.
Monitoring	The vehicle shall communicate data that is required for fleet-level energy management to the fleet depot.	Used for remotely monitoring the vehicle for energy management purposes. [BPOST] BPost makes use of Telematics in its last mile fleet. Multiple vendors are used but one example is Masternaut https://www.masternaut.com/

3.2 Assessment plan

For each one of the requirements described in Section 3.1, an assessment routine has been added. Common assessment procedures range from experimental (e.g., driving the whole vehicle under certain conditions), simulations (e.g., running the vehicle model in a realistic environment), datasheet (e.g., the component datasheet fulfils a particular requirement), or a combination of several.

The following subsections follow the structure of the detailed requirements (Section 3.1). The assessment is fully described in (TNO, 2021). Such a document contains several fields which do not fit in the available space of this document (e.g., validation responsible, validation status, etc). Therefore, only the "validation" column which describes the main assessment experiment is included in the upcoming subsections.

3.2.1.MPR: key performance indicators assessment

Table 5: key performance indicators assessment of MPR

Title	Description	Assessment
OBJ 5 fleet-level cargo load cargo	[BPost] The vehicle shall have an increase in the fleet-level cargo load factor of up to 95%.	A vehicle shall be demonstrated in delivery operations in an urban road in Belgium. Multiple routes are to be tested where the load cargo factor shall be evaluated using eco-routing tools. The baseline cargo factor is to be taken as 70% (current value indicated by BPost).
OBJ 5 fleet-level driven kilometres	[CI] The vehicle shall show a fleet-level reduction of daily driven distances by at least 15% while achieving the same logistic effort.	The vehicle fleet shall be simulated in the city environment of Thessaloniki. The baseline to be considered is a simulation which does not include the fleet-level optimization strategies developed in URBANIZED. The driven distance improvement shall be visible when the fleet-level optimization techniques are applied.
OBJ 5 fleet-level idle time	[CI] The fleet shall show a reduction of idle time by at least 20% through the application of fleet-level optimizations.	The vehicle fleet shall be simulated in the city environment of Thessaloniki. The baseline to be considered is a simulation which does not include the fleet-level optimization strategies developed in URBANIZED. The driven distance improvement shall be visible when the fleet-level optimization techniques are applied.

3.2.2.MPR: typical drive-cycle assessment

The assessment routine for the requirements described in Section 3.1.2 is shown in Table 6. Notice that a single assessment experiment is described for all the requirements of such a section. This is because the single assessment experiment is to be carried out using all the conditions described in these requirements.

Table 6: Assessment of all the rows in the typical drive-cycle description of Table 2.

Title	Description	Assessment
All drive-cycle fields (e.g., GPS coordinates, temperature profile, cargo mass, etc)	The mission profile shall contain GPS information described in the Title column *Example:* *Loc. start (lat,lon) Loc. end (lat,lon)* *40.643, 22.937 40.626, 22.948* *40.626, 22.948 40.630, 22.960*	Simulation: The vehicle shall be simulated with the mission profiles of BPost and COI, under the conditions specified in MP005-MP013. Experimental: The vehicle shall be driven during the application of one of the mission profiles of BPost, with the coordinates of MP005 and conditions as similar as possible to MP004,MP006-MP013.

3.2.3.MPR: performance requirements assessment

Table 7: Assessment of performance requirements of the MPR

Title	Description	Assessment
Minimum number of delivery routes per day	The vehicle shall be able to drive 1 delivery route per day.	Simulation: The vehicle shall be simulated with a WLTP cycle and with the mission profiles of BPost and COI, under the conditions specified in MP005-MP013.
Desired number of delivery routes per day	The vehicle shall be able to drive more than 1 delivery routes per day.	Simulation: The vehicle shall be simulated with a WLTP cycle and with the mission profiles of BPost and COI, under the conditions specified in MP005-MP013. The possibility of charging the vehicle between delivery routes will be evaluated, so that multiple delivery routes are achieved a day.

Range	[BPOST] The vehicle shall attain a driving range of 100 km based on WLTP [COI] The vehicle shall attain a driving range of 70 km based on indicated driving cycle.	Simulation: The vehicle shall be simulated with a WLTP cycle and with the mission profiles of BPost and COI, under the conditions specified in MP005-MP013. The possibility of charging the vehicle between delivery routes will be evaluated, so that multiple delivery routes are achieved a day.
Braking power	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating.	Experimental: The vehicle brakes shall be tested according to the description provided in the type approval standard, which is composed of real tests and/or simulations.
Charging during night	The vehicle shall be fully charged during the night.	Experimental: The vehicle shall be fully charged from any initial SoC to 100% SoC, within 8 hours. The power level shall be chosen according to the depth of discharge of the vehicle at the moment of start charging.
Charging in between routes	The vehicle shall be able to include fast charging capabilities of 11kW.	Experimental: Presence of the described feature.
Parking on slope	The vehicle shall be capable of parking at road slopes of at least 18% slopes when fully loaded without a trailer attached.	The vehicle brake shall be tested in a test bench or/and factory level with simulated slope scenario (use of dynamometer).

Parking on slope with trailer	The vehicle shall be capable of parking at road slopes of at least 12% slopes when fully loaded with a trailer attached.	The vehicle brake shall be tested in a test bench or/and factory level with simulated slope scenario (use of dynamometer).
Ambient temperature range	The vehicle shall be able to operate in a temperature range of -20°C to 40°C.	Each one of the vehicle components shall be able to operate in the requested temperature range. The temperature range of each component is to be taken from the corresponding datasheet.
Vehicle acceleration	The vehicle shall have a powertrain able to accelerate on flat regular road, no wind, with 205/65R15 tires: - in low speed from standstill to 50km/h within 15sec at empty weight - in high speed from standstill to 70km/h within 25sec at empty weight.	Simulation: The vehicle acceleration shall be tested on an early stage of development by simulating the power output of the electric machine. The vehicle shall be accelerated from standstill to the speeds described in the test, under the mentioned test conditions (i.e., flat regular road, no wind, 205/65R15 tires).
Maximum vehicle speed	The vehicle shall have a powertrain able to deliver a top speed of: - 70km/h on flat road, no wind, in high speed - 50km/h on flat road, no wind, in low speed.	Simulation: The vehicle acceleration shall be tested on an early stage of development by simulating the power output of the electric machine. The vehicle shall be accelerated from standstill to the speeds described in the test, under the mentioned test conditions (i.e., flat regular road, no wind, 205/65R15 tires).

Maximum road slope	The vehicle fully loaded shall deal with at least 18% slopes without trailer.	Test performed at bench or factory level with scenario simulating the road load (use of dynamometer).
Maximum road slope with trailer	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	Test performed at bench or factory level with scenario simulating the road load (use of dynamometer).

3.2.4.MPR: other requirements assessment

Table 8: Assessment of other requirements of the MPR.

Operability	Description	Assessment
Type of roads	The vehicle shall be able to drive on all roads classified as secondary or lower, on road types of road.	The vehicle shall comply with the related requirements of the N1 type approval (e.g., minimum speed limit).
Usability	The vehicle shall be able to be used 7 days a week, for 52 weeks a year.	The vehicle shall be composed of components which are selected for heavy duty and continuous usage.
Public charging and depot	The vehicle shall be able to charge at the BPost/COI depots.	The vehicle shall be charged in Alke's facilities, where the charging conditions (e.g., available power, connection outlet, AC/DC connection, etc) are to be the same as in the depots of BPost and COI. Moreover, the vehicle shall be also charged in the facilities of BPost, previous to the application of the mission profile cycle described in MP004-MP013.
Monitoring	The vehicle shall communicate data that is required for fleet-level energy management.	The feature is present in the vehicle.

Target market	[CI] The vehicle shall be able to deliver fresh and non-fresh products from distribution centres to local shops. [BP] The vehicle shall be able to deliver packages to customers.	The vehicle shall be simulated with the mission profiles of COI, specified in MP005-MP013. The vehicle shall be driven according to the mission profiles of BPost, under the conditions specified in MP005-MP013. For the delivery of fresh products, the vehicle's cooled body shall meet the temperature-related requirements related to the transportation of these products. The provider of the cooled body shall guarantee these requirements.

4. Vehicle requirements (VR)

The vehicle requirements collection is oriented on identifying vehicle specifications to satisfy the MPRs defined in the previous chapter and KPIs defined at DOA level. Such elements are relevant to be used as basis for the design requirements phase and to set up the activity of next work packages. The whole list of requirements can be found in (ALKE (a), 2021).

In the following subsections, the vehicle requirements are described in detail. The following subsections are therefore sub-divided in two parts: requirements and assessment plan.

4.1 Requirements

The VR are subdivided in ten parts: key performance indicators, main specs & performance, front part of the vehicle, cabin and comfort, rear part of the vehicle, drive train and battery, modular cargo body, ICT platform and energy management system, economic analysis and efficiency, passive safety.

4.1.1. Key performance indicators

The KPI's covered in the VR are related to vehicle-level requirements. The source of such KPI's is the URBANIZED project proposal. The KPI's related to vehicle requirements are shown in Table 9, which is taken from (ALKE (a), 2021).

Table 9: Key performance indicators on vehicle requirements level

Title	Description	Rationale
OBJ 1 Powertrain inverter efficiency	The vehicle powertrain inverter shall achieve up to 98 % efficiency.	KPI mentioned on project grant agreement (KPI1).
OBJ 1 integrated on-board charger efficiency	The vehicle integrated on-board charger plus port for external power tooling shall achieve 95% efficiency.	KPI mentioned on project grant agreement (KPI2).
OBJ 1 integrated e-powertrain efficiency	The vehicle integrated e-powertrain solution (eAxleDrive) shall increase the energy efficiency of at least 10 % (WLTP cycle at test bench), achieving a total efficiency of 91 % compared to current 82% baseline.	KPI mentioned on project grant agreement (KPI3). The efficiency target includes the combined efficiency of inverter and electric machine. The transmission efficiency is not included.
OBJ 2 Multi-level EMS energy efficiency increase	The vehicle shall integrate a multi-level EMS with fleet connectivity that reduce the energy consumption at least 12.8% using 4 ECO functionalities: eco-comfort, eco-driving, eco-routing, and eco-charging. The efficiency increase is to be shown with the missions	KPI mentioned on project grant agreement (KPI4). A self-adaptable, multi-level predictive EMS architecture will be designed to optimize energy consumption and fleet

	profiles specified in MP005-MO013, when enabling the eco-functions.	operations thanks to the use of synergies at different system levels, leveraging vehicle connectivity through integrated sensors, GPS and real-time data from the traffic environment and vehicle scheduling.
OBJ 2 Vehicle lifecycle cost reduction	The vehicle multi-level EMS shall deliver a vehicle lifecycle cost reduction of at least 20% for the specifically defined mission profiles to be tested. The baseline costs are estimated while using the same vehicle without the multi-level EMS.	KPI mentioned on project grant agreement (KPI5).
OBJ 3 Vehicle fleet acquisition cost reduction	The vehicle shall demonstrate a lower fleet acquisition cost by up to 40% obtained thanks to the multi-purpose swappable cargo body design having the possibility of using different cargo bodies with a single vehicle to cover fluctuating demands.	KPI mentioned on project grant agreement (KPI9). Example of cost reduction: from €60.000 for two vehicles to €36.000 for one vehicle and 2 cargo bodies.
OBJ 3 Powertrain inverter cost reduction	The vehicle shall provide a cost reduction of 20% for the powertrain inverter (from €350 today to €280).	KPI mentioned on project grant agreement (KPI6).
OBJ 3 On-board charger cost reduction	The vehicle shall provide a cost reduction of 25% for the on-board charger (from €400 today to €300).	KPI mentioned on project grant agreement (KPI7).
OBJ 3 E-powertrain production costs reduction	The vehicle shall provide a total production cost reduction for the novel e-powertrain (excluding the battery) of up to 25% (from €2.900 today to €2.175).	KPI mentioned on project grant agreement (KPI8).
OBJ 5 Superior performance	The vehicle shall demonstrate superior performance compared to benchmark vehicles, under defined testing scenarios and targets: (e.g. driving experience, stability, manoeuvrability, usability, ergonomics, reduced use of urban space).	KPI mentioned on project grant agreement (KPI11).
OBJ 5 Delivery efficiency	The vehicle shall demonstrate increased overall delivery efficiency (deliveries/day) for the targeted missions by at least 30%.	KPI mentioned on project grant agreement (KPI12).
OBJ 4 EuroNCAP 4	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	KPI mentioned on project grant agreement (KPI10). The target is to achieve a final rating between 60% and 74,9% in the overall weighted score, where

		75% accounts for Adult Occupant Protection (AOP) in Frontal Impact and 25% accounts for Adult Occupant Protection in Side Impact.

4.1.2. Vehicle requirements related to main specs and performance

The vehicle requirements related to main specs and performance are shown in following table, which is taken from (ALKE (a), 2021):

Table 10: Vehicle requirements related to main specs and performance

Title	Description	Rationale
N1 type approval	The vehicle shall comply with European N1 category small series type approval requirements.	N1 type approval compliance is a compulsory requirement to be able to drive on public road around Europe. Vehicle components chosen for the new vehicle platform will need to be certified (except parts developed within the project) with applicable regulations proper of N1 type approval.
Two speed powertrain	The vehicle shall have a powertrain able to deal with 2 speeds: - "low speed" (top speed of 50km/h) delivering a higher torque for demanding urban routes with 18% (12% with trailer) gradients or difficult road surfaces (e.g., with presence of snow or Ice during winter, or with unregular finishing (not good maintenance, holes, rocks, etc) or even totally not asphalted roads). - "high speed" (top speed 70 km/h) for activities on more traditional urban routes.	
Speed	The vehicle shall have a powertrain able to deliver a top speed of: - 70km/h on flat road, no wind, in high speed. - 50km/h on flat road, no wind, in low speed.	SOTA vehicle has a top speed of 44km/h, a higher speed is required to deal with urban environments in a better way during routes to/from satellite hubs where highway circulation can be required. In some countries a minimum speed of

		about 60-70km/h is needed to be able to drive on specific connection roads and make such vehicles more flexible and useful.
Acceleration	The vehicle shall have a powertrain able to accelerate on flat regular road, no wind, with 205/65R15 tires: - in low speed from standstill to 50km/h within 15sec at empty weight - in high speed from standstill to 70km/h within 25sec at empty weight.	
Wheel diameter	The vehicle shall have 15"-16" wheel rim diameter.	Present wheel rim diameter (12"-14") needs to be increased to 15"-16" to be able to apply stronger brakes needed to deal with higher speed and heavy-duty operations. Also, the procurement of tyres is much simpler when going to wheel diameters compatible with the ordinary commercial vehicles.
2WD / 4WD	The vehicle shall have a 4WD set-up or at least apply a design compatible with a 4WD configuration upgrade.	2WD is in principle good for most urban environments but the possibility to deliver a 4WD design can maximise the exploitation of the new platform targeting uncovered markets that most automotive brands are not approaching due to smaller sales volumes expected (hilly, rural, mountain scenarios, vehicles for park maintenance, Northern countries urban environments, etc).
GVW	The vehicle shall have a GVW (gross vehicle weight) of at least 2.15 tons and compatible with expected payload requirements.	GVW (gross vehicle weight) means the maximum weight for fully loaded vehicle (empty vehicle + driver + passengers + loaded goods). Value chosen is the minimum target to deal with logistics activity in urban environment. Expected empty weight with 2500 mm van box

		set-up and 20 kWh battery is about 1.35-1.4 tons.
GCW	The vehicle shall support a GCW (gross combined weight) of at least 4.1 tons when in high torque mode and shall support 3.3 tons in high speed mode.	GCW (gross combined weight) means the maximum weight for fully loaded vehicle + trailer combination (empty vehicle + driver + passengers + loaded goods + trailer weight + goods loaded on the trailer towed by the vehicle). Combination with trailers or semitrailers can be strategic when dealing with high volume items during logistics operations and GCW value is relevant in that sense.
Payload (weight)	The vehicle shall carry an overall payload of at least 800 Kg.	Payload required for carrying post or Coffee Island materials.
Payload (volume)	The vehicle shall have a payload volume of at least 3 m^3.	Volume required for carrying post or Coffee Island materials.
Vehicle overall dimensions	The vehicle without mirrors and including the cargo body shall have a target dimensions of 440 x 150 x 220 cm.	Width max size is given by the max width of the rear body, not by the one of the cab.
Vehicle cab height	The vehicle cab shall have a height lower than 2m to access covered parking spaces.	The height of the cab must be less than 2 m to allow access to covered parking spaces and service tunnels when coupled with specific low-profile van body with same height of the cab. This is not excluding the possibility to fit also larger/higher bodies in case this requirement is not compulsory. The choice of this value is dictated by ALKE's direct experience in the market.
Vehicle cab width	The vehicle cab shall have a width without mirrors not exceeding 130 cm.	Cab width is relevant for vehicles oriented to old town city centres where narrow streets/passages are present. In such situation the overall vehicle width is given by the larger part. Rear body can easily be reduced in width but if the cab remains large the effort

		doesn't make sense. As opposite a narrow cab can anyway host a larger body if necessary. SOTA cab is 120 cm width.
Turning circle	The vehicle shall have a turning radius of: - 500 cm kerb to kerb. - 540 cm wall to wall.	
Power steering	The vehicle shall have EPS.	Electric power steering is important to provide a good driving comfort when moving on congested traffic and narrow streets with lot of turns.
Max slopes without trailer	The vehicle fully loaded shall deal with at least 18% slopes without trailer.	Given slope values are defined by type approval minimum requirements independently by mission profiles for the vehicle. Drivetrain performance and braking system must both comply with such scenario. It will have an impact on the maximum wheel torque requirement.
Max slopes with trailer	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	Given slope values are defined by type approval minimum requirements independently by mission profiles for the vehicle. Drivetrain performance and braking system must both comply with such scenario. It will have an impact on the maximum wheel torque requirement
Drive range	The vehicle shall be able to cover at least 130km with a full charge (WLTP reference).	A max autonomy of 200km (best value in standard conditions, WLTP reference) would add exploitation potential. To consider multi-battery options.
Efficiency	The vehicle shall have an efficiency of 135 Wh/km when applying the drive cycles of the mission profile requirements described in MP005-MP013.	Average value measured at plug level from electric grid including efficiency of on-board charger.

Charging time	The vehicle equipped with 20kWh battery shall be charged to 80% from fully discharged: - in 5 hours in case of regular charge (3kW) - in 2,5 hours in case of fast charging (11kW).	Volume required for carrying post or coffee island materials.
Charger interface	The vehicle shall be compatible with CEE and TYPE 2 connectors for charging.	Available/intended charging interface at the vehicle depo.
Charging specs	The vehicle shall be charged with AC 230V 50-60Hz.	Available/intended charging interface at the vehicle depo.
Braking	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating.	Being increased the max speed to investigate the need to upgrade to ABS or equivalent brake system (required by EU standards).
Automatic parking brake	The vehicle shall have mechanical/electric parking brake system able to deliver automatic parking brake feature when driver is out the cab.	SOTA vehicle has mechanical hand brake, adding also electronic control can provide the possibility to manage an automatic braking functionality when vehicle stops in specific conditions. This can help providing higher safety standards during last mile deliveries, waste collection operations, etc. In such scenario the driver / operator goes in/out the vehicle hundred times per day and an automatic parking brake system activated once driver leaves his seat is key aspect to avoid unintended (dangerous) movements of the vehicle.
Parking brake torque	The vehicle shall have parking brake system able to deliver at least 2500 Nm brake torque on rear axle.	Braking torque needed to comply with overall performance stated on parallel requirements and to comply with N1 category type approval.
Regenerative braking	The vehicle shall be equipped with regenerative braking.	Regenerative braking is used to improve overall efficiency in the vehicle.
Gravity centre	The vehicle shall have gravity centre 50mm lower than SOTA.	The lowest gravity centre is important to deal with logistics but also any other application to

		provide best driving comfort especially when turning to keep stability and to be safe.
Weight distribution	The vehicle shall have a target weight distribution fully loaded of 35% on front axle and 65% on rear axle.	Front axle weight shall be increased from 800kg (SOTA value) to 1.000kg to shift weight from rear to the front of the vehicle. This improved balance is important especially at empty vehicle to have good drivebility in such situation.
Operative temperature range	The vehicle shall be able to operate in a temperature range of -20°C to 40°C.	Start-up in extreme temperatures is supposed to be done with pre-conditioning.

4.1.3. Vehicle requirements related to the front part of the vehicle

The vehicle requirements related to the front part of the vehicle are shown in following table, which is taken from (ALKE (a), 2021):

Table 11: Vehicle requirements related to the front part of the vehicle

Title	Description	Rationale
Front suspension	The vehicle shall provide front suspension redesign to fit the new EURONCAP compliant frame and if possible to allow 4WD front differential housing.	Front suspension geometry check is expected and linked redesign study. Driving comfort feeling delivered by the new system must be equal or better than SOTA.

4.1.4. Vehicle requirements related to cabin and comfort

The vehicle requirements related to cabin and comfort are shown in following table, which is taken from (ALKE (a), 2021):

Table 12: Vehicle requirements related to cabin and comfort

Title	Description	Rationale
Driver visibility	The vehicle shall have a driver visibility equal or better than SOTA, measured as view angle/coverage.	Cab & glazing design must be studied to have best driver visibility. Driver visibility is essential when moving on

		narrow streets and spaces to avoid impacts with objects or accidents with people. At same time good view is important also to perform in best way activities where approaching as much as possible a target position can improve the efficiency of operations carried out (last mile deliveries > lockers, waste management > waste bins, etc.).
Overall cabin comfort	The vehicle shall have a cab structure where driver & passenger comfort (ergonomics / room available for movements) should be maximized keeping as much as possible a compact size. Comparison is the SOTA vehicle ergonomics to be improved.	The new vehicle platform is intended to address the professional sector where comfort is not expected to be so important as into passenger cars, but market has showed a strong change in this sense in last years. An overall study about ergonomics needs to be performed into the new platform. Volumes and layout can be changed / modified keeping in mind that anyway a compact size must be delivered by the new design. A max increase on sizes for about 10 cm in width and length can be accepted and justified.
LHD and RHD	The vehicle shall have the possibility to have both left-hand drive (LHD) and right-hand drive (RHD) configuration.	RHD is useful to target international markets they require it to be road legal. RHD is requested also by several LHD countries for specific activities where the operator / driver is performing an activity with frequent stop&go and need direct access to the side paths (waste collection, postal services, logistics last mile delivery, etc).
Steering column and Seats comfort	The vehicle shall have steering column and seats layout designed to provide best ergonomics. Driver seat shall be adjustable.	A combined study for positioning steering, seats and other near parts must be carried

		out to identify best set-up for maximum flexibility in terms of drivers. The solution chosen must be compatible with drivers of different size and gender. Small, thin people and tall, "heavy" people at the same time. Adjustable steering and seats are expected.
Air-conditioning system	The vehicle shall have a cab airco system able to deliver at least same cooling capacity of SOTA.	This defines the power of the air-conditioning.
Heating system	The vehicle shall have a cab heating system able to deliver at least same heating capacity of SOTA.	This defines the power of the heating.
Heated windshield	Timed heated windshield.	Device oriented to windscreen defogging to maximise visibility. Installed to reduce the activation of cab heating system it takes more time/energy and it is less performing/efficient for the purpose.
Battery pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the battery.	Pre-heating the vehicle battery during wintertime while still connected to the charger allows to improve energy management and under specific scenario also to make possible the charging itself when under zero °C.
Cab pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the cab.	Pre-heating the vehicle cab while still connected to the charger allows to improve energy management and occupants comfort. A/C preconditioning will be studied as a complementary option, but priority will be given to pre-heating.
2-4 seats	The vehicle shall have 2-4 seats design as the SOTA model.	Possibility to have 4 seats version is needed to deal with specific markets where larger teams of workers are using such kind of vehicles.

Cab in/out accessibility	The vehicle shall deliver same or better accessibility of the driver's seat compared to SOTA and measured as 2D area of the exit with door fully open and removing obstacles in between. The driver must be able to exit through the passenger side.	The driver must be able to work on his daily schedule while minimising the time he has to get in and out of the cab and, of course, the effort required to do this. Important elements in optimising this are the design of the doors, the ground clearance of the cab floor, the position of the steering wheel and seats, etc.
Cab accessories / compartments	The vehicle shall provide user-oriented interiors designed for the cabin to host proper accessories and compartments for intensive daily usage.	Study is needed for the layout of the cabin to allow intensive use of the cabin while putting the driver and any passengers at ease. Market experience tells that professional operators expect to have glove boxes, cup holders, Bluetooth radio, USB charging sockets, smartphone/tablet holders, etc. available.
Central lock	The vehicle shall be equipped with a remoted controlled central locking system.	
Navigation tools	The vehicle shall be equipped with a navigation tool able to share traffic/delivery information.	
Park assist devices	The vehicle shall be equipped with park assist devices such as reverse camera and/or front/rear sensors.	
Audio system / Radio	The vehicle shall be equipped with audio system with DAB radio and Bluetooth integrated.	
Connection/charging ports	The vehicle shall have 12V port and USB or wireless smartphone charging port.	

4.1.5.Vehicle requirements related to rear part of the vehicle

The vehicle requirements related to the rear part of the vehicle are shown in following table, which is taken from (ALKE (a), 2021):

Table 13: Vehicle requirements related to the rear part of the vehicle

Title	Description	Rationale

Rear frame design	The vehicle shall have an upgraded rear frame design with a lower fitting area layout.	The upgraded rear layout will need to see the battery moved under the seats or to another less invasive position to lower the height of available room for the rear cargo area set-up. New frame design needs also bolted sectional rather than welded continuous frame design for modularity purposes. Present design uses single chassis design and the presence of vehicles with multiple wheelbases means to keep in stock different full chassis. The new design looks at having modular frames they can be combined by bolts to have different vehicle lengths and keeping smaller the stock of parts in terms of their volume.
Rear suspensions	The vehicle shall have rear suspension redesign to allow new drivetrain housing.	A rear suspension redesign is needed to allow extra room for the new VITESCO drivetrain housing, for such a reason a switch from De Dion bridge to independent suspensions is expected.

4.1.6. Vehicle requirements related to drivetrain and battery

The vehicle requirements related to the drivetrain and battery are shown in following table, which is taken from (ALKE (a), 2021):

Table 14: Vehicle requirements related to the drivetrain and battery

Title	Description	Rationale
Operating voltage	The vehicle shall have 48V operating voltage for the power train (51,2V actual) as the SOTA vehicle.	48V provides best flexibility to the choice of available extra components and accessories. This is a standard Voltage in industrial sector and similar ones. When moving to other alternative tensions the choice is more limited for on the shelf items.

Battery lifetime	The battery lifetime shall last at least 4 years, 2.000 cycles.	48V provides best flexibility to the choice of available extra components and accessories. This is a standard Voltage in industrial sector and similar ones. When moving to other alternative tensions the choice is more limited for on the shelf items.

4.1.7.Vehicle requirements related to the modular cargo body

The vehicle requirements related to the modular cargo body are shown in following table, which is taken from (ALKE (a), 2021):

Table 15: Vehicle requirements related to the modular cargo body

Title	Description	Rationale
Swappable modular cargo system	The vehicle shall have a swap system to allow the swap of different cargo bodies in less than 10 minutes.	The system will be composed by two sub-parts, one common and fixed to the vehicle, and one fixed on each body. This second not shared item must be simple and cheap to optimize the overall cost of the system.
Multi-body basic scenario	The vehicle swap system shall be designed to be compatible with multiple bodies with a minimum basic scenario of at least 3 solutions: 1 van box body, 1 refrigerated body and 1 dropside body.	The basic scenario includes very different cargo bodies and it has been chosen to demonstrate the flexibility of the system.
Swap body stands	The vehicle swap system shall include specifically designed stands useful for the swap procedure and to support the cargo bodies when not installed on the vehicle.	
Height of cargo area floor	The vehicle swap system presence shall not increase the height of the cargo area floor compared to SOTA.	Height of cargo area floor must reduce as much as possible arm lift efforts from human operators when dealing with heavy packages loading and unloading operations.
Van box body with swap system	The vehicle shall be equipped with a van box body with swap system targeting the BPOST case study.	

Van box size	The van box shall target an overall size of 250x150x140H cm.	
Van box load capacity	The van box shall have a load capacity of at least 800 kg.	
Van box rolling frame	The van box shall be able to hold a set of containers which are organized in a rolling frame. The vehicle's rolling frame shall be able to be fast loaded (max 5 min) via a rear door. The vehicles' bags/bins shall be individually accessible via side doors.	A detachable rolling frame becomes an easy to load, easy to store, easy to use urban micro depot for refresh of cargo bikes and trailers. Containers within the rolling frame might be plastic bin, might be a fabric tote bag.
Van box accessibility	The van box shall have 2 side doors (vertical roller shutter opening) to allow quick access to goods stored and a rear door to introduce the rolling frame.	
Van box load security	Side doors should have a lock to protect goods stored into the van box, better if an automatic lock to allow quicker opening/closing procedure.	
Van box power supply	The van box shall have proper internal connector set-up to allow the power supply of tools and e-hand Truck module when stored into the cargo area.	E-Hand truck preliminary design: 
Refrigerated body with swap system	The vehicle shall be equipped with a refrigerated body with swap system targeting Coffee Island case study.	Refrigerated box expected to be built as mono block structure made of fibreglass sandwich panels and rigid expanded polyurethane, machined and moulded joints for isothermal optimisation. Finishing in white gel coat specific for foods.
Refrigerated body size	The refrigerated body shall target an overall size of 250x150x140H cm.	

Refrigerated body load capacity	The refrigerated body shall have a load capacity of at least 650 kg.	
Refrigerated body accessibility	The refrigerated body shall have 1 side door (optional) and 1 rear door (compulsory) to allow quick access to refrigerated goods stored.	
Refrigerated body load security	The refrigerated body doors should have a lock to protect goods stored into the van body.	
Refrigerated body operating temperature	The refrigerated body shall have an operating temperature of 0°C / +4°C and comply with applicable standards for refrigerated food logistics (ATP - FRAX certification).	
Dropside body with swap system	The vehicle shall be equipped with a dropside body with swap system to target basic logistics scenarios.	Dropside body is required when large items need to be loaded and there are not problems for safety or weather influence. Design will be derived from SOTA dropside body adding the swap system
Dropside body size	The dropside body shall target an overall size of 250x150x30H cm.	
Dropside body load capacity	The dropside body shall have a load capacity of at least 800 kg.	
e-hand truck module	The vehicle shall be equipped with an e-hand truck module to facilitate load/unload operations from rear van box area.	The e-hand truck module will be designed to support the load/unloading operation from vehicle van box height to ground level and to move goods on pathway and private areas where vehicles cannot move.
e-hand truck size/weight	The e-hand truck shall have a max size in storing mode inside the vehicle of 40x60x120cm and a max weight of 30 kg (rif. 50th percentile male) without loads attached.	Shape and size of the e-hand truck must be chosen to provide best integration with the vehicle rear body. The anchoring system with the vehicle and the rail system to move the e-hand truck in-out the vehicle must be designed to minimize the loss of room useful for goods transportation.
e-hand truck load capacity	The e-hand truck shall be able to move up to 75kg loads they can have a max size of at least (WxLxH) 35 x 26 x 100 cm.	The e-hand truck frame and driving system will be designed in order to bear the weight of

		the carrying load and be light enough to load and unload from the vehicle.
e-hand truck with goods load, unload and hold features	The e-hand truck shall be equipped with proper electro-mechanical mechanisms to enable load-unload-holding capabilities of loads/goods in a quick way (load/unload in up to 60 sec).	The mechanisms fulfil fill load-unload capabilities must be compact, lightweight and easy to control.
e-hand truck with driving capabilities	The e-hand truck shall have capability to move on paved roads, on uphill/downhill 15% ramps, on stairs with up to 20cm high steps.	The e-hand truck will have driving capability to be able to move on different urban and indoor scenarios including ramps and stairs. Movement, steering, safety braking of the e-hand truck will be studied.
e-hand truck drivetrain system	The e-hand truck shall have a motorized mechanism to allow driving functions and delivering up to 5 km/h max speed on flat paved grounds.	e-hand truck mechanical system to fulfil the road capabilities of the e-hand truck must be compact, lightweight and easy to control.
e-hand truck with in/out the vehicle system	The e-hand truck shall be integrated with the vehicle with a properly designed system to move from storing mode inside the van box to ready-to-use mode at ground level off the vehicle and vice versa (up to 60sec for each of these steps).	The loading and unloading of the e-hand truck will be designed with a moving tray or equivalent system. The loading and unloading system need to impact as little as possible the van box volume.
e-hand truck HMI ergonomics	The e-hand truck shall be target of HMI ergonomics study to check its control, applied configurations and ergonomic use.	The completion of all its functions with the minimum effort and risk of injury from the user.
e-hand truck EMS	The e-hand truck shall have a proper Energy Management System able once on board the vehicle to communicate with the vehicle ICT platform.	The EMS of the e-hand truck must provide sufficient power and energy for the completion of the tasks. The possibility of charging the e-hand truck from the vehicle will be explored.

4.1.8. Vehicle requirements related to the ICT platform and the Energy Management System

The vehicle requirements related to the ICT platform and the Energy Management System are shown in following table, which is taken from (ALKE (a), 2021):

Table 16: Vehicle requirements related to the ICT platform and the Energy Management System

Title	Description	Rationale
Vehicle monitoring	The vehicle shall communicate energy related data required for fleet-level energy management.	Data shared with a common cloud platform.
Vehicle diagnostic	The vehicle shall communicate vehicle status data for fleet-level diagnostic management.	Data shared with a common cloud platform.
Vehicle tracking	The vehicle shall communicate geo-tracking data for operational fleet-level management	Data shared with a common cloud platform
Data security	The vehicle data transmission system shall be equipped with an encryption protocol.	Used to protect the privacy of the end users.
Local communication protocol	The vehicle shall maximise the use of CAN J1939 as communication protocol for on-board vehicle data exchange between vehicle devices (increasing the volume of CAN J1939 traffic from SOTA value of 30% to at least 75% target value).	Currently, a mix of CAN J1939, CAN 2.0A and CAN 2.0B is being used in relation to the on-board communication protocol. The intention is to maximise the use of CAN J1939 to increase compatibility with third-party industrial and automotive components and to standardise vehicle communication protocols as much as possible.
Battery intelligent charging capability	The vehicle shall enable the intelligent charging of batteries controlled from a centralized system.	The vehicle's charging shall be possible to be scheduled at a certain rate at a certain time at night to a certain charge level as determined by the central management platform.
Driver presence recognition	The vehicle shall be able to recognize the driver/operator presence thanks to smartphone pairing or equivalent scenario (transponder, keyless tech, etc).	
Automatic unlock of doors after driver presence recognition	The vehicle shall be able to automatically unlock the vehicle locks (cab doors, van box doors) once the driver/operator is approaching it after a delivery (within 2m distance round the vehicle).	
Large display on dashboard as operator support tool	The vehicle shall link a large display in the vehicle dashboard area to mirror/replicate information available on BPOST smartphone	The vehicle's display shall give the delivery person touch access to maps, delivery apps,

	fleet management tool to support operator tasks including navigation features.	messaging delivered from the phone.

4.1.9. Vehicle requirements related to economic analysis and efficiency

The vehicle requirements related to the economic analysis and the efficiency are shown in following table, which is taken from (ALKE (a), 2021):

Table 17: Vehicle requirements related to the economic analysis and the efficiency

Title	Description	Rationale
Fleet TCO reduction	Total Cost of Ownership (TCO) for a target fleet scenario need to be reduced at least 10%.	TCO intended as cost of vehicles plus the costs of operation including maintenance within a time scenario of 5 years. Target reference to be defined between BPOST or Coffee Island during the project.
Vehicle longevity	The vehicle shall have lifespan of 6 years at least.	Common lifetime operational range of combustion counterpart.

4.2 Assessment Plan

For each one of the vehicle requirements described in Section 4.1, an assessment plan has been added. Common assessment procedures range from field test, experimental, virtual simulations, component datasheet check, etc.

The following subsections follow the structure of the detailed requirements (Section 4.1). The assessment is fully described in (ALKE (a), 2021). This document contains several fields which do not fit in the available space of this document (e.g., validation responsible, validation status, see section 2.2). Therefore, only the "validation" column which describes the main assessment experiment is included in the following subsections.

4.2.1. Assessment of key performance indicators

Assessment elements of key performance indicators on vehicle requirements level are shown in following table, which is taken from (ALKE (a), 2021):

Table 18: Assessment of key performance indicators on vehicle requirements level

Title	Description	Assessment
OBJ 1 Powertrain inverter efficiency	The vehicle powertrain inverter shall achieve 98 % efficiency.	Mechanical load profile according to WLTP - separate measurement of the inverters electric power consumption compared with its output power / Check simulation results from the high-fidelity model of inverter and experimental testing with different load conditions.
OBJ 1 integrated on-board charger efficiency	The vehicle integrated on-board charger plus port for external power tooling shall achieve 95% efficiency.	Measurement of output values the losses. Experimental measurement.
OBJ 1 integrated e-powertrain efficiency	The vehicle integrated e-powertrain solution (eAxleDrive) shall increase the energy efficiency of at least 10 % (WLTP cycle at test bench), achieving a total efficiency of 91 % compared to current 82% baseline.	Mechanical load profile according to WLTP - measurement of electric power consumption compared with the achieved mechanical equivalents / Check simulation results from the low-fidelity model of drivetrain system and experimental testing over a driving cycle.
OBJ 2 Multi-level EMS energy efficiency increase	The vehicle shall integrate a multi-level EMS with fleet connectivity that reduce the energy consumption at least 12.8% using the 4 ECO functionalities during specified missions, compared to not using them.	Virtually validated by simulation models.
OBJ 2 Vehicle lifecycle cost reduction	The vehicle multi-level EMS shall deliver a vehicle lifecycle cost reduction of at least 20% for the specifically defined mission profiles to be tested.	Virtually validated by simulation models.
OBJ 3 Vehicle fleet acquisition cost reduction	The vehicle shall demonstrate a lower fleet acquisition cost by up to 40% obtained thanks to the multi-purpose swappable cargo body design having the possibility of using different cargo bodies with a single vehicle to cover fluctuating demands.	Acquisition cost comparison for a defined operation scenario between a SOTA fleet and a new project-based fleet.

OBJ 3 Powertrain inverter cost reduction	The vehicle shall provide a cost reduction of 20% for the powertrain inverter (from €350 today to €280).	Analyse cost breakdown for components, modules in the inverter and compare with SOTA Si-based inverter available in market. Increased performance vs. Costs will be quantified with market-based figures.
OBJ 3 On-board charger cost reduction	The vehicle shall provide a cost reduction of 25% for the on-board charger (from €400 today to €300).	Analyse cost breakdown for components, modules in the OBC and compare with SOTA Si-based inverter available in market. Increased performance vs. Costs will be quantified with market-based figures.
OBJ 3 E-powertrain production costs reduction	The vehicle shall provide a total production cost reduction for the novel e-powertrain (excluding the battery) of up to 25% (from €2.900 today to €2.175).	Analyse cost breakdown for components, modules in the e-powertrain system and compare with SOTA ATX3. Increased performance vs. Costs will be quantified with market-based figures.
OBJ 5 Superior performance	The vehicle shall demonstrate superior performance compared to benchmark vehicles, under defined testing scenarios and targets: (e.g. driving experience, stability, manoeuvrability, usability, ergonomics, reduced use of urban space).	Test done with at least 5 users to rate personal feeling about vehicle performance when dealing with a defined testing environment in comparison with SOTA scenario (usage of evaluation chart with numerical rating from 0 to 10).
OBJ 5 Delivery efficiency	The vehicle shall demonstrate increased overall delivery efficiency for the targeted missions by at least 30% (deliveries/day).	Simulation / Test done using specific target routes defined by mission profile doc and oriented to replicate real delivery environment operativity (efficiency measured in reduction of time to cover a specific mission or increased number of deliveries in same time scenario).

OBJ 4 **EuroNCAP 4**	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Real tests / Simulations will be applied to validate the Euro NCAP 4 standards having as target the light quadricycles reference chart.

4.2.2. Assessment of vehicle requirements related to main specs and performance

Assessment elements related to main specs and performance are shown in following table, which is taken from (ALKE (a), 2021):

Table 19: Assessment of vehicle requirements related to main specs and performance

Title	Description	Assessment
N1 type approval	The vehicle shall comply with European N1 category small series type approval requirements.	Check of type approval requirements (ref. Regulation EU 2021/535). Each requirement line must be satisfied or at least need to have performed a preliminary compliance check at theoretical/simulated level justifying the expected positive result.
Two speed powertrain	The vehicle shall have a powertrain able to deal with 2 speeds: - "low speed" delivering a higher torque for demanding urban routes with gradients or difficult road surfaces. - "high speed" for activities on more traditional urban routes.	Presence of described feature.
Speed	The vehicle shall have a powertrain able to deliver a top speed of: - 70km/h on flat road, no wind, in high speed. - 50km/h on flat road, no wind, in low speed.	Vehicle at bench level or in real environment must deliver given top speed (measurement of top speed reached).
Acceleration	The vehicle shall have a powertrain able to accelerate on flat regular road, no wind, with 205/65R15 tires: - in low speed from standstill to 50km/h within 15sec at empty weight.	Vehicle at bench level or in real environment must deliver given acceleration (measurement of time to reach given speed).

	- in high speed from standstill to 70km/h within 25sec at empty weight.	
Wheel diameter	The vehicle shall have 15"-16" wheel rim diameter.	Presence of described feature.
2WD / 4WD	The vehicle shall have a 4WD set-up or at least apply a design compatible with a 4WD configuration upgrade.	Presence of described feature.
GVW	The vehicle shall have a GVW (gross vehicle weight) of at least 2.15 tons and compatible with expected payload requirements.	FE static/dynamic simulation at given scenario and/or equivalent physical test at prototype level.
GCW	The vehicle shall have a GCW (gross combined weight) of at least 4.1 tons when in high torque mode and can be lowered to 3.3 tons in speed mode.	FE static/dynamic simulation at given scenario and/or equivalent physical test at prototype level
Payload (weight)	The vehicle shall carry an overall payload of at least 800 Kg.	FE static/dynamic simulation at given scenario and/or equivalent physical test at prototype level
Payload (volume)	The vehicle shall have a payload volume of at least 3 m^3.	Presence of described feature.
Vehicle overall dimensions	The vehicle without mirrors and including the cargo body shall have a target dimensions of 440 x 150 x 220 cm.	Presence of described feature.
Vehicle cab height	The vehicle cab shall have a height lower than 2m to access covered parking spaces.	Presence of described feature.
Vehicle cab width	The vehicle cab shall have a width without mirrors not exceeding 130 cm.	Presence of described feature.
Turning circle	The vehicle shall have a turning radius of: - 500 cm kerb to kerb. - 540 cm wall to wall.	Presence of described feature.
Power steering	The vehicle shall have EPS	Presence of described feature
Max slopes without trailer	The vehicle fully loaded shall deal with at least 18% slopes without trailer.	Test performed at bench or factory level with simulated scenario (use of dynamometer).
Max slopes with trailer	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	Test performed at bench or factory level with simulated scenario (use of dynamometer).
Drive range	The vehicle shall be able to cover at least 130km with a full charge (WLTP reference).	WLTP cycle simulated.

Efficiency	The vehicle shall have an efficiency of 135 Wh/km.	WLTP cycle simulated.
Charging time	The vehicle equipped with 20kWh battery shall be charged to 80% from fully discharged: - in 5 hours in case of regular charge (3kW). - in 2,5 hours in case of fast charging (11kW).	Presence of described feature.
Charger interface	The vehicle shall be compatible with CEE and TYPE 2 connectors for charging.	Presence of described feature.
Charging specs	The vehicle shall be charged with AC 230V 50-60Hz.	Presence of described feature.
Braking	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating.	Test performed in real environment with simulated scenarios. N1 standards targeting Regulation (EU) 2018/858 (and following ones) of the European Parliament and of the Council of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.
Automatic parking brake	The vehicle shall have mechanical/electric parking brake system able to deliver automatic parking brake feature when driver is out the cab.	Presence of described feature.
Parking brake torque	The vehicle shall have parking brake system able to deliver at least 2500 Nm brake torque on rear axle.	Test performed at bench or factory level with simulated scenario (use of dynamometer).
Regenerative braking	The vehicle shall be equipped with regenerative braking.	Presence of described feature.
Gravity centre	The vehicle shall have gravity centre 50mm lower than SOTA vehicle equipped with same or equivalent options, cargo area set-up, battery and tyres as the new based model to compare with.	Calculation done on 3D model of the vehicle .
Weight distribution	The vehicle shall have a target weight distribution fully loaded of 35% on front axle and 65% on rear axle.	Calculation done on 3D model of the vehicle.
Operative temperature range	The vehicle shall be able to operate in a temperature range of -20°C to 40°C.	Check of main components data sheets for compliance with given operative T range.

4.2.3. Assessment of vehicle requirements related to the front part of the vehicle

Assessment elements related to the front part of the vehicle are shown in following table, which is taken from (ALKE (a), 2021):

Table 20: Assessment of vehicle requirements related to the front part of the vehicle

Title	Description	Assessment
Front suspension	The vehicle shall provide front suspension redesign to fit the new EURONCAP compliant frame and if possible, to allow 4WD front differential housing.	Presence of described feature

4.2.4. Assessment of vehicle requirements related to cabin and comfort

Assessment elements related to cabin and comfort are shown in following table, which is taken from (ALKE (a), 2021):

Table 21: Assessment of vehicle requirements related to cabin and comfort

Title	Description	Assessment
Driver visibility	The vehicle shall have a driver visibility equal or better than SOTA, measured as view angle/coverage.	Calculation done on 3D model of the vehicle .
Overall cabin comfort	The vehicle shall have a cab structure where driver & passenger comfort (ergonomics / room available for movements) should be maximized keeping as much as possible a compact size. Comparison is the SOTA vehicle ergonomics to be improved.	Test done with at least 5 users with both SOTA and new vehicle to rate personal feeling about cab comfort for both models (usage of evaluation chart with numerical rating from 0 to 10).
LHD and RHD	The vehicle shall have the possibility to have both left-hand drive (LHD) and right-hand drive (RHD) configuration.	Presence of described feature.
Steering column and Seats comfort	The vehicle shall have steering column and seats layout designed to provide best ergonomics. Driver seat shall be adjustable.	Test done with at least 5 users with both SOTA and new vehicle to rate personal feeling about steering column and seats layout for both models (usage of evaluation chart with numerical rating from 0 to 10).

		Here, the baseline vehicle is a baseline vehicle produced by ALKE identified as an ATX340E with same specs as the new one in terms of cargo area set-up, optional, battery size, tyres.
Air-conditioning system	The vehicle shall have a cab airco system able to deliver at least same cooling capacity of SOTA.	Presence of described feature and comparison of given spec against SOTA. Here, the SOTA vehicle is a baseline vehicle produced by ALKE identified as an ATX340E with same specs as the new one in terms of cargo area set-up, optional, battery size, tyres.
Heating system	The vehicle shall have a cab heating system able to deliver at least same heating capacity of SOTA.	Presence of described feature and comparison of given spec against SOTA. Here, the SOTA vehicle is a baseline vehicle produced by ALKE identified as an ATX340E with same specs as the new one in terms of cargo area set-up, optional, battery size, tyres.
Heated windshield	Timed heated windshield.	Presence of described feature.
Battery pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the battery.	Presence of described feature.
Cab pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the cab.	Presence of described feature.
2-4 seats	The vehicle shall have 2-4 seats design as the SOTA model, without affecting cargo space.	Presence of described feature.
Cab in/out accessibility	The vehicle shall deliver same or better accessibility of the driver's seat compared to SOTA and measured as 2D area of the exit with door fully open and removing obstacles in between. The driver must also be able to exit through the passenger side.	Calculation done on 3D model of the vehicle.
Cab accessories / compartments	The vehicle shall provide user-oriented interiors designed for the cabin to host proper accessories and compartments for intensive daily usage.	Presence of described feature.

Central lock	The vehicle shall be equipped with a remoted controlled central locking system.	Presence of described feature.
Navigation tools	The vehicle shall be equipped with a navigation tool able to share traffic/delivery information.	Presence of described feature.
Park assist devices	The vehicle shall be equipped with park assist devices such as reverse camera and/or front/rear sensors.	Presence of described feature.
Audio system / Radio	The vehicle shall be equipped with audio system with DAB radio and Bluetooth integrated.	Presence of described feature
Connection/charging ports	The vehicle shall have 12V port and USB or wireless smartphone charging port.	Presence of described feature.

4.2.5. Assessment of vehicle requirements related to rear part of the vehicle

Assessment elements related to the rear part of the vehicle are shown in following table, which is taken from (ALKE (a), 2021):

Table 22: Assessment of vehicle requirements related to the rear part of the vehicle

Title	Description	Assessment
Rear frame design	The vehicle shall have an upgraded rear frame design with a lower fitting area layout.	Calculation done on 3D model of the vehicle.
Rear suspensions	The vehicle shall have rear suspension redesign to allow new drivetrain housing.	Presence of described feature.

4.2.6. Assessment of vehicle requirements related to drivetrain and battery

Assessment elements related to the drivetrain and the battery are shown in following table, which is taken from (ALKE (a), 2021):

Table 23: Assessment of vehicle requirements related to the drivetrain and the battery

Title	Description	Assessment
Operating voltage	The vehicle shall have 48V operating voltage for the power train (51.2V actual) as the SOTA vehicle.	Presence of described feature.

Battery lifetime	The battery lifetime shall last at least 4 years, 2.000 cycles.	Check of data sheet of adopted battery for compliance with given specs.

4.2.7. Assessment of vehicle requirements related to the modular cargo body

Assessment elements related to the modular cargo body are shown in following table, which is taken from (ALKE (a), 2021):

Table 24: Assessment of vehicle requirements related to the modular cargo body

Title	Description	Assessment
Swappable modular cargo system	The vehicle shall have a swap system to allow the swap of different cargo bodies in less than 10 minutes.	Presence of described feature, check compliance with the required target.
Multi-body basic scenario	The vehicle swap system shall be designed to be compatible with multiple bodies with a minimum basic scenario of at least 3 solutions: 1 van box body, 1 refrigerated body and 1 dropside body.	Presence of described feature, check compliance with the required target.
Swap body stands	The vehicle swap system shall include specifically designed stands useful for the swap procedure and to support the cargo bodies when not installed on the vehicle.	Presence of described feature, check compliance with the required target.
Height of cargo area floor	The vehicle swap system presence shall not increase the height of the cargo area floor compared to SOTA.	Check compliance with the required target.
Van box body with swap system	The vehicle shall be equipped with a van box body with swap system targeting the BPOST case study.	Presence of described feature.
Van box size	The van box shall target an overall size of 250x150x140H cm.	Check compliance with the required target
Van box load capacity	The van box shall have a load capacity of at least 800 kg.	Check compliance with the required target
Van box rolling frame	The van box shall be able to hold a set of containers which are organized in a rolling frame. The vehicle's rolling frame shall be able to be fast loaded (max 5 min) via a rear door.	Presence of described feature, check compliance with the required target.

	The vehicles' bags/bins shall be individually accessible via side doors.	
Van box accessibility	The van box shall have 2 side doors (vertical roller shutter opening) to allow quick access to goods stored and a rear door to introduce the rolling frame.	Presence of described feature.
Van box load security	Side doors should have a lock to protect goods stored into the van box, better is an automatic lock to allow quicker opening/closing procedure.	Presence of described feature.
Van box power supply	The van box shall have proper internal connector set-up to allow the power supply of tools and e-hand Truck module when stored into the cargo area.	Presence of described feature.
Refrigerated body with swap system	The vehicle shall be equipped with a refrigerated body with swap system targeting Coffee Island case study.	Presence of described feature.
Refrigerated body size	The refrigerated body shall target an overall size of 250x150x140H cm.	Check compliance with the required target.
Refrigerated body load capacity	The refrigerated body shall have a load capacity of at least 650 kg.	Check compliance with the required target.
Refrigerated body accessibility	The refrigerated body shall have 1 side door (optional) and 1 rear door (compulsory) to allow quick access to refrigerated goods stored.	Presence of described feature.
Refrigerated body load security	The refrigerated body doors should have a lock to protect goods stored into the van body.	Presence of described feature.
Refrigerated body operating temperature	The refrigerated body shall have an operating temperature of 0°C / +4°C and comply with applicable standards for refrigerated food logistics (ATP - FRAX certification).	Presence of described feature, check compliance with the required target under ambient temperature of 20°C.
Dropside body with swap system	The vehicle shall be equipped with a dropside body with swap system to target basic logistics scenarios.	Presence of described feature.
Dropside body size	The dropside body shall target an overall size of 250x150x30H cm.	Check compliance with the required target.
Dropside body load capacity	The dropside body shall have a load capacity of at least 800 kg.	Check compliance with the required target.
e-hand truck module	The vehicle shall be equipped with an e-hand truck module to facilitate load/unload operations from rear van box area.	Presence of described feature.

e-hand truck size/weight	The e-hand truck shall have a max size in storing mode inside the vehicle of 40x60x120cm and a max weight of 30 kg (rif. 50th percentile male) without loads attached.	Check compliance with the required targets.
e-hand truck load capacity	The e-hand truck shall be able to move up to 75kg loads they can have a max size of at least (WxLxH) 35 x 26 x 100 cm.	Check compliance with the required targets.
e-hand truck with goods load, unload and hold features	The e-hand truck shall be equipped with proper electro-mechanical mechanisms to enable load-unload-holding capabilities of loads/goods in a quick way (load/unload in up to 60 sec).	Check compliance with the required targets.
e-hand truck with driving capabilities	The e-hand truck shall have capability to move on paved roads, on uphill/downhill 15% ramps, on stairs with up to 20cm high steps.	Check compliance with the required targets.
e-hand truck drivetrain system	The e-hand truck shall have a motorized mechanism to allow driving functions and delivering up to 5 km/h max speed on flat paved grounds.	Presence of described feature, check compliance with the required target.
e-hand truck with in/out the vehicle system	The e-hand truck shall be integrated with the vehicle with a properly designed system to move from storing mode inside the van box to ready-to-use mode at ground level off the vehicle and vice versa (up to 60sec for each of these steps).	Presence of described feature, check compliance with the required target.
e-hand truck HMI ergonomics	The e-hand truck shall be target of HMI ergonomics study to check its control, applied configurations and ergonomic use.	Check compliance with the required targets.
e-hand truck EMS	The e-hand truck shall have a proper Energy Management System able once on board the vehicle to communicate with the vehicle ICT platform.	Check compliance with the required targets.

4.2.8. Assessment of vehicle requirements related to the ICT platform and the Energy Management System

Assessment elements related to the ICT platform and the Energy Management System are shown in following table, which is taken from (ALKE (a), 2021):

Table 25: Assessment of vehicle requirements related to the ICT platform and the Energy Management System

Title	Description	Assessment
Vehicle monitoring	The vehicle shall communicate energy related data required for fleet-level energy management.	Presence of described feature.
Vehicle diagnostic	The vehicle shall communicate vehicle status data for fleet-level diagnostic management.	Presence of described feature.
Vehicle tracking	The vehicle shall communicate geo-tracking data for operational fleet-level management.	Presence of described feature.
Data security	The vehicle data transmission system shall be equipped with an encryption protocol.	Presence of described feature.
Local communication protocol	The vehicle shall maximise the use of CAN J1939 as communication protocol for on-board vehicle data exchange between vehicle devices (increasing the volume of CAN J1939 traffic from SOTA value of 30% to at least 75% target value).	Check compliance with the required targets.
Battery intelligent charging capability	The vehicle shall enable the intelligent charging of batteries controlled from a centralized system.	Virtually validated by simulation models for eco-charging function.
Driver presence recognition	The vehicle shall be able to recognize the driver/operator presence thanks to smartphone pairing or equivalent scenario (transponder, keyless tech, etc).	Presence of described feature.
Automatic unlock of doors after driver presence recognition	The vehicle shall be able to automatically unlock the vehicle locks (cab doors, van box doors) once the driver/operator is approaching it after a delivery (within 2m distance round the vehicle).	Presence of described feature. Check compliance with the required targets.
Large display on dashboard as operator support tool	The vehicle shall link a large display in the vehicle dashboard area to mirror/replicate information available on BPOST smartphone fleet management tool to support operator tasks including navigation features.	Presence of described feature.

4.2.9. Assessment of vehicle requirements related to economic analysis and efficiency

Assessment elements related to the economic analysis and efficiency are shown in following table, which is taken from (ALKE (a), 2021):

Table 26: Assessment of vehicle requirements related to the economic analysis and efficiency

Title	Description	Assessment
Fleet TCO reduction	Total Cost of Ownership (TCO) for a target fleet scenario need to be reduced at least 10% with the SOTA	TCO comparison for a defined operation scenario between a SOTA fleet and a new project-based fleet.
Vehicle longevity	The vehicle shall have lifespan of 6 years at least, without considering the lifespan of "consumables" e.g., the battery.	Check of main components data sheets and parts usage historical data for compliance with given target.

5. Design specifications

Design specifications are oriented on identifying starting design scenario answering to MPR and VR and building boundary conditions necessary to develop new project based vehicle design and related sub-systems during next WPs activity.

Full data about design specifications can be found into (ALKE (b), 2021).

The design specifications have been divided in nine parts: main specs & performance, front part of the vehicle, cabin and comfort, rear part of the vehicle, drive train and battery, modular cargo body, ICT platform and energy management system, economic aspects, passive safety.

5.1 Design specifications related to main specs and performance

Design specifications related to the vehicle main specs and performance are shown in following table, which is taken from (ALKE (a), 2021; ALKE (b), 2021):

Table 27: Design specifications related to the vehicle main specs and performance

Title	Description	Rationale
N1 type approval guidelines	The vehicle shall comply with EU N1 "small series" requirements check-list (ref. Regulation EU 2018/858, appendix 1, table 2).	Link ref document: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0858&from=EN.
Number of gears	The vehicle shall target as optimal choice a 1 gear design covering full torque requirements. Alternative (B choice) will approach a 2 gears design.	2 gears with "low speed" delivering a higher torque for demanding urban routes with gradients or difficult road surfaces and a "high speed" for activities on more traditional urban routes.
Speed	The vehicle shall have a powertrain able to deliver a top speed of 70km/h on flat road, with no wind, with 205/65R15 tires, using empty weight + 75kg driver. If a 2 gears design will be adopted (B choice) the low gear will target 50km/h and high gear 70km/h."	
Acceleration	"The vehicle shall have a powertrain able to accelerate on flat regular road, no wind, with 205/65R15 tires from standstill to 70km/h within 25sec at empty weight.	

Wheel diameter	The vehicle shall have 15"-16" wheel rim diameter.	
2WD / 4WD	The vehicle shall have a 2WD design (rear driving axle) keeping the possibility to add an extra front driving axle to reach 4WD design. A full 4WD design will be considered as an extra feature surely welcome but not compulsory.	
GVW	The vehicle shall have a design compatible with a GVW (gross vehicle weight) of at least 2.15 tons and compatible with expected payload requirements.	
GCW	The vehicle shall have a design compatible with a GCW (gross combined weight) of 3.3 tons.	
Payload (weight)	The vehicle shall carry an overall payload of at least 800 Kg.	
Payload (volume)	The vehicle shall have a payload volume of at least 3 m^3.	
Vehicle overall dimensions	The vehicle without mirrors and including the cargo body shall have a target indicative dimensions of 440 x 150 x 220 cm.	
Vehicle cab height	The vehicle cab shall have a height lower than 2m.	
Vehicle cab width	The vehicle cab shall have a width without mirrors not exceeding 130 cm.	
Turning circle	The vehicle shall have a turning radius of: - 500 cm kerb to kerb. - 540 cm wall to wall.	
Power steering	The vehicle shall have EPS.	
Max slopes without trailer	The vehicle fully loaded shall deal with at least 18% slopes without trailer.	
Max slopes with trailer	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	
Drive range	The vehicle shall be able to cover at least 130 km with a full charge (WLTP reference).	
Efficiency	The vehicle shall have an efficiency of 135 Wh/km.	Average value measured at plug level from electric grid including efficiency of on-board charger.
Charging time	The vehicle equipped with 20kWh battery shall be charged to 80% from fully discharged:	

	- in 5 hours in case of regular charge (3kW). - in 2,5 hours in case of fast charging (11kW).	
Charger interface	The vehicle shall be compatible with CEE and TYPE 2 connectors for charging.	
Charging specs	The vehicle shall be chargeable with AC 230V 50-60Hz.	
Braking	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating.	
Automatic parking brake	The vehicle shall have mechanical/electric parking brake system able to deliver automatic parking brake feature when driver is out the cab.	
Parking brake torque	The vehicle shall have parking brake system able to deliver at least 2500 Nm brake torque on rear axle.	
Regenerative braking	The vehicle shall be equipped with regenerative braking.	
Gravity centre	The vehicle shall have gravity centre 50mm lower than SOTA.	
Weight distribution	The vehicle shall have a target weight distribution fully loaded of 35% on front axle and 65% on rear axle. Front axle weight shall be increased from 800kg (SOTA value) to 1.000kg to shift weight from rear to the front of the vehicle.	
Operative temperature range	The vehicle shall be able to operate in a temperature range of -20°C to 40°C.	

Beside main vehicle dimensions a preliminary available volume has been Identified for the new powertrain and located into the rear part of the vehicle. Picture below highlights such area in red giving also linked sizing:

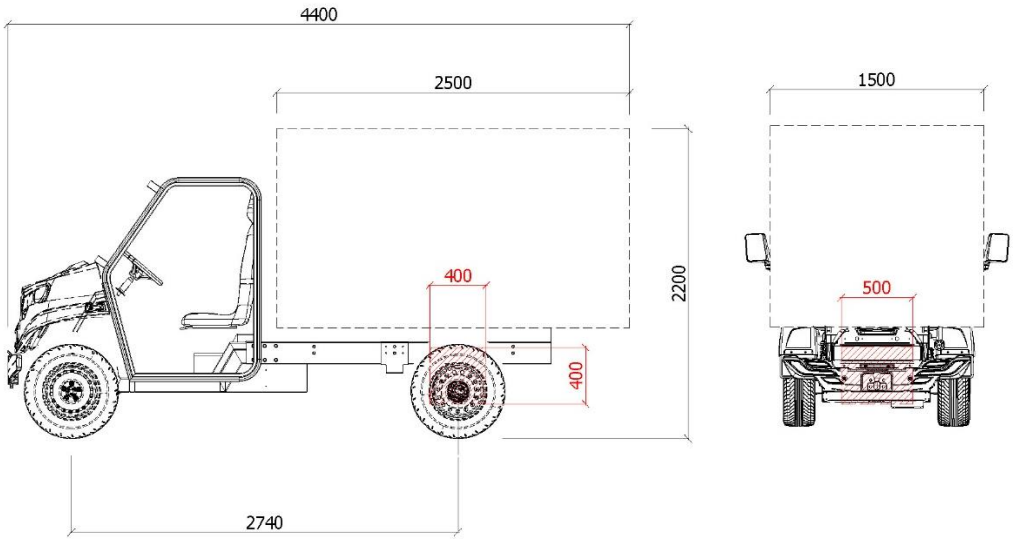

Figure 12: Location and available volume for the new powertrain

5.2 Design specifications related to the front part of the vehicle

Design specifications related to the front part of the vehicle are shown in following table, which is taken from (ALKE (b), 2021)

Table 28: Design specifications related to the front part of the vehicle

Title	Description	Rationale
Front suspension	The design of front part of the vehicle shall provide front suspension redesign to fit the new EURONCAP compliant frame and to allow 4WD front differential housing (not necessarily installed on final prototype).	

5.3 Design specifications related to cabin and comfort

Design specifications related to cabin and comfort are shown in following table, which is taken from (ALKE (a), 2021; ALKE (b), 2021):

Table 29: Design specifications related to cabin and comfort

Title	Description	Rationale
Driver visibility	The vehicle shall have a driver visibility equal or better than SOTA, measured as view angle/coverage.	
Overall cabin comfort	The vehicle shall have a cab structure where driver & passenger comfort (ergonomics / room available for movements) should be maximized keeping as much as possible a compact size. Comparison is the SOTA vehicle ergonomics to be improved.	An overall study about ergonomics needs to be performed into the new platform. Volumes and layout can be changed / modified keeping in mind that anyway a compact size must be delivered by the new design. A max increase on sizes for about 10 cm in width and length can be accepted and justified.
LHD / RHD	The vehicle shall have dashboard design, steering design and front lights set-up compatible (with proper reversal and/or dedicated assembly) to both left-hand drive (LHD) and right-hand drive (RHD) configuration.	
Steering column and seats comfort	The vehicle shall have steering column and seats layout designed to provide best ergonomics. Driver seat shall be adjustable.	A combined study for positioning steering, seats and other near parts must be carried out to identify best set-up for maximum flexibility in terms of drivers. The solution chosen must be compatible with drivers of different size and gender. Small, thin people and tall, "heavy" people at the same time. Adjustable steering and seats are expected.
Air-conditioning system	The vehicle shall have a cab airco system able to deliver at least same cooling capacity of SOTA.	
Heating system	The vehicle shall have a cab heating system able to deliver at least same heating capacity of SOTA.	
Heated windshield	The vehicle shall have timed heated windshield.	

Battery pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the battery.	
Cab pre-conditioning	The vehicle shall be equipped with pre-conditioning capabilities for the cab while still connected to the charger. A/C preconditioning will be studied as a complementary option, but priority will be given to pre-heating.	
2-4 seats	The vehicle shall be compatible with 2-4 seats design as the SOTA model. Project prototypes anyway will physically target only the 2 seats design.	
Cab in/out accessibility	The vehicle shall deliver same or better accessibility of the driver's seat compared to SOTA and measured as 2D area of the exit with door fully open and removing obstacles in between. The driver must be able to exit through the passenger side as well.	Important elements in optimising this area are the design of the doors, the ground clearance of the cab floor, the position of the steering wheel and seats, etc.
Cab accessories / compartments	The vehicle shall provide user-oriented interiors designed for the cabin to host proper. accessories and compartments for intensive daily usage.	Market experience tells that professional operators expect to have glove boxes, cup holders, Bluetooth radio, USB charging sockets, smartphone / tablet holders, etc. available.
Central lock	The vehicle shall be equipped with a remoted controlled central locking system.	
Navigation tool	The vehicle shall be equipped with a navigation tool able to share traffic/delivery information. This is not necessarily needed to be integrated with vehicle dashboard, can be implemented into an external device (smartphone, secondary display, etc) it needs a specific holding unit in case.	
Park assist devices	The vehicle shall be equipped with park assist devices such as reverse camera and/or front/rear sensors.	
Audio system / Radio	The vehicle shall be equipped with audio system with DAB radio and Bluetooth integrated.	
Connection / charging ports	The vehicle shall have at least 1x 12V port and 1x USB smartphone charging port. Wireless smartphone charging port can be considered as extra feature beside the just listed ones.	

5.4 Design specifications related to rear part of the vehicle

Design specifications related to the rear part of the vehicle are shown in following table, which is taken from (ALKE (b), 2021):

Table 30: Design specifications related to the rear part of the vehicle

Title	Description	Rationale
Rear frame design	The vehicle shall have an upgraded rear frame design with a lower fitting area layout. Battery is going to be moved under the seats or to another less invasive position to lower the height of available room for the rear cargo area set-up. New frame design will be based on bolted sectional rather than welded continuous frame design for modularity purposes.	
Rear suspensions	The vehicle shall have rear suspension redesign to allow new drivetrain housing.	

5.5 Design specifications related to drivetrain and battery

Design specifications related to the drivetrain and the battery are shown in following table, which is taken from (ALKE (b), 2021):

Table 31: Design specifications related to the drivetrain and the battery

Title	Description	Rationale
KPI 1 Powertrain inverter efficiency	The vehicle powertrain inverter shall achieve up to 98 % efficiency .	Ref. OBJ. 1 DOA
KPI 2 Integrated on-board charger efficiency	The vehicle integrated on-board charger plus port for external power tooling shall achieve 95% efficiency.	Ref. OBJ. 1 DOA
KPI 3 Integrated e-powertrain efficiency	The vehicle integrated e-powertrain solution (eAxleDrive) shall increase the energy efficiency of at least 10 % (WLTP cycle at test bench), achieving a total efficiency of 91 % compared to current 82% baseline.	Ref. OBJ. 1 DOA

Operating voltage	The vehicle shall have 48V operating voltage for the power train (51,2V actual) (same as the SOTA vehicle).	
Battery lifetime	The vehicle shall be chosen to have a lifetime of at least 4 years, 2.000 cycles, 80% of original battery capacity.	

5.6 Design specifications related to the modular cargo body

Design specifications related to the modular cargo body are shown in following table, which is taken from (ALKE (b), 2021):

Table 32: Design specifications related to the modular cargo body

Title	Description	Rationale
Swappable modular cargo system	The vehicle shall have a swap system to allow the swap of different cargo bodies in less than 10 minutes.	The system will be composed by two sub-parts, one common and fixed to the vehicle, and one fixed on each body. This second not shared item must be simple and cheap to optimize the overall cost of the system.
Multi-body basic scenario	The vehicle swap system shall be designed to be compatible with multiple bodies with a minimum basic scenario of at least 3 solutions: 1 van box body, 1 refrigerated body and 1 dropside body.	
Swap body stands	The vehicle swap system shall include specifically designed stands useful for the swap procedure and to support the cargo bodies when not installed on the vehicle.	
Height of cargo area floor	The vehicle swap system presence shall not increase the height of the cargo area floor compared to SOTA.	
Van box body with swap system	The vehicle shall be equipped with a van box body with swap system targeting the BPOST case study.	
Van box size	The van box shall target an overall size of 250x150x140H cm.	

Van box load capacity	The van box shall have a load capacity of at least 800 kg.	
Van box rolling frame	The van box shall be able to hold a set of containers which are organized in a rolling frame. The vehicle's rolling frame shall be able to be fast loaded (max 5 min) via a rear door. The vehicles bags/bins shall be individually accessible via side doors.	Containers within the rolling frame might be plastic bin, might be a fabric tote bag.
Van box accessibility	The van box shall have 2 side doors (vertical roller shutter opening) to allow quick access to goods stored and a rear door to introduce the rolling frame.	
Van box load security	Side doors should have a lock to protect goods stored into the van box, better if an automatic lock to allow quicker opening/closing procedure.	
Van box power supply	The van box shall have proper internal connector set-up to allow the power supply of tools and e-hand Truck module when stored into the cargo area.	
Refrigerated body with swap system	The vehicle shall be equipped with a refrigerated body with swap system targeting Coffee Island case study.	Refrigerated box expected to be built as mono block structure made of fibreglass sandwich panels and rigid expanded polyurethane, machined and moulded joints for isothermal optimisation. Finishing in white gel coat specific for foods.
Refrigerated body size	The refrigerated body shall target an overall size of 250x150x140H cm.	COI loads for the refrigerated van box: Average weight of boxes 2-3 kilos, size of the boxes used are approximately 50X50 or 40X40cm.
Refrigerated body load capacity	The refrigerated body shall have a load capacity of at least 650 kg.	
Refrigerated body accessibility	The refrigerated body shall have 1 side door (optional) and 1 rear door (compulsory) to allow quick access to refrigerated goods stored.	
Refrigerated body load security	The refrigerated body doors should have a lock to protect goods stored into the van body.	

Refrigerated body operating temperature	The refrigerated body shall have an operating temperature of 0°C / +4°C and comply with applicable standards for refrigerated food logistics (ATP - FRAX certification).	
Dropside body with swap system	The vehicle shall be equipped with a dropside body with swap system to target basic logistics scenarios.	
Dropside body size	The dropside body shall target an overall size of 250x150x30H cm.	
Dropside body load capacity	The dropside body shall have a load capacity of at least 800 kg .	
e-hand truck module	The vehicle shall be equipped with an e-hand truck module to facilitate load/unload operations from rear van box area.	
e-hand truck size/weight	The e-hand truck shall have a max size in storing mode inside the vehicle of 40x60x120cm and a max weight of 30 kg (rif. 50th percentile male) without loads attached.	
e-hand truck load capacity	The e-hand truck shall be able to move up to 75kg loads they can have a max size of at least (WxLxH) 35 x 26 x 100 cm.	
e-hand truck with goods load, unload and hold features	The e-hand truck shall be equipped with proper electro-mechanical mechanisms to enable load-unload-holding capabilities of loads/goods in a quick way (load/unload in up to 60 sec).	
e-hand truck with driving capabilities	The e-hand truck shall have capability to move on paved roads, on uphill/downhill 15% ramps, on stairs with up to 20cm high steps.	
e-hand truck drivetrain system	The e-hand truck shall have a motorized mechanism to allow driving functions and delivering up to 5 km/h max speed on flat paved grounds...	
e-hand truck with in/out the vehicle system	The e-hand truck shall be integrated with the vehicle with a properly designed system to move from storing mode inside the van box to ready-to-use mode at ground level off the vehicle and vice versa (up to 60sec for each of these steps)	
e-hand truck HMI ergonomics	The e-hand truck shall be target of HMI ergonomics study to check its control, configurations and ergonomic use.	

e-hand truck EMS	The e-hand truck shall have a proper Energy Management System able once on board the vehicle to communicate with the vehicle ICT platform.	The EMS of the e-hand truck must provide sufficient power and energy for the completion of the tasks. The possibility of charging the e-hand truck from the vehicle will be explored.

5.7 Design specifications related to the ICT platform and the Energy Management System

Design specifications related to the ICT platform and the Energy Management System are shown in following table, which is taken from (ALKE (b), 2021):

Table 33: Design specifications related to the ICT platform and the Energy Management System

Title	Description	Rationale
KPI 4 Multi-level EMS energy efficiency increase	The vehicle shall integrate a multi-level EMS with fleet connectivity that reduce the energy consumption at least 12.8% using the 4 ECO functionalities during specified missions, compared to not using them.	Ref. OBJ. 2 DOA A self-adaptable, multi-level predictive EMS architecture will be designed to optimize energy consumption and fleet operations thanks to the use of synergies at different system levels, leveraging vehicle connectivity through integrated sensors, GPS and real-time data from the traffic environment and vehicle scheduling.
KPI 5 Vehicle lifecycle cost reduction	The vehicle multi-level EMS shall deliver a vehicle lifecycle cost reduction of at least 20 % for the specifically defined mission profiles to be tested.	Ref. OBJ. 2 DOA.
Vehicle monitoring	The vehicle shall communicate energy related data required for fleet-level energy management.	Data shared with a common cloud platform.
Vehicle diagnostic	The vehicle shall communicate vehicle status data for fleet-level diagnostic management.	Data shared with a common cloud platform.
Vehicle tracking	The vehicle shall communicate geo-tracking data for operational fleet-level management.	Data shared with a common cloud platform.

Data security	The vehicle data transmission system shall be equipped with an encryption protocol.	
Local communication protocol	The vehicle shall maximise the use of CAN J1939 as communication protocol for on-board vehicle data exchange between vehicle devices (increasing the usage of CAN J1939 traffic from SOTA value of 30% to at least 75% target value).	
Battery intelligent charging capability	The vehicle shall enable the intelligent charging of batteries controlled from a centralized system.	The vehicle's charging shall be possible to be scheduled at a certain rate at a certain time at night to a certain charge level as determined by the central management platform.
Driver presence recognition	The vehicle shall be able to recognize the driver/operator presence thanks to smartphone pairing or equivalent scenario (transponder, keyless tech, etc).	
Driver presence recognition	The vehicle shall be able to recognize the driver/operator presence thanks to smartphone pairing or equivalent scenario (transponder, keyless tech, etc).	
Automatic unlock of doors after driver presence recognition	The vehicle shall be able to unlock automatically the vehicle locks (cab doors, van box doors) once the driver/operator is approaching it after a delivery (within 2m distance round the vehicle).	
Large display on dashboard as operator support tool	The vehicle shall link a large display in the vehicle dashboard area to mirror/replicate information available on BPOST smartphone fleet management tool to support operator tasks including navigation features.	The vehicle's display shall give the delivery person touch access to maps, delivery apps, messaging delivered from the phone.

5.8 Design specifications related to economic aspects

Design specifications related to the economic aspects are shown in following table, which is taken from (ALKE (b), 2021):

Table 34: Design specifications related to the economic aspects

Title	Description	Rationale
KPI 9 Vehicle fleet acquisition cost reduction	The vehicle shall demonstrate a lower fleet acquisition cost by up to 40 % obtained thanks to the multi-purpose swappable cargo body design having the possibility of using different cargo bodies with a single vehicle to cover fluctuating demands.	Ref. OBJ. 3 DOA Example of cost reduction: from €60.000 for two vehicles to €36.000 for one vehicle and 2 cargo bodies.
KPI 6 Powertrain inverter cost reduction	The vehicle shall provide a cost reduction of 20 % for the powertrain inverter (from €350 today to €280).	Ref. OBJ. 3 DOA.
KPI 7 On-board charger cost reduction	The vehicle shall provide a cost reduction of 25 % for the on-board charger (from €400 today to €300).	Ref. OBJ. 3 DOA.
KPI 8 E-powertrain production costs reduction	The vehicle shall provide a total production cost reduction for the novel e-powertrain (excluding the battery) of up to 25 % (from €2.900 today to €2.175).	Ref. OBJ. 3 DOA.
Fleet TCO reduction	Total Cost of Ownership (TCO) for a target fleet scenario need to be reduced at least 10%.	TCO intended as cost of vehicles plus the costs of operation including maintenance within a time scenario of 5 years. Target reference to be defined between BPOST or Coffee Island during the project.
KPI 11 Superior performance	The vehicle shall demonstrate superior performance compared to benchmark vehicles, under defined testing scenarios and targets: (e.g. driving experience, stability, manoeuvrability, usability, ergonomics, reduced use of urban space).	Ref. OBJ. 5 DOA.
Vehicle longevity	The vehicle shall have lifespan of 6 years at least.	

5.9 Design specifications related to passive safety

Design specifications related to passive safety are shown in following table, which is taken from (ALKE (b), 2021):

Table 35: Design specifications related to passive safety

Title	Description	Rationale
KPI 10 **Euro NCAP 4**	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Ref. OBJ. 4 DOA The target is to achieve a final rating between 60 % and 74,9 % in the overall weighted score, where 75 % accounts for Adult Occupant Protection (AOP) in Frontal Impact and 25 % accounts for Adult Occupant Protection in Side Impact.
Steering column displacement	Steering column displacement <90mm rearwards, <72mm upwards and <90mm lateral movement vs SOTA.	Steering column displacement < 90% EEVC limits. The EEVC recommended limits are: 100mm rearwards, 80mm upwards and 100mm lateral movement.
Displacement A pillar	Displacement A pillar < 100mm displacement.	
More section in the pillars	More section in the pillars to have overlap with the door beams.	
Door beams	Door beams needed.	
A/B pillar section	Increase section in A-pillar and B-pillar.	Not enough section in A-Pillar and B-Pillar so support a side crash.
Long members load	Reinforcement to support the load arriving from the long members.	
Long members section	Increase section in the long members.	Not enough section in the long members.
Sill section	Increase section in the sill.	Not section in the sill to stop the barrier in side impact
Sill / Long member connection	Connection between sill and long member.	There is no connection between sill and long member.
Trimmings	Trimmings in order to be friendly to the crash test (possibility of adding paddings).	
Knees area	No hard points on knees area, controlled pedal intrusion.	

6. Risk analysis

6.1 Introduction

In principle, every new technological achievement might present some form of risks and/or conflicts that might occur during the implementation, especially during the initial of the design process. However, these risks can be overcome if they are detected at an early stage of the system's design and adequate compensation strategies are assigned to address them. The major system possible malfunctions may be due to the following reasons:

- System error.
- Inappropriate use by the users.
- Legal or organisational barriers.

For the first case, URBANIZED vehicle developers need to put more effort and fix the possible problems, while for the second one, the users' personal limits are the main concern. The last case requires system adaptation or standardisation activities.

In URBANIZED project the risks will be identified in two stages:

- Stage 1, estimation of a priori/foreseen risks, along with mitigation/alternative solutions.
- Stage 2, a posteriori risks analysis, in order to identify actual risks that occurred after the project developments and examine the compensation solutions that were applied.

The a-priori and a posteriori analyses will follow in the course of the project (on Month 6 and Month 30 respectively). In both stages, risks will be categorized based on their nature, e.g. technical-related ones (dealing with the system or its sub-elements functionalities, their limitations and possible complications), behavioural-related (according to the targeted users – from WP2 – potential unexpected/erroneous actions), legal (in relation to the possible legislative conflicts in various EU countries). The details of the risk categorization will be presented in the methodology Section. Specific mitigation actions will be defined that are appropriate to deal and overpass the most important potential identified risks.

The aim of this chapter is to present the risk-assessment methodology of URBANIZED system and its components, based upon the initial Vehicle Requirements (VR), as they emerge from T2.1 "Identification of vehicle requirements: functional, operational, safety & protocols" and the Mission Profile Requirements (MPR) as they emerge from T2.2 "Definition of specific mission profiles and KPIs within main 2 use cases", as they are presented in Section 3 and Section 4, respectively. Hand in hand with the methodology to be followed, the means for realising the risk assessment will be presented. The template that was shared with the respective partners is developed, as well as additional clarifications that have assisted the partners to fill in the appropriate information.

6.2 Methodology of URBANIZED risks analysis

6.2.1.Overview

The risk assessment of the URBANIZED vehicle design and development has been based on the Failure Mode and Effects Analysis (FMEA) methodology, which is a tool adapted in many different ways for many different purposes. FMEA is a useful tool especially during the decision-making process, since it is really effective when it comes to the early definition of design problems. While FMEA can be of no use after building the system under development its primary benefit is the early identification of all critical and catastrophic subsystem or system failure modes so they can be eliminated or minimized through design modification at the earliest point in the development effort through specific mitigation actions that are appropriate to deal and overpass the potential risks. In URBANIZED project, more specifically, the extended FMEA methodology is followed, developed at ADVISORS project (Bekiaris & Stevens, 2005), which is based on FMEA, but includes the indicators of *hazard consequence severity, occurrence probability and detectability*, and extends the typical FMEA methodology by covering not only technical risks, but also *behavioural, legal and organizational – related* risks.

Therefore, the guideline is that FMEA should be performed at the system level as soon as preliminary design information is available and extended to the lower levels as the detail design progresses. Taking this into account, in URBANIZED the first stage of FMEA has been performed early in the project duration right after the identification of the Vehicle and the Mission Profile requirements.

Requirements are the starting point of a well-structured and well-performed FMEA and using requirements as baseline provides the best yield of such an analysis. This way an FMEA can be done on concept designs as well as detail designs, on hardware as well as software, and no matter how complex the design is. So, after considered the URBANIZED vehicle to be operating within requirements and specifications, it can be extended by consequently using possible failure modes of one function of the interfacing hardware as a cause of failure for the design element under review and in this way, make the design robust for function failure elsewhere in the system.

The FMEA is a methodology designed to:

- Identify potential failure modes for a product or process.
- Assess the risk associated with those failure modes and prioritize issues for corrective action.
- Identify and carry out corrective actions to address the most serious concerns.

The Failure Modes, Effects and Analysis (FMEA) procedure is a tool that has been adapted in many different ways for many different purposes. It can contribute to improved designs for

products and processes, resulting in higher reliability, better quality, increased safety, enhanced customer satisfaction and reduced costs. It provides a knowledge base of failure mode and corrective action information that can be used as a resource in future troubleshooting efforts and as a training tool for new engineers. In addition, an FMEA is often required to comply with safety and quality requirements, such as ISO 26262, QS 9000, ISO/TS 16949, Six Sigma, FDA Good Manufacturing Practices (GMPs), Process Safety Management Act (PSM), etc.

Before realizing any FMEA, the ground rules (e.g., a set of project selected procedures) are defined. They describe the indenture level of the analysis. In URBANIZED WP2 FMEA, each part failure postulated is considered to be the only failure in the system (i.e., it is a single failure analysis). Additionally, the FMEA is not done on system or component level to evaluate the impact lower level failures have on system operation. It is a high-level risk analysis, on project level, which aims to identify if and how each requirement might fail and the consequences that this failure might have to the whole project.

6.2.2.The extended Failure Mode and Effects Analysis

The overall process proposed by the extended FMEA methodology is summarized in Figure 13 and it combines a number of different types of risk (technical, behavioural, legal and organizational). There may be incompatibilities or conflicts between different issues. Depending on the stakeholders validating the risks, some of the risks are unfavourable to all whilst others may be inconvenient to some but benefit others. The left-to-right arrows in the figure indicate that analysis builds on previous boxes; for example, legal risks are affected by technical failures and human behaviour. As can be seen in the figure, FMEA is only the first part of the process which deals with technological risks, while the rest of the boxes are part of the extended FMEA methodology.

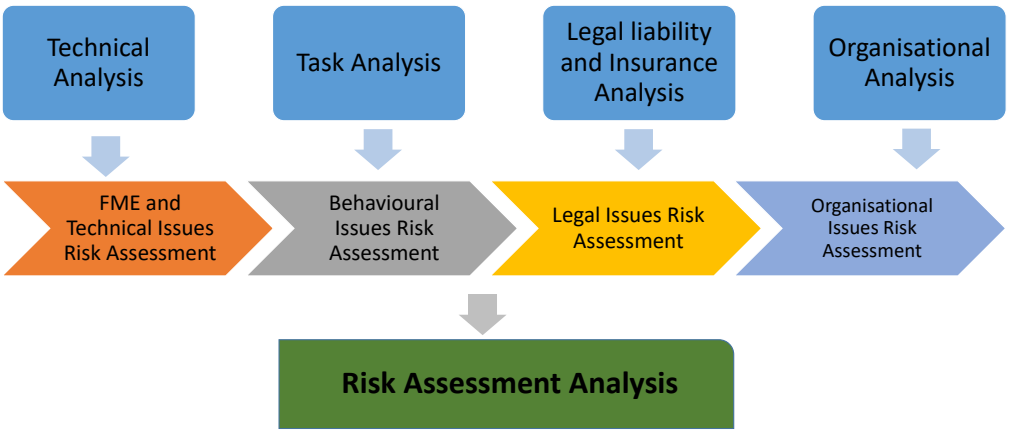

Figure 13: Extended FMEA proposed by (Bekiaris and Stevens 2005)

In general, a risk assessment methodology is comprised by an analysis of risks (i.e. the identification of potential hazards and some estimation of their magnitude) and an evaluation

of the tolerability of that risk in its anticipated context. The steps that follow for the calculation of the risk within the **extended FMEA methodology** as applied in URBANIZED project are depicted in Figure 14.

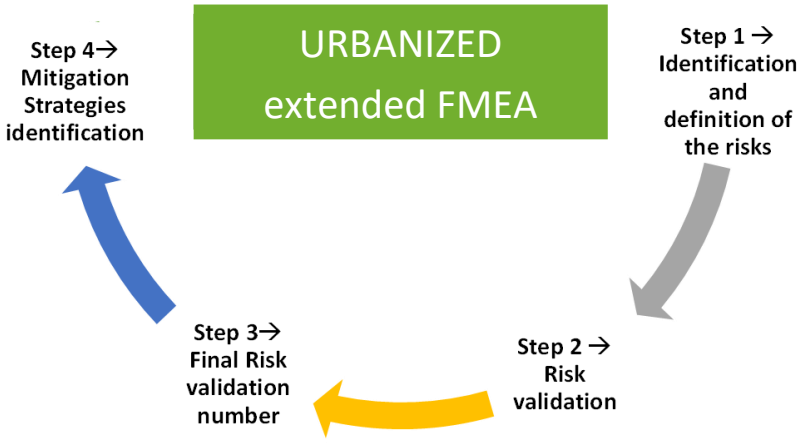

Figure 14: Risk analysis methodology steps.

In the following Sections, the extended FMEA methodology is described step by step, as it will be realised in URBANIZED project in the context of Task 2.3, see Chapter 1. Additionally, an explanation of all the parameters used in the extended FMEA methodology analysis is given together with a reference table for each parameter that helps in understanding the meaning of such parameters and the criteria utilized for the value assignment.

6.2.3.Risk analysis methodology template

A template has been developed, see Table 36, and shared with all the WP2 partners of URBANIZED who have identified the mission profile requirements (see Chapter 3) and the vehicle requirements (see Chapter 4). Each WP2 partner was called to follow the guidelines that accompanied the template to fill it in.

Table 36: URBANIZED risks assessment template

Risk type	Failure Mode/ Hazards	URBANIZED Req ID (Vehicle or MP)	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	Risk judgement							Mitigation strategy (if RN≥13)
						S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	Risk Number (RN)	
Technical **Behavioural** **Legal** **Organisational**													
STEP 1						**STEP 2**						**STEP 3**	**STEP 4**

6.2.4. Risk analysis methodology steps

Step 1: Identification and definition of the risks

The initial step for the extended FMEA methodology is the identification of the risk for each system requirement. Technical assessment considers not fully achieving a requirement due to technical (hardware and software) reasons. Behavioural risks connected with not fully achieving a requirement, are mainly due to the behaviour of users of the vehicle and encompass issues like human error, that can potentially be a barrier for URBANIZED outcome evaluation and/or adoption. Significant legal issues that might lead to not fully achieve a requirement exist when changes of existing or application of new law is required or if there is uncertainty about where large potential liabilities will fall. The regulatory pressures for improved risk assessment and reporting on internal control is of high importance before implementing a specific solution, since organisational risks like accounting failures, frauds, internal control breaches, and governance failures may occur.

Step 2: Risk validation

After the initial identification of the risks, a grade was assigned to each one regarding its *S*=Severity, *O*=Occurrence, and *D*=Detectability. For each type of risk, the level of the above factors is measured accordingly, as shown in tables Table 37 to Table 40.

The Occurrence Probability (O) is the probability that all the risk causes related to the risk modes described in the analysis can occur. This is often a qualitative index especially when new technologies are concerned because of the few reliability data available.

Detectability (D) is the probability to detect the occurrence of a risk mode identified in Step 1 of the methodology. Detection of a developing risk is an important aspect of overall risk management, as early detection is a prerequisite for the application of mitigation strategies. In the technical, and to some extent behavioural, domains, detection can be facilitated by additional sensors and processing. In the legal and organisational domains surveys, monitoring and feedback are important tools.

Table 37: Technical risks

Severity level	**Explanation on technical risks**
5 (extremely severe)	The failure could put user safety at risk.
4 (severe)	The failure implies the total loss of the system functions, resulting in user's dissatisfaction.
3 (slightly severe)	The failure implies the partial loss of the system function, resulting in user's dissatisfaction.
2 (significant)	The failure implies slight dissatisfaction to the user.
1 (insignificant)	The failure does not imply perceptible effects to the system function and to the user's satisfaction.
Occurrence level	**Explanation on technical risks**
5 (extremely high)	It is certain that some failures will sometimes occur.
4 (high)	A failure could occur often.

3 (medium)	A failure could occasionally occur.
2 (slight)	There is only a slight probability that an error/failure will occur.
1 (improbable)	It is unlikely that a fault will occur.
Detectability level	**Explanation on technical risks**
5 (improbable)	It is impossible or improbable that a problematic area will be detected.
4 (slight)	The problematic area is detected only in particular cases.
3 (moderate)	It is probable that the problem will be detected (depending on the situation).
2 (high)	It is very probable that a problem will be detected.
1 (very high)	It is certain that a problem will be detected.

Table 38: Behavioural risks

Severity level	**Explanation on Behavioural risks**
5 (extremely severe)	The user error in operating the system could lead to an incident worseness (i.e., safety effects).
4 (severe)	User behavioural error may abort the system benefits (i.e. safety effects due to changes in ways of acquiring info).
3 (slightly severe)	User's behavioural changes may significantly reduce the positive effects of the system.
2 (significant)	User's behavioural changes may somehow influence the positive effects of the system.
1 (insignificant)	User's behaviour is not expected to reduce the system benefits significantly or may even further enhance them.
Occurrence level	**Explanation on Behavioural risks**
5 (extremely high)	It is certain that some behavioural effects will occur (by the system users).
4 (high)	Some behavioural effects could occur often.
3 (medium)	Some behavioural effects could occasionally occur.
2 (slight)	There is only a slight probability that some behavioural effects will occur.
1 (improbable)	It is unlikely that some behavioural effects will occur.
Detectability level	**Explanation on Behavioural risks**
5 (improbable)	It is impossible or improbable that a user's behavioural effect will be detected.
4 (slight)	The user's behavioural effect is detected only in particular cases.
3 (moderate)	It is probable that the user's behavioural effect will be detected.
2 (high)	It is very probable that the user's behavioural effect will be detected.
1 (very high)	It is certain that the user's behavioural effect will be detected.

Table 39: Legal risks

Severity level	**Explanation on Legal risks**
5 (extremely severe)	Are there laws in each country that do not allow the system to be implemented?
4 (severe)	New laws are required for system implementation and no relevant work has been performed yet.
3 (slightly severe)	New laws are required for system implementation and work required has already been performed.

2 (significant)	New laws are required for system implementation but consensus on them exist.
1 (insignificant)	No new laws are required for implementation.
Occurrence level	**Explanation on Legal risks**
5 (extremely high)	It is certain that some legal problems will occur.
4 (high)	Some legal problems could occur often.
3 (medium)	Some legal problems could occasionally occur.
2 (slight)	There is only a slight probability that some legal problems will occur.
1 (improbable)	It is unlikely that some legal problems will occur.
Detectability level	**Explanation on Legal risks**
5 (improbable)	It is impossible or improbable that a legal problem will be detected.
4 (slight)	The legal problem is detected only in particular cases.
3 (moderate)	It is probable that the legal problem will be detected.
2 (high)	It is very probable that the legal problem will be detected.
1 (very high)	It is certain that the legal problem will be detected.

Table 40: Organizational risks

Level of severity	**Explanation on Organizational risks**
5 (extremely severe)	Wide and different organizational framework is needed, that is completely missing (i.e. new services).
4 (severe)	Organizational framework adaptation is needed (some initial actions have been taken on this domain).
3 (slightly severe)	Organizational framework adaptation is needed which has already started being realized.
2 (significant)	There is a need for limited and easily realized organizational changes.
1 (insignificant)	There is no need at all for organizational changes.
Occurrence level	**Explanation on Organizational risks**
5 (extremely high)	It is certain that there will be a need for organizational restructuring.
4 (high)	A need for organizational restructuring could occur often.
3 (medium)	A need for organizational restructuring could occasionally occur (depending on the needs of the service, that will arise after the operation of the system).
2 (slight)	There is only a slight probability that a need for organizational restructuring will occur.
1 (improbable)	It is unlikely that a need for organizational restructuring will occur.
Detectability level	**Explanation on Organizational risks**
5 (improbable)	It is impossible or improbable that an organizational problem will be detected.
4 (slight)	The organizational problem is detected only in particular cases.
3 (moderate)	It is probable that the organizational problem will be detected.
2 (high)	It is very probable that the organizational problem will be detected.
1 (very high)	It is certain that the organizational problem will be detected.

In addition, at this step the partners defined the reasoning for the severity ranking, the means to avoid the occurrence of the risk and the means to detect the risk.

Step 3: Final risk validation number

After each risk has a grade for all its components, the overall Risk Number is calculated by the following equation:

$$RN = S \cdot O \cdot D \qquad (1)$$

Where:

S = Severity

O = Occurrence

D = Detectability

This overall Risk Number is calculated automatically for each risk at the given template. The total risk that will be calculated has been matched to five levels of severity (with which should be filled in the Risk number 'RN" column of the above table), as follows.

Table 41: Correlation of Overall risk factor with overall risk severity level

Overall risk factor	Overall severity
28-125	I- Severe
13-27	III - Moderate
1-12	V - Insignificant

Step 4: Mitigation strategies identification

The Risk Analysis results may indicate problematic areas in which the system developers are called to put more effort on (i.e. to offer mitigation strategies). The next step is to attempt to assess the risk of each of those issues and to identify possible mitigating strategies.

Risk reduction is an iterative process involving dependencies between the different issues. In terms of mitigation strategies, risk can be reduced in a number of generic ways:

- reducing the magnitude (severity) of the consequences of the potential risk.
- reducing the probability of the risk occurring.
- increasing failure detection speed and probability.
- protecting against the risk-mitigating strategies to compensate for a failure (e.g. back-ups), transferring the risk to another party.

In URBANIZED project's case, which is a very complex system that is comprised by numerus parts and the risk list is endless, mitigation strategies will be offered ONLY FOR THE RISKS THAT ARE SEVERE AND MODERATE (RN≥13).

6.2.5. List of risks and mitigation strategies

Table 42 is the outcome of the risk analysis assessment performed by all the WP2 partners, including the outcomes of all the aforementioned steps. Here, only the severe and moderate risks with RN≥13 are presented. The complete list of risks can be found in (CERTH (b), 2021).

Table 42: List of risks and mitigation strategies

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
1	Legal	The vehicle cannot comply with one (or more) N1 category type approval requirement/s	VR 001	The vehicle shall comply with European N1 category type approval requirements	Change in regulations	EU N1 standards change during project duration	Vehicle cannot be type approved in EU as N1 meaning it cannot be driven in public roads	4	Type approval grant is not in scope within the project but can affect strongly the exploitation of developed solution.	3	EU rules are not changed so often, latest update if date 2021, meaning very recent, so forecast is not for relevant modifications in medium term	2	This risk can be detected immediately monitoring regularly the applicable standards	24	1. Continuous monitoring of EU regulation covering the topic also thanks to support of external consultants ALKE is working with in a continuous way
2	Technical	The vehicle cannot comply with one (or more) N1 category type approval requirement/s	VR 001	The vehicle shall comply with European N1 category type approval requirements	No technical compliance with one EU requirement for type approval	A specific vehicle feature cannot comply with EU requirements for type approval	Vehicle cannot be type approved in EU as N1 meaning it cannot be driven in public roads	4	Type approval grant is not in scope within the project but can affect strongly the exploitation of developed solution.	4	New platform has good amount of new parts vs SOTA. New parts / systems are the most at risk.	2	This risk can be detected immediately monitoring regularly certifications from used items and the design/prototyping evolution	32	1. Continuous monitoring of new parts documentations 2. attention in looking to new design and layout to fit EU standards from early stage

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
17	Technical	The vehicle fully loaded cannot deal with at least 18% slopes without trailer	VR 016	The vehicle fully loaded shall deal with at least 18% slopes without trailer	Technical incompatibility with defined slope performance.	Technical incompatibility with defined slope performance. Not enough power from drivetrain.	Poor performance on slopes, no possibility to go on public road due to lack of type approval compatibility.	5	Compulsory requirements to fit N1 type approval and important safety requirement in general	2	It is quite unlikely for this risk to occur, this target has been defined in line with SOTA model, so there is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. Preliminary simulations 2. Check of drivetrain performance at bench level 3. preliminary additional tests performed as soon as drivetrain is available to the OEM
18	Technical	The vehicle fully loaded cannot deal with at least 12% slopes when coupled with a trailer	VR 017	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer	Technical incompatibility with defined slope performance.	Technical incompatibility with defined slope performance. Not enough power from drivetrain.	Poor performance on slopes, no possibility to go on public road due to lack of type approval compatibility.	5	Compulsory requirements to fit N1 type approval and important safety requirement in general	2	It is quite unlikely for this risk to occur, this target has been defined in line with SOTA model, so there is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. Preliminary simulations 2. Check of drivetrain performance at bench level 3. preliminary additional tests performed as soon as drivetrain is available to the OEM
19	Technical	The vehicle cannot reach at least 130km with a	VR 018	The vehicle shall be able to cover at least 130km with a full charge (WLTP reference)	Technical incompatibility with defined battery performance.	Technical incompatibility with defined battery performance. Too high	Poor performance, low autonomy, not enough for	3	Possible autonomy deviation could affect market acceptance and reduce	3	It is unlikely for this risk to occur, but monitoring is needed, this target has been defined in line	2	This risk can be recognized monitoring regularly the developmen	18	1. Preliminary simulations 2. Check of battery + drivetrain efficiency at bench level

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
		full charge (WLTP reference)				consumption, Wrong design of vehicle (too heavy, not good aerodynamics, ...)	defined mission profiles.		exploitation potential in a medium way.		with SOTA model keeping already some margin. There is already a good expertise on delivering such result on this topic.		t of vehicle design in particular looking to battery and drivetrain compartment		3. preliminary additional tests performed as soon as battery and drivetrain are available to the OEM
24	Technical	The vehicle brakes cannot comply with N1 standards for given GVW/GCW rating	VR 023	The vehicle shall have brakes complying with N1 standards for given GVW/GCW rating	Technical incompatibility with defined braking specs	Technical incompatibility with defined braking specs. Brake system too poor or not well designed/integrated. Usage of wrong components.	Vehicle not in compliance with EU rules, not possible to go on public road, potential risk for users.	5	Compulsory requirements to fit N1 type approval and important safety requirement in general	3	It is unlikely for this risk to occur, this target has been defined in line with SOTA model, so there is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	30	1. Preliminary simulations and check of braking system parts to comply with expected results 2. Preliminary tests specifically oriented to the braking system made at bench level 3. preliminary tests performed as soon as braking system is installed on board the first prototype

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
25	Technical	The vehicle cannot deliver automatic parking brake feature when driver is out the cab	VR 024	The vehicle shall have mechanical/electric parking brake system able to deliver automatic parking brake feature when driver is out the cab	Technical incompatibility with defined braking specs	Technical incompatibility with defined braking specs. Electronic brake at motor level not available or possible.	Not possible to provide automatic brake when driver is out of the cab. Longer times on deliveries to use manual handbrake each time. Possible wear of handbrake system due to too high usage.	4	Automatic brake improve safety in certain scenarios. Lack beside safety issues could reduce exploitation potential in very specific sectors (usage on hilly environments)	4	Risk could occur due to lack of proper technical solution, if drivetrain chosen for instance cannot host such extra brake at motor level.	2	This risk can be recognized monitoring regularly the development of vehicle design	32	1. Preliminary discussions with powertrain partner and OEM, check of feasibility in early stage 2. study of potential alternatives such as mechanical brake with actuator
28	Technical	The vehicle cannot have gravity centre 50mm lower than SOTA	VR 027	The vehicle shall have gravity centre 50mm lower than SOTA	Technical incompatibility with defined design	Technical incompatibility with defined design. Conflict with other parts presence.	Worse driving comfort, lower total height available for loading gods.	2	Possible deviation could affect market acceptance and reduce exploitation potential in a medium way.	4	It is an upgraded feature to monitor in a good way.	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Preliminary 3D simulations to check rear vehicle design to comply with expected results from early stage 2. Exchange of detailed info with drivetrain partner

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
															and OEM to fit such target
29	Technical	The vehicle cannot provide a target weight distribution fully loaded of 35% on front axle and 65% on rear axle.	VR 028	The vehicle shall have a target weight distribution fully loaded of 35% on front axle and 65% on rear axle.	Technical incompatibility with defined design	Technical incompatibility with defined design. Unbalanced design. Wrong estimate of weight of sub-systems	Worse driving comfort for unbalanced weight distribution.	2	Possible deviation could affect market acceptance and reduce exploitation potential in a medium way.	4	It is an upgraded feature to monitor in a good way.	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Preliminary 3D simulations to check front/rear vehicle design to comply with expected results from early stage both empty and fully loaded 2. Get weights of subsystems as soon as possible to calculate properly the new weight distribution
30	Technical	The vehicle cannot operate in a temperature range of -20°C to 40°C	VR 029	The vehicle shall be able to operate in a temperature range of -20°C to 40°C	Technical incompatibility with defined T spec	Technical incompatibility with defined T spec. Borderline temperatures can provide functionality issues to the vehicle.	Vehicle not operating in specific T scenarios or operating in bad way.	5	Vehicle can stop, meaning risk for the usage of the vehicle. In general, this happens before starting the vehicle, not during driving so less risk for passengers but anyway	3	It is unlikely for this risk to occur, this target has been defined in line with SOTA model, so there is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	30	1. Check of all main parts in advance before selection to be able to deal with given T scenario 2. Having possible parts alternatives to replace not compliant items

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
									affect working operations.						
31	Technical	The vehicle cannot have front suspension redesign to fit the new EURONCAP compliant frame	VR030	The vehicle shall provide front suspension redesign to fit the new EURONCAP compliant frame and if possible to allow 4WD front differential housing	Technical incompatibility with suspensions chosen and required safety standards.	Technical incompatibility with suspensions chosen and required safety standards. Suspension layout bring decision to front vehicle design not in line with EURONCAP needs	Vehicle during an accident can collapse on suspension areas generating damages to the occupants.	5	Issues can generate problems for the occupants during accidents	2	Suspension design is not the only parameter affecting the front vehicle design and reinforcement of other parts such as chassis etc. can cover problems on that side.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. Preliminary check of suspension design in the direction of passive safety 2. Frequent interchange on info between ALKE and IDIADA to simulate reaction in case of impact of such part of the vehicle in advance
38	Technical	The vehicle cannot have timed heated windshield	VR037	Timed heated windshield	Lack of heated windshield feature	Lack of heated windshield feature. Front windscreen not compatible with such set-up	Bad defogging during winter of humid seasons. Risk when driving.	5	Lack of visibility can generate accidents when driving.	2	It is quite unlikely for this risk to occur. SOTA already has such feature. There is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	Such feature must be planned in early stage of the cab design

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
39	Technical	The vehicle cannot provide pre-conditioning capabilities for the battery	VR 038	The vehicle shall be equipped with pre-conditioning capabilities for the battery	Technical incompatibility with defined feature	Technical incompatibility with defined feature. Battery cannot host this feature	Lower efficiency during charging and when vehicle is driving due to not optimal battery temp.	2	Lack of this feature can reduce the battery range but not affects safety	4	Not applied on SOTA, must be designed properly. Battery compartment would be affected, and this can be critical	3	This risk can be recognized monitoring regularly the development of vehicle design	24	Such feature must be planned in early stage of the drivetrain/battery/thermal system set-up
46	Technical	The vehicle cannot be equipped with park assist devices	VR 045	The vehicle shall be equipped with park assist devices such as reverse camera and/or front/rear sensors	Technical incompatibility with defined set-up	Installation of reverse camera and/or front/rear sensors don't comply with vehicle design or available spaces.	Risk for damaging the vehicle when operating in narrow places / during parking operations / during operations they require fine-tuned turns-movements.	5	Possibility of small impacts during parking or moving in narrow places. Potential impact against people when reverse driving.	2	It is quite unlikely for this risk to occur. SOTA already has such feature. There is already a very good expertise on delivering such result on this topic.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	Such feature must be planned in early stage and consider proper installation

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
50	Technical	The vehicle cannot have rear suspension redesign to allow new drivetrain housing	VR 049	The vehicle shall have rear suspension redesign to allow new drivetrain housing	Technical incompatibility with defined set-up	Rear suspensions not compatible as layout with new drivetrain size.	Impossible to match the two vehicle components.	5	Vehicle development not possible for incongruence of design	2	It is quite unlikely for this risk to occur. This is taken in consideration for any new project at very early stage.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. such feature must be planned in early stage and consider proper installation
57	Technical	The vehicle cannot have a swap system to allow the swap of different cargo bodies	VR 055	The vehicle shall have a swap system to allow the swap of different cargo bodies in less than 10 minutes.	Technical issues during the development process	Problems risen when developing the new body system. Interference with other parts for the vehicle.	New vehicle cannot count on new modular system. Lower exploitation potential of the new platform.	4	Possible issues on this side could affect market acceptance and reduce exploitation potential when one pillar of the project would miss.	3	Planned swap system is a new concept in the terms of the project but find already a good background on previous development from ALKE. Proper skills are available for the purpose.	2	This risk can be recognized monitoring regularly the development of vehicle design	24	1. such feature must be planned in early stage with proper 3D studies, simulation of dynamic movements, interferences, etc. 2. an early stage prototype of the swap system independently by the development of the vehicle should be developed

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
64	Technical	The van box cannot be able to hold a set of containers which are organized in a rolling frame.	VR 062	The van box shall be able to hold a set of containers which are organized in a rolling frame. The vehicle's rolling frame shall be able to be fast loaded (max 5 min) via a rear door. The vehicle's bags/bins shall be individually accessible via side doors.	Technical issues during the development process	Problems on dealing with expected design of the rolling frame	Not possible to deal with inter-modularity within the van box scenario. Longer loading/unloading time for the full cargo.	3	Issues on dealing with BPOST scenario and similar ones. Possible deviation could affect market acceptance and reduce exploitation potential.	3	The concept is new but ALKE already has large expertise on similar solutions and proper supply chain to ask support for parts if needed.	2	This risk can be recognized monitoring regularly the development of vehicle design	18	1. such design must be planned in early stage with proper 3D studies, simulation of dynamic movements, interferences, etc. 2. an early stage prototype of the system independently by the development of the vehicle should be developed
73	Technical	The refrigerated body cannot deal with an operating temperature of 0°C / +4°C	VR 071	The refrigerated body shall have an operating temperature of 0°C / +4°C and comply with applicable standards for refrigerated food logistics	Technical issues during the development process	Problems on reaching the target temperature at van box level.	Not allowed to make transportation of fresh food, not possible to get proper certification.	4	Lack of this feature could affect market appeal and reduce exploitation potential into food logistics.	2	It is quite unlikely for this risk to occur considering the system not difficult to realize with on-the-shelf components/solutions	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Specific refrigerated body feasibility checked at early stage. 2. Link with specialized partners from the ALKE supply chain to have a preview of the target configuration.

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				(ATP - FRAX certification).											
78	Technical	The e-hand-truck frame fails due to overload	VR 076	The e-hand truck shall have a max size in storing mode inside the vehicle of 40x60x120cm and a max weight of 30 kg (rif. 50th percentile male) without loads attached .	Technical/ e-hand truck failure	Overload of the e-hand-truck frame	There is bending in some areas of the frame. Repair is required	4	It is not severe since it does not prevent its use just reduces its functionality. However, repair is required.	4	The probability of the risk is based on the use of the e-hand-truck, if the e-hand-truck is overloaded this risk will materialize.	2	Visual detection is easy.	32	1. Stickers with max load will be placed on the e-hand-truck 2.A non-catastrophic failure mode will be designed for the e-hand-truck.
82	Technical	Not enough power to achieve the speed of 5 km/h for an overloaded e-hand-truck	VR 080	The e-hand truck shall have a motorized mechanism to allow driving functions and delivering up to 5 km/h max speed on flat paved grounds	Technical	Insufficient wheel torque	The e-hand truck will move slower	2	It is not severe since it does not prevent its use just reduces its maximum speed. No repair is required.	3	Based on the loading of the e-hand truck	4	The e-hand truck will move slower	24	Stickers for of overloading the e-hand truck will be placed on it. The e-hand truck will be able to move at lower speed.

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84	Technical	The charge state of the e-hand truck is no clear.	VR 082	The e-hand truck shall be target of HMI ergonomics study to check its control, configurations and ergonomic use.	Not correctly designed indicator	The indicator is not clearly visible	The e-hand truck may fully discharge without the deliverer noticing it	4	It is moderately severe since all the electric functions will not be available.	1	Based on the placement of the charge state indicator	5	The discharged e-hand truck will have no power	20	The indicator will be placed in a clearly visible position.
85	Technical	The e-hand truck is not charging on board.	VR 083	The e-hand truck shall have a proper Energy Management System able once on board the vehicle to communicate with the vehicle ICT platform.	Technical	Charging port disconnection	The e-hand will not charge while on board	4	It is moderately severe since all the electric functions will not be available.	1	Based on how secured the charging connection is	5	The discharged e-hand truck will have no power	20	The charging connection will be secure, no additional action will be required for the charger connection it will be the same as storing the e-hand truck.
86	Technical	The vehicle is not achieving the targeted energy reduction	VR 084	The vehicle shall integrate a multi-level EMS with fleet connectivity that reduce the energy consumption at least 12.8% using the 4 ECO	Technical	Initial target of 12.8% was inaccurate	Vehicles will not achieve energy reduction, more energy consumption and related	4	The energy reduction is one of the USP's of the project and the vehicle	2	Target is based on initial calculations that are not a result of detailed simulation models	2	Initial calculations that led to 12.8% target can be compared with more detailed simulation results	16	Update the requirement and lower the target value

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
				functionalities during specified missions, compared to not using them			GHG than targeted						along the project		
88	Technical	The vehicle is not achieving the targeted reduction in cost	VR 085	The vehicle multi-level EMS shall deliver a vehicle lifecycle cost reduction of at least 20 % for the specifically defined mission profiles to be tested	Technical	Initial target of 20% was inaccurate	Vehicles will not achieve cost reduction; vehicles may be too expensive over vehicle lifetime	4	The energy reduction is one of the USP's of the project and the vehicle	2	Target is based on initial calculations that are not a result of detailed simulation models	2	Initial calculations that led to 12.8% target can be compared with more detailed simulation results along the project	16	Update the requirement and lower the target value
90	Technical	The vehicle cannot communicate energy related data required for fleet-level energy	VR 086	The vehicle shall communicate energy related data required for fleet-level energy management	Technical issues during the development process	Problems on dealing with expected specific data exchange	No possible to manage cloud-based computing for energy management	4	Lack of this feature can compromise the EMS cloud platform feasibility	2	SOTA vehicle already has a similar solution available, the new one will be an evolution/upgrade so in line with skills available at ALKE and support	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target

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		management									available from ALKE supply chain				
91	Technical	The vehicle cannot communicate vehicle status data for fleet-level diagnostic management	VR 087	The vehicle shall communicate vehicle status data for fleet-level diagnostic management	Technical issues during the development process	Problems on dealing with expected specific data exchange	No possible to manage remote diagnostic management	4	Lack of this feature can compromise diagnostic capabilities of fleet management platform. On board electronics failure not detected remotely.	2	SOTA vehicle already has a similar solution available, the new one will be an evolution/upgrade so in line with skills available at ALKE and support available from ALKE supply chain	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target
92	Technical	The vehicle cannot communicate geo-tracking data for operational fleet-level management	VR 088	The vehicle shall communicate geo-tracking data for operational fleet-level management	Technical issues during the development process	Problems on dealing with expected specific data exchange	No possible to manage cloud-based fleet management tasks	4	Lack of this feature can compromise diagnostic capabilities of fleet management platform. No localization of vehicle.	2	SOTA vehicle already has a similar solution available, the new one will be an evolution/upgrade so in line with skills available at ALKE and support available from	2	This risk can be recognized monitoring regularly the development of vehicle design	16	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
											ALKE supply chain				
93	Technical	The vehicle cannot deal with data transmission system with encryption protocol	VR 089	The vehicle data transmission system shall be equipped with an encryption protocol.	Technical issues during the development process	Problems on dealing with encryption protocol linked to vehicle ICT platform external connection	Risk for data detection and risk to have data stolen. Cyber security risk.	3	Lack of this feature put risk on data security but doesn't compromise main functionalities of the vehicle or the expected operativity	3	SOTA vehicle already has a similar solution available, need to understand new protocols to adopt. ALKE already has good background on the topic it can help on facing the problem.	2	This risk can be recognized monitoring regularly the development of vehicle design	18	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target
98	Technical	The vehicle cannot recognize the driver/operator presence	VR 092	The vehicle shall be able to recognize the driver/operator presence thanks to smartphone pairing or equivalent scenario (transponder, keyless tech, etc.).	Technical issues during the development process	Problems on dealing with expected recognition system	No possibility to adapt actions/features to the presence of a specific operator	3	This is a wished feature but not essential for operations. Not risk for safety or functionality	3	It's a new feature to study from zero but already investigated early stage options to deal with that. Good background of ALKE ICT team.	2	This risk can be recognized monitoring regularly the development of vehicle design	18	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target

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99	Technical	The vehicle cannot unlock automatically the vehicle locks	VR 093	The vehicle shall be able to unlock automatically the vehicle locks (cab doors, van box doors) once the driver/operator is approaching it after a delivery (within 2m distance round the vehicle).	Technical issues during the development process	Problems on dealing with automatization of locks	No possibility to open/close automatically locks in specific circumstances. Time lost for doing that manually.	3	This is a wished feature but not essential for operations. Not risk for safety or functionality	3	It's a new feature to study from zero but already investigated early stage options to deal with that. Good background of ALKE ICT team.	2	This risk can be recognized monitoring regularly the development of vehicle design	18	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target
100	Technical	The vehicle cannot link a large display in the vehicle dashboard area to mirror/replicate information from operator	VR 094	The vehicle shall link a large display in the vehicle dashboard area to mirror/replicate information available on BPOST smartphone fleet management tool to support	Technical issues during the development process	Problems on dealing with mirroring feature or to access smartphone data	No possibility to facilitate operator when inside the cab to access delivery or navigation apps.	3	This is a wished feature but not essential for operations. Not risk for safety or functionality.	3	It's a new feature to study from zero but already investigated early stage options to deal with that. Good background of ALKE ICT team.	2	This risk can be recognized monitoring regularly the development of vehicle design	18	1. Early stage monitoring of such feature. 2. Involvement of ICT team at ALKE and other partners involved to facilitate such target

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		smartphone		operator tasks including navigation features.											
101	Technical	The vehicle shall demonstrate a lower fleet acquisition cost by up to 40 % obtained thanks to the multi-purpose swappable cargo body design having the possibility of using different cargo bodies with a	VR 095	The vehicle shall demonstrate a lower fleet acquisition cost by up to 40 % obtained thanks to the multi-purpose swappable cargo body design having the possibility of using different cargo bodies with a single vehicle to cover fluctuating demands	Modular cargo system more expensive than expected	Modular cargo system components more expensive than expected. Swap system design too complex to make possible cost reduction.	No convenience on adopting the new modular system concept.	4	Lack of this feature could affect market appeal and heavily reduce exploitation potential of the developed solution	3	It's a new feature to study from zero but already investigated early stage options to deal with that. Good background of ALKE on this sense.	2	This risk can be recognized monitoring regularly the development of vehicle design	24	1. Early stage monitoring of such feature. 2. Involvement of technical team at ALKE and supply chain partners to facilitate such target

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
		single vehicle to cover fluctuating demands													
105	Organizational	Total Cost of Ownership (TCO) cannot be reduced at least 10%	VR 099	Total Cost of Ownership (TCO) for a target fleet scenario need to be reduced at least 10%	Expected TCO costs higher than expected	Added systems generate costs higher than SOTA set-up and don't bring major improvement	Solutions is not cost appealing.	5	This element can impact on exploitation strongly if convenience is not clear.	2	Contribution in TCO reduction is affected by many elements but preliminary studies are in the direction to support the convenience, so risk is low rated.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. Detailed monitoring of cost structure from early stage 2. cost oriented selection of parts and solutions considered during the development process
106	Technical	The vehicle cannot demonstrate superior performance compared to benchmark vehicles, under defined	VR 100	The vehicle shall demonstrate superior performance compared to benchmark vehicles, under defined testing scenarios and targets: (e.g. driving experience, stability,	New platform design cannot reach same performance of equivalent ones	Performance is affected negatively by new technical solutions targeting other factors	Poor vehicle performance and drivability	5	This element can impact on exploitation strongly if performance is poor	2	Contribution in performance target is affected by many elements but preliminary studies are in the direction to support the convenience, so risk is low rated.	2	This risk can be recognized monitoring regularly the development of vehicle design	20	1. Performance linked development must be carefully followed from early stage, in particular powertrain performance, weight of the vehicle, battery specs, steering and braking system 2. Preliminary

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		testing scenarios		manoeuvrability, usability, ergonomics, reduced use of urban space)											performance test should be carried out at bench level or with preliminary versions of the vehicle prototype
107	Technical	vehicle not meeting the targeted increase delivery efficiency	VR 101	The vehicle shall demonstrate increased overall delivery efficiency for the targeted missions by at least 30 % (deliveries/day)	Technical	Initial target of 30% was inaccurate	BPost will need more vehicles to deliver all packages than anticipated	4	The delivery efficiency improvement is one of the USP's of the project and the vehicle	2	Target is based on initial calculations that are not a result of detailed simulation models	2	Initial calculations that led to 30% target can be compared with more detailed simulation results along the project	16	Update the requirement and lower the target value
110	Technical	No presence of airbag	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Airbag not installed	No supplier found	"No 4 stars Head impact likely -2 points"	5	Target	5	The risk is highly probable to occur because airbag is necessary to get good punctuation in head / it is possible to be solved by finding a supplier	2	Already detected	50	Risk mitigated by contacting supplier Autoliv

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111	Technical	Seat belt anchorages failure	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Seat belt not properly connected	Wrong dimensioning	"No 4 stars Head impact likely -2 points"	5	Target	5	The risk is highly probable to occur because a bad seatbelt connected has consequences to the passenger (Chest, head). /Proper design by simulation	2	This risk can be recognized during the initial simulations	50	Risk could be mitigated by making simulations
112	Technical	steering column doesn't work properly during the crash test	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	steering column	Wrong dimensioning	"No 4 stars Head impact likely -2 points"	5	Target	5	The risk is highly probable to occur because a bad structure during the crash could collapse causing injuries to the occupant. /Proper design by simulation	2	This risk can be recognized during the initial simulations	50	Risk could be mitigated by making simulations
113	Technical	longitudinal members of the front chassis don't absorb enough energy during	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Crash resistance structure not enough	Wrong dimensioning	"No 4 stars "	5	Target	5	The risk is highly probable to occur because a bad structure during the crash could collapse causing injuries to the occupant. /Proper design by simulation	2	This risk can be recognized during the initial simulations	50	Risk could be mitigated by making simulations

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		the impact													
114	Organisational	Limited number of full crash test (1 frontal crash and 1 side crash)	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Prototype & simulation model are not correlated	"Possible failure: Welding lines not matching between prototype and virtual defined; material characterization test not included in the initial scope, airbag model not correlated (coming from external company), other prototype manufacturing failures."	"No 4 stars "	4	Target	4	The risk is medium probable to occur.	3	Difficult to detect, only during manufacturing and before sign-off	48	Check the critical points on the prototype during manufacturing and before crash. Working with a safety margin del 15% on simulations.

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116	Technical	e-motor controller failure	VR 103	The vehicle shall achieve equivalent Euro NCAP 4 stars rating based on the current Euro NCAP heavy quadricycle assessment protocol.	Short circuit in any component, failure in any component.	Faulty connections, incompatibility, failure in semiconductors.	Motor doesn't start RPM variations.	5	Risk of stopping vehicle	2	Low probability	2	Visual detection	20	Connections are checked properly, repair electrical component if required.
121	Technical	Daily ambient temperature not available	MP 004	The mission profile shall contain the daily temperature as function of time for the specific location of the use case, specified for every month of the year.	Technical	Live connection to weather database not working	Required power for HVAC for vehicle cabin and cargo cannot be predicted, limiting the functionality of the EMS system	3	The vehicle will still be functional, but the demonstration of the developed EMS will not be complete	3	Malfunctioning of connections to external databases are to be expected in a demonstration project	2	Availability of connection to weather database can be checked by controller at all times	18	Implement statistical data of daily ambient temperature in vehicle controller such that EMS algorithm can use this data as a backup in case the live connection to the weather database does not work
129	Technical	Cargo mass estimations inaccurate	MP 008	The mission profile shall contain a cargo mass profile as a function of time per day. This cargo	Technical	Estimations done for the mass of the cargo delivered at each stop is inaccurate	Prediction of energy consumption along the route is inaccurate, as the	2	Vehicle will be fully operational, and routes can be driven, EMS prediction results may be	4	Only average number for mass per delivery is used. Deviations in actual mass are very likely to happen	3	Total cargo mass can be determined at start of each delivery route by	24	More detailed cargo mass information could be provided for each delivery route based on the information of the parcels

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				mass profile will be based on recorded data.			cargo mass will have an influence on energy consumption		inaccurate. Total mass of all cargo/packages should still be quite accurate				weighing pallet		that will be delivered on that route. Weigh total cargo at start of each delivery route
130	Technical	Air humidity information not available	MP 009	The mission profile shall contain a daily air humidity profile as function of time for the specific location of the use case, specified for every month of the year. This can be set up similar as the daily temperature profile.	Technical	Live connection to weather database not working	Required power for HVAC for vehicle cabin and cargo cannot be predicted, limiting the functionality of the EMS system	3	The vehicle will still be functional, but the demonstration of the developed EMS will not be complete	3	Malfunctioning of connections to external databases are to be expected in a demonstration project	2	Availability of connection to weather database can be checked by controller at all times	18	Implement statistical data of daily air humidity in vehicle controller such that EMS algorithm can use this data as a backup in case the live connection to the weather database does not work
142	Technical	vehicle not fully charged during the night	MP 018	The vehicle shall be fully charged during the night	Technical	Charger malfunctioning	Vehicle not fully charged in the morning and cannot start its	3	Logistical planning for demonstration routes expected to be somewhat flexible	3	If the charger is newly installed, some start-up issues may be expected	2	chargers are equipped with diagnostics functionality and can display/report	18	Make sure that sufficient flexibility is planned in the first weeks of the demonstration

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							route at the planned time						malfunctions		
145	Technical	Park lock not engaging	MP 020 + MP 021	The vehicle shall be capable of parking at road slopes of at least 18% slopes when fully loaded without a trailer attached	Technical	Park lock mechanism not engaging (fully) when requested	Vehicle will roll down road slope if not detected	5	Vehicle moving down mountain when driver has already left vehicle can lead to fatal accidents	3	Vehicle not expected to operate on these steep slopes during the demonstration	1	Park lock position can be measured, and vehicle can be prevented from shutting down if park lock not engaged. Dashboard can be used for warning driver	15	Take park lock design into account in functional safety analysis. Only plan demonstration routes with slopes far below the requirement value
147	Technical	Park lock unintended disengaging	MP 020 + MP 021	The vehicle shall be capable of parking at road slopes of at least 18% slopes when fully loaded without a	Technical	Park lock mechanism unintentionally disengaging	Vehicle will roll down road slope if not detected	5	Vehicle moving down mountain when driver has already left vehicle can lead to fatal accidents	3	Vehicle not expected to operate on these steep slopes during the demonstration	5	Once the vehicle is switched off, this failure cannot be detected anymore	75	Take park lock design into account in functional safety analysis. Only plan demonstration routes with slopes far below the requirement

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
				trailer attached											value. Make sure that park lock design is robust and that it cannot unintentionally disengage under high loads
148	Technical	Park lock unintended engaging	MP 020 + MP 021	The vehicle shall be capable of parking at road slopes of at least 18% slopes when fully loaded without a trailer attached	Technical	Park lock mechanism unintentionally disengaging	Harsh vehicle braking	5	Vehicle braking harshly, potentially causing serious danger and/or harm to driver and/or other road users	2	Unintended engaging of the park lock is not likely. It will only happen due to incorrect software or wrong design	3	Park lock position can be measured continuously, but in case of unintentional activation this detection is not fast enough to prevent it	30	Take park lock design into account in functional safety analysis. Make detailed design of park lock system early in project and spend enough time on validating
151	Technical	The vehicle is not able (due to eDrive performance) to accelerate as required	MP 023		Technical. Design	eDrive is too weak (machine, inverter, cooling system, only one gear ratio)	Acceleration too low	5	Customer satisfaction	3	Occurrence is the higher the lower the voltage / careful dimensioning of all relevant components, systems	1	Easy to verify in advance by calculations	15	Increase of the voltage (e. g. up to 96V), 2-gear transmission (costs!), more efficient cooling system (costs!)

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153	Technical	The vehicle is not able to deliver a top speed as required	MP 024	The vehicle shall have a powertrain able to deliver a top speed of: - 70km/h on flat road, no wind, in high speed - 50km/h on flat road, no wind, in low speed	Technical. Design	eDrive is too weak (machine, inverter, cooling system, only one gear ratio)	Top speed too low	5	Customer satisfaction	3	Occurrence is the higher the lower the voltage / careful dimensioning of all relevant components, systems	1	Easy to verify in advance by calculations	15	Increase of the voltage (e. g. up to 96V), 2-gear transmission (costs!), more efficient cooling system (costs!)
155	Technical	The vehicle fully loaded shall deal with at least 18% slopes without trailer	MP 025	The vehicle fully loaded shall deal with at least 18% slopes without trailer	Technical. Design	eDrive is too weak (machine, inverter, cooling system, only one gear ratio)	Vehicle cannot drive uphill	5	Customer satisfaction	3	Occurrence is the higher the lower the voltage / careful dimensioning of all relevant components, systems	1	Easy to verify in advance by calculations	15	Increase of the voltage (e. g. up to 96V), 2-gear transmission (costs!), more efficient cooling system (costs!)
158	Technical	The vehicle fully loaded shall deal with at least 12%	MP 026	The vehicle fully loaded shall deal with at least 12% slopes when coupled with a trailer.	Technical Design	eDrive is too weak (machine, inverter, cooling system, only one gear ratio)	Vehicle cannot drive uphill	5	Customer satisfaction	3	Occurrence is the higher the lower the voltage / careful dimensioning of all relevant components, systems	1	Easy to verify in advance by calculations	15	Increase of the voltage (e. g. up to 96V), 2-gear transmission (costs!), mor efficient cooling system (costs!)

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		slopes when coupled with a trailer.													
168	Behavioural	Lack of IoT capacity (telematics) for the provision of real time information regarding COI operation	MP 029 MP 030	[CI] The vehicle shall show a fleet-level reduction of daily driven distances by at least 15%, using a simulation environment. [CI] The vehicle shall show a fleet-level reduction of idle time by at least 20%, using a simulation environment.	External transport operators	IoT capacity (telematics)	No real time information	2	Raw data will be collected manually thus the user's behavioural changes won't be affected much	4	It is quite possible for this risk to occur since the common practice of transport operators for last mile operations to not using IoT solutions for data capturing	2	This risk can be detected immediately following the first set of data collected.	16	1. Developing a strong collaboration strategy for exchanging information and knowledge on their current operation. 2. Developing well defined and multiple scenarios for last mile distribution for mitigating the risk of lack of data.
169	Organizational	Lack of resources for replacing COI and external	MP 031	[CI] The vehicle shall be able to deliver fresh and non-fresh products from	Financial	Lack of resources	Low penetration of electric vehicles	5	Without the resources it is quite unlikely this change towards	5	Replacing the fleet needs a great investment and constitute a great risk for a	2	This risk can be detected immediately following the first discussions	50	1. Developing clear policy recommendations that will support the last mile operators

No	Risk type	Failure Mode/ Hazards	Req ID	Requirement description	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	RN	Mitigation strategy
		transport operators' conventional fleet with electric vehicles		distribution centres to local shops.					electromobility to happen		private company.		with the company		towards this change and will provide the appropriate incentives to the companies for changing their current conventional fleet with the URBANIZED solutions. 2. Communicating the benefits and the opportunities arising from the use of the URBANIZED solution to the companies involved as well as to other companies in the same sector.

6.3 A-priori risk analysis conclusions

From the realization of the URBANIZED risks analysis, 169 risks have been identified in total. The majority of them, 152, are technical risks, 3 are behavioural risks, 2 are legal risks and 12 are organizational ones. From those 169 risks, 114 were considered to be insignificant (RN 0-12) and no mitigation strategy needed to be provided from them. 42 were considered to be of moderate importance and only 13 were considered to be severe (see chart below). So, 55 risks in total needed mitigation strategies.

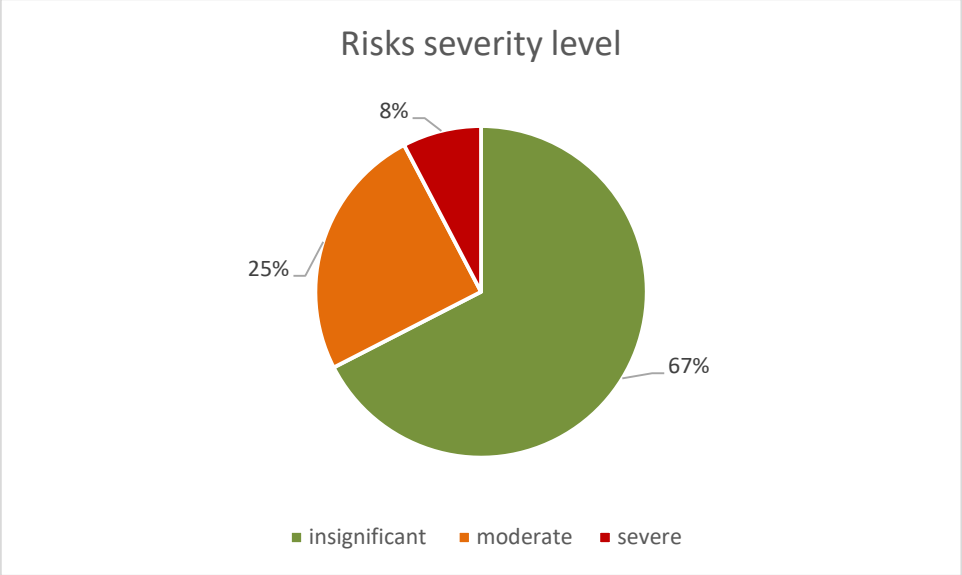

Chart 1: URBANIZED risks severity level percentages

From the 55 risks that were of moderate or severe importance, 42 were connected to vehicle requirements and 13 to mission profile requirements. The 13 severe risks were in their majority technical including also 2 organisational risks, one connected to VR103 that relates to the Euro NCAP 4 stars requirement and the other one is connected to MP31 which related to Coffee Island Use Case and more specifically the freshness of the products to be delivered. Table 43 summarises the risks by severity level and type for all the requirements.

Table 43: Summary of potential a priori risks in URBANIZED, per severity level and type

Issue severity	Technical risks	Behavioural risks	Legal risks	Organisational risks	Total
Insignificant	103	2	0	9	7
Moderate	38	1	2	1	31
Severe	11	0	0	2	27
Total	**152**	**3**	**2**	**12**	**86**

As the work is in progress and the requirements will pass to the next work packages (WP3 and WP4 for the vehicle design, WP5 for the vehicle build and WP6 for the vehicle validation) they will be the basis upon which the vehicle will be built. The risks analysis provides a very important guidance on these developments. The developers of the next work package should have in mind the risks analysis and specifically the requirements with the greater failure risk and probably start from them in order to avoid facing high risk issues at the end of the project/development cycle.

Since mitigation strategies have been proposed for all moderate and severe risks then the overall risk importance has been moderated. The next steps will reveal which of these risks actually occurred and if the mitigation strategy worked as designed.

6.4 Risk analysis next steps

Based on the initially detected risks of the a-priori risk analysis, the risks that will be actually met and the way they were dealt with (either during the development or during the tests) will be presented in the a-posteriori risks analysis which will be performed at M30 Feedback will be provided both by the pilot sites and the URBANIZED technical and use cases development teams following the templates presented below. The difference between the a-priori and the a-posteriori template is that the "Risk judgement**"** is relevant to the actual severity, probability and detectability that is related to the risk that actually happened. Additionally, regarding the mitigation strategies, one column is used for the mitigation strategy performed and another one for the mitigation strategy proposed after the occurrence of the risks (if different). In that way the mitigation strategies that have been proposed at the a-priori risks assessment can also be validated. Here mitigation strategies performed and proposed will be added for all risks that occurred regardless their severity level.

The same template will be used also for risks that occurred but were not foreseen at the a-priori risk analysis.

Table 44: URBANIZED actual risks assessment template

Risk type	Failure Mode/ Hazards	URBANIZED Req ID (Vehicle or MP)	Failure Cause (main)	Failure Cause (detailed)	Failure Effect (result)	ACTUAL Risk judgement							Mitigation strategy performed	Mitigation strategy proposed (if different)
						S	Severity Reasoning	O	Occurrence probability / Avoiding means	D	Detection means	Risk Number (RN)		
Technical														
Behavioural														
Legal														
Organisational														

7.Conclusions

This document reports the results of work package 2 of the project URBANIZED. These results correspond to the development of the mission profile requirements, vehicle requirements and design specifications, on which the design and implementation of the demonstrator vehicle will be based. Additionally, the report also includes a preliminary risk analysis of possible problems that the project might encounter during development.

The mission profiles requirements presented in this report are tailored for the two project use cases: BPost and Coffee Island. A total of 31 requirements were identified. These requirements are clustered in KPIs, a drive cycle, and performance requirements. KPIs capture the improvements that the vehicle will show, when used on a fleet level. Drive cycles definitions are derived from input data of the end users (e.g., route coordinates) and from a software tool that enriches the provided data (e.g., with traffic conditions). These drive cycles capture an average trip that the vehicle would encounter in a regular operation. Performance-related requirements guarantee that the vehicle can fulfil the intended usage of the end users. Each mission profile requirement includes an assessment strategy, which will be carried out at the end of the project.

The vehicle requirements are derived based on the mission profile requirements, such that the resulting vehicle design meets the expectations of the end users. A total of 103 vehicle requirements were identified. The vehicle requirements are subdivided in ten parts: key performance indicators, main specs & performance, front part of the vehicle, cabin and comfort, rear part of the vehicle, drive train and battery, modular cargo body, ICT platform and energy management system, economic analysis and efficiency, passive safety. As with the mission profile requirements, each vehicle requirement is accompanied by an assessment routine to be carried out at the end of the project.

From the vehicle level requirements, the design specifications for the vehicle components are derived. A total of 113 design specifications were found. The design specifications have been divided in nine parts: main specs & performance, front part of the vehicle, cabin and comfort, rear part of the vehicle, drive train and battery, modular cargo body, ICT platform and energy management system, economic aspects, passive safety.

The risk assessment is carried out using the Failure Mode and Effects Analysis (FMEA) methodology. A step-by-step explanation of the FMEA tool used is proposed together with a excel template, where partners inputted risks related to their developments. The FMEA tool is applied on two phases: an a-priory analysis and an a-posteriori analysis. In the a-priory analysis, a total of 169 risk were found. From those, 55 were of moderate or severe importance, with 42 connected to Vehicle requirements and 13 to Mission Profile requirements. A mitigation strategy is already proposed for each of these risks. The a-posteriori analysis will be carried out at M30 based on the initially detected risks of the a-priori risk analysis, the risks that will be actually met and the way they were dealt with (either during the development or during the tests).

Acronyms

Acronym	Meaning
2WD	2 Wheel Drive
4WD	4 Wheel Drive
BEV	Battery Electric Vehicle
CAN	Controller Area Network
COI	Coffee Island
DAB	Digital Audio Broadcasting
DOA	Description of Activities
EMS	Energy Management System
EPS	Electric Power Steering
EU	European Union
EV	Electric Vehicle
FMEA	Failure Mode and Effects Analysis
GCW	Gross Combined Weight
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HoReCa	Hotel/Restaurant/Catering
HV	High Voltage
ICT	Information and Communication Technology
KPI	Key Performance indicator
lat	latitude (in context of GPS position)
LCV	Light Commercial Vehicle
LHD	Left Hand Drive
lon	longitude (in context of GPS position)
MPG	Mission Profile Generator
MPR	Mission Profile Requirement
OBJ	Objective
OEM	Original Equipment Manufacturer
OBC	On-Board Charger
RHD	Right Hand Drive

SORT	Standardised On-Road Test
SOTA	State of the Art
TCO	Total Cost of Ownership
URBANIZED	modUlaR and flexible solutions for urBAN-sIzed Zero-Emissions last-mile Delivery and services vehicles
VR	Vehicle Requirement
WLTP	Worldwide harmonized Light vehicle Test Procedure
WP	Work Package

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