D2.1 Ecosystem mapping, end user requirements (fleet & system level)

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Deliverable information sheet

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1.1	23.02.2026	TØI	Correction of minor mistakes and re-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.

Executive summary:

This deliverable (D2.1) presents an aggregated list of user and stakeholder requirements and stakeholder mapping at the fleet and system level for the Shift2Zero project's planned innovations. The work complements other tasks within WP2, which employ different methods such as surveys and workshops to elicit requirements. Together, these inputs provide a comprehensive understanding of the needs and expectations that will guide the development of specific solutions in WP3.

To generate requirements, 44 interviews were conducted to collect inputs from logistics actors, public authorities, and technology developers. The interviews generated 1581 statements which were then categorized and aggregated into 58 requirements covering the 6 innovations to be developed. The deliverable identifies both specific operational needs and broader systemic challenges. This allows for a more holistic view of how innovations can be implemented and scaled in real-world logistics contexts.

The interviews were also used to refine stakeholder maps for each innovation that visually illustrate the range of actors involved in or affected by the adoption of sustainable logistics solutions. These maps highlight the interdependencies between logistics actors, public authorities, technology developers, and interest organizations. By identifying where responsibilities and points of influence lie, the maps provide an

important reference for understanding how requirements are shaped and where coordination efforts will be most critical in subsequent project phases.

A central finding is the critical role of regulations and governance frameworks. While technical barriers remain, organizational and regulatory conditions, such as vehicle access rules, incentives, and fragmented responsibilities across government levels, often weigh more heavily in determining whether innovations can succeed. At the same time, economic viability, stakeholder coordination, and the availability of adequate charging and service infrastructure are essential for ensuring adoption at scale.

The requirements also highlight the importance of data availability, sharing, and standardization, as well as the integration of connected vehicle technologies and advanced fleet management tools. Across innovations, stakeholders emphasized that operational efficiency, cost competitiveness, and clear business cases are decisive factors. The deliverable thus underscores that achieving sustainable urban logistics requires coordinated progress across technology, policy, and organizational practices, with user and stakeholder needs at the core.

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A2B Finland
ACS
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Bologna municipality
BPost
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DPD Poland
Get Around
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IKEA Norway
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Jumbo
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Logistics in Wallonia
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Posten
PostNL
Statens Vegvesen (Norwegian Public Roads Authority)
Swiss Post
Wroclaw municipality

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Terminology and Acronyms

CBC	*Choice Based Conjoint methodology*
EC	*European Commission*
e-LCV	*(electric) Light Commercial Vehicle*
EU	*European Union*
HEC	*Holistic-Experience-Centred Method*
LCA	*Life Cycle Assessment*
LEZ	*Low Emission Zone*
N1	*Vehicles used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes*
GDPR	*General Data Protection Regulation*
S2Z	*Shift2Zero*
TCO	*Total Cost of Ownership*
VRU	*Vulnerable Road User*
V2G	*Vehicle to Grid*
V2V	*Vehicle to Vehicle*
WP	*Work Package*
ZEZ	*Zero Emission Zone*

1. Introduction

The primary goal of Shift2Zero is to advance zero-emission logistics solutions for sustainable urban mobility. To do so, the project is developing 6 innovative concepts for the N1 electric vehicle segment that enhance operational efficiency and reduce emissions. Central to the project is developing innovations in accordance with the needs of users and stakeholders. Shift2Zero applies an array of different methodologies across Work Package 2 (WP2) to elicit user requirements for the various project innovations at the System, Fleet, and Vehicle levels. Methods for extracting user requirements include semi-structured interviews, Choice Based Conjoint CBC surveys, observation of users, workshops, and a review of existing literature.

WP2 will provide a list of user requirements for the project's innovations that can then be integrated into the later design and development of the project's solutions in WP3. Understanding user requirements is a critical step in any innovation project and is essential for designing solutions that meet actual problems. The goal is to avoid spending time and resources designing solutions for problems that either do not exist or are not experienced by users.

Shift2Zero applies a user- and mission-oriented design methodology that keeps stakeholders closely involved throughout the entire development process. This approach ensures that vehicles are specifically designed to address both present and future demands in urban logistics. The different innovations explored in Shift2Zero offer key advantages such as reduced spatial footprint, enhanced safety, improved energy efficiency, and the ability to support new operational logistics models—responding to the diverse challenges faced by urban logistics stakeholders. The overall methodology in WP2 for identifying requirements follows a five-step process, with user needs placed at the core of each phase (Table 1).

Deliverable	Description
Step 1 (Task 2.1)	End-user identification and requirements elicitation through in-depth interviews, expanding on the MODI project's method by focusing on user goals, their strategies to achieve them, and the limitations of current vehicle use.
Step 2 (Task 2.2)	A Holistic-Experience-Centred (HEC) method, which captures conceptual design challenges to inform future design guidelines through interviews and workshops with direct process participants such as workers and fleet managers.
Step 3 (Task 2.3)	User-specific surveys featuring choice experiments, aimed at uncovering user preferences and understanding trade-offs.
Step 4 (Task 2.4)	Synergies with new logistics concepts and innovations using simulation models.
Step 4 (Task 2.5)	Co-creation workshops, where final user requirements are analysed and refined collaboratively.

Table 1 Overview of WP2 tasks and methodologies

Insights from interviews, surveys, and workshops are then synthesized to define relevant simulation scenarios for further development and validation in WP3 and WP4. This deliverable is an output of Task 2.1, providing both an initial user and stakeholder mapping as well as a list of user requirements at the fleet and system level.

1.1 Objectives of the deliverable

This deliverable takes a system and fleet perspective to identify user requirements within the Shift2Zero project so as to more broadly understand how the proposed innovations fit within various logistic ecosystems. The output from this task (2.1) is intended both to support the other tasks within WP2 as well as inform the development of the innovations and use cases in WP3 and WP4. Task 2.1 will also support the development of the impact assessment framework in WP7 by identifying relevant KPIs through interviews with users and stakeholders.

As such, the results of this deliverable are intended as a complement to deliverables 2.2 and 2.3 which, taken together, comprehensively assess user needs at the system, fleet and vehicle levels for the innovations within the Shift2Zero project.

1.2 Innovations in Shift2Zero

Shift2Zero is piloting six innovative concepts. An initial description is provided here, though the intention and expectation are for the design of the innovations to be adapted depending on the outputs from WP2 and WP3, as well as the results of the testing during the pilots as part of WP6. The following descriptions were also used as part of the interview process (described more in depth in section 2.1.1).

Innovation	
(1) Cargo-body with multiple temperature zones. A cargo body with a sliding wall that allows the size of the temperature zones (from -18 to +18 degrees) to be adjusted for different needs.	
(2) Thermal comfort and safe ergonomics. Infrared heating panels provide driver comfort and improved energy efficiency. Reduces energy used for heating to allow expanded range and use of cooling for cold-chain deliveries. Safe ergonomics outside the vehicle increases both driver and pedestrian safety.	

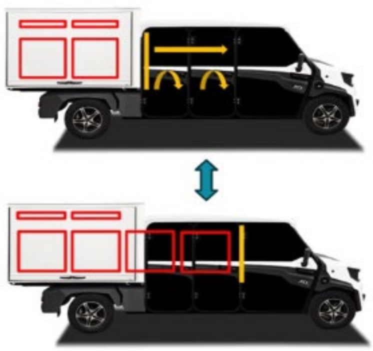
(3) Holistic energy management and control strategies for braking, tyres and powertrain to increase overall efficiency and reduce environmental impact (particle emissions), and support V2G and V2L bi-directional charging.	
(4) Swap box to facilitate transshipment. Standardized lightweight box that is removeable and foldable to ease return logistics. Can transfer between different vehicle types to allow vans to better interact with and/or support different vehicle types such as trucks, mopeds or cargo bikes.	
(5) Geofencing strategies to encourage safe driving and streamlined activities in urban cores. Scenarios include automatically limiting speed to gain access to pedestrian areas, sharing data or booking of loading/transshipment zones.	
(6) Dynamic optimized space for goods and passengers while maintaining separation with the goods compartment using a moveable protective partition. Allows vehicle to be quickly adapted to different uses.	

Table 2 Overview of the different innovations to be developed in Shift2Zero

1.3 Structure of the deliverable

Chapter 1 (this chapter) introduces the project and its innovations, the objectives of the deliverable and an explanation of different types of requirements and how they are used. Additionally, a brief review of literature and relevant EU projects is presented. Chapter 2 explains the methodology used to develop the stakeholder maps and extract requirements at a system and fleet level. Chapter 3 presents the stakeholder maps and provides an aggregated list of user requirements for each innovation. Finally, Chapter 4 concludes the deliverable. Additional materials, such as the interview guide, use case elicitation templates, and the full list of specific requirements for each innovation available in the appendices.

1.4 Defining user and stakeholder requirements

Understanding requirements of users and stakeholders is an essential part of design and development in any complex project (McKay et al., 2022). Requirements exist at multiple levels, from high level requirements that consider the goals of a system, down to lower-level solution requirements that define how specific components need to behave (Courage & Baxster, 2005). Taking a structured approach towards user and stakeholder requirement elicitation allows a connection to be built between the higher-level system goals to the components it is comprised of, ensuring that the overall goals of the project are better supported. In the case of Shift2Zero, the overarching goal of the project is to support the more rapid adoption of zero emission electric vehicles by providing mission focused, right sized vehicles that meet the needs of users.

In this deliverable we are looking at higher level requirements related to user and stakeholder needs. A single user requirement may have many solution requirements associated with it. For example, a general user requirement such as “the vehicle must accelerate smoothly” would be fulfilled by multiple solution requirements that define aspects such as the power output available, the power transfer to the tires, and the maximum acceleration curve allowed. Using the generated user requirements from WP2 as an input, the definition of solution requirements will occur in WP3.

Figure 1 Relationship between system goals and different types of requirements (Phillips et al., 2023)

Anchoring the elicitation of user requirements within the larger goals of a project is also important to ensure that the wider contexts around a project are adequately considered. Technological innovation systems are strongly shaped by their contextual structure, such as supportive and competing technologies, the characteristics of the sector in which they are embedded, its regulations, norms, infrastructure, the regional variation and geographical features, and the political landscape (Bergek et al., 2015).

Therefore, it is important that user requirement elicitation goes beyond the immediate technology level and considers the broader system factors and interactions that can determine its adoption. In design of innovative solutions, user requirement elicitation is a critical activity in the process of incorporating different needs of stakeholders into the engineering process (Pacheco et al., 2018).

WP2 considers the different innovations in Shift2Zero at the System, Fleet and Vehicle levels. To effectively elicit user requirements, the innovations were sorted into groups and considered how they interact with these different levels (Figure 2). Geofencing was considered to be a system level innovation as it had implications for the context in which vehicles operate. The swap box, multi-temperature cargo body and dynamic space innovations were most closely aligned with the fleet level as they have implications on how fleets operate and interact, allowing for new types of operational patterns. Finally, Holistic Energy Management and Thermal comfort and Safe ergonomics reside at the vehicle level, providing direct improvements to vehicle behaviour.

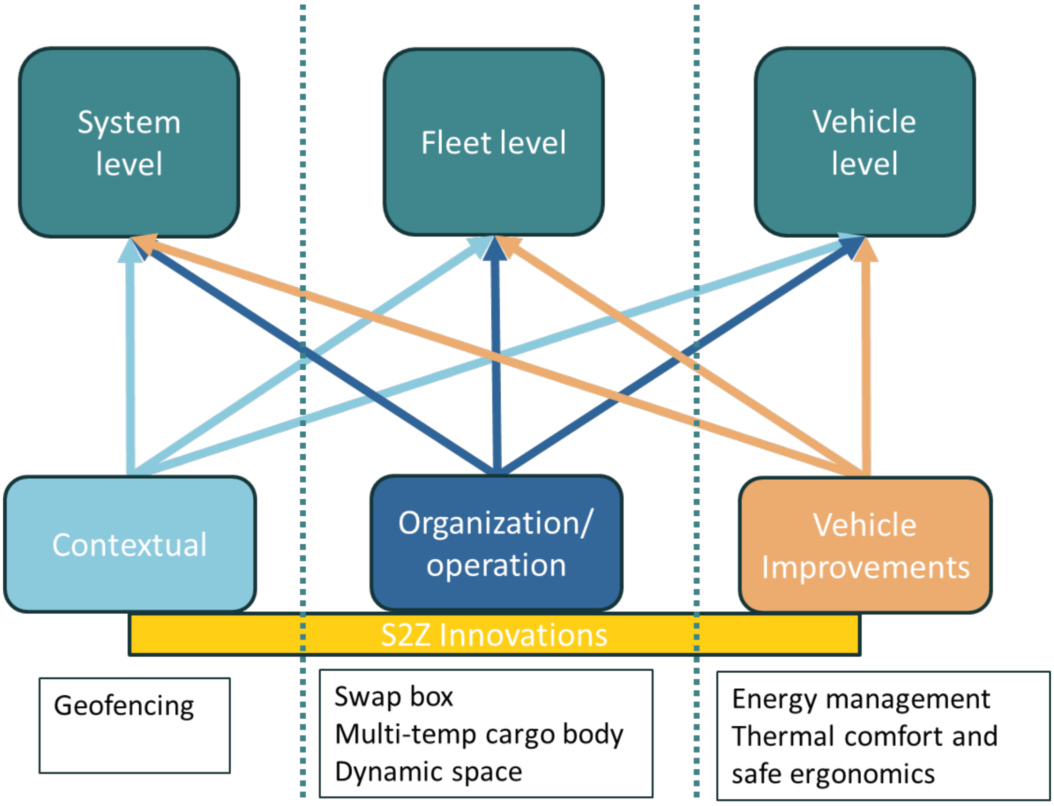


Figure 2 The connection between the different innovations within S2Z and their connection to different levels of user requirements

Different tasks within WP2, using different methodologies, are better able to address specific levels. For example, surveys may be most appropriate for fleet level requirements as they consider more general vehicle attributes from many users; workshops with drivers appropriate for vehicle level requirements as they focus more in-depth on interaction with the vehicle itself; and interviews more appropriate to understand concerns at the system level as they can provide insights into the interaction between different stakeholders and their constraints. Importantly, there is significant overlap here, and requirements elicited through interviews will not be solely related to the system and fleet level, though much of the focus will be there.

Likewise, a specific innovation may be most relevant for system level requirements, but this does not mean it is only relevant at the system level. For example, implementing geofencing has many requirements that must be met at a system and fleet level. Related to building the context in which it is used through cooperation between multiple partners, However, it also has some requirements at the vehicle level in terms of technical compliance. The entirety of Figure 2 can be considered as part of the centre box for user and stakeholder requirements (Figure 1) that need to be connected to the wider system goals and eventually be specified into solution requirements needed for WP3.

1.5 Review of user requirements from EU projects

Relevant completed and ongoing EU projects with a focus on light electric vehicles in logistics were identified using the CORDIS database, web-based searches, and networks such as 2Zero and ALICE. To capture the most recent developments, the review focused on ongoing projects or projects completed in or after 2020.

Using the criteria i) focus on low emission/electric vehicles, ii) relevance for logistics, and iii) documented approach to eliciting user requirements; we identified 5 projects of interest with published Deliverables or articles that would further inform our approach in Shift2Zero. For each project selected, deliverables related to stakeholder mapping and user requirements were reviewed. For each project we examined which stakeholder groups were identified, how they had been identified, and which user requirement elicitation approach was used.

EU Project	Date	Stakeholders	Stakeholder mapping approach	User requirement elicitation approach	Relevant Deliverable(s)
ZEFES	2023-2026	Logistics Service Providers (LSPs), Shippers, Transport Operators, Drivers, Logistics Site Operators, Energy Suppliers, Infrastructure Providers, Charging Station Network Operators, OEMs, Vehicle Designers, Logistics Mission Planners, Researchers. Authorities and regulatory bodies	(1) Start with logistics actors and do snowball effect. (2) Define the vehicle's core purpose. (3) Identify transport organizers (4) Identify the primary user (driver). (5) Map logistics sites operators. (6) List charging/fueling stakeholders. (7) Add OEMs and designers. (8) Include digital/logistics planners.	Survey, Interview, Delphi method, adjust to context of geographical location, Use agree/disagree statements on needs, Use MoSCow method to rank needs, Categorize the needs, Derive KPIs.	D1.1Technical Requirements (Henning & Schmid, 2023); D1.2 Defined use cases, target metrics and needs (Kraaijenhagen et al., n.d.)
SOLUTIONSplus	2020-2024	Public Transport Companies, National / Regional / Local Authorities, OEMs, Service providers (Private and small-scale operators (also informal), energy companies), Charge Point Operator (CPO), Charge Location Owner, Mobility Service Provider (MSP), Roaming Platform or Aggregator, EV Driver, Distribution System Operator (DSO), Transmission System Operator	(1) City teams list their stakeholder groups including their subsidiaries. (2) administer a qualitative online survey to map intended user groups and some insight into their barriers. (3) Develop the stakeholder interview based on survey insights.	Survey, interview to gather KPIs. Map the current status, the desired future and the gap and needs, the process to reach a target and use the relevant KPI for impact assessment.	D1.2 Evaluation Framework: user needs and data requirements (Pham et al., 2021); D1.3 User needs assessment (Pham et al., 2021)

		(TSO)Research, NGOs			
STARDUST	2017-2024	Government, Research, Business, Civil Society and their corresponding subsidiaries.	Start with major stakeholder categories per City. Further describe the stakeholder. (for example, Government Municipality, Sustainability group). This is followed by contact information for the stakeholder group and the topic area of affinity (Energy, Mobility, ICT, more than one)	Engage the stakeholders. (1) develop operational scenarios on how the system would be used. (2) Conduct functional decomposition where high level goals are broken down to subsystems and functions. (3) Requirement traceability where user requirement is mapped to system requirement. (4) Iterative review and (5) Documentation	D1.7 Report on requirements and architecture for the open city information platform (Gómez et al., 2018); D5.6 Report on stakeholder and citizen engagement activities (Ntavos et al., 2018)
ULaaDs	2020-2024	shippers, transport operators, receivers, shopkeepers, offices, residents, public authorities, associations, academic institutions, city residents, users, vehicle providers, IT providers.	(1) Use local knowledge of the city, previous projects and partners to map network including public and private organizations, NGOs, citizens and researchers. (2) Categorization based on their level of influence and interest. (3) Evaluate and analyse each stakeholder's role and impact and conflict and collaboration. (4) Develop an engagement plan and use interviews, co-creation workshops, surveys.	surveys, interviews, workshops, co-design, and usability testing	D2.6 Local ecosystem stakeholder's needs and requirements and prioritisation of use cases (Illek et al., n.d.)
ELVITEN	2017-2020	Municipalities, Manufacturers, Maintenance Companies, Electric distributors, Logistics companies, Booking platform providers, Competitors with other EL-V categories, public transport companies, Hotels and National Parks, Suppliers, EL-V owners, EL-V sharing, rental or leasing companies, Citizens, Tourists, Commuters, Delivery carriers	(1) Identify the stakeholders relevant to the specific tool or service. (2) Map the Business Model Canvas and map any actor involved. (3) Map the relationships and connections between the stakeholders. (4) Map the relevance of policy makers and the broader ecosystem' stakeholders. (5) Include the regional and external stakeholders.	(1) Map the users' functional requirements, including operational needs, ICT needs, policy needs. (2) Classify the needs based on their importance into essential, desirable and nice-to-have needs.	D1.2 ELVITEN Usage Schemes and functional requirements (Winder et al., 2018); D5.1 Real mobility needs of EL-V's users (Papi et al., 2020)

Table 3 Overview of relevant EU projects

1.6 Implications for Shift2Zero approach

The reviewed projects suggest the following steps in user requirement elicitation approach: Begin by identifying stakeholders and categorizing users based on their roles, expertise, or usage frequency. This is followed by initial data collection through surveys, interviews, and workshops to gather contextual information such as geographic location and current practices. Next, the current situation is defined alongside the desired future state to perform a gap analysis, which highlights user needs. These needs are then elicited in detail, exploring user expectations and pain points. Requirements are prioritized using frameworks like MoSCoW (Must have, Should have, Could have, Will not have) and grouped into functional, operational, ICT, or policy-related types.

In the reviewed projects, once requirements are elicited, high-level goals are broken down into specific system functions through functional decomposition, and a traceability matrix is used to link user needs to technical specifications. Insights are then integrated with local context and original plans, and requirements are iteratively reviewed to ensure consistency. Finally, key performance indicators (KPIs) are defined to measure the fulfilment and alignment of requirements across all stakeholders.

Methods implied by EU project review
Stakeholder identification and categorization based on roles, expertise, or frequency of use.
Data collection through surveys, interviews, and workshops to understand current practices and environments.
Gap analysis between current state of operation and the desired state to identify needs, expectations, and challenges.
Prioritization and functional breakdown of elicited needs using methods such as MoSCoW to break down goals into functional components linked to technical specs.
Integration, revision and evaluation of KPIs.

Table 4 Methods implied by EU project review

The review of the EU projects solidified the intended plan for Shift2Zero, as it was clear the overall structure of WP2 (Table 1) followed a similar trajectory that could be tailored as needed.

For Shift2Zero, initial stakeholders were identified through project meet ups, a workshop and a literature review of relevant projects. Interviews were planned and conducted, occasionally leading to new potential interviewees through the snowball effect. The gap analysis was performed by formulating pain points, challenges and expressed needs into requirements when applicable. These requirements were then aggregated based on underlying and recurring theme. Other tasks within WP2 will implement surveys and workshops.

However, conducting an analysis such as MoSCow was deemed as premature for this deliverable and best suited for later in WP2 and WP3 where technical and functional requirements are to be clarified and prioritized more closely with the experts and users. Nevertheless, identified KPIs were coded for future reference if needed. Our adopted method ensures an iterative and developing process of stakeholder mapping and an identification of needs and challenges to be translated into users and stakeholder requirements.

2. Methodology

As the first task in Work Package 2, task 2.1 focuses on a broader approach to better understand user requirements at a system and fleet level. Using the results from the literature review and building upon the methodology used in project MODI (Phillips et al., 2023), the specific methods used in this task for stakeholder mapping and requirements elicitation are described in greater detail below.

2.1 Data Sources

The stakeholder mapping and the elicitation of user and stakeholder requirements were based on three data sources: a workshop, use case descriptions for each innovation, and interviews.

2.1.1 Workshop

During Shift2Zero's kick off meeting, held in January 2025, a workshop was held focused on user requirements. During the workshop discussions focused on the role of user requirements in large projects, who the users and stakeholders are, and culminated in participants mapping the freight ecosystem from their perspective as a user.

The individual ecosystem maps for participants were photographed and the information transferred to an Excel spread sheet, in addition to the responses from two WooClap questions (below) conducted with consortia members during the kick-off meeting.

Question 1: Who do you consider relevant Shift2Zero stakeholders?

Question 2: Who are important users within Shift2Zero?

The responses were then organized and categorized into different stakeholder groups.

Notes taken during the workshop informed the questions for the interview guide and suggested potential stakeholder groups to prioritise when reaching out for interviews. The workshop also served as an initial stakeholder mapping.

2.1.2 Use case descriptions

As a prerequisite to the elicitation of requirements, a common definition and understanding of the innovations and their use cases was needed, especially in order to get the most up-to-date knowledge on the planned innovations and the intended use cases.

To do so, a use-case generation template was distributed to, and filled in by, pilot-leads (Annex 1, section 6.1). It allowed to confirm the innovations descriptions as presented in 1.2 that were then used in the interviews (see 2.1.3). It also provided more context and knowledge to draw on for the interviewing researchers, allowing them to ask more specific questions about the innovations and clarify the intention of the innovations to the interviewees.

2.1.3 Interviews

According to (Ensslen et al., 2016), there are several methods that are common to gain empirical insight into user or customer needs for innovative solutions. These methods include quantitative and qualitative methods, including semi-structured interviews. Indeed interviews are considered to be a primary technique in user elicitation, which can provide more details into work processes in a variety of contexts (Pacheco et al., 2018). It is particularly suitable for new products with developing concepts that still have diffuse needs, which is why interviews were chosen as main data source for task 2.1.

Conducting interviews early on ensures that users' pain points are understood and the innovation design could be adjusted to address real operational needs. However, according to (Lee et al., 2022) one must be aware of the trade-off between identifying real needs and getting sidetracked by users that may not know what they want. Therefore, it is important to interview a variety of stakeholders from various points of views and with varying degree of involvement.

For that reason, a total of 44 interviews were conducted between March and August 2025 with a variety of relevant users and stakeholders from 11 European countries. Interview participants were recruited from the project consortia, from TØI's own network, and through support of research partners VUB, BAX and FIT. Of the 44 interviews held, TØI conducted 43 of them, and BAX conducted an additional interview and subsequently provided the transcript to TØI. VUB observed 4 of the interviews.

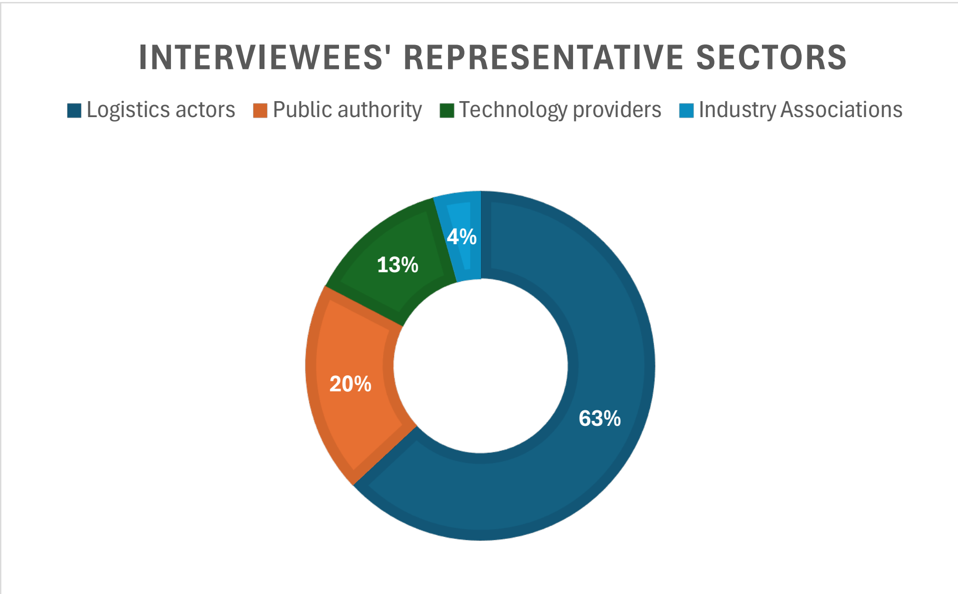


Figure 3 An overview of the interviews conducted with actors from major stakeholder groups

Figure 3 provides an overview of participants. The main stakeholder groups spoken with were public authorities, logistics providers (transporters), industry associations, and technology developers. The final sample is relevant as these stakeholders are considered the primary users and stakeholders of the innovations in Shift2Zero. Of the logistics actors, 12 were regional operators, 9 were National operators, and 5 were regional arms of Global operators. During the final coding, the industry associations were grouped with the logistics actors as the statements made aligned closely with the perspective of logistics actors. This was also done to maintain anonymity.

The interviews were semi-structured and conducted using an interview guide designed to elicit statements related to challenges, needs and values associated with the planned innovations in the project. When developing the interview guide, questions were included to understand the underlying reason for differing levels of interest in certain innovations in light of the challenges and pain points of stakeholders, including non-users (Mesimäki & Lehtonen, 2023).

In that sense, interviews can provide insight into underlying reasons that go beyond what surveys and experiments could capture. The interview guide also included questions to identify stakeholder needs, uncover problems in existing systems, and clarify misunderstandings through feedback. Through these questions, the intention was to help distinguish facts from opinions, provide a general and holistic view of requirements, and reveal contextual aspects for better problem understanding. Moreover, interviews are effective for gathering complete information, clarifying ambiguities, supporting innovation, and driving process improvement (Pacheco et al., 2018). The interview guide is presented in Annex 2 in section 6.2.

In anticipation of the interview, each interviewee received:

- short descriptions of each innovation (see 2.1.2),
- consent form for recording of the interview.

While researchers anticipated which innovations were most interesting to interviewees prior to recruitment, participants were free to engage and discuss the other innovations in which they were interested. Generally, each interview elicited statements on 2-3 of the different project innovations in Shift2Zero.

Interviews were conducted on Microsoft Teams and lasted between 45-70 minutes. Interviews were recorded and transcripts were automatically generated using transcription software.

2.2 Analysis

The analysis was organised in two parts:

- The elicitation of user and stakeholder requirements, based on interviews conducted with a guide informed by the workshop and use case descriptions.
- The stakeholder mapping, based on data from the workshop, use case descriptions and the interviews.

2.2.1 User and stakeholder requirements elicitation

Using the transcripts from the interviews, researchers extracted **statements** or short paragraphs that expressed a need, challenge, or value. During this process, each statement was coded according to which innovation it referred to. This process resulted in 1581 statements of which 84 statements were coded as relevant to at least two innovations (for example, relevant to both swap box and Holistic Energy Management).

The original statements were given unique ID numbers and then further analysed by researchers who interpreted them into the expression of need from the viewpoint of the user or stakeholder.

Over several sweeps by multiple researchers to maintain quality control, these statements underwent a first level of aggregation when possible, becoming **specific requirements**.

For example- consider these two statements of need from two different interviews discussing speed restrictions using geofencing:

> "As a logistics operator we need access to city centres, and we are willing to compromise with some restrictions that allow access."

> "As a logistics operator we need to secure access to restricted zones through collaboration with the city."

The above statements could be aggregated into a single specific requirement:

> "Geofencing needs to offer logistics actors clear gains to operational efficiency by providing access in exchange for restrictions on vehicle speed/behaviour."

The many specific requirements produced in this first step were then grouped thematically and combined further into the fully **aggregated requirements**.

In the example given above, the specific requirement was grouped into the theme "Stakeholder value and business case" (see section 3.6.2) and aggregated into the following general requirement:

> "Geofencing must demonstrate clear, shared value by delivering operational, social and environmental benefits to both public authorities and logistics stakeholders- improving efficiency, safety and compliance while reducing administrative burdens and enabling better urban space management."

The above general requirement is an aggregation of 41 specific requirements.

In chapter 3, the requirements presented are the **aggregated requirements**. All **specific requirements** for each innovation are available in the Annex in section 6.3. The annex also gives the ID numbers of original **statements** that supported each specific requirement.

Table 4 below summarizes the process from interview statement to aggregated specific and general requirement.

Step 1	Step 2	Step 3	Step 4
Interview statement	Statement of need	First aggregation (specific requirement)	Thematic aggregation (aggregated requirement)

Table 5 Overview of steps to extract and aggregate requirements

2.2.2 Stakeholder mapping

Through the initial workshop and use case descriptions provided by pilot leads, we identified 7 main user and stakeholder groups.

Main User and Stakeholder Groups						
Technology Developers	Logistics Actors	Public Authorities	Interest Groups	Infrastructure and landowners	Receivers	Citizens

Table 6 Overview of the main user and stakeholder groups identified

To complete this first overview of the different users and stakeholders, the department and role of all interviewees were identified to give a more thorough overview of the direct and indirect potential stakeholders relevant for each innovation.

In addition, all statements from the interviews mentioning a key stakeholder were coded with a specific label. It enabled us to review all these statements and to identify additional stakeholders who were added to the stakeholder maps for each innovation. The final stakeholder maps are presented in chapter 3 alongside the aggregated requirements for each innovation.

3. User Requirements for Shift2Zero (Fleet and System level)

This section provides a list of aggregated user and stakeholder requirements for the Shift2Zero innovations. Each innovation has its own sub-section, containing an introduction, a stakeholder map, a table with a list of aggregated requirements and more thorough explanation of each aggregated requirement. Finally, the section ends in a discussion of the requirements and innovations as a whole.

The document is set up so each aggregated requirement can be traced back to its constituent specific requirements. The full list of specific requirements is available in Annex 6.3 and the specific requirements are grouped by the aggregated requirement to which they belong.

In addition to the six innovations in the project, a 7th category, "General requirements" was established. Each interview began by discussing the interviewees work more generally before speaking more specifically about one or more of the innovations that was of interest to them. As a result, a larger number of statements were generated that did not specifically discuss the projects innovations but still provided insights into the needs of electric vehicle users and stakeholders. The distribution of statements and requirements across the innovations are presented in Table 6. As 84 statements were coded to 2 or more innovations (see 2.1), summing the statements column in Table 7 gives a higher number (1667) of statements analysed than what was actually extracted.

Innovation	Statements	Specific Requirements	Aggregated Requirements
General	775	327	11
Multi temp Cargo Body	142	85	9
Thermal comfort and ergonomics	51	25	6
Holistic Energy Control and Management	118	84	7
Swap box	224	118	10
Geofencing	306	205	9
Dynamic space use	51	26	6

Table 7 Number of statements extracted from interviews and the corresponding number of Specific and Aggregated requirements determined

Geofencing and the swap box generated the largest number of statements (aside from the general category). This is likely due to a combination of factors, including the type of innovation, the selection of interviewees and the use of interviews as a methodology. As discussed in section 1.4 and shown in Figure 2 this deliverable is focused on user and stakeholder requirements at the fleet and system level. Interviewees were often in a manager role and thus had a larger perspective over the broader system, but may have had less insight into driver experiences, for which innovations such as Thermal comfort and ergonomics may be more relevant. Dynamic space use also had fewer statements. This innovation is potentially interesting for those interested in having a multi-purpose fleet (such as a car-share company) but is less relevant for logistics actors engaged solely in parcel and goods delivery. This meant interviewees potentially interested in this innovation needed to be directly targeted.

3.1 General requirements for adopting e-LCVs

The general requirements were generated through discussions with users and stakeholders about their current and expected challenges when using electric vehicles. The impact of current and expected regulations on vehicle choice was also a key topic in discussions, especially in relation to access to city centres. In some cases, the general requirements here serve as a prerequisite before actors can begin considering the implementation of Shift2Zero's proposed innovations. Prior experience with electric vehicles and the associated challenges related to cost, range, and charging, will make them better positioned to understand the potential needs, challenges and value when considering the proposed innovations.

3.1.1 Stakeholder map

Figure 4 Key users and stakeholders for Shift2Zero's innovations according to interview participants

Through the analysis of the general requirements, an overall stakeholder map was generated. This non-exhaustive map provides an overview over the key users and stakeholders mentioned during the interviews. Scaling up the innovations planned by the project will require a concerted and coordinated effort to involve all of these stakeholders to varying degrees. At the core, however, is the interplay between technology developers, public authorities and logistics actors.

3.1.2 Aggregated requirements

The interviews provided 775 statements on general requirements for electric vehicle use, which were then aggregated to 327 specific requirements. Upon thematic grouping, a total of 11 aggregated requirements were generated.

	Aggregated Requirements		Number of Associated specific reqs
1	**Costs and TCO**	Electric vans need to be financially viable with competitive purchase prices, operating costs and long-term TCO compared to fossil fuel alternatives	28
2	**Value Creation and Market fit**	Solutions must clearly demonstrate measurable value for customers, logistics operators, and public stakeholders while balancing sustainability with efficiency.	24
3	**Fleet planning and delivery operations**	Logistics operators need efficient fleet planning and delivery operations that balance route optimization, vehicle availability, and adaptability to changing urban contexts. Efficient sorting and loading strategies are needed to enable more efficient routing.	124
4	**Safety, usability and workforce**	Vehicles, operations, and systems must be safe, user-friendly, and designed to attract and retain a skilled workforce.	26
5	**Stakeholder coordination**	The logistics ecosystem needs stronger collaboration and communication across private actors, public authorities, and subcontractors to reduce fragmentation and align strategies.	25
6	**Sustainability Objectives**	Logistics systems must measurably reduce emissions and environmental impact while embedding sustainability into long-term operations and reporting.	22
7	**Use of space and facilities**	Urban logistics requires optimized use of limited space, including depots, hubs, loading zones, and curb access, to ensure efficient and sustainable deliveries.	12
8	**Vehicle capability and support**	Vehicles must be reliable, versatile, and capable of meeting diverse operational needs while supported by robust maintenance and service networks.	32
9	**Energy and service infrastructure**	Logistics operations require reliable, affordable, and widely available charging infrastructure that integrates with depots, grids, and urban environments.	23
10	**Policies, access, and incentives**	Clear, consistent, and supportive policies and incentives are needed to provide predictable operating conditions and drive the transition to sustainable logistics.	43

11	**Data, knowledge and foresight**	Stakeholders require reliable, accessible knowledge and data on logistics, fleets, customer needs, and best practices to plan, test, and scale innovations.	27

Costs and TCO

Initial purchase price remains a major barrier to adoption for electric vehicles, despite potentially lower TCOs, initial costs must be lowered to speed up adoption. Users operate on thin margins and need to see clear financial gains to adopt electric vehicles. Related to this was the reluctance to purchase due to rapid improvements in technology meaning that vehicles were unlikely to hold their value over time as compared to fossil vehicles. The availability of financially competitive leasing of electric vehicles can mitigate these concerns. Other incentives to purchase, such as less expensive tolls or other subsidies are needed to more quickly drive electrification.

Energy prices and battery replacement were also of concern. Access to cheap, fast charging competitive with fuel prices is needed for adoption. The ability to replace old batteries, match the size (and cost) of batteries to intended operations and generally reduce the overall price of batteries are also key barriers to electric vehicle adoption that must be addressed.

Though not necessarily related to electric vehicle adoption, the need to reduce labour costs through efficient operations was clearly expressed as a need by multiple actors.

Value creation and market fit

The value of adopting more sustainable solutions need to be reflected in the price customers are willing to pay or by allowing companies to better establish themselves in the market. Clear, tangible benefits need be shown regarding operational efficiency, customer satisfaction and meeting sustainability objectives. It is important that value is shown for multiple actors, both public and private, to create a mutually beneficial situation that can drive progress more rapidly.

Navigating a new market with new solutions is challenging and companies need to anticipate future demand and consumer preferences and must therefore identify specific needs that require new vehicle solutions. Potential solutions must be flexible enough to adapt to changing demands and needs without major re-investment.

Fleet planning and delivery operations

Efficient fleet management requires logistics actors to coordinate processes across charging, sorting, routing, and vehicle deployment. Before vehicles begin their delivery routes, they need to be sufficiently charged to carry out their planned tour. Sorting and loading procedures must be carried out efficiently, reducing personnel required and time used. Effective sorting is also needed to enable more efficient route planning that can involve multiple vehicle types or exchanges of goods at city hubs.

On route, vehicles must reduce the amount of vehicle kilometres travelled per stop by implementing efficient routing. For fleet composition, trade-offs must be made to suit the local context, considering the presence of access restrictions, ease of manoeuvrability, vehicle capacity (weight/volume), range and the potential to refill goods during the day. Route planning should consider driver discretion and experience based on on-the ground realities. Reducing driven kilometres, and thus the need for charging, offers further operational benefits by reducing the frequency and time spent charging and allowing it to be staggered throughout the fleet during off-hours.

Adopting new vehicle types requires the establishment of new routines. Fleet management software should be standardized and interoperable with multiple vehicle types/brands enabling logistics actors to better adapt to evolving technological and regulatory environments.

Safety, Usability and Workforce

While a promising innovation may be implemented into a logistic system, an engaged, trustworthy and capable workforce is needed to ensure its success. Companies need ways to retain and attract drivers. Logistics actors must address resistance or scepticism to using new vehicle types by building familiarity, highlighting advantages and setting clear expectations (such as the use of electric vehicles) as an employer. Drivers' comfort and safety must be ensured through tactics such as limiting workloads, maintaining vehicles well, and providing feedback on driving behaviour. Companies need recruitment strategies that work for different types of vehicles, ensuring that employees end up driving a vehicle that they like and is easy to maintain and use.

The safety of vulnerable road users (VRUs) must also be prioritized by considering the type of vehicles used and the context in which they operate. Driver behaviour must avoid conflicts with VRUs while carrying out logistics activities and user interfaces in vehicles must minimize driver confusion through simplicity of design and ease of use.

Stakeholder Coordination

Effective communication is at the core of this requirement, and something that must occur at all levels between both private and public actors. Public actors must find ways to manage sometimes fragmented responsibilities and decision making within internal departments and across local, regional and national levels of government. Clear lines of communication must also be established with private actors to connect landowners, business and logistics actors when trying to implement solutions to logistics challenges.

Private actors must also manage coordination at multiple levels, both between internal departments and to front-facing employees such as delivery drivers. Tier 1 suppliers, OEMs and logistics actors need to coordinate so they can anticipate the impacts expected regulations may have on their businesses and implement plans to adapt to changing regulatory environments.

Sustainability Objectives

There is a clear need for companies to manage the transition to electric vehicles quickly to achieve their primary sustainability objectives of reducing C02 emissions. Standardised ways of reporting C02 emissions for different low emission fuel types (biogas, BEVs) need to be implemented accounting or the source of power generation (e.g. coal vs hydro). Companies need long term strategies that allow them to manage the transition to more sustainable technologies without degrading their business models. Sustainability needs to be embedded in the core of vehicle, battery and component design, and impacts considered from the perspective of a lifecycle analysis.

Smaller, more space efficient vehicles need to be considered as tools to reduce emissions and traffic congestion in urban areas. To further reduce traffic, a reduction in the use of cars for private mobility needs to happen. Finally, the importance and benefits of energy efficiency and more sustainable solutions need to be more clearly communicated to build support.

Use of space and facilities

Space availability in urban areas is a significant challenge for logistics actors. Loading zones need to be available to carry out deliveries, often in the form of parking spaces at the curb side. Parking spaces designated as loading zones must be large enough for their intended purpose, accommodating the LCEVs carrying out the delivery operations. Flexibility in the designation of loading zones is another key factor needed to enable solutions such as mobile pick-up points, where vehicles may need to wait in a single space for a longer period of time.

There is also a need for space to support the use of city hubs and/or nano hubs. These facilities need enough room for logistics processes such as loading, sorting, charging or vehicle storage. They must also be strategically placed to support efficient delivery operations and potentially enable the use of smaller, more space efficient vehicle types. Coordination with landowners, both public and private, is needed to make the space for such facilities available.

Vehicle capability and support

Sufficient range is naturally a key requirement for electric vehicles and has significant implications on operations and planning. Range can be considered both in terms of number of kilometres driven, but also number of tours (days of operation) that can be completed. The need for a vehicle able to complete multiple tours is dependent on the availability of charging during down time, but vehicles should at least be able to complete a single day's operations without charging. 200km is frequently mentioned as sufficient range for most daily operations.

OEMs should offer flexibility allowing operators to balance payload capacity, battery weight and costs according to their specific needs. Vehicles must be able to operate across diverse climates, geographies and operators need access to various sizes of vehicles to operate in contexts such as narrow urban streets.

Standardisation of vehicle platforms and components is needed to streamline repairs and reduce complexity. This would also support the need for a structure service network that can ensure timely service and maintenance. At the same time, platforms must be flexible enough to enable customisation for different use cases so as to support the transport requirements of different goods types (fresh food, cold chain goods, parcels).

Energy and service infrastructure

Properly implementing charging infrastructure is a major need and challenge for scaling up the use of electric vehicles. Operators need to charge quickly and efficiently, in strategically well-placed locations with standardized interfaces. Logistics actors have varying needs dependant on the size of the operations, with some needing onsite charging at their warehouse, whereas sub-contractors may have a greater need for fast and available public charging. Grid capacity must be expanded to meet the growing demand for charging infrastructure. Processes to build charging infrastructure should be streamlined. Coordination between logistics actors, landowners and public authorities is needed to drive increased investment implemented in the areas its needed.

Policies, Access and Incentives

Policy and access determine the context in which logistics operates. Companies need predictable regulations that allow them to plan for long-term investments in electrification, vehicle fleets and infrastructure. Regulations should be technology neutral, while pushing the need for lower speeds and more space efficient operations using smaller vehicles when possible.

Regulations allowing 4,250kg electric trucks to be treated as 3,500kg vans need to be more evenly applied at the European levels, including registration and licensing.

Access to urban areas is an additional challenge that requires flexible regulations that consider aspects such as time of day, vehicle size, or the delivery needs of different types of businesses.

Access also serves as an incentive to drive adoption of new, more sustainable technologies, rewarding companies for investing in more expensive technologies. Companies need to see that responding to a regulatory push with investment in R&D or new vehicle types in order to meet expected regulations.

Data, knowledge and foresight

Both operators and public authorities need more knowledge to plan effectively for future needs. Public authorities, especially, need data on urban freight movements and clear, actionable methods to collect and use such data to implement knowledge-based interventions to meet their goals. Data must be handled sensitively and data sharing routines implemented that protect GDPR and proprietary data from companies while still allowing useful insights to be gleaned.

Logistics actors who have limited experience with electric vehicles need more knowledge about best practices, implementation, and decision making in terms of future fleet composition and purchase. Companies also need methods to more easily collect data automatically and utilize that information to improve their fleet management systems.

3.2 Multi-temperature Cargo Body

The multi-temperature cargo body provides greater flexibility in the types and volume of goods that can be carried by a vehicle. The cargo body will have a sliding wall that allows the size of three temperature zones (potentially from -20 to +18 degrees) to be adjusted. This allows a single vehicle to be potentially used for multiple purposes, especially in situations where cold chain goods volumes vary significantly from day to day.

3.2.1 Stakeholder map

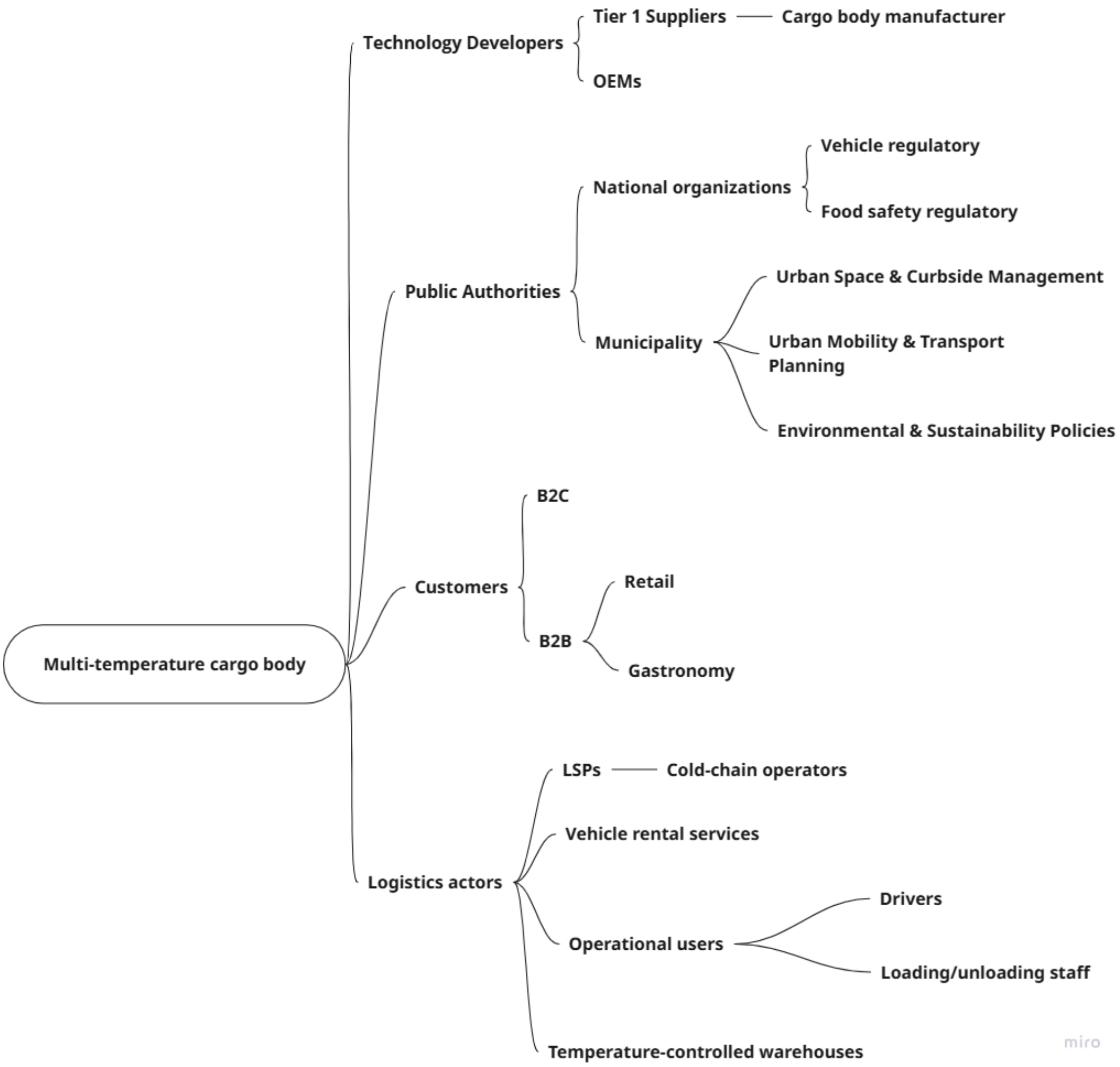


Figure 5 Key users and stakeholders in the multi-temperature cargo body ecosystem as reported by interview participants

The stakeholder map for the multi-temperature cargo body reflects the particularities of transporting temperature-sensitive goods, where the integrity of the cold chain is a critical concern. Compared to generic vehicle innovations, the map emphasises B2B customers in gastronomy sector, who rely on strict temperature control to ensured product quality and safety. This requirement is further reinforced by the role of national food safety regulators. At the same time, enabling the transport of goods at different temperatures within a single vehicle has the potential to reduce the overall number of vehicles in city centres, a development with direct implications for municipalities across several policy areas, which are therefore also represented in the stakeholder map.

3.2.2 Aggregated requirements

The interviews provided 142 statements about the multi temperature cargo body, which were then aggregated to 85 specific requirements. Upon thematic grouping, a total of 9 aggregated requirements were generated.

Aggregated Requirements			Number of Associated specific reqs
1	**Accessibility to cold body**	The design of the cold body must facilitate safe and easy access to the different temperature zones	6
2	**Compatible goals, systems and handling processes across actors**	Through a co-creation process, the design of cold body must be aligned with the needs, goals and policies of the various stakeholder involved. Compatibility must be ensured with the existing logistics processes and infrastructure, both internally and across logistics actors. It must also be aligned with local and national regulatory demands and strategic goal such as emission reduction.	18
3	**Flexible cargo space**	Cold body must be adaptable to the operation volume and needs. It must be flexible, expandable and foldable. It must not take cargo space or take away from the permitted total weight of goods that can be carried.	6
4	**Optimize energy consumption**	Cold body temperature adjustment and maintenance must show an advantage in energy consumption compared to fully refrigerated vans.	14
5	**Impact on vehicle's range**	Negative impacts on vehicle range must be limited as much as possible.	3
6	**Reduction of fleet size through goods consolidation**	Cold body must enable fleet size and variety reduction through consolidation of goods into one vehicle and reduce traffic.	4
7	**Regulatory compliance for multitemperature cargo solutions**	Cold body must comply with regulation for both the vehicle specifications and the carried cold goods food safety requirements. Clarity is needed on regulatory adjustments for both logistics and technology developers.	6
8	**Temperature and humidity adjustment**	Cold body must allow for temperature and humidity adjustment in the three different temperature zones, for a period of 12 hours.	5
9	**Viable business models**	Cold body must demonstrated value for different stakeholders in the energy consumption, efficiency of operations, reduced traffic, fleet size and subcontractor/driver hours, and minimum adjustment and investment in human, technical and physical resources.	23

Accessibility to cold body

The cold body innovation must ensure safe and efficient accessibility to all cargo areas for drivers. The design should allow the driver to enter and operate within the cold body easily, for example through lengthwise doors. These doors must provide equal access to different compartments (cool, fresh, and dry goods). The choice between side doors and rear doors should be made in co-development with users, based on their specific use cases. Access to different temperature zones must be straightforward, and external entry points should account for interior moveable panels.

Compatible goals, systems and handling processes across actors

Cold body innovation must be compatible with logistics actors' goals, systems, and handling processes to ensure seamless integration. Compatibility was identified as a key theme across contexts, including logistics operations, infrastructure, partner collaboration, organizational goals, and the broader regulatory and political environment.

From the public authorities' perspective, the cold body should support sustainability goals by lowering emissions, reducing traffic congestion in city centres, and minimizing the number of delivery vehicles. This may require dedicated parking zones in central areas. To maximize efficiency, one parking spot should enable deliveries to multiple customers. Loading and unloading must be quick—industry benchmarks suggest five minutes per trolley of boxes. The cold body must integrate with existing urban logistics flows, including microhubs.

From the logistics actors' perspective, the cold body is more attractive if it is compatible with pallet sizes suitable for bikes and trailers. Safety during loading/unloading and the protection of goods (temperature stability and damage prevention) are critical. This requires attention to staff training, vehicle specifications, handling procedures, and compatibility with existing operations, fleets, and infrastructure (e.g., warehouses and distribution centres). The cold body must be co-developed in alignment with OEM and supplier specifications, customer needs, and national regulations.

Flexible cargo space

Flexibility was a recurring requirement. The cold body should feature expandable and foldable compartments, with adjustable separators for multiple temperature zones. It should allow for more than the two-zone options currently offered by competitors.

Cold compartments should only be in use when needed, so as not to reduce overall cargo capacity or add unnecessary weight. Alternatives to space-consuming trolleys must be developed. Loading and unloading processes should enable optimal use of available space, aligned with the delivery route and plan.

Optimize energy consumption

The innovation is most valuable if it improves energy efficiency. To meet sustainability goals, cooling should rely on electricity rather than diesel. Idle vehicle time—such as overnight charging—should be used to pre-set temperatures, with daytime power consumption focused on maintaining conditions. Ideally, compartments should maintain temperature for up to 16 hours of continuous use.

Each compartment must remain insulated from external heat when doors are opened, potentially using curtains or internal doors. A single cooling system should serve all compartments to simplify operations. Additional energy sources, such as solar panels on vehicle roofs, could further improve efficiency.

The cold body must optimize energy use by considering the vehicle's overall consumption, weight capacity, and aerodynamics. It must demonstrate advantages in battery life and efficiency compared to fully refrigerated vans, across various vehicle sizes—including vans and trucks up to 4.25 tons. Integration into distribution centres should not compromise energy performance.

Weight must be minimized to avoid reducing vehicle efficiency. In line with cargo flexibility requirements, the cold body should be adjustable in size, shrinking when cold deliveries are not required, to conserve energy.

Impact on vehicle's range

The cold body must operate without reducing the vehicle's range. If range impact is unavoidable, it must be accounted for. This requirement is already considered achievable.

Reduction of fleet size through goods consolidation

Cold body innovation can reduce fleet size and traffic by enabling goods consolidation. A multifunctional vehicle carrying different cargo types can replace multiple specialized vehicles. This reduces not only the fleet size but also the diversity of vehicle types required.

Consolidation also improves driver satisfaction by distributing workloads more evenly. Combining low-volume cold goods with regular deliveries ensures fairer scheduling of hours and tasks.

Regulatory compliance for multitemperature cargo solutions

The cold body must comply with regulations for both vehicles and cold goods.

Vehicle regulations: Logistics actors emphasized the need for electric vans to carry the same loads as diesel equivalents under the same licensing conditions, without being classified as trucks. This would simplify adoption. Technology providers also noted the complexity of certification and regulation as a challenge, highlighting the need for clearer pathways to pilot projects and fast-track exemptions.

Goods regulations: The system must be certified by independent bodies and comply with food safety standards. For frozen goods it must also meet RTP (Returnable Transit Packing) requirements, maintaining –20°C for at least 12 hours.

Temperature and humidity adjustment

Logistics actors require at least three simultaneous temperature ranges, from frozen to ambient. Frozen compartments must maintain –20°C for 12 hours, even when the vehicle is idle. Humidity levels should also be adjustable to prevent ice from dampening goods. Temperature and humidity must be adaptable to the cargo type and conditions.

Viable business models

For cold body innovation to have business value, it must open new opportunities in the logistics sector by enabling delivery of cold goods within the already dense delivery areas of regular goods which are about 80% of goods delivered. Cold body use must result in saving kilometres travelled, increasing deliveries per trip, and reducing traffic in city centres. By consolidating different goods in one vehicle, thus one driver, the number of drivers/subcontractors needed per route can be reduced. Furthermore, through integration of goods, the subcontractors could reach sufficient volume and delivery numbers, helping address the shortage of fresh goods delivery in Europe in a cost-effective way. The solution should also allow last-minute, and on-demand refrigerated deliveries using the existing fleet, offering a clear advantage over existing fixed-temperature-zone solutions. It is best done independently of the public authority investment.

Cold body must ensure operational costs benefits and as such its development is best pursued in alignment with warehouses that have broader infrastructure than those handling only dried goods, ensuring compatibility with existing logistics flows. It must support speedy delivery without requiring costly distribution centre upgrades, and its smaller size should enable better access to urban centres. In urban environments, cold body solutions in sprinter vans must show greater fuel and delivery volume efficiency than larger vans, while remaining light enough to carry more or heavier goods.

To ensure adoption, additional costs such as training costs must remain within a justified range, with pricing models adjusted to accelerate market uptake. Costs and infrastructure driven upgrade expenses should not be passed on to customers. Cold body must result in operational simplicity, improved goods flow dynamics for different actors in city centres. Cold body cooling mechanisms must be independent of battery capacity and be lightweight enough so that loading capacity for goods remains operationally viable. The solution must be transparent in cost, energy use and regulatory compliance to be adopted.

3.3 Thermal comfort and safe ergonomics

This innovation supports thermal comfort and ergonomics. Infrared heating panels provide driver comfort and improved energy efficiency. Reducing energy used for heating to allows for expanded range or frees energy to be used for cooling devices needed for cold-chain deliveries.

Safe ergonomics envisions changes to the interior and exterior of the vehicle (such as the bonnet) to increase safety in the event of a crash. This aspect of the innovation was less discussed in interviews, as mentioned above in the intro to section 3.

3.3.1 Stakeholder map

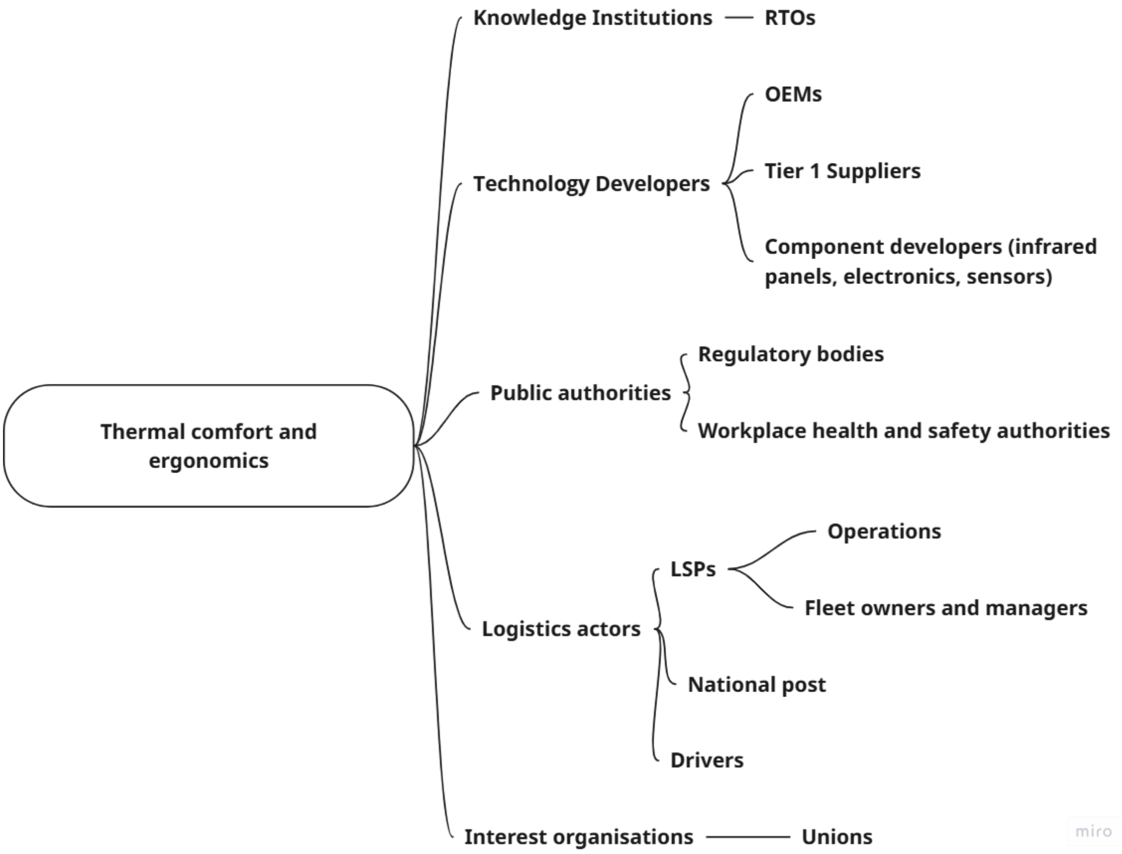


Figure 6 Thermal comfort and safe ergonomics ecosystem as reported by interview participants

The stakeholder map for the thermal comfort and safe ergonomics innovation (Figure 6) in logistics vehicles highlights the salience of labour- and welfare-oriented actors alongside traditional technology developers and logistics operators. In this context, drivers constitute a critical stakeholder group, as they are both the direct beneficiaries of the supposed enhanced thermal comfort and the evaluators of its ergonomic and practical implications. Their perspectives are institutionally reinforced by unions, which act as collective representatives shaping sectoral acceptance and negotiating improvements to working conditions. In parallel, workplace health and safety authorities play a regulatory role by establishing standards that link occupational well-being to vehicle design and equipment requirements. These stakeholders are also reflected in the requirements which emphasize driver comfort and safety.

3.3.2 Aggregated Requirements

The interviews provided 51 statements about the multi temperature cargo body, which were then aggregated to 25 specific requirements. Upon thematic grouping, a total of 6 aggregated requirements were generated.

	Aggregated Requirements		# of related specific reqs.
1	**Driver comfort**	Infrared heating solution must enhance driver comfort while being easy and efficient to use	4
2	**Defrosting function**	Infrared heating could be useful for defrosting windshields	1
3	**Safe and efficient heating**	Heating innovations must comply with homologation requirements while being practical, efficient, and focused on key areas rather than the whole cabin.	4
4	**Preserving vehicle's range**	Heating systems must be energy-efficient and provide estimates of energy savings to ensure they do not excessively drain the battery. Vehicles should also include extra battery margin for heating to maintain overall driving range and reliability.	2
5	**Reasonable costs for useful technologies**	Heating systems should provide operational benefits without driving up total cost of ownership unnecessarily, avoiding excessive or low-value technologies. Any added comfort features must be justified by improvements in efficiency or usability rather than mere luxury.	11
6	**Sustainability focus while meeting market demands**	Heating solutions should minimize energy consumption to align with sustainability goals while meeting customer demands for comfort. With warming climates, the necessity for heating is decreasing, making existing air conditioning sufficient in many cases to maintain a safe and fair working environment.	3

Driver comfort

The infrared heating solution is intended to bring thermal comfort to the driver. It must be easy to use and not require any additional steps to work tasks. As such, it is required that this heating innovation improves working condition for drivers, especially in cold environments. Increased comfort may increase job attractiveness.

If well designed, this solution must ensure that drivers consistently prioritize seat and steering wheel heating instead of cabin heating.

Defrosting function

An added value of heating solution was mentioned to be defrosting of the windshield in cold seasons where driver's sight might be hampered due to frost and cabin heating is usually used to defrost the windshield.

Safe and efficient heating

Heating innovation should comply with homologation requirements, ensuring that different vehicle elements can be heated with appropriate systems, while also addressing practical needs for drivers. Some argue that heating innovations are unnecessary and that drivers should simply wear warm clothes, as this remains the most efficient solution in cold climates. However, when applied, heating systems must be efficient for delivery routes with fewer stops where drivers may remove their jackets, as well as in scenarios with frequent door openings or large cabin spaces where heat loss is significant. To improve usability, heating innovations should include a timer function for preheating the cabin and should prioritize focused, localized heating rather than heating the entire cabin, ensuring both efficiency and comfort in diverse operating conditions.

Heating solutions must not compromise the safety of drivers, passengers, other road users, or the cargo. Safety remains a core requirement alongside comfort and efficiency.

Preserving vehicle's range

Heating innovations should be designed to be energy efficient and accompanied by clear estimates of potential energy savings to demonstrate their value. They should contribute to preserving the vehicle's battery range, ensuring that heating does not significantly reduce overall performance. To support this, the vehicle battery should also include an extra margin dedicated to heating, providing reliability and comfort without compromising driving range.

Reasonable costs for useful technologies

The logistics actors need added infrared heating as a cost-efficient solution to help keep the total cost of ownership acceptable, while ensuring that innovative vehicles remain reasonably priced. The heating solution should not need excessive technologies that drive up the price, especially since most of them provide little to no value in parcel delivery operations. From the driver's perspective, comfort features such as additional heating are not seen as critical pain points, as their work involves frequent stops and movement in and out of the vehicle.

The solution is required to show enhanced operational efficiency. Any additional comfort features should therefore be carefully evaluated against their added cost, ensuring that investments are directed toward elements that improve day-to-day performance rather than features that increase expense without tangible benefits.

Sustainability focus while meeting market demands

The heating solutions must be aligned with sustainable practices, while they must also satisfy market demand. Some customers demand heating systems, making them necessary to include in the price list despite the original goal of being fully green, but at the same time energy use must be minimized. It was mentioned that with climate change leading to warmer conditions, the need for heating is becoming less critical, and many consider existing air conditioning sufficient to ensure a fair and safe working environment for couriers.

3.4 Holistic energy control and management

Holistic energy control and management considers the interplay between the vehicle's tires, brakes, and chassis under behaviours such as braking and acceleration to increase overall efficiency of vehicle systems and reduce non-exhaust emissions from tires and brakes. Improvements to braking systems will lead to further improvements by reducing drag on brake discs and allowing regenerative systems to capture more energy.

3.4.1 Stakeholder map

Figure 7 Key users and stakeholders in the holistic energy management ecosystem as reported by interview participants

Tier 1 suppliers, regulators at the EU level, and energy system actors are key stakeholders for Holistic Energy Control and Management innovation. Component manufacturers must collaborate to successfully integrate and increase the overall efficiency and performance of vehicles. More stringent standards at the EU level, primarily the Euro standards, drive innovation to reduce non-exhaust emissions from tires and brakes. Energy system actors, in combination with optimization of routing and scheduling charging, are needed to use available infrastructure effectively and utilize features such as bi-directional charging.

3.4.2 Aggregated Requirements

The interviews provided 118 statements about holistic energy and control management, which were then aggregated to 83 specific requirements. Upon thematic grouping, a total of 8 aggregated requirements were generated.

	Aggregated Requirements		# of related specific reqs.
1	Collaboration with workers/unions/ actors	Control strategies must be developed with unions, subcontractors and drivers to ensure acceptance and compliance while and supporting safe, healthy working conditions.	8
2	Energy availability and operational range	Fleets need cost-effective charging and sufficient range for daily tasks to avoid downtime. Smart scheduling tools for charging are needed to optimize charging times against route plans and reduce operational delays.	15
3	Regulatory Push	A predictable and forward-looking regulatory framework is needed to accelerate the transition to electric vehicles, ensure compliance with existing standards (such as Euro 7), and anticipate future rules on safety, digital connectivity, and non-exhaust emissions.	6
4	Driving behaviour, data and efficiency	Vehicles must provide data and feedback that support efficient driving, reduced wear, and easier eco-driving practices. Data ownership and legal use must be clear to enable improvements across fleets and components.	11
5	Stakeholder value and business case	Energy management innovations must show a clear cost-benefit for businesses, OEMs, and customers. Proven value, attractive pricing, and transparent communication of benefits are needed to drive adoption at scale.	11
6	Sustainability objectives	Strategies must prioritize electrification, reduce non-exhaust emissions, and improve lifecycle impacts. Bi-directional charging and holistic energy management should also make sustainable vehicle choices more attractive for customers and policy makers.	11
7	Improved vehicle and component performance	Brakes, tires, and suspension must be designed as integrated systems to reduce energy loss, improve longevity, and cut emissions. Regenerative braking and component innovations should extend range while lowering maintenance costs.	14
8	Safety, Compliance and communication	Control strategies that affect vehicle behaviour must consider the operational contexts and inform drivers of any changes to ensure safety. Live data should be collected to identify and prevent risky behaviour and promote safe driving patterns.	8

Collaboration with workers/unions/actors

Effective management and control strategies for vehicles must be developed in close collaboration with drivers, unions, logistics actors, and subcontractors to ensure both acceptance and successful implementation through the use of telematics and other enabling systems.

Control strategies that alter work processes or vehicle behaviour need to be socially acceptable for workers and unions, while also being designed to make safe and efficient driving the easiest and most natural choice. Drivers should be supported with tools, information and guidance to operate vehicles efficiently and safely.

Vehicles and strategies must prioritize driver health, safety, and well-being, potentially including strategies to reduce exposure to non-exhaust emissions and avoid polluted areas.

Energy availability and operational range

Electric vehicle users need more efficient strategies in place that reduce vehicle downtime and ensure that vehicles start routes with enough range for their daily operations. Planning and installation of charging infrastructure needs to be more streamlined, with logistics actors preferring on site charging at their own warehouses to take advantage of lower electricity prices and greater potential to optimize charging routines.

There is a need for software to better optimize charging by enabling communication between vehicles, chargers and route planning or other fleet management software. Chargers could then automatically detect which vehicle was connected, provide sufficient power based on planned routes or other operational constraints and notify when vehicles were ready.

Bi-directional charging needs to be investigated for the potential to relieve pressure from the grid and/or take advantage of unused battery capacity in vehicles and differing energy prices throughout the day.

Regulatory push

Energy management and control strategies need a robust regulatory framework to be implemented. Standards are needed to drive and scale technical improvements. Parking regulations should be flexible enough to allow for new use cases such as zones to carry out bi-directional charging between vehicles.

Technology developers need a predictable regulatory environment in order to meet future requirements. They must plan for the coming Euro7 standards and anticipate future regulations that are expected to increasingly focus on non-exhaust emissions. Technology developers must also consider how future regulations might set standards for digital connectivity between different components both within a single vehicle but also between vehicles (such as informing of braking activity to vehicles on the road behind).

Driving Behaviour, Data and Efficiency

Optimising energy use requires not only better vehicle technology but also smarter driving practices. This theme highlights the need for systems that monitor, evaluate, and provide feedback on driver behaviour, encouraging eco-driving styles that reduce energy consumption, tire wear, and maintenance costs. Data plays a central role, but clarity is needed on ownership, legal use, and value-sharing across different stakeholders. At the same time, reducing the burden of training and making efficient driving the easiest choice for drivers are key to widespread adoption. Together, these measures ensure that driving behaviour contributes to efficiency gains at both the vehicle and fleet level.

Stakeholder value and business case

The implementation of control management strategies needs to clearly communicate benefits to potential customers, such as lower costs by saving energy, less frequent charging for operational benefits, lower maintenance, or reduced non-exhaust emissions. There is a need to communicate the value of additional sustainability improvements beyond electrification to customers to create a greater willingness to pay. Innovations that offer only small gains in efficiency can still be viable if they are low cost and easy to implement.

Viable, attractive use cases need to be demonstrated for bi-directional charging to provide logistics actors more understanding of potential value and use areas. The development of connected components has created the need to differentiate products by offering differing levels of software control over braking systems for customers.

Sustainability Objectives

Beyond efficiency and economics, energy management and control strategies must align with societal and environmental priorities. This includes reducing both CO_2 emissions through electrification and non-exhaust emissions such as brake and tire particles, which are increasingly under regulatory and public scrutiny. Bi-directional charging can support cleaner fleets and renewable energy integration, while lifecycle analysis should show clear improvements over previous solutions. These strategies must also strengthen the sustainability profile of logistics companies, ensuring they can demonstrate tangible environmental impact reductions and maintain public trust.

Improved Vehicle and Component Performance

At its core, energy efficiency depends on advancing vehicle systems and components. Brakes, suspension, tires, and chassis must be developed in an integrated way, reducing drag, improving regenerative braking, and extending component lifetimes while ensuring safe operation under diverse conditions. Strategies such as reducing reliance on brake oil, minimising particle emissions, and optimising acceleration patterns can directly cut energy use and operating costs. OEMs and technology developers must understand how these new components impact overall performance and adapt them for varied operational contexts. By focusing on system-level optimisation, vehicles can achieve higher range, lower emissions, and improved durability.

Safety, Compliance and Communication

Changes to vehicle behaviour must be done in a manner that considers operational contexts- for example areas where it may be necessary to accelerate quickly or where there may be high speed differentials between other vehicles.

A mechanism to apply control strategies across multiple types of OEMs is needed to enable effective implementation for fleet owners and drivers need information on restrictions to vehicle behaviour to be clearly communicated to them. The use of live data should allow risky behaviour to be identified and should support driving styles that are less aggressive to enhance safety for vulnerable road users.

3.5 Modular Swappable Concept

The swap box developed by Paxster is intended to facilitate transshipment. It consists of a standardized lightweight box that is removeable and foldable to ease return logistics. It can be transferred either vehicle to vehicle or vehicle to infrastructure. Use in a mixed fleet allows vans to better interact with and/or support different vehicle types (such as trucks, mopeds or cargo bikes) by facilitating the quick transfer of cargo. The swap box can be outfitted with sensors to aid tracking or maintain the cold chain by measuring temperature.

3.5.1 Stakeholder map

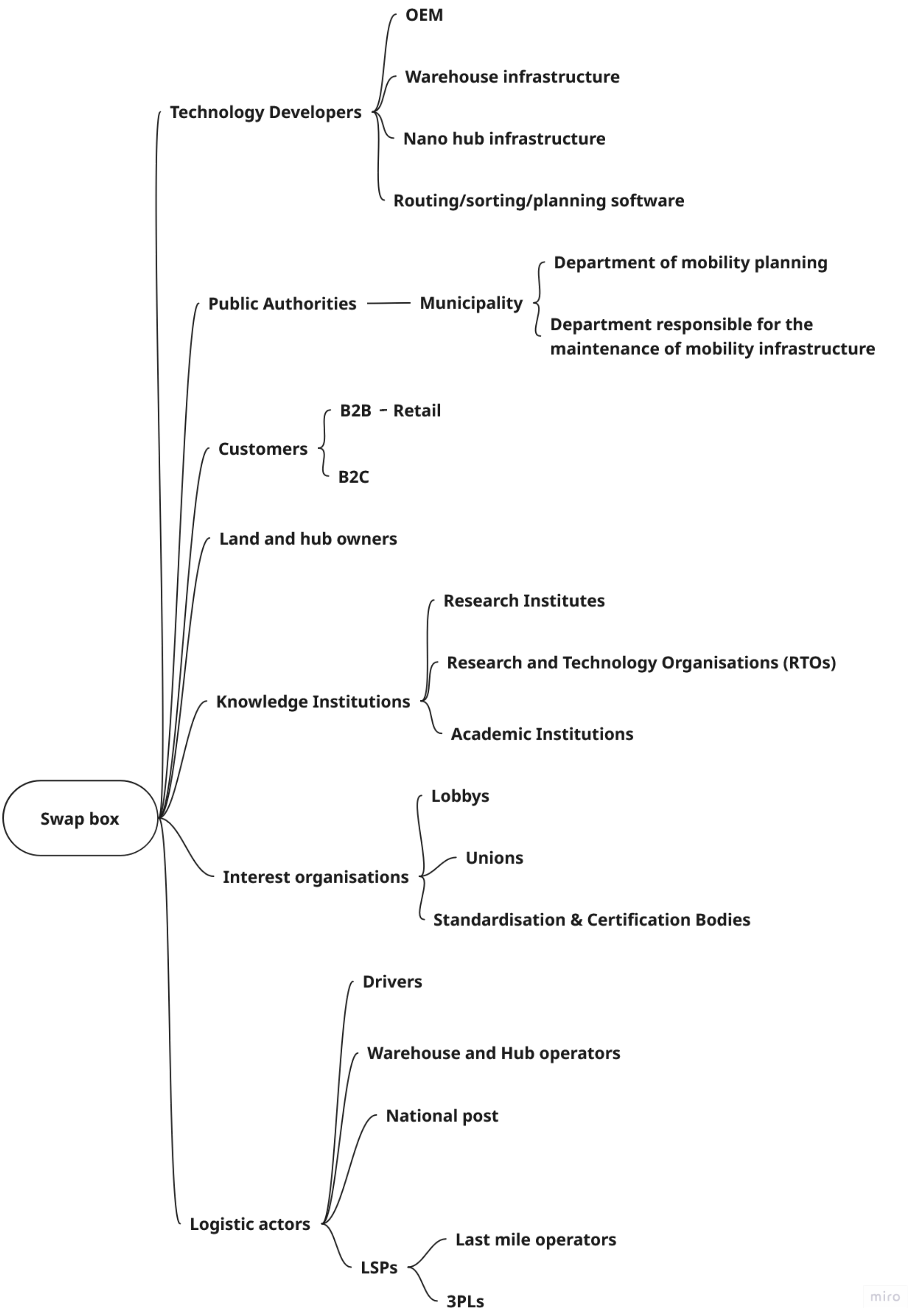


Figure 8 Key users and stakeholders in the swap box ecosystem as reported by interview participants

Unlike traditional freight systems, the stakeholder map for the swap box (Figure 8) illustrates the need for strong involvement from municipal-level public authorities to ensure alignment with mobility planning and infrastructure maintenance, as well as to coordinate the diverse range of actors (e.g., land and hub owners, hub operators, logistics providers). Standardisation and certification bodies can play a crucial role in guaranteeing interoperability across operators. This is reflected in the requirements, which emphasize the need for coordinated governance and collaboration, and highlight the importance of standardisation.

3.5.2 Aggregated Requirements

The interviews provided 224 statements about the swap box, which were then aggregated to 110 specific requirements. Upon thematic grouping, a total of 10 aggregated requirements were generated.

	Aggregated Requirements		**# of related specific reqs.**
1	Coordinated governance and collaboration	Swap boxes require coordinated governance between public authorities, logistics operators and providers, ensuring shared hubs and common standards and processes.	11
2	Balancing size variability with standardisation	Swap boxes must balance sector-wide standardisation with adaptable sizes that fit diverse vehicles and delivery needs.	16
3	Compatibility with vehicles, equipment, and existing processes	Swap boxes must integrate smoothly with existing vehicles, infrastructure and systems to avoid operational disruption.	13
4	Business viability	Swap boxes must be cost-effective and durable, delivering efficiency gains without undermining profitability.	9
5	Worker safety, ergonomics and acceptance	Swap boxes must be safe to handle, ergonomic and user-friendly, improving working conditions and driver acceptance.	11
6	Knowledge, training, and phased implementation	Swap box adoption requires knowledge, training and a phased roll-out with adapted processes and infrastructure.	7
7	Sustainability	Swap boxes must support sustainable logistics by using eco-friendly materials and reducing vehicle use.	3

8	Goods security and safe operations	Swap boxes must ensure secure hubs, safe transshipment and reliable protection of goods in transit.	7
9	Operational efficiency in space, flow, and delivery	Swap boxes must maximize vehicle and warehouse space, support efficient sorting and route planning, and enable quick loading, unloading, and transshipment to ensure smooth and time-effective delivery operations.	34
10	Tracking and identifying parcels	Swap boxes must support quick parcel identification and tracking to improve accuracy and efficiency.	8

Coordinated governance and collaboration

This requirement focuses on how stakeholders, including logistics companies, public authorities, and private landowners, must coordinate and collaborate to enable the effective use of swap boxes and hub infrastructure. It highlights both the governance structures and the cooperative processes needed to make shared logistics operations functional, efficient, and widely accessible.

To operate swap boxes, logistics actors first need access to suitable hubs and supporting infrastructure for transshipment. For example, a large truck may unload several swap boxes at one or more hubs, where smaller vans or cargo bikes can collect them for last-mile distribution. However, accessing areas and space in cities remains a significant challenge, and actors also need a clear understanding of the price and availability of hub locations. To secure sites in strategic places, collaboration with private landowners is essential, while hubs themselves should ideally be actor-neutral, enabling multiple companies to share them. In some cases, this may mean sharing hub locations even if the infrastructure is not fully neutral.

Public authorities play a central role in enabling swap box implementation. Their responsibilities include supporting logistics companies in adopting innovations, facilitating transshipment between vans and bikes, and coordinating the many different stakeholders around hubs. At the same time, logistics actors need new processes to integrate the use, circulation, and tracking of swap boxes across stakeholders, ensuring seamless operations.

Finally, containerisation should be implemented at the larger organizational level, including subcontracted carriers working for different branches, to ensure alignment and smooth coordination across all partners involved.

Balancing size variability with standardisation

A key challenge for swap box implementation is balancing the need for common standards with the flexibility to adapt to diverse delivery operations. Stakeholders recognize the importance of defining a standard early, before one is imposed by the international market, and agree that container providers must collaborate rather than compete to achieve this. Several actors argue that standardisation should be supported and pushed by the public sector, and that stakeholders at the European level should work together to agree on one swap box standard. Until such a standard is widely adopted, swap boxes may need to be rolled out at fleet level, ensuring operational continuity while paving the way for broader harmonisation.

At the same time, the design of swap boxes must remain adaptable. They should be usable across the entire delivery process, from last-mile home deliveries of single parcels to large B2B consignments, and they should be sized appropriately—between half a pallet and a full pallet—while fitting seamlessly into existing vehicles. In some cases, dimensions may need to vary to adapt to different vehicle heights or to accommodate specific operational requirements. Actors also note that different sizes of containers may be required to match different sorting needs or types of delivery, while vehicles themselves may need to be standardised to align with swap box dimensions.

There is also debate on the degree of standardisation. Some logistics operators call for a single functional design used across networks, while others stress that swap boxes should be custom-made to fit their specific operations, especially when handling special goods that do not fit into standard containers, such as TVs. Importantly, swap boxes should remain functional and practical rather than overly high-tech, ensuring ease of use, interoperability, and cost-effectiveness.

Compatibility with vehicles, equipment, and existing processes

For containerisation to be viable, swap boxes must be compatible with existing vehicles, equipment, and operational processes. They should fit a wide range of vehicle types and sizes, including those with shelves, as well as customers' vehicles. Compatibility also extends to infrastructure, meaning swap boxes must work within warehouses and nano hubs, and comply with local regulations such as bicycle dimensions. To ensure smooth adoption, swap boxes should align with current logistics routines, including sorting, loading, and transshipment processes, while also being compatible with existing standards such as pallets. Swap boxes must also integrate with labelling, handling, and automated systems, so that operations can continue without major disruption. Furthermore, swap boxes must be designed to interoperate with other innovations, such as cold bodies, to create a coherent logistics chain.

Goods security and safe operations

Ensuring the safety and security of goods throughout the logistics process is critical. The innovation needs to ensure that hubs are secured from theft and vandalism, and swap boxes should ensure secured goods storage while going along secured hubs. Swap boxes must not compromise safe operations around other road users during transport. Containerization can help to prevent damage and loss when handling goods or loading and unloading, and containerization needs to go along with safe handling of goods and safe transshipment. Additionally, we need measures against loss and damage of different goods during delivery to maintain product quality. Swap boxes need to be safe, sturdy, while remaining cost effective, providing reliable protection while supporting operational efficiency. Collectively, these measures ensure that both goods and people are protected throughout storage, handling, and delivery operations.

Tracking and identifying parcels

Containerisation must be accompanied by reliable systems for tracking and identifying parcels. Swap boxes should make it possible to quickly locate packages inside vehicles during delivery, reducing search time and improving accuracy. This requires solutions that provide clear and accurate information on the content of each container, supported for example by barcode scanning at the level of each pallet or swap box, and where relevant, the use of RFID in selected facilities. Tracking and identification should be quick and easy for drivers, who must be able to locate parcels without disrupting their workflow. To further support efficiency, smart placement solutions should guide how parcels are organised within swap boxes so that they can be retrieved in the right order during delivery.

Knowledge, training, and phased implementation

While there is an expressed need for containerisation solutions, the implementation of swap boxes requires adequate knowledge, preparation, and gradual implementation. Before adoption, stakeholders need knowledge of best practices and potential benefits, as well as clear information about swap box dimensions, weight limits, and storage compatibility, so that containerisation solutions can be properly evaluated and implementation accurately planned. Effective use also depends on training and procurement guidance.

The implementation of swap boxes requires to adapt operational routines, processes (e.g. handling), but also infrastructure, and warehouse layout to achieve efficient use. In particular, loading step must be streamlined to enable the implementation of Swap boxes.

Since the transition represents a significant organisational change, implementation should follow a phased approach, starting with small containers and progressively scaling up. This step-by-step adoption should go hand in hand with ensuring that both loading and delivery personnel are aligned in how they work with swap boxes, so that containerisation is embedded smoothly into day-to-day logistics operations.

Worker safety, ergonomics and acceptance

For swap boxes to be successfully implemented, they must be safe, ergonomic, and broadly accepted by workers. Their design should support safe and easy manoeuvrability, for example through the use of wheels that reduce strain and risk, while being robust and stable without excessive weight. Swap boxes should be accessible from three sides of the vehicle, ensuring easy and ergonomical access for loading and unloading, thus improving drivers' acceptance. Alternatives to manual handling are needed to further reduce physical effort and enhance workplace safety. At the same time, swap boxes must be ergonomic and user-friendly, easing drivers' workload, helping them to sort and load goods more efficiently, and remaining easy to use effectively in daily operations. They should also offer flexibility, allowing drivers to sort parcels as they prefer and adapt their routines where necessary. Finally, worker acceptance also depends on broader factors: swap boxes should make the job more attractive by improving working conditions, while still preserving human interaction with customers, which is considered an important part of service quality for some logistics actors.

Operational efficiency in space, flow, and delivery

Efficiency of operations in different steps of the process must be maintained and enhanced by the swap box innovation. This includes the handling and use of space in the vehicle, the sorting of goods and planning of the delivery route and the loading and unloading of boxes.

Efficiency in space utilization and vehicle capacity is critical to optimizing logistics operations. Swap boxes should allow maximum utilization of the capacity of vehicles, ensuring that we make the most of the space available. To support this, swap boxes should be nestable and stackable to save space in warehouses, while empty swap boxes should be filled in or foldable to minimize wasted space. Loading solutions should ensure maximum utilization of the vehicles' loading capacity, and we need to use maximum capacity to use the fewest vehicles possible, especially with lighter and smaller vehicles. At the same time, we need a solution to manage our empty containers and potentially also those from our customers. A balance must also be found between saving space on one side and sorting and containerization on the other side, maintaining operational efficiency without compromising other processes.

Efficient sorting and route planning are essential to streamline the delivery process and save time. Human validation of the sorting is needed, with both the driver and the loader checking the content of the swap box. Solutions that optimize parcel sorting and placement, in coordination with route planning, are needed, and containerisation helps avoid sorting goods during the delivery trip. Containers should be placed in the vehicle according to weight to have better stability, and for containerisation, sorting should be done at route level, ensuring sorting is not repeated at the local store. A suitable swap box would contribute to a more streamlined sorting process, and sorting and placing parcels on the shelves should be calculated automatically for safer loading and better accessibility during delivery. Sorting should be automated to save time, while experts in routing should finetune the routes issued by the system. For containerization to be interesting, we need swap boxes to help logistics operators save time, and swap boxes should go along a system that optimizes delivery routes based on the sorting. Routes should be predetermined, allowing drivers to make only minor adjustments, and we need to maintain the use of trolleys (not pallets) to comply with lifting legislation and preserve flexibility, while introducing mechanization in route preparation to pre-sort goods by consumer type and reduce searching during delivery. Collectively, these measures enhance operational efficiency by aligning sorting and routing with both human oversight and automated optimization.

Efficiency in loading and unloading ensures that drivers and riders spend their time delivering rather than handling cargo. Swap boxes should relieve the driver from loading duty to focus on delivering, and they need to be preloaded and placed on the cargo-bike routes to enable riders to avoid driving back several times to the depot or hub. Swap boxes should help loading and unloading efficiently and quickly, and they should also help reload the vehicles along their delivery route when they are empty. Furthermore, swap boxes should make transshipment between large and small vehicles quicker and more efficient, improving the flow of goods throughout the logistics network and contributing to overall operational efficiency.

Business viability

For containerisation to be adopted at scale, swap boxes must be financially sustainable and profitable. They should be durable enough to justify high levels of investment. Swap boxes should be safe, sturdy, and cost-effective, reducing the risk of damaged goods and thereby helping to lower insurance claims. Their operation should ensure that tracking costs do not erode profitability. When implemented together with micro-hubs for transshipment in smaller vehicles, swap boxes will require extra vehicles and drivers, as well as an extra stop at the hub. This should not erode profitability either. At the same time, they must deliver efficiency gains—both by improving logistics efficiency and by saving time for operators, so that the effort required to develop new routines is offset by operational benefits. Importantly, logistics actors should be able to assess the profitability of swap box investment in advance.

At the operational level, swap boxes should allow companies to adjust quickly to fluctuations in customer demand, for example regarding temperature-controlled goods. Beyond day-to-day operations, swap box systems must also be capable of adapting to broader market changes, ensuring that containerisation remains relevant in an evolving logistics environment.

Sustainability

Swap boxes must contribute to sustainable logistics, both through their materials and their operational impact. They should be manufactured from sustainable materials, with a preference for textiles over plastics. Beyond material choice, swap boxes are also expected to support a more efficient use of logistics vehicles, helping to reduce the overall number of logistics vehicles driving in the city centres, thereby cutting congestion and emissions.

3.6 Geofencing

In the context of Shift2Zero, geofencing represents several different potential use cases that will be partially or wholly influenced by the specific rules and regulations in a given city/country. However, the most frequently discussed scenarios during interviews with stakeholders revolve around implementing restrictions on vehicle behaviour when entering a specific geofenced area, such as reducing speed or acceleration. Such restrictions could either be implemented by the logistics actors themselves, or in collaboration with the municipality, in which case the concept might focus on providing access to logistics actors in exchange for data and/or accepting the rules of the geofence.

3.6.1 Stakeholder map

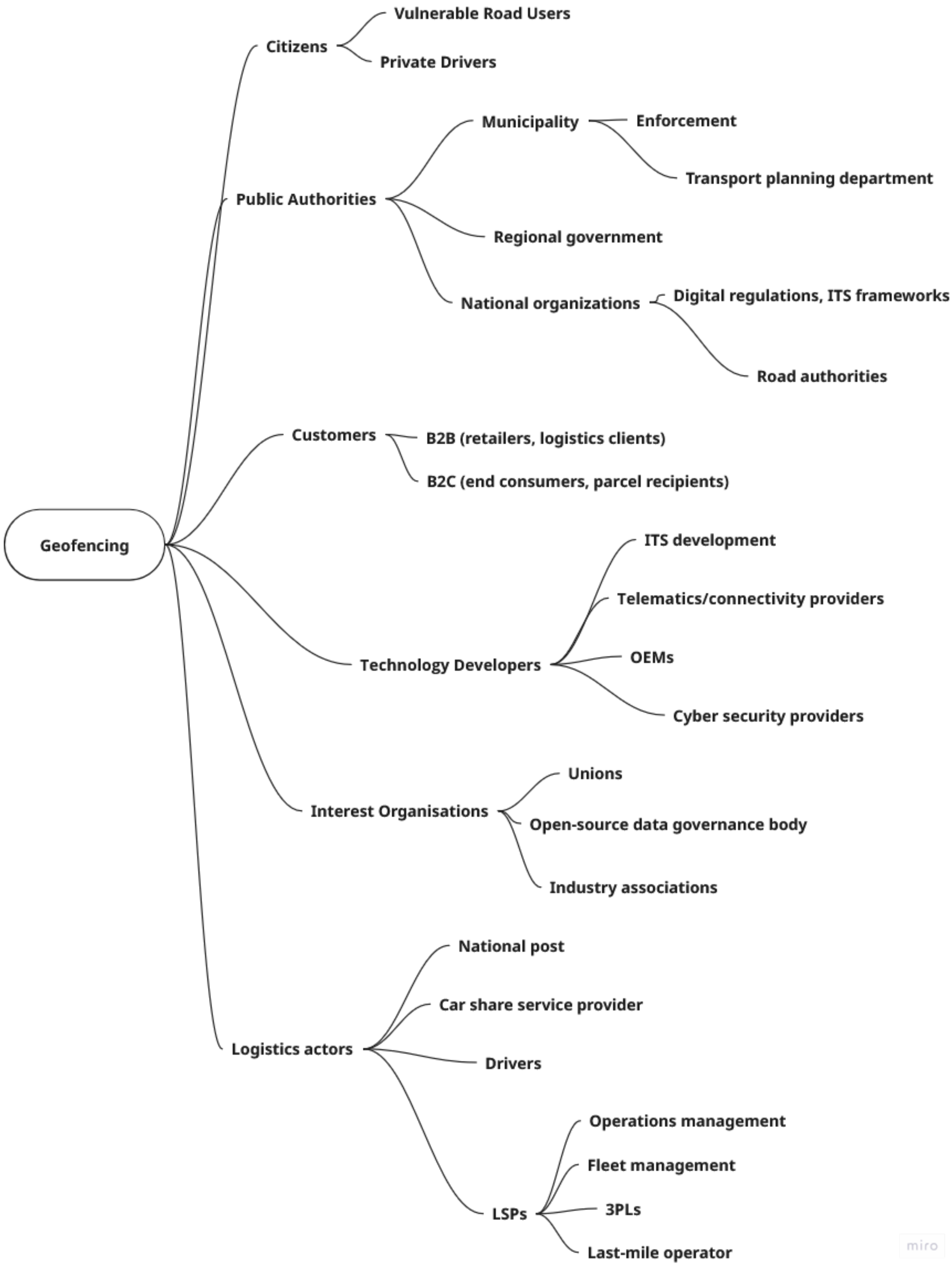


Figure 9 Key users and stakeholders in the geofencing ecosystem as reported by interview participants

The geofencing stakeholder map shows the importance of involving multiple actors related to digital tools and data sharing, for example the inclusion of both digital regulation for public authorities and governance bodies that support the development of open-source standards to share mobility data. This is reflected in the requirements for implementation of geofencing, with a clear focus on data standards, interoperability and data sharing as key enablers.

3.6.2 Aggregated requirements

The interviews provided 306 statements on geofencing, which were then aggregated to 205 specific requirements. Upon thematic grouping, a total of 9 aggregated requirements were generated.

	Theme	Aggregated Requirement	# of related specific reqs.
1	Knowledge and information needs	Geofence implementation requires improved knowledge across stakeholders, especially municipalities, regarding freight flows, actor behaviour, potential impacts and benefits as well as guidance on how, where and when to implement zones in a technically feasible, publicly acceptable manner.	15
2	Access to city centres and operational conditions	Geofence restrictions must provide predictable and operationally viable access to urban delivery zones for logistics actors by aligning restrictions (speed, time windows, vehicle types) with the logistical needs of goods flows and critical services	16
3	Digital infrastructure, Interoperability and Data Governance	Digital systems must be interoperable across partners, secure, privacy-compliant, and designed to exchange real-time, standardized data between vehicles, operators, infrastructure, and authorities.	19
4	Actor coordination and institutional readiness	Geofencing needs a mature ecosystem with all partners capable of collaborating technically and organisationally to coordinate data sharing, develop flexible regulations and enact a predictable roll out of dynamic regulation that accounts for technological readiness.	16
5	Monitoring, enforcement and fairness	Geofencing restrictions must be fairly and predictably applied, using enforcement mechanisms that are cost effective, differentiate between connected and non-connected vehicles and inform non-connected vehicles through physical media.	13
6	Stakeholder value and business case	Geofencing must demonstrate clear, shared value by delivering operational, social and environmental benefits to both public authorities and logistics stakeholders-improving efficiency, safety and compliance while reducing administrative burdens and enabling better urban space management.	41
7	Safety efficiency and security	Geofencing must support the efficient operation of vehicles in a safe, secure manner by reliably implementing restrictions in high-risk areas to protect vulnerable traffic users, encouraging energy efficient driving styles to reduce emissions, and allowing drivers autonomy to override restrictions in emergencies	18
8	Regulatory frameworks	To enable geofencing, a regulatory framework must be developed that allows flexible regulations adaptable to local contexts, provides predictability for operators, can	25

	and adaptive governance	differentiate between vehicle types and streamline piloting processes	
9	Vehicle compliance, connectivity and fleet readiness	Vehicles must be digitally equipped to receive and act on geofencing instructions via fleet management and IoT systems. Implementation should start with connected vehicles, while supporting retrofitting of older fleets. Reliable, standardised connectivity with minimal downtime is essential, alongside collaboration to ensure readiness across diverse vehicle types and use cases.	11

Knowledge and information needs

Implementing geofencing is hindered by a lack of knowledge among both public and private stakeholders. Municipalities, especially, need more information on freight movements, their operations, load types, emissions, subcontracting structures and how these interact with public space. Available data sources must be mapped (who owns them, how to access them and how to use them) to understand the scope of the problem and the potential impact of solutions.

Municipalities also need knowledge on when, where and how to implement geofenced zones in a way that is technically feasible, safe, and socially acceptable. The impacts of geofencing on logistics efficiency, traffic flow, capacity utilization, emissions, and driver experience and acceptance must be assessed.

Drawing on learnings from existing geofencing use cases (such as shared micromobility and curbside management) is needed to fill knowledge gaps.

Access to city centres and operational conditions

Enabling restrictions on vehicles (speed, acceleration, etc..) in exchange for movement and access within geofenced areas is at the core of this requirement. Geofencing needs to be attractive for logistics actors to implement and doing so should provide operational advantages to logistics actors such as reducing the number of vehicles needed for operations by expanding access times so a single vehicle can reach more delivery areas or by enabling more direct routes.

Geofenced access windows and pick up points need to be determined through collaboration with city authorities and logistics actors and result in predictable locations for customers and time windows that reflect the need to carry out both deliveries and returns at different parts of the day. Access can be controlled through vehicle communication with infrastructure (bollards, gates).

Logistics actors need to respond to regulations with vehicles that maintain access and using geofencing to implement access restrictions must consider the existence of viable alternatives and maintain goods flows and other critical services. Restrictions should take into the account the size, speed and capacity of vehicles, not necessarily just vehicle class.

Digital infrastructure, Interoperability and Data Governance

Geofencing requires interoperable systems between OEMs, fleet management systems, Municipality data, or the platform defining the geofence rules. This interoperability requires the development of data standards, exchange protocols (e.g., MQTT, GBFS) and collection routines be aligned across all involved actors. Fleet management systems need to exchange correctly formatted, standardised data with geofencing management platforms. Open APIs need to be developed to enable data sharing and integration across jurisdictions (both locally and nationally).

At the same time, GDPR must be considered, and data collection must ensure that useful, relevant data is collected while alleviating fears of data tracking and maintain GDPR compliance. An additional concern is data sharing between different actors, and agreements must balance sharing data on vehicle movements and capacity with concerns about competition and privacy.

Interoperable systems should also alleviate burdensome registration processes by automating registration of vehicles in loading zones or other geofenced areas such as low-emission zones, making use of live data connected to municipal parking data bases.

Actor coordination and institutional readiness

Geofencing requires a mature ecosystem capable of collecting, sharing and acting on data to implement dynamic regulations. This demands established communication channels between multiple actors within both the private and public sectors. Within the public sector, communication and harmonisation of rules and regulations needs to occur between municipal departments (e.g. planning, parking, ITS), as well as between local, regional and national governance levels. Public authorities must also engage with vehicle manufacturers, technology developers and logistics actors.

On the technical side, all actors need to reach a level of digital maturity at which they are able to share and exchange real time data on vehicle movements, geofence zones, and parking locations and then comply with digital regulations.

Implementation timelines must reflect the varying technological readiness across actors and vehicle fleets as well as the adoption rates of compliant vehicles and/or technologies necessary to comply with geofencing and dynamic regulation. Support mechanisms for logistics authorities to reach the needed maturity should be implemented.

Municipalities need to implement platforms to support the coordination of the involved actors, enabling dynamic regulations to be digitally communicated to operators in a clear, enforceable way.

Monitoring, enforcement and fairness

This requirement concerns the fair application of geofencing and dynamic regulations in the physical world. There must be a regulatory possibility to differentiate between vehicles that have accepted dynamic regulations through geofencing and those that have not. Doing so would make compliance more palatable for LSPs that want to ensure they are not losing a competitive edge by willingly accepting movement restrictions that don’t apply to others.

Common methods of enforcement require a physical presence which is costly, time consuming, and ineffective. Cost effective enforcement mechanisms must be implemented. Cameras, physical barriers or other sensors that can automate enforcement and prevent non-geo-fenced vehicles from other commercial actors or private people from entering restricted areas or using dynamically regulated parking should be employed.

At the same time, digital regulations need to be reflected in the real world through signage or physical barriers to inform non-connected vehicles of changing regulations.

Stakeholder value and business case

There are several areas in which geofencing solutions need to demonstrate value to make adoption more attractive by addressing clearly defined problems that support the achievement of broader societal goals. There is a need to find mutually beneficial use cases in which both public authorities and logistics actors see clear advantages in implementing geofencing spanning multiple contexts (social, safety, security, efficiency, environmental).

From the side of logistics actors, accepting restrictions on their vehicle movements/behaviour should result in operational advantages such as better access to city centres or loading zones or improved (efficient, safer) driving from employees. Drivers should also experience benefits to build acceptance. As such, geofencing should result in reduced stress by supporting efficient route choice or reducing the need for time consuming manual registration as they travel into loading or low emission zones. Limits on vehicle speeds and acceleration could contribute to safer behaviour and reduce fines.

Municipalities need systems that are not complicated to implement and result in a reduction of person hours needed to manage urban logistics. Geofencing should result in better data collection on freight movements, more efficient logistics operations that reduce the amount of space needed for logistics vehicles in cities and not reduce access to sidewalks for pedestrians.

Geofencing solutions need to enable capacity, not transport, meaning that vehicles should make better use of their available capacity through coordination, reducing the overall number of vehicles needed and aligning with public space management goals.

Safety efficiency and security

Geofencing must ensure safe operation of the vehicles and requires an accurate and reliable geofence that has safeguards against sudden, unexpected changes in vehicle behaviour for drivers. This is especially important when mixed with other, non-connected vehicles and the potential for a high speed-differential exists. Drivers should be able to override restrictions and reassert control if needed.

Information on geofence restrictions must be clearly communicated to the driver. Geofencing restrictions to speed and acceleration should be implemented in specific high-risk areas to ensure safety for vulnerable road users and reduce non-exhaust emissions. Geofencing can also be considered as a tool to mitigate terror threats from large vehicles in areas with many vulnerable users.

Geofencing should support efficient driving of the vehicles, reducing energy used by encouraging or enforcing desired behaviours such as lower maximum speeds and more gentle acceleration. Enforced behaviour on the vehicle side in exchange for access needs to be seen as a positive trade-off for drivers.

Regulatory frameworks and adaptive governance

Geofencing needs the development of a more flexible regulatory framework in order to enable dynamic regulation. Current regulations in some cases are too static to allow the dynamic regulation of space and vehicle behaviour. Implementation should be gradual and predictable to reflect both political sensitivities and provide clarity for businesses to respond appropriately.

Regulatory frameworks must consider national, regional and local levels and allow for local exceptions, especially related to piloting. Geofencing needs to be connected to access regulations to allow for preferential treatment of desired vehicle types based on size and emissions.

To gain public and political support, controversial topics like tolling or route restrictions must be handled cautiously, and the business case for operators must be reflected in the rulemaking process.

Vehicle compliance, connectivity and fleet readiness

Finally, geofencing requires that the vehicles themselves be connected and able both to exchange information about location and speed, as well as implement new behaviours determined by the geofence. Vehicles must be connected to a fleet management system and equipped with IoT systems able to connect via the CAN Bus. In use cases were lowering bollards or opening gates is required, vehicles must be capable of V2I (vehicle to infrastructure).

Pilots with geofencing should use newer vehicles that are already able use telematics for interaction, and wider scale implementation must either rely on the expected time frames for newer, connected vehicles to enter the fleet, or assess the possibility of retrofitting existing vehicle fleets and enabling them to respond to geofences.

3.7 Dynamic space use

This innovation seeks to dynamically optimize the interior space of vehicles for goods and passengers while maintaining separation with the goods compartment using a moveable protective partition. Implementing this innovation in a vehicle would allow a vehicle to be quickly adapted to different uses. Vehicle rental companies are seen as potentially interested in this innovation as they could reduce the number of vehicles in their fleet if a single vehicle is able to serve multiple purposes effectively.

3.7.1 Stakeholder map

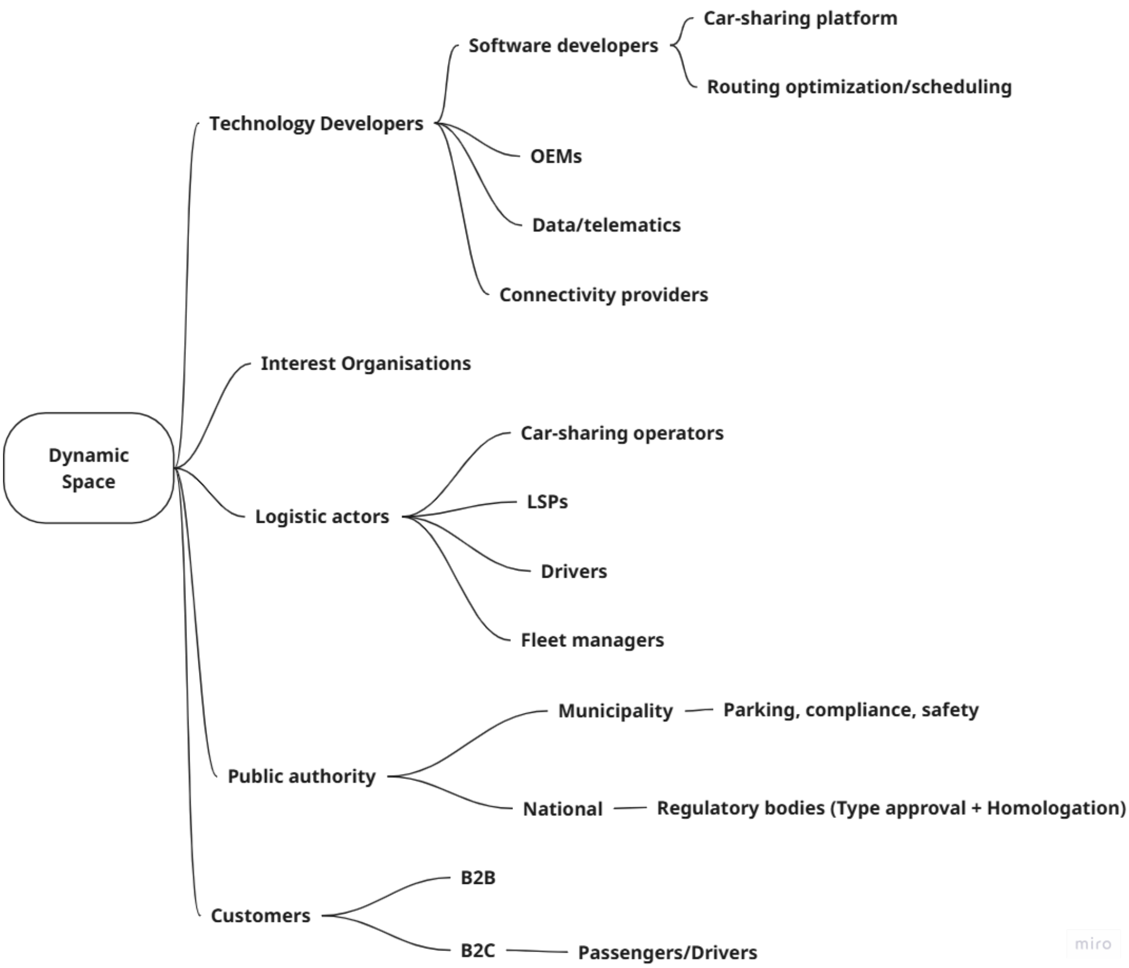


Figure 10 Dynamic Space use stakeholder map as reported by interview participants

The dynamic space innovation has key stakeholders related to regulatory compliance as it must be able to meet safety requirements for the transport of both goods and people. The flexibility of the solution also means that coordination between multiple types of users is critical, so the use of scheduling, routing and management software using telematics is essential. Car sharing operators are well positioned to be the coordinating actor for different user types.

3.7.2 Aggregated Requirements

The interviews provided 51 statements on dynamic space use, which were then aggregated to 26 specific requirements. Upon thematic grouping, a total of 6 aggregated requirements were generated.

Theme	Aggregated Requirement	# of related

			specific reqs.
1	**Attractiveness and flexibility**	Dynamic solutions must combine flexible, customizable cargo and passenger space with practical features like easy cleaning, flat surfaces, and adaptability to seasonal demand, all while remaining attractive to users and compatible with existing transport operations. They should balance versatility and usability without disrupting regular services.	10
2	**Safety and resilience**	Dynamic space design must ensure safety and resilience by using robust, non-slippery materials and durable foldable seats, while allowing normal driving behaviour without restrictive limits.	4
3	**Technical and operational feasibility**	Dynamic space must show technical and operational feasibility through designing a mode switch system that is simple, usable by diverse users, and versatile enough to operate beyond city-only contexts.	4
4	**Regulatory compliance**	Dynamic Space innovation must comply with both commercial and private vehicle regulations.	2
5	**Dynamic space and actor coordination system design**	Dynamic space is a system with multiple actor groups, including renters, owners and the platform. There must be a mechanism to regulate their interaction and vehicle use in a sustainable manner.	2
6	**Contextual value and niche market**	Dynamic Space must demonstrate clear value in specific contexts by offering advantages over existing vehicles that switch between cargo and passenger modes.	4

Attractiveness and flexibility

Dynamic solutions must be designed with flexibility in mind, particularly at the rear of the vehicle, allowing easy adaptation for different cargo and passenger needs. They should be large enough to accommodate sizable cargo while maintaining flat, regular surfaces that simplify loading, unloading, and cleaning. These solutions must also respond effectively to seasonal variations in customer demand, offering legal, safe, and flexible options that users are willing to pay for.

At the same time, dynamic solutions should maintain a balance between overall attractiveness for a broad range of customers and the functional flexibility of the space. Customized configurations may be required to meet specific use cases, but the design should ideally build on existing vehicle platforms to reduce complexity and cost. Importantly, dynamic spaces must integrate seamlessly into regular transport operations, ensuring they do not disrupt or hinder standard services while providing versatile, practical solutions for both goods and passenger transport.

Safety and resilience

Dynamic space design must have safe and robust design for passengers and goods. The van must have a surface material that is hard and robust, but not slippery. The van must allow normal driving behaviour without imposed speed restrictions. to ensure safety in certain traffic situations. Resilience must be ensured through using robust materials that can endure frequent wear and tear in loading and unloading cargo. This also applies to the seats that may be folded underneath the cargo load.

Technical and operational feasibility

From the technical perspective, dynamic space must have a partition system between the goods and the passengers that is feasible, easy and practical to use, fitting to different customer needs. It must be compliant with safety regulations. This further feeds into operational feasibility, where mode switching is simple enough that it does not require special facilities, workshop or skilled staff. Various users must be able to easily use the van for their purpose.

Furthermore, dynamic space is appealing if it is not designed exclusively for city use and has the potential to cover a wider range in the operational scope.

Regulatory compliance

Dynamic space innovation must be designed in accordance with the regulatory requirements of commercial and private vehicles. For technology developers it is advantageous to implement this innovation in vehicles that have already been type approved. It was mentioned that the current regulations for the commercial vehicles where back seats are not permitted, makes it challenging for conducting passenger transport with the vehicle. This means that not only technical feasibility, but also legal feasibility must be determined before the innovation is put in use.

For logistics actors, it is also important to update the regulation because of the combined functionality of the vehicle. This can be difficult to navigate for logistics actors and legal aid is needed to help them remain compliant.

Public authority needs to consider the implications for differing regulations for the commercial and private vehicles and evaluate how dynamic space regulation impacts this categorization and their associated costs.

Dynamic space and actor coordination system design

The dynamic space innovation is not intended to be used by professional logistics actors only. It is targeting a wider range of users. Therefore, for this solution to work effectively, a coordination mechanism amongst the actors (vehicle owners, vehicle renters and platform for vehicle-sharing) is needed.

The platform must effectively coordinate between casual vehicle owners, professional fleet owners, and renters while remaining a neutral marketplace that does not own vehicles itself. Owners require guidance and frameworks to manage their vehicles consistently and maintain acceptable quality for each rental. Coordination mechanisms should ensure that vehicles are handed over in proper condition to ensure user satisfaction.

Renters must be encouraged to use vehicles responsibly, with systems in place to prevent neglect or damage that could impact subsequent users. The design and operations of the platform and vehicles should balance the needs of professional renters with casual renters, ensuring a positive experience for all.

Contextual value and niche market

Dynamic space must show value in specific contexts and markets. the value of a van capable of switching between transporting goods and passengers is most apparent in rural or suburban areas where public transport is limited and trips to hospitals, shops, or other services are needed. In urban areas with frequent and efficient public transport, the innovation may not add significant value.

Additionally, the innovation must offer unique value compared to existing solutions, which already allow switching between cargo and passenger configurations. Users are accustomed to renting vehicles tailored to specific needs, so dynamic space must clearly demonstrate advantages beyond what conventional car sharing provides, such as more versatility or convenience for varied use cases. It was mentioned that the value proposition of car sharing is to choose a vehicle that is most efficient for a specific goal. This may be lost in Dynamic space solution. Therefore, it is important to define the niche in which it offers a clear value.

3.8 Discussion

Despite the inherent differences between Shift2Zero's planned innovations, there are still several areas of commonality between the extracted requirements. Across innovations, the challenges presented by organizational and regulatory requirements outstrip the difficulty of managing technical barriers.

This is not to say that the technical challenges are necessarily easy to solve, but generally the project innovations are iterations on, or adaptations to, existing technologies. Meeting cost requirements and the need to develop viable business models with interesting use cases weighs more heavily here than the technical ability of technology developers to provide a solution. This again ties back to the impact of regulations and the context they create for businesses to operate in.

Vehicles are more connected now, speaking with each other, infrastructure and fleet management platforms. More efficient and/or safer vehicle behaviours can be supported remotely through control strategies and geofencing. Connected vehicles and more advanced fleet management systems are also key enablers for more complex routing strategies, allowing mixed fleets to operate efficiently and take advantage of variable cargo volumes (as with the cold body and dynamic space innovations) or exchange goods between larger and smaller vehicles.

The availability of data to better inform decision making processes is a key concern. For both public authorities and private actors, collecting, sharing, interpreting and acting upon data is a critical shared need. Data on freight movements are often fragmented, non-standardized and difficult to share due to GDPR and/or company policies aimed at maintaining a competitive edge. Public authorities in particular need access to standardized freight data while companies require assurances that participation in data sharing will not erode their competitive advantage nor result in unnecessarily strict regulations.

Surprisingly, while adequate vehicle range was mentioned as a requirement, few users expressed a need for more than 200km of range, well within the abilities of most new electric vehicles. Concerns were more related to increasing capacity, both volume and weight, as time is the limiting factor for many logistics companies. In these cases, a larger, expensive battery for more range is a burden rather than an asset. However, charging infrastructure remains a concern, not only access to charging but also software that is able to efficiently plan charging routines considering the planned routes.

While the methods used in this deliverable allowed insights into the fleet and system levels and the wider needs of the ecosystems related to the innovations, it faced limitations when trying to consider the needs of those that would interact more directly with the vehicles. The high number of innovations in Shift2Zero also meant that achieving full coverage was challenging and required recruitment of multiple different types of actors (cold chain, parcel logistics, car sharing, etc..), potentially limiting the depth of investigation that could have occurred if there were fewer innovations to cover. However, it is important to consider the results of this deliverable in coordination with the rest of WP2, where additional methods are employed (surveys, workshops) to ensure a comprehensive understanding of the project's user requirements.

4. Conclusions

This deliverable presents an aggregated list of requirements at the fleet and system level for the different innovations within the Shift2Zero project. It is intended as a complement to the other tasks within WP2 which use additional methodologies to elicit user requirements. Taken together, the outputs from WP2 provide needed insights on users and stakeholders that are relevant for the development of more specific solution requirements in WP3. Focusing on the fleet and system levels, this deliverable allows a wider view of the needs and requirements faced by logistics actors, technology developers and public authorities when adopting innovations.

One overarching theme that became clear through the analysis is the importance of regulations in setting the operational context. Rules and regulations decide the level of access that logistics actors have to city centres- what types of vehicles can operate where and when. This in turn incentives companies to adopt specific technologies or operational patterns to maintain compliance and their market position.

However, to take advantage of the possibilities provided by new technologies, regulations must be flexible enough to adapt. Current regulations are often rigid, and responsibility may be fragmented across multiple internal departments or the national, regional and local levels. A well-considered, knowledge-based, predictable and fair regulatory framework is essential to driving innovation and sets priorities for companies that are willing to adapt if needed but are unlikely to do so when it risks putting them at a competitive disadvantage.

Ultimately, the requirements presented in this deliverable highlight that implementing sustainable logistics innovations must look beyond just technological innovation. The interplay between regulations, operational practices, data sharing and business models determines the scalability of an innovation. Collaborative frameworks and cross-sector coordination are essential.

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6. Annexes

6.1 Annex 1 Use case generation template

The following document was distributed to pilot leaders and filled out by project partners. The results were used to better understand the intended use for each of the project innovations in Shift2Zero and further refine the interview guides:

Generating use case descriptions SHIFT2ZERO

To generate requirements that are relevant and useful for the S2Z project, we need a clear understanding of the activities that will take place in each pilot. In other words, a description of the use case envisioned for each S2Z innovation. To do this, we want to look more closely at critical transfer phases or distinct situations that are to be demonstrated.

The use case descriptions generated are meant as starting point that will be further refined as the project progresses. We suggest the following template to be filled out by the different pilot leads in coordination with relevant S2Z partners.

The template is intended to provide 1) a description of current activities and 2) an updated description of the specific uses cases to be demonstrated by the pilots.

General information

Name of pilot & location:

Relevant S2Z innovations to be demonstrated:

Pilot lead & contact details *(e-mail address):*

Baseline description:

1. Briefly describe your current activities *(area of operation, where loading occurs, type of goods, etc...).*

2. Which aspects of your current operations will be impacted by S2Z innovations?

3. What are some of the biggest challenges you face in carrying out your current operations?

Pilot Activities

For **each** S2Z innovation to be demonstrated, please describe:

4. What is the main logistics or operational challenge this use case addresses? *(E.g., high fleet energy consumption, inefficient last-mile delivery, etc.)*

5. What will S2Z learn by demonstrating this use case?

6. What specific activities will be demonstrated? Please describe as a series of events *(i.e. sorting of goods at terminal into a swap box, swap box loaded into van, transferred to microhub, transferred to smaller vehicle etc…)*

7. Where in the pilot area will each event take place *(loading, sorting, delivery, etc.)?* If possible, use illustrations (see example below using google maps) to show delivery zone, transfer points or test area.

8. What actors will need to be involved for carrying out the planned activities? (E.g., road authorities, warehouse managers, fleet managers, drivers, etc..). For each involved actor please describe:
   a. Who is the actor? (I.e., Organization, role, etc.)

   b. What will they do? (I.e., Their role in the demonstration, what feedback they will provide, etc.)

Support infrastructure, technology or regulations

9. Please describe any surrounding infrastructure that may constrain or enable activities. *(E.g., charging stations, dedicated urban delivery zones, modal filters, etc.)*

10. Are there any existing or upcoming laws or regulations (now or expected in the future) that may constrain or enable activities? *(E.g., LEZ/ZEZ rules, urban freight access restrictions, etc.)*

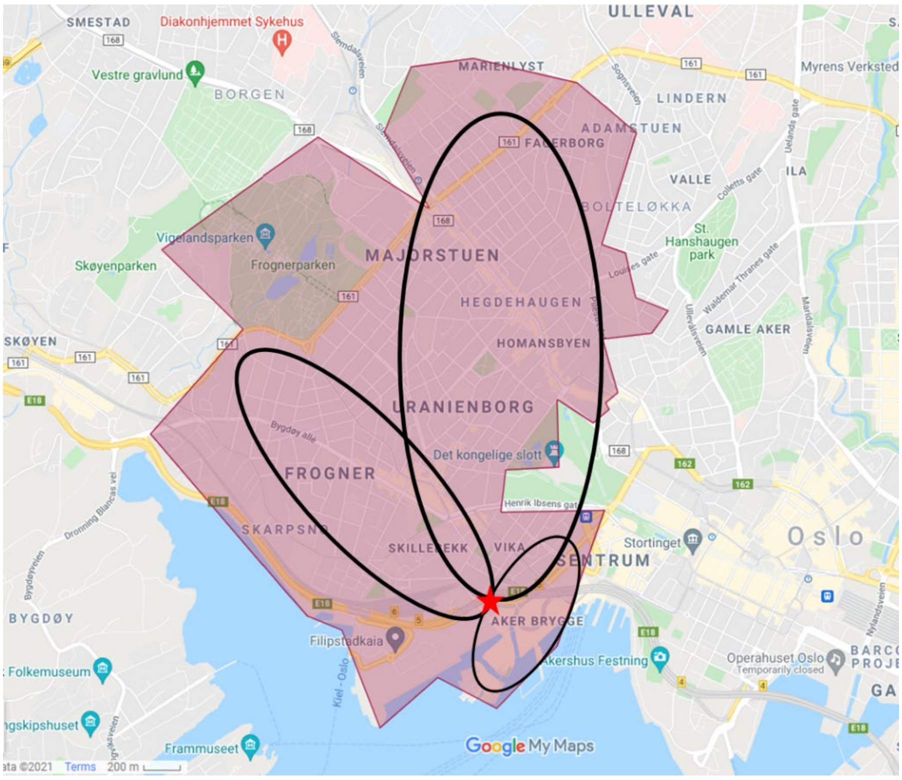
11. Please describe any technology that will be involved and what it will do. *(E.g.,* Battery Technology & Bi-Directional Charging, Route planning software, ADAS, etc.*)*

Additional information

12. Which other stakeholders should be interested in this use case? Try to name some specific local users and stakeholders. Why would they be interested? *(E.g., regulatory insights, cost-efficiency improvements, etc.)*

13. Do you have any other comments or inputs about the pilot?

Example of type of illustration that could be included for question #7:



Delivery area and route choice for light electric freight vehicles based from a city hub in Oslo. Red star = city hub.

6.2 Annex 2 Interview Guide

The following interview guide was used to conduct the semi-structured interviews:

Before interview:

- send consent form via e-mail
- send use case description(s)

Start interview:

- Introduce TØI and ourselves
- Present the project and the aim for interview
- Review consent
- Start registration

1. You and your organization
    a. Can you briefly tell us about your current role and experience?
    b. Can you tell us about your organization? [what is business/customers] [what do you do for who?]

c. What are [your organization's main goals / the main goals in your work?]
d. Which main activities [do you / does your organization] need to perform to reach these goals?
e. Which assets / resources are the most important [in your work / to your business]? Main partners, suppliers?
f. What are the biggest challenges you face with your current operations?
g. What role does goods transport play in your organization's activities?
h. In what way is your organization interested in [S2Z solution A]?
i. In what way is your organization interested in [S2Z solution B]?

Clearly state which S2Z solution is concerned for the questions below.

2. Value
    a. Would you [business/organization] want to use [S2Z solution]? Why? What would improve?
    b. What value do you see for you / your organization in [S2Z solution]?
    c. How would [S2Z solution] allow your organization to work differently to achieve your goals?
    d. If [S2Z solution] was available throughout [your/logistics] operations, what would become possible for your organization?
    e. What would need to happen for [S2Z solution] to be useful/attractive?
    f. How could [S2Z solution] affect logistics KPIs/ your organization?
3. Challenges
    a. What challenges do you see for your business/organization in the use/application of [S2Z solution]?
    b. What would need to happen for [S2Z solution] to be easy to use? What Kind of support would you need?
    c. What challenges do you see for other actors in the use/application of [S2Z solution]?
    d. Would use of [S2Z solution] require any changes to your processes? What would need to be done, what would new systems look like?
4. Requirements
    a. What requirements would [S2Z solution] need to meet in order to be accepted by you or your organization? Can it be measured?
    b. What would make you like it, not like it? Can it be measured?
    c. What would you need to change in order to accommodate [S2Z solution] in your organisation activities/in your job? What would you want/ not want to change?
    d. Can you think of changes other actors would need to make?
5. Information

   a. What information do you need about [S2Z solution]? Who would need it? [About vehicle, cargo surroundings, people on site]

6. Real and unusual situations

   a. What unusual situations might occur and cause problems?

   b. Social, informal or cultural aspects that should be considered to operate with [S2Z solution]?

6.3 Annex 3 Specific Requirements full list

This section contains the full list of specific requirements for each innovation, as well as for general requirements for adopting e-LCVs. They are grouped alphabetically by the short name for each general requirement. Each specific requirement originates from one or more statement made by a specific user or stakeholder. Each individual statement was given a number in combination with a prefix of T, L, or P to designate Technology Developer, Logistics Actor, or Public Authority respectively. For example, a specific requirement with the Origin statements (T-1, P-3, L-15), would be comprised of three statements, one made by a Technology Developer, one by Public Authority and one by a Logistics Actor).

6.3.1 General requirements

Aggregated Requirement	Req#	Specific Requirements	Origin statement(s)
Costs and TCO	1	We need lower charging costs to public charging infrastructure encourage use of available infrastructure	P-1
	2	We need the TCO for new vehicles to be competitive with that of the alternatives	L-13, L-14, L-15, L-16, L-24, L-25, L-26, L-29, L-32, L-36, L-40, L-8, L-9, P-2
	3	We need to see a specific value to our operations in the implementation of expensive, complicated IoT features	L-1
	4	We need to ensure that electric vehicles are affordable for smaller logistics actors	L-2, L-3
	5	We need to invest in electrification for our subcontractors that cannot afford el-vans	L-4
	6	We need electricity costs to be competitive with fuel costs	L-28, L-5
	7	We need EV leasing to be competitive to diesel vehicle leasing	L-6
	8	we need to minimize vehicle maintenance costs	L-34, L-35, L-44, L-7
	9	We need to provide cheaper vehicles to companies	L-10
	10	We need access to affordable charging from the (micro) grid	L-11, L-12
	11	we want to use EVs to reduce costs for toll and ferry on long routes	L-17
	12	we need to operate on extremely thin economic margins	L-18
	13	we need to reduce personnel-related costs	L-19
	14	Need to find a break-even considering the price of sold goods and the vehicle costs	L-20

	15	we need to price of new and innovative vehicles to reduce over time	L-21
	16	we need vehicles that reliably retain value over time	L-22, L-229, L-27, L-33
	17	we need financial support and/or incentives for electrifying our fleet	L-23, L-43
	18	we need to accurately judge price vs quality of vehicles	L-30, L-31
	19	we need to reduce cost per unit time	L-37
	20	we must consider the higher cost of heavier and/or long-haul EVs	L-38, L-41
	21	we need to prioritize profit over sustainability	L-39
	22	we need to be able to afford the up-front costs of purchasing Evs	L-42
	23	we need cheaper fast charging	L-45
	24	we need to be able to afford the high up-front costs of EVs even if the long-term TCO is lower	L-46
	25	we need to be able to replace old batteries with new ones at a reasonable cost	L-47
	26	We need flexibility in battery size of vehicles to match the cost of the vehicle with the range needed for daily operations	L-48
	27	We need access to less expensive batteries (and therefore important from China)	T-1
	28	need to deliver as much as possible with as few drivers as possible to reduce labour costs	P-3
Data, knowledge and foresight	29	we need more knowledge on charging requirements during logistics operation	P-4, P-5
	30	Need to better understand the scope of the problem and the potential impacts of solutions for urban logistics	P-6
	31	Need for an overview about how infrastructure is being used by logistics actors	P-7
	32	we need data on logistics vehicles and operations	L-53, P-10, P-15, P-16, P-18, P-8, P-9
	33	we need continuous knowledge on customer needs	T-2
	34	we need to use co-design to ensure optimum product design	T-3
	35	we need to test new solutions to determine their viability	L-49, L-56
	36	we need telematics data that provides overview of our operations and help increase efficiency	L-50
	37	we need knowledge on the costs and benefits of fleet electrification	L-51
	38	we need to be able to scale up innovations from pilot to all operations	L-52
	39	we need to be able to plan for future changes in the logistics sector	L-54, L-55, L-63
	40	we need better data on incoming goods to better plan routes and sorting	L-57
	41	we need automatically collected data on logistics vehicles and operations	L-58
	42	we need clear, easier data reporting routines and methods	L-59
	43	we need to learn about best practices and new technologies	L-60, L-61, L-62, L-66
	44	we need more knowledge on fleet management	L-64
	45	we need to build competence with EVs without prior experience with diesel vehicles	L-65
	46	we need to map available tools to introduce digital regulations	P-11
	47	We rely on PPP for knowledge on reducing emissions reduction	P-12
	48	we need more knowledge on customer needs for cold chain and warm deliveries	T-4
	49	We need to access to data from OEM partners	T-5

	50	Need more information about freight movements	P-13
	51	Need information about freight movements	P-14
	52	we need to protect sensitive industry data and information	P-17
	53	We need to better understand the impact of non-exhaust emissions	T-6
	54	Municipalities need a better understanding of what data is needed, where to find it, how to deliver it, and to who	P-19
	55	We need data sharing routines that are acceptable from a GDPR perspective	T-7
Energy and service infrastructure	56	We need to ensure that 3rd party drivers who use private vehicles (and thus don't use charging at terminals) have adequate charging facilities and range when starting deliveries	L-67
	57	we need charging infrastructures to be paid for, operated and managed by the logistics operators themselves	P-20, P-21
	58	we need a fuelling/charging solutions that don't use too much time	L-68, L-69, L-70, L-71, L-72
	59	we better infrastructure at unloading areas for customers	L-73
	60	we need solutions to fast charge the vehicles during loading and unloading	L-74
	61	we need standardised charging interfaces to ease usability	L-75
	62	we need to adapt our depots for EVs by installing chargers	L-76
	63	we need infrastructure that meets the high level of logistics transport demand	L-90, L-91, P-22
	64	we need sufficient and affordable charging infrastructure	L-101, L-102, L-108, L-77, L-78, L-83, L-84, L-85, L-88, L-97, P-25
	65	we need our own charging/fuelling systems	L-103, L-104, L-106, L-79, L-80, L-82, L-86, L-87, L-89, L-96
	66	we need our charging stations to be on the microgrid (and not on the grid)	L-81
	67	we need more intermediate charging opportunities	L-92
	68	we need sufficient grid capacity to charge our vehicles	L-93, L-99
	69	we rely on public power grids	L-94
	70	we need more actors' investment in charging infrastructure	L-95
	71	we need to increase the utilization of our charging infrastructure	L-98
	72	we need more charging infrastructure in the city centre	L-100
	73	we need more charging infrastructure outside the city centre	L-105
	74	we need faster charging solutions	L-107
	75	we need charging infrastructure in strategically placed locations	L-109
	76	need agreements with customers to set up charging facilities in different locations that support our operations	L-110
	77	Need lower energy prices to make electric vehicles more attractive	P-23
	78	We need more streamlined processes for implementing charging stations	P-24
Fleet planning and delivery operations, Vehicle capability and support	79	we need to time to coordinate new fleet adoption with sub-contractors	L-111, L-530
	80	As a logistics operator, we need solutions to help plan routes for multiple shifts considering range of electric vehicles and variable route lengths due to late cut off times for sorting	L-112
	81	for last mile courier deliveries, packages must be small and light	L-113

82	Logistics companies need support in implementing new routines when they use a new solution	T-10, T-8, T-9
83	Need more standardized software tools to manage fleets	T-11
84	Need to facilitate data sharing and operational cooperation between actors to facilitate more efficient operations	T-12
85	need to reduce incidents related to dropped and damaged goods that result in delays and long processes related to reimbursement	L-114
86	Need to reduce the amount of driving and stops in urban areas	P-26
87	we must drive at least 100-180 km per shift given current load capacity	L-115
88	we must have capacity for returned goods	L-116
89	we need a combination of effective sorting, lockers, and routing in order to be efficient	L-117
90	we need access to warehouses at specific times (i.e. just prior to morning and afternoon rushes)	L-118
91	we need an operational plan that maximizes volume of delivery, limits kilometres travelled and need for charging stations	L-119
92	we need automated route planning	L-120
93	we need dedicated staff to ensure that vehicles are operating properly	L-121
94	we need different crews for loading and driving	L-122
95	we need efficient routing and delivery strategies in areas with dense number of stops	L-123
96	we need fleet management systems that work for multiple vehicle types	L-124, L-125
97	we need high order density in order to shift from vans to bikes and other electric vehicles	L-126
98	we need innovations and electric vehicles to actually work in real world environments and have the systems around them to implement them efficiently	L-127
99	we need to continue adding more electric vans to our fleet	L-128
100	We need more flexibility in solutions that enable direct deliveries as opposed to rerouting through hubs and sorting terminals	T-13
101	we need more electric vehicles to meet increased parcel volumes	L-129
102	we need reduce unnecessary VKT	L-130
103	we need regular and predictable routes	L-131
104	we need reliable delivery of goods to terminals to ensure enough time for sorting and further delivery	L-132, L-133, L-134
105	we need short-term access to vehicles	L-135
106	we need smaller (than car) vehicles that can more easily access central areas that are narrow and or have heavy traffic	L-136, L-137
107	we need smaller vans that can drive to strategically placed hubs more efficiently	L-138
108	we need solutions that reduce time spent sorting goods and loading vehicles	L-139, L-140, L-141, L-142, L-143, L-144, L-145
109	we need standardized vehicles and components to optimize efficiency	L-146, L-147, L-148
110	we need strategies that increase loading efficiency and reduce vehicle kms (for example one vehicle working as a mobile depot picking up packages for multiple others)	L-149
111	we need sufficient vehicle supply to meet our logistics needs	L-150, L-151, L-152

112	we need to adapt logistics operations and the types of vehicles used to the needs of the local context (range, volume, capacity, type)	L-153, L-154, L-155, L-156, L-157, L-158, T-14
113	we need to adapt to a changing technological environment and the new potential use cases it generates	L-159, L-160
114	We need to adopt our fleet composition and services to changing realities	T-15
115	we need to balance route planning with driver discretion for optimizing deliveries	L-161
116	we need to balance the trade-offs between range, weight and cost	L-162, L-501
117	we need to combine delivery orders to make fewer stops	L-163
118	we need to consider customer travel patterns and preferences when delivering to pick-up points	L-164, L-165
119	we need to consider how autonomous vehicles can change operations	L-166
120	we need to consider the use of cargo-bikes for certain delivery options	L-167, L-168
121	we need to deliver across a range of times and distances	L-169, L-170
122	we need to deliver different product types and sizes	L-171, L-172
123	we need to deliver on time	L-173, L-174
124	we need to effectively coordinate different parts of the logistics chain	L-175
125	we need to effectively manage goods across the entire supply chain	L-176
126	we need to efficiently use the cargo space we have and achieve high fill rates	L-177, L-178, L-179, L-180, L-181, L-182, L-183, L-184
127	we need to ensure efficient operations despite heavy traffic in urban areas	L-185, L-186, L-187, L-188, L-189, L-190, P-27
128	We need to ensure our electric vehicles are being used as much as possible to ensure we are using our less expensive (energy is cheap), less polluting assets	L-191
129	we need to maximize the number of deliveries per vehicle, per route	L-192
130	we need to minimize the number of depot trips to refill cargo when considering van vs cargo bike	L-193, L-194
131	we need to minimize time lost for charging vehicles	L-195
132	we need to optimize the parcels/letters delivered per hour against cost	L-196
133	we need to reorganise operations when driving electric vehicles	L-197
134	we need to start the day with fully charged vehicles	L-198
135	we need to support mixed vehicle fleets through exchange of goods between different sized vehicles that avoid trips back to a hub to refill and keep advantages of small vehicles in city centres	T-16
136	we need to take into consideration local events that can affect access or traffic on routes	L-199
137	we need third-party companies in some instances to deliver efficiently in city centres with smaller vehicles	L-200
138	we need to transition away from energy sources that will not be cheap and abundant in the future	L-201
139	we need to develop good internal systems to manage our own logistics and avoid dependencies on others	L-202
140	we still need diesel vehicles for long daily transport	L-203
141	we want technological innovations that are quick to implement	L-204

	142	we want to minimize the number of necessary vehicles	L-205, L-206, L-207
	143	we want to optimize routes with long driving distances with low delivery density that are expensive for vans	L-208
Policies, access and incentives	144	Need implementation of rules allow lighter electric trucks weighing 4.25 ton to be treated as 3.5-ton van (due to battery weight to be on the same level as diesel vehicles considering payload and license)	L-289, L-290, L-291, L-292, L-293, L-294, L-295, L-296, L-297
	145	Policies need to support a change to market structure to shift out both vehicle fleets and ingrained practices to get more sustainable urban logistics	P-34
	146	public authorities need tools to ensure a high fill rate of vehicles entering city centres	P-35
	147	Regulations need to be flexible enough to adapt to changing circumstances	P-36
	148	The process of piloting and upscaling needs to be streamlined from a regulatory perspective so that processes are not repeated again and again	T-27
	149	we must strategically own and lease vehicles depending on tax liabilities and incentives	L-298
	150	we need a predictable/foreseeable regulatory situation	L-299, L-300, L-301, L-302, L-303, L-304, L-305, L-306, P-37, P-38, P-39, T-28, T-29
	151	we need access to city centres and other high-demand areas	L-307, L-308, L-309, L-310, L-311
	152	we need better planning of loading and unloading points with municipalities to maintain access to city centres	L-312
	153	we need incentives for companies to share data on freight movements and coordinate	P-40
	154	We need more streamlined regulations	L-313
	155	We need policies such as lower speeds that increase safety and meet vision zero	P-41
	156	We need policies that are flexible and take account for the needs of many types of goods	P-42
	157	We need policies that reduce congestion in the city centre	P-43
	158	we need regulations that are appropriate for different types of vehicles	L-314, T-30, T-31
	159	we need regulations that take a long-term perspective	L-315, L-316, L-317, P-44, P-45
	160	we need regulations to be tech neutral	T-32
	161	we need regulations to build on existing partnerships	P-46
	162	we need regulations to push us toward sustainable solutions	L-318, L-319, L-320, L-321, L-322, L-323, T-33
	163	we need regulations to support expanded access to charging infrastructure	L-324
	164	we need specialized solutions to access restricted urban areas	L-325, L-326, L-327, L-328, L-329, L-330, L-331, L-332, L-333, T-34
	165	we need support for adopting digital and green solutions	L-334
	166	we need support for developing charging infrastructure	L-335
	167	we need support for the purchase/lease of sustainable vehicles	L-336, L-337, L-338, L-339,

			L-340, L-341, L-342, L-343, L-344, P-47, T-35
	168	We need to adjust our fleet composition/route planning to anticipate restrictions that only allow electric vehicles in city centres	L-345
	169	we need to avoid burdensome regulations that do not contribute to sustainability	T-37
	170	we need to balance logistics operations and installation of charging infrastructure with historic preservation in city centres	P-48
	171	we need to be able to streamline type approval tests for upgrading batteries	T-38
	172	we need to comply with regulations and norms for sustainable logistics	L-346, L-347, L-348, L-349, L-350, L-351, L-352, L-353, L-354, T-39, T-40, T-41, T-42
	173	we need to comply with regulations and norms for welfare	L-355
	174	we need to consider social/political viability when implementing regulations	L-356, P-49
	175	We need to implement R&D results quickly if we are to capitalize on the investment	T-43
	176	we need to enforce existing regulation	P-50
	177	we need to ensure that regulations are socially just	P-51
	178	we need to ensure that rules for mandatory breaks do not interfere with timely delivery	L-357
	179	we need to follow the requirements of public tenders for delivery by electric vehicle	L-358
	180	we need to fulfil mandated registration and maintenance obligations for electric vans as if they were trucks because of the 4250 regulations	L-359
	181	we need to have clarity in regulations	L-360, P-52, T-44
	182	we need to provide regulatory support for bike solutions for urban logistics	P-53
	183	we need to provide regulatory support for smaller vehicles for urban logistics	P-54
	184	we need to regulate access and restrictions to urban areas dynamically	T-45
	185	we need to regulate to restrict access to urban centres to certain vehicle types	P-55, P-56, P-57, P-58
	186	we need to support sustainable solutions for urban loading zones	P-59, P-60
Safety, usability, and workforce	187	Need to prioritize the right vehicle in the right location- cargo bikes aren't necessarily safe on certain types of bike infrastructure	L-361
	188	We need to ensure that logistics is safe for vulnerable road users	L-362
	189	we need to improve the health of drivers (potentially by offering more active travel)	L-363
	190	we need to provide feedback to drivers on safety performance to improve behaviour and operational performance	L-364
	191	we need access to well trained, trustworthy drivers	L-365, L-366
	192	we need access to more trained drivers (class C)	L-367
	193	we need drivers to be able to afford licensing fees	L-368
	194	we need to ensure that other road users are aware of our presence with quieter vehicles	L-369
	195	we need to minimize driver confusion owing to different user interfaces in different vehicles	L-370

	196	we need to avoid emotional barriers to the use of new solutions	T-50
	197	We need to set the use of electric vehicles as an expectation for our drivers/sub-contractors	L-371
	198	we need to ensure adequate levels of driver comfort	L-372, L-380, L-393
	199	we need to improve driver comfort	L-373
	200	we need to overcome drivers' scepticism towards the efficiency of sustainable delivery solutions	L-374, L-388, L-389, L-390
	201	we need new vehicles to be simple for our drivers to maintain and use	L-375, L-382
	202	we need to make the driver job more attractive to retain and attract workforce.	L-376, L-377, L-378, L-379, L-397
	203	we need to establish new behavioural routines among drivers	L-381, L-391, L-394, L-396, L-399
	204	we need to be able to recruit drivers for both vans and trucks	L-383
	205	we need to be able to recruit drivers for different types/brands of vans and trucks	L-384
	206	we need to improve driver familiarity with new vehicle solutions	L-385, L-395
	207	we must contend with drivers who are unwilling to adopt new vehicle solutions	L-386, L-387
	208	we need to ensure that we are not placing too much workload onto our workers	L-392
	209	we need drivers to like the vehicles they are using	L-398
	210	we need to train our drivers ourselves	L-400
	211	we need well maintained vehicles to encourage drivers to continue to maintain them well	L-401
	212	Logistics activities must not come in conflict with vulnerable road users	P-66, P-67, P-68
Stakeholder coordination	213	Municipalities and companies need to find good use cases that leverage available data	P-78
	214	Public authorities need good communication across different levels and internal departments	P-79
	215	we need a structured service network to ensure timely service and maintenance	L-402, L-492, L-493, L-494
	216	we need effective communication and cooperation between private entities	L-403, L-404, L-405, L-406, L-407, L-408, L-409, L-410, L-411, L-412, L-413, L-414, L-415, L-416, L-417, L-418, L-419, P-80, P-81, P-82, P-83, T-55, T-56, T-57, T-58, T-59, T-60
	217	we need effective communication and cooperation between private entities to ensure flexibility	L-420, P-84
	218	we need effective communication and cooperation between private entities to prepare for coming regulations	T-61
	219	we need effective communication and cooperation between public and private entities	L-421, L-422, L-423, L-424, L-425, P-85, P-86, P-87, P-88, P-89, P-91, T-62
	220	we need effective communication and cooperation between public and private entities	P-90

	221	technology providers need effective communication with the different departments in a single company	T-63
	222	we need good internal communication to ensure that all layers of the organization are on the same page	L-426, L-427
	223	we need logistics actors to understand and support one another sustainability visions	L-428, P-92
	224	we need reliable EVs and reliable ways to ensure our subcontractors are maintaining our goal of zero emission deliveries	L-429
	225	we need share smaller vehicles and bikes with other actors	L-430
	226	we need timely communication and cooperation between public and private actors	P-93, P-94, P-95, T-64
	227	we need to agree on strategy internally before we can effectively communicate with partners	L-431
	228	we need to align sustainability goal across our network of stakeholders	L-432
	229	we need to coordinate actors to grow new markets and explore new business models of collaboration	L-433, L-434, L-435, L-438
	230	We need to ensure that smaller logistics actors receive adequate attention	L-436, L-437
	231	we need to ensure that we do not grow too dependent on one key partner for all transport	L-439
	232	we need to manage fragmentation of responsibility across different actors in the private sector	L-440, L-441
	233	we need to manage fragmentation of responsibility across different actors in the public sector	L-442, P-100, P-101, P-102, P-103, P-104, P-105, P-106, P-107, P-108, P-110, P-96, P-97, P-98, P-99
	234	we need to support users in reorganizing operations around a smaller vehicle	T-65
	235	we need to work with independent contractors who also use the logistics vehicles for private purposes	L-443
	236	we need to evaluate new solutions in cocreation arenas with citizens and relevant stakeholders to build acceptance	P-109
	237	we rely on good internal communication to ensure driver compliance with rules and expectations	L-444
Sustainability objectives	238	we need to share resources in order to reduce our carbon footprint	L-445
	239	we need to source more environmentally friendly solutions in the supply chain	L-446
	240	we need to reduce co2 emissions	L-447
	241	we need standardised ways of reporting C02 for different energy types (e.g. biogas, battery) that also consider local power generation (coal vs hydro for example)	L-448
	242	we need to be able to report sustainability information about our operations	L-449
	243	we need plans that are replicable and provide long-term sustainability	L-450
	244	we need to find alternate ways of working to reduce emissions and congestion in urban areas	L-451
	245	Need to engage with innovative and sustainable practices to find new solutions despite the daily pressure and attention on operations	L-452
	246	we must achieve our sustainability targets irrespective of public sector activities and support	L-453
	247	we must carry out a minimum number of zero emission deliveries	L-454
	248	we need innovations and electric vehicles that allow us to reach sustainability objectives without degrading our business model	L-455

	249	we need to show the energy/emission impact of our product/service	L-473, T-66
	250	we need to minimize VKT to reduce environmental impact	L-456
	251	We need to reduce our carbon footprint to meet climate goals	P-111
	252	Emissions from last mile transport need to be reduced	P-112
	253	We need to reduce the share of private cars in personal mobility	P-113
	254	We need to encourage the use of smaller more space efficient vehicles	P-114
	255	we need to make all kinds of transport more sustainable	P-117
	256	Environmental impact needs to be measured by lifecycle analysis	T-67
	257	Sustainability needs to be embedded in the core of design	T-68
	258	Customers need to be more aware, and companies better to communicate, the benefits of energy efficiency and lower env. Impact	T-69
	259	We need to consider the lifecycle and recyclability of batteries	T-70
Use of space and facilities	260	we need parking spaces that are large enough for LCEVs	L-457
	261	We need the right partnerships to manage the complicated process of localizing a car sharing space	L-458
	262	we need parking spaces to test out mobile pick-up solutions	L-459
	263	We need parking spaces to carry out deliveries	L-460
	264	we need enough space to sort goods at smaller city hubs	L-461
	265	We need private landowners interested in providing space to place nano hubs	P-118
	266	we need solutions that offer more space efficient delivery of goods in city centres	P-119
	267	we need access to loading zones in urban areas	L-462
	268	we need more local consolidation/sorting centres	L-463
	269	we need pick-up points/lockers that allow for better operational efficiency and less rush hour driving and more flexibility for customers	L-464, L-465
	270	we need strategically placed warehouses to minimize travel distances	L-466, L-467, L-468, L-469, L-470
	271	Need to consider limited space in city centres and varying ownership of parking areas (public vs private) when implementing logistic solutions	P-120
Value creation and market fit	272	we need to provide clear and measurable value for our logistics choices	L-471
	273	we need to show clear and measurable value to the public sector	L-472
	274	we need to provide clear and measurable value to our customers	L-474
	275	we need to weigh competing concerns for expressed desire sustainability and real-world expectations of effective delivery	L-475
	276	we need to provide clear and measurable value to our customers	L-476, T-74, T-79
	277	we need to weight competing concerns for sustainability and effective delivery	L-477
	278	we need help to show the energy/emission impact of our product/service	L-478
	279	Companies must see a value to engaging in pilot projects	P-121
	280	need to have a business case where the price of development of a new vehicle/solution and the market demand are compatible	T-71, T-72
	281	we need to strategically target markets with demand for new vehicle solutions	L-479, L-480, L-482, T-73

	282	We need to make the importance of developing efficient urban logistics clearer to other stakeholders	P-122
	283	we need mass adoption to see the benefits of new solutions	T-75
	284	we need to provide clear and measurable value to our customers	T-76
	285	we need customers to be willing to pay more for sustainable good delivery	L-481, L-488
	286	we need to ensure measurable customer satisfaction	L-483
	287	we need to park our vehicles in a way that satisfies our customers and the public (not blocking sidewalks, etc..)	L-484
	288	we need to build a reputation by adopting environmentally friendly solutions	L-485, L-486, L-487
	289	we need to use electric fleet when customers demand it	L-489
	290	Need to develop solutions that are flexible enough to adapt to future changes in logistics systems	T-77
	291	Need to consider the trade-offs of developing vehicles in different categories and the additional regulatory demands (L7, N1 etc..)	T-78
	292	we need to strategically target markets with demand for new vehicle solutions that fill gaps between existing systems	T-80
	293	Need to provide vehicle solutions based on needs customers express	T-81
	294	we need solutions that are mutually beneficial to multiple actors (public/private) to make progress	T-82
	295	We need solutions that are mutually beneficial to multiple actors (public/private) to make progress to decarbonization objectives	P-123, P-124
Vehicle capability and support	296	we need vehicles with a range of at least 200 km	L-490
	297	we need a range of options in the vehicle market	L-491
	298	We need batteries that maintain performance over time	L-495
	299	we need cooling solutions that will last for long journeys	L-496
	300	we need customized cargo body spaces	L-497
	301	we need increased energy efficient vans for last mile deliveries	L-498
	302	we need alternative solutions (such as cargo bikes) to be reliable and tolerate daily use	L-499
	303	we need reliable vehicles	L-500
	304	we need enough vehicle range to deliver two routes in the same day.	L-502, L-503
	305	we need to be able to drive at least 100 km	L-504
	306	we need to choose vehicles that can carry the necessary volume	L-505, L-506, L-507, L-508, L-509, L-510
	307	we need vehicles capable of delivering different product types and sizes	L-511, L-512
	308	we need to deliver different product types and sizes and sizes	L-513
	309	we need to choose vehicles based on their purpose and ability (volume, capacity, access to delivery area)	L-514, L-515, L-516, L-517, L-518
	310	we need to manage incorporating various vehicle weights and sizes in our electrified fleet	L-519
	311	we need to maximize the load capacity considering the weight of the battery and range	L-520, L-521, L-522, L-523, L-524, L-525, L-526, L-527
	312	we need vans to be able to drive about 150-200 km	L-528
	313	we need vehicles that are appropriate for the cultural contexts in which they operate	L-529

314	we need vehicles that are suitable for climatic and geographical characteristics of an area	L-531, L-532, L-533, L-534, L-535, L-536
315	We need vehicles with enough range	L-537, L-538, L-542, L-543, L-544, L-545, L-546, L-547, L-548, L-549, L-550, L-551, L-552, L-553, L-554, L-555
316	We need vehicles with enough range for regional transport	T-83
317	We need vehicles with enough range for a full day	L-539, L-540
318	We need vehicles with enough range for two days	L-541
319	we need vehicles with proper 4-wheel drive and sufficient range	L-556
320	we need vehicles that can navigate narrow streets	L-557
321	we need to balance performance trade-offs between tires and other vehicle components	T-84
322	Need to develop vehicles that support multiple use cases	T-85
323	Need for smaller vehicles that work well in urban areas	P-125
324	Need for vehicles that are safe for users outside the vehicle	P-126
325	we need optimal energy density for batteries considering weight and vehicle capacity	T-86
326	Vehicles must balance between being too generic and too specialized	T-87
327	Vehicles should be standardized around a platform that makes customisation and changing out components easy	T-88

6.3.2 Multi-Temperature Cargo Body

Aggregated Requirement	Req#	Specific Requirements	Origin statement(s)
Accessibility to cold body	1	The cold body should have side door	L-1
	2	Cold body must ensure safe and efficient access of drivers to cold body through well designed doors	T-1, T-2
	3	Cold body design must allow access to 3 compartments for cool, fresh and dry goods	L-2
	4	Cold body design must facilitate the use of volumetric height (shelving, stacking)	L-3
	5	Cold body should have a division of temperature zones that are equally accessible	L-4
	6	Cold body loading process should ensure that the driver can quickly locate goods in the cold body	L-23
Compatible goals, systems and handling processes across actors	7	Cold body innovation must support public authority's sustainability goals while helping businesses achieving their business objectives	P-1, P-2
	8	Cold body must be implemented in 3.5t vans to avoid increasing vehicle size in city centre and must have dedicated parking/(un)loading zones close to end customer	P-3
	9	Cold body vans must be able to serve several customers in a close proximity with one parking space	P-4
	10	Cold body solution must be co-developed and aligned with the OEMs and suppliers' specifications, the customer's needs and the national regulatory needs	L-5, T-3, T-4, T-6
	11	Cold body needs to be unanimously handled with the right tools and procedures across partners to prevent damage	L-6

	12	Cold body would need to fit into existing flow of cold goods into city centres and the existing infrastructure such as microhub	P-5
	13	Cold body should introduce minimum change to existing operations, fleet and infrastructure	L-17, L-20, L-24, P-6
	14	Cold body solution design should clarify distribution centre design and operational routines	L-18
	15	Cold body must be quick to load and unload in under five minutes which is the standard with boxes on trolleys	L-19
	16	Cold body solution must be easy and intuitive to use	L-21
	17	Cold body could be more appealing if it is compatible with pallet sizes that can be transported on to bikes and trailers	L-22
	18	Cold body must ensure safe loading and unloading process	L-25, L-28, L-29
	19	Cold body solution must be in line with existing loading/unloading safety procedures from the rear side	L-26
	20	The cold body innovation needs to avoid two risks: false or missing temperature information and insufficient volume of cold goods to use the cold compartment	L-27
	21	Cold body solution must deliver higher standards in delivery service and extra control of the process	L-30
	22	Cold body must ensure compliance with existing standards and needs in staff skills, procedures and vehicle specifications	L-31
	23	Cold body needs updating the standard operating procedures and infrastructure for shippers	L-32
	24	Cold body innovation must ensure that shippers have means to protect goods against loss and damage due to temperature failure, spilling and dropping	L-33
Flexible cargo space	25	The cold body should not negatively impact daily operation with loss of space and added weight	L-7, L-9
	26	Containers or frames fitted to the vehicles are preferred to expandable or foldable frames using a separator	L-10, L-13, L-16, L-8, T-5
	27	Cold body system must have an alternative to using trolleys for moving boxes that consume more space and reduce volume efficiency	L-11
	28	Cold body should allow more temperature options than the existing two-temperature range options and better than the box with energy converter	L-12
	29	Cold body solution would be more appealing if it is compatible with existing practice of loading frozen and fresh goods boxes based on delivery plan to optimize space use	L-14
	30	Cold body is appealing if it fits current approach of having flexible size cold boxes that can be used based on need rather than fixed compartment	L-15
Optimize energy consumption	31	Cold body could benefit from having additional energy sources such as photovoltaics on top of the vehicle's roof	L-34
	32	Cold body innovation requires sustainable temperature maintenance in distribution centres	L-35
	33	Cold body needs to use the charging time to set the temperature and only use power to maintain it during the day when the vehicle is not charging	T-7
	34	Cold body should maintain the cool temperature in each compartment and insulate from outside temperature when doors open with means of extra door or a curtain	L-41, L-42, L-44, L-48, T-11, T-9
	35	Cold body must optimize energy preservation from nighttime to daytime operation	T-10
	36	The cold body must allow optimized energy consumption through considering consumption of the vehicle, the weight the vehicle can carry, the aerodynamics of the vehicle	L-36
	37	Cold body should be in use for 16 hours	L-37
	38	Cold body innovation should also show optimized energy consumption when placed in larger vans and trucks of 4.25 tons	L-38

	39	Cold body trucks of 4.25 must have cooling and heating functionality	L-39
	40	Cold body must use electricity for cooling and not diesel	L-40
	41	Cold body must facilitate longer journeys with cold goods where ice may get dampened and humidity needs to be managed	L-43
	42	Cold body weight and its added systems must not compromise efficiency	L-45
	43	Cold body would be appealing if the size can be changed so that during delivery route it can be minimized and energy can be saved if no cold delivery is planned	L-46
	44	Cold body solution should not require different cooling systems for different compartments and size adjustment	L-47
Range prediction	45	The effect of cold body on range must be accounted for	L-49, L-50, L-51, L-52, L-53, T-12, T-13
	46	The cooling system must allow enough range for operations independent of the truck energy	T-14
	47	Adjustment of temperature should not affect range	L-54
Reduction of fleet size through goods consolidation	48	The cold body innovation should help reduce dedicated fleets to different goods to a multifunctional fleet and allow all drivers to have enough volume and delivery	L-55, L-56, L-57
	49	Cold body should be multifunctional across range of goods to be transported consolidate including dry, fresh and frozen goods in one van	L-59, T-15
	50	Cold body is most valuable if it decreases vehicle number in city centre	P-7
	51	Cold body's diversity of use could potentially reduce vehicle type in a fleet	L-58
Regulatory compliance for multitemperature cargo solutions	52	Ease of piloting and need for faster potential exemptions from licensing terms and requirements	L-60
	53	Cold body must ensure compliance with food safety standards	L-61, P-8, T-19
	54	Cold body must be approved by independent certifying bodies	T-16
	55	Cold body can achieve high TRL, but the major need is to understand certification and regulation needs	T-17, T-18
	56	Cold body solution must maintain minus 20 for 12 hours in accordance with RTP rules	T-20, T-21
	57	Approval of El-vans to carry same load as their equivalent diesel vans and the same licensing, without being classified as trucks	L-62
Temperature adjustment	58	The cold body should allow for at least three different temperature ranges	L-63, L-65
	59	The cold body should allow for simultaneous transport of products at different temperatures from frozen to ambient temperature	L-64
	60	Cold body must ensure that it can maintain -20 degrees for a period of 12 hours	T-22
	61	Cold body must ensure temperature maintenance even when the vehicle is idle	T-23
	62	Cold body should also allow humidity adjustment	L-66, T-24
Viable business model	63	Cold body should show advantage in energy and battery use compared to a full cold van	T-8
	64	Cold body must prove to be cost effective considering its potential to open new business areas	L-67, L-68, L-80, L-82, L-83, L-85, L-87, L-89, L-93, L-96, T-25, T-26, T-28, T-29
	65	The cold body innovation could potentially enable delivery of cold goods in already dense delivery areas of regular goods	L-69

		(about 80% of volume of goods delivered) to save kilometres travelled and add deliveries per trip	
	66	Cold body must allow having one driver delivering cold and regular goods on one route rather than paying two drivers with two vans for different temperature goods	L-70
	67	Cold body must open logistics sector to incorporate more food and fresh good delivery in their regular operation to address market shortage for fresh goods delivery in Europe in a cost-effective way	L-71
	68	Cold body integration with regular goods delivery must allow subcontractor to have sufficient volume and delivery number	L-72
	69	Cold body mechanism must be independent of battery capacity or quantity, resulting in potential higher costs	L-73
	70	Cold body should show benefits for the dynamics of goods flow in city centre for different actors	P-9
	71	Cold body innovation is best done independent of public authority's investment	P-10
	72	Cold body innovation should support speedy delivery without causing too much distribution centre upgrade costs	L-75
	73	Cold body solution costs and driven infrastructure upgrade costs should not be imposed on the customers	L-77, L-78
	74	Pricing model must be adjusted to speed up adoption process	T-27
	75	Cold body vehicles through their smaller size must show advantage in accessing city centres	T-30
	76	The cold body should allow last minute and on demand delivery of refrigerated good with the existing fleet	L-81
	77	Cold body must convince business operators of its benefit in decreasing fleet size and traffic in city centre	P-11
	78	Cold body solution in sprinter vans must show efficiency in fuel and delivery volume compared to bigger vans, when driven in urban areas	L-84
	79	Cold body must consolidate different goods and reduce the number of subcontractors needed for different goods delivery	L-86
	80	Cold body development is best done in alignment with warehouses with broader infrastructure than dried goods	L-88
	81	Cold body solution must be transparent in cost, energy use and regulatory compliance to be adopted	L-90
	82	Cold body investment and maintenance and training costs must be within a justified range	L-91
	83	Cold body should make operations easier even if the cost is higher	L-92
	84	The cold body solution must show an advantage over the exiting fixed temperature zones solutions	L-94
	85	Cold body solution should be light in weight to allow more/heavier goods to be transported	L-95

6.3.3 Thermal comfort and ergonomics

Aggregated Requirement	Req#	Specific Requirements	Origin statement(s)
Driver comfort	1	Heating innovations are important to increase drivers working conditions and job attractivity	L-1, L-2, T-1, T-2, T-3, T-4, T-5
	2	Heating innovations should be easy to use and not require extra work from our drivers	L-3, L-4
	3	Heating innovations should provide comfort to the drivers.	L-5
	4	Heating innovations should include effective solution (e.g. training, incentives, and driver confidence-building) to ensure drivers consistently use seat and steering wheel heating instead of cabin ventilation for warmth.	L-6, L-7, L-8
Efficient defrosting, safety	5	Heating innovations should also provide efficient windshield defrosting	L-10, L-9

Preserving range	6	Heating innovations should be energy efficient.	L-11, L-12
	7	Heating innovations should help preserve battery range.	L-13, L-14, L-15, L-16, L-17, L-18, L-20, T-6
	8	Heating innovations should be provided with estimates of energy savings	L-19
	9	The vehicle battery should have extra margin for heating.	L-21
Reasonable costs for useful technologies	10	Heating solutions need to have reasonable costs	L-22
	11	Heating innovations need to maintain acceptable costs while avoiding unnecessary technologies and comfort features that add cost without clear operational benefit.	L-23, L-24, L-25
Safe and efficient heating	12	Innovations should be safe for pedestrians	T-7
	13	Heating innovations should provide focused heating rather than cabin heating.	L-34, T-8
	14	Heating innovations should be efficient in large cabin spaces.	T-9
	15	Heating innovation should comply with homologation requirements (e.g. different vehicle elements should be heated with different types of systems)	T-10
	16	Heating innovations should be efficient enough in spite of frequent door openings.	L-26
	17	Operations need to be conducted safely for drivers, people and goods	L-27
	18	Heating innovations should deliver rapid cabin warmth and quick windshield defrosting.	L-28
	19	Heating innovations should include solutions to reduce heating loss.	L-29
	20	Heating innovations are not needed. Drivers should wear warm clothes; it is the most efficient solution in cold climates.	L-30
	21	Heating innovations should include a timer function to preheat the cabin.	L-31
	22	Heating innovations need to be efficient for delivery routes with less frequent stops, where drivers take off their jacket.	L-32, L-33
Sustainability objectives	23	Heating innovations should fit market demands even we have to compromise our sustainability goals	T-11
	24	Heating innovations should help reducing energy consumption	L-35
	25	Heating innovations will be less important than cooling solutions due to global warming.	L-36

6.3.4 Holistic energy control and management

Aggregated Requirements	Req #	Specific Requirements	Origin statement(s)
Collaboration with workers/union s/actors	1	Vehicles need to support a safe and healthy working environment for drivers including exposure to non-exhaust emissions	L-1
	2	Control strategies that change work processes and vehicle behaviour need to be acceptable for workers and unions	L-2, L-6
	3	Logistics actors need to work with 3rd parties and subcontractors to enact telematic and energy management systems on vehicles	L-3
	4	Drivers need support to operate vehicles safely and efficiently	L-4
	5	New innovations need to be acceptable for drivers	T-1
	6	Define expected behaviour from our drivers and make that the easiest choice for drivers	L-5
	7	Implementing control strategies requires collaboration between many actors	T-2
	8	We need strategies to support a safe and healthy working environment for drivers by avoiding polluted areas	L-7

Driving behaviour, data and efficiency	9	It needs to be clear who owns data generated by different parts of the vehicle and how it can be legally used	T-3
	10	It needs to be clear who owns data generated by different parts of the vehicle and how it can be used legally, by whom and to for what (improving components, vehicles, providing maintenance recommendations, etc..)	T-4
	11	Electric vehicles need to be driven efficiently to save energy	L-46
	12	Need feedback from vehicles to drivers that rewards efficient driving behaviour	L-47
	13	Need to implement driving strategies that increase energy efficiency	L-48
	14	Need information on driver behaviour and to measure driving efficiency	L-49
	15	Need for data on driver and vehicle behaviour to evaluate efficiency and potential for improvement	L-53, L-55, L-56, L-57, L-58
	16	Need to support driving styles that reduce tire wear	L-54
	17	Need to manage driver behaviour to reduce maintenance costs	L-59
	18	Need reduced effort to train eco-driving for drivers	L-60, L-61
	19	Vehicles need to avoid repeated hard braking and acceleration to save energy	L-65, L-66
Energy availability and operational range	20	Need own charging infrastructure to keep energy costs low as charging on other chargers is expensive	L-14
	21	Installation of charging infrastructure needs to be easier to plan and carry out in specific sites with more chargers instead of fragmented across many locations	L-15
	22	Vehicle downtime due to charging must be limited	L-16
	23	Need to drive further per charge to reduce fleet size and provide more flexibility for charging times and driver scheduling	L-17
	24	Charging of electric vehicle fleets needs to be organised efficiently through software that communicates between vehicles and chargers and determines optimal strategies	L-18
	25	Charging of electric vehicle fleets needs to be organised efficiently through software that communicates between vehicles and chargers and determines optimal strategies based on planned routes, automatically detecting which vehicle is connected, how much charge it requires and sending out a message when it is ready	L-19, L-20
	26	Vehicles need to start routes with enough range for daily operations	L-21
	27	Need for bi-directional charging strategies to help manage energy, grid pressure and charging across the fleet from vehicles not in use	L-22, L-23
	28	Electric charging infrastructure needs to be expanded	P-2
	29	Need to take advantage of cheap energy compared to fuel	L-24
	30	Need gains to operational efficiency, range is sufficient (150-200km is maximum daily range needed)	L-38
	31	Need range for two days of operation without charging to reduce burden on charging network	L-39
	32	Vehicles need enough range to perform daily tasks/routes without charging	L-40, L-41
	33	Need to use batteries efficiently to not lose time to charging	L-42
	34	Need to focus on electrification over battery range	L-43
Regulatory push	35	We need standards to enable and enforce more scalable improvements to tires	T-21
	36	Parking infrastructure needs to have clear and flexible regulations to adopt new use cases such as bi-directional charging of smaller vehicles	P-6
	37	Need predictable regulatory environment to hasten transition to electric vehicles	L-44

	38	Future regulations around non-exhaust pollution need to be considered and planned for	T-23
	39	We need to comply with regulations like Euro 7	T-24
	40	need to anticipate regulations on both safety and connectivity between vehicles that result from braking data being digitally available	T-25
Safety, compliance and communication	41	Control strategies need to take into account different operational contexts and speeds for safety	L-12, L-13, L-9
	42	Drivers need information on vehicle restrictions communicated to them	L-45
	43	Live data on acceleration and vehicle movements to identify potential accidents or dangerous manoeuvres	L-51
	44	Need clear standardised methods to apply control strategies regardless of OEM	L-52
	45	Control strategies and braking systems should enhance safety for vulnerable road users	T-26
	46	The potential to put restrictions on vehicle behaviour needs to be communicated to and understood clearly by logistic actors	L-62
	47	Vehicle control strategies need to reduce aggressive driving in congested areas	L-63
	48	Vehicles must accelerate safely	L-64
Stakeholder value and business case	49	Incentives for logistics actors to share data with public authorities need to be established	P-1
	50	Businesses need respond to demands from customers for electric transport	L-25
	51	Solutions with small gains to efficiency (such as tires) need to be inexpensive and easy to implement	L-26
	52	The cost/benefit of additional demands (lower emission brakes, tires, etc..) on vehicle tenders need to be considered	P-4
	53	Bi-directional charging needs to show a viable use case and positive cost benefit	L-27, L-28, L-29, L-30, L-31, L-32, L-35
	54	Holistic energy mgmt strategies must be acceptable/attractive to users to implement	P-5
	55	Proven cost/benefit needs to be more highly prioritised than comfort	L-33
	56	Holistic energy mgmt strategies need to lower costs by saving energy	L-34
	57	Tier 1 suppliers need to provide solutions that are attractive for OEMs	T-18
	58	Need to make sustainable attributes related to energy efficiency and environmental impact attractive for customers	T-19
	59	We need to differentiate different products for customers, such as different levels of software control over braking systems	T-22
Sustainability objectives	60	We need to remove brake oil from brake systems to reduce maintenance and lower env. Impact	T-17, T-20
	61	Bi-directional charging should support the use of smaller more sustainable vehicles	P-7
	62	Need to prioritise electrification over non-exhaust particles due to societal focus on C02 emissions	L-67, L-68, L-69, L-70, L-71
	63	Need for a wider awareness of problems to be solved (dust from tires/brakes) to accept restrictions on behaviour	P-8
	64	bi-directional charging needs to make the use of sustainable vehicles more attractive	P-9
	65	Holistic energy management needs to clearly show benefits for customers (efficiency, sustainability)	T-27, T-29
	66	Policy makers need to communicate the safety and sustainability needs of the general public	T-28
	67	New strategies need to improve on the lifecycle analysis of previous versions to lower env. Impact	T-30
	68	Environmental impact needs to be at the core of design	T-31
	69	We need to understand the impact of non-exhaust emissions	T-32

	70	We need to maintain a sustainable image in the market	T-33
Vehicle and component performance	71	Brakes need to adapt and provide safe performance on differing road and climate conditions	T-5
	72	We need brakes that reduce energy consumption allow a reduction in battery size	T-6
	73	Brakes need to reduce drag force on tires to save energy	T-7
	74	We need to control both regenerative braking and adjustment of brake callipers to provide the best performance in different road conditions	T-8
	75	Brakes, suspension and tyres need to be considered more holistically, and brake oil removed	T-9
	76	We need to increase the longevity of our tire	T-10
	77	OEMs need to understand how new components impact performance	T-11
	78	Bi-directional charging needs to charge multiple bicycle batteries onboard the van	L-8
	79	Control mgmt strategies need to increase hours/km driven per charge	L-10
	80	Tires need to support the overall performance of the vehicle considering chassis stiffness, rolling resistance, etc..	T-12, T-13
	81	More energy needs to be saved by regenerative braking	T-14
	82	The life of the brake pads should be increased and particle emissions reduced	T-15
	83	Vehicles need to accelerate in a way that consumes less energy and causes less tire wear	L-11
	84	We need brakes that improve energy efficiency and reduce emissions	T-16

6.3.5 Swap box

Aggregated Requirement	Req #	Specific Requirements	Origin statement(s)
Balancing size variability with standardisation	1	Swap boxes dimension and size should be adaptable (e.g. to adapt to different vehicle heights).	L-109, L-124, L-132, L-154, L-20, L-50, L-98
	2	Different containers of different sizes are required to adapt to different activities and to different levels of sorting.	L-151, L-34
	3	Swap boxes should be standardised: one type used by everyone (e.g. across the B2B network).	L-160, L-42, L-51
	4	Vehicles should be standardised so that swap boxes can be adapted and standardised accordingly.	L-43, L-68
	5	We need to choose our own standard before one will be imposed by the international market.	L-86
	6	Container providers need to work together instead of competing to find a common standard.	L-92
	7	Swap boxes need to be standardized and functional rather than high-tech containers.	L-104
	8	Standardisation of containers should be pushed by the public sector.	L-108
	9	Swap boxes should account for special goods that do not fit in containers (e.g. a TV).	L-112
	10	Swap boxes should fit our vehicles instead of being expandable/foldable.	L-122
	11	Swap boxes should be between one palette and half palette size.	L-144
	12	Swap boxes should be able to be used for the entire delivery process including last mile and all types of deliveries (e.g. 1 piece for home delivery or deliveries of tens/hundreds at same address).	L-149

	13	Swap boxes should be able to be used for the entire delivery process including last mile and all types of deliveries (e.g. 1 piece for home delivery or deliveries to businesses).	L-155
	14	Swap boxes should be custom-made to fit our customized operations rather than standardized and unfitting to existing operations.	L-166
	15	Swap boxes should be adopted at fleet level until a wider standard is adopted.	T-13
	16	Stakeholders need to collaborate (e.g. at the European level) and agree on one swap box standard used by the whole sector.	L-11, L-130, L-14
Business viability	17	The implementation of Swap boxes together with micro-hubs must ensure that operations remain viable.	L-2
	18	Swap boxes need to improve efficiency to justify investing time in developing new processes.	L-25, L-38
	19	We need to anticipate whether swap boxes will be profitable in delivery volume goal without needing extra handling processes.	L-40
	20	Tracking costs should not erode the profitability of the swap boxes.	L-49
	21	Swap boxes investment should be profitable.	L-52
	22	We need swap boxes to be durable if the investment is high.	L-127, L-95
	23	We need to reduce insurance claim due to damaged goods.	L-153
	24	We need swap boxes to adapt our operations to fluctuating customer's demand.	T-5
	25	We need swap boxes systems to adapt to changes in the market.	T-7
Compatibility with vehicles, equipment, and existing processes	26	Swap boxes need to be compatible with different vehicle types (e.g. with shelves) and sizes, swapped at microhubs and enable on-route loading to fill in capacity in other vehicles	L-1
	27	All innovations should fit together (swap boxes, cold body, microhub) to support consistent flow of goods in the city centre	P-1
	28	Swap boxes need to be compatible with different vehicle types (e.g. with shelves) and sizes.	L-12, L-136, L-47, L-59, L-75, L-94, T-3
	29	Swap boxes should fit current logistics operations, current routines, current sorting, loading and transshipment processes.	L-165, L-195, L-39, L-80, T-2
	30	Swap boxes must comply with local regulations regarding bicycle dimensions.	P-13, P-14
	31	Swap boxes should fit in nano hubs.	P-15, P-16
	32	Vehicles should be adapted to swap boxes.	T-1
	33	Swap boxes should be compatible with the warehouse setup.	L-69
	34	Swap boxes should be compatible with existing systems (e.g. labelling systems, handling systems, automated systems).	L-105, L-110, L-77
	35	Swap boxes should be compatible with our customers' vehicles.	L-142, L-88
	36	Swap boxes should be compatible with current package and existing containers (e.g. pallets).	L-111, L-113
	37	Swap boxes should be compatible with current package and existing containers (e.g. pallets) as well as cargo bike bag-based standards and bridge these formats for smooth parcel delivery.	L-118
	38	we need the solution to mechanize route preparation while keeping flexible vehicle and trolley designs to optimize sorting without using pallet	L-187
Coordinated governance and collaboration	39	We need to access area/space in cities to carry out logistics operations, but this is a problem today.	L-10
	40	Logistics actors need hub locations that are shared with other logistics actors.	L-32, L-35
	41	We need to know the price of hub locations.	L-33, L-41

	42	To support the use of swap boxes, locations and infrastructure are needed.	L-36, L-79
	43	We need to collaborate with private landowners to locate the hubs.	P-2, P-7
	44	Public authorities' role is to coordinate all the different stakeholders around the hubs.	P-3
	45	Public authorities' role is to support logistics companies in adopting innovations.	P-4, P-8
	46	Hubs should be actor neutral so that they can be used by different companies.	P-5, P-6
	47	Public authorities need to support transshipment between vans and bikes.	P-10, P-9
	48	New logistics processes are needed to integrate the use, circulation and tracking of the swap boxes between stakeholders.	L-44, L-46, L-48
	49	Containerisation should be implemented at the group level (firm level), including also carriers operating for the different branches.	L-145
Goods security and safe operations	50	Containerization can help to prevent damage and loss when handling goods or loading and unloading.	L-22, L-28, L-3, L-4
	51	We need to ensure that hubs are secured from theft and vandalism.	P-11, P-12
	52	Swap boxes should ensure secured goods storage and go along secured hubs.	L-67, L-99, T-12
	53	Containerization needs to go along safe handling of goods and safe transshipment.	L-89
	54	Swap boxes could lead to safer operations around other road users.	L-119
	55	Swap boxes need to be safe, sturdy and cost-effective.	L-133
	56	We need measures against loss and damage of cold goods during delivery.	L-190
Knowledge, training, and phased implementation	57	We need knowledge on best practices and potential benefits from containerization before implementing it.	L-31, L-7
	58	We need a solution for containerization.	L-8
	59	Swap boxes require to adapt routines, processes (e.g. handling), infrastructure, and warehouse layout to achieve efficient use.	L-129, L-172, L-56, L-66
	60	Implementation of containerization will happen step by step, starting from small containers.	L-57, L-74
	61	Training and initial procurement guidance are needed to use swap boxes.	L-115
	62	Loading and delivery personnel should be aligned in how they work with the swap box.	L-164
	63	To implement containerization, information is needed about swap boxes dimensions, weight limits and storage compatibility.	L-183
Operational Efficiency in space, flow, and delivery	64	Swap boxes should help loading and unloading efficiently and quickly.	L-131, L-152, L-19, L-5, L-53, L-90
	65	We need a solution to manage our empty containers and potentially also those from our customers.	L-175, L-6
	66	Sorting and placing parcels on the shelves should be calculated automatically for safer loading and better accessibility during delivery.	L-17, L-174, L-179, L-29
	67	A suitable swap box would contribute to a more streamlined sorting process.	L-18
	68	For containerisation, sorting should be done at route level.	L-24
	69	Solutions that optimize parcel sorting and placement, in coordination with route planning, are needed.	L-55, L-73
	70	We need to find a compromise between saving space on one side and sorting and containerization on the other side.	L-58, L-81
	71	Sorting should not be done once more at the local store.	L-60

	72	Containerisation help avoiding sorting goods during the delivery trip.	L-61
	73	Swap boxes need to be preloaded and placed on the cargo-bikes routes to enable riders to avoid driving back several times to the depot/hub.	L-62, L-64
	74	Swap boxes should go along a system that optimizes delivery routes based on the sorting.	L-168, L-63, L-70
	75	Loading solutions should ensure maximum utilization of the vehicles loading capacity.	L-65
	76	Swap box should relieve the driver from loading duty to focus on delivering.	L-71, L-93
	77	Swap boxes must ensure exchangeability	L-83
	78	Swap boxes should allow maximum utilization of the capacity of vehicles.	L-100, L-117, L-137, L-170
	79	Empty swap boxes should be filled in or foldable.	L-116
	80	Swap boxes should have wheels for easier transshipment.	L-135
	81	Swap boxes should be nestable.	L-141
	82	Swap boxes should be stackable to save space in our warehouse.	L-146
	83	We need to use maximum capacity to use the fewest vehicles possible, especially with lighter and smaller vehicles.	L-150, L-159
	84	Swap boxes should help reload the vehicles along their delivery route, when they are empty.	L-158
	85	Containers should be placed in the vehicle according to weight to have better stability.	L-169
	86	Loading should be streamlined to enable containerization.	L-171
	87	Sorting should be automated to save time.	L-180, L-191
	88	Experts in routing should finetune the routes issued by the system.	L-181
	89	We need to maintain the use of trolleys (not pallets) to comply with lifting legislation and preserve flexibility, while introducing mechanization in route preparation to pre-sort goods by consumer type and reduce searching during delivery.	L-182
	90	Swap boxes should make transshipment between large and small vehicles quicker and more efficient.	T-14, T-6, T-9
	91	For containerization to be interesting, we need swap boxes to help logistics operator save time.	T-10
	92	The driver and the loader should both check the content of the swap box.	L-185
	93	We need good quality solution that prove to be interesting to use.	L-186
	94	Human validation of the sorting is needed.	L-188
	95	Routes should be predetermined and drivers allowed to do only some minor changes (fixed routes).	L-193
	96	We need preplanned routes and an order of parcels, to give time notification for parcel delivery.	L-194
Sustainability	97	We need swap boxes to reduce the number of logistics vehicles in city centres.	P-19
	98	Swap boxes should be in textile rather than plastics.	L-125
	99	Swap boxes' materials should be sustainable.	L-126
Tracking and identifying parcels	100	Identifying/Locating parcels should be quick and easy.	L-13, L-16, L-176
	101	Our drivers should be able to locate packages easily within their vehicles.	L-23, T-11
	102	We need smart solutions for the drivers to place parcels in an efficient way and to track them.	L-30, L-45
	103	With containerization, we need a system to know accurately the content of each container.	L-78
	104	We need the solution to integrate parcel scanning with box sensors to ensure accountability only for scanned items	L-84

	105	A solution is needed to scan and track the parcels in the containers.	L-143, L-162
	106	We need to use barcodes to scan and know the content of each palette or swap box.	L-189
	107	We only need RFID in a couple of facilities.	L-192
Worker safety, ergonomics and acceptance	108	Swap boxes should have wheels (easier and safer to manoeuvre).	L-114, L-21
	109	We need to have an alternative to manual handling of swap boxes.	L-27
	110	Swap boxes should still allow drivers to sort parcels as they prefer.	L-103, L-96, L-97
	111	Swap boxes should be easy to use effectively for drivers and workers.	L-101
	112	Swap boxes should be accessible from three sides of the vehicle for better ergonomics and acceptance from drivers.	L-102
	113	Swap boxes should ease drivers' workload.	L-106
	114	Swap boxes should be robust and stable but not weight too much.	L-120, L-121, L-157
	115	Swap boxes change processes should be managed to support drivers and handlers.	L-138
	116	Swap boxes should be accepted by workers.	L-139
	117	We need to keep a human interaction with our customers.	L-177
	118	Swap boxes should be ergonomical and attractive for drivers to improve the conditions and reduce the time used for sorting and loading goods.	L-184, T-8

6.3.6 Geofencing

Aggregated Requirement	Req#	Specific Requirements	Origin statement(s)
Access to city centres and operational conditions	1	Access restrictions should consider size, speed and capacity used of vehicles instead of just vehicle class	T-1
	2	Geofence access should enable more direct, efficient routes	L-8, L-9
	3	Geofence access should enable more direct, efficient routes that reduce the number of vehicles needed to reach different parts of the city	L-10
	4	Geofence restrictions need to consider time windows for both deliveries and returns	L-11
	5	Geofence restrictions needs to still allow access for goods flows and emergency vehicles	L-12
	6	Geofencing needs to support digital communication with infrastructure such as gates or bollards to provide access	L-38
	7	Geofencing should allow exemptions to existing access restrictions in exchange for enabling restrictions on vehicle movements	L-47
	8	Geofencing should provide operational advantages for companies that implement	L-52, L-53
	9	Geofencing access windows need to reduce the number of employees/drivers/vehicles to serve a delivery area	L-83
	10	Geofencing needs to support locations to carry out mobile pick up points through reserving space or allowing access	L-89
	11	Companies need to be prepared for future changes in regulation affecting space availability and parking	L-93
	12	Companies need to communicate with municipal planning departments to express their need to use areas for logistics activities	L-95
	13	Logistics actors need to respond to regulations by using vehicles that maintain access	L-102, L-124
	14	Reservation of zones for pick up points needs to occur at fixed times for reliability for customers	L-105

	15	We need to manage limited parking areas efficiently	P-122
	16	Restrictions to access need to be implemented considering the existence of viable alternatives	L-106, L-107, L-108
Actor coordination and institutional readiness	17	Cities need to set up incentives for data sharing between fleet owners	T-3
	18	Cities need tools to regulate public space to encourage desired types of uses	T-8
	19	Dynamic regulation needs to be coordinated with multiple actors such as road owners, the business council, stores and other goods receivers	P-7
	20	Dynamic regulation needs to be implemented gradually, predictably and with consideration of political contexts	P-13
	21	Dynamic regulation needs to consider country specific regulatory contexts and frameworks to be implemented	T-11, T-9
	22	Dynamic regulation requires cooperation between multiple departments within public authorities	P-20, P-25
	23	Dynamic regulations needs collaboration between logistics actors and municipalities to develop tools to better understand what is happening at the local level	L-7
	24	Geofencing implementation needs support mechanisms for companies that have not used geofencing to promote a smoother integration	T-19
	25	Geofencing needs a clear plan to be communicated by the municipality to logistic actors	L-15
	26	Geofencing needs a mature ecosystem of actors capable of sharing data and reacting to dynamic regulations	L-16, L-17, P-30, P-31, P-32, P-33, P-34, P-35, P-36, P-37, P-38, T-26
	27	Geofencing needs good relationships between municipalities and business partners to enable pilots (especially in the absence of a regulatory framework)	P-48
	28	Geofencing needs to be implemented by the city with a platform that other actors can connect digital tools to optimize parking	L-72
	29	Geofencing restrictions/use cases should be implemented gradually	T-28
	30	Implementing geofencing restrictions needs to consider adoption rates/availability of necessary technologies to comply	L-73, L-74, L-75, L-76, L-77
	31	Implementing geofencing and dynamic regulation requires clear rules and regulations	T-29, T-31
	32	Implementing geofencing requires interaction with actors in the public and private sector at multiple levels (local, national)	T-39
	33	Logistics actors need open dialogues with municipal planning departments on areas that need to be used for logistics activities	L-94
	34	Logistics companies need to reach a minimum level of digitisation to implement geofencing	L-98
	35	Need to communicate access rules to logistics actors to support better planning	P-99
	36	Pilots need to take advantage of already established cooperative agreements by supporting similar goals	P-102
	37	Strategies needed to build cultural acceptance to restrictions placed on their vehicles	T-50
Digital infrastructure, Interoperability and Data Governance	38	Cities need to coordinate with each other and standardize registration systems for low emission zones and loading zone booking	L-1, L-2
	39	Data exchange protocols to implement geofencing between, OEMs, operators need to be established (OCPP, MQTT, GBFS, etc..)	L-3
	40	Data exchange protocols to implement geofencing between, OEMs, operators need to be established (OCPP, MQTT, GBFS, etc..)	L-4

41	Data sharing routines need to consider GDPR, tailoring the collecting of data on deliveries and vehicle movements to avoid sensitive data	P-9, T-15, T-23, T-4
42	Data standards /protocols across cities and countries for geofencing need to be developed	L-5, L-6
43	Data standards need to be developed in collaboration with OEMS	T-5
44	Dynamic regulation needs to be simple for the municipality to implement- for example by drawing on a map	P-8
45	Dynamic regulation needs to collect and use data that is GDPR compliant. For example, a geofence crossing can be registered without tracking a vehicle's route.	P-10, P-11
46	Dynamic regulation of geofencing needs to be tested iteratively before large scale pilots	T-10
47	Dynamic regulation should take advantage of real time data collection requirements resulting from EU directives	P-21
48	Fleet systems need to exchange correctly formatted standardised data with the geofencing mgmt platform	T-13
49	Geofence boundaries need to be based on high quality, reliable data	P-26
50	Geofencing needs an IT infrastructure to be implemented	T-20
51	Geofencing needs OEMs to support data sharing from vehicles	T-21
52	Geofencing needs to be integrated end-to-end from customer to delivery considering dynamic restrictions	L-22
53	Geofencing needs to connect to and support understanding of vehicle movements through fleet mgmt systems	L-27
54	Geofencing needs to support data gathering of vehicle movements	L-37
55	Geofencing should provide digital information on changing access regulations to logistics operators	L-51
56	Geofencing should support better use of telematic data	L-56
57	Geofencing should provide information on vehicle movements by providing timestamps on when vehicles enter specific areas	L-57
58	Geofencing solutions need to alleviate concerns about data sharing and tracking	T-27
59	Geofencing systems that support loading zones should be automated to eliminate individual manual registrations by drivers	L-64, L-65
60	Geofencing systems that support loading zones should be integrated between companies, cities and route planning software	L-66
61	ICT solutions need to be developed to implement access restrictions	P-49
62	Implementing speed limits through geofencing requires an exchange between municipalities and logistics actors	P-51
63	Municipalities need a platform to communicate geofencing rules to operators	P-53
64	Need automatic, flexible interactions for digital reservation of loading zones and access to low emission zones	L-84, L-85
65	Need clear data sharing agreements that allow implementation while limiting information on vehicle movements to remain GDPR compliant	L-87, P-75
66	Need data sharing between companies and municipalities that brings value to both	P-65
67	Need for more digital data on driving behaviour on route to improve planning	L-88
68	Geofencing needs well defined data standards to be implemented	T-32
69	Need open APIs to enable data sharing between actors and enable efficient deliveries	T-35
70	Geofencing needs position data and vehicle status (in/out of service)	T-36, T-37

	71	Need solutions that work with signage regulations through physical communication or V2I (vehicle to infrastructure) to lower bollards	T-38
	72	Need solutions to integrate horizontally between IT systems of different logistics actors	P-72
	73	Need to improve digital tools that support connectivity at the fleet level	T-41
	74	Need to provide real time data on booking parking and loading zones to drivers	L-97
	75	Need to work with Open Mobility Foundation (and other organisations) to develop future standards	T-45
	76	Registration for loading zones need to be quick and easy for drivers to use	L-103
	77	TMS (Transportation mgmt systems) need to be integrated with database of parking zones	L-118, L-119
	78	We need a platform to communicate geofencing rules to operators	P-111
	79	Geofencing needs to support providing information on safe, efficient driving to drivers	L-21, L-23, L-40
Knowledge and information needs	80	Geofencing for use cases such as curb side management need to collect better data on parking spots (purpose, location, size)	P-5
	81	Municipalities need a better understanding of freight movements	P-52
	82	Need a clear understanding of data exchange and routines around implementing dynamic regulation	P-57
	83	Need better understanding of freight operations and the possible gains of dynamic regulation	P-59, P-60, P-61, P-62, P-63
	84	Need data on freight activity to support the best use of vehicle capacity in public space	T-30
	85	Municipalities need information on freight vehicle movements, what they contain and emissions data	P-64
	86	Need knowledge on when/where/how to implement zones safely and in a way that is acceptable for users	T-34
	87	Need to know data available, who owns them, how to collect them, and what is needed to implement dynamic regulation	P-73, P-80, P-81
	88	Need to collect data that can show the impacts of geofencing	T-40
	89	Need to learn from existing use cases from other transport sectors	P-82
	90	Need to understand freight vehicle movements to measure effect	P-87, P-88
	91	Need to understand how drivers will perceive vehicles being restricted	P-89
	92	Need to understand potential behind new innovations	L-100
	93	Need to understand the impact on logistic activity and traffic when changing speed limits	P-94
	94	Need to understand which regulatory bodies they need to interact with to discuss geofencing	L-101
	95	Technical requirements for municipalities need to be communicated clearly to implement dynamic regulation	P-103
	96	We need to know more about freight movements and an overview of subcontractors for logistics actors	P-119
Monitoring, enforcement and fairness	97	Digital regulations need to communicate through physical infrastructure	P-6, T-6
	98	Geofencing needs to be supported by enforcing mechanisms to differentiate between participants using it and not	L-25
	99	Geofencing restrictions need to be equally and fairly applied to road users in a predictable way	L-44, P-44
	100	Geofencing/reserved parking needs to be supported by enforcement mechanisms (physical presence, camera, sensors)	L-69

	101	Geofencing/reserved parking needs to be supported by enforcement mechanisms (physical presence, camera, sensors) fairly on all relevant actors	L-70, L-71
	102	It must be possible to differentiate and enforce rules between geofenced and non-geofenced vehicles	L-78, L-79, L-80
	103	Municipalities need enforcement mechanisms for digital access regulations	P-54
	104	Need for enforcement mechanisms for dynamic regulation of loading and unloading zones/parking spaces	P-67, P-68
	105	Need for enforcement mechanisms for dynamic regulation that distinguish between private vehicles and commercial vehicles	P-69
	106	Need live data on loading zone occupancy to support enforcement	P-70, P-71
	107	Need to reflect digital regulations in the real world through signage to inform non-connected vehicles	P-84, P-85
	108	Regulation of loading/unloading zones needs clarity in terms of enforcement jurisdiction combined with strategies to implement (frequent controls at the start of implementation)	P-100
	109	We need enforcement mechanisms for dynamic regulation beyond physical presence of police/parking guards	P-112, P-113, P-114
	110	We need low-cost enforcement mechanisms for dynamic regulation	P-115, P-116, P-117
Regulatory frameworks and adaptive governance	111	As a public authority we need effective ways to regulate and enforce parking zones for deliveries that differ from existing delivery norms and rules	P-1
	112	As a technology provider we need to challenge existing static rules and regulations on vehicle access	T-2
	113	As the municipality we need to be able to implement exceptions to national level regulation when needed	P-3
	114	Changing regulations needs to be gradual and predictable with well-defined steps that takes into account political considerations	P-4
	115	Dynamic regulation through dynamic signs needs to consider changing environmental conditions	P-12
	116	Geofencing needs to be connected to access regulations for different types of vehicles to allow exceptions	L-19, L-20, P-14
	117	Geofencing implementation needs a regulatory environment flexible enough to account for dynamic changes to regulation	T-16, T-17
	118	Geofence implementation needs adoption of standards that fulfil legal obligations while being acceptable to society	T-18
	119	Geofencing needs to be supported by systems from public authorities	L-26
	120	Geofencing use cases need to be supported by regulation	L-67
	121	Implementation of new standards needs to be predictable and consider turnover rate for logistics fleets	P-50
	122	Need to tailor operations and vehicle choice to the regulatory context of the city	L-82
	123	Need a regulatory framework before implementing dynamic regulations	P-58
	124	Need knowledge about the possibility space for regulating commercial transport dynamically with geofencing, i.e. how much can be demanded from restrictions or data sharing	T-33
	125	Need to adapt to local contexts and regulations	L-92
	126	Need to develop regulations that anticipate future needs and implement confidently	P-77
	127	Need to understand regulatory possibilities at the local, regional and national levels	P-90, P-91, P-92, P-93
	128	Need to work with political constraints, avoiding politically sensitive topics such as increasing tolls	P-96, P-97
	129	Regulations need to be flexible enough to adopt new use cases for dynamic parking	L-104
	130	Regulations need to be predictable for businesses so they can adapt their business models	P-101

	131	Need to build acceptance for geofencing vehicles and open for connecting regulations to speed	L-111
	132	The piloting process and granting exceptions to regulations needs to be more streamlined	T-46
	133	Geofence regulations need to be designed considering political restraints on sensitive issues such as tolls	P-123
	134	Geofencing restrictions on speed with greater access times would mean changes in route structures that need to be discussed with the municipality and is more about regulation than technical implementation	L-128
	135	There needs to be a regulatory context that supports the implementation of dynamic regulations	L-115, L-116, L-117
Safety, efficiency and security	136	Geofencing needs to avoid dramatic restrictions on driving style and drivers must be able to override restrictions	L-18
	137	Geofencing should support desired behaviours from drivers	L-24
	138	Geofencing should support safe and energy efficient operations	L-28
	139	Geofencing needs to help optimise delivery routes to reduce emissions	L-29
	140	Vehicles need to drive efficiently and as far as possible on a single charge to reduce costs	L-39
	141	Geofencing needs to be implemented with security measures to prevent sudden changes both for safety and to avoid sudden challenges for businesses	T-24
	142	Geofencing needs to work with telematics to ensure vehicles are properly secured (handbrake engaged)	L-42
	143	Geofencing needs to be safe and accurately and reliably communicate the bounds of the geofence to vehicles	L-45, L-46
	144	Geofencing needs to consider any potential drawbacks of implementing speed restrictions	L-48
	145	Geofencing needs to consider potential unsafe situations due to speed differentials	P-45
	146	Geofencing restrictions need to consider the safety and needs of the driver in situations when more speed is needed for safety reasons	L-49, L-50
	147	Geofencing should allow restriction of movements in certain areas or times where they cause problems	L-58, L-59
	148	Geofencing should allow restrictions on speeds in specific, high-risk areas to increase safety and reduce non-exhaust emissions	L-61, L-90
	149	Geofencing slow zones can reduce terror threats from large vehicles	L-96
	150	The driver needs to be able to override geofence restrictions when necessary	P-79, T-42
	151	vehicles must have safety mechanisms to avoid dramatic braking or acceleration in case a geofence isn't registered correctly	T-44
	152	Vehicles need to be able to accurately measure their location and respond safely to instructions	P-104, P-86
	153	Speed restrictions in exchange for access needs to be experienced as a positive trade-off for drivers	L-112
Stakeholder value and business case	154	Dynamic regulation can be a tool to support the implementation of digital traffic circulation plans	P-2
	155	Dynamic regulation needs to show clear benefits for companies accepting restrictions	T-7
	156	Dynamic regulation needs to support larger societal goals	P-15, P-16
	157	Dynamic regulation needs to support use cases that reduce the amount of space needed for logistics vehicles in cities	P-17
	158	Dynamic regulation solutions need to be interesting for LSPs to test/implement	P-18, P-22
	159	Dynamic regulations must not reduce access to sidewalks for pedestrians	P-23

160	Dynamic regulations need to address specific problems with a high political profile	P-24
161	Geofencing and dynamic regulation should reduce work burden for municipalities and employees	T-12
162	Geofencing and restrictions need to consider different use cases and contexts (social, safety, security, efficiency, environmental)	P-27, P-28
163	Geofencing capability needs demand from customers and regulatory bodies	T-14
164	Geofencing implementation needs to provide clear benefits for drivers	L-13, L-14
165	Geofencing needs to ensure continued flow of goods when implementing new logistics solutions	P-29, P-39
166	Geofencing needs to find mutually beneficial use cases to build acceptance/progress	P-40, T-22
167	Geofencing needs to help reduce fines for drivers	L-30
168	Geofencing needs to offer LSPs clear gains and not just a tool for more regulation	L-31
169	Geofencing needs to offer LSPs clear gains by providing access in exchange for restrictions	L-32, L-33
170	Geofencing needs to offer LSPs clear gains to operational performance by providing access in exchange for restrictions on vehicle speed/behaviour	L-34, L-35
171	Geofencing needs to provide data showing improvements in traffic conditions	P-41
172	Geofencing needs to show it is effective in producing desired driver behaviours (e.g. Maintaining speed limits)	P-42
173	Geofencing needs to show use cases that make it attractive to adopt	L-36
174	Geofencing needs to support cities in managing capacity better- enable transport not traffic	P-43, P-46
175	Geofencing should make parking and deliveries less stressful for drivers by enabling access to delivery areas	L-54
176	Geofencing should provide operational advantages for companies that implement it	L-55
177	Geofencing should reduce person hours needed for the municipality to manage logistics	P-47
178	Geofencing should reduce the need for physical signs and offer more flexible regulations	L-62
179	Geofencing systems should reduce effort for companies to register access for low emission zones and parking through standardized systems and/or apps	L-63, L-68
180	Geofencing to be seen as possible to implement with clear gains in order to supersede other existing priorities for cities	L-81
181	Geofencing/dynamic regulation should support reaching municipal goals for transport	P-55
182	It needs to be clear what the goal of geofencing is and what problem it addresses	P-56
183	Municipalities need to see value, such as data, in exchange for giving companies access	P-66, P-74
184	Need evidence of positive impacts/use cases for geofencing to drive regulation	P-76
185	Need to see a specific value and incentive in implementing geofencing	L-99, P-78
186	Need to communicate dynamic (digital) regulations in physical space	P-83
187	Need to look at existing geofencing use cases for shared scooters and apply them to larger vehicles	T-43
188	Need to show a positive impact for citizens	P-98
189	The cost benefit of accepting fines in exchange for access needs to be considered	L-113
190	Users need to see value in accepting restrictions on vehicle movements	P-106

	191	We need new business models that support sharing data and take advantage of available capacity in vehicles	P-118
	192	We need to consider the accuracy of geofencing and the costs of retrofitting fleets to be able to accept and respond to geofencing	L-125
	193	We need vehicles to follow speed limits in pedestrian areas	P-120
	194	Without a regulatory framework forcing adoption, dynamic regulation needs to show a benefit for companies participating	P-121
Vehicle compliance, connectivity and fleet readiness	195	Geofencing pilots need to begin with vehicles that can already receive and act on instructions	P-19
	196	Geofencing needs vehicles to be connected to a fleet management system	T-25
	197	Geofencing requires IoT to be connected to the vehicle's CAN Bus (Controller Area Network)	L-43
	198	Need relevant use cases to implement geofencing with existing use of telematics	L-114
	199	Need to consider age and different technical capabilities in vehicle fleets	P-105
	200	Need to have focus on newer vehicles able to be geofenced as ecosystem matures with the introduction of new vehicles	P-107
	201	Need to support connectivity features in new cars (or retrofit old ones) to support long term results	P-108, P-109
	202	The geofence must be reliably implemented to ensure no downtime	L-120
	203	Vehicles need to use IoT systems capable of V2I to gain access to centres by lower gates/bollards	L-121
	204	Vehicles need to be able to receive and implement geofencing rules	L-122, P-110, T-47
	205	Vehicles need to be easily retrofit to work with geofencing	L-123

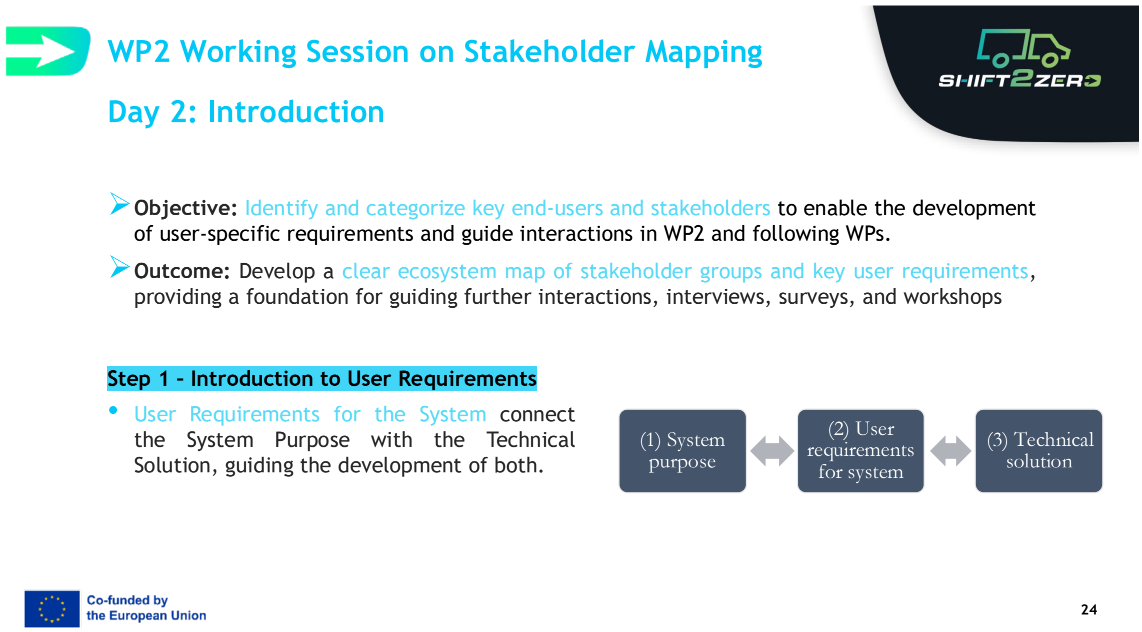
6.3.7 Dynamic space use

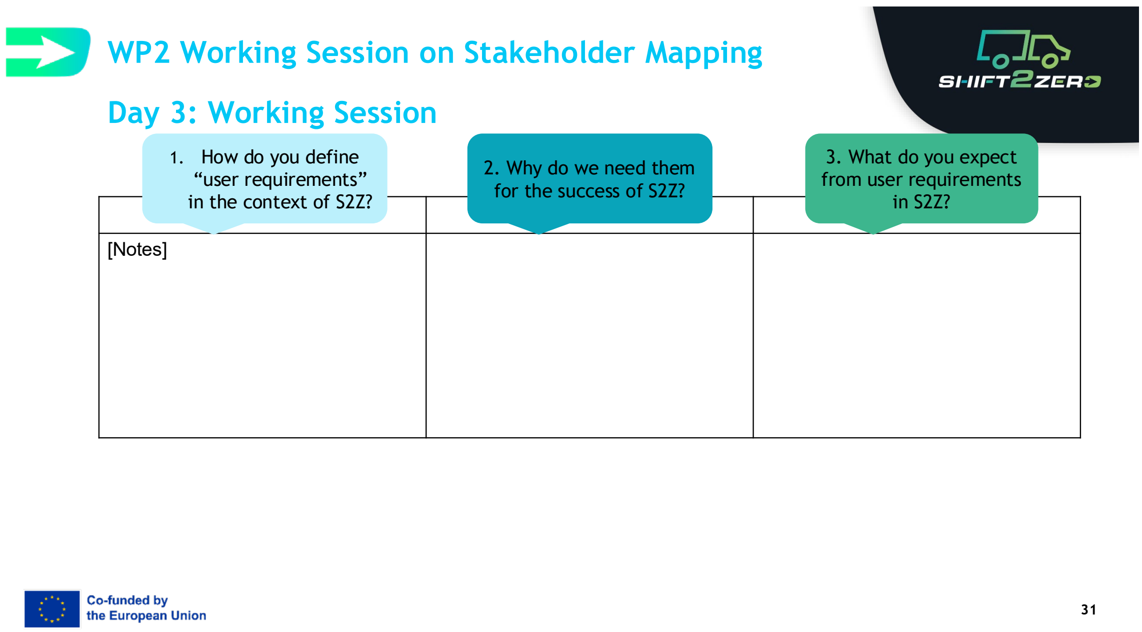
Aggregated Requirement	Req#	Specific requirements	Origin statement(s)
Attractiveness and Flexibility	1	Dynamic solutions must be flexible in terms of the rear of the vehicle	T-1
	2	Dynamic solutions require customized configurations	T-2
	3	Dynamic solutions should build on existing vehicle platforms	L-9, T-3
	4	Dynamic solutions must offer legal and flexible solutions that customers are willing to pay for	T-4
	5	Dynamic spaces must not hinder the regular operation of transport services	P-1
	6	Dynamic solutions need to maintain a balance between attractiveness for all types of customers and flexibility of space	L-1, L-2, L-3, L-4, L-7, L-8
	7	Dynamic solutions need to be easy to clean	L-5
	8	Dynamic solutions need to have flat regular surfaces for the cargo zone	L-6
	9	Dynamic solutions must be large enough to accommodate large cargo	L-10, L-11
	10	Dynamic solutions must meet the demands of seasonal variations in customer demand	L-12
Contextual value and niche market	11	Dynamic solutions must be applied in areas where there is a gap in other transport services	P-2
	12	Dynamic solutions must be implemented in appropriate markets	T-5
	13	Dynamic solutions must be adapted to the type of transport service at hand	L-13, L-15, L-16
	14	The Innovation must show its advantage over existing solutions and practices that are already in use with seats that can be put up and down	L-14

Regulatory compliance	15	Dynamic solutions must account for the different regulatory requirements for commercial and private vehicles	L-17, P-3, P-4, T-7, T-8
	16	Dynamic solutions need updating regulations so that they are clear and apply to the transport activity at hand	
	17	Dynamic solutions should build on vehicles that are already compliant with regulations	T-6
	18	Dynamic solutions must comply with regulations	T-9
Safety and resilience	19	Dynamic solutions must not hinder driver control in ways that are unsafe	L-18
	20	Dynamic solutions need to have a robust and safe design for passengers and goods	L-19, L-20, L-21, L-22, L-23, L-24
Dynamic space and actor coordination system design	21	We need vehicle owners to provide the vehicles on our platform	L-25, L-26, L-30
	22	Dynamic solutions require that the drivers properly maintain the vehicle	L-27, L-28, L-29
Technical and operational feasibility	23	Dynamic solutions must be technically viable solutions that can fit to different customers' needs and preferences	T-10
	24	Dynamic solutions must be technically viable and compliant with regulations	T-11
	25	Dynamic solutions may require a special facility and skills to carry out the changes	L-32, P-5
	26	We need vehicles that can cover the wider range of operation beyond the city	L-31

6.4 Annex 4 Stakeholder mapping workshop materials

The following are the slides containing the prompts for the stakeholder mapping workshop (held in 2 sessions).





WP2 Working Session on Stakeholder Mapping

Day 3: Working Session

Step 2 - Group Discussion User Requirements & Stakeholder Groups (20 min.)

- **Objective:** Begin identifying general stakeholder groups that will be relevant for S2Z.
- **Task:** Focus on categorizing stakeholders in broad terms, thinking about the main sectors and types of users, partners, and institutions that might be involved.
- **Facilitator** will write down the contributions on the flipchart / whiteboard for the group and clarifies any questions.

Cities	OEMs	LSPs	(more)

To be filled out by facilitator on flip chart

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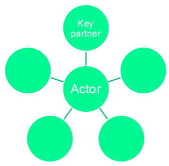
WP2 Working Session on Stakeholder Mapping

Day 3: Working Session

Step 3 - Identify Specific Relevant Stakeholders (10 min.)

- **Objective:** Define a list of specific stakeholders for the S2Z activities and the S2Z solutions that are most relevant to them.
- **Task:** Each participant writes down specific stakeholders that are important to their S2Z activities, considering potential S2Z solutions.
- **Participants** write contributions on paper.



To be filled out by participants

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6.5 Annex 5 Preliminary list of KPIs

During the interviews, participants were also asked about relevant KPIs for their operations. During analysis, these were coded and extracted into a preliminary list intended to support tasks 5.1 and 7.1 which look at developing an impact assessment framework and data requirements for specific KPIs.

KPIs Category	Specific KPI	Comment
Cost	Cost/hour	
	Cost/delivery	
	Cost/shift	
	cost/route	
	Total cost of new solution vs old solution	
	Driver share of cost	
	Energy/fuel cost	
	Revenue to cost (ratio)	
	TCO	
	Depreciation rate (of vehicles)	
	Battery cost	
Efficiency and operations	Deliveries/shift	
	Number of deliveries/hour	
	Number of stops/hour	
	Space occupied/time	
	Vehicle range	
	Fill rate (volume)	
	Number of people needed to enact transhipment of swap box	Swap Box specific
	Km driven	
	km/time period (day, week)	
	Hours in operation (vehicle) (utilisation rate)	
	delivery weight	
	Density of stops in delivery area	
	Route length	
	Vehicle loading time	
	Stem time	
	Share of frozen, vs refrigerated vs dry goods	Cold chain specific
	time/energy to defog window	
	Loading capacity/vehicle type	
	Heat loss per stop/opening of vehicle	Cold chain specific
	Energy needed for cooling	Cold chain specific
	Basic capacity - minimum vehicles always in use	
	Flexible capacity - vehicles that can be shifted	
	Battery weight	
	Battery energy density	
	Longevity of tires under use (km before change out)	
Environmental	Energy usage	
	Km driven/energy used/battery charge	
	Scope 1 emissions	

	Scope 2 emissions Electrification rate of fleet/fleet composition number of zero emissions deliveries (of total) Zero emission targets	
Behaviour and safety	G-force while driving Speed Location	
Quality/reliability	On-time Time per customer delays to delivery Temperature Humidity/condensation Product damage rate	 Cold chain specific Cold chain specific