D2.5 Technical requirements and targets integrated for pilots

Project ref. no.	HORIZON-CL5-2024-D5-01-06 GA. N.º 101192375
Project title	Shifting to zero-emission logistics with right-sized, mission-focused, N1 eLCVs
Project duration	1st January 2025 – 30th June 2028 (42 months)
Related WP/Task	WP2 / T2.5
Dissemination level	PUBLIC
Deliverable type	REPORT
Document due date	M12 (31.12.2025)
Actual delivery date	29.12.2025
Deliverable leader	RWTH
Document status	Submitted

Co-funded by the European Union

The Shift2Zero project has received funding from the European Union Horizon Europe Programme: project num. 101192375. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA Neither the European Union nor the granting authority can be held responsible for them.

Deliverable information sheet

Version	Date	Author	Document history/approvals
0.1	06/11/2025	Lukas Seibertz, Christopher Peters (RWTH-IKA)	Draft version
0.2	04/12/2025	ALI, ALKE	Revision by cross readers
1.0	10/12/2025	Lukas Seibertz (RWTH-IKA)	Validation and release of final version
	17/12/2025	Project Coordinator (EUT)	Last checks
1.0	29/12/2025	Project Coordinator (EUT)	Submission

Executive summary

Project summary

Shift2Zero, Shifting to zero-emission logistics through right-sized, mission-focused, N1 e-LCVs

Current market dynamics in EU reveal a gap between supply - existing N1 vehicles, and demand - evolving needs of urban logistics and climate targets. In 2023, 1.2M new LCV registrations were diesel-powered, and only 108,200 battery electric. Last-mile logistics, the least efficient and most complex part of the supply chain, presents significant opportunities for improvements at vehicle and operations levels. Dynamic requirements and increasing environmental impact require innovative solutions from the automotive industry, both from high volume OEMs and new entrants. S2Z aims to capitalize on the benefits of both vehicle platforms in the N1 segment - represented by IVECO's eDaily multipurpose platform, and Alke's ATX design-for-purpose platform - ultimately contributing to "Shifting to zero-emission logistics through right-sized, mission-focused, N1 e-LCVs".

To achieve this vision, S2Z proposes a 4-step user- and mission-centric design approach placing end-users and their needs at the core of all project activities. To this end, S2Z involves 5 LSPs & mobility operators as partners: Gruber, DHL, Diakinisis, Clem, DPD. As a result, S2Z will co-develop and shape at least 6 novel N1 concepts with enhanced and safe functionalities leading to tighter market fit, particularly in the segments of e-commerce, returns and cold deliveries.

Innovative concepts, from modular cargo bodies to vehicle control strategies with optimized tyres & brakes, as well as dual transport of people & freight, will be physically prototyped and tested in real-life operations in 6 pilot sites (Belgium, Greece, Italy, 2 in Norway, Poland).

S2Z brings a multidisciplinary consortium of 30 partners from 10 countries to cover the complete automotive and logistics value chains, complemented by policymakers to effectively ensure route to market: overcoming barriers for the adoption of S2Z eLCVs, reducing operational costs and environmental impact in scalable urban & sub-urban operations.

D2.5 Executive summary

Deliverable 2.5 documents the process of user-centred requirements elicitation for the Shift2Zero innovations within Task 2.5 (User requirements analysis for pilot preparation and definition of technical requirements), starting with the project and ending with the completion of Work Package (WP) 2 in project month 12. The aim of this deliverable is initially to summarise the information gained from Tasks 2.1 (End-user & stakeholder mapping, user-specific contexts & needs), Task 2.2 (User-specific needs for conceptual design guidelines), Task 2.3 (User-specific preferences and trade-offs) and Task 2.4 (Synergies with new logistics concepts & innovations). Based on these insights, the findings are transferred into a harmonised list of requirements. These requirements are then validated through co-creation workshops from the user perspective and through discussions from the developer perspective. This final list of requirements covers the perspective of the various users and stakeholders and the necessary characteristics and capabilities that the innovations need to fulfil. These requirements in turn form the basis for further innovation development of WP 3 conceptual designs and ensure that the innovations meet the actual needs of users and stakeholders by offering tangible added value.

To collect the requirements for the Shift2Zero innovations, a systematic and methodical approach is applied. User needs and initial requirements are collected through expert interviews, workshops with end users, surveys, simulations and discussions in Task 2.1 to Task 2.4. In total, 87 interviews, eight workshops, seven mapped ecosystems, a survey with 512 participants and seven simulations provide a

solid data basis with well-founded insights. These user needs and preliminary requirements are then thoroughly analysed, converted into formal requirements and sorted thematically. Based on this foundation, the systematic documentation of requirements is carried out in a central requirements list.

After this step, the requirements are available in a complete and unambiguous form, making it possible to validate them from both the user and developer perspectives. The user side validation aims to validate the earlier interpretative step in which user statements were transformed into formal requirements. For this purpose, co creation workshops in Bologna, Padua and Aachen are conducted at three locations in collaboration with Gruber Logistics, Alke Electric Vehicles, RWTH Aachen University and additional external companies. Using augmented reality glasses, an immersive scenario is created that allows participants to digitally experience the Shift2Zero innovations at this early project stage. The realistic and interactive representation allows participants to open doors, test mechanisms and evaluate ergonomic usability. All relevant insights from these activities are then integrated into the requirement list.

In addition to the validation from the user perspective, validation from the developer perspective is equally important to ensure technical feasibility and to maintain the intended project focus. For this purpose, the requirements are aligned with the responsible developers in several iteration cycles, beginning at the General Assembly in Bergen in September 2025.

After completing the final iteration loop of the requirements list in Task 2.5 and incorporating feedback from both users and developers, the requirements for each innovation are documented in an updated version. This requirement list is the outcome of this deliverable and contains 181 formulated requirements, providing a detailed description of the objectives for the Shift2Zero innovations while considering the social, political, economic and technical layers.

These requirements now serve as the baseline for the design and development of innovative vehicle solutions within Work Package 3. This ensures that the eLCV innovations developed within Shift2Zero are not only technologically advanced but also practical, user friendly and market oriented.

Furthermore, the requirements contribute to the planning of pilot activities in Work Package 6. Within these pilot activities, the developed innovations will be tested and verified in real life demonstrations. Finally, based on the current requirements, an adapted and validated list of user needs and technical requirements will be generated that reflects the practical experience gained.

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Terminology and Acronyms

AR	*Augmented Reality*
EC	*European Commission*
(e)LCV	*(electric) Light Commercial Vehicle*
EU	*European Union*
IKA	*Institute for Automotive Engineering*
LSP	*Logistics Service Provider*
RWTH	*Rheinisch-Westfälische Technische Hochschule Aachen*
S2Z	*Shift2Zero*
V2G	*Vehicle-to-Grid*
V2L	*Vehicle-to-Load*
WP	*Work Package*
ZEZ	*Zero Emission Zone*

1. Introduction

Shift2Zero aims to promote zero-emission logistics solutions for sustainable urban mobility. To achieve this, it develops six innovative concepts tailored to the N1 electric vehicle segment to improve operational efficiency and minimize emissions. A key focus of the project is to ensure that these innovations are developed in line with the needs of users and stakeholders. For this purpose, various methods were used in Work Package 2 (WP 2) to gather user needs and requirements at the system, fleet and vehicle levels. Finally, a comprehensive list of technical requirements has been compiled, which will be incorporated into the design and development phase in WP 3.

Grasping these requirements is vital for crafting relevant solutions and preventing unnecessary expenditure on issues that may not exist. The Shift2Zero design approach keeps stakeholders engaged throughout the entire development process, ensuring that vehicles are designed to meet both current and anticipated demands in urban logistics.

So far, Tasks 2.1 to 2.4 have provided needs and requirements for different stakeholders. Thereby, Task 2.1 has focused on end-user identification and requirement elicitation through in-depth interviews, Task 2.2 on workers and fleet managers through user workshops. Within Task 2.3 user-specific surveys featuring choice experiments were conducted, whilst in Task 2.4 new logistic concepts and innovations were investigated regarding synergies with simulation models. Task 2.5 now aims to summarize the information from the previous tasks and provide it for further development in the form of a unified requirements list within deliverable D2.5.

1.1 Objectives of the deliverable

The aim of this deliverable D2.5 is to derive one holistic requirement list by consolidating all relevant user and technical requirements. The user needs and preferences from the concluded Tasks 2.1 to 2.4 are analysed in co-creation workshops and refined into one requirements list. This requirements list is intended to support the development of the six project innovations, as well as the use cases (WP3 and 4) and the preparation of the pilots for real-life demonstration (WP6).

1.2 Structure of the deliverable

The structure of this deliverable is intended to lead the reader from the theoretical background through the practical implementation to the future application of the findings. Chapter 2 presents the theoretical framework and the method applied to collect user-centred requirements. Chapter 3 explains the practical implementation of this approach and covers the collection, analysis, documentation, validation and adjustment of requirements carried out in collaboration with the project partners. Finally, Chapter 4 summarises the developed content. It outlines how the identified requirements will be integrated into the ongoing project work within Shift2Zero to support the development of innovations and preparation of the pilots for real-life demonstration. Additional materials, such as the results of the co-creation workshops and the list of requirements are available in the annex.

2. Methodical approach

To ensure that systems or components meet all necessary attributes, capabilities and constraints, requirements serve as fundamental building blocks within the context of engineering and product development. They are essential for guiding the design, development and validation processes throughout the lifecycle of a product. Requirements act as a roadmap for designers and developers by providing clear specifications on what needs to be realised. Partsch (2010) describes requirements as statements about the properties to be fulfilled or the services sic to be provided by a system or product, a process, or the people involved in the process. Typically, they include information about why a system is being designed, what this system is supposed to achieve and what constraints must be adhered during its development[1].

Moreover, requirements establish a shared understanding among all relevant stakeholders regarding what the product will entail. This alignment helps manage expectations and reduces the risk of misunderstandings between different parties involved in the project. This aspect is particularly critical in collaborative initiatives like Shift2Zero, which consists of multiple project partners. The earlier a shared understanding is reached, the greater the stakeholders' ability to exert influence becomes; conversely, this reduces the likelihood of costly changes during later phases of the project. Figure 1 highlights this coherence.

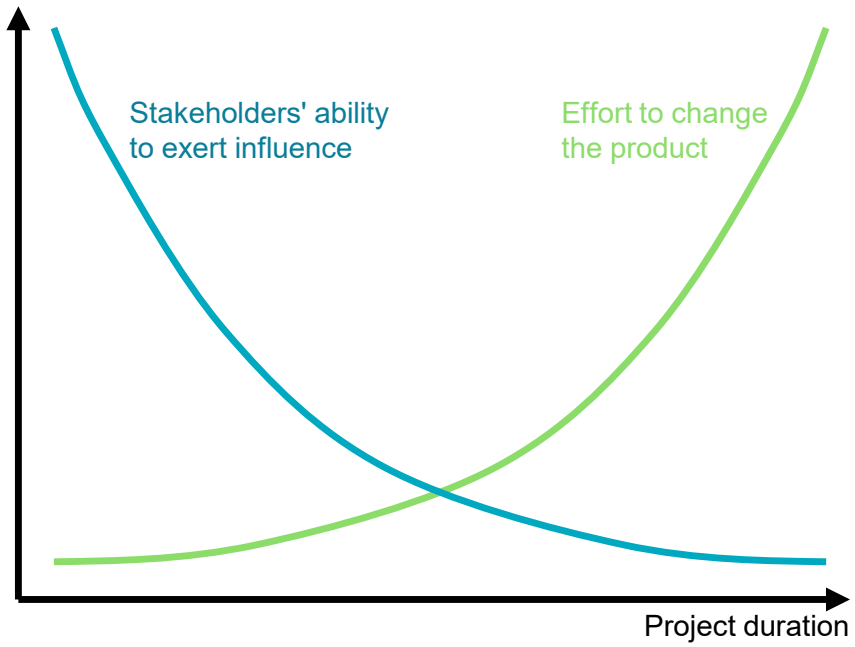

Figure 1. "Rule of 10" regarding influence and effort needed to change the product[2]

[1] Partsch, H. A. (2010). Requirements-Engineering systematisch
[2] Peterjohann, H. (2023). Die 10er-Regel der Fehlerkosten

A well-defined requirement is characterized by its clarity, feasibility and necessity. Clarity ensures that all stakeholders have a mutual understanding of what is being specified; ambiguity can lead to misinterpretations and project failures. Feasibility assesses whether the requirement can realistically be achieved within given constraints such as time and budget while ensuring that it aligns with technological capabilities. Finally, necessity addresses whether the requirement adds tangible value to the overall system; unnecessary requirements can complicate design efforts without contributing meaningful benefits.

Requirements can be classified into various categories. One classification method is the Kano model[3]. This framework is used to prioritize and categorize requirements in product development in relation to customer satisfaction. The Kano model is represented in Figure 2. Developed by Professor Noriaki Kano in the 1980s, it classifies requirements into five distinct categories: Must-be, one-dimensional, attractive, indifferent and reverse.

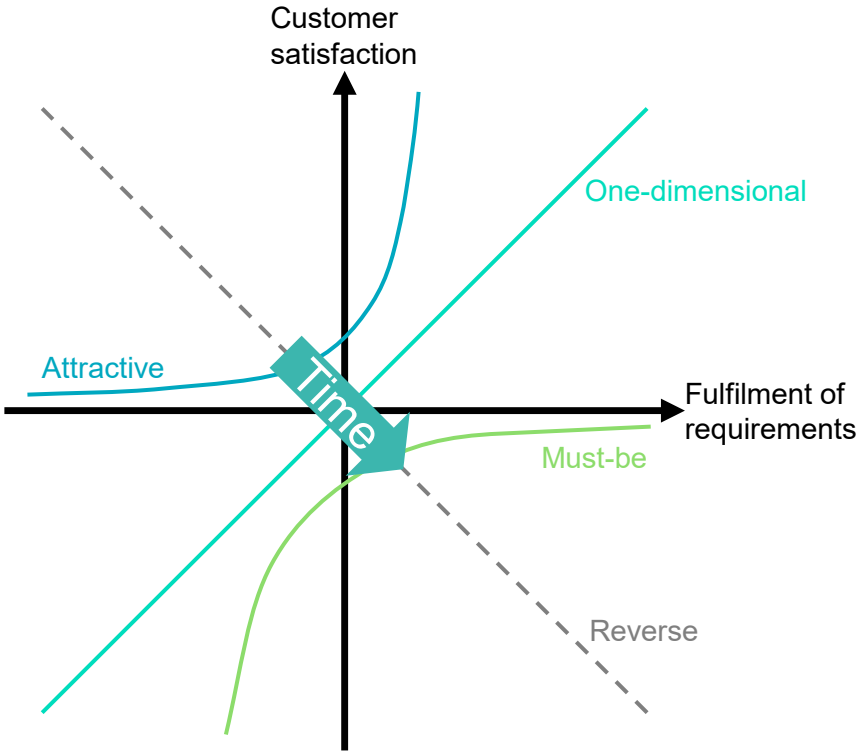

Figure 2. Kano model based on Feldhusen and Grote (2013)[4]

Must-be contains all essential requirements that customers expect and take for granted. Failing to meet them will result in dissatisfied customers. Since customers take these requirements for granted, they often do not communicate them, making it essential to identify these implicit requirements[5]. One-dimensional requirements provide direct

[3] Kano, N; Seraku, N; Takahashi, F; Tsuji, S (1984). Attractive Quality and Must-Be Quality
[4] Feldhusen, J; Grote, K.-H. (2013). Pahl/Beitz Konstruktionslehre
[5] Ulwick, A. W. (2005). What customers want. Using outcome-driven innovation to create breakthrough products and services

satisfaction proportional to their level of fulfilment. These requirements are explicitly demanded by the customers. Attractive requirements refer to unexpected features that the customers are not aware of beforehand. Over time, as features become more familiar or standardised, requirements that were once classified as attractive may shift and become classified as one-dimensional or must-be later on. Indifferent requirements are those features that do not impact customer satisfaction, regardless of whether they are included in the product or not. Within the Kano model indifferent requirements correspond with the X-axis. Lastly, reverse requirements are aspects that can lead to dissatisfaction when present and satisfy the customers when not present.

Tenet of Design Thinking and the User-Centred Design process is to understand the perspective of users for the successful development of solutions or systems. "Users" encompass not only the people with the main contact to the product but also all stakeholders involved in the system. This comprehensive understanding ensures that diverse needs and expectations are taken into account throughout the design process. For each stakeholder requirements are identified, analysed, documented, validated and adjusted. This process is based on the steps described by Hood et al (2007)[6]. This model is adopted by enhancing the first step *requirements elicitation* into two separate steps *identification* and *analysis*. In Figure 3, the process from the requirement identification to the final requirement list is illustrated.

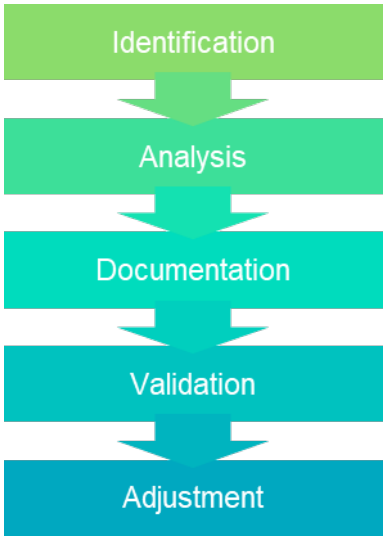

Figure 3. Process to derive requirements based on Hood et al. (2007)

[6] Hood, C.; Mühlbauer, S.; Rupp, C.; Versteegen, G. (2007). iX-Studie Anforderungsmanagement

Identification

Users often do not articulate their requirements directly[7]. Instead, they express their experiences, desires and challenges. Additionally, users may not be aware of the specific technical details or functionalities needed to address their needs. Therefore, it is crucial to translate the requirements from the users via their statements. By systematically analysing the users' statements, the underlying requirements are unveiled. For this reason, user statements are translated into user needs, which in turn are translated into user requirements. This process ensures that all user needs are incorporated into the final list of requirements for the design of the system.

In the first step, user statements must be collected via direct expressions or comments from users. These statements can be gathered through interviews or surveys[8]. User statements reflect the subjective experiences, desires and challenges faced by the users. It is important to document these statements in their original form to authentically capture the users' perspective.

The second step involves deriving user needs from the collected user statements. In this phase, the statements need to be analysed to identify underlying needs and motivations. During this process, attention should be paid to recognizing patterns and filtering out general needs. Implicit needs, that are not explicitly mentioned but crucial for user experience (compare Kano model) are also taken into account.

In the final step, the user requirements are formulated based on the identified user needs. These requirements are formulated so they fulfil clarity, testability, feasibility and necessity. The user requirements describe what the system must achieve to meet the user needs effectively.

Additionally, requirements can also originate from other sources beyond user statements[9]. Standards and regulations define mandatory requirements that must be adhered to. Previous projects provide insights and lessons learned, from which new requirements can be defined. Furthermore, market analysis identifies trends and demands that are necessary for competitive advantage. Lastly, internal processes within an organization yield operational requirements aimed at improving efficiency or effectiveness in delivering services. By extending the user requirements to include these additional sources, a comprehensive understanding of the requirements needed for the successful innovation development is ensured.

Analysis

After the identification of requirements, they must be formalized and formulated in an understandable manner. To categorizes requirements, Heßeler et al. (2004) differentiate between "must" and "desire" requirements[10]. They propose to use the verbs *must*, *must not* and *should,* to distinguish between the two requirement categories. For each requirement, a single sentence should be used, nested sentences that conceal multiple

[7] Ulwick, A. W. (2005). What customers want. Using outcome-driven innovation to create breakthrough products and services
[8] Partsch, H. A. (2010). Requirements-Engineering systematisch
[9] Feldhusen, J; Grote, K-H (2013). Pahl/Beitz Konstruktionslehre
[10] Heßeler, A; Hood, C; Misslind, C; Stücka, R (2004). Anforderungsmanagement

requirements should be avoided. To assess the quality of the formulated requirements, Heßeler et al. (2004) have defined criteria in the form of control questions:

- Is the requirement content-wise correct?
- Is the requirement complete, or does it only describe a partial aspect?
- Is the requirement clearly understandable?
- Is the requirement consistent and does it not conflict with any other requirement?
- Can the requirement be tested for proper implementation?
- Is the requirement unambiguous, or does it allow for different interpretations?
- Is the requirement feasible both in terms of time and considering the planned costs?

Additionally to Heßeler et al. (2004), the IEEE 830 standard describes the properties or characteristics of requirements for a high-quality requirements list[11]. Ideally, the requirements are:

- Necessary
- Appropriate
- Unambiguous
- Complete
- Singular
- Feasible
- Verifiable
- Correct
- Conforming

To ensure an understandable and consistent formulation of requirements, Rupp (2014) developed the requirements template *MASTeR (Mustergültige Anforderungen – die SOPHIST Templates für Requirements*, English *Exemplary Requirements - the SOPHIST Templates for Requirements*)[12]. This MASTeR exists for functional and non-functional requirements in different versions, i.e. functional requirements with and without conditions and various non-functional requirements. Rupp determines the requirements template as a blueprint that defines the structure of an individual requirement statement. Figure 4 depicts the MASTeR for a functional requirement without conditions.

[11] ISO/IEC/IEEE (2018). Systems and software engineering – Life cycle processes – Requirements engineering
[12] Rupp, C (2014). Requirement Engineering und Management

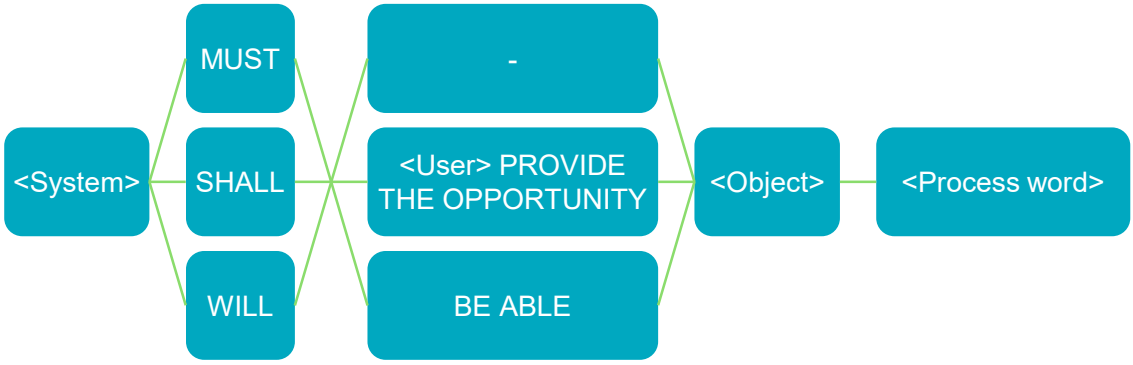

Figure 4. Requirements template according to Rupp (2014) for functional requirements without conditions

The construction of requirements according to the requirements templates allows each requirement to have a similar structure. Rupp thereby uses a similar categorisation of requirements with *must* and *shall* as Heßeler et al. (2004).

Documentation

To ensure consistency, traceability and effective communication among all stakeholders it is necessary to store the collected and formulated requirements in a central document. A centralized requirements list acts as a single source of truth, enabling all stakeholders to access the most up-to-date information regarding requirements throughout the project lifecycle. This approach minimizes the risk of miscommunication or discrepancies that may arise from having requirements scattered across multiple documents or platforms. Additionally, it facilitates easier management and tracking of changes, ensuring that all stakeholders are aligned with the project's goals.

As a first step, all requirements gathered are checked for consistency and possible duplicates. The categorization of requirements within the central requirements list is carried out based on several key aspects. Each requirement is assigned a unique number for clear identification, classified into a high-level category that reflect its overarching purpose and detailed with the specific requirement statement itself. The origin of each requirement is noted to track its source. Requirements are further classified into social, political, economic and technical categories to highlight their context and impact. Prioritization according to the Kano model helps identify which features will most significantly enhance user satisfaction. Finally, the definition of the responsible person, department or company ensures accountability in meeting these requirements. This structured approach not only streamlines the development process but also enhances collaboration among team members and stakeholders involved in the project.

Validation

Following the documentation of requirements, it is crucial to conduct requirement validation to ensure that they are complete and aligned with user needs. This process involves the review of the requirements by future responsible developers for completeness and feasibility, ensuring that all necessary aspects have been addressed.

Additionally, users play a vital role in this validation phase through the use of prototypes and mockups during co-creation sessions.

Co-creation is a collaborative approach that actively involves users in the design and development process. It allows stakeholders to contribute their insights, preferences and feedback directly, fostering a sense of ownership over the final product. During co-creation sessions, users interact with prototypes or mockups to provide real-time feedback on functionality, usability and overall design. This iterative process not only helps identify any gaps or issues in the requirements but also enhances user satisfaction by ensuring that their needs are effectively met.

Adjustment

The requirements list is a living document within an agile process, serving as a dynamic foundation that is expanded and specified throughout the development lifecycle. Agile methods emphasize flexibility and responsiveness to change, allowing stakeholders and developers to adapt requirements based on evolving user needs, market conditions, or technological advancements. This iterative nature of agile development means that requirements are not static, they can be refined, added, or adjusted as new insights emerge.

However, it is crucial to ensure that all changes to the requirements are meticulously documented and managed. Proper documentation helps maintain clarity and transparency among team members and stakeholders, ensuring awareness of the current state of requirements and any modifications made. This practice not only supports effective communication but also aids in tracking the rationale behind changes, which can be invaluable for future reference.

By adopting a structured approach to managing requirement adjustments teams can effectively navigate the complexities of an agile environment while maintaining alignment with project goals. Ultimately, this flexibility in adjusting requirements enhances the likelihood of delivering a product that truly meets user expectations and adapts to their needs over time.

3. Application of the approach and results

The methodical approach for requirements elicitation presented in Chapter 2 is applied within the innovation development process of the Shift2Zero project, as it effectively supports the achievement of the project objectives. Since the project aims for a holistic, user-centred development of the six vehicle innovations (see Figure 5), it is essential to first gain a precise understanding of the various stakeholders and their differing needs. Based on this foundation, the requirements for the innovations are derived following the steps of the presented methodical approach, providing the baseline for the subsequent development activities.

Figure 5. Innovations to be developed in the Shift2Zero project

The Shift2Zero developments include the following innovations:

A **modular swappable concept** featuring a swappable cargo unit (swap box) designed to facilitate efficient transshipment processes. The standardized, lightweight swap box is both removable and foldable, simplifying return logistics and minimizing empty transport volume. It enables smooth transfer across different vehicle types, allowing vans to seamlessly interface with or support trucks, mopeds and cargo bikes.

Holistic energy management and control strategies for braking systems, tyres and the powertrain to enhance overall efficiency and minimize environmental impact (e.g. particle emissions), while also enabling bi-directional charging through V2G and V2L technologies.

A cargo-body with **multiple temperature zones**. A cargo body with a sliding wall that allows the size of the temperature zones to be adjusted for different needs.

Thermal comfort and safe ergonomics. Infrared heating panels ensure driver comfort while improving overall energy efficiency. By reducing energy consumption for cabin

heating, they help extend vehicle range and make additional energy available for refrigeration in cold-chain deliveries. Ergonomic design features outside the vehicle enhance both driver and pedestrian safety during operation.

Dynamically optimised space for goods and passengers. A movable protective partition separates the cargo area from the passenger space, enabling quick reconfiguration of the vehicle for different use cases. This allows flexible adaptation between transporting goods, people, or a combination of both.

Geofencing strategies for safer and more efficient urban operations. Includes scenarios such as automatic speed limitation to access pedestrian zones, data sharing for improved coordination and the booking of loading or transshipment areas all aimed at promoting safe driving behaviour and streamlined logistics in dense urban environments.

3.1 Requirement identification

Identifying the sources of potential requirements for the different innovations represents the first step in the requirements derivation process. This step is particularly essential, as it provides the data foundation for all subsequent stages. Within WP 2, various methods were applied to obtain a broad and comprehensive understanding. An overview of these activities and the corresponding methods is shown in Table 1. Further details about the methods and the activities carried out can be found in the corresponding deliverables.

Deliverable	Method	Description	Result
Task 2.1	In-depth interviews	End-user identification and requirements elicitation through in-depth interviews.	870 specific requirements, 58 aggregated requirements
Task 2.2	User-workshops	Identification of user-specific needs through 2-stage workshops with end-users.	270 solution-neutral user needs
Task 2.3	User-specific surveys	User-specific surveys featuring choice experiments, aimed at uncovering user preferences and understanding trade-offs.	User preferences and trade-offs
Task 2.4	Simulation models	Synergies with new logistics concepts and innovations using simulation models.	11 aggregated requirements

Table 1. Overview of WP 2 activities and methods

The in-depth interviews from Task 2.1 produced a total of 870 specific requirements and 58 aggregated requirements. Of these, 543 specific and 47 aggregated requirements were generated from the planned project innovations, while the remaining requirements were more generally related to e-LCVs. Within Task 2.2, user-centred, two-stage workshops and interviews with drivers and fleet managers revealed 270 solution-neutral user needs. The surveys with drivers, fleet managers, and depot / branch managers in Task 2.3 analysed preferences and trade-offs across the vehicle, fleet, and system levels. The T2.3 requirements were analysed at three different levels: general user

preferences (one full-sample profile), preferences across six user group categories with user role, experience level, vehicle type, delivery type, delivery area, and country (36 subgroup comparisons), and four latent user segments (4 segment-specific profiles). The simulation models in Task 2.4 additionally generated 11 aggregated requirements for the Shift2Zero innovations.

3.2 Requirement analysis

With the collected data as a foundation, the next step is to translate this input into harmonised, clear and non-contradictory requirements. Due to the variety of methodical approaches used across the tasks, the resulting material from each task contains different formulations as well as partially overlapping user needs and requirements. It is therefore necessary to first consolidate and standardise the collected information into a unified requirements format.

Since Task 2.2 produced user needs, these must initially be translated into requirements. To do this, the solution-neutral needs, already assigned to the corresponding innovations, are transformed by experts into concrete, actionable requirements. An example of this translation process is shown in Figure 6.

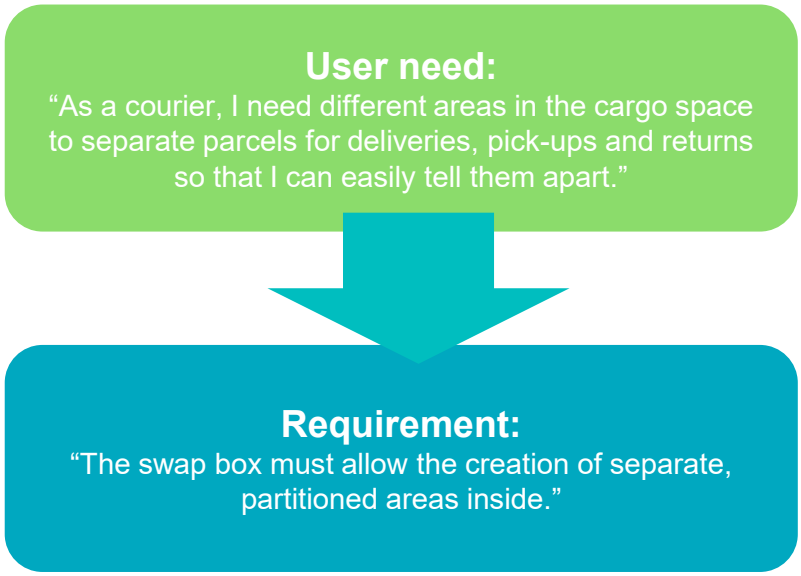

Figure 6. Procedure for transition from user needs to requirements on an example from swap box

Once the input from Task 2.1 to Task 2.4 has been consolidated into a consistent set of requirements, the next step is to structure and organise these requirements. For this purpose, the following high-level categories are defined, and the requirements are then grouped thematically for each innovation accordingly. The thematic groups are grounded in the categories established in T2.1–T2.4, and new categories were introduced where required.

Business & operations

The business and operations category encompasses requirements that address the economic feasibility, operational performance and organisational integration of a solution. It captures considerations relating to the implementation, management and scaling of innovations within a business or operational context. Particular emphasis is placed on ensuring coordination among stakeholders, achieving measurable benefits and aligning with existing processes and workflows.

Digital platform

The digital platform category pertains to requirements associated with digital connectivity, information exchange and system interoperability. It emphasises the reliable flow of operational and contextual data across platforms, devices and stakeholders, thereby enabling informed, coordinated and data-driven decision-making within complex systems.

Production & sustainability

This category focuses on requirements concerning material quality, durability, manufacturing processes and environmental impact. It encompasses considerations of maintainability, long-term operational reliability and sustainability, with particular attention to lifecycle performance, resource efficiency.

Safety & security

The safety and security category captures requirements aimed at ensuring the protection of users, goods, vehicles and the surrounding environment. It addresses regulatory compliance, risk mitigation, hazard prevention and ergonomics, ensuring that solutions can be operated safely and reliably under varying operational conditions.

Size & integration

Size and integration refer to requirements associated with spatial dimensions, modularity and compatibility with existing infrastructures, systems or processes. It emphasises the need for efficient space utilisation, functional adaptability and seamless integration within operational or physical frameworks, supporting both flexibility and interoperability.

User interactions

The user interactions category incorporates requirements relating to usability, ergonomics and overall user experience. It highlights the importance of intuitive operation and accessibility, as well as guidance and support to ensure effective and efficient use by users.

At this stage, the collected requirements are available in a harmonized format, organized by high-level categories for each innovation. However, due to the different origins of the requirements, there are duplicates in terms of content, which leads to a lack of clarity.

3.3 Requirement documentation

For the further documentation of the requirements, it is essential to resolve content-wise duplicates and consolidate them into unique requirements. To achieve this, all

requirements were checked for multiple occurrences and subsequently merged while ensuring that no content from the original requirements was lost.

After consolidation, the requirements are captured in a central list for each innovation. In addition to the previously established high-level categories, each requirement is assigned additional attributes. These include a unique identification number and documentation of the originating task to ensure traceability. Furthermore, for each requirement the applicable dimensions, social, political, economic and technical, are recorded. Given the complexity of the innovations, many requirements pertain to multiple dimensions, which is reflected in the requirement list.

Requirements are also categorized according to system, fleet and vehicle level. This classification facilitates the identification of interrelationships between requirements and simplifies subsequent implementation.

Based on stakeholder feedback from the various tasks and the intended project focus, the requirements are additionally prioritized using the Kano model, as described in Chapter 2. This prioritisation gives developers guidance on the importance of functions and allows them to consider requirements that are not initially critical but can be implemented later if possible.

Finally, for each requirement, the responsible project partner is specified to ensure clear accountability. In cases where multiple partners are involved, the primary responsible partner is listed first, followed by secondary responsible partners.

3.4 Requirement validation

The validation of requirements constitutes an important step in the overall requirements elicitation process. Due to the preceding interpretative steps, from user statements through user needs to the derived requirements, it is essential to ensure that the final requirements align with user expectations. At the same time, it is equally necessary to coordinate with the innovation developers to confirm that the formulated requirements are feasible and implementable within the scope of the project.

3.4.1 Co-creation workshops

The conducted co-creation workshops aim to validate the requirements for the innovations from the users' perspective. The goal of these workshops is to present the current state of the Shift2Zero innovations to subject matter experts within an immersive scenario that realistically adapts to the intended use cases. Feedback from the experts is then used to adjust and refine the requirements. A particular challenge at this stage is that the innovations exist only at a conceptual level. Therefore, it is necessary to create a realistic and immersive digital scenario in which the innovations are intended to be used in the future to collect qualitative feedback.

Augmented Reality (AR) technology is especially suitable for this purpose because it allows digital content to be overlaid on the real world. This makes it possible to combine a physically existing vehicle with virtual models of the innovations. Participants can therefore digitally evaluate upcoming vehicle concepts. The full-scale virtual model allows participants to open doors, test mechanisms, examine interior layouts and assess each component in detail as if the innovations already existed physically.

Due to the high effort required to implement the innovations in an AR environment, the focus was placed on the swap box, the multi-temperature cargo body and the dual transport system. These innovations involve the highest physical development effort later on and are therefore particularly suitable for early expert evaluation to identify potential issues in advance.

For the technical preparation of the workshops, all relevant information is initially collected from the innovation-developing partners to accurately represent the current state of development. Using CAD data, drawings, dimensions and documentation, the innovations are then built as 3D models in Blender (see Figure 7).

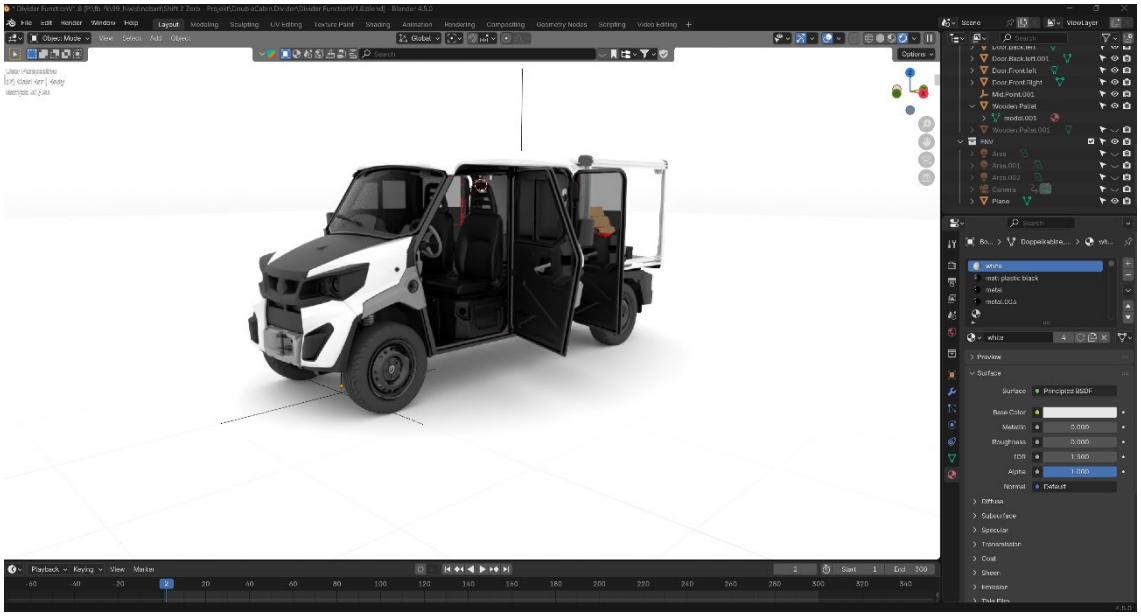

Figure 7. Modelling of the 3D models in Blender, example of the dual transport system

Following the 3D modelling process, the models were transferred into the Unity game engine. There, preparations were made for programming an application that is executed on the Meta Quest 3 Augmented Reality headset used during the workshops. Within Unity, possible interactions with the models were programmed, such as opening doors and roller shutters, moving the walls in the multi-temperature cargo body and operating the mechanisms of the dual transport system. Additionally, the textures of the models were defined and the interaction mechanisms, such as hand tracking, were configured (see Figure 8).

Figure 8. Creation of the environment for the AP-APP in Unity

The workshops were conducted at three locations in Bologna, Padua and Aachen in collaboration with Gruber Logistics, Alke Electric Vehicles, RWTH Aachen University and further companies, specialised in urban logistics operations. A total of 32 participants took part in the workshops, some of whom were already involved in the Shift2Zero project, while the majority were encountering the innovations for the first time. The participants were drivers, fleet managers, car-sharing users and OEM employees with the relevant experience. During the workshops, participants were tasked with testing the innovations sequentially from their own perspective. The realistic, interactive representation of the innovations allow participants to open doors, test mechanisms and evaluate ergonomic usability (see Figure 9).

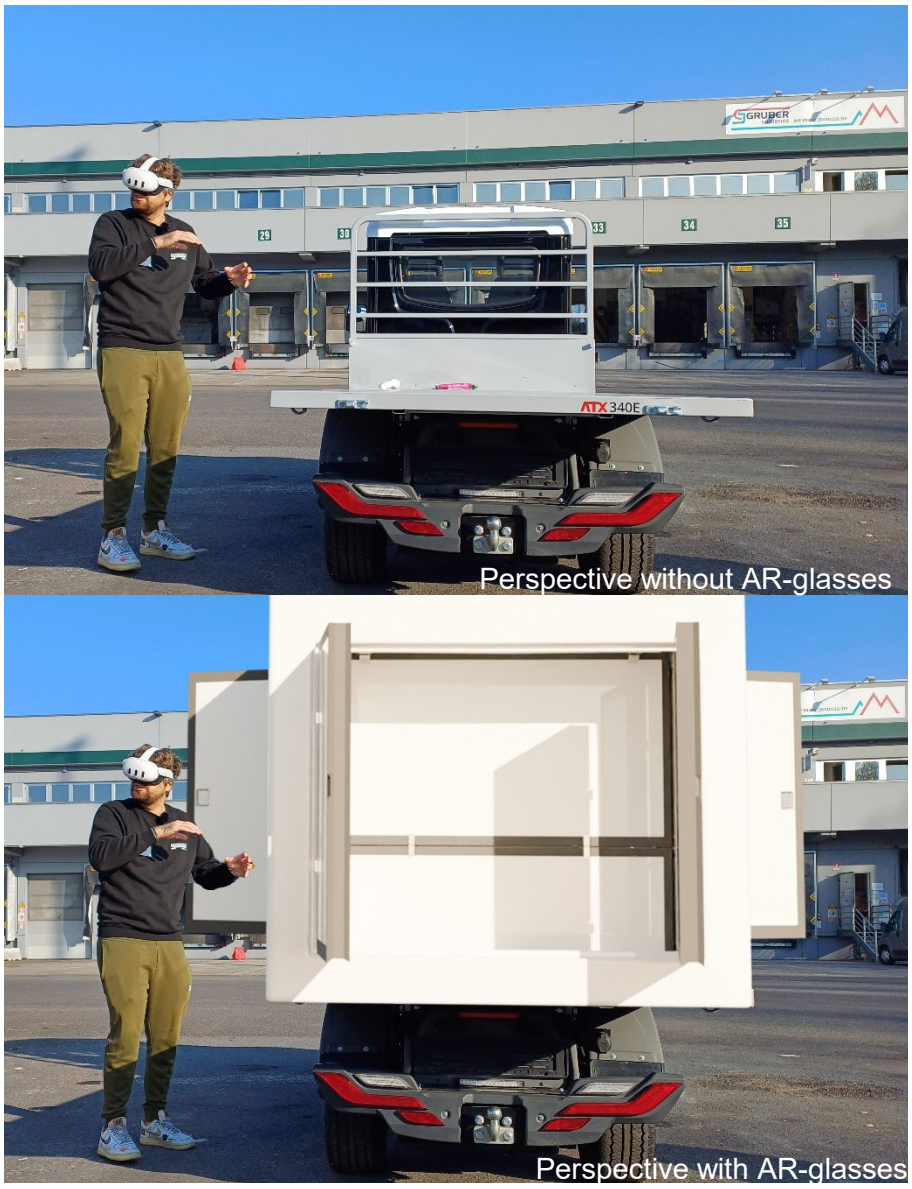

Figure 9. Co-creation workshop from the perspective without AR glasses (top) and with AR glasses (bottom)

The workshops are conducted using the Think-Aloud method within an in-depth interview format. Participants are asked to verbalize their thoughts while performing their daily tasks with the innovations. These spoken observations are additionally recorded using a microphone for subsequent analysis.

The combination of the realistic representation of the innovations and the expertise of the workshop participants generates constructive and valuable feedback. In total, 102 statements are collected, encompassing problems, facts, ideas or improvements related to the Swap Box, the multi-temperature cargo body, the dynamically optimised space and the vehicle in general. These statements are systematically documented in a table, which is included in Annex 5.1.

3.4.2 Feedback by innovation developers

So far, the requirements for the Shift2Zero innovations have been collected and described primarily from the user perspective. This approach is essential in user-centered development, as it allows requirements to be formulated in a solution-neutral manner without technical constraints. Nevertheless, it is equally important to involve the developers of the innovations in the formulation of requirements, since they are responsible for translating these requirements into concrete designs and prototypes. Therefore, the requirements must be evaluated by the innovation leads for technical feasibility and alignment with the overarching project focus of Shift2Zero.

To this end, the results from each task (T2.1-T2.4) as well as the preliminary requirement lists for each innovation were discussed and aligned with the relevant development partners during the second General Assembly in Bergen on 17 September 2025. These preliminary lists integrate insights from Task 2.1 through Task 2.4. The final requirement list was subsequently aligned with the partners in meetings at the end of November 2025. For this purpose, a dedicated meeting for each innovation was organised with the involved innovation developers, during which each requirement was discussed, feedback was provided, adjustments were implemented where needed, and the requirement was either agreed or rejected. The final list also took into account the results from the co-creation workshops and the feedback received during the General Assembly discussions as part of Task 2.5.

3.5 Requirement adjustment & results

After completing the final iteration loop of the requirements list in Task 2.5 and incorporating feedback from both users and developers, the requirements for each innovation are documented in an updated version. An example of a finally documented requirement is shown in Table 2.

No.	Category	Requirement	Origin from Task	Classification	Level	Prioritisation	Responsible partner
6	Size & integration	The swap box must minimise street and vehicle space use.	2.2	Technical	Vehicle	Must-be	PAX

Table 2. Example of a documented requirement

The complete requirement list for each innovation is provided in Annex 5.2. Using the applied methodical approach, a total of 181 requirements for the Shift2Zero innovations were derived. An overview of the distribution of these requirements across the different innovations, including a breakdown by vehicle, fleet and system levels, is shown in Figure 10.

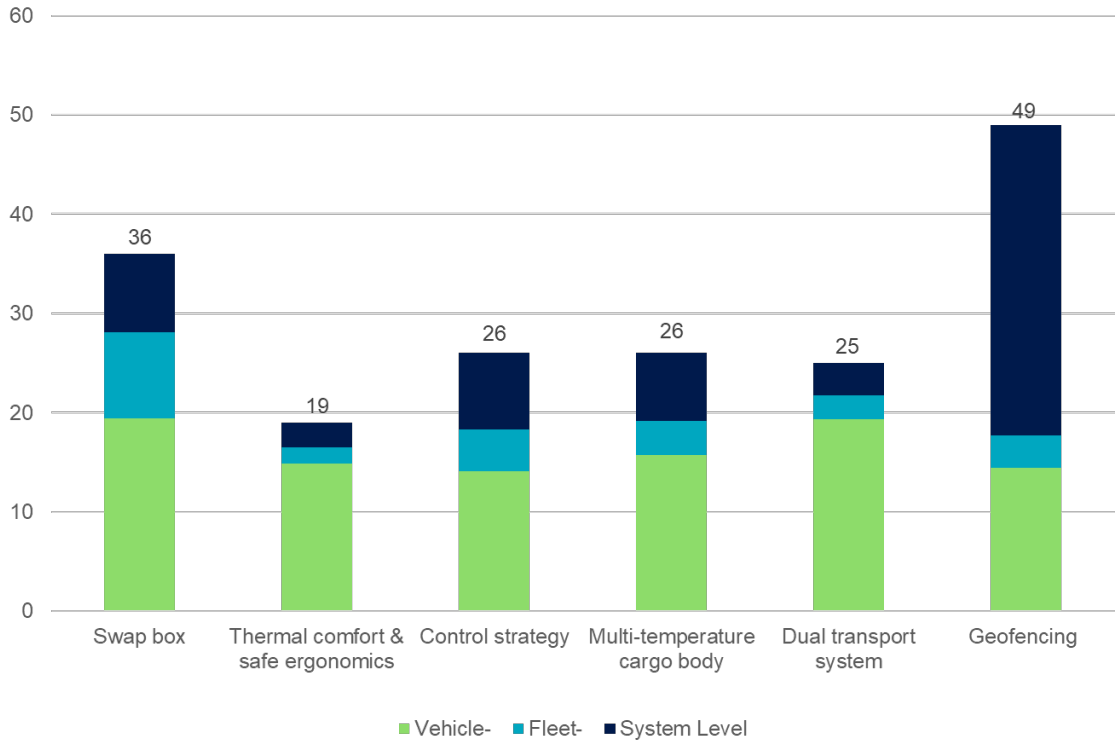

Figure 10. Overview of requirements per innovation

The figure shows that all six innovations reveal requirements across the vehicle, fleet, and system level with different occurrences. Focusing on the most frequent occurrences, many of the requirements for geofencing, as well as for the swap box and the control strategies, address the system level. This indicates that the successful implementation of the innovations depends not only on vehicle level development but also on establishing system conditions and integrating them into existing infrastructures. In this context, responsibility for meeting the requirements does not lie solely with the innovators but also with municipalities and logistics service providers working together with the developers. This is reflected in the assignment of responsibility for each requirement (see Annex 5.2).

Furthermore, among all of the innovations, the swap box requirements and interactions mostly extend to the fleet level. This arises from the integration of the swap box into existing vehicle fleets, operational processes and the associated challenges.

Overall, the requirement list presented in this deliverable reflects the current project status at month 12 and should not be considered final for future project work packages. Since requirements management is an iterative and agile process that relies on updating and expanding requirements based on new insights, the list will need to be continuously revised. Future milestones that will provide further insights include the translation of requirements into designs (WP 3), prototype development (WP 4), simulation of processes and software development (WP 5) and finally, the real-life demonstrations (WP 6).

4. Conclusion and outlook

The systematic elicitation of requirements at the system, fleet and vehicle level provides an essential foundation for the user-centred development of innovations for electric light commercial vehicles (eLCVs) within the Shift2Zero project. By incorporating expert interviews, workshops with end users, surveys, simulations and discussions, the various relevant stakeholders were actively involved in the derivation and refinement of requirements.

In total, 87 interviews, eight workshops, seven mapped ecosystems, a survey with 512 participants and seven simulations were conducted within Work Package 2. These activities were complemented by numerous meetings and discussions within the Shift2Zero project consortium. All this valuable input was subsequently processed through systematic analysis, documentation, validation and refinement to produce a comprehensive list of requirements.

The resulting requirements list comprises 181 formulated requirements, providing a detailed description of the objectives for the Shift2Zero innovations while taking into account the different social, political, economic and technical layers.

These requirements now serve as the baseline for the design and development of innovative vehicle solutions within Work Package 3. This approach ensures that the eLCV innovations developed within Shift2Zero are not only technologically advanced but also practical, user-friendly and market oriented.

Furthermore, the requirements contribute to the planning of pilot activities in Work Package 6. Within the pilot activities, the innovations developed will be tested and verified in real-life demonstrations. Finally, based on the current requirements, an adapted and validated list of user needs and technical requirements will be generated, taking into account the practical experience gained.

5. Annexes

5.1 Annex 1 Co-creation workshops results

The following annexes contain the statements collected from the participants during the co-creation workshops. The original statements made by participants in the workshops are listed in the order in which they were made. For a better overview, the statements are sorted thematically according to the Shift2Zero innovations and the different classifications. The categories are defined as follows:

- Problem: Statements that highlight difficulties, challenges, or negative experiences. These entries address existing deficiencies, inadequacies, or obstacles within the examined context.
- Fact: Neutral, descriptive statements that report observations or factual information without implying judgment or proposing solutions.
- Idea: Suggestions or thoughts indicating new approaches, possibilities, or alternative methods. These statements are often hypothetical or creative in nature.
- Improvement: Concrete proposals aimed at enhancing existing structures, processes, or systems. Unlike the Idea category, these statements generally have a practical and directly implementable focus.

5.1.1 Swap box

No.	Statement	Classification	Role
39	Pre-loaded boxes that can be swapped out are cool. It may take an extra step, but you save sorting time and can reload faster.	Idea	Driver
53	Pre-packed boxes are the most practical idea for this vehicle; you can take various types of goods with you, modular use – letters, parcels, food.	Idea	Driver
54	It is certainly possible to open the swap box when it is in the vehicle; it must be practical.	Fact	Driver
55	It is important that all boxes are the same size.	Fact	Driver
56	The rail system is a solution for securing the box in place.	Idea	Driver
57	A more complicated solution would be a magnetic system that fixes the wheels in place (as with shopping trolleys on roller conveyors).	Idea	Driver
58	As a driver, you need to be able to load the box quickly. An automated fastening system would be good for getting going quickly. It would also reduce the likelihood of errors during fastening, for example if suppliers forget to fasten one of five boxes after a long shift. Automation would really be necessary.	Idea	Driver
59	It is also important to be able to clean the interior of the swap boxes, especially as food can go off quickly.	Fact	Driver

60	The idea of the boxes is cool because you can also use the system in large vehicles.	Idea	Driver
61	The most important thing is the connection with the whole box (the manageability), so that you can access everything easily.	Fact	Driver
67	Electrical rolling shutters would be good combined with keyless-go.	Improvement	Driver
68	Lost space between swap boxes. Changing geometry of some swap boxes to optimise usage of space would be beneficial.	Improvement	Driver
69	Fix swap boxes in place so that they are secured.	Problem	Driver
71	How are the swap boxes fixed in place so that they don't move?	Problem	Driver
72	Swap boxes are not secured, they can roll back and forward.	Problem	Driver
78	Lost space between swap boxes.	Problem	Driver
79	It would be great if you were able to access the swap boxes from the sides.	Idea	Driver
82	Combination of swap boxes and multi-temperature cargo body.	Idea	Driver
83	Ramps to load and unload the swap box.	Idea	Driver
84	Usability of swap boxes depends on the size of the goods that have to be delivered.	Problem	Driver
90	Swap boxes improve loading of the vehicle	Fact	Driver
91	The concept is great if one swap box is delivered to one customer who ordered many parcels. However, if there are parcels from different customers in one swap box, then I can hardly imagine how to use this system.	Problem	Driver
92	Swap boxes limit possible space in the cargo department.	Problem	Driver
99	Swap boxes must be fixed in place.	Fact	Driver
100	It's great that the swap box doors fold inwards. Very space-saving.	Fact	Driver

5.1.2 Multi-temperature cargo body

No.	Statement	Classification	Role
41	Movable walls, different temperatures can be set, which is really good, much more flexible, depending on the size of the cool boxes.	Idea	Driver
42	Folding up the walls to create a large loading area is great, I think it's really clever, no space is wasted. The doors are large enough.	Idea	Driver
43	Doors on cool boxes could slam shut, e.g. on slopes; stoppers would be needed.	Improvement	Driver
44	Doors are designed to be functional, opening in the way they open (stop/direction) and being easy to grasp, even from behind. Having sufficient width means plenty of space to work.	Idea	Driver
52	Extra box for cold temperatures included, already pre-sorted.	Idea	Driver

70	There is enough space in multi-temperature compartments.	Fact	Driver
73	Fixed positions for partition walls instead of them being completely movable.	Idea	Driver
77	Ramp to load vehicle.	Idea	Driver
81	Shelf inside the Temperature Compartments would be helpful.	Idea	Driver
82	Combination of swap boxes and multi-temperature cargo body.	Idea	Driver
85	Freezing compartments are great if the customer is present when the parcel is delivered. Otherwise, there is no use in cooling the parcels during delivery.	Fact	Driver
86	Possibility of new business models for goods that have to be cooled down.	Fact	Driver
87	Moving the walls between compartments offers great flexibility.	Fact	Driver
88	Needed isolation would limit cargo space greatly.	Fact	Driver
93	In winter months when it's very cold the isolation would be very helpful to protect fruits and vegetables from the cold.	Fact	Driver

5.1.3 Dual transport system

No.	Statement	Classification	Role
3	I like that you can open all three sides of the cargo area.	Fact	Driver
4	No space for additional seats for adults.	Fact	Driver
6	A mesh box should fit inside, and the floor should be a surface that can withstand heavy use (robust).	Fact	Driver
8	Continuous wall is protective wall (good/important).	Fact	Driver
9	I prefer to do the folding mechanism myself.	Fact	Driver
11	Clever cargo area floor with fastening option, not very usable due to the geometric arrangement – improvement recommended.	Fact	Driver
12	The bench folds down and the cargo area floor extends forward.	Improvement	Driver
13	I would install an airline rail in the outer areas of the cargo space so that straps can be tightened, e.g., for pallets.	Improvement	Driver
14	I would install a lamp in the interior/cargo area—this is especially important during the dark season.	Improvement	Driver
15	I would make the angle of the loading edge rather flat so that the load can be pushed in flat when loading.	Improvement	Driver
16	The folding mechanism—more cargo space or more seats—is stylish and flexible for use; the combination solution is a great thing.	Improvement	Driver
17	When you fold away the cabin and have the large cargo area floor, you cannot access the airline rail in the small cargo area.	Problem	Driver
19	Manually switching between the second row of seats and the cargo area is awesome: I can drive with four people, or	Idea	Driver

	I can make the cargo area very large for the size of the vehicle, in which case a payload of 1.6 tons makes sense.		
21	Lashing eyes in the corners would be useful for heavy loads so that they can be lashed crosswise.	Improvement	Driver
22	There is no light in the cargo area.	Problem	Driver
23	I think the height at which you can load things is very stressful for my back. I always have to load and lift from my back, and I can't do it without bumping my head—if necessary, raise the base height of the vehicle.	Problem	Driver
24	I would install airline rails in the corners of the cargo area, e.g., for transport securing bars. This is a minor expense, but it makes things very flexible. It would even be conceivable to place airline rails on the ceiling. This would also allow the transition to the passenger compartment to be separated, providing protection from heavy objects that could otherwise fly forward.	Improvement	Driver
25	Airline rails on folding floor not load-bearing.	Problem	Driver
26	The 4-seater function or enlarged cargo space is cool and fascinating.	Idea	Driver
27	It makes sense to place the airline rails on the very outside or at the back, i.e. around the outside, in order to secure the pallet.	Idea	Driver
28	Large cabinets can only be placed in the cargo area lying down using the tilt function.	Fact	Driver
29	Interior lighting = no cargo space, does not need to be 8000 lumens.	Problem	Driver
30	Detachable box body, fold-down cargo space extension is really cool, 2 mechanical levers + wall locking mechanism.	Fact, Idea	Driver
31	It's really important to have all-round access to the cargo area, especially when you want to secure loads.	Idea	Driver
32	It's always important to have airline rails in the back.	Idea	Driver
33	For safety reasons, the seat belts cannot be removed, but a small cover can be used to prevent damage to the belts, depending on what is being transported.	Problem	Driver
34	To rent a car from a car-sharing service, e.g., to drive to IKEA, you need a loading area length of up to 2.40 m, otherwise you won't be able to fit a Pax wardrobe in it—it's important to pay attention to the dimensions.	Idea	Driver
35	If a Euro pallet fits + 4 people, that's ideal.	Idea	Driver
36	Truck beds aren't that comfortable, but you don't drive 100 km in them in urban areas.	Fact	Driver
37	Recommended to provide headrests for the rear seats, at least a head cushion, as the suspension may be rough—it would be uncomfortable to hit the steel partition.	Idea	Driver
38	The advantage of a roller door is that it does not slam shut, e.g. when you are standing on a slope.	Fact	Driver

45	Folding mechanism – the seat folds down, giving me a larger loading area, and I can also access the loading area from the rear door of the double cab.	Idea	Driver
46	The fact that I can convert it means you gain a lot of space in the cargo area.	Idea	Driver
47	It looks to me as if you could fold it down quickly and effectively, lock the seat into place – it's a very quick modular system, which can also be helpful for car sharing.	Idea	Driver
48	It's a simple way to make a car that can transport four people with a large loading area – that's really cool.	Improvement	Driver
49	The movable partition wall is protection to secure the load - important.	Idea	Driver
50	Rear seats have more space – no pedals like in the front, no wheel arch.	Fact	Driver
51	It is advantageous that there are doors on both sides for deliveries.	Fact	Driver
62	The folding mechanism is a good idea, well implemented, you immediately have much more space, which I think is very good.	idea	Driver
63	Switching between the two modes manually is easy, I'm confident I can do it.	Fact	Driver
64	The system is very well suited for errands; it is very flexible.	Fact	Driver
65	Folding down the seats is good, enough space for 4 people.	Improvement	Driver
66	The folding mechanism gives me much more space in the boot.	Improvement	Driver
74	Safety net or similar between passengers and cargo space for safety in case of a crash.	Improvement	Driver
96	The seat belt would sometimes get in the way when loading.	Problem	Driver
101	I think I could convert the back seat. It only takes two steps and looks easy.	Fact	Driver

5.1.1 Not specified

No.	Statement	Classification	Role
1	Where do I put the warning triangle, where do I put the safety vests, where is the first aid kit? There is no glove compartment where I would expect to find the operating instructions. Where is there space/a box for tension belts - under the rear seat? Where do I put the charging cables?	Problem	Driver
5	A roof rack would be an idea.	Idea	Driver
7	I would appreciate a cup holder in the front area.	Fact	Driver
10	I don't like the door handle under the mirror; the mirror is in the way.	Problem	Driver
18	There are few storage compartments for the driver—including cup holders, etc.	Problem	Driver

20	It would be good to use the box under the front seats as storage space, e.g. for backpacks.	Improvement	Driver
23	I think the height at which you can load things is very stressful for my back. I always have to load and lift from my back, and I can't do it without bumping my head—if necessary, raise the base height of the vehicle.	Problem	Driver
40	The vehicle is extremely narrow, perfect for finding parking spaces in city centres, really good compared to a Sprinter, for example.	Fact	Driver
76	Vehicle is very high, if parcels are heavy, it will be very hard on the back.	Fact	Driver
80	Forklift or ramp is needed for loading the swap boxes.	Problem	Driver
89	Cargo Space is small in total height	Fact	Driver
94	For our use case, driving back and forth to re-load the vehicle would not work. That's why we're currently using huge vehicles like a Mercedes Sprinter where 80-90 boxes fit.	Problem	Driver
95	Our routing could definitely be optimised. Especially if the number of customers would further increase.	Improvement	Driver
96	The seat belt would sometimes get in the way when loading.	Problem	Driver
97	There is no flat loading edge, so you would always have to lift the pallet to load and unload it.	Problem	Driver
98	I would always have to bend over to load the vehicle	Problem	Driver
102	Without an airbag, I find this very dangerous even at low speeds.	Problem	Driver

5.2 Annex 2 Requirements list

The following annex 2 contains the collected requirements for the six core innovations throughout WP 2 in Shift2Zero.

5.2.1 Swap box

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Size & Integration	The swap box must have a standardised size that is optimised for use in sector-wide applications.	2.1, 2.2, 2.4, 2.5	☐	☐	☐	☒	☒	☒	☐	Must-be	PAX
2	Size & Integration	The swap box must be able to be integrated into existing vehicles, infrastructures and processes commonly used on the market.	2.1, 2.2, 2.4, 2.5	☒	☒	☐	☒	☒	☒	☐	Must-be	PAX
3	Size & Integration	The swap box must support standardised cargo types (e.g. containers, pallets, modular units) with compatible loading/unloading systems.	2.4	☐	☐	☐	☒	☒	☒	☒	Must-be	PAX
4	Size & Integration	The swap box must enable quick loading, unloading, and transshipment.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
5	Size & Integration	The swap box must allow the creation of separate, partitioned areas inside.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
6	Size & Integration	The swap box must minimise street and vehicle space use.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
7	Size & Integration	The swap box must take up as little space as possible when it is loaded or unloaded.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
8	Size & Integration	The swap box must offer flexible and easily accessible storage that allows spontaneous pickups.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
9	Size & Integration	The swap box must enable exchange between vehicles of different dimensions.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☒	☐	Must-be	PAX
10	Size & Integration	The swap box must be designed in such a way that the parcels are easily accessible during delivery, and no additional doors need to be opened.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
11	Size & Integration	The swap box must be equipped with sensors that detect open and closed doors, temperature, humidity and movement.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
12	Business & Operations	The swap box must demonstrate measurable efficiency gains.	2.1, 2.2	☐	☐	☒	☐	☒	☒	☐	One-dimensional	PAX
13	Business & Operations	The swap box must have a compromise between cost, robustness and light weight.	2.1, 2.2	☐	☐	☒	☒	☒	☒	☒	One-dimensional	PAX
14	Business & Operations	The swap box must support fast and accurate parcel organisation.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
15	Business & Operations	The introduction of the swap box must be accompanied by knowledge transfer, training and a gradual rollout with adapted processes and infrastructure.	2.1	☒	☐	☒	☒	☒	☒	☐	Must-be	PAX, LSPs, Municipality
16	Business & Operations	The introduction of the swap box must be accompanied by coordinated cooperation between public authorities, logistics operators and providers.	2.2	☒	☒	☒	☒	☒	☒	☐	Must-be	PAX, LSPs, Municipality

17	Business & Operations	The swap box adoption requires strategically located micro hubs enabling exchange of pre-loaded cargo.	2.1, 2.2	☒	☒	☒	☒	☒	☒	☐	Must-be	LSPs, Municipality
18	Digital platform	The swap box must provide an open data transfer for digital platforms.	2.4	☐	☐	☐	☒	☒	☒	☐	Attractive	PAX
19	Safety & Security	The swap box must provide reliable protection for the goods being transported, especially fragile products (such as wine).	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
20	Safety & Security	The swap box must hold the cargo securely in place, even when the vehicle is on an incline.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
21	Safety & Security	The box body of the vehicle in which the swap box is attached must have protection against break-ins.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
22	Safety & Security	The swap box must be secured in the vehicle in such a way that it does not damage the vehicle during use.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX, ALKE
23	Safety & Security	The box body of the vehicle in which the swap box is attached must be illuminated to support safe and efficient use.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
24	Safety & Security	The swap box must have a simple, quick securing mechanism for safe use in vehicles.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
25	Production & Sustainability	The swap box should be constructed using eco-friendly materials.	2.1	☐	☐	☒	☒	☐	☐	☒	Attractive	PAX
26	Production & Sustainability	The swap box must be durable, stable, and reliable for continuous daily use.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
27	Production & Sustainability	The swap box must have easily replaceable components.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	PAX
28	Production & Sustainability	The swap box must have easily available spare parts.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	PAX
29	Production & Sustainability	The swap box must have easy maintenance possibilities.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	PAX
30	User interaction	The swap box must be easy for new users to understand.	2.2	☒	☐	☐	☒	☒	☒	☐	Must-be	PAX
31	User interaction	The swap box must be explained in an introductory presentation that can be used as training material for new employees.	2.2	☒	☐	☐	☒	☒	☒	☒	Attractive	PAX
32	User interaction	The swap box must be operable when wearing gloves.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
33	User interaction	The swap box must be handleable on uneven terrain such as cobblestones.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
34	User interaction	The swap box in its locked position in the vehicle must allow the parcel labels to remain visible before unloading.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	PAX
35	User interaction	The box body of the vehicle in which the swap box is attached must be accessible without requiring additional space on the road when opening (e.g. box body with roller doors).	2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	ALKE
36	User interaction	The swap box must allow safe handling by one person without requiring significant physical strength.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	PAX

5.2.2 Thermal comfort & safe ergonomics

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Business & Operations	The infrared heating systems must provide clear evidence of measurable cost savings or efficiency improvements that justify their initial investment.	2.1	☐	☐	☒	☒	☒	☒	☒	One-dimensional	AIT
2	Business & Operations	The infrared heating system must deliver operational benefits while maintaining a reasonable total cost of ownership, avoiding unnecessary increases in expenses.	2.1	☐	☐	☒	☒	☒	☒	☐	One-dimensional	AIT
3	Business & Operations	The infrared heating system must improve energy savings and achieve thermal comfort more quickly.	2.1	☐	☐	☒	☒	☐	☐	☒	One-dimensional	AIT
4	Business & Operations	The infrared heating system must be more energy-efficient than a conventional heating system.	2.1	☐	☐	☒	☒	☐	☐	☒	One-dimensional	AIT
5	Business & Operations	The infrared heating system must be checked with homologation requirements.	2.1	☐	☒	☐	☒	☒	☐	☒	Must-be	AIT
6	Business & Operations	The infrared heating system must be usable continuously throughout the day every day.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	AIT
7	Business & Operations	The heating system should be usable whilst the vehicle is parked and locked.	2.2	☒	☐	☐	☒	☐	☐	☒	Attractive	AIT, ALKE, IVE
8	Safety & Security	The vehicle must be protected against collisions at speeds of up to 50 km/h.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE, IDI
9	Safety & Security	The vehicle must not cause safety concerns and must give the driver a feeling of safety in use.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	ALKE, IDI
10	Safety & Security	The infrared heating system must not cause safety concerns and must give the driver a feeling of safety in use.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	AIT
11	Safety & Security	The heating system must keep the windscreen free of ice and condensation throughout the entire working day.	2.1	☐	☐	☐	☒	☐	☐	☒	Must-be	AIT, ALKE, IVE
12	User interaction	The infrared heating system must enhance the driver comfort.	2.1, 2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	AIT
13	User interaction	The infrared heating system must be easy and efficient to use.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	AIT
14	User interaction	The infrared heating system must prioritise the heat to the core body, feet, face and hands.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	AIT
15	User interaction	The infrared heating system must be able to maintain a comfortable and constant feeling of temperature of the passengers.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	AIT
16	User interaction	The infrared heating system must provide heat immediately at the start of the route.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	AIT

17	User interaction	The controls for the infrared heating system must be in the natural reach of the driver.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	AIT
18	User interaction	The controls for the infrared heating system must be operatable with gloves.	2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	AIT
19	User interaction	The infrared heating system must be adjustable without causing significant distractions while driving.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	AIT

5.2.3 Control strategy

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Business & Operations	The vehicle control strategy must decrease the environmental impact, especially the energy consumption and particle emission.	2.1, 2.2	☐	☐	☒	☒	☒	☒	☒	Must-be	IKA
2	Business & Operations	The vehicle control strategy must provide clear evidence of measurable cost savings or efficiency improvements that justify their initial investment.	2.1	☐	☐	☒	☒	☒	☒	☒	One-dimensional	IKA
3	Business & Operations	The vehicle control strategy must provide an open data transfer for digital platforms.	2.1	☐	☒	☐	☒	☒	☐	☐	Must-be	IKA
5	Business & Operations	The vehicle control strategy should support smart charging scheduling tools to optimize charging times against route plans.	2.1	☐	☐	☒	☒	☒	☐	☒	Attractive	LPIM
6	Business & Operations	The vehicle control strategy must warn the driver in good time before reaching the "point of no return" (remaining battery is less than what is needed to reach the depot without recharging).	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	IKA
7	Production & Sustainability	The vehicle control strategy must be developed with stakeholders (e.g. unions, subcontractors and drivers) to ensure acceptance and support safe, healthy working conditions.	2.1	☒	☒	☐	☒	☒	☒	☒	One-dimensional	IKA
8	Production & Sustainability	The vehicle control strategy must improve lifecycle impacts.	2.1	☒	☐	☒	☒	☒	☐	☐	One-dimensional	IKA
9	Safety & Security	The vehicle control strategy must comply with existing standards (such as Euro 7).	2.1	☐	☒	☐	☒	☒	☐	☒	Must-be	IKA
10	Safety & Security	The vehicle control strategy must meet stability and reliability standards that are suitable for continuous daily use.	2.2	☐	☒	☐	☒	☐	☐	☒	One-dimensional	IKA
11	Size & Integration	The vehicle control strategy should support V2L via ePTO.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	LPIM
12	Size & Integration	The vehicle control strategy must support V2V via ePTO.	2.2	☐	☐	☐	☒	☐	☒	☒	One-dimensional	LPIM
15	Size & Integration	The vehicle control strategy must monitor and communicate the driving parameters to the driver and coordinator permanently in real-time.	2.4	☒	☐	☐	☒	☒	☒	☒	Must-be	IKA
17	Size & Integration	The vehicle control strategy must be able to provide energy to the heating system and / or multi temperature cargo body whilst the vehicle is parked and locked.	2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE, IVE
18	Size & Integration	Brakes, tires and suspension must be integrated into the vehicle control strategy.	2.1	☐	☒	☐	☒	☒	☐	☒	Must-be	IKA
19	Size & Integration	Regenerative braking and component innovations / auxiliary consumers must be integrated into the vehicle control strategy and have an impact on range.	2.1	☐	☐	☐	☒	☒	☐	☒	Must-be	IKA

20	User interaction	The vehicle control strategy must indicate the impact of energy consumption by auxiliary consumers (heating system, multi temperature cargo body) or strong accelerations on the remaining range in real time.	2.2	☐	☐	☐	☒	☒	☐	☒	One-dimensional	IKA
21	User interaction	The vehicle control strategy must provide feedback and tips supporting efficient eco-driving (recuperation, auxiliary energy use, driving style), reduction of wear and easier eco-driving practices.	2.1, 2.2	☐	☐	☒	☒	☐	☐	☒	One-dimensional	IKA
22	User interaction	The feedback of the vehicle control strategy must be available in real-time as well as post-trip.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	IKA
23	User interaction	The feedback of the vehicle control strategy should motivate energy efficient mechanisms and driving.	2.1, 2.2	☐	☐	☒	☒	☐	☐	☒	Attractive	IKA
24	User interaction	The feedback of the vehicle control strategy should be forwarded to the driver if he chooses this option.	2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	IKA
25	User interaction	The vehicle control strategy should warn the driver and / or operator if the charging process is interrupted during charging.	2.2	☐	☐	☐	☒	☐	☒	☒	Attractive	LPIM
26	User interaction	The vehicle control strategy should offer different driving support strategies that can be chosen by the drivers.	2.3	☒	☐	☐	☒	☐	☐	☒	Attractive	IKA

5.2.4 Multi-temperature cargo body

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Size & Integration	The multi-temperature cargo body must provide at least three different temperature zones.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	COL
2	Size & Integration	The temperature zones of the multi-temperature cargo body must be divided by a flexible, movable barrier to adjust the size of the zones for different needs.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
3	Size & Integration	The walls in the multi-temperature cargo body must be foldable.	2.1, 2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
4	Size & Integration	The multi-temperature cargo body must be designed in such a way that compatible loading and unloading systems can be used.	2.4, 2.5	☐	☐	☐	☒	☒	☒	☒	One-dimensional	COL
5	Size & Integration	The multi-temperature cargo body must enable transportation of goods with different temperature in one vehicle.	2.1	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
6	Size & Integration	The multi-temperature cargo body concept must be compatible with different vehicles from different manufacturers.	2.1	☐	☐	☒	☒	☒	☒	☒	Must-be	COL
7	Size & Integration	The multi-temperature cargo body must be equipped with sensors that detect open and closed doors, temperature in the different compartments.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Attractive	COL
8	Production & Sustainability	The multi-temperature cargo body must be durable, stable, and reliable for continuous daily use.	2.2	☐	☒	☐	☒	☐	☐	☒	Must-be	COL
9	Business & Operations	The multi-temperature cargo body must show an advantage in energy consumption and temperature adjustment compared to a fully refrigerated body.	2.1	☐	☐	☒	☒	☒	☒	☒	One-dimensional	COL
10	Business & Operations	The multi-temperature cargo body must operate for at least 12 hours and maintain the temperature without an external power supply.	2.1	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
11	Business & Operations	The multi-temperature cargo body must cover a temperature range of -18°C to +18°C.	2.1	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
12	Business & Operations	The multi-temperature cargo body should provide an open data transfer for digital platforms.	2.2, 2.5	☐	☐	☐	☒	☒	☒	☐	Attractive	COL
13	Business & Operations	The multi-temperature cargo must ensure that the goods stored inside do not fall below a critical temperature and document this.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
14	Business & Operations	The multi-temperature cargo body air temperature should be monitored and communicated to driver and coordinator in real-time.	2.4	☒	☐	☐	☒	☒	☒	☒	Attractive	COL
15	Safety & Security	The access to the multi-temperature cargo body must be safe and easy.	2.1, 2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	COL
16	Safety & Security	The access to the multi-temperature cargo body must not pose any danger for pedestrians.	2.1, 2.2	☒	☐	☐	☒	☒	☐	☒	Must-be	COL

17	Safety & Security	The access to the multi-temperature cargo body must be ergonomic.	2.1, 2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	COL
18	Safety & Security	The multi-temperature cargo body must comply with national and international regulations.	2.1	☐	☒	☐	☒	☒	☐	☐	Must-be	COL
19	Safety & Security	The multi-temperature cargo body must comply with the safety requirements for cooled goods.	2.1	☐	☒	☐	☒	☒	☐	☒	Must-be	COL
20	Safety & Security	The multi-temperature cargo body must be well illuminated to support safe and efficient use.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	COL
21	User interaction	The multi-temperature cargo body must facilitate access to all temperature zones at any time (e.g. even if one side is blocked).	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	COL
22	User interaction	The adjustment of the multi-temperature cargo body must be quick and easy.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
23	User interaction	The adjustment of the multi-temperature cargo body must require as little physical effort as possible.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	COL
24	User interaction	The multi-temperature cargo body must be easy for new users to understand.	2.2	☒	☐	☐	☐	☒	☐	☒	One-dimensional	COL
25	User interaction	The multi-temperature cargo body should be explained in an introductory presentation that can be used as training material for new employees.	2.2	☒	☐	☐	☐	☒	☐	☐	Attractive	COL
26	User interaction	The multi-temperature cargo body must be operable when wearing gloves.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	COL

5.2.5 Dual transport system

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Size & Integration	The dual transport system must offer a dynamic space allocation by switching between additional passenger compartment or additional cargo compartment.	2.1, 2.2	☐	☐	☒	☒	☐	☐	☒	Must-be	ALKE
2	Size & Integration	The dual transport system must offer as much storage space as possible when the additional row of seats is not in use.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
3	Size & Integration	The dual transport system must provide a flat loading floor.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
4	Size & Integration	The floor of the dynamic space allocation must have the same height as the floor of the normal cargo compartment.	2.1,2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
5	Business & Operations	The vehicle must provide an open data transfer for digital platforms.	2.1	☐	☐	☐	☒	☒	☒	☐	Must-be	ALKE
6	Business & Operations	The vehicle must provide position, speed, ignition status, battery charge level, mileage, error codes, and lock status data.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
7	Safety & Security	The dual transport system must be checked for homologation for the first and second rows.	2.1, 2.2	☐	☒	☐	☒	☒	☐	☒	Must-be	ALKE
8	Safety & Security	The moveable protective partition of the duals transport system must provide a physical separation of passenger and cargo compartment.	2.1, 2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	ALKE
9	Safety & Security	The dynamic space of the dual transport system must be securely fixed in either of the positions so that it does not move during the ride.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
10	Safety & Security	The movable protective partition of the dual transport system must protect passengers from loads in all application situations.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
11	Safety & Security	The windows of the dynamic space of the dual transport system must be protected and not be destroyed by the load when the dynamic space is used as a cargo compartment.	2.2, 2.5	☒	☐	☐	☒	☐	☐	☒	Must-be	ALKE
12	Safety & Security	The dynamic space of the dual transport system must not significantly obstruct the all-round visibility for the driver. (rear camera)	2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
13	Safety & Security	The dynamic space of the dual transport system must offer the possibility of securely fixing different loads so that they do not move during driving.	2.2, 2.5	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
14	Safety & Security	The dual transport system must be illuminated inside to support safe and efficient use.	2.2, 2.5	☒	☐	☐	☒	☐	☐	☒	Must-be	ALKE
15	Production & Sustainability	The foldable seats/bench in the dynamic space of the dual transport system must be made of durable and scratch-resistant materials.	2.1	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
16	Production & Sustainability	The dynamic space of the dual transport system must be made of robust and non-slippery materials.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE

17	User interaction	The dual transport system must be easy to clean.	2.1, 2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
18	User interaction	The dual transport system must be compatible with standardised loading / unloading systems.	2.2	☐	☐	☐	☒	☒	☒	☒	One-dimensional	ALKE
19	User interaction	The additional passenger compartment of the dual transport system must provide comfortable seats and sufficient leg space for adults.	2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
20	User interaction	The dual transport system must be accessible from the front and the back.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
21	User interaction	The dual transport system should provide openable windows in the second row.	2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	ALKE
22	User interaction	The dual transport system must provide acceptable climate conditions in the second row.	2.2	☒	☐	☐	☒	☐	☐	☒	One-dimensional	ALKE
23	User interaction	The dual transport system must be easy for new users to understand.	2.2	☒	☐	☐	☐	☐	☐	☒	One-dimensional	ALKE
24	User interaction	The dual transport system should be explained in an introductory presentation that can be used as training material for new employees.	2.2	☒	☐	☐	☐	☒	☒	☒	Attractive	ALKE
25	User interaction	The mechanism to switch the dynamic space of the dual transport system should be operatable by diverse users.	2.1, 2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	ALKE

5.2.6 Geofencing

No.	High-level category	Requirement	Origin from Task	Classification				Level			Prioritisation according to Kano	Responsible partner
				social	political	economical	technical	System	Fleet	Vehicle		
1	Business & Operations	The geofencing system must be able to exchange data and transfer data to booking systems via APIs.	2.1, 2.2	☐	☒	☒	☒	☒	☐	☐	One-dimensional	PAX
2	Business & Operations	The geofencing system must provide clear evidence of measurable cost savings or efficiency improvements that justify their initial investment.	2.2	☐	☒	☒	☒	☒	☐	☐	One-dimensional	PAX
3	Business & Operations	The geofencing system must deliver shared operational, social and environmental value for both authorities and logistics stakeholders.	2.2	☒	☐	☒	☐	☒	☐	☐	One-dimensional	PAX
4	Business & Operations	The geofencing system must be interoperable across partners.	2.1	☐	☐	☐	☒	☒	☐	☐	Must-be	PAX
5	Business & Operations	The geofencing system must use standardized data.	2.1	☐	☐	☐	☒	☒	☐	☐	Must-be	PAX
6	Business & Operations	The geofencing system must be able to exchange data in real-time.	2.1	☐	☐	☐	☒	☒	☐	☐	Must-be	PAX
7	Business & Operations	The geofencing system must enable data exchange between vehicles, operators, infrastructure and authorities.	2.1	☐	☐	☐	☒	☒	☐	☐	Must-be	PAX, ALKE
8	Business & Operations	The geofencing system should provide an ecosystem involving all partners.	2.1	☒	☐	☐	☒	☒	☐	☐	Attractive	PAX
9	Business & Operations	The geofencing system must be open standard.	2.1	☐	☒	☐	☒	☒	☐	☐	One-dimensional	PAX
10	Business & Operations	The geofencing system must enable all partners to collaborate technically and organisationally.	2.1	☐	☐	☐	☒	☒	☐	☐	One-dimensional	PAX
11	Business & Operations	The geofencing system should facilitate coordinated data sharing among all partners.	2.1	☐	☐	☐	☒	☒	☐	☐	Attractive	PAX
12	Business & Operations	The geofencing system must enable the development of flexible regulations to accommodate varying needs and contexts.	2.1	☐	☒	☐	☒	☒	☐	☐	One-dimensional	PAX
13	Business & Operations	The geofencing system should enact a predictable rollout plan for dynamic regulations related to different conditions.	2.1	☐	☒	☐	☒	☒	☐	☐	Attractive	PAX
14	Business & Operations	The rollout plan of the geofencing system should take into account the technological readiness of all involved parties for dynamic regulation.	2.1	☐	☐	☐	☒	☒	☒	☐	Attractive	PAX
15	Business & Operations	The geofencing system should improve knowledge among stakeholders regarding actor behaviour related to freight flows.	2.1	☒	☒	☐	☐	☒	☐	☐	Attractive	PAX
16	Business & Operations	The geofencing system must improve knowledge among stakeholders regarding potential impacts and benefits of geofencing implementation.	2.1	☒	☐	☒	☐	☒	☐	☐	One-dimensional	PAX

17	Business & Operations	The geofencing system must provide recommendations on how to implement zones in a manner that is technically feasible and publicly acceptable.	2.1	☒	☒	☐	☐	☒	☐	☐	One-dimensional	PAX, Municipalities
18	Business & Operations	The geofencing system must provide recommendations on where to implement zones in a manner that is technically feasible and publicly acceptable.	2.1	☒	☒	☐	☐	☒	☐	☐	One-dimensional	PAX, Municipalities
19	Business & Operations	The implemented zones of the geofencing system should be fairly and predictably applied.	2.1	☒	☒	☐	☐	☒	☐	☐	Attractive	PAX, Municipalities
20	Business & Operations	The geofencing system must align restrictions within the delivery zone with logistical needs of good flows and critical services.	2.1	☐	☒	☒	☐	☒	☒	☐	One-dimensional	PAX
21	Business & Operations	The geofencing system should monitor and enforce access to reserved delivery zones.	2.2	☐	☒	☐	☒	☒	☐	☐	Attractive	PAX
22	Safety & Security	The geofencing system must encourage safe driving and streamlined activities in urban cores.	2.1, 2.2	☐	☒	☒	☒	☒	☐	☒	Must-be	PAX
23	Safety & Security	The geofencing system must limit the speed of the vehicle reliably and contextually to gain access to restricted areas.	2.2	☐	☒	☐	☒	☒	☐	☒	Must-be	PAX
24	Safety & Security	The geofencing system must be secure and privacy compliant.	2.1	☒	☒	☐	☒	☒	☐	☐	Must-be	PAX
25	Safety & Security	The geofencing system must register vehicle information automatically.	2.2	☐	☒	☐	☒	☒	☐	☒	One-dimensional	PAX
26	Safety & Security	The geofencing system must be verified by city traffic control.	2.2	☐	☒	☐	☒	☒	☐	☐	Must-be	Municipalities, PAX
27	Safety & Security	The geofencing system must provide drivers with automatic updates on operational conditions in real-time (e.g. access rules, zone restrictions, construction-related changes in unloading zones, etc.).	2.2	☐	☐	☐	☒	☒	☐	☒	One-dimensional	PAX
28	Safety & Security	The geofencing system must support the efficient operation of vehicles in a safe and secure manner.	2.1	☒	☒	☐	☒	☒	☐	☒	One-dimensional	PAX
29	Safety & Security	The geofencing system must reliably implement restrictions in high-risk areas to protect vulnerable traffic users.	2.1	☒	☒	☐	☒	☒	☐	☐	Must-be	PAX, Municipalities
30	Safety & Security	The geofencing system should incorporate an emergency mode that allows drivers the autonomy to override restrictions in emergencies in a safe way.	2.1	☒	☒	☐	☒	☒	☐	☒	Attractive	PAX, ALKE, LSPs
31	Safety & Security	The geofencing system must provide visible vehicle identification indicating access authorisations.	2.1	☐	☐	☐	☒	☐	☐	☒	Must-be	Municipalities, PAX
32	Safety & Security	The geofencing system must attract attention of pedestrians regarding the presence of the vehicle within restricted areas (e.g. pedestrian zones) in a friendly manner.	2.2	☒	☒	☐	☒	☐	☐	☒	Must-be	ALKE
33	Size & Integration	The geofencing system must be able to automatically limit the speed of the vehicle.	2.2	☒	☐	☐	☒	☒	☐	☒	Must-be	PAX, ALKE
34	Size & Integration	The geofencing system should monitor the traffic conditions and communicate them to the driver and coordinator.	2.4	☐	☐	☐	☒	☒	☐	☒	Attractive	PAX
35	Size & Integration	The geofencing system should monitor the client requirements and communicate them to the driver and coordinator.	2.4	☐	☐	☒	☒	☒	☐	☒	Attractive	PAX
36	Size & Integration	The vehicle must be equipped with GPS for the geofencing system to enable real-time tracking.	2.4	☐	☐	☐	☒	☐	☐	☒	Must-be	ALKE
37	Size & Integration	The geofencing system should incorporate a function that allows the logistic service providers to designate temporary or alternative loading zones.	2.2	☐	☒	☐	☒	☒	☐	☐	Attractive	Municipalities, PAX

38	Size & Integration	The geofencing system must be connected via a standardised interface so that vehicles from manufacturers who are willing to open up their systems can be equipped to receive and execute geofencing instructions.	2.1	☐	☐	☐	☒	☒	☒	☐	Must-be	PAX
39	Size & Integration	The geofencing system should offer a retrofit option, for manufacturers who are willing to open up their system, to ensure readiness across diverse fleets.	2.1	☐	☐	☐	☒	☐	☒	☐	Attractive	PAX
40	Size & Integration	The geofencing system must ensure smooth transitions between different zones with either a gentle or abrupt deceleration, depending on local factors.	2.2	☐	☐	☐	☒	☐	☐	☒	One-dimensional	PAX
41	Size & Integration	The geofencing system must enable access to urban delivery zones for logistics actors.	2.1	☐	☒	☐	☐	☒	☐	☐	Must-be	PAX, Municipalities
42	User interaction	The geofencing system must be easy to understand for new users.	2.2	☒	☐	☐	☒	☒	☐	☐	Must-be	PAX
43	User interaction	A introductory presentation for the geofencing system must be available for affected stakeholders (e.g. drivers, operators, planners).	2.2	☒	☐	☐	☒	☒	☐	☐	One-dimensional	PAX
44	User interaction	The geofencing system must encourage energy-efficient driving styles to reduce emissions.	2.1	☐	☐	☒	☒	☒	☐	☐	One-dimensional	PAX
45	User interaction	The geofencing system must provide the driver with clear information when entering a geofenced area.	2.2	☒	☐	☐	☒	☐	☐	☒	Must-be	PAX
46	User interaction	The information when entering a geofenced area must be visible or audible.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
47	User interaction	The information when entering a geofenced area must not distract the driver.	2.2	☐	☐	☐	☒	☐	☐	☒	Must-be	PAX
48	User interaction	The information when entering a geofenced area should incorporate information regarding the delivery zone.	2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	PAX
49	User interaction	The geofencing system should assist drivers in finding parking spots at delivery locations.	2.2	☐	☐	☐	☒	☐	☐	☒	Attractive	PAX, Municipalities