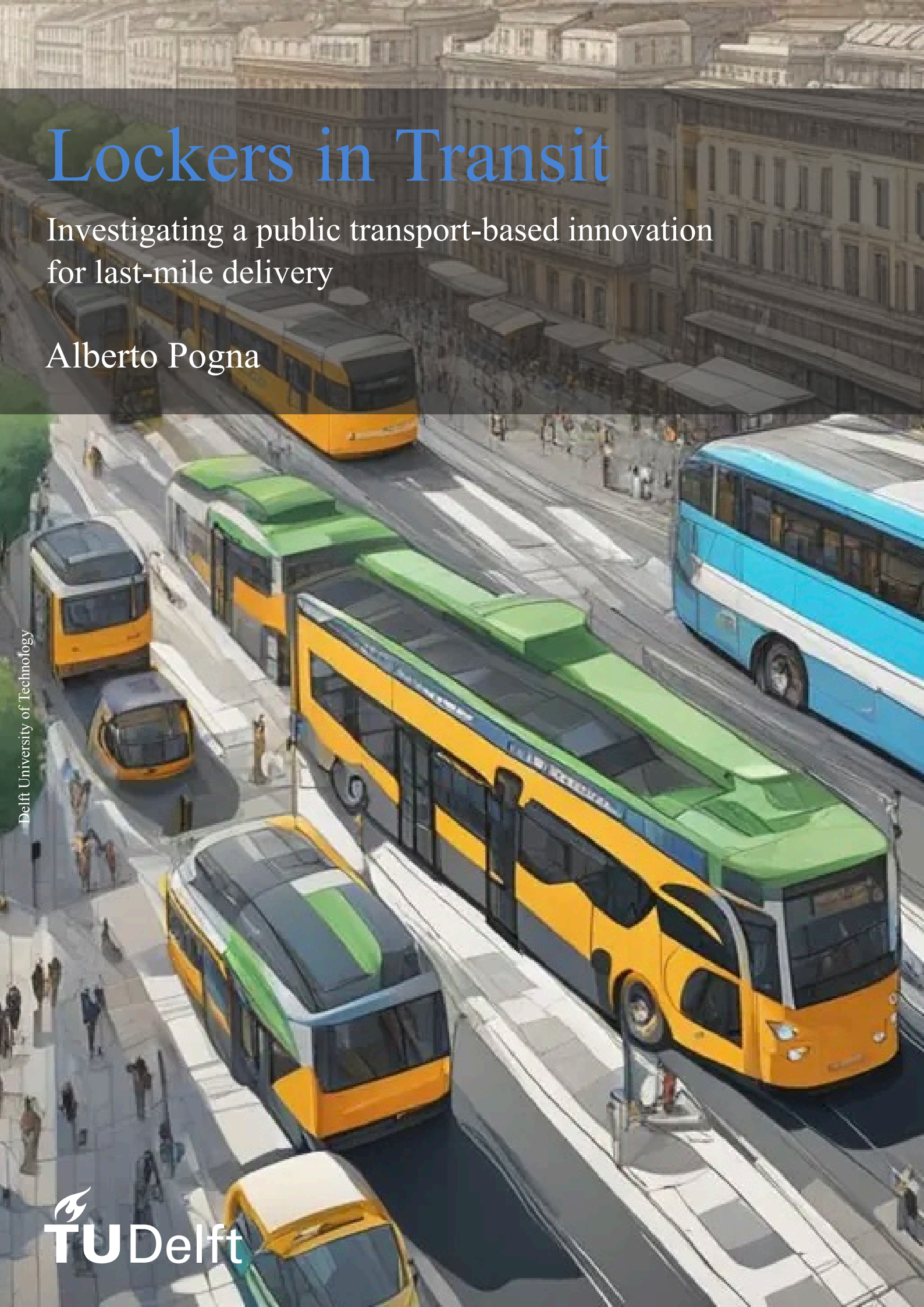
Lockers in Transit

Investigating a public transport-based innovation for last-mile delivery

Alberto Pogna



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Project Duration: February, 2025 - July, 2025
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Abstract

In the last few years, e-commerce has experienced exponential growth, increasing the pressure, especially on last-mile delivery. This thesis, building on the freight-on-transit (FOT) concept, investigates whether mobile parcel lockers, when integrated into public transport vehicles, can alleviate the pressure and negative consequences of last-mile delivery.

In this research, a mixed-methods design was adopted, incorporating both qualitative and quantitative analysis. Eleven semi-structured interviews with public transport operators, logistics firms, municipalities, and academics have been conducted to understand whether this idea was feasible from operational, economic, and governance points of view. Additionally, to capture the end-user's acceptance, trust, and design preferences, a questionnaire (n = 122) was delivered. Moreover, built on the initial idea of combining freight and public transport for last-mile delivery, six scenarios were created that explore possible alternatives. Regarding the scenarios developed, they have been described as possible ideas which, if combined, can have the most significant effect on emission and cost reduction.

The findings reveal that the original idea of "locker-on-board" is technically feasible but economically unproven and operationally fragile when applied in dense urban areas; this is because lockers remove seats that generate revenue or wheelchair bays, complicate the duties of drivers, and clash with regulations. However, this idea has been sustained for rural areas, specifically using busses, since this would save many km for delivery vans which, if they have to reach a remote area for just a few deliveries, emit many emissions. In addition, the structure of the busses to rural areas that have a luggage space which is often empty supports, even more, the transportation of packages without disrupting the comfort of passengers.

Keywords: last-mile delivery, public transport, parcel lockers, freight-on-transit, urban logistics, sustainability

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Introduction

1.1. Background and context

In recent years, e-commerce has grown significantly in the majority of wealthy nations, increasing by 22 percentage points (pp) between 2010 and 2023 (Council of the European Union, 2024). This trend has been further stimulated by the COVID-19 pandemic. According to McKinsey & Company (2025), when the pandemic triggered lockdowns around the world, e-commerce increased 1.6 times in China, 3.3 times in the United States, and 4.5 times in the United Kingdom as a share of total retail sales. This rapid growth in e-commerce has placed significant pressure on logistics and supply chain operations. Among these, last-mile delivery has emerged as a critical challenge since businesses are striving to meet the expectations of customers while reducing their emissions.

Last-mile delivery is one of the most expensive and challenging phases of the supply chain, commonly defined as the last stretch of a business-to-consumer (B2C) parcel delivery service (Lim et al., 2018). This phase occurs once the order is confirmed and continues through delivery to the final recipient's chosen location (Viu-Roig & Alvarez-Palau, 2020). Before the 21st century, shopping was done in stores, and the "last-mile" delivery was on customers. Nowadays, however, consumers have the unbeatable convenience of pressing an order button and getting the parcel at their doorstep. Unfortunately, bringing the world to the customer's doorstep comes at a cost (Kearney, 2024). While convenient, this shift in consumer behaviour has driven up the costs of last-mile delivery to 53% of total shipping expenses and increased carbon emissions. Fragmented routes and frequent stops highly affect carbon emissions and operational costs, and with no interventions, we can expect a 32% jump in carbon emissions from urban delivery traffic by 2030 (Accenture, 2021). Moreover, according to PwC (2023), the European last-mile delivery market is expected to nearly double compared to 2022 induced by the continuous growth of e-commerce without a sign of slowing down.

To address the rising costs and environmental impact related to last-mile delivery, innovative solutions such as local fulfilment centres and alternative delivery methods have been developed. A study by Accenture (2020), using data from London, Chicago, and Sydney showed how local

fulfilment centres for e-commerce drastically could reduce delivery traffic and carbon emissions. Both Chicago and London achieved a 13% reduction in delivery traffic, saving 68k and 144k tonnes in carbon emissions respectively, while Sydney, at 2%, saved 52k tonnes. This indicates how the integration of innovative last-mile methods can significantly reduce congestion and environmental impact (Accenture, 2021).

However, according to Li et al. (2021), collection and delivery points (CDPs) could generate new car trips that would make CDPs less environmentally sustainable as urban logistics solutions. To address this issue, mobile lockers on public transportation have recently emerged as an innovative solution to address these challenges. These secure, compartmentalized lockers installed onboard buses, trams, or trains provide access while in transit rather than at stops. By integrating mobile lockers into the existing public transportation networks, costs and emissions can be reduced and meanwhile offering greater convenience to end-users. In this way, customers can drastically reduce the CO_2 emissions meeting their needs and consequently meeting the needs of companies.

1.2. Problem statement

Despite the numerous options for last-mile delivery, such as human-driven delivery vans, cargo bikes, and self-service techniques (parcel lockers), and the futuristic solutions including drone parcel delivery, robot-assisted delivery, the concept of integration of mobile parcel lockers into public transportation systems remains unexplored (Mohammad et al., 2023). Significant gaps exist that prevent us from understanding its real-world feasibility, cost-effectiveness, environmental impact, and customer satisfaction. At the same time, the expansion of e-commerce keeps straining the urban infrastructure, increasing the need for more sustainable last-mile delivery systems with a customer-centric focus. Moreover, questions remain about who should own and govern these systems, public transportation authorities, logistics companies, or specialized startups, and how can these diverse interests be reconciled. To answer all these questions, a thorough investigation into the operational, financial, and social dimensions regarding the integration of mobile lockers into public transportation is crucial. Such research could provide valuable insights, on how the urban congestion, and consequently reduce emissions, could be affected by the introduction of these systems and improve the overall delivery experience.

1.3. Research question and sub-questions

Based on the research gap identified from the literature review in section 2.5, the main research question and several subquestions have been developed. Answering these research questions would create insights into lockers in public transport as a novel solution to last-mile delivery:

RQ: "What are the key potential and possible challenges for the integration of on-board mobile parcel lockers into the public transportation network?"

This question is addressed by triangulating findings from expert interviews, user questionnaire data, and the development of six scenarios. Each component explores different dimensions—feasibility, user acceptance, regulatory barriers, and spatial constraints— to provide a comprehensive understanding of where and how onboard lockers may be realistically deployed.

To fully answer this main research question, the following four sub-questions (SQs) have been formulated.

SQ1: "What are the key logistical, regulatory, and technical factors that enable or inhibit the acceptance of mobile parcel lockers on public transportation systems?"

The first sub-question aims to identify and determine the practical conditions under which mobile parcel lockers can be successfully deployed on public transport networks. This question is answered through a qualitative analysis of semi-structured expert interviews. The analysis identifies context-specific enablers and barriers from the perspectives of logistics and public transport professionals. In Chapter 4, this methodology has been explained in more detail, especially the interview design and coding strategy.

SQ2: "To what extent do on-board mobile parcel lockers impact key performance indicators such as operational costs and carbon emissions compared to conventional last-mile delivery methods?"

After the feasibility aspects have been explored, the second sub-question aims to understand how this innovation impacts the economic and environmental dimensions. This is crucial to understand for stakeholders concerned with sustainability goals and return on investment. Also, this question has been addressed with the analysis of the expert's interviews.

SQ3: "How do stakeholders—public transportation authorities, logistics providers, and end-users—perceive parcel lockers on public transport?"

After having understood how mobile parcel lockers might be deployed on the public transport network and the benefits that they could bring, the third sub-question is relative to stakeholder acceptance. This involves examining factors that influence trust, convenience, and willingness to adopt the service. In this way, it is possible to capture the most critical drivers of user satisfaction and institutional endorsement. This question is examined with mixed methods: through a combination of expert interviews and a quantitative user questionnaire. The interviews serve to capture institutional perspectives and the questionnaire quantifies user trust, perceived usefulness, and willingness to adopt by different demographic and behavioral profiles.

SQ4: "Which public, private, or startup-led ownership model can support the sustainable and scalable deployment of mobile parcel lockers in public transportation systems?"

Lastly, we want to understand the ownership aspect based on the feasibility, impact, and acceptance insights from SQ1–SQ3, to determine the most appropriate ownership mode to help clarify how the responsibilities, risks, and benefits can be distributed among stakeholders to ensure the long-term viability of this emerging logistics solution. The question is explored through qualitative insights of expert interviews, in which various ownership and governance models were discussed.

The insights generated from these research questions would generate a comprehensive evaluation of mobile parcel locker integration in public transportation settings to guide policymakers, transit authorities, and industry stakeholders in determining the most effective strategies to adopt mobile parcel lockers within public transportation.

1.4. Societal relevance

This thesis has a substantial impact on today's society, tackling contemporary challenges brought by rapid urbanization and the exponential growth of e-commerce. Specifically, it aims to prompt people and society to reconsider how last-mile delivery has been approached to date, utilizing public transport for the final leg to mitigate the environmental and operational burdens associated with last-mile delivery, including urban congestion and carbon emissions. Moreover, scenarios 6a and 6b, which focus on implementing parcel lockers in rural and less populated areas, also offer additional benefits to society, including the reduction of depopulation through improved accessibility and enhanced service quality in remote communities. This initiative, if implemented, would support young people and families in these regions with improved connectivity and convenience, making rural living more attractive and economically viable. Collectively, this research provides insights for policymakers, urban planners, and logistics providers who seek strategies that impact densely populated areas while also serving underserved rural communities.

2

Literature review

The following literature review has been conducted according to the style of unsystematic narrative reviews, which, according to Green et al. (2006) is a synthesized summary of existing research on a topic that condenses the various authors' findings; in this case, the topic analyzed where many, starting from logistics then moving to last-mile and then freight on transit. The choice of this specific methodology has been made for its flexibility and suitability in exploring emerging, interdisciplinary topics, in this case, lockers on public transportation, where a constraint-based methodology might not capture all the important topics that influence this concept.

2.1. The evolving nature of logistics

Logistics has faced significant transformation over the years, shifting the focus from supporting military operations to commercial applications. Initially, the term meant the freight movement to support military activities. By the 1960s, the current understanding of logistics "physical distribution" emerged (Sindi & Roe, 2017). The advent of information and communication technology (ICT) brought new applications in the logistics field, allowing new tools development and platforms for Transportation Management (TM) applications, Supply Chain Execution (SCE), Field Force Automation (FFA), and Fleet and Freight Management (FFM). These advancements have created space for more efficient data exchange and decision-making in logistics (Perego et al., 2011). Artificial Intelligence (AI) has recently been indicated as the subsequent significant development. According to Burnham (2024), routes and schedules can be optimized by AI models, which are constantly trained on logistics data and continuously learn from new information. Considering that these models are trained continuously, they will learn better policies for future routes. They are more flexible with new characteristics and generalize well to previously unseen problems. Despite all these developments, many challenges persist, specifically in the urban logistics, due to the rise of e-commerce, diverse stakeholder goals, and growing negative impacts on the environment. Bachofner et al. (2022) underscore that the progress is hampered by the underutilized technological solutions (e.g., IoT, modular vehicles), high costs, and regulatory

barriers.

2.2. Last-mile delivery: challenges and complexities

Last-mile delivery has often been a topic of research given its centrality in logistics; with the recent development of e-commerce around the globe, it has become a tough challenge for companies offering services in the logistics industry (Ouyang et al., 2023). It refers to the final segment of the supply chain of goods; it includes the trip from the last distribution center operated by the carrier to the final customer, which is usually situated in urbanized areas. This process can occur in business-to-business (B2B) and business-to-consumer (B2C) contexts. Statistics predict that B2B could reach a turnover of $13.6 billion by 2027, with an annual growth rate of 8.5%, while B2C is expected to have a yearly growth rate of 8.5% within the next ten years (Mail Boxes Etc., 2023). Moreover, it is possible to see it in different aspects of the literature on the courier express parcel (CEP) market (e.g., e-commerce, mail collection, and delivery), retail replenishment, food delivery, delivery of construction materials, and even garbage collection (Bachofner et al., 2022).

A significant theme in the literature is the complex array of operational, environmental, and service reliability related to last-mile logistics.

I. Operationally, dynamic online orders, short delivery times, and overlapping customer preferences pose significant challenges. Moreover, orders are unpredictable, so they require immediate integration into delivery plans because customers need fast and flexible delivery (Archetti & Bertazzi, 2020).

II. The environmental dimension highlights the high pollution of last-mile delivery and the challenges to overcome this. Maxner et al. (2022) argue that cities have misaligned policies and miss coordination with freight companies. Furthermore, the high costs and missing infrastructure hinder the use of EVs for last-mile delivery. Consequently, to have a more effective solution, it is important to have more collaboration, better resources, and support from state and federal governments with subsidies and regulatory adjustments.

III. Finally, service reliability remains one of the most important aspects of customer satisfaction. (Lai et al., 2022) identify tangibility, responsiveness, security, reliability, and timeliness as key components of customer satisfaction. However, timeliness was the strongest predictor, indicating that the pressure on last-mile logistics is continually increasing.

2.3. Innovations in last-mile delivery

Numerous solutions have been proposed in the literature in response to all these challenges. Mangiaracina et al. (2019) highlight a wide range of innovative approaches; however, only the most related innovations are reviewed here.

I. **The reception box and delivery box**

   Punakivi et al. (2001) explore using a customer specific reception box installed in the customer's garage or home yard. This innovation has been studied in Helsinki and have shown how it reduces costs by up to 60% compared to the more traditional solutions. Reception boxes are usually installed outside the customer's residence; access is granted via a key or

electronic code. Kämäräinen et al. (2001) have studied their use in the e-grocery industry, and according to the findings of their studies, delivery costs were reduced by over 40% and the driving distance by 50%; moreover, they helped not only in the delivery and picking workloads but also the overall supply chain efficiency.

A similar approach is the delivery boxes, which function like reception boxes but are owned by the retailer instead. These are secured at the customer's home but, in the next round of delivery, are retrieved. One of the main advantages is that the customer-specific reception boxes require lower investment and can be shared among multiple users, allowing for greater flexibility and a higher utilization rate. Indeed, their payback period is around 2 years (Punakivi et al., 2001).

Overall, delivery boxes can reduce transportation costs by 55-66% compared to traditional methods, and the investment payback period is 2-5 years. On the other hand, reception boxes offer 44-53% cost reductions, and due to the higher initial investments, their payback period is 6-13 years (Punakivi, 2003).

II. **Parcel locker**

Parcel lockers are a system that enables both receiving and sending parcels 24 hours a day, 7 days a week, usually located in the most attended places in a chosen location, minimizing failed deliveries and travel distances. Iwan et al. (2016) state that strategic placement is crucial for maximum efficiency. A case study in Amsterdam is also presented to support this solution. According to van Duin et al. (2020), using parcel lockers in the city area of De Pijp could save up to 121,356€, so if applied on a larger scale, it could have a significant impact. Moreover, Peppel and Spinler (2022) have studied the optimization of stationary parcel locker (SPL) networks to reduce last-mile delivery costs and CO2e emissions. The findings show that if strategically placed, SPLs can cut costs up to 11% and lower urban CO2e emissions by 2.5%; however, in rural areas, due to longer pick-up travel distances, emissions may increase by 4.6%. Moreover, they have shown that consolidating deliveries into a weekly schedule could further reduce costs by 6.4% and emissions by 5.4%. Furthermore,Lemke et al. (2016) conducted a research in Polish cities to study the use of parcel lockers from a customer perspective, and found that individual customers generally trust parcel locker services, and parcels are usually collected along people's commute routes, which encourages eco-friendly behaviors.

III. **Pick-up points**

Pick-up points are dedicated locations (e.g., kiosks, stores) where customers collect parcels. These collection points are a valid solution since they offer the possibility of conducting non-attended delivery (i.e., delivering the goods without a receiver), drastically decreasing the number of failed deliveries. Moreover, the demand is consolidated, increasing the ratio of deliveries per stop (Niemeijer & Buijs, 2023). Similarly, Brown and Guiffrida (2014) also have testified the reduction in failed deliveries, consolidating demand, and lowering carbon emissions. This is because the unnecessary trips are reduced by leveraging trip chaining; moreover, this is reinforced by the fact that failed home deliveries increase emissions, while consolidated deliveries to collection points optimize transport routes.

IV. **Crowd Logistics**

In the literature, crowd logistics has been defined by Mehmann et al. (2015) as "the outsourcing of logistics service to a mass of actors, whereby a technical infrastructure supports the coordination. Crowd Logistics aims to achieve economic benefits for all stakeholders and shareholders.". It has also been assessed for its potential to reduce the environmental impacts of urban delivery tasks and, in the meantime, impact supporting low-income participants Sina Mohri et al. (2023). Moreover, some variations of the more traditional crowd logistics have been studied to develop systems that attract more crowd-shippers to serve more demand, such as depot-based crowd-shipping systems, in which a depot located at strategic locations is constructed. This way, crowd-shippers can pick up parcels from depot locations and deliver them to the final destination (Stokkink & Geroliminis, 2023).

V. **Drones**

Research by Cornell et al. (2023) suggests that this technology can meet different use cases for last-mile logistics, B2B, such as medical samples for labs, and B2C, such as prepared food, convenience products, and other small packages. One of the main advantages is related to increased accessibility for individuals with limited transportation options and services. Furthermore, they are more cost-effective than traditional express delivery methods, so they can open the doors to a new era of sustainable last-mile logistics (Garg et al., 2023).

VI. **Trunk delivery**

Trunk delivery is an innovative last-mile delivery model in which couriers unlock a customer's car trunk via a one-time digital key, and the order is delivered there. The study conducted by Reyes et al. (2017) has shown that the distance traveled significantly reduced by 40–65%, based on the depot's location. This reduction can potentially reduce economic costs, emissions, and congestion.

VII. **Dynamic Pricing**

Abdollahi et al. (2023) investigate how dynamic pricing, applied to last-mile delivery, is used to influence customers' choices of servicing slots. Based on the customer's preference, the actual order is replaced, and the route map is re-optimized. This strategy creates a better schedule for the entire route map, and the delivery costs have decreased and increased in the number of accepted orders, leading to higher profits.

VIII. **Data Mining Technique**

Beginning studies have started to be conducted regarding integrating data mining techniques in urban freight transportation. Pan et al. (2017) explained an approach based on two stages. The first is related to estimating the probability of the purchaser's absence. The second one uses this calculation as input to optimize models that execute home delivery. The study has shown that the total travel distance could be reduced by 3-20%, and the success rate at the first delivery round would be approximately 18-26%.

IX. **Underground delivery**

Underground logistics systems (ULSs) are currently being studied as low-carbon, energy-saving, and ground-space-saving logistics and transportation approaches. These approaches

rely on underground tunnels/pipelines, which do not require couriers, saving social human resources. They also have several other advantages, including reducing emissions of pollutant gases during transportation, saving urban ground space resources, and protecting the urban environment (Wei et al., 2024).

X. **Robots**

Autonomous ground vehicles are a new technology starting to be analyzed; this innovation is similar to drones, given the small number of parcels they can carry. Moreover, it has been discovered that the robots are very effective in areas with high traffic congestion and when many consecutive deliveries are present (Simoni et al., 2020).

These innovations demonstrate the numerous research-driven initiatives to reimagine last-mile delivery. However, some possible new cutting-edge innovations still need to be deeply studied.

2.4. Freight on transit (FOT)

Public Transportation is traditionally recognized to reduce the share of travelers from private vehicles and consequently reduce traffic congestion (Aftabuzzaman et al., 2010). Many researchers have shown its positive economic effects and the operational benefits it provides in highly congested areas. For instance, Anderson (2013) demonstrates that each peak-hour transit passenger mile reduces congestion costs by $1.20 to $4.10, sufficient to justify investments in the transit infrastructure. Moreover, it has been demonstrated how every €1 invested in public transport infrastructure generates €4 in value by creating jobs and boosting local businesses (International Association of Public Transport, 2021). Furthermore, fixed routes and timed schedules provide an orderly system that can be applied to build reliable delivery systems resistant to disruption.

Despite these well-known advantages, parcel services related to public transport infrastructure have been mainly used only stationary at the transport stations. These systems have demonstrated substantial benefits in reduced delivery times, lower costs, and improved accessibility (Anand et al., 2024). The literature also presents examples of crowd-shipping services for e-commerce delivery. Indeed, in that case, lockers can be used as mini hubs for last-mile deliveries, and crowd shippers can use public transportation to deliver goods (Oliveira et al., 2022). Besides the reduced congestion, PT also improves air quality, supports the economy, and, given its fixed routes and regular schedules, provides a structured framework that can be leveraged to design reliable delivery systems.

Freight on Transit (FOT), the practice of using public transit vehicles or infrastructure to move freight, has been under growing attention in recent years. Cochrane et al. (2017) formally introduced the term "operational strategy that uses public transit vehicles or infrastructure to move freight.". Through a three-round Delphi study involving a diverse group of transportation experts, the authors identified the benefits and drawbacks of FOT. Among them, the most positive aspects were environmental benefits, congestion reduction, and increased network efficiency. The potential for the transit agency to have a new revenue stream and the possibility of using off-peak capacity were also highlighted. On the negative side, the study pinpointed the need for subsidies and increased handling costs. In addition, the authors underscored the challenges that hinder the implementation of FOT, the need for substantial capital investment, and the difficulty in finding sufficient capacity within existing public transit networks.

Subsequent research has sought to refine and expand the concept of using public transportation infrastructure to support urban freight distribution. Different studies have explored FOT from varied methodological and practical perspectives. Azcuy et al. (2021) investigated the use of public transport infrastructure to support urban freight delivery, showing that integrating public transport into urban delivery reduces system-wide distance and negative externalities. Their work indicated that the capacity of public transport to support urban delivery could save up to 7.1 percent of the distance. However, the study has been conducted considering a two-tier urban delivery system, meaning that public transport is used only from a depot to a transfer station, and there are still last-mile vehicles to complete the deliveries.

Further optimization-oriented research has continued to shape the discussion. Delle Donne et al. (2023) have proposed a new combinatorial optimization problem to help public authorities integrate this freight and passenger transport concept while simultaneously optimizing the Public Transport System (PTS). Their study introduced three mixed-integer programming (MIP) formulations based on paths, flows, and aggregated flows to study which stations, which lines, and with which capacities could accommodate freight. This work highlights the growing focus on providing strong decision support tools to promote effective FOT deployment.

Complementary efforts have focused on the economic and operational implications of FOT. Ma et al. (2023) researched a public transit system that can serve passengers and urban freight, defined as co-modality or FOT, where one transit operator serves passengers and provides freight-on-transit (FOT) services. One freight forwarder serves customers and makes arrangements to transport the freights by using/either a freight carrier and/or the co-modal mode operated by the transit operator. Their findings reveal that co-modal operations can improve or maintain profits for all operators of the freight forwarder, carrier, transit operator, and consumer surpluses of freight customers and transit passengers. The transit operator and freight forwarder benefit in a non-cooperative setting, but the carrier faces losses due to reduced road freight demand. Moreover, if the transit operator covers the connection trip cost, the freight forwarder's co-modality is higher. On the other hand, an excessive use of co-modal transport may reduce the overall profitability. Nonetheless, to ensure a Pareto-improving co-modal system, the operator has to lower the freight/transit service fare and the co-modal transportation price.

Research has also delved into specific modal applications, such as urban rail. Li et al. (2021) explore a specific case of FOT, integrating freight transport into urban rail transit. In particular, it is based on a practical approach in which a mixed-integer programming model for train service design is formulated, allowing some adjustments to the standard timetable to accommodate freight. His work analyzes two transportation schemes: the first with dedicated freight trains and the second with passenger-freight vehicles.

Beyond methodological and operational studies, performance evaluation and broader policy implications have been analyzed. Bruzzone et al. (2021) proposed a set of key performance indicators (KPIs) to assess the integration of passenger and freight flows. By studying two case studies in Venice (Italy) and Velenje (Slovenia), Their findings corroborated earlier suggestions that the FOT approach is efficient in contexts where freight volumes and delivery points are limited and the travel demand is inelastic. The results indicate a potential benefit of integrating passenger and freight transport by reducing travel distances and externalities. However, they also stressed that current transport policies treat passenger and freight transport as separate systems when they share space, infrastructure, and challenges instead.

Finally, a synthesis of the field by Cavallaro and Nocera (2022) stated that passenger and freight transport have gained increasing attention in recent years. However, the research is heterogeneous and exploratory, with a notable absence of a unified theoretical framework, systematic models, and real-life case studies. The study highlights, with the support of the quadruple helix model, the role of policymakers, transport operators, academia, and civil society in shaping the role of policymakers in integrated transport solutions. The study suggests that passenger and freight transport should collaborate instead of competing.

Overall, the literature converges on the notion that FOT promises environmental, economic, and operational benefits when implemented under the right conditions and with well-designed strategies. However, many barriers still need to be overcome. Current research continues to refine optimization models, explore co-modality frameworks, and offer policy recommendations. However, real-world implementation and longitudinal studies will be crucial to making FOT widespread.

Integrating parcel lockers within public transport networks represents an innovative but insufficiently studied concept. Even though fixed parcel lockers have widely been studied, the use of on-board mobile parcel lockers, which use public transport vehicles, remains primarily unexamined. The existing research on Freight-Oriented Transport (FOT) principles has highlighted the potential of combining goods and people for the urban transport; however, there is a lack of empirical and theoretical analysis on how public transport systems can facilitate last-mile parcel distribution. In particular, no studies have addressed the feasibility of this solution based on a deep analysis of stakeholder perspectives and governance models.

To address this research gap some questions have been developed. In particular, the 1st SQ will analyze the core operational and policy challenges, the 2nd sub-question will understand the potential benefits in terms of sustainability and cost-efficiency, and this will provide essential insights for urban mobility planners and logistics operators, and the 3rd SQ will assess the user acceptance, trust, and institutional readiness, which are crucial factors for real-world implementation. The final 4th sub-question will explore the best governance structure to ensure long-term viability. Finally, after answering the research question "What are the key potentials and possible challenges for the integration of on-board mobile parcel lockers into the public transportation network?", the study will provide a comprehensive framework for integrating mobile parcel lockers into public transport.

2.5. Research gap

This thesis notably distinguishes itself academically by being the first study to adopt an integrated, mixed-method approach specifically targeting the concept of on-board mobile parcel lockers within public transportation networks. While existing literature has extensively analyzed fixed parcel locker systems and Freight-on-Transit (FOT) solutions independently, no previous research has systematically combined stakeholder interviews, end-user questionnaires, and detailed technological scenario development specifically for mobile parcel lockers integrated directly onto transit vehicles. Furthermore, the thesis uniquely contributes by developing and evaluating a spectrum of novel scenarios, ranging from simpler station-based lockers to advanced, technology-driven models such as automated robotic transfer hubs and autonomous micro-hubs. Such an innovative scenario-based approach, supported by comprehensive empir-

ical data from both stakeholder interviews and end-user perspectives, provides a pioneering methodological framework that fills a significant research gap, laying a robust foundation for future theoretical explorations and practical implementations in sustainable urban logistics.

3

Urban transformation and sustainable logistics: contextualizing mobile parcel lockers

This chapter serves as the conceptual hinge of the thesis, translating the sweeping transformations in urban form, governance, and technology into a clear rationale for experimenting with mobile parcel lockers on public transportation. The exploration of mega-trends in urbanization, such as the 15-Minute City paradigm and the rise of the City-as-a-Platform government, which have reshaped the spatial, environmental, and digital DNA of European cities, are analyzed. The problem space in which mobile lockers emerge as an innovation is examined. The analysis of the chapter not only justifies the research question but also serves as an interpretive lens for later chapters on stakeholder acceptance (SQ1 & SQ3), environmental and economic impact modeling (SQ2), and ownership scenarios (SQ4). To conclude, this chapter anchors the thesis by linking global urban challenges to the local, practical innovation explored in the subsequent chapters. Similarly to Chapter 2 also, in this case, unsystematic narrative reviews have been conducted to explore in the most flexible way the mega-trends influencing the urbanisations.

European cities are facing a fundamental shift since they need to adapt to technological change and socio-economic and environmental dynamics. Fast urbanization, global warming, digital technology, and changes in the behavior of consumers are increasingly shaping the contemporary urban context. In fact, how cities function, how citizens travel and engage, and how logistics systems are organized and regulated are revolutionized by those drivers. In this continuous evolution of the environment, it is crucial to understand the historical and theoretical trajectories of urban growth together with new and emerging paradigms in urban planning and governance so that the urban futures can be more resilient, inclusive, and sustainable.

3.1. The Historical trajectory of urbanization

Urbanization is a recent phenomenon in human history. The need for urban settlements can be tracked down to 10,000 years ago when agriculture started to support half-permanent settlements. Around 5,000 years ago, permanent habitation flourished after the development, and widespread irrigation and tilling of the land brought food abundance, trade, and labor diversification (Kite, 2017). After that, the Roman Empire continued expanding the extent and sophistication of the urban infrastructure, and the Industrial Revolution began unprecedented urban growth.

Nowadays, more than 55% of the world's population lives in cities, and projections suggest that probably by 2050, this number will be 68% (United Nations Department of Economic and Social Affairs, 2018). In particular, 80% of people in Europe reside in urban settings; this reflects a long history of high-density urban networks and an early transition from agrarian to industrial economies. A city from the European Commission is defined as an area with more than 50,000 residents and a population density of 1,500/km² or higher; on the other hand, a town must contain at least 5,000 residents and 300/km² (Ritchie et al., 2024b).

Even though urbanization has not been uniform, some patterns can be found. In Europe, urban growth has historically followed a relatively continuous trajectory with a dense system of small and medium-sized cities. Conversely, "New World" urban systems, such as those in the United States or Australia, that have been developed later have more abrupt hierarchies and spatial polarization. Ex-colonized regions show hybrid systems with a combination of traditional settlements and externally-focused metropolises (Pumain, 2018).

3.2. Urban systems as complex adaptive networks

Urban systems are not only clusters of buildings or population centers; they are complex and self-organizing structures shaped by numerous dynamics related to history, geography, and relation. According to Pumain (2018), cities work into a broader system of cities, where the evolutionary trajectory is affected by size and interconnectivity. This theory is derived from Zipf's law and other rank-size models, which argue that urban hierarchies remain relatively stable despite persistent change. In fact, cities' growth, stagnation, or decline is not based solely on top-down planning but through adaptive interactions, diffusion of innovation, and spatial competition.

From local commuter flows to global trade flows, cities develop on different scales. This multidimensional character explains how cities can be shock-resilient, such as in the case of pandemics, wars, or economic crises.

3.3. Urbanization and its socio-spatial implications

The surrounding rural areas of cities that are going on often become suburbs, which leads to the expansion of metropolitan areas and sometimes leads to the formation of vast megalopolises. However, many challenges are brought by the process of suburbanization, particularly the conversion of farmland and wilderness into built environments, the strain of infrastructure, and the degradation of the environment. Many concerns related to urban development are raised,

especially to sustainability and the creation of new strategies for growth management (Society, 2024).

The key tenets of smart growth are mixed-use development, compactness, green spaces, and limitations on spreading suburbs. These policies relate to reducing environmental impact, making it more accessible, and creating more equitable urban experiences. Of note is that while urban land constitutes just 1% of the global land area, the ecological footprint is enormous, making efficient logistics, infrastructure, and planning even more crucial (Ritchie et al., 2024a).

In this formula, population density is a determining variable; high density areas delineate urban areas, and low-density areas define rural areas. Population distribution is a critical factor in the formulation of infrastructure, healthcare, mobility, and environmental policy choices. However, the collection of accurate data is still highly challenging because of the census limitations and the exclusion of marginalized populations. However, physiological or agricultural density can be alternative metrics for understanding land-use pressure and resource availability (The Wise Apple, 2024).

3.4. Planning paradigms: from modernism to resilience and participation

Over the centuries, urban planning has undergone significant transformation shaped by political change and interdisciplinary understanding. Haghani et al. (2023) reviewed nearly 100,000 articles related to urban planning; from his work, it is possible to understand how urban planning has developed from curiosity regarding the growth of the city and welfare economics to focal areas like green space planning, smart cities, and resilience. Even with the growing attention to digital innovation, technologies like AI and IoT are still underrepresented in the practical urban planning debate and, if represented at all, tend to be reserved for theoretical writing.

This continuous but incremental paradigm shift separates urban planning from other, faster-developing areas. Planning discourse, in particular, is increasingly becoming global in character, and global collaboration is growing. Moreover, the changes have been further accelerated by COVID-19, which has exposed the vulnerabilities of car-centric, tech-driven cities and highlighted the urgency of human-centered design.

Deloitte (2021) is envisioning a near-future urbanism based on purpose-driven change: greener cities, connected neighborhoods, and more resilient infrastructure. Walkability, local accessibility, and digital inclusion are becoming increasingly important. An example is the 15-Minute City concept, developed by Carlos Moreno (Moreno et al., 2021), which includes the shift towards a city that encapsulates this shift: a chrono-urbanism model that prioritizes proximity, multifunctionality, and human well-being as the highest priorities.

3.5. The 15-minute city and post-pandemic urbanism

The COVID-19 pandemic exposed deep vulnerabilities of urban systems, illustrating the inequalities in healthcare access, lack of digital infrastructure, and the fragility of centralized services. In this context, The 15-Minute City concept has been raised as a holistic urban planning approach that advocates that citizens ought to be able to access workplaces, education, food, healthcare,

and entertainment within a 15-minute walk or bike (Moreno et al., 2021). The main goal of this concept is to encourage social integration, reduce pollution, be good for mental health, and reduce the need for vast infrastructure.

There are four pillars at the center of the 15-Minute City approach: proximity, density, diversity, and digitalization. These pillars facilitate decentralized services, mixed neighborhoods, and the use of digital tools to enhance urban efficiency and reduce the need for longer travel (Allam et al., 2022). In contrast to techno-centric models like smart cities, thanks to the inclusivity, community, and human-scale urbanism, this reaffirms the importance of city design around human needs rather than technological imperatives (Abdelfattah et al., 2022).

However, retrofitting the existing infrastructure is another important fact. This difficulty consists of fixing sidewalks, implementing local markets, and using transport means like e-scooters and bicycles. The latter can enable people to move around and improve their lives. Additionally, implementing micro-mobility means brings with it many safety and security issues. Another aspect to consider is that roads and pathways can support micro-mobility and ensure everyone can access them, especially in places where few live. It is important to balance being close to necessary places with staying connected online. This reflects how our daily lives and work have significantly changed since the pandemic (Abdelfattah et al., 2022).

3.5.1. Case studies of real urban implementations

The 15-Minute City concept has started being applied across several cities, with a diverse variety of successes and challenges. Paris, under Mayor Anne Hidalgo, has integrated this model into its urban design philosophy, transforming its neighborhoods into vibrant and walkable centers. Initiatives have enhanced urban livability and social harmony by converting highways along the Seine River into pedestrian spaces and integrating social housing into affluent areas (Horton, 2024).

The 15-Minute City concept has started. Milan is an intriguing test case, which, compared to Paris or Barcelona, is structurally less compact; however, this has not stopped the city from exploring its post-pandemic strategy, the 15-Minute City. The current mayor, Sala, proposed a polycentric urban model that balances the urban development between more central areas and peripheral neighborhoods. This intervention encompasses, in the short-term period, the redesign of sidewalks and the promotion of soft mobility, which are the first steps towards a more structural change in the city. The city's openness towards innovation makes it an ideal environment to adopt the global concept of a 15-Minute City (Plan, 2021).

However, the concept has encountered several challenges in other applications. Misinformation and conspiracy theories have controversially redefined the 15-Minute City idea as an oppressive "climate lockdown" in Oxford, especially in the UK, showing how socio-political forces can influence the model's acceptability and receptivity (Horton, 2024).

Meanwhile, Seoul has approached the concept of walkability with an evaluation system based on rigorous data. This method combines pedestrian infrastructure, transit availability, and spatially detailed analysis to produce actionable walkability scores to inform targeted urban planning interventions. Results from Seoul demonstrate that Jongno-gu and Mapo-gu, which are centrally located districts, perform well based on dense transit networks and built pedestrian

forms. In contrast, peripheral districts struggle with problems associated with topography and fragmented transportation networks. This empirical assessment shows the priority need for infrastructural changes and transit integration targeted for less walkable neighborhoods (Jeong et al., 2023).

To conclude, the 15-Minute City is a transformative and revolutionary design model that redefines accessibility by integrating proximity and digital connectivity. Its realization hinges on careful localization, inclusive public participation, and innovative financing strategies, particularly in low-resource settings (Allam et al., 2022).

3.6. Digital transformation and urban governance: the rise of CaaP

Urban governance models have been radically revolutionized with the advent of the digital age, changing the primary function of the cities from simple reactive service providers to facilitators of civic ecosystems. Repetto et al. (2021) introduced the City-as-a-Platform (CaaP) concept, in which urban governments use open data, participatory platforms, and digital co-creation to engage citizens and stimulate innovation. CaaP platforms have various functions, from simple information portals to advanced systems that use APIs, hackathons, and citizen science. While these are very promising, many implementation challenges exist, including resistance from bureaucrats and privacy. Solutions can include inclusiveness, transparency, targeted training, and ethical design principles. Even though there is no single one-size-fits-all model for CAAP, the underlying philosophy is well aligned with today's society's urban requirements, including adaptive governance, collective intelligence, and socially embedded technology (Repetto et al., 2021).

Building on this idea, smart city leverages digital technologies to improve traditional urban services, which include transport, energy, waste management, and public administration, so that they can become more efficient, sustainable, and responsive to the needs of citizens. However, it is important to underly that smart cities are not only related to technological progress; they embody a broader concept that includes improving quality of life, reducing emissions, addressing social challenges, and promoting sustainability (Commission, n.d.) . To facilitate this transition toward smart cities, marketplaces such as the Smart Cities Marketplace unite cities, industries, researchers, and investors. To facilitate this transition, there is a rational three-step process: first, "Explore," which includes the part acquisition of new knowledge and best practices; second, "Shape," where solid, investment-ready project plans are formulated; and third, "Deal," where there is the connection with financiers to achieve the implementation (Commission, n.d.).

This evolution towards smart cities is derived from the previous digital city concepts, with the integration of technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data, Cloud Computing, 5G, and Digital Twins to improve the service effectiveness, reduce the pollution and increase the quality of life significantly (Innovation, 2025). These technologies are the cornerstone of important city domains: smart mobility, bright lighting, security, environmental sensing, waste handling, smart grid, digital tourism, and active engagement of citizens. As a direct consequence of all these developments and insights in real-time, there have been leading examples, which include Zurich, Oslo, Copenhagen, and London, and there have been outstanding examples in Italian cities like Milan, Turin, Trento, Verona, and Florence. All these cities have implemented specific projects, which include intelligent irrigation systems and traffic lights that directly respond to emergency vehicles. A good example of efforts is dictated by Italy,

which, even though it is facing a market growth that is slower compared to other countries and limitations dictated by the government in 2023, has reached an investment of one billion euros with many significant investments in public lighting, green mobility, intelligent grids, and metering, driven partly by the National Recovery and Resilience Plan (PNRR) (Innovation, 2025).

It is important to highlight that the development of smart cities needs an integration of technology, data, governance, and citizen services into a coherent, interactive, user-oriented model (Yin et al., 2015). There is also a difference between digital cities, which focus on technology infrastructure, and smart cities, which focus on data-driven governance, where citizen satisfaction, business success, and environmental sustainability are proactively improved. Yin et al. (2015) have proposed a four-layer architecture to properly deal with this complexity: data acquisition, data vitalization (cleaning and contextualizing raw data), a common data service layer, and domain-specific application layers offering real-world services. At the core of their argument is the concept of "data vitalization," transforming individual data points into connected, dynamic systems and enabling real-time decision-making and efficient urban management (Yin et al., 2015).

Supporting these findings, Institute (2018) further emphasizes how smart cities with the use of digital solutions improve urban quality-of-life indicators through the integration of three interconnected layers: digital infrastructure (sensors, connectivity, open data), innovative applications, and substantial public usage leading to behavioral change. Their research shows how smart cities improve travel time by 15–20% through intelligent traffic management, decrease crime rates by 30–40% through predictive policing, and save up to 30% in water usage through efficient tracking technologies. McKinsey further underscores that technological innovation should never be an end in itself but a means to enhance residents' lives, promote equitable access, safeguard data privacy, and prioritize tangible, real-world impacts (Institute, 2018).

Lastly, smart cities are cross-disciplinary projects in which technological sophistication, aggressive data analysis, and deep social understanding converge to create urban places that are adaptive, sustainable, and highly responsive to changing citizen needs.

3.7. Stakeholder analysis and experts identification

The successful deployment of lockers on public transport depends on various stakeholders who must coordinate and align their interests and agendas.

According to Brugha and Varvasovszky (2000), stakeholder analysis is a method used to better understand actors, which can encompass both organizations and individuals. The researcher can learn about their behavior, goals, relationships, and interests and understand how they contribute to decision-making processes.

According to Schmeer (2000), stakeholders can be divided into specific categories: international/donors, national political (legislators, governors), public (ministry of health [MOH], social security agency, ministry of finance), labor (unions, medical associations), commercial/private for-profit, nonprofit (nongovernmental organizations [NGOs], foundations), civil society, and users/consumers.

In this innovation under the public category can be identified: public transport authorities (PTAs) and the public sector, specifically the municipal governments and urban planners, as

well as the research and education institutions. The commercial/private for-profit group includes key stakeholders such as retailers, logistics companies, and tech vendors. Lastly, the users/consumers category encompasses end-users and commuters.

Public transport authorities (**PTAs**), the owners and operators of the transport infrastructure, such as trains, trams, and metros, so they also have considerable control related to access and viability. With this solution, they could diversify their revenue with the rent of lockers; they could align better with the new urban mobility objectives and, in general, become more sustainable. On the other hand, they could face several issues related to the loss of passenger comfort and safety, disruptions to transport schedules, issues related to the liability for the contents of the lockers, and regulatory issues.

The other two commercial constituencies are **retailers** and **logistics companies**, which split has been strongly emphasize in the interview number 7. Even though they are central to the delivery system, their interaction with the lockers is different; the retailers are the initiators of the parcel movement, while the logistics companies are the physical handlers. Retailers like big e-commerce platforms and physical chains such as Amazon, Zalando, and Vinted forward customer orders to third-party carriers. The central aspect they would consider with this innovative solution is whether the satisfaction of customers increases with the offer of a faster and more convenient delivery solution. Another important aspect they consider is whether the delivery failure rate decreases, consequently increasing efficiency and reducing costs. However, they might also be worried about losing control over the customer delivery experience.

Logistics providers such as DHL, PostNL, UPS, FedEx, and DPD are more directly involved in the locker system. They are the ones who transport parcels and insert locker stops onto their existing routes. Lockers allow them to reduce costs and the need for vehicles. Moreover, this solution can assist them in the green transition. Even so, their interests remain pragmatic and real-time since they depend on public transport timetables, are bound by space and time constraints for loading/unloading, and require well-delineated access control mechanisms.

Other crucial stakeholder to remember are **commuters**, who are the senders or receivers of parcels and will have direct dealings with the locker system. They are interested in the convenience, so they must be able to drop off or collect packages during their daily commute. However, their mass adoption will determine the system's viability; the most significant issues for this group are trust in the system's reliability, personal privacy, and security.

Tech vendors are the core of the locker's infrastructure. These companies are responsible for designing the physical lockers, the software behind them, and any IoT that integrates them into transport and logistics networks. Their motivation to adopt this solution is related to the openness of new markets, scalability, and strategic partnerships with PTAs or logistics operators.

The **municipalities**, who control city-level policy, funding, and infrastructure planning, are also crucial. Their interest, of course, is related to the well-being of the citizens, such as reducing traffic jams and emissions and supporting initiatives of smart cities. Their main issue is maintaining public value in the face of commercial involvement.

Lastly, **research and education institutions** have supported the initiative to do feasibility studies, simulation models, and pilot implementation. They have the role of bringing credibility and best practices. However, they also face challenges in data access.

Stakeholder relationships are also marked with synergies and tension; for example, PTAs and logistics providers can derive synergies from the sharing of infrastructure. However, there are also problems related to scheduling conflicts, issues of liability, and sharing profits. Logistics firms and commuters can have many benefits; however, there are problems related to data privacy concerns and user trust. Herein, the multifaceted actors show how their alignment is crucial to successfully deploy this solution.

3.7.1. Power-Interest grid

Table 3.1: Stakeholder matrix and strategy

Quadrant	Stakeholder Group	Description	Strategy
High Power, High Interest	**Public Transport Authorities (PTAs)** **Logistics Companies** (e.g., DHL, PostNL)	PTAs control access to fleet and scheduling; as a consequence, and they are responsible for safety and security of both passengers and goods so this innovation cannot be implemented without their approval (El Amrani et al., 2024). Adoption, integration, and use, on the other hand, rely on logistics providers, who must integrate this solution into their current delivery routes and at the same time comply with government regulations (and, 2001).	**Manage closely**: Given their importance, it is crucial to co-design the solution, prepare the pilot, and ensure regulatory compliance. Another important aspect is to have mutual value to move forward with this innovation.

Quadrant	Stakeholder Group	Description	Strategy
High power and low interest	**Municipalities**	Municipalities have a direct impact on the city-planning of urban freight, meaning that they have to permit freight and people to travel together on a public vehicle (Ringsberg et al., 2023). However, there is a need for more attention to coordination and support in active transportation, especially in areas of jurisdictional overlap (European Commission, n.d. Tremblay-Racicot et al., 2023).	**Keep satisfied**: These actors are important to give priority to compliance with green mobility and smart city plans. Moreover, it is important to provide policy briefs and have environmental KPIs to show them.
Low Power, High Interest	**Retailers**(e.g., Amazon, H&M) **Commuters/End-Users**	Retailers would have a better delivery option and consequently a better service to the client; however, they do not have control over infrastructure, and many times, they outsource the entire delivery process. End-users also is crucial to consider because they create the demand for freight, and they might bring new suggestions previously not considered (and, 2001).	**Keep informed**: The use of surveys and co-creation workshops is essential to incorporate feedback and facilitate user acceptance.
Low Power, Low Interest	**Academia**	They provide technical advice and give credibility to the innovation. However, they are not the core operators or financiers but they need to be involved to develop comprehensive and sustainable last-mile solutions. (El Amrani et al., 2024)	**Monitor**: Use the research field to validate, give legitimacy to the solution, and include advisory roles in order to give feedback on the solution and effectively deploy it.

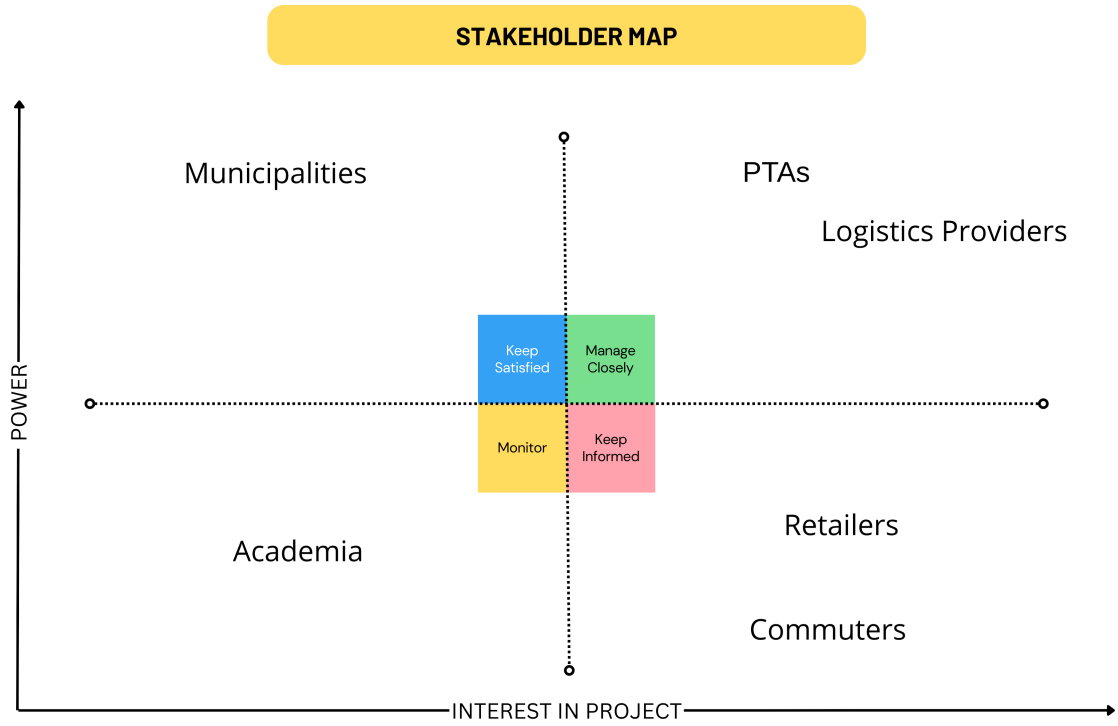

Figure 3.1: Stakeholder map – power-interest grid

4

Research approach and methods

4.1. Methodology

This section outlines the methodological approach used to gather relevant data and investigate the integration of mobile parcel lockers into public transportation systems.

Data gathering precedes every type of analysis. In this research, two different methods were employed to gather the data: (a) semi-structured interviews and (b) questionnaires.

This combination of qualitative data from semi-structured interviews and quantitative data from structured questionnaires can be reconnected to the triangulation methodology (Olsen et al., 2004). In particular, this mixed-methods approach enabled a robust analysis by incorporating diverse perspectives from key stakeholders and end-users, thus enhancing the validity and credibility of the findings.

In the process of gathering the correct data, it is crucial to identify the stakeholders who are most relevant and possess the proper knowledge to contribute in the best possible way to the research. The relevant actors have been identified through an in-depth stakeholder analysis based on the literature review, as shown in Table 3.1. After identifying the required roles, potential targets with the necessary knowledge and relevant fields of expertise, the different experts were contacted to schedule an interview. In this case, they were directly known people, or if they were not the first connection, a secondary person introduced the researcher to them. In the final phase, interviews were conducted with public transportation experts and logistics experts to analyze the perspectives of other stakeholders and users. Additionally, a questionnaire was used to gauge their possible acceptance level.

The decision to conduct semi-structured interviews with public transport, municipalities and logistics experts is based on the fact that semi-structured interviews are designed to gather strong, in-depth knowledge to answer complex questions, such as the deployment of a new solution. Conversely, the questionnaire for end-users has been used to gather quantifiable data that provides an overview, in this case, of their perception of lockers on board (Codó, 2008). The combination of both methods has enabled the research to incorporate both detailed expert insights and

broad user perceptions. This enables the scenarios developed to be both practically feasible and aligned with end-user needs and preferences. Moreover, this mixed-methods approach enables effective triangulation, which enhances the validity and reliability of the findings. This comprehensive integration ensures more robust and actionable insights, facilitating a better-informed decision-making process that is more user-centric.

Combining both methods allows the research to integrate detailed expert insights with broad user perceptions, ensuring that the developed scenarios are both practically feasible and align closely with end-user needs and preferences. This mixed-method approach enables effective triangulation, enhancing the validity and reliability of the findings by cross-verifying qualitative and quantitative data. Such comprehensive integration ensures more robust and actionable insights, ultimately facilitating better-informed and user-centric decision-making.

4.2. Semi-structured interviews conduction

Based on the stakeholders identified in section 3.7, we have identified the experts to be interviewed. The total number of interviews conducted is 11. A purposive, criterion-based sampling has been applied to try to reduce the bias as much as possible by letting varying ages and fields of work. In particular, 4 were logistics experts, 3 were public transportation experts, 2 were academic professors, 1 was a logistics expert who was also deeply involved in the public transportation field, and 1 was from municipalities. Moreover, their role also had diverse seniority given by the young or older age, passing from CEOs to young managers.

The method used was semi-structured interviews. The decision has been based on the fact that this type of interviews are more appropriate for addressing more complex social-behavioral research questions. In particular this include how a service should be implemented, which in this case is the lockers on public transportation (Adeoye-Olatunde & Olenik, 2021).

The deployment of this data collection strategy aligns with best practices identified in the literature. Specifically, on the five-phase framework developed by Kallio et al. (2016). The first step starts by confirming whether this study is aligned with the use of semi-structured interviews, and as highlighted before, the implementation of lockers on public transportation is a complex social-behavior study; consequently, it is a good fit. Second, in the interview, even though it was impossible to retrieve information on lockers on public transportation, this solution was influenced by several themes extensively treated in the chapter 2. Moreover, experts have been consulted to understand which questions were relevant for the study. An extensive stakeholder analysis has also been conducted 3.7 to identify all the relevant actors. The third phase is aimed at formulating the preliminary interview guide; this phase is critical because it is the one that transforms the conceptual insights and prior knowledge into a practical tool - the interview itself. According to the framework, this step also encompasses the design of researcher- and interviewee-friendly questions. In this research, the formulation of the guide was based on several key elements:

- Stakeholder categories identified with the stakeholder analysis
- Insights from the literature review, which gave background information
- The research questions, which helped to create the questions to ensure alignment with the study's objectives

Fourth, the framework sees the step of pilot testing. This was conducted with the first interviewee; however, given the nice response from the interview, it was kept as relevant material for the study. The fifth step represents the culmination of a rigorous process. In this research, the consolidation of the previous phases: After identifying the appropriate stakeholders (Step 1), theoretical and empirical knowledge mapping (Step 2), and creating an initial guide (Step 3), the interview questions were critiqued and fine-tuned to a limited extent through pilot testing and expert opinion (Step 4, informal piloting). Moreover, it is possible to find the entire interview guide in the Appendix D.

To conclude, by including all five framework phases, this study ensured that the semi-structured interviews were credible, confirmable, and dependable.

4.2.1. Qualitative analysis approach

To analyze the transcript derived from the interviews, the research has followed the approach highlighted in Figure 5.3. After cleaning the raw transcripts (Step 1), the researcher read the transcripts multiple times to become familiar with the content (Step 2). In the third step, open coding was conducted, in which key segments were labeled and grouped into emerging categories to allow the natural emergence of new insights. In the fourth step, the uncoded text, in this case, given the semi-structured nature of the interviews, was analyzed, specifically the part that was outside the transcript. In the final step, the categories were revised and merged, where needed, to extrapolate the main categories. This method enabled a structured and flexible interpretation of the expert perspectives, generating rich conclusions that addressed the core research questions.

4.3. Questionnaire

According to Jenn (2006), a conceptual framework that guided the development of the questionnaire is essential. In particular, the first step included the creation of a dependent variable, which in this case is the perception and acceptance of parcel lockers on public transport, as well as the independent variable that may influence it. The independent factors include demographic characteristics (such as age, nationality, and urban/rural residence), public transport and e-commerce usage habits, past exposure to lockers, motivations for public transport, desired features and trust-related considerations, and comfort with locker integration. All of these have been selected because of their possible directional influence on the perception and acceptance of the innovation.

To go more into detail, as it is possible to see in figure 4.1, the dependent variable is the perception and acceptance of parcel lockers on public transportation, which includes, first of all, the willingness to use such lockers (Q13, Q17, Q22, Q24), their trust in the system (Q14), which benefits they perceived (Q11, Q12, Q16), comfort and concerns related to this system (Q18, Q19, Q21, Q26), preferences for design or integration of the mobile lockers (Q15, Q20, Q25, Q27, Q28). However, several independent variables influence this central construct. On the left side, behavioral and experimental factors include the use of public transport, their online shopping habits (Q6, Q7), and their past exposure to lockers (Q9, Q10, Q23). On the right side, the trust and the desired features, such as 24/7 access and real-time tracking, are studied (Q15), as well as whether the end-users feel comfortable sharing the space with lockers and integration concerns

(Q18, Q19, Q20, Q26). At the top, there are the socio-demographic variables, which include the age (Q2), nationality (Q3), education level (Q4), and area of residence (Q5) of the respondents. At the bottom, the factors driving the use of public transportation are cost savings and time efficiency (Q8). Finally, the moderating themes influence the strength or direction of relationships between variables, such as trust and perceived reliability (Q14, Q19) and pen-ended improvement suggestions (Q25, Q27, Q28).

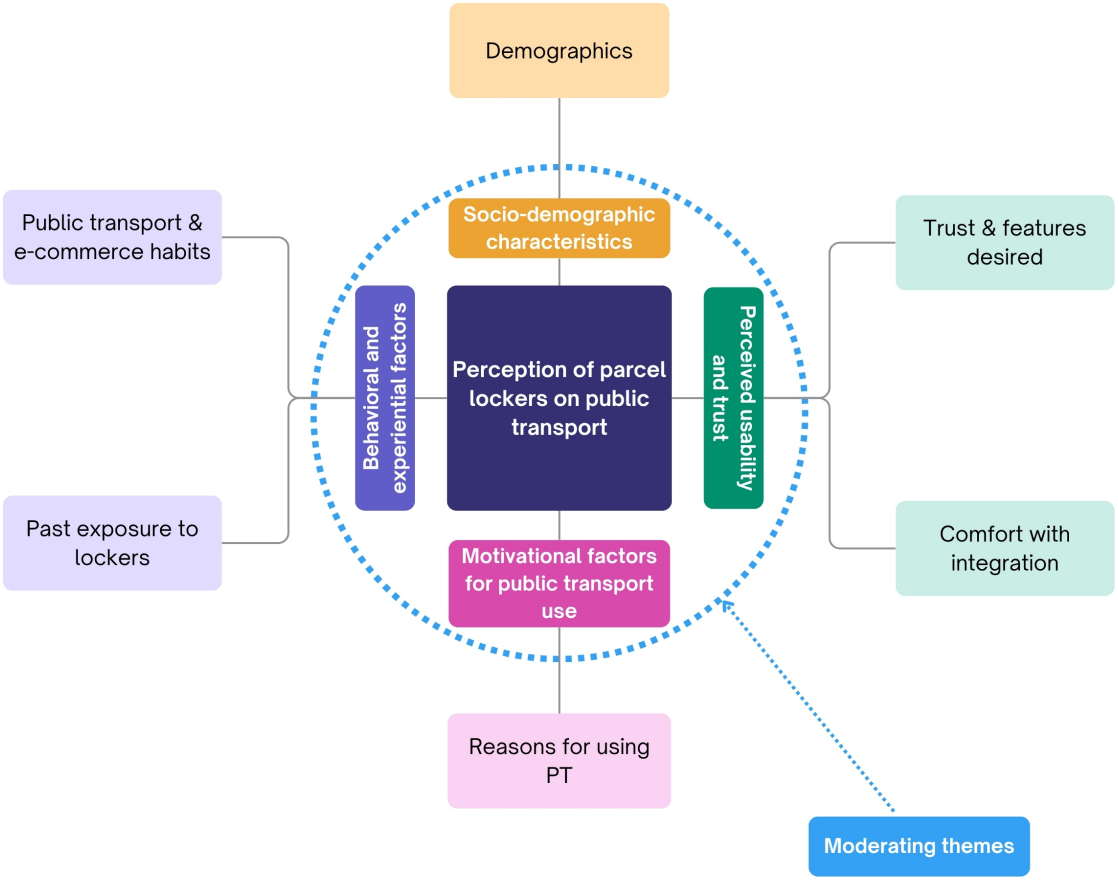

Figure 4.1: Design framework of questionnaire

Moreover, still according to Jenn (2006), the questionnaire needs to respect some core principles in order to be a good questionnaire: validity, reliability, clarity, interest, and succinctness. This questionnaire has been tried to be as much as possible according to these principles; first of all, validity has been reached by having all the questions that are clearly phrased in order to measure what they intend to and cover the key themes relevant to the research such as public transport usage, e-commerce habits, and perceptions of mobile parcel lockers. The careful use of the words and the inclusion of definitions where needed (e.g., for "trust") also increase the conceptual clarity. Regarding reliability, the questionnaire uses consistent, well-structured answer formats such as Likert scales and time frames that would have stable responses. In terms of clarity, the questions are short, non-ambiguous, and follow a logical order from general demographic information to more opinion-based questions. Moreover, there is a mix of closed and open-ended questions; this latter is to catch the opinion of the respondent and, in fact, are positioned at the end of the questionnaire in order to have it after the respondent has familiarized with the concepts. Finally, it is succinct, in fact, unnecessary complexity or length, and every

item contributes to the research objective.

4.3.1. Quantitative analysis

To analyze the questionnaire, a combination of descriptive statistics, comparative visualizations, and thematic categorization of open-ended answers was employed to gather as many answers as possible from the data. The closed-ended questions were processed quantitatively, and this has enabled a demographic analysis (e.g., age, education, residence) and behavioral traits (e.g., online shopping and PT usage) through frequency distributions and bar charts (Figures 6.1–6.4). The perceived usefulness and willingness to adopt were correlated to these traits (Figures 6.6–6.10) to identify possible patterns across user groups. Regarding the open-ended questions, they were manually coded and grouped into dominant themes (see Tables 6.1 and 6.2). This has enabled the extraction of preferences, conditions for acceptance, and perceived concerns. This multifaceted approach has ensured that both statistical trends and qualitative insights were captured.

4.4. Methodological reflection on research questions

The first sub-question (SQ1) on logistical, regulatory, and technical factors was addressed through the eleven interviews conducted. These latter have provided insights into real-world operational constraints, legal restrictions, and technological dependencies, and this has offered a broad understanding of the aspects that enable or inhibit the widespread of the solution.

The second sub-question (SQ2) was also explored through expert interviews. Although no numerical simulation was conducted, the reflections of the different stakeholders involved have allowed for the identification of KPIs to understand the impact of the solution.

Sub-question 3 (SQ3), which pertains to the perception of stakeholders, was addressed through the triangulation of interviews and user questionnaires. This was crucial because if, on the one hand, interviews captured divergent expert perspectives (e.g., urban vs. rural viability, PT vs. logistics sector views), the questionnaire (N=122) provided the end-user input, with the willingness to adopt this solution, the perceived usefulness and trust, with also design suggestion to increase the potential of successful deployment.

Sub-question 4 (SQ4), related to ownership models, has been addressed using qualitative data derived from interviews. Experts in the interviews discussed public, private, and hybrid ownership configurations, with a strong focus on shared infrastructure, multi-brand access, and context-dependent governance models. The inputs derived from the interviews were then used to develop and justify alternative deployment models.

The main research question was finally addressed through the integration of all findings across all methods and the combination of answers to the different subquestions.

5

Expert perspectives on on-board parcel lockers: a qualitative analysis

This chapter, which extracts key themes from 11 expert interviews, answers SQ1 by revealing the principal enablers and inhibitors of onboard lockers. Moreover, the interviews and their analysis help in understanding the different perceptions of stakeholders, thereby answering SQ3 and extrapolating the possible impact of on-board lockers, as well as how to measure it to address SQ2. During the interviews, the theme of ownership models also emerges, meaning that this chapter contributes to SQ4.

According to Lim et al. (2024), there are four main reasons to conduct qualitative research: the need to address complex social phenomena, the importance of generating rich insights and human-centered understanding, the relevance of connecting research to real-world issues, and the urgency to respond to rapid social changes. In this research, qualitative inquiry was essential; in fact, the introduction of parcel lockers into public transport systems is an innovation that relies on the perception of different stakeholders to analyze this complex innovation, given the intriguing interconnection to develop it. To better catch this complicated interaction with public transport and logistics experts, semi-structured interviews have been conducted, while to capture the perspective of end-user questionnaires have been done. Moreover, this innovation is so new and revolutionary that it needs to gain insights and a human-centric perspective to be deployed correctly with the help of experts. This idea also needs to be connected to real-world scenarios to understand the possible doability and the drawbacks that can create problems, and this innovation tackles many problems related to pollution, which has the urgency to be solved. Thus, it is clear that this topic fits perfectly within the conditions required for qualitative research. This latter will be conducted in this chapter accordingly to the approach of Thomas (2003):

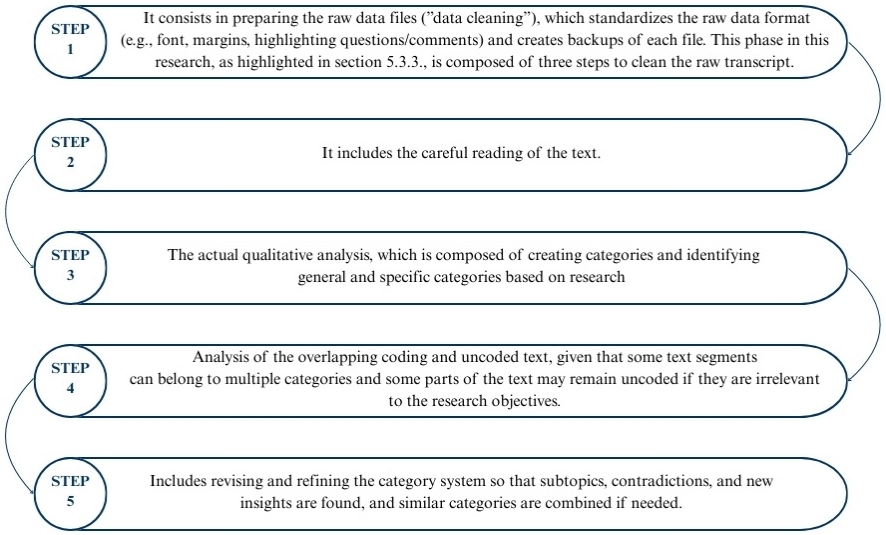

Figure 5.1: Process from open coding to thematic categories. Adapted from Thomas (2003)

5.1. Data preparation

It is important to follow established protocols to ensure consistency in the various interview data preparations and to minimize potential biases. In fact, a standardized method has been employed to prepare the audio and obtain the transcript. The process was planned to produce reliable, accurate, and clear transcribed content, which would provide a solid foundation for the subsequent qualitative analysis.

It is important to highlight that analyzing the audio data of each interview was the same for every interview to avoid any possible bias.

- **Phase 1: Automated transcription with Google Notebook LM**
  The first step was to listen to the audio, remove the parts that could reveal the identity of the interviewee, and use Google Notebook LM to generate the raw transcript, a full-text representation of everything said during the conversation. This software is used because it has good-quality speech recognition. Even though the first draft was structurally inaccurate, it gave a complete baseline for further refining.
- **Phase 2: Manual check and correction in Microsoft Word**
  The raw transcript was then cross-checked with Microsoft Word, including a built-in audio transcription feature. Using this feature, the audio transcription could be compared directly, and manual checks for misheard words, speaker identification errors, and unclear parts could be made. This step played a vital role in maintaining the transcription's accuracy, especially when background noise, overlapping speech, or diverse accents would have disrupted automated recognition.
- **Phase 3: Structural and linguistic refinement through ChatGPT**
  At this stage, the transcript was run through ChatGPT to clean up grammar, punctuation, and structure. Moreover, the transcript was reordered so that answers were matched to corresponding interview questions, which immensely facilitated thematic analysis subsequently. Using ChatGPT proved effective in transforming raw text into a polished and

analytically usable format without losing the original meaning and tone of the conversation.

Adherence to this three-step process ensured that the preparation of interview data was both systematic and replicable, reinforcing the study's methodological rigor.

After having prepared the raw data files, as highlighted in the first step of the process, the second step was to read the transcript carefully. However, this was an iterative process with continuous adjustments, which was done for all ten interviews. In the end, after completing these steps for all the interviews, the researcher reviewed all the texts to familiarize with the content, in fact as highlighted by Kyngäs (2020), the researcher should go through the data multiple times before analysis so that is able to perform a more effective qualitative analysis. This loop and repetition helped consistency in interpretation and created a good groundwork for the following coding phases.

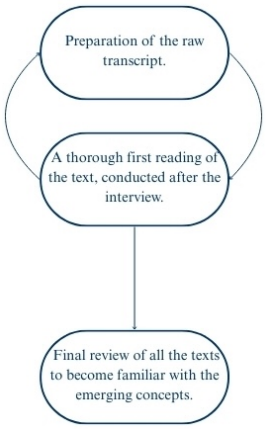

Figure 5.2: Steps to familiarize with the transcripts before qualitative coding.

5.2. Qualitative analysis

The third step is the core of the qualitative analysis, which consists of creating and identifying categories based on the coded words. To do this qualitative analysis, it has been decided to use inductive content analysis because it begins without predefined frameworks, utilizing open-ended data collection on undefined themes. It is advantageous when the topic has not been explored or the existing knowledge is limited, as highlighted in section 2.5. This step has been divided into three sub steps: **open coding**, **data grouping** and the **formation of concepts used to answer the research questions** (Kyngäs, 2020). Open coding is the initial stage of the qualitative analysis, in which data are reduced and labeled with code names; this approach is crucial to uncover new information (Strauss & Corbin, 1990). This first step was done singularly for each interview, as shown in Appendix B. The open coding was done by hand, identifying each coding word and writing it directly in the table while also selecting the text to which it refers. After that, there is the data grouping into concepts, which has also been done for each interview and by hand by checking the similar coding words, and it is possible to see it in Appendix C. And finally, there is the extrapolation of conclusions, which is the final step also of the entire qualitative

research and has been done to answer at the research questions, it is possible to find it in the fifth step section.

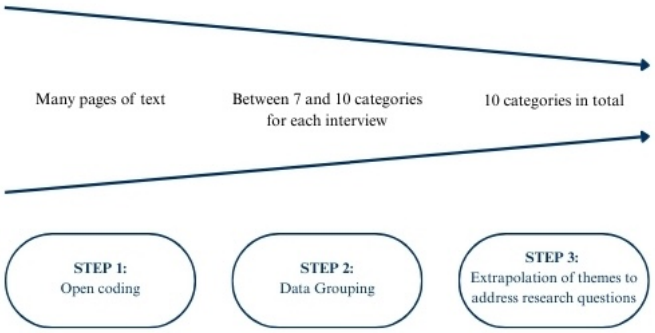

Figure 5.3: Three-step process from open coding to thematic categories.

5.2.1. Interviewee narrative

Given the length of the open coding and data grouping, they have been included in Appendix A and Appendix B, respectively. However, to facilitate the understanding of each interview and how it has contributed in different ways, the narratives of all 11 interviews are included in the actual research.

Table 5.1: Interviewee narratives

Interviewee narrative	Expertise	Summary of insights
First interviewee narrative	Logistics	The interest in the solution is increased by the environmental impact (Theme 9) and the potential niche market target (Theme 2). On the other hand, there are factors that hinder the deployment of this solution, such as the space constraints (Theme 3), the pickup reliability (Theme 4), and the operational complexity (Theme 5). This solution also strongly relies on a digital and technical basis (Theme 6) and a proactive approach from the government (Theme 7). However, also these considerations are sustained only if there is actual demand for the service (Theme 2).

Interviewee narrative	Expertise	Summary of insights
Second interviewee narrative	Mixed	The stationary lockers concept (Theme 2) is recognized as having substantial benefits in the decongestion of traffic and improving reliability. However, the idea of lockers on PT is new (Theme 1), and the benefit in this case seems to be only in rural areas. Many concerns on operational complexity(Theme 3), regulatory and safety conditions(Theme 5), and the necessity of financially viable incentives (Theme 6) are raised and strongly impact the feasibility in the short term. Moreover, the success depends on adequate digital and technical infrastructure (Theme 4) and effective stakeholder coordination (Theme 8).
Third interviewee narrative	Mixed	Strong support for this innovative idea emerged due to the perceived environmental, logistical, and economic advantages (Theme 3). This is the only interviewee who already knew the solution and had previous exposure to EU-funded locker projects (Theme 2). Even though the expert is strongly supportive, some constraints are recognized related to operational, spatial, and safety issues (Theme 4), which can only be mitigated through a well-thought-out and digitally robust system (Theme 5). Additionally, there are Regulatory constraints and governance uncertainty (Theme 7). Because of the solution's intricacy, technical feasibility and strategic stakeholder buy-in must be considered (Theme 6). Finally, the importance of iteratively co-designing and piloting first (Theme 8) is vital.
Fourth interviewee narrative	Logistics	The possible environmental advantages partially drive the interest in lockers; however, given the evolution of the current electric van evolution, these benefits are reduced (Theme 6). Moreover, their adoption is influenced by the context in which this innovation is inserted (Theme 7). The most problematic aspects are the operation and vehicle-space constraints (Theme 3) and the need for an effective coordination system (Theme 4). The regulatory bans, worker-based restrictions (Theme 2), and the tight economic margin (Theme 5) only reduce the probability of a successful deployment.

Interviewee narrative	Expertise	Summary of insights
Fifth interviewee narrative	Logistics	The interviewee compares the lockers on the PT to the stationary lockers, and this rapid comparison (Theme 2) quickly reveals how the lockers at the bus station offer a more straightforward and scalable solution. In fact, the feasibility would be influenced by Stringent operational and spatial constraints on trucks (Theme 3), the human capital burdens they create (Theme 4), and network regulatory and safety barriers (Theme 5). In addition to these problems, there is organizational opposition from courier branding agreements (Theme 6) and a complex, low-margin business model (Theme 7); even the green advantages are considered marginal, thanks to the advent of electric vans. In conclusion, the final verdict is that the practical application would be unrealistic (Theme 9).
Sixth interviewee narrative	Public Transport	Smart-city (Theme 3), a concept very close to the interviewee's knowledge, policy incentives for EU funding investment are the drivers for the demand for onboard lockers. However, significant challenges remain: lockers reduce passenger seats and service accessibility (Theme 4), and the financial model is unconvincing due to unclear returns and high capital costs (Theme 5). Moreover, operational and security risks (Themes 6 and 9) could increase the resistance from stakeholders. A crucial enabler is coordination (Theme 7), which manages courier integration and data protection to operationalize the system across MaaS platforms. Another important aspect highlighted is the context; in fact, the scalability of this solution is limited to metro areas with enough demand to offset lost seats (Theme 10).
Seventh interviewee narrative	Logistics	According to the interviewee, there are clear environmental and cost benefits (Theme 2) and strong retail/logistics stakeholder demand (Theme 6). However, the mix of freight and passengers in vehicles creates many concerns about space, time, safety limitations (Theme 3), and liability (Theme 5). These problems can be reduced with a secure digital platform (Theme 4), which can minimize coordination risks and increase transparency. Another aspect to consider in the financial viability is implementing the system in only high-density, high-volume transit corridors (Theme 7).

Interviewee narrative	Expertise	Summary of insights
Eighth interviewee narrative	Public Transport	According to the expert, punctuality and passenger capacity are the primary concerns (Themes 3 & 4). Even though the onboard lockers are innovative (Theme 1), they pose operational risks; in the context of the interviewee, the risk spans across a 5,400-train-per-day network. These risks are compounded by logistical complexity and vehicle-modification costs (Theme 5), and the business model struggles under-regulated revenue constraints and low end-user willingness to pay (Theme 6). The flexibility is also limited by legal and policy frameworks (Theme 7).In order for the model to gain traction, stakeholders—operators, couriers, regulators, and passengers—must be aligned in a margin-neutral, service-safe system (Theme 8).
Ninth interviewee narrative	Logistics	The interviewee perceives time savings, cost cuts, and environmental as perceived benefits (Theme 3). However, there are real risks related to Space and accessibility constraints (Theme 4) and highly sensitive timing and coordination challenges (Theme 5), especially given the design of PT, which has the passengers' highest priority. Regulatory and legal issues (Theme 7) further narrow what is physically and legally possible, while technical layers (Theme 8) are required just to reach basic functionality. Underlying the alignment needed in the business model of couriers, cities, and PT operators is essential in a shared-revenue and shared-risk model (Theme 9).
Tenth interviewee narrative	Public Transport	The concept of the onboard lockers is new to the interviewee (Theme 1); the green branding for PT, CO_2 cuts, and added revenue potential for PT (Theme 3) are the perceived benefits. On the other hand, severe space, boarding, and battery-weight trade-offs (Theme 4) and service-flow complexity (Theme 5) are seen as significant challenges. To overcome these challenges, a robust digital backbone (Theme 7) and tamper-proof locker design are essential. Even if all these challenges are overcome, there is the need to establish clear existing risks and satisfy labor/insurance obligations (Theme 6), within a policy landscape that must evolve to support freight-on-PT services (Theme 8). The end success hinges on multi-actor coordination and balanced economics (Theme 9).

Interviewee narrative	Expertise	Summary of insights
Eleventh interviewee narrative	Public Transport	The interviewee is the regional mobility director of the Italian region of Molise, and the concept is new to the expert (Theme 1). The benefits perceived are the increased reach of rural areas, lower delivery costs, anti-depopulation effects, and CO2 reduction (Theme 2). Specifically, Molise could be the proper context because its inter-urban bus service usually runs with empty luggage bays where packages could be easily stored (Theme 3). However, a problem that emerged is helping residents "catch the right bus," given the high number of repeated runs daily. Moreover, the engagement of the bus driver in the remote delivery is crucial (Theme 4). To overcome this problem of "catch the right bus" problem, a real-time-tracking system for the package is needed, and a one-time digital code to retire the package is also crucial (Theme 5). In the region of Molise, there is already a mix of passenger and goods transport, so there is only the need for slight policy improvement to have the actual formalization (Theme 6). Financial incentives for drivers and operators are crucial to guarantee the service, and clear logistics ownership is also needed to coordinate the service. Finally, the expert noted that rural and regional networks like Molise provide good ground to implement this innovative service.

5.2.2. General sentiment across interviewees

Across the eleven interview, three different thoughts emerged, who is skeptical, who is in favour and who thinks the success depends on the conditions. Their positions were shaped by deeper views on how cities work, how the logistics need to evolve accordingly.

1. The skeptics: lockers off the bus. Interviews 4 and 5 were the ones most against the idea of lockers on board public transport. To them, the idea had several problems; first, the addition of lockers removes seats that generate revenue, which is a red line for them. Even if there is a way to accommodate them, the coordination costs, such as missed pickups, rescheduled drop-offs, and returns, would drastically reduce the savings. Moreover, there is also a structural problem: courier companies need cages that are branded so one train cannot carry an Amazon cage, a UPS cage, and a DHL cage all at once without creating chaos. However, they were not completely closed, but they saw fixed lockers at transit hubs as the most viable solution. Indeed, this solution already has the advantages associated with lockers, but it does not compromise the transit capacity.

2. The pragmatists: if the conditions are right. In this section, interviews 1, 9, 8, 10, 6, and 2 were the ones that were in the middle and context-dependent. For them, the context was essential; no one wanted to see lockers during peak hours, but only in off-peak hours or on long distances and rural trips. Alternative solutions, which maintain the interaction between public transport and logistics, have also emerged, such as buses that replenish stationary lockers. However, these interviews highlighted that, before this project was launched, there was a need for specific regulations that would allow for careful consideration of vehicle accessibility for the mix of freight and passengers, as well as a digital platform to facilitate communication among all these actors. They have been placed in this halfway category because their tone was constructive, even if they were not completely for or against the idea.

3. The enthusiasts: ready for the pilot phase. Interviewees 3, 7, and 11 were the most supportive, seeing this solution as an opportunity. For instance, interviewee number 11 saw this solution as an opportunity to avoid the depopulation of rural areas by young people. For them, the environmental benefits were also significant, specifying that this would have a huge impact because the majority of delivery vans still use fossil fuels (Interview 7). However, they also had some conditions, real-time, open-data APIs, secure loading windows, and strict neutrality, which have been highlighted as crucial to prove the efficacy of the concept.

It is interesting to notice that the "skeptics" were from a logistics background. The "pragmatists" were from a variety of backgrounds and were the most significant portion. The "enthusiasts" were found across all sectors, indicating that this optimism is more about the mindset than the job title, unlike the "skeptics." There are also some common themes across everyone that will be discussed more deeply in the tab 5.15. Everyone agrees that real-time tracking is crucial; peak hour is a universal no-go for this solution, and regulation and coordination are the real problems.

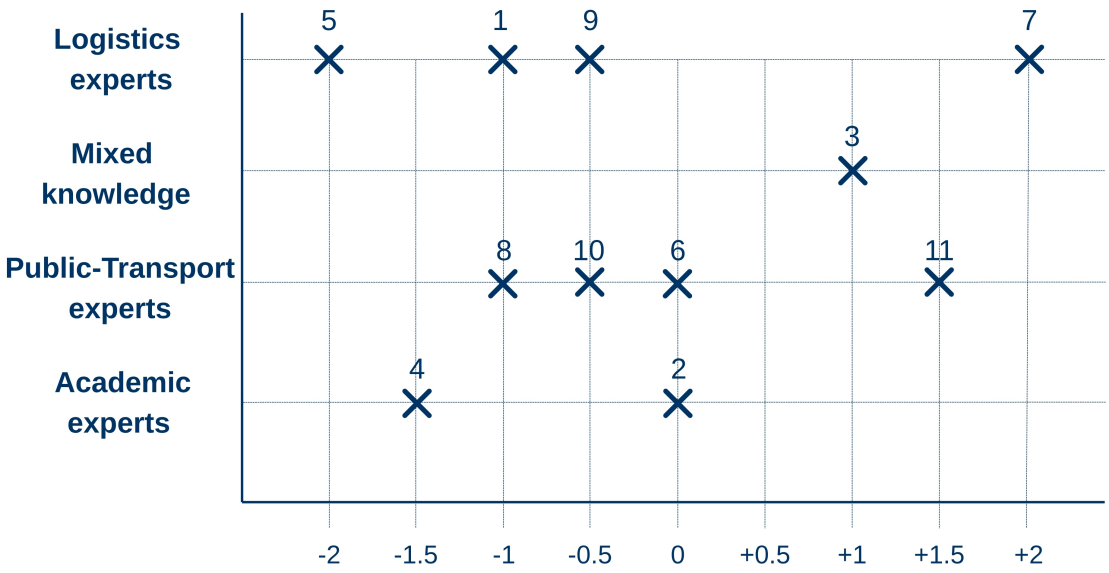

Figure 5.4: Support for on-board parcel-locker(- skeptical <- -> supportive +)

5.3. Uncoded text analysis

The fourth step codes the texts that have remained uncoded because they are not relevant to the research objectives. However, even though the third step coded the structured part of the interview, the semi-structured nature of the interview raised some extra themes. Given their interesting insights, the unstructured part will follow the same coding process: open coding, data grouping, and forming concepts to answer the research questions.

Extra themes open coding

Table 5.2: Extra Theme 1 (Interview 1)

#	Code label	Brief description	Literal source text
1	Limited window pickups	Same day retrieval → night reprocessing cost	"pickup window ... limited ... collect and reprocess it the same evening"
2	Mobile locker failure = fail	No second chance if locker breaks in transit	"if the locker is on a train ... the delivery fails completely"
3	Wheelchair-space	Removing accessible area deemed unacceptable	"taking away something essential from a vulnerable group ... isn't acceptable"
4	Eco-commuter target	Appeals to riders who already choose PT for environmental reasons	"could appeal to people who ... take public transportation regularly"
5	Demand	Feasibility hinges on market research	"If there's no real interest ... it doesn't matter how innovative the idea is"

Table 5.3: Extra Theme 2 (Interview 2)

#	Code label	Brief description	Literal source text
1	Flexibility loss trade-off	Users don't like being tied to bus/train timing	"don't like being tied to a specific time and place"
2	Real time rerouting	Exceptions handled with redirection	"have it dropped ... or transferred to a fixed locker nearby"
3	PT fee per parcel model	New R revenue encourages the operators buy-in	"earn a fee per delivered parcel—especially on remote routes"

#	Code label	Brief description	Literal source text
4	Ownership ambiguity	CAPEX & risk vary with locker owner	“business case changes ... whether the lockers are owned by ... provider, operator, or third party”

Table 5.4: Extra Theme 3 (Interview 3)

#	Code label	Brief description	Literal source text
1	Premature launch risk	An early flop could affect future adaption	“risk it failing early and leaving a negative impression”
2	Staff design input	Need day-to-day staff suggestion	“low-level staff ... will know what the real problems are”
3	Placement -> audience	Vehicle lockers serve industry; station lockers serve consumers	“placement defines the audience”
4	Ramp / safety constraints	Loading on bus faces physical & safety limits	“ramps might not support the equipment ... safety becomes a concern”

Table 5.5: Extra Theme 4 (Interview 4)

#	Code label	Brief description	Literal source text
1	Emergency fix cost wipe out	One failure erases savings of many successes	“One failure can wipe out the savings of ten successful runs”
2	Movement using PT	Use PT to move parcels, not to store them	“exploit empty kilometres to shuttle parcels between hubs”
3	Operator own lockers	PT owns hardware; lean platform books slots	“Lockers should belong to the transport operator ... slim external platform handles booking”

Table 5.6: Extra Theme 5 (Interview 5)

#	Code label	Brief description	Literal source text
1	Turin bus stop pilot	Fixed stop lockers work, no passenger-space loss	"good turnover and—crucially no loss of passenger space"
2	Agnostic locker	Neutral lockers avoids possible conflicts among couriers	"Neutral ownership is the only way ... avoid ... 'one bus for Amazon, another for DHL'"
3	Parcel loop	Missed bus means parcel keeps going around	"the item just keeps looping the route"

Table 5.7: Extra Theme 6 (Interview 6)

#	Code label	Brief description	Literal source text
1	Unified digital infrastructure	Merge mobility & logistics in one platform	"true smart city operation requires a single digital infrastructure"
2	2050 urban-freight imperative	Increase urbanisation makes freight sustainability critical	"70% ... will live in cities ... freight sustainability is therefore crucial"
3	Live vehicle data	Existing PT companies can support parcel tracking	"most bus agencies already share live positions"

Table 5.8: Extra Theme 7 (Interview 7)

#	Code label	Brief description	Literal source text
1	Empty vehicle loading	Loading only when there are no passengers on-board due to safety issue	"loaded only while the vehicle is empty"
2	Roller-cage + strap securing system	Simple, repeatable containment method	"roller cages ... a simple strap/belt is added for extra stability"
3	Container-barcode tracking	Scan bag/cage once → low handling	"only the bag/cage barcode is scanned ... minimising handling"
4	Dynamic operator bans	Extra safety rules may appear overnight	"additional bans (e.g., e-scooter battery) ... dynamic rules"

Table 5.9: Extra Theme 8 (Interview 8)

#	Code label	Brief description	Literal source text
1	Station locker precedent	DB's station lockers as real-world example	"Deutsche Bahn's station-based parcel-locker programme"
2	Dual revenue regimes	Subsidised rail can't keep profits	"regulated services ... must return surplus to the State"
3	Punctuality fragility	5400 daily trains in Italy, 3 min delay create a domino-effect	"even a three-minute delay can ripple across seven trains"

Table 5.10: Extra Theme 9 (Interview 9)

#	Code label	Brief description	Literal source text
1	Saturation risk	Missed pickups fill locker capacity	"missed pickups can quickly saturate the system"
2	Bulky item incompatibility	Vehicle space suits only small parcels	"Bulky goods ... incompatible with vehicle space"
3	User punctuality	Success of the delivery depends on rider discipline	"hinges more on end user punctuality than provider performance"

Table 5.11: Extra Theme 10 (Interview 10)

#	Code label	Brief description	Literal source text
1	Privacy vs misuse dilemma	Secrecy invites illicit shipments	"could tempt people to move drugs'"
2	On board social awkwardness	Opening locker in crowd might make customer uncomfortable	"feel pretty awkward opening a locker in a packed bus"
3	Courier night time safety	Thieves may target late night off loads	"two minutes for them to clear out the load"
4	Fixed locker restock by buses	Off-peak buses as 'after-hours delivery vans' avoids on board issues	"using off-peak buses as 'after-hours delivery vans' to restock [fixed] lockers"

Table 5.12: Extra Theme 11 (Interview 11)

#	Code label	Brief description	Literal source text
1	Rural vs urban context	The solution is perceived as easier in a rural area such as Molise than in a metropolitan area such as Milan.	"I believe this kind of solution might work well in a rural region like Molise, but it would be much harder to implement in a big city like Milan."
2	Urban space constraints	In urban areas, buses are more crowded, and there is no space to retrieve the package.	"In urban settings, buses are often full, and there's no space to place lockers or allow people to access them during a crowded ride."
3	Rural space and route simplicity	The higher physical space and the simpler routes that are present in rural areas increase the successful deployment	"In contrast, here we usually have more space available, and the structure of the routes is simpler to manage."
4	Driver interaction	In rural areas, the exchange of packages will probably require interaction with the driver.	"From my experience, especially in smaller communities, the handover of a package would likely involve some direct interaction with the driver."
5	Informal interaction	Informal exchanges and services with the driver are common in Molise.	"That's quite normal around here—people are used to informal exchanges and services."

5.3.1. Extra themes data grouping

Data grouping of extra-theme interviews

Theme	Associated Codes	What Binds These Codes
Timing, reliability & service-flow risk	ET1-1, ET1-2, ET2-1, ET3-1, ET4-1, ET5-3, ET7-1, ET8-3, ET9-1, ET9-3	Highlight how the very short pickup window, schedule slips, or rider non-punctuality can create a domino effect on service delays, consequently causing delivery to fail and the innovation to face premature reputational damage.

Physical space, energy & accessibility constraints	ET1-3, ET3-4, ET4-2, ET7-2, ET7-4, ET9-2, ET10-2, ET11-2, ET11-3	Illustrate the hard constraints posed by the interior design of the vehicles: loss of wheelchair space, added weight on e-buses, ramp or securing hardware, sudden safety bans, customers' discomfort, and the reality that only small packages fit.
Business model, ownership & revenue sharing	ET2-3, ET2-4, ET3-3, ET4-3, ET8-2, ET10-4	Focus on who pays CapEx and OPEX, how fees are split, and how on-board placement or public vs market rail regimes of stations change the math for profitability.
Market fit, demand & user segments	ET1-4, ET1-5, ET3-2, ET5-1, ET6-2, ET8-1, ET9-2, ET10-2, ET11-1, ET11-5	Questions regarding the actual demand, what audiences (eco-commuters, remote users) get reached, and what pilots and past experiences show about latent demand.
Security, privacy & liability	ET10-1, ET10-3, ET7-4, ET1-2, ET3-4	It highlights issues regarding possible theft, illegal goods, night driver safety, surprise prohibitions after accidents, and who pays if the moving locker fails.
Digital & data-exchange infrastructure	ET2-2, ET6-1, ET6-3, ET7-3, ET8-3, ET7-2, ET9-1	Collection of data plumbing-GTFS feeds, integrated MaaS freight layers, APIs for rerouting, scan-based hand-offs that enables strong, scalable operation.
Operational workflows & mitigation tactics	ET4-2, ET6-3, ET7-1, ET7-2, ET8-3, ET10-4, ET3-2, ET11-4	More practical solutions encompass off-peak or depot loading, cage-based handling, using buses outside of hours, and co-designing with frontline staff to preserve passenger service flow while adding freight tasks.

Policy, regulation & governance levers	ET7-4, ET8-2, ET6-2, ET6-1, ET3-1, ET5-2	External rules, public service contracts, sudden safety bans, green-deal goals, and neutral access can influence the concept and accelerate or slow down adoption.

5.4. Combination of similar categories

In this last step, after having checked all the categories, which can be found in Appendix C, they have been grouped based on similarities. The output labels of the data grouping have been grouped under common themes based on their content and seen how often they emerged in the structured transcript. Some themes are prevalent across interviews, reaching a 9 out of 10 frequency. However, overall, it is possible to notice a general homogeneity across categories, so it is possible to understand that the thematics that influence the solution are similar across all the experts, considering both advantages and disadvantages.

Table 5.14: Recurrent themes across data grouping analysis

#	Theme (shorthand)	How often?	Typical coding labels
1	Governance, regulation & liability	10 / 11	Governance, regulation & stakeholder alignment [Int. 1] · Regulatory, safety & design requirements [Int. 2] · Regulatory landscape [Int. 3] · Existing locker landscape & regulatory issues [Int. 4] · Regulatory & safety barriers [Int. 5] · Governance & funding needs [Int. 6] · Absence of rules and liability issues [Int. 7] · Regulatory regimes [Int. 8] · Legal, privacy rules [Int. 9] · Regulatory framework [Int. 10] · Legal & policy framework [Int. 11]
2	Business model & incentives	10 / 11	Business model & incentives [Int. 2] · Business model, incentives & stakeholder economics [Int. 4] · Business model [Int. 5] · Revenue trade-off [Int. 6] · Business Model [Int. 7] · Economic viability barriers [Int. 8] · Business Model, incentives & stakeholder alignment [Int. 9] · Business model [Int. 10] · Business model, incentives & stakeholder alignment [Int. 11]
3	Vehicle-space / physical-integration constraints	8 / 11	Vehicle Space & Physical-Integration constraints [Int. 1] · Operational & capacity challenges [Int. 4] · Spatial constraints & passenger experience on vehicles [Int. 5] · Vehicle-space & accessibility constraints [Int. 6] · Vehicle space & passenger-capacity constraints [Int. 8] · Vehicle-space & accessibility constraints [Int. 9] · Physical space, energy & accessibility constraints [Int. 10] · Vehicle space & capacity constraints [Int. 11]
4	Operational complexity, timing & labour	9 / 11	Timing, pick-up & return risks [Int. 1] · Operational & logistical challenges [Int. 2] · Operational & capacity challenges [Int. 4] · Staffing, coordination & delay risks [Int. 5] · Operational Complexity [Int. 6] · Passenger–freight mix risks [Int. 7] · Timing, punctuality & user punctuality risks [Int. 9] · Service-flow & timing risks [Int. 10] · Operational-coordination challenges [Int. 11]

#	Theme (shorthand)	How often?	Typical coding labels
5	Technical / digital enablers	9 / 11	Technical & digital requirements [Int. 1] · Technical & data enablers [Int. 2] · Technical & digital enablers [Int. 3] · Digital coordination requirements [Int. 4] · Data fragmentation [Int. 6] · Digital platforms [Int. 7] · Digital & security tech requirements [Int. 9] · Digital infrastructure [Int. 10] · Technology requirements [Int. 11]
6	Environmental impact / sustainability case	9 / 11	Environmental benfit [Int. 1] · Environmental & economic impact [Int. 2] · Expected benefits [Int. 3] · Environmental considerations [Int. 4] · Environmental impact limited [Int. 5] · Smart-City concept / Impact-assessment metrics [Int. 6] · Environmental, cost & user-convenience value propositions [Int. 7] · Environmental metrics [Int. 9] · Perceived value & societal benefits [Int. 11]
7	Stakeholder coordination & alignment	7 / 11	Governance, regulation & stakeholder alignment [Int. 1] · Stakeholder coordination [Int. 2] · Stakeholder attitudes [Int. 3] · Business model, incentives & stakeholder economics [Int. 4] · Governance & funding needs [Int. 6] · Stakeholder alignment & incentive requirements [Int. 8] · Business Model, incentives & stakeholder alignment [Int. 9]
8	Existing locker precedents vs. novelty	6 / 11	Existing locker landscape & regulatory issues [Int. 4] · Existing pilot [Int. 5] · Existing station-hub project [Int. 6] · Interviewee expertise & Existing demonstration [Int. 7] · Station-locker precedent [Int. 8] · Closest precedents [Int. 10]
9	Security & safety (physical & cyber)	6 / 11	Regulatory, safety & design requirements [Int. 2] · Operational, Capacity & Security Risks [Int. 3] · Regulatory & safety barriers [Int. 5] · Security & safety barriers [Int. 6] · Security & safety barriers [Int. 8] · Security, liability & labour barriers [Int. 10]
10	Impact-measurement / KPIs	4 / 11	Impact Measurement [Int. 3] · Impact-assessment metrics [Int. 6] · Impact Assessment [Int. 7] · Evaluation Metrics [Int. 10]

5.5. Conclusions

At this point, the entire qualitative analysis has been conducted; consequently, the conclusion of this analysis will be extrapolated following the natural flow of the analysis.

Table 5.15: Qualitative analysis conclusion

#	Takeaways	Relevant supporting codes*
1	**The opportunity in the market is narrow and niche.** The concept can thrive in (a) very high frequency metro/BRT in which commuters are already communicating daily and can "piggyback'' parcel pick-up, or (b) low-demand rural lines that have to do their service with plenty of spare capacity and have low frequency, so synchronization is easier. Otherwise, fixed lockers and pickup-point networks have already solved the missed-delivery problem very cheaply.	I1 #4, 45, 46 I2 #7, 37 I3 #50 I5 #5 I6 #41, 42 I7 #49, 50 I8 #41, 42 I9 #38 I11 #2, 4, 7, 35, 38, 39
2	**Vehicle space and accessibility are the firm physical boundaries.** Wheelchair bays are displaced by the onboard locker; moreover, there is a lot of congestion during peak hours. A high-speed train could be a more viable solution, however, only in the restaurant carriage.	I1 #5, 6, 7, 25 I2 #12, 21 I3 #13, 26 I4 #18, 20 I5 #7, 13, 20, 30 I6 #8, 23, 24, 35 I7 #31, 46 I8 #22, 23, 24 I9 #5, 17, 31 I10 #9, 20, 31 I11 #17, 21, 33, 36, 37
3	**The dominant operational challenge is the parcel, vehicle, and rider synchronization.** One missed depot window or a no-show of the rider generates costly loops, and for instance, in Italy, with $> 5\,400$ daily rail departures, a slip of three minutes is unacceptable; even worse would be on the bus.	I1 #8, 9, 17, 18, 19, 30–33 I2 #10, 11, 14, 15, 22, 48 I3 #24, 25, 27, 39 I4 #10, 14, 21, 22, 26, 27, 37 I5 #11, 12, 21, 22, 27 I6 #14, 38 I7 #14, 23, 24, 34, 47 I8 #15, 16, 17, 18, 25, 26, 27 I9 #6, 12, 14, 15, 32, 33 I10 #10, 11, 21, 22, 24–28, 50 I11 #8, 9, 15, 19, 29, 31

*Notation: I1–I10 denote Interviews 1–10; numbers are the open-coding IDs, which can be found in Appendix B

#	Takeaways	Relevant supporting codes
4	**A real-time, interoperable system is crucial.** It needs to be combined with live feeds, slot-allocation APIs, and one-time codes, which are prerequisites. However, this cannot solve the problems related to laws and policies; it can only create the prerequisites.	I1 #26–29 I2 #24–27, 35 I3 #35–39 I4 #11–13, 24, 35 I6 #39, 43 I7 #25, 26, 36, 37 I8 #25, 26 I9 #22, 23 I10 #38, 43, 44 I11 #16, 22, 23
5	**The economics at the base of this service is that paying for the seats you remove is required.** PT operators want to rent or have a risk-free margin; couriers only play if net cost beats van delivery and riders are price-sensitive. Moreover, ESG branding or locker-door advertisements don't cover the gap.	I1 #6, 15, 16, 41, 42 I2 #18–20, 43, 45–47 I3 #40–42 I4 #15, 16, 17, 25, 28 I5 #18, 22, 29, 34, 35 I6 #13, 27, 44 I7 #19, 41, 42, 43 I8 #7, 10–14, 20, 27–30, 33, 34 I9 #7, 10, 11, 25, 28, 35 I10 #15, 18, 45 I11 #5, 11, 14, 24, 28, 32
6	**Law, labor deals, and security measures block the near-term deployment.** In fact, safety regulations continue to ban mixed passenger-freight transport, anti-terror locker bans remain in place, unions forbid assigning parcel tasks to drivers, and accessibility requirements cannot be negotiated.	I1 #13, 14, 22 I2 #29–31, 34 I3 #14, 31, 32 I4 #4, 5, 23 I5 #14, 23–26 I6 #19, 23, 24, 36, 37 I7 #5, 21, 27–30, 45 I8 #19, 35 I9 #17–19 I10 #31–35 I11 #10, 12, 18, 20, 26, 30

*Notation: I1–I10 denote Interviews 1–10; numbers are the open-coding IDs, which can be found in Appendix B

#	Takeaways	Relevant supporting codes
7	**The environmental benefit is good but narrow.** The van-kilometer substitution is excellent if the fleet is diesel; otherwise, electric vans and other stationary lockers are already shrinking the benefit, especially in big cities.	I1 #10, 34, 35 I2 #5, 6, 38, 39 I3 #8, 9, 43–45 I4 #29–31, 38 I5 #31 I6 #11, 28, 29 I7 #9, 38, 39 I8 #30 I9 #26 I10 #7, 47 I11 #6, 25, 34, 40
8	**Station or stop-based agnostic lockers are the pragmatic answer.** The experts converge on fixed, multi-carrier lockers at hubs—already in Turin and Madrid. This way, they capture all the advantages without having the problems caused by in-vehicle lockers.	I1 #22, 25 I2 #27 I4 #10, 17 I5 #4, 33, 37 I6 #5, 16 I7 #4, 48 I8 #5, 44 I9 #29 I10 #50

*Notation: I1–I10 denote Interviews 1–10; numbers are the open-coding IDs, which can be found in Appendix B

After the deep analysis of eleven expert interviews, a combined picture is drawn: on-board parcel lockers are technically doable, economically unproven, operationally very complex. Unless the city itself rewrites all the accessibility laws, subsidises lost seats and mandates green freight, the smarter bet is scaling agnostic station lockers. The physical constraint is the first break; the lockers displace revenue-earning seats or legally protected wheelchair bays, and no metro, tram, or bus has free floor space at rush hour. Even high-speed trains can spare only restaurant and carriage space. Operational is the second brake: there is no margin for misloaded cages, late couriers, or rider no-shows, given the thousands of daily departures. If a three-minute window is missed, this has a domino effect, causing expensive reverse logistics loops. Economics, therefore, rely on reimbursing public transport operators for lost seats; couriers will join only if total cost drops below van delivery, riders are still influenced by price and branding, and locker door promotion rarely compensates. The climate dividend, however, is significant in rural diesel networks but negligible in big cities with electric vans. Not unexpectedly, almost every practitioner finds himself drawn to fixed, multi-carrier lockers at stops or bus stations, which capture most of the green and convenience advantages with no on-board suffering. The bottom line is that the concept is technically viable but economically unproven and operationally complex. Legislative change lost seat subsidies, and aggressive city mandates for green freight are needed. However, the safer bet is an agnostic station locker.

6

Questionnaire-based analysis of user acceptance for mobile parcel lockers

Chapter 6 completes SQ3 by presenting the end-users perception through the analysis of the questionnaire. Additionally, it provides new information to SQ1, as extrapolated from the questionnaire responses.

In order to complement the expert interviews and provide a user-centered perspective related to onboard parcel locker viability, a questionnaire found in appendix D has been distributed among potential users. The questionnaire offers demographic and behavioral profiles of the respondents and their possible levels of acceptance of this innovative service. In addition to these outcomes, it is possible to map (a) practical enablers and barriers creating new insights for sub-question 1; (b) helps in justifying the answer to sub-question 3 with a data-driven approach, which helps the direct quantification of end end-users trust, acceptance, and willingness to adopt the innovation; (c) highlights the attributes that value this solution, contributing to sub-question 4.

6.1. Sample Characteristics

This section will analyze the sample structure to understand how respondents' background might influence their perception of last-mile logistics. First, the age group profile has been analyzed because older people might prefer usability or accessibility. In comparison, younger people might be more focused on the innovation and evolution of digital technologies without caring about eventual problems. After this, the education level has been analyzed; this can influence the answers given that if the respondents have higher education, their technology literacy can be higher, and their sophistication expectations on, for instance, environmental impact, can be higher. Finally, the place of residence is explored to understand how density, infrastructure, and transportation options affect the last-mile perception. The three analyses provide a rich sample portrait, enabling a complete interpretation of attitudinal and behavioral findings.

Age-group distribution: the majority of the sample (68 out of 122) is between 18-25 years old,

followed by smaller groups with the age of 46–55 (20 interviewees) and 26–35 (18 interviewees). The number in the 36-45 or above 55 range is extremely low. Crucial to highlight is the fact that given that the majority of the sample is very young, the general sample might be more familiar with digital services and potentially more inclined towards adopting innovations. However, even if they are present in smaller groups, the older age groups can reveal interesting information on other aspects, such as usability and accessibility, that young people might overestimate.

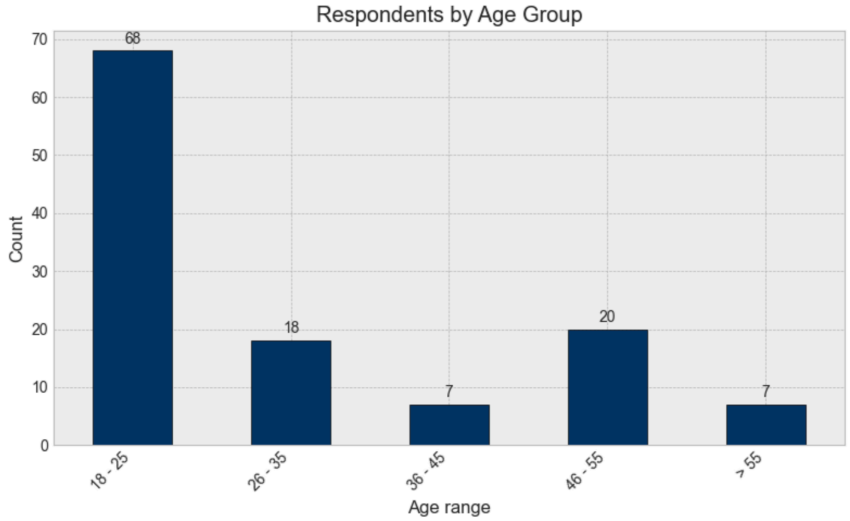

Figure 6.1: Age-group distribution

Education level: the majority of the respondents hold a bachelor's degree (49 respondents). The second highest category in terms of number is high school diploma, with 35 respondents, followed by 26 with a master's degree. A few participants reported middle school (2) and PhD (4) qualifications.

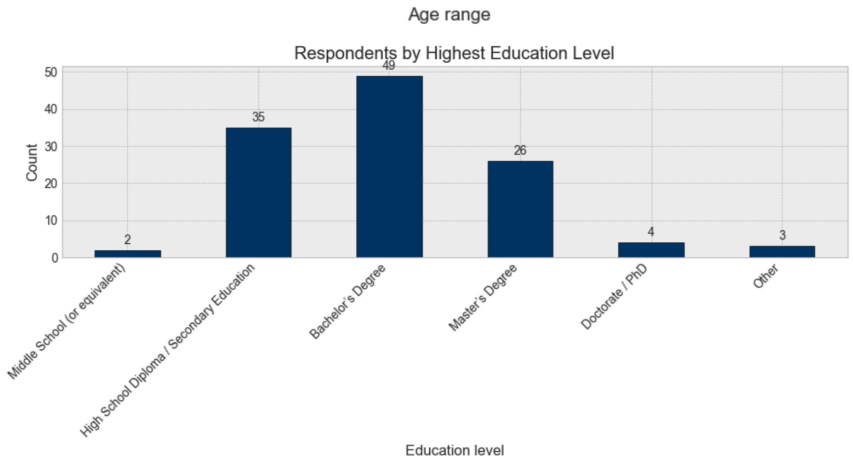

Figure 6.2: Education Level

Place of residence: the graph shows that the majority of respondents live in urbanized settings: 60 of them live in a town or small city, and 53 live in a large city or metropolitan area. Only five respondents live in rural areas, with a single response classified as "Other." This distribution of

the sample increases the relevance of the research for urban last-mile logistics, particularly in metropolitan environments.

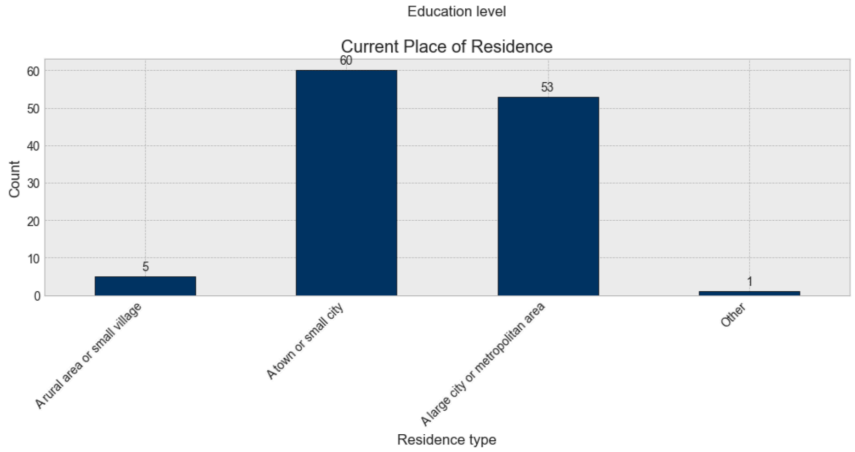

Figure 6.3: Place of Residence

Online shopping frequency: respondents show a pattern of sporadic online shopping. Most buy only a few times a month (53), and 49 do so rarely. Only one respondent answered "daily." This graph demonstrates how even if e-commerce is widespread, it does not translate into high-frequency parcel flows at the individual level. Consequently, the lockers on PT must be designed to serve irregular demand and not rely on high-frequency demand by just a few customers.

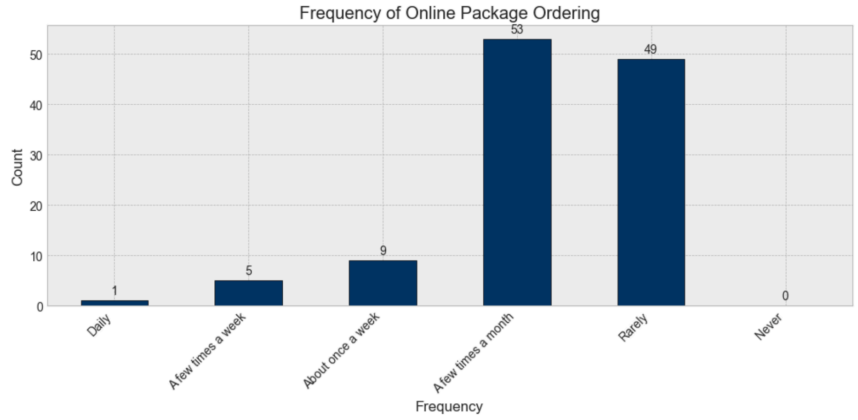

Figure 6.4: Online shopping frequency

Public-transport usage: the questionnaire sample is formed by nonassiduous users of public transportation. While 24 individuals reported daily use of PT, the highest usage rate was "rarely" (42 respondents). This can be explained by the fact that there is a reliable set of heavy users, presumably students, professionals, and inhabitants of well-connected neighborhoods. A big part of the population has low exposure to PT. These results suggest that this innovation should target people who could incorporate parcel pickup as part of their daily routine.

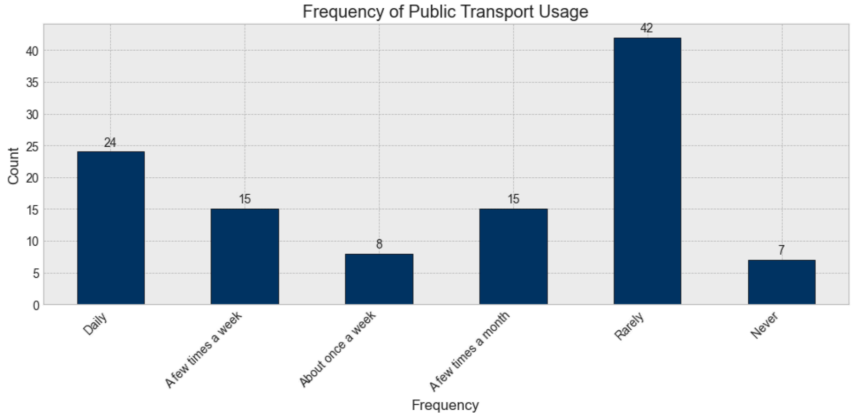

Figure 6.5: Public-transport usage

6.1.1. Key take-aways

The demographic and behavioral profiles of respondents give information regarding the context of this analysis to facilitate the interpretation of survey results and identification of possible limitations of the study. The sample is composed mainly of young people in the 18–25 age group. From the educational point of view, they are also highly educated, with most respondents holding bachelor's or master's degrees. This means that the people answering the questionnaire will mainly be familiar with digitalization and might have a more flexible routine; their educational level, on the other hand, indicates that technological literacy and openness to service innovation might be higher than the average population. From the geographical point of view, most of them are located in towns or urban metropolitan areas, which reinforces the study's relevance for integrating mobile lockers in dense environments where last-mile delivery poses many logistical challenges. From a behavioral point of view, the respondents are moderately engaged with public transport and online shopping. Most of the participants use public transportation occasionally. The majority also buy goods online a few times a month or less, indicating that the demand for this service might not be constant in time. Moreover, it should not only focus on frequent shoppers or commuters but also accommodate occasional users.

6.2. Perceived usefulness and adoption

This section analyzes how certain socio-cultural and behavioral traits affect interest in mobile parcel lockers. Firstly, the analysis focuses on the perceived usefulness of the solution in relation to the use of public transport and the regularity of internet purchasing, to indicate where early demand is strongest and weakest. After this, the willingness to adopt by age group is analyzed. In combination, this analysis helps to decompose the use of mobility and shopping behavior variables and cultural variables that affect potential adoption and guide the development of focused rollout strategies.

6.2.1. Perceived usefulness by public transport usage

The second graph reveals a slightly positive correlation between the frequency of public transport use and the perceived usefulness of mobile lockers. Respondents who have a frequency of

taking PT between daily (n=33), a few times a week (n=15), about once a week (n=8), and a few times a month (n=15) assign higher average usefulness scores. On the other hand, the respondents who rarely use public transport (n=42, mean = 3.02) or never do (n=7, mean = 2.71) have lower results. This graph illustrates a trend, as increased integration with public transport leads to a more positive view of linking parcel pickup to mobility patterns.

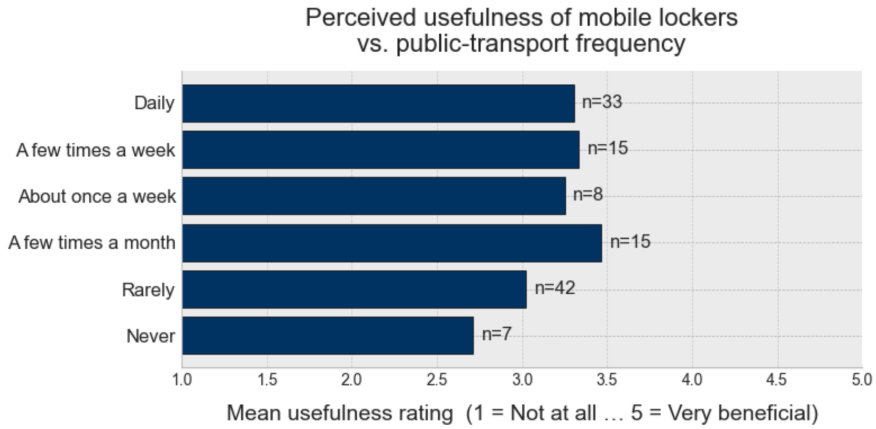

Figure 6.6: Perceived usefulness by public transport usage

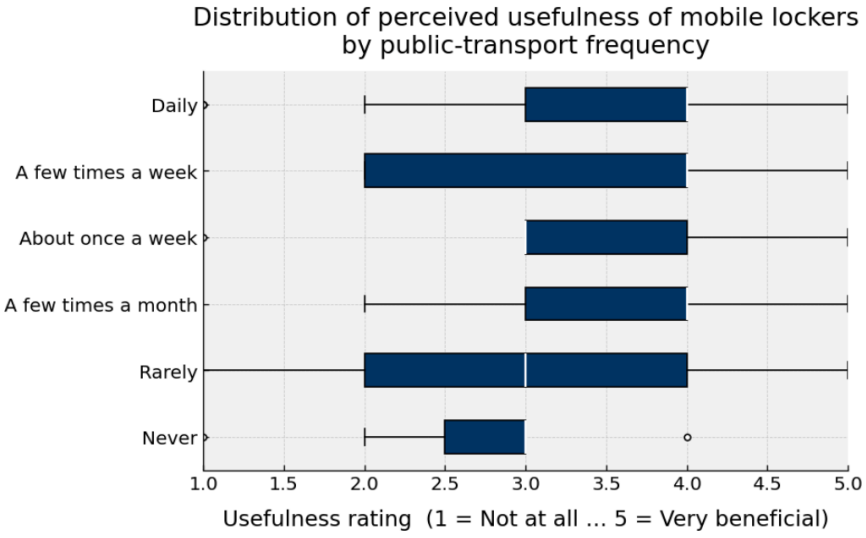

Figure 6.7: Distribution of perceived usefulness by public transport usage

6.2.2. Perceived usefulness by online ordering frequency

This visualization shows how daily online shoppers (n=4) have the highest average usage rating (4.50), followed by shop-a-few-times-a-week (3.40) or weekly buyers (3.33). Like the trend highlighted in Figure 6.8, those who ordered online less frequently gave lower ratings (3.06 and 3.18). There were no people who never ordered online as predictable. Despite the high-frequency online consumers who value the most, even less regular shoppers see potential benefits.

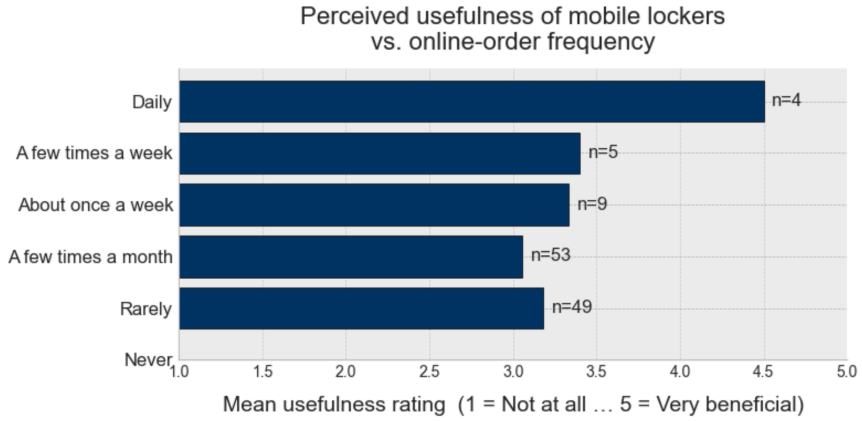

Figure 6.8: Perceived usefulness by online ordering frequency

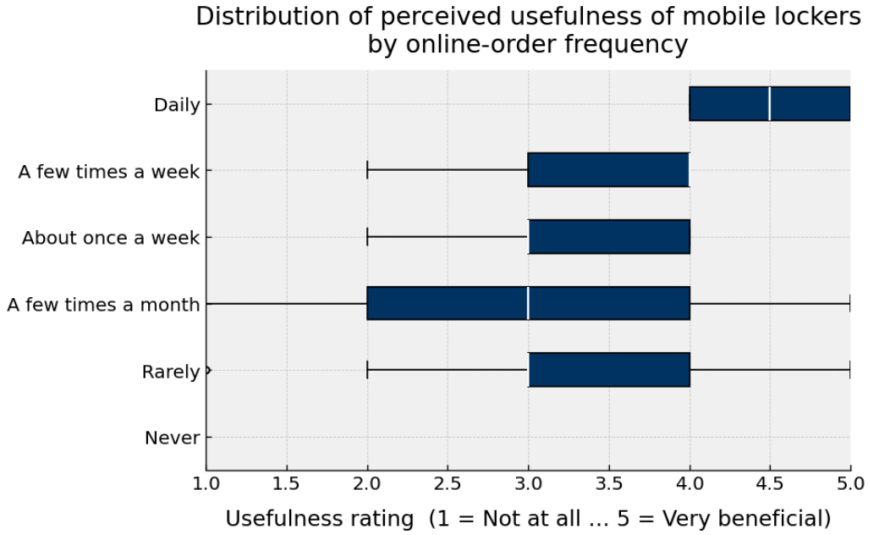

Figure 6.9: Distribution of perceived usefulness by online ordering frequency

6.2.3. Perceived usefulness by online ordering frequency

The willingness to adopt by age group is studied in this graph. The 18-25 age group. Out of these respondents, 42.6% were open to utilizing mobile lockers, and another 41.2% opted for "Maybe," a combined total of 83.8% who are open to the concept. Only 16.2% rejected the concept. Within the 26–35 group, 50.0% replied "Yes," and 38.9% replied "Maybe," with barely 11.1% expressing unwillingness. In the group of 36–45, the answers are "Yes" (57.1%) and "Maybe" (42.9%). However, it is important to highlight that the sample size is small (n=7). In contrast, the 46–55 group is less optimistic, with only 20.0% answering "yes," 45% answering "maybe," and 35.0% would not use the service at all. Finally, in the 55+ cohort, 57.1% were unsure, and 28.6% ruled it out, and 14.3% demonstrated a positive enthusiasm. Overall, the analysis shows that the willingness to adopt mobile lockers decreases among people 45 years old and increases indecision and resistance. However, as shown in the graph below, there is an overexposure in the 18-25 age category.

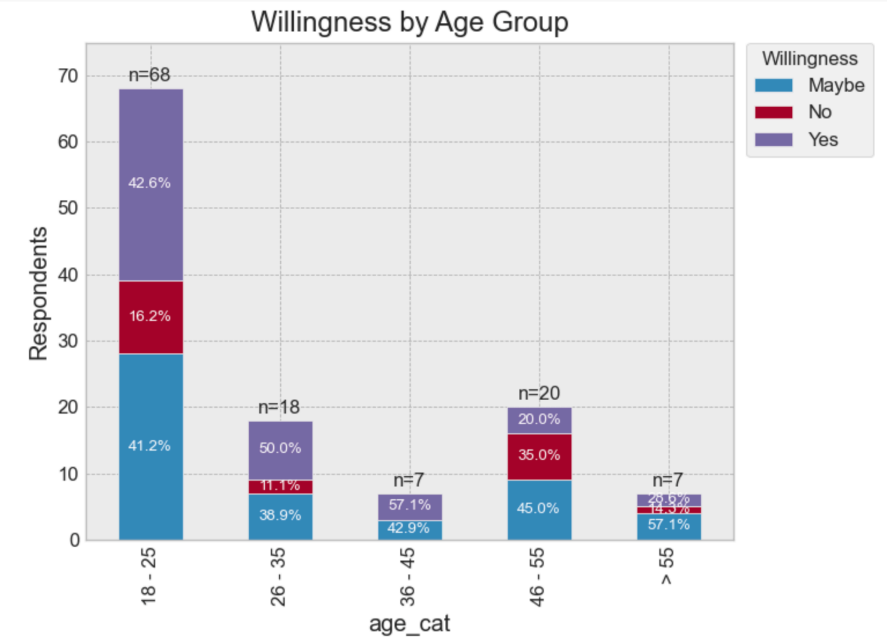

Figure 6.10: Willingness to Use by Age Group

6.2.4. Synthesis of adoption potential

The adoption potential of mobile parcel lockers on public transport emerges as context-dependent but generally promising. Nationality appears to play a significant role in shaping perceived usefulness, with participants from English-, French-, Greek-, and Iraqi backgrounds rating the innovation most highly, while ratings were notably lower among Germanic, Portuguese, and East Asian respondents. This suggests the need for culturally adaptive strategies that take into account regional norms and expectations around delivery and public service integration. Usage patterns also reveal meaningful insights: individuals who use public transport daily or a few times per week rate lockers as more beneficial than those who rarely or never do, indicating that familiarity with transit systems reinforces perceived practicality. Similarly, the more frequently a person orders online, the more likely they are to value the convenience of mobile lockers—highlighting the synergy between digital commerce habits and urban mobility. Age, too, plays a differentiating role: younger users (especially those under 35) are markedly more open to adopting the innovation, while older cohorts show growing hesitation and uncertainty. Taken together, these findings underscore that while broad interest exists, successful implementation will depend on carefully tailored outreach—prioritizing frequent commuters, digital natives, and early-adopting national segments—while also addressing concerns among less familiar or more skeptical groups through targeted engagement, education, and pilot experiences.

6.3. Trust and perceived advantages

This section goes a step further compared to before analyses; it studies why or why not—would they embrace the innovation? The first part studies the trust in onboard lockers, analyzing the passengers who already feel secure with this innovation versus those who remain suspicious and may require additional protection or communication. After, we catalog the perceived ben-

efits most appealing to end-users. This analysis can then be translated into design and policy implications. Together, the benefits map and the trust measure reveal the psychological barriers and the incentive levers that must be addressed to move from cautious openness to widespread adoption.

6.3.1. Trust in on-board lockers

Respondents, as parcel recipients, were asked to what degree they trust having lockers on public transportation, with trust indicated as feeling confident that their parcel will be delivered securely, remain safe until they collect it, and that their privacy will be respected during the process. Most respondents (33.1%) answered "Neutral", so a sentiment neither of deep trust nor distrust. This might mean that even though the idea doesn't arouse immediate alarm, further information might be required before complete acceptance. 29.8% say that they trust the system, 8.3% completely, with a total of 38.1% who are seemingly willing to trust the solution. On the other hand, 24.0% of the respondents trust the parcel lockers on public transportation to a small extent, and 5.0% said that they do not have trust at all. Moreover, no respondent selected the option "Other", meaning the scale of answers was adequate.

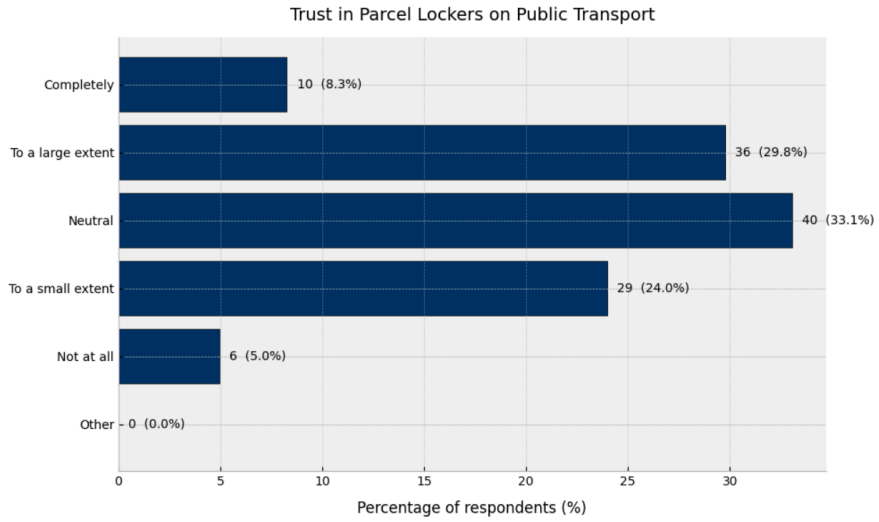

Figure 6.11: Trust in on-board lockers

6.3.2. Perceived advantages

When asked to the respondents to identify the most significant benefits perceived, two main responses emerged: reduced delivery costs and convenience for users, each identified by 53 respondents (26.1%). The third most quoted answer was the improvement in environmental impact, which has been answered by 42 people (20.7%). Even though more subtle, they still have received significant support because of the increase in the appeal of the public (12.3%) and Urban traffic congestion decrease (11.8%) transport. And finally, only 3% indicated "Other."

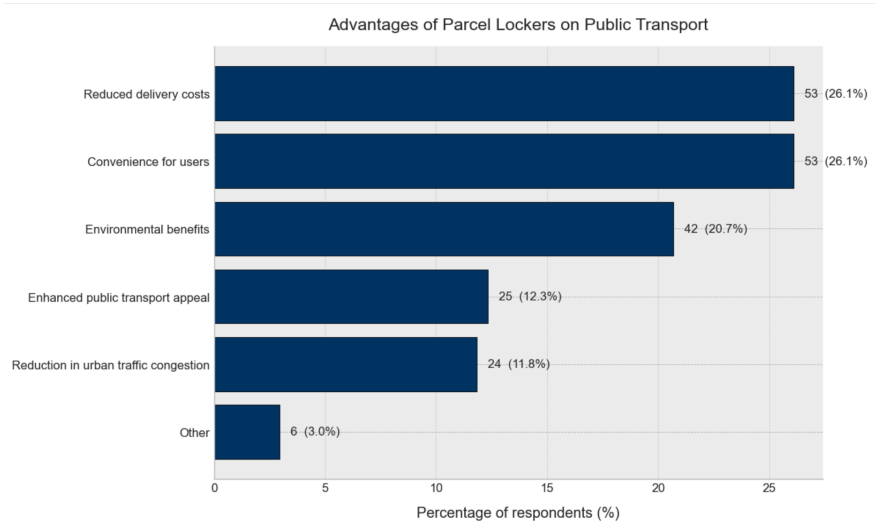

Figure 6.12: Perceived advantages

Compared to the interviews, these results show how the respondents expect lower prices, but experts highlight how increased coordination might lead to higher prices, so there might be some contrast. Regarding the environmental benefits, it is aligned with expert expectations, for example, with interview number 7, with just some exceptions that see the environmental benefits as marginal due to the existing electric vans (interview number 5). Additionally, the appeal of extra transport and the reduction in traffic congestion emerged as benefits in interviews. To conclude, most of the benefits perceived by end-users are the same as those in the interviews, with one exception: the contract. The costs are expected to be low for end-users, but experts think they could potentially increase.

6.3.3. Interpretation & implications

To summarize, the population is not fundamentally opposed to parcel lockers on the transport network but tends to be cautiously open, meaning they might need reassurance and transparency. To gain users' trust, transparent communication is needed, including talking about security, genuine system benefits, and environmental gains. Moreover, the benefits that have emerged from the answers could be closely associated with broader policy objectives regarding more sustainable urban logistics and multi-modal efficiency. This alignment adds to the strategic value of the innovation.

6.4. User acceptance of lockers on public transport: key enablers, risks, and design preferences

This section presents the main findings of the open-ended questions answered in the questionnaire, highlighting both the advantages and concerns of onboard parcel lockers. Tables 6.1 and 6.2 are the summaries of the themes treated in that specific section of the questionnaire, and these reveal the characteristics that the user values most, the conditions needed to let the user accept the innovation, and the preferred strategies to minimize the disruption.

Table 6.1: Summary of user-valued *features, benefits and integration preferences*

Survey topic	Three most–cited themes	Sample size
Desired features *for mobile lockers*	Real-time tracking (52%), Surveillance/security (29%), 24/7 or flexible access (17%)	$n = 83$
Integration *without disruption* – preferred strategies	Dedicated carriage/zone (29.6%), Station-based only (12.3%), Using dead space (11.1%)	$n = 81$
Desired features *for stop-based lockers*	Convenience/proximity (38.9%), Security & safety (20.4%), 24/7 availability (7.4%)	$n = 54$
Increasing appeal of lockers *on vehicles*	Accessibility/convenience (35%), Security (20%), Location integration (17%)	$n = 60$

Table 6.2: Summary of concern themes and mitigation conditions

Survey topic	Three most–cited themes	Sample size
Safety, privacy & space *concerns*	Conditional-mitigation* (40%), Safety/theft (17%), No concern (23%)	$n = 87$
Concerns on integrating lockers on PT	Space/crowding (18%), Security/theft/privacy (15%), Retrieval reliability (11%)	$n = 72$
Final open-ended feedback	No suggestion/neutral (64%), Concerns about mobile lockers (11%), Preference for fixed lockers (11%)	$n = 36$

*The "conditional-mitigation" cluster captures answers that expressed acceptance *only* if extra safeguards such as camera surveillance or 24-hour access are provided.

The open question section in the questionnaire highlights the key preferences of the user and concerns about the deployment of lockers in public transportation systems. In particular, users value real-time tracking, surveillance, and security, as well as flexible access. Additionally, the preferred strategy to integrate mobile lockers without disruption is to have a dedicated carriage zone. Regarding the alternative idea of lockers at stops, convenience, and proximity are the most important characteristics.

In terms of concerns, security and safety were among the most cited, which means that constant surveillance is an essential feature. Moreover, the space and crowdness were also mentioned, which strongly aligns with interview concerns. In the final open-ended question, (64%) did not have any additional opinion on this, while (11%) preferred stationary lockers.

Overall, the data show that mobile locker adoption hinges on convenience, security, and minimal disruption. Important features to incorporate are safety measures.

6.5. Conclusion

This quantitative analysis helps to give a data-driven approach to the qualitative analysis previously conducted to study lockers for public transport. Although a worldwide solution does not emerge from the findings, many insights emerge on which factors influence innovation. The demographic and behavioral factors analyzed strongly influence respondents' acceptance levels. The youngest group between 18-35 years old are the ones most prone to use this innovation, thanks to the alignment of their habits. Nationality also influences their perceived usefulness; infrastructure and culture influence readiness for this innovative solution. Moreover, real-time monitoring, surveillance, and 24/7 access have been indicated as top priorities. Users also demanded physical and digital services; these were essential requirements. Another significant resonance theme was space; in fact, the respondents were concerned about crowding on board and possible disruptions of passenger comfort, particularly during the peak of demand. Some strategies have emerged to tackle these problems, such as using exclusive compartments, underutilized spaces in the vehicle, or even stationary lockers at stations and stops. An important finding was that fixed lockers at bus or tram stops have been indicated as a better solution, especially if they are near home or work. In both cases, with lockers onboard or stationary, proximity, safety, and cost efficiency strongly influenced the user's judgment. Overall, it is possible to say that there were not many objections because the majority of the respondents were in a flexible middle position that can be positively influenced if their considerations are taken into account. So, it is possible to say that there was conditional support for the innovation. In the end, lockers on public transportation are promising from the point of view of end-users, so the actual demand is promising. However, their adoption strongly relies on how they are rolled out, so careful thought is required.

7

Reimagining last-mile delivery: evolving scenarios for public-transport parcel delivery

This thesis started with a central idea: installing lockers on public transportation to allow people to get on the bus, pick up their parcels, and get down or keep going to work in case they are commuters. However, after the interviews and qualitative analysis, the research concluded that this idea, as it was thought, was not feasible; however, in some contexts, it could have worked, or some variation of it in which the essence of combining logistics and public transportation was kept was maintained. For these reasons, in this chapter six scenarios have been developed. All these scenarios have been based on the conclusions extrapolated in the qualitative analysis 5.15 and quantitative analysis 6.5 conducted. The first three are the core of the analysis; they start from a conservative model that is based on central station lockers, then they expand toward a more decentralized nodal deployment, arriving at the third scenario that is the most ambitious approach, which combines public transport with micro-logistics for home delivery. Built on these three practical scenarios, there are 2 variants that are even more challenging but include a big technology component. Finally there is the sixth scenario that is the closer to the initial idea of lockers on public transportation, The following section analyzes these models in detail.

7.1. Scenario 1: locker-based central hub delivery

This first scenario stands out as the most feasible and conservative. This design is mainly founded on the experts that underline technical realism, legal security, and prudence. Nonetheless, it should be observed that despite being conservative, its impact on the environment and the logistical benefits are still important. As highlighted in figure 7.1, the van drops off parcels at the public transport depot; there, they are loaded in the vehicle and transported in the dead-head trip to the central station. There, they are unloaded and loaded inside the fixed lockers, where the customers can go and pick up the parcel.

As highlighted by experts in **conclusion 1: the opportunity in the market is narrow and niche** (1) for the initial idea. However, in this scenario, the lockers will be placed at the central stations, increasing the number of individuals covered, and therefore, the daily flow will be more predictable. Consequently, the market opportunity will not be narrow and niche. The other challenge that is overcome with this solution is **conclusion 2: vehicle space and accessibility are the firm physical boundaries** (2). The original idea of having lockers on public transport clashed with accessibility needs and passenger comfort, especially during peak hours. In this case, the lockers would not be inside the vehicle, but conversely, the locker infrastructure would be outside the public transport. Hence, Scenario 1 does not violate the legal and physical limitations. The **conclusion 8: station or stop-based agnostic lockers are the pragmatic answer** (8) is also a key driver impacting this scenario. Indeed, agnostic lockers at large transit nodes are seen as a viable and scalable solution. This solution would also reduce the deployment complexity across the network, but the van kilometer reduction would be high anyway. From an operational point of view, this arrangement reduces the problem posed in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3). The limited delivery of parcels to a few predictable locations during off-peak hours (e.g., early morning "dead-head" trips) cut the problem of triple coordination between couriers, vehicles, and station personnel. This simplicity improves reliability and reduces failures due to the stationary lockers. Moreover, this scenario solves the financial problem highlighted in **conclusion 5: the economics at the base of this service is that paying for the seats you remove is required** (5). Indeed, lockers would be placed outside the vehicle, and no revenue-generating seats or wheelchair bays would be removed. This arrangement would allow maximum compatibility with the existing revenue model and enable costs to be shared with the logistics industry. Even though experts could still be skeptical about bunching freight on public transportation, this format is the one that allows for the easiest roll-out with minimal possible friction. Furthermore, the problems highlighted in **conclusion 6: law, labor deals, and security measures block the near-term deployment** (6) are no longer present. In fact, the drivers have nothing more to do than their daily work, and the combination of passengers and freights would not be presented. So, the first scenario would overcome the union's resistance and anti-terrorism regulations. In this way, the reduced benefits highlighted in **conclusion 7: the environmental benefit is good but narrow** (7) would increase because of the increased market opportunity thanks to the high flow of people passing through the main stations. In particular, these benefits would be higher in areas where diesel vans still serve the central stations.

To conclude, scenario 1 has the lowest complexity because it uses the existing infrastructure, the risks related to legal and technical risks are avoided, and it offers a minimum intervention in the public transport industry. Furthermore, it does not require any change in legislation, real-time dispatching, or behavioral change. Consequently, this scenario is the most promising one in the near term, especially when the public transportation and logistics companies are willing to collaborate.

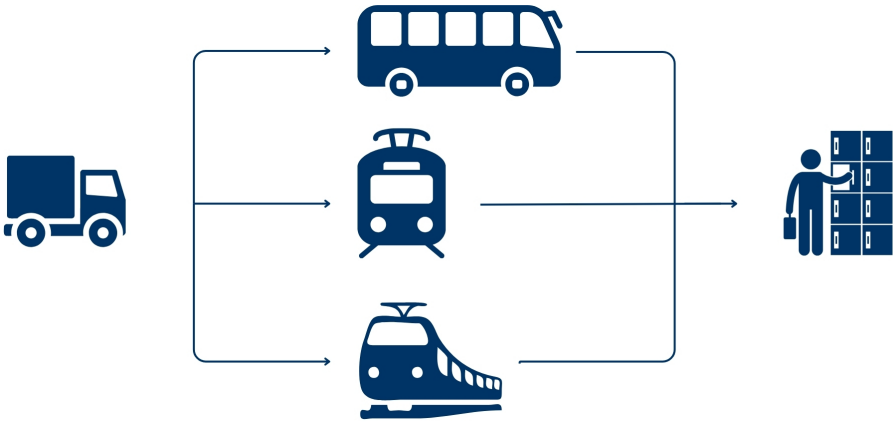

Figure 7.1: Locker-based central hub delivery

7.2. Scenario 2: locker-based nodal delivery

The second scenario is built on the first one. However, it aims to realize the accessibility and equity reach across the entire public transport network. Instead of concentrating the lockers in one or two hubs, this model dispersed them across the entire network of secondary or nodal stations, such as neighborhood metro, bus, or tram stations. This model of combining freight and public transport would also apply to medium-sized towns with multimodal mobility infrastructures. In figure 7.2 is displayed how this scenario works, as in scenario 1, the van drops off parcels at the public transport depot; there, they are loaded in the vehicle and transported. However, instead of having only the dead-head trip where the packages are transported, given that the vehicles also need to reach more widespread nodes, they are transported during the off-peak travels, e.g., early morning. Another important operational aspect to consider is that when arriving at the stops in which the lockers have been installed, the logistic delivery person needs to have the time to put the packages in the lockers and get on the same bus, for this time lost a monetary incentive needs to be instituted for both the customers and the transportation company. However, this additional time is not too long, so it is not disruptive, but it is important to consider it.

Conclusion 8: station or stop-based agnostic lockers are the pragmatic answer (8) directly support this model. In fact, as in the first scenario, this solution privileges the stationary lockers. However, compared to the first scenario, nodal lockers also serve less-trafficked neighborhoods or inner-city neighborhoods otherwise inaccessible through central deployments. This method would allow spatial justice to be brought to city logistics, making sustainable solutions available not only in some privileged corridors. Regarding **conclusion 2: vehicle space and accessibility are the firm physical boundaries** (2), scenario 1 also avoids the space and accessibility issues in the onboard locker proposal. Indeed, lockers would be installed on the station or adjacent public spaces. The most significant difference of this scenario from its centralized counterpart is in its response to **conclusion 1: the opportunity in the market is narrow and niche** (1). This solution would use unused capacity and should unlock latent demand in intermediate nodes in suburban or peri-urban areas where last-mile connectivity is non-efficient. Regarding the operational complexity, this model acknowledges the issues depicted in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3). In fact, decentral-

ization does not change the passiveness of lockers, and the solution remains in the realm of what logistics companies are already doing. From a financial point of view, it also solves the problem highlighted in **conclusion 5: The economics at the base of this service is that paying for the seats you remove is required** (5), especially if the nodal lockers are placed at underused or publicly owned sites that do not have rent or retrofitting expenses. Moreover, no vehicle capacity is sacrificed, and the drivers are not involved in supervision or handoff. From the legal and labor standpoints, Scenario 2 is as compliant as Scenario 1. Logistics personnel and external couriers still do all the handling, so there are no problems concerning the labor union for drivers solving the issues highlighted in **conclusion 6: Law, labor deals, and security measures block the near-term deployment** (6). Another difference between the first and second scenarios is that decentralization of nodal lockers can facilitate higher van-km substitution in under-served areas. These are the areas where diesel fleets remain prevalent. Therefore, the carbon savings would be higher, having a positive influence in **conclusion 7: the environmental benefit is good but narrow** (7).

Overall, this scenario maintained the viability of external, fixed lockers and solved many equity, coverage, and network flexibility issues. However, it can be more complicated than scenario one because it cannot use early morning "deadhead" trips, which usually only connect to the main stations. Consequently, even if on a small scale, it interferes with the normal service of public transportation. However, its roll-out can be progressive, facilitating its scalability. In sum, Scenario 2 preserves the foundational viability of fixed and external lockers while addressing equity, coverage, and network adaptability. It is more ambitious than Scenario 1 in spatial reach but only modestly more complex. As a result, it is especially well-suited for metropolitan areas with vast peri-urban areas. While not frictionless to implement, its high scalability and moderate technological requirements make it a strong candidate for progressive roll-out, especially where urban policies are aligned with sustainable goals.

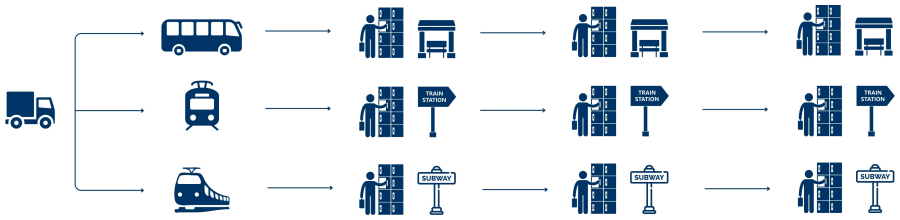

Figure 7.2: Locker-Based nodal delivery

7.3. Scenario 3: home delivery via public transport and micro-logistics

The third scenario is the most innovative and ambitious of the three proposed until now. The central distinguishing aspect is that it preserves the convenience for the customer of the delivery door-to-door like in the traditional model but uses more environmentally friendly methods. The picture 7.3 shows how the delivery process should look. Vans delivers the parcels to hubs at the main stations; it is important to highlight that, in this case, the station is not only the central one but the main ones so that the cyclist can deliver in every area of the city. The cyclist takes the parcel from the station and brings it to the customer's house.

From the interviews, in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3) emerged how fragile the coordination between couriers, depots, riders, and public vehicle schedules. In response to this problem, this scenario decentralizes the handoff away from the public vehicle itself, thanks to micro-hubs near transit stops. This latter acts as temporary storage, where the bicycle couriers pick up the package and deliver it to the end consumer, externalizing the coordination effort. However, the synchronization is still very complex because the delivery windows need to be coordinated with public transport arrival, which can still be done with early morning "deadhead" trips, micro-hub availability, courier availability, and customer availability. In this way, the **conclusion 4: a real-time, interoperable system is crucial** (4) remains important; without these, this scenario collapses. Compared to scenarios 1 and 2, this model is more challenging from a legal point of view. Considering the problems highlighted in **conclusion 6: law, labor deals, and security measures block the near-term deployment** (6), this solution introduces another labor union, the bicycle riders' one; however, compared to the initial idea of having a locker on PT, the main functions of the actors involved remain the classic ones, so there should not be problems. From an economic point of view, this scenario is the least efficient compared to scenarios 1 and 2 because of the additional layer to deliver the package. It relies on labor-intensive, per-parcel costs that are not well-scaled. However, it is still more convenient than lockers on board because there is no need to compensate for the removed seats as highlighted in **conclusion 5: the economics at the base of this service is that paying for the seats you remove is required** (5). Considering the **conclusion 1: the opportunity in the market is narrow and niche** (1), this solution could reach a broader population of people who do not use the lockers system but still rely on home delivery. Moreover, this consideration of reaching a broader population remains also for the **conclusion 7: the environmental benefit is good but narrow** (7); in fact, the benefits will be larger because of the eventual increase in demand.

Overall, scenario 3 is the most visionary but also the most vulnerable. It is a solution that combines public transportation with micro-logistics, keeping the customer's comfort in mind, given the home delivery. However, it is important to consider the eventual operational complexity that this solution could bring.

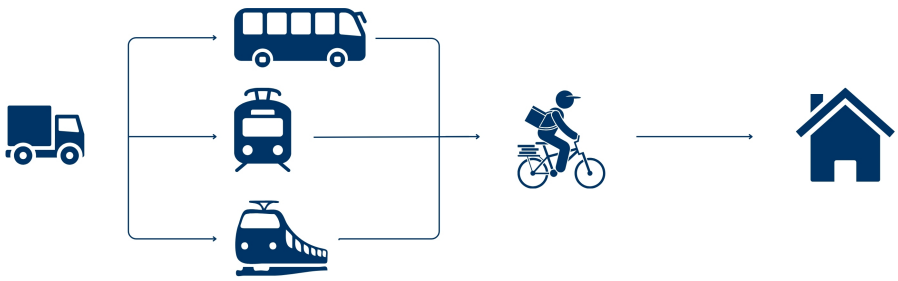

Figure 7.3: Home delivery via public transport and micro-logistics

7.4. Scenario 4: automated locker transfer at central hubs

Scenario 4 is an extension of the first scenario with the addition of automation. The automation, in this case, is not important which type it is but the function; an example could be robotic parcel arms, conveyor belts, or automated sorting gates into fixed lockers at central transit hubs with

connections similar to airport baggage and port logistics and are theoretically possible even if currently underdeveloped at the urban parcel scale. However, the crucial aspect is that the function is highlighted in the third and fourth points of 7.5. The final goal is to remove the manual handling, optimize processing speed, and improve operating safety, especially at high-volume interchange stations. This concept, even though implicitly, was predicted in several expert interviews as a response to the problem of scalability, labor expense, and exposure to the law. As shown in figure 7.5, as in the first example, parcels are transported to public transport hubs. However, the real difference is in the handover of parcels and filling of lockers without the use of human support, and then the package is picked up by the customer.

This solution deals with the problem highlighted in the initial idea in the **conclusion 6: law, labor deals, and security measures block the near-term deployment** (6) where regulatory and labor challenges are presented, more precisely union rules, driver liability, and stringent restrictions on freight and passenger mixing in the same vehicle. It has been expressed during several interviews that driver-based handling would be unacceptable, but if a logistic operator does this, it would be another salary to add to costs. This scenario acknowledges these constraints and proposes deploying automation that allows sealed containers to be dropped off or retrieved at transit hubs without human handling. From a labor-efficiency standpoint, this scenario establishes a capital-intensive but labor-light design from a labor-efficiency point of view. Even though this design requires high up-front investment, it should be compensated with reduced handling costs for each parcel. This would be a good idea, especially in high-volume stations with enough volume to make investment worthwhile. Another supporting argument is **conclusion 5: the economics at the base of this service is that paying for the seats you remove is required** (5) where compensation measures for seats lost or more staff being required came up. In this scenario, given that public transport is only used during dead-head trips, no seats are lost, and consequently, the limitation of the initial idea no longer stands. Regarding **conclusion 4: a real-time, interoperable system is crucial** (4), real-time interoperability identified the growing need for digital synchronization of transport operations and logistics systems. In this scenario, real-time interoperability is not value-added but a condition for efficient, multi-actor systems. In this case, high coordination is needed. APIs would be needed to connect public transport timetables, parcel tracking, locker status, and automation triggers.

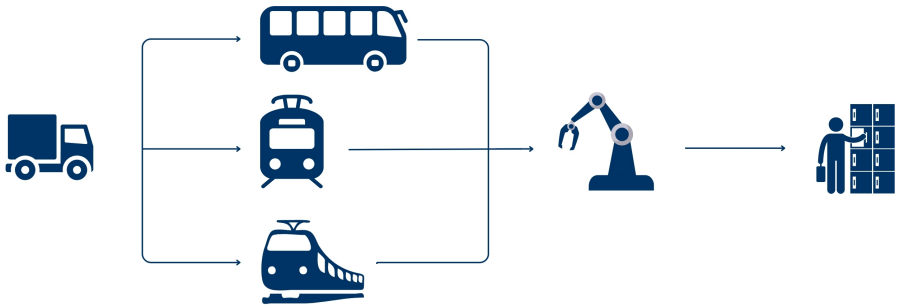

Figure 7.4: Automated locker transfer at central hubs

7.4.1. Process Flow

The following process flow shows the entire path that the package has to take with minimal human involvement. From the first step of hand-off from a logistics van to a public transport vehicle, it is brought to the central station using a dead-head run. There, robotic systems manage

transfer and locker loading, followed by automated customer notification for pickup. The loop closes with the return of empty containers.

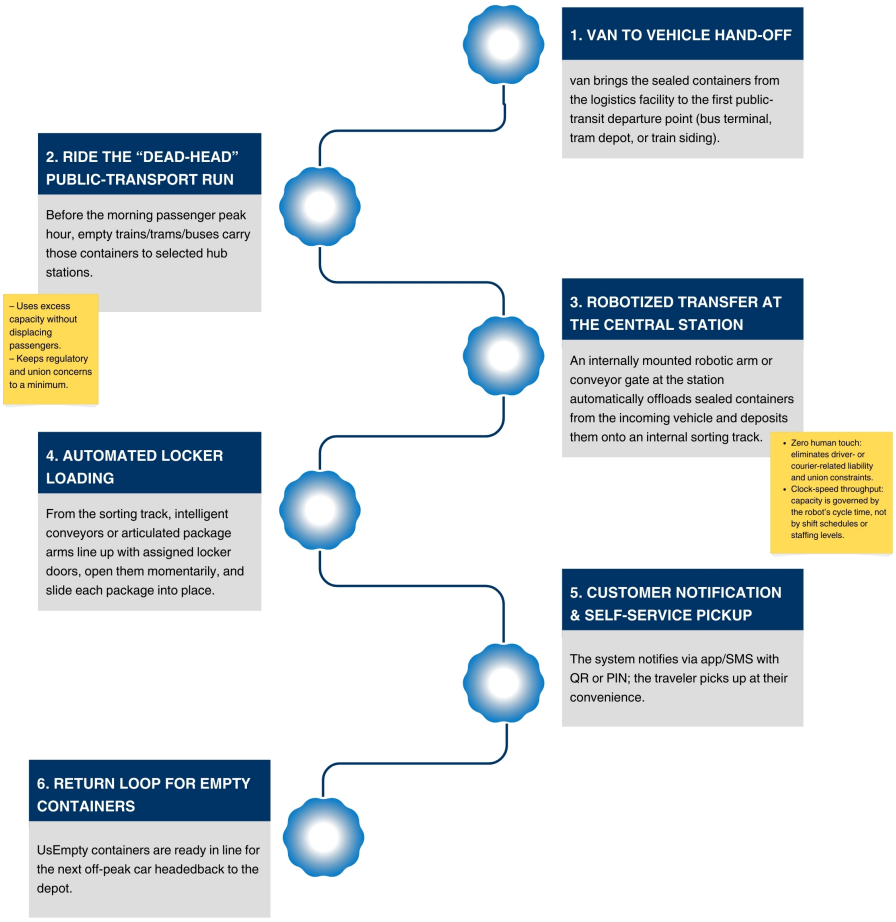

Figure 7.5: Process of automated locker transfer at central hubs

7.4.2. Conclusion

This scenario is the most viable of the automated designs. First, it maintains the legal and spatial premises of Scenario 1 since the lockers are not on the vehicle. Second, the complexity derived from the automation given the few nodes where it is applied is manageable. However, the model faces challenges; it requires high initial investment and precise integration between robotics and transport planning systems. Moreover, if the automation malfunctions in a single node, the entire service collapses, which is unacceptable. Finally, considering the equity implications, underserved areas will remain the same. To this degree, Scenario 4 is not an alternative to universal delivery reform but a can work in high-volume urban markets.

To conclude, scenario 4 is a realistic but visionary development of the hub model. It incorporates automation to boost performance. Its strength is its modularity: it can be tested at one station and expanded where volumes justify investment.

7.5. Scenario 5: autonomous delivery systems via public transport micro-hubs

The fifth scenario is the most technologically ambitious of all the scenarios. It takes the logic of Scenario 3 (micro-logistics home delivery), and instead of using bicycle riders, it uses autonomous delivery systems. Parcels are distributed in this model from the logistics hubs to micro-lockers or ad hoc depot points near public transport hubs. From there, autonomous delivery systems assume the final leg—dropping off packages at the recipient's home. This concept is based on maximum customer flexibility and zero-emission last-mile logistics, particularly for low-access, low-density, or topographically difficult areas.

This scenario responds to many limitations of the first idea of having onboard lockers emerged in the qualitative analysis. First, the issue emerged in the **conclusion 1: the opportunity in the market is narrow and niche** (1) no longer stand; in fact, this delivery method can reach everyone from the city center to rural areas and the final customer primary concern is to receive the package at home not whether it is done with autonomous vehicles or not. Another problem solved is as highlighted in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3), the synchronization will be higher in this scenario compared to the other ones, but the risk will be lower thanks to the autonomous delivery systems, which remove the human error. Moreover, scenario 5 tackles the challenges expressed in **conclusion 6: law, labor deals, and security measures block the near-term deployment** (6), however, it faces them from a different angle because this solution will enter the regulatory domain of autonomous delivery systems. However, this could introduce new barriers related to autonomous systems use, and this, unfortunately, is not yet addressed in most EU urban logistics frameworks. Regarding **conclusion 7: the environmental benefit is good but narrow** (7) with this scenario, the emission would be drastically reduced, especially in rural areas currently served only by vans.

While the fifth scenario is far from ready to be implemented, it can be an important frontier in last-mile delivery, where public transit, automation, and autonomous systems intersect. The autonomous delivery systems were not directly advertised during the interviews; however, some of them highlighted the need for last-mile logistics to be very adaptive to rural or infrastructure-low regions. Conceptually, autonomous delivery systems would have an answer: they would bypass physical roads in case they are delivery drones and also traffic congestion.

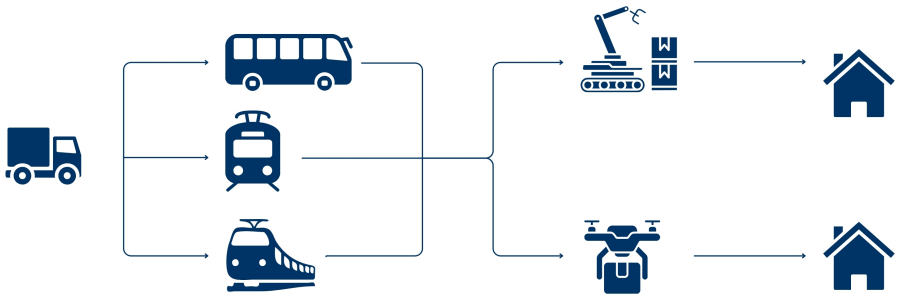

Figure 7.6: Autonomous delivery system via public transport micro-hubs

7.5.1. Process flow

The diagram below shows the process that couples public-transit "micro-hubs" with autonomous delivery systems. The packages are first moved from the van in an off-peak bus, tram, or train

trip to use a dead-head run. At the central station, autonomous delivery systems pick up the packages and delivered them to the customer, following a pre-approved route, snaps a picture as proof of delivery, and returns to the central station.

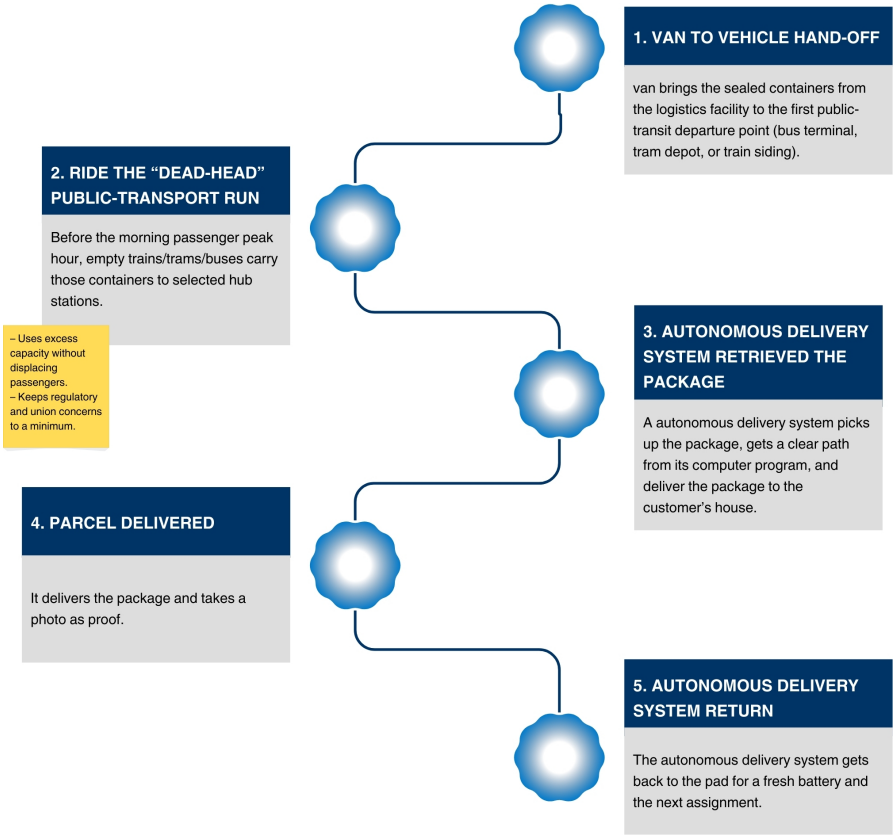

Figure 7.7: Autonomous delivery system via public transport micro-hubs

7.5.2. Conclusion

Scenario 5 is the most visionary and the most complicated to implement. First, the use of autonomous delivery systems is currently constrained from a legal point of view in most jurisdictions. Moreover, even though the technology of autonomous systems is already widespread, it is still not completely developed, and its acceptance is still in the early/mid-phase of development. Consequently, they depend significantly on future developments and policies to favor their implementation. Autonomous delivery systems are expensive per unit. They would require investment in specific containers, maintenance, anti-hacking and anti-theft mechanisms, and platform integration. Moreover, their ability to bring packages is limited; they can bring just a few small packages simultaneously. This scenario is also very complex from an operational point of view. This model intersects public transport logistics and autonomous delivery systems, so it becomes a two-stage delivery system that drastically increases operational fragility. However, in the long term, it can reach a bigger market. Before that, testing the solution in real-world areas and assessing its efficiency is crucial. Its future depends highly on technology development and regulatory evolution.

7.6. Scenario 6: rural-areas bus delivery

The initial idea was to install lockers on public transportation to allow people to get on the bus, pick up their parcels, and get down or keep going to work in case they are commuters. However, the precedent scenarios developed are completely different from the initial idea. Instead, this scenario is the closest one to the initial idea. However, it identifies the right context and the best way to implement it. In particular, this scenario was based on two main interviews, N°2 and N°11. There are two variants in this scenario; the first one is closer to the initial idea, while the second one has been developed mainly from interview N°11, which emphasizes the unstructured interaction present in the interviewee's region. Moreover, these two solutions have been identified only for the bus, given that it is usually the only public transport able to reach rural areas.

7.6.1. First variant - No human interaction

In this context, there are lockers installed inside the bus empty luggage compartments that have been loaded in the morning by the logistic company employee, and once the bus arrives at the predetermined bus stop, the driver opens the compartment, the customer with a QR code and pick up the package. In this case, there is no interaction between the driver and the customer.

In the initial idea there was the issue highlight in **conclusion 5: The economics at the base of this service is that paying for the seats you remove is required** (5), while given the diverse nature of busses for rural areas which are more "tourism-oriented" they have an empty luggage space where it is possible to load the packages without removing revenue-generated seats. Moreover, the challenges posed by **conclusion 6: law, labor deals, and security measures block the near-term deployment** (6) only partially stand, because even if there are packages mixed with people they are in the luggage compartment and the driver do not have anything to do with them. This solution also strongly reinforce the topic emerged with **conclusion 7: the environmental benefit is good but narrow** (7) in fact vans would avoid deliveries that might be in small number in very rural areas which have to do a lot of km to reach it. Unfortunately some challenges still remain, such as the coordination problems highlighted in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3).

Figure 7.8: Rural-areas bus delivery with no human interaction

7.6.2. Second variant - Human interaction

In this variant there are no lockers installed while the packages are all loaded in the empty luggage compartments, that also in this case have been loaded in the morning by the logistic company employee, however, in this case once the bus to the predetermine bus stop the driver get down from the bus open the compartment and personally deliver the package to the customer.

The advantages of this solution are pretty close to the one highlighted for the first variant. However, regarding the **conclusion 6: law, labor deals, and security measures block the near-term**

deployment (6), there might be more problems related to the fact that there is the need for interaction between the driver and the customer, but this could also be solved with incentives per delivery for the bus driver. On the other hand, the challenges highlighted in **conclusion 3: the dominant operational challenge is the parcel, vehicle, and rider synchronization** (3) are reduced. Human interaction might facilitate synchronization and make it more flexible.

Figure 7.9: Rural-areas bus delivery with human interaction

7.6.3. conclusion

To conclude, scenario 6 is closest to the original concept; however, it identifies rural areas as the most viable context. The first variant, with no interaction between the driver and customer, minimizes legal and labor constraints. On the other hand, the second variant, which involves the driver handover, introduces potential regulations-related challenges but improves flexibility. Both options present a promising opportunity to serve sustainably in remote areas.

7.7. Scenario synthesis

This chapter has analyzed six different scenarios to think about the interaction of parcel delivery and public transit. This research started with the idea of having installed lockers right onto buses, however, using the stakeholders' input gathered through the qualitative and quantitative analysis the initial vision has evolved into a variety of more feasible visionary options.

Scenario 1 is the most conservative but, at the same time, the most viable. It consists of fixed lockers at central stations, where packages are brought using dead-head trips of public transport. This solution minimizes the legal, technical, and operating complexity and offers a low-risk and high feasibility, maintaining the logistical and environmental advantages without altering the structure of transport systems.

Scenario 2 extends the first scenario to a network of nodal stations, trying to address spatial equity and cover underserved suburban areas. This solution is more complicated even if the concept is similar to Scenario 1, but it introduces many more lockers, which also cannot be served using dead-head trips, requiring freight and people mixing.

Scenario 3 tries to enlarge the number of people reached even more by bringing the packages directly to home but keeping the interaction of parcel delivery and public transit. It preserves customer convenience but requires higher coordination and cost, along with facilitating digital and labor systems.

Scenario 4 adds automation to the first scenario and, in fact, adds robotic sorting in high-volume nodes. Even though it is attractive because of the labor savings and speed of processing, it is dependent on high capital investments and technical strength, thus restricting it to high-volume urban nodes.

Scenario 5 built on scenario 3, replace the human micro-logistics with autonomous delivery systems. This choice could potentially allow for flexible and zero-carbon delivery. However, it

introduces new legal, technical, and infrastructure questions and remains mainly speculative in the near future.

Scenario 6 is the closest scenario to the initial idea. Indeed, it keeps the lockers on board but identifies a context in which almost all the problems highlighted in the interviews are overcome. Potentially, this can drastically reduce the km done by delivery vans and consequently the environmental impact.

Together all these six cases present a scalable path for cities and carriers to rethink last-mile delivery. It is important to highlight how these scenarios need to be combined to have even the highest possible positive effects on the cities.

7.8. Integration of questionnaire insights into each scenario

Scenario 1 – locker-based central hub delivery The results from the questionnaire show how the top drivers for stop-based (15) were proximity (38.9 %), security measure (20.4 %), and 24/7 availability (7.4 %). This first scenario, even though it can include safety measures and be available night and day, cannot satisfy the most important aspect: proximity. The lockers would only be installed at the central station. Regarding the concerns (16) respondents have on implementing lockers on public transportation, the main ones are space and crowdedness, which no longer stand in this scenario given that the lockers are not on the vehicle. In contrast, for the second concern, security, if the measures highlighted before are used, it should not be a problem anymore. Also, the number of lost parcels would be even lower than the current deliveries. Moreover, because cost and convenience are the most significant perceived advantages (both 26 %; (11)), the pick-up should be free, and a lower delivery surcharge than home shipping must be included in the central hub proposition.

Scenario 2 – locker-based nodal delivery As highlighted for Scenario 1, the top drivers for stop-based (15) were proximity (38.9 %), security measure (20.4 %), and 24/7 availability (7.4 %). However, in this case, all the characteristics can be respected. Proximity is the primary driver of this solution, and it also wants to allow equal access to this service across the entire city. Similar to Scenario 1, many concerns (16) no longer stand, such as space and crowdedness, security, and lost parcels. Moreover, this solution, compared to the lockers on board and Scenario 1, should also attract the older people who, regarding the onboard lockers, expressed less enthusiasm after 45 years (9) because of the eventual closeness to their houses.

Scenario 3 – home delivery via public transport and micro-logistics In this scenario, the parcel is brought directly to the customer; consequently, the trust (10), which in the onboard lockers was judged neutral for the 33.1 % of people, is higher in this solution. Moreover, to ensure this feature is improved in this solution, customers should receive push notifications of cyclist ID, real-time tracking as highlighted in (12), and proof-of-delivery images. This solution would also be accepted by all the customers, meaning that the findings in the (9) no longer stand because the service would be the same as traditional home delivery.

Scenario 4 – automated locker transfer at central hubs The fourth scenario, with the inclusion of robotic handling, meets the customer's desire for convenience and security: 29 % ask for "security/surveillance" and 17 % for 24/7 (12). Moreover, automation can also address the

40 % who conditionally trust the system provided there are more safeguards (13). Automation will allow for constant surveillance, and given the non-human involvement, thus, trust in the system should increase. Another consideration is that each nationality's perceived usefulness is different (6). Pilot hubs must start in markets already inclined to the idea (e.g., UK, France, Greece).

Scenario 5 – autonomous delivery systems (drones / robots) from PT micro-hubs This solution sees at its core autonomous vehicles to deliver in the last leg of delivery. However, the developments of autonomous are still in their early phase; consequently, respondents might be neutral also on this scenario in regard to the trust (10), and as in the onboard lockers, which see 33.1 % of respondents neutral in regard to trust, the same answer could be expected here, so all the characteristics highlighted in the desired features need to be respected (12). Moreover, in comparison to the initial idea in which 26 % of respondents saw the reduced delivery costs as the main advantage (11), here this could be a problem because until autonomous vehicles become the normality, their costs per parcel delivered will be high, so a dynamic pricing system that rewards off-peak could be implemented.

Scenario 6: rural-areas bus delivery This solution is the closest to the initial idea, so many insights from the questionnaire, which have been mainly based on that, can also be applied in this case. Unfortunately, the questionnaire responses are for the (93%) mainly from people living in towns or large cities (3). From the quantitative analysis, it is possible to understand that both online ordering and PT usage positively influence the perceived usefulness (6), (7), and given that this solution can be used by both the people that order online in remote areas and also the one that use the bus to go to the remote areas. Regarding the desired features highlighted are real-time tracking (52 %), security/ surveillance (29 %), 24/7 or flexible access (17 %) (11). At the same time, the last one is not possible, given that the customer must stay at the stop at the scheduled time. The other two can be done with the location of the bus shared with the customer, and the driver will provide the sentiment of safety. While the concerns of that are space/crowding (18 %), security/privacy (15 %), and retrieval reliability (11 %) no longer stand because the crowd is no longer a problem, and as said before, bus driver maintains the security and their reliability is not a problem because usually busses arrive in areas where there are no traffic jams so the schedule should be maintained, and the rides are less if compared to the city busses.

To conclude, this analysis of the comparison of scenarios demonstrates that the acceptance of this solution mainly relies on proximity, security, and clear cost advantages. It is also crucial to incorporate these considerations in the scenarios to respect the population's needs and increase the probability of successful deployment.

7.8.1. Support mapping of scenarios by constraint category

Qualitative Conclusion	Scenario 1 (7.1)	Scenario 2 (7.2)	Scenario 3 (7.3)	Scenario 4 (7.4)	Scenario 5 (7.7)	Scenario 6 (7.9) (7.8)
(1)The opportunity in the market is narrow and niche	✓ Targets central station with high predictable flows.	✓ Target also secondary or nodal stations.	✓ Target also the house delivery.	✓ Suitable for high-volume central stations.	✓ Target also the house delivery.	– Valuable for isolated rural areas.
(2)Vehicle space and accessibility are the firm physical boundaries	✓ Avoids onboard installation.	✓ Same benefit; lockers are off-vehicle.	✓ Bypasses on-vehicle lockers using micro-hubs.	✓ Locker remains off-vehicle.	✓ No use of vehicles.	✓ Uses unused luggage compartments.
(3)The dominant operational challenge is the parcel, vehicle, and rider synchronization.	✓ Simplified coordination, few actors.	– Increased complexity with more nodes.	× High coordination risk; sensitive to delays and no-shows.	– Risk of failure in automated transfer process; localized.	× Risk of failure of automated delivery systems.	– Variant 1 higher fragility; Variant 2 reduces it via human involvement.
(4)A real-time, interoperable system is crucial	✓ Minimal need	– Moderate integration across locations.	× High tech dependency due to the coordination needed	× Requires robust integration of locker, vehicle, and station systems.	× Requires autonomous vehicles synchronization.	– Variant 1 may require more coordination; Variant 2 more adaptable.

(5)**The economics at the base of this service is that paying for the seats you remove is required**	✓ Avoids lost seats.	✓ Avoids lost seats but higher infrastructural costs	× Financially fragile; need an extra layer.	× High upfront CAPEX; economically convenient at central stations with high flow of people.	× Expensive per delivery.	✓ Low cost: uses idle space; avoids lost seats.
(6)**Law, labor deals, and security measures block the near-term deployment**	✓ Legally safe; no freight on board with people, no driver handling.	✓ Same protection through external locker model.	– Avoids onboard limits but introduces labor risks for riders.	✓ Avoids freight-onboard issues.	× Autonomous vehicles still need regulations.	– Variant 1 bypasses most issues; Variant 2 may require labor deals.
(7)**The environmental benefit is good but narrow**	– Moderate gains via commuter "piggybacking".	✓ Reduces van-km in low-access areas.	✓ Highest potential to target also home deliveries	✓ Reduces van-km at congested central hubs.	✓ Zero-emission in rural zones; potential in diesel-heavy contexts.	✓ Reduces van-km for rural deliveries.
(8)**Station or stop-based agnostic lockers are the pragmatic answer**	✓ Fully stationary solution.	✓ Fully stationary solution.	× Deviates from fixed-locker model.	✓ Strong alignment; builds directly on Scenario 1.	× Contradicts fixed-locker consensus; lacks support.	✓ Interview 2 and 11 support rural rollout; contextually appropriate.

Questionnaire insights	✓ Always secure and available × Miss top priority: Proximity ✓ Appealing only if pickup is free and cheaper than home delivery	✓ Deliver Proximity, 24/7 access, and equity ✓ Attract broad user base (~45 + users) ✓ Aligns with all top user needs	✓ Offers high Trust ✓ Includes tracking and confirmation ✓ Suitable for all segments	✓ Boost Surveillance and Convenience ✓ Appeals to security-conscious users ✓ Could increase overall trust	× Neutral Trust due to immature tech × High Pricing currently ✓ May require dynamic pricing to be viable	✓ Ensures Security through tracking and driver presence × No 24/7 access ✓ Effective for Rural e-shoppers

Legend: ✓ = strong / clearly positive support; – = limited or context-dependent support; × = weak or no support.

Overall verdict: The first scenario is the most feasible and straightforward, as it unifies the quality analysis conclusion with user preferences. The second scenario is also highlighted as a good solution. However, the expanded node network introduces more complexity. Scenario number three, although innovative and with a high focus on the customer, is fragile and increases operational risks. The fourth scenario, if applied to nodes with high volume, could be promising. Scenario 5 is the most challenging to implement due to its technological immaturity and coordination demands. Lastly, the sixth scenario has good potential in a rural context, and if humans are involved, some logistics fragilities can be mitigated.

7.9. From concept to practice: integrated public-transport and logistics in Milan

As highlighted in section 7.7, these scenarios need to be combined to have the highest possible effect to rethink last-mile delivery. To provide a more straightforward and practical example, this has been conducted in the city of Milan.

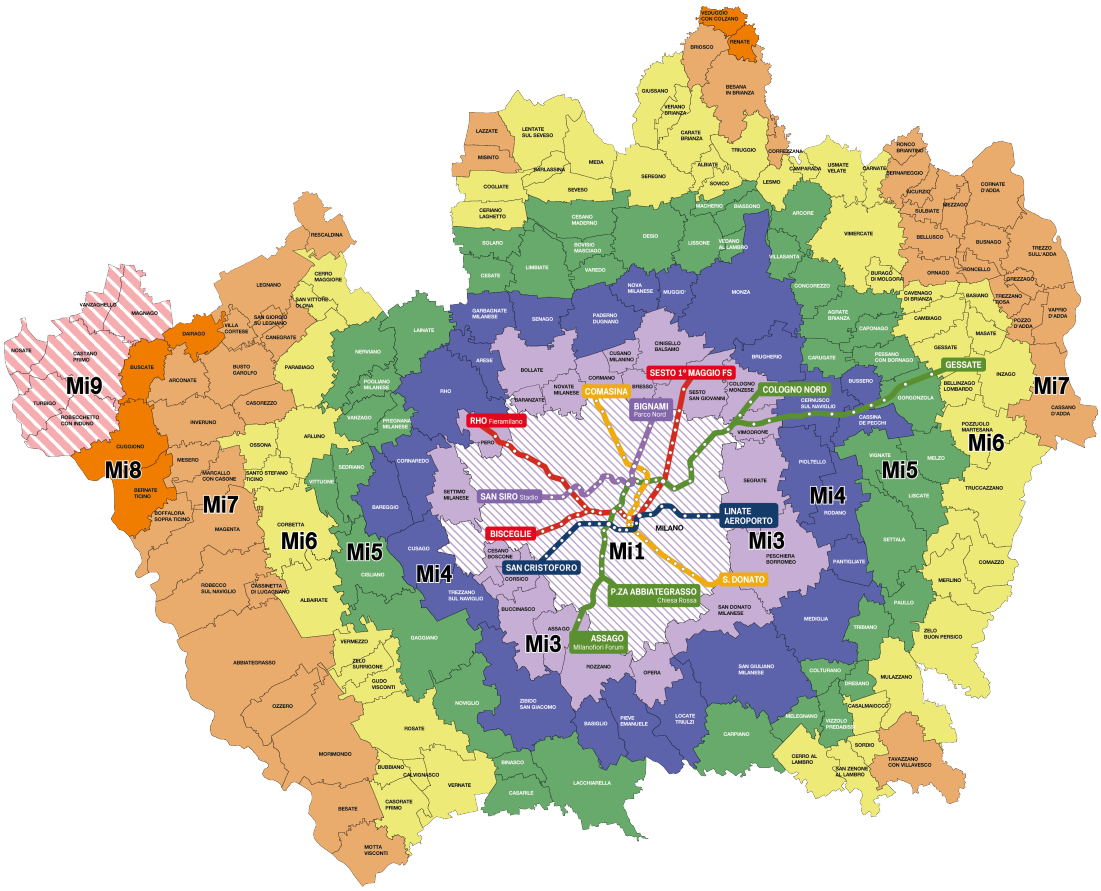

Figure 7.10: Fare zones across the greater Milan area. Adapted from (Azienda Trasporti Milanesi, n.d.)

Figure 7.10 shows the Milan metropolitan area (Mi1–Mi9); this map divides the entire metropolitan area of Milan into nine administrative microzones. These zones include from the hyperdense urban center (Mi1) to rural areas (Mi9). This structure can be used to understand what

has been highlighted in 7 so that the scenarios need to be considered together to reach their maximum potential.

Mi1 is the center and is the most infrastructure-dense area, with multimodal transit nodes such as Centrale FS, Cadorna, Garibaldi, and Rogoredo. Moreover, from Mi3 to Mi6, including the inner and mid-belt suburbs, which are ideal for nodal lockers and micro-logistics expansion. At the same time, Mi7 and Mi9 are the peri-urban and rural areas where bus-based parcel delivery and future autonomous logistics (e.g., drones or robotic vans) are proposed.

The deployment is split in three different phases, and it is a progressively ambitious scenario: Phase 1 (Years 0–2), Phase 2 (Years 5-8), Phase 3 (Years 8–15). The first phase start with Scenario 1 (central hub lockers) and Scenario 6 (rural bus-based delivery), this start by provining the feasibility in the central urban statons and low-density areas, this should be a high-impact "easy wins." The second phase starts to be a bit more complicated with the inclusion of Scenario 2 (nodal lockers) and Scenario 3 (micro-logistics via public transport). Than the third phase which include automation, with Scenario 4 (robotic lockers) and Scenario 5 (autonomous delivery systems), however, the investment need to be justified by the volumes.

Applied to Milan this means that phase 1 include the deployment of lockers at at Centrale, Garibaldi, and Rogoredo. Moreover, the Scenario 6 can be applied in bus lines such as Milano Romolo to Abbiategrasso, that are not overcrowded but goes from Mi1 to Mi7 and than afterwards expanded.

Figure 7.11: Bus line from Milano Romolo to Abbiategrasso. Map retrieved from (Google, 2025)

Phase 2 integrates micro-logistics, with corridors such as Centrale to Porta Venezia and Garibaldi to Duomo in figure 7.12, and from Rogoredo to Calvairate and Corvetto 7.13.

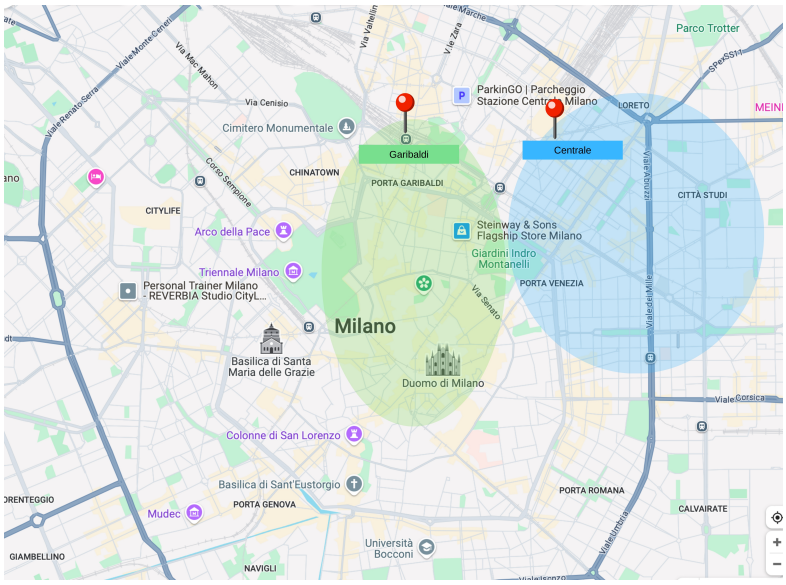

Figure 7.12: Corridors Centrale to Porta Venezia and Garibaldi to Duomo. Map retrieved from (Google, 2025)

Figure 7.13: Corridor from Rogoredo to Calvaraite and Corvetto. Map retrieved from (Google, 2025)

The last phase introduces automated robotic handling in the city's busiest hubs, such as Garibaldi and Centrale. At the same time, lightweight drone logistics can start to be used for urgent deliveries in Mi7 and Mi8.

8

Discussion

The following chapter condenses the results of the entire thesis, including the interviews, the questionnaire, and the scenario design. This chapter will serve as a bridge between the analysis conducted, the research questions established at the beginning of the thesis, and the practical recommendations that follow. These insights will help stakeholders involved in creating a roadmap for improving city logistics.

8.1. Answer to the main research question

"What are the key potentials and possible challenges for the integration of on-board mobile parcel lockers into the public-transportation network?"

The integration of lockers on public transport is supported by several changes that are affecting urbanity that have emerged in chapter 3. In particular, the development of neighborhoods that are multifunctional in the broader sense of a 15-Minute concept creates concentrated demand and short travel distances, thereby increasing the potential effectiveness of lockers onboard. At the same time, the strong political ideas on reducing emissions from freight transport increase the momentum for deployment. Digital integration, as it emerges, has been highlighted as a strong need for the effective deployment of on-board lockers, and this aligns perfectly with the emerging smart city initiatives and open-data platforms, which can help synchronize the lockers with transit schedules and payment systems. During the interviews, the initial idea to install lockers on public transportation has been further analyzed. The key challenges that emerged are:

Narrow market window The market potential has been identified during the interviews as very niche, with the main potential in (a) ultra-high-frequency metro/BRT corridors or (b) rural lines. However, it emerged later in the interviews that the rural lines could be the best option, given the different structure of the service and vehicles. At the same time, in the urban environment, numerous problems arise in terms of space and accessibility.

Space & accessibility limits The lockers on board have been judged as very complicated by the experts in terms of accessibility and space. In fact, except for the case of rural lines, the lockers would require many changes in the design of the interior of vehicles.

Operational fragility Logistics operators have especially highlighted the operational fragility. The Depot → vehicle → rider synchronization would require perfect coordination that, in many cases, also due to traffic jams, is difficult to reach. Moreover, it has been highlighted that even a 2-minute delay can cause many problems in the public transport service, having a "domino effect."

Technology dependencies Nowadays, companies have a large part of their operations based on technology; the same would be required for this service, which would need live feeds, slot-allocation APIs, and one-time codes. This would facilitate the coordination of the different parts involved.

Unproven economics A crucial aspect highlighted, especially by public transport experts, is that every seat removed needs to be compensated. This would allow for some risk-free rent. However, there are two other sides to consider: the couriers, who want the total cost to be below van runs, and the riders, who are sensitive to price. In this context, a profitability gap emerges that could only be closed by ESG branding, which could also include European policies established to achieve environmental gains.

Legal & labour barriers One of the biggest challenges is the legal and labor barriers; in fact, there are problems with anti-terror locker bans and union contracts, which forbid the mixing of passengers and freight, as well as driver parcel handling.

On the other hand, also some opportunities arose:

Environmental gains In the last-mile delivery, there are still a lot of diesel vans, and the use of public vehicles already running can reduce van-km and reduce CO_2. However, it is important to keep in consideration that if fleets are already electric, the incremental CO_2 savings become marginals.

Narrow market window This has been highlighted as a challenge; however, at the same time, it is an advantage. In fact, the place in which there is more potential is in rural areas where the vans have to do many km to reach a single location, increasing the emissions a lot. In that niche market, this solution could be very advantageous.

Overall acceptance In addition, the qualitative analysis has revealed that this solution has a high potential for acceptance among end-users, with 40.5% of respondents indicating that they would adopt it and 42% stating that they might adopt it based on how the solution is deployed.

To conclude, even though the onboard lockers have many operational, spatial, economic, and regulatory challenges. It also offers unique opportunities, especially in rural areas. These findings highlight that even if the urban rollout is unrealistic, a targeted deployment in rural or low-density areas could represent a viable and sustainable solution. Therefore, the final answer

to the main research question is that it is not applicable in every context; however, it can be effective in specific areas.

8.1.1. From challenges to action-oriented scenarios

This conclusion, based on what has been demonstrated, is neither a cure-all nor a lost cause; their developments depend on the context and the many trade-offs that have emerged. However, rather than abandoning the concept,, the research has focused on the context where this idea could work (rural areas) and developed other scenarios that keep the essence of the solution: a combination of public transport and last-mile delivery. The chapter 7 transforms almost each challenge into an opportunity and a concrete deployment model from conservative hub-lockers (Scenario 1) to rural bus delivery (Scenario 6). Indeed, they demonstrate where the identified barriers are mitigated (e.g., seat-loss costs are no longer a problem in Scenarios 1–2, or the legal issues are drastically reduced in Scenario 6). Additionally, they highlight which technological developments still require further maturation (robotics in Scenario 4, autonomous vehicles in Scenario 5).

8.2. Sub-question 1

"What are the key logistical, regulatory, and technical factors that enable or inhibit the acceptance of mobile parcel lockers on public transportation systems?"

Regulatory & liability A positive enabler in this context is that, in an interview, a context has emerged in which this is already possible, demonstrating how this solution if deployed in the correct context, is feasible. However, across the interviews, different scenarios have emerged based on the context in which the interviewee was located. In many cases, the mix of freight and passenger was not allowed, imposing a strong break in the solution. Moreover, there are anti-terror rules for lockers, and this would create many problems given the mix of freights and people. Another crucial regulatory factor that inhibits the deployment is related to labor unions, which would not allow any additional work by the driver(6, 10, 13).

Technical factors The key enabler, according to the interviews, would be to, instead of installing them on-board, install them in the stations. For the end-user to install lockers without disruption, a dedicated carriage or zone is needed. Moreover, this problem no longer subsists in case of this solution being applied in rural zones given the more "tourism-oriented" busses. On the other hand, the main inhibitors are the space on the vehicle, especially during peak hours. Additionally, given the typical urban bus environment, installing such systems would remove or compromise profitable seats or places needed for security or equality, such as wheelchair bays, which would not be ethical or legal (2, 5, 8, 12).

Logistical factors The main enabler in terms of logistics for this solution is technology. In fact, this would allow to have a clear idea of the package position facilitate the coordination and communication among the involved parts. However, the synchronization of parcel-vehicle-rider, in case this create some delays, there would be a domino-effect (3, 4, 12).

8.3. Sub-question 2

"To what extent do on-board mobile parcel lockers impact key performance indicators such as operational costs and carbon emissions compared to conventional last-mile delivery methods?"

In this research, this sub-question has been analyzed qualitatively. Specifically, the interviewees were asked to describe the impact of this solution on emissions and operational costs. Concerning the cost, this solution was not completely clear whether it had advantages or not, because if, on the one hand, it reduces the costs associated with the numerous vans that are required nowadays and all the costs associated with them, on the other hand, it increases the coordination costs, it also adds the costs of an additional layer, the public transport company, and it eventually needs to compensate for the seats lost. Moreover, it is essential to consider that customers expect lower delivery costs due to the use of lockers, which, given the high coordination costs, may not be guaranteed. Considering the emissions, it has been highlighted how the environmental benefits strongly depend on the context in which this has been developed. If the context includes many diesel vans, the emissions would be drastically reduced; however, if electric vans or stationary lockers were already present, these advantages would be significantly diminished, and consequently, this solution would lose its effectiveness. It has also emerged that if this solution were implemented in rural areas, the distance covered by a van would be significantly reduced, and the delivery company would avoid long distances for a few deliveries. Supporting codes: 1, 2, 5, 7, 20.

Table 8.1: Qualitative KPI assessment

KPI	Locker impact (qualitative)
Van-km	One of the easy way to measure the actual benefits is to measure the van-km saved with the use of this solution
Van-km impact on costs	As direct consequence the saved km is multiply by the cost of one km could identify the gross savings of using this solution.
PTO cost / revenue	Net loss unless compensated for removed seats
CO_2-eq per parcel	15–25 % reduction on diesel-van routes; benefit shrinks in cities with e-vans or fixed lockers

In Chapter 3, the increase in urban density, the 15-Minute City model, and smart city infrastructures have been discussed. This emphasis on compact urban form implies that the delivery radius is being reduced. In this context, the viability of lockers on board is significantly increased, resulting in drastically reduced total vehicle kilometers traveled. Moreover, the developments of smart city innovations, such as real-time data sharing and route optimization, would further increase operational efficiency and consequently reduce the cost of synchronization.

8.4. Sub-question 3

"How do stakeholders—public transportation authorities, logistics providers, and end-users—perceive parcel lockers on public transport?"

In the interviews even though they had very different jobs, spanning for example from municipalities, to professor to consultant they generally had a specific knowledge in logistics or public transportation as it is possible to see in 8.2.

Table 8.2: Interviews categorized by expertise

#	Interviewee (short description)	Category
6	FS Sistemi Urbani – rail PT real-estate & operations	Public-Transport
8	FS Group corporate strategy	Public-Transport
10	LINKS / GTT researcher – Turin PT innovation	Public-Transport
11	Director, Molise regional mobility service	Public-Transport
2	Academic (passenger-&-freight networks)	Mixed
3	Urban-mobility startup founder	Mixed
1	Logistics operations manager	Logistics
4	Academic (container, air-cargo)	Logistics
5	Chair of freight leaders council and owner of a consultancy company	Logistics
7	Logistics innovator	Logistics
9	Programme manager	Logistics

The sentiment among **public transport experts** was skepticism in the urban context and optimism in the rural context. For **logistics experts**, the general sentiment was skepticism, while for those with **mixed knowledge**, the sentiment was positive if specific conditions were met. The section below goes into more detail for the sentiment of each interviewee.

8.4.1. Public transport experts

Public transportation experts were more skeptical about deploying it in an urban environment. However, they were more optimistic about rural applications, also due to unused luggage space and reduced e-commerce access. They had concerns about the synchronization with the rigid schedule of public transport, the crowding during peak hours, and the reduction of battery life for EVs due to the additional energy required by lockers. Nonetheless, they see opportunities in off-peak operations, or they also suggested an alternative idea to refill lockers at bus stops, which has been further elaborated in Chapter 7. A more detailed description of each public transport expert can be found below:

Interviewee N°6 The idea fits the new narrative of smart-city. However, there are risks involved in strict timetables, and these risks are only mitigated if there is spare capacity (e.g., off-peak hours).

Interviewee N°8 The interviewee prefers stationary lockers, given that even a small delay could cause serious problems for the PT.

Interviewee N°10 Likes the idea of public transport as a double job; however, there are many concerns regarding the crowding of buses during peak hours, extra dwell time, and, in the case of electric vehicles, the reduction of battery range due to the power required for locking, as well as union regulations. A new idea emerges of refilling fixed lockers at stops using public transport.

Interviewee N°11 Very positive to use the concept in rural areas due to the possible reduction of van km, different structure of buses that have empty luggage, and bringing e-commerce in remote areas.

8.4.2. Logistics experts

Logistics experts were more critical, mainly due to the operational complexity, coordination costs, and space-related constraints. Some of them appreciated the innovative idea and the potential benefits it would bring; however, others argued that stationary lockers already solve many of the problems associated with delivery without disrupting the service to passengers. Most of them highlighted risks such as missed pickups, locker saturation, and multiple courier space-related problems. A more detailed description of each logistic expert can be found below:

Interviewee N°1 Define the solution as very innovative but "operationally very complex." This latter is mainly fueled by high night returns in cases where the package has not been picked up during the day due to a missed public transport vehicle (high chance) and no-show risks. However, this could be implemented in high-speed trains, where the no-show risk is lower.

Interviewee N°4 The savings would be absorbed by the high costs of coordination. Moreover, there are already stationary lockers that solve the problem of failed deliveries, thereby avoiding the disturbance caused by public transport.

Interviewee N°5 Calls it "fascinating but unfeasible": lockers would eliminate too much space for customers, routes vary, and the courier's companies would require one bus per company. The agnostic lockers at stops would be preferred.

Interviewee N°7 See the environmental gain as very big 60-80 % CO_2 reduction. Overall, it is very positive about the idea.

Interviewee N°9 The solution has potential, especially in saving time for commuters; however, everything hinges on the rider's punctuality. In case many packages are not picked up, the lockers can be saturated very fast.

8.4.3. Mixed (public-transport & logistics)

Experts with a mix of expertise in both public transport and logistics highlighted the potential of this solution in remote or underserved areas where traditional last-mile delivery is costly and

inefficient. These interviews also highlighted the possibility of combining onboard and stationary lockers and emphasized the importance of a gradual pilot in small cities. Their feedback suggested that the success also heavily relies on a careful plan and stakeholder engagement. A more detailed description of each expert can be found below:

Interviewee N°2 There is high potential in remote areas because, in very crowded cities, the space on board is minimal. It has been proposed a hybrid model that combines the "onboard + station" models, allowing for smart re-routing in case of a missed pick-up.

Interviewee N°3 The innovation would have a positive impact on congestion and the re-use of infrastructure. However, in the case of a premature roll-out, people may stop using the service if it is not optimal, so it requires small city pilots and strong buy-in from operators.

8.5. Sub-question 4

"Which public, private, or startup-led ownership model can support the sustainable and scalable deployment of mobile parcel lockers in public transportation systems?"

Neutral or shared ownership lockers have been highlighted as one of the most important features by many interviewees. Parallel to this idea, several interviewees emphasized the importance of multi-brand lockers. Both ideas have at their center the fact that, in this way, all the couriers would have equal access, and monopolization by a single logistic provider would be avoided. On the other hand, other ownership models emerged. Indeed, public transport or third-party ownership was also considered a viable option to avoid service fragmentation, as it would eliminate the need for a different bus for each locker system. The third interview highlighted how a hybrid approach could also work, where a startup coordinates the software and a public operator owns the physical infrastructure. The only interview that had a different idea, dictated by the context in the expert, was in which the public transport was contracted to many public transport companies and saw the courier-led ownership as a better option. Overall, the lockers should be owned by public transport companies or by third parties. However, this heavily depends on the context in which this innovation is applied.

Table 8.3: Interview views on ownership model

Interview Nº	Ownership model supported
2	The interviewee sees the ownership model as an issue related to investment risk. According to the expert, each choice shifts the capital and maintenance costs, and the probability of failure increases or decreases accordingly.
3	The expert sees a dual-split, with the intellectual property and coordination software owned by a start-up delivery firm and the public transport operator that owns the physical lockers.
4	According to the interviewee, the public transport operator owns the lockers, the logistics companies pay every time they use the service, and an external platform handles the booking and tracking of parcels.
5	See the unbranded locker as the only feasible way. The public transport owns the hardware, and the couriers rent a slot. Otherwise, there would be one bus for each logistic company, which is infeasible.
6	Also this interviewee thinks that unbranded lockers are needed. The ownership and control should be managed by a third party that ensures equal access to the service.
7	The solution highlighted is the multi-brand locker, which is open to every courier. The ownership so can still be neutral (public operator or third-party platform).
11	The courier company manages the lockers because otherwise, it is impossible due to the high number of regional bus operators that act as subcontractors.

9

Conclusion

This thesis began with a clear goal: to determine whether parcel lockers installed in public vehicles could alleviate the economic, operational, and environmental pressures associated with last-mile delivery. Using a mixed-methods design, which included eleven expert interviews, a questionnaire with 122 responses, and six scenarios, this study explored the concept and potential variants that could address the issues arising from the initial idea. This investigation has confirmed that the original idea is technically achievable; however, it remains economically unproven and operationally fragile in a dense urban context, primarily because it would remove seats that generate revenue or wheelchair bays. Additionally, it would complicate the driver's duties and conflict with regulations. Interviewees then defined the solution as workable only in low-demand rural lines where buses already have spare luggage. It is possible to define three main structural barriers: (i) space and accessibility constraints, (ii) parcel–vehicle–rider synchronization, and (iii) an unresolved revenue split that must pay for every seat removed. Considering user acceptance, 85% of travelers under 35 and frequent e-shoppers perceive the service as useful; however, it needs to have real-time tracking, robust security, and 24/7 access. Regarding the space or crowdness respondents favour dedicated locker zones or station-based in order to minimize the passenger disruption. These findings emphasize the importance of design choices in determining adoption, not just the concept itself. To overcome the barriers previously highlighted, the research has developed six scenarios. Scenarios 1, 2, and 3, respectively, involve a central hub, nodal lockers, and a central hub with autonomous transfer at the central station. These scenarios relocate the locker itself to stations and peripheral stops, solving the problem of on-board space conflicts while still utilizing dead-head trips or off-peak trips. Scenarios three and five aim to maximize customer satisfaction by delivering directly to their homes, thereby reducing CO_2 emissions. Finally, scenario 6, rural bus delivery, revives the on-board model for sparsely populated regions, promoting both environmental and social benefits, as a single bus can replace long, low-utilization tours. To conclude, the evidence suggests that lockers-in-transit can be a meaningful way to create a cleaner and more resilient city logistics system, though context-specific. However, it is crucial to properly integrate parcel infrastructure into the rhythms, capacities, and geographies where public transport already excels. Moreover,

it is essential to reiterate, as previously noted, that the identified scenarios reach their maximum potential when combined in this manner. Cities can then trim delivery traffic, spur rural inclusion, and advance climate goals without compromising the core mission of moving people efficiently.

9.1. Societal Contributions

This research contributes to the development and rethinking of last-mile delivery, as it has been understood until today. Supported by stakeholder engagement, it has been understood where the combination of public transportation and parcel deliveries can work more effectively (e.g., rural areas) and how this solution can directly contribute to society by reducing depopulation and increasing the connectivity of rural areas. By also including the preferences of end-users, it incorporates the population into the design of innovative solutions, which is crucial for adoption. The study also maps social acceptance among different age groups, identifying how younger people feel a greater need for change in last-mile delivery, which reduces the adverse effects that traditional delivery brings. To conclude, this thesis provides policymakers, urban planners, and businesses with a robust framework for developing scalable, equitable, and environmentally sustainable parcel logistics solutions, which are increasingly needed given the sharp increase in e-commerce and, consequently, home deliveries. Beyond the academic contributions, this thesis is also helpful for practitioners, including urban planners, public transportation authorities, logistics providers, and policymakers. Indeed, they should utilize the scenarios identified in Chapter 7 to develop localized implementations, particularly in rural areas and urban settings where the benefits are most evident. Moreover, logistics companies could experiment with the use of real-time tracking and dedicated locker zones at transit stations, adding additional security features aligned with user preferences. Finally, policymakers are encouraged to develop context-sensitive regulatory frameworks that facilitate cross-sector collaboration, enabling the smooth integration of mobile parcel lockers within public transportation networks.

9.2. Academic Contributions

This research makes significant contributions in various aspects to the field of sustainable urban logistics and freight transportation. Firstly, the use of a mixed-methods research design enables the first systematic empirical assessment of mobile parcel lockers integrated with public transportation vehicles. Subsequent works in related fields can also replicate this methodology. Moreover, this thesis enriches the field of freight on transit by exploring and critically evaluating an extensive spectrum of novel logistics scenarios—ranging from simple station-based lockers to sophisticated technological integrations such as automated transfer hubs and autonomous micro-delivery hubs. Third, still related to the field of freight on transit, it identifies logistical, regulatory, and technical factors that enable or hinder the adoption of integrated mobile lockers, thereby contributing to the development of guidelines for policy and practice. Finally, even though it is implicit in the work, it explores the interactions between public-private collaborations, which can provide the groundwork for further theoretical exploration and practical implementation in sustainable urban and rural logistics innovations.

9.3. Limitations of the research

This thesis presents an innovative perspective in the last-mile delivery world, beginning with the initial idea of installing lockers on public transportation and culminating in the development of six alternative scenarios, which are more closely aligned with the findings of the interviews and questionnaire. However, the identification of limitations is also crucial because it helps increase the quality of the findings and the interpretation of the study conducted (Theofanidis et al., 2018). First and foremost, the empirical foundation of the research is relatively small, even though it has been attempted to represent all relevant stakeholders as accurately as possible. Only eleven semi-structured interviews have been conducted, with 73% of them in Italian. This issue of nationality is also reflected in the questionnaire, consequently, the findings tend to be more focused on the Italian context. Therefore, for the conclusions of this study to be applicable in other countries, additional local research and adaptation may be needed.

Beyond geography, the characteristics of the survey also affect the representativeness of the findings. Although the questionnaire is robust (N = 122), it was dominated by young adults between 18 and 25 years old (56%), living in urban areas (93%)and having an higher education level(two-thirds). The main consequence of this might be that older age groups or people in rural areas might have different thoughts on this innovation.

Additionally, this research is at a conceptual level, so no real-world pilot or feasibility study has been conducted. So many uncertainties remain regarding the quantification of financial, operational, and actual emission savings. Moreover, in this research, the legal barriers have been generalized despite the high heterogeneity across all EU countries.

9.4. Future research recommendations

This research has primarily focused on the exploratory aspect of innovation in last-mile delivery. This means that future research should implement pilots on urban and regional transit lines to study the actual impacts of boarding times, locker use, passenger comfort, seating capacity, and overall operational costs. However, these pilots need to be implemented for each scenario. These pilots would generate the quantitative data that are currently not included in the chapter 7. However, before actually implementing the pilots, it would be interesting to study these different scenarios using agent-based and system dynamics modeling to simulate the effects on the network and thereby elaborate on how public transport vehicles equipped with lockers influence delivery performance and passenger load conditions. These pilots would also be helpful in identifying the most efficient routing and scheduling strategies. As highlighted in the limitation 9.3, not too much attention has been posed to the regulatory heterogeneity of the EU, so future research should also conduct a comparative legal and policy analysis to understand where freight on board is permitted or restricted and how the safety standards and labor agreements vary by country. This analysis would clarify the feasibility beyond Italy.

Moreover, the environmental benefits have been suggested qualitatively, but they also need to be quantified. This could also clarify how the impact is in a context where the majority of the vans are already electric. This would also increase the transferability of the study to other settings (e.g., Germany, Netherlands, Spain, and Eastern Europe). Additionally, the qualitative analysis conducted in this thesis could be further strengthened by conducting focus groups in multiple

cities to understand the diverse attitudes toward the co-use of public services. Furthermore, the cost per parcel could be analyzed across all scenarios to understand which one is the most convenient. Future studies should also investigate different pricing options for customers and various access schemes to the services. A crucial aspect that has emerged is the ergonomic design of lockers on public transport; consequently, further studies need to be human-centered, focusing on safety and ergonomics. The studies should focus on ergonomics for locker placement and study emergency-access protocols that preserve universal design principles. Another research that could help in the deployment of the solution is the integration of digital twin technology into simulation frameworks. In this way, the replica of the system can help simulate behavior in real-time conditions and conduct a what-if analysis. This solution could also achieve success if implemented in Mobility-as-a-Service (MaaS) apps, allowing travelers to book seats, micromobility, and parcel pick-ups in a single transaction. Furthermore, given that the concept of social equality has emerged in some interviews, quantitative studies should also analyze whether the innovation improves or worsens parcel access in peri-urban and low-income districts. Finally, immersive technologies such as virtual reality (VR) can be used to test prototype locker layouts and simulate passenger interactions in controlled, 3D environments.

9.5. Management of Technology relevance

This thesis is perfectly catching the core of the Management of Technology module, given the research's focus on innovation. It presents public transport lockers as the starting point for delivering advanced technology-driven scenarios. Initially, the thesis presents more pragmatic solutions, such as station lockers, and then introduces more significant technological advancements with scenarios that encompass automatically loading and unloading parcels at central transit hubs. Even further technologically, this thesis proposes scenarios that introduce autonomous vehicles, either ground-based or drones, to create micro-hubs at public transport stops. Ultimately, this thesis also employs the pragmatic approach developed through the Management of Technology Master program, which teaches how to effectively implement innovation and utilize technology as a corporate resource. Indeed, the research examines how this innovation can be realistically implemented, considering all the complications related to legal, financial, and synchronization requirements. By doing this, the technological opportunities are translated into clear, practical, and sustainable business models.

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A

Transcript interviews

Transcript of interview N°1

1. Could you describe your role and experience in the public transportation/logistics sector?
I'm a manager, and I work in the logistics sector. Specifically, I'm responsible for relationships with our courier providers, we use external companies, so I manage those interactions. I also coordinate with other departments like finance and account management. On top of that, I handle metrics analysis, KPIs, and organize the operations of the warehouse. In short, I do a bit of everything across logistics and performance monitoring.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you?
Honestly, no. I'd never heard of the idea before this conversation, not even the more general concept of using public transportation for last-mile delivery.

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
What comes to mind immediately is that this could serve a niche group of customers—people who travel often and might not be home to receive deliveries. If someone knows they're going to be traveling that day and still needs to buy something, this could fill a gap that isn't currently being addressed.

4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
Yes, several. The first thing that comes to mind is logistics—specifically, the issue of space. Where would you actually put these lockers on a train or a bus? You might have to sacrifice a cabin or a section of it, which would reduce capacity for passengers. On buses, maybe you'd put them where wheelchair users sit, but then you're creating another problem. Even when we install lockers in shops, space is always a major issue.
Another problem is the timing. If I'm on a specific train at a specific time, the parcel has to be there too—and that's not easy. Delivery routes are defined, yes, but there's always unpredictability. We often don't meet scheduled time slots because of traffic or road issues. So ensuring the

parcel gets to the right locker at the right time could be really difficult.

5. How would stakeholders—public transport authorities, logistics providers, and end-users—view this technology?
From a logistics company's perspective, I'd say it could be seen as innovative, especially in terms of environmental impact. If it helps reduce carbon emissions by replacing van trips with existing public transport routes, that's potentially positive.
That said, operationally it's very complex. For example, it's hard to imagine getting our delivery drivers to switch from vans to taking public transportation. People are resistant to change, especially in this sector. In Lombardy, for instance, there are strong unions, and changes like this could be extremely delicate. So I imagine there would be significant pushback, especially from the people on the ground.

6. What incentives or disincentives might attract or deter stakeholders from using on-board parcel lockers?
In our case, it's not so much about offering incentives. What matters more is whether this kind of solution fits into our business model and operational processes. We'd need to do a thorough feasibility and cost-benefit analysis. From what I can tell now, it's a really cool and innovative idea—but everything needs to be looked at in detail. I can't say "yes" or "no" without more data. We'd have to analyze how it would actually benefit our business.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
It goes back to what I said earlier. Deliveries are structured around planned routes and schedules, but if you add a locker on a bus or train, the delivery person would need to be at the terminus at a specific time let's say early morning and load the packages. That part is manageable. But the problem comes at the end of the day. If parcels aren't picked up, we'd have to collect and reprocess them during the night shift. That's a cost we normally avoid.
Also, compared to regular lockers, I imagine a higher percentage of failed pickups—people who thought they'd take the bus but didn't. On high-speed trains, this risk is lower, because people are more committed to those trips. But on buses, it's far more unpredictable. That unpredictability adds significant complexity to the operation.

8. How can these logistical issues be tackled?
If we overcome the space issue and manage to install lockers on the transport vehicles, then yes, technically we can coordinate the first delivery stop—at the bus or train terminus. That part is solvable. What's harder is dealing with the uncollected parcels. Right now, our system gives the customer several days to pick up their package. If we had to collect and reprocess unclaimed parcels every night, that's an added cost.
Also, again, on buses, the no-show rate is high. I could see this working better on long-distance trains, where customers are more likely to follow through on the trip. With trains, it's easier to plan because people know exactly when they're traveling.

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit?
Yes, we have strict rules for where lockers can be installed. They have to be in locations that are publicly accessible and open for a minimum number of hours. If the locker is on a train and the customer can't retrieve the package because something breaks or access is denied, it

becomes a big problem. In that case, the delivery fails, and we have to start the whole return process—sending the parcel back to the warehouse, updating the system, dealing with customer complaints. Customer dissatisfaction is one of the worst outcomes for us.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Not necessarily, but again, everything depends on customer satisfaction. If a locker fails or access is limited, the whole system breaks down. Our entire model depends on reliable delivery and customer trust. If that breaks, it's a failure.

11. From a technical point of view, what might be the most important considerations when incorporating parcel lockers into public transportation?
Space is the main issue. Lockers are bulky and hard to fit, even in retail locations. So integrating them into buses or trains will require careful design. And from a systems point of view, we'd need reliable processes for loading, monitoring, and collecting the packages, especially if they go unclaimed.

12. Do you think technology like real-time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
While I didn't mention it directly before, yes, I think it would be crucial. If we're going to rely on time-sensitive pickups and deliveries on moving vehicles, we'll need robust tech—real-time tracking, secure access, and software that integrates seamlessly with our systems.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
It depends on the implementation. If packages are consistently picked up, it could be efficient. But with public transport, especially buses, the risk of failed pickups is high. If that happens often, we face higher costs in returns and reprocessing. And again, managing unscheduled retrievals adds operational strain. On trains, though, where schedules are more predictable, these costs could be minimized.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability?
If it reduces the need for van deliveries, then yes, it could help lower emissions. Using existing transport infrastructure to deliver parcels has environmental value. But again, it depends on how it's implemented.

15. How would you propose measuring or benchmarking these impacts?
One of the main metrics we'd look at is the percentage of successful deliveries, how many parcels actually get picked up versus how many have to be returned. We'd also track returns caused by technical issues, timing problems, or missed pickups. Those numbers would tell us whether the solution is working or not.

16. Which stakeholders must align to successfully implement the onboard parcel lockers?
You'd definitely need alignment between logistics companies, public transport operators, and local governments. Municipalities might be interested if it fits within a smart city strategy. It could also appeal to environmentally conscious citizens.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?

There should be direct and transparent communication, especially in the beginning. Problems need to be addressed proactively before they escalate. That way, you build a solid foundation for the service.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over traditional last-mile delivery methods?
As I said earlier, for us it's not about incentives it's about feasibility. If it fits our operations and makes sense from a cost-benefit perspective, we'll consider it. The concept is feasible, but it needs deeper analysis before making decisions.

19. What are the most significant challenges in integrating on-board parcel lockers?
Space is the first thing that needs to be considered it's the biggest constraint. Then there's the question of cost. Is it worth it? From both a financial and operational perspective? That's the real issue.

20. What are the key enablers that would ensure widespread acceptance?
Understanding the actual demand is essential. If customers show interest, then companies will be more willing to explore the solution. Surveys and market research can help clarify this. Everything is technically feasible but only if it makes sense for all parties involved.

21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
Definitely. In Northern European countries, where public transportation is more heavily used, this idea might succeed. Even in Italy, cities like Bologna where people drive less and use bikes or public transport more could be a good fit. Personally, I wouldn't use it because I don't use lockers at all, so I'm not the target audience. But for certain demographics, it could work.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
At this stage, the idea is still in its early phases. We've discussed it in general terms, but it would be interesting to revisit it once you have a more detailed plan or prototype. I'd be happy to talk again if you want to go deeper later on.

Extra Themes Discussed:

- **Limited Pickup Window vs. Standard Lockers:**
  In our current model, customers have several days to pick up their parcels from lockers. But with lockers on public transport, especially buses or trains, the pickup window would be limited to that specific route or day. That means if the parcel isn't picked up, we'd have to collect and reprocess it the same evening, which adds operational strain and cost—particularly during night shifts, which we usually try to minimize.
- **Failure Risk Specific to Moving Vehicles:**
  Lockers sometimes fail—whether it's hardware, software, or connectivity issues. Normally, we resolve those within 48 to 62 hours. But if the locker is on a train and the customer can't access it because it's broken, that's it—the delivery fails completely. Unlike fixed lockers, there's no second chance. That could lead to customer dissatisfaction, which for us is a big deal—it's one of the most critical failure points in our service.
- **Ethical Concern Over Replacing Wheelchair Spaces:**

There was a moment I thought about installing lockers in the space currently reserved for wheelchair users on buses. But that immediately raises ethical concerns. It's not just a logistical issue; we'd be taking away something essential from a vulnerable group, which isn't acceptable. So even if space is available, we have to think carefully about what kind of trade-offs we're making.

- **Targeting Environmentally Conscious Commuters:**
  If I think about who might actually use this service, I'd say it could appeal to people who already care about reducing their environmental footprint—people who take public transportation regularly instead of driving. That could be a good angle to engage municipalities and position this as part of a broader smart city or green mobility initiative.
- **No Market Research Conducted Yet:**
  One of the first questions I had during the conversation was whether you had done any surveys or market research to see if people would actually use this service. Because for any new solution, especially one this complex, demand is key. If there's no real interest from users, it doesn't matter how innovative the idea is. When I pitch projects internally, I always go in with data—it's the only way to have a real conversation about feasibility.

Transcript of interview N°2

1. Could you describe your role and experience in the public transportation/logistics sector?
I work with transportation models, mostly focused on optimization over transport networks. This includes facility location, routing, scheduling, and incorporating customer behavior into these models. For example, understanding whether customers prefer improved reliability, reduced time, or other factors. Recently, we've also integrated data-driven learning techniques when historical data is available.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
I'm familiar with parcel lockers in general, especially in the logistics context. However, I had not encountered the specific idea of placing them inside public transportation vehicles until now. I think lockers can reduce redundant delivery van traffic and solve the problem of unsuccessful home deliveries.

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
There may be some benefit for remote areas where dedicated delivery is inefficient. If buses or trains pass through such locations, and if drivers can interact with local drop-off points or individuals, it might make sense. This could reduce the need for separate freight trips.

4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
Yes, especially in urban areas. Timing and spatial coordination between the parcel and the passenger is problematic. If someone misses a crowded train or bus, the package could be lost or inaccessible. There are also space limitations and the operational complexity of loading/unloading packages on public vehicles.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
Public transport operators may see it as an operational burden, particularly if it affects punctuality or increases service complexity. Regular commuters might benefit, particularly if the service helps them avoid going to another location. Logistics providers may not see a clear advantage, especially if station-based lockers provide similar benefits with less complexity.

6. What incentives or disincentives might attract or deter such stakeholders from using on-board parcel lockers?
For transit operators, a financial incentive per parcel could make the solution viable, especially for remote routes. Logistics providers might benefit if home delivery is reduced, but the incentive has to be clear. Users could be encouraged with discounts or loyalty rewards when opting for parcel lockers instead of home delivery.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
Major challenges include synchronizing the package location with the user's trip, managing space on-board (especially during peak hours), and monitoring parcel activity. There's also the issue of what happens when packages are not picked up someone needs to retrieve or relocate them.

8. How can these logistical issues be tackled?
Real-time tracking is critical. If people can track their parcels, communicate with operators, or divert packages to a nearby station or stop, many of these issues could be mitigated. Still, this limits user flexibility. A hybrid system (onboard and at-station lockers) could offer more flexibility.

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit? If yes, which ones?
I'm not aware of specific regulations that would block this. However, safety could be a concern—e.g., passengers accessing lockers while in transit could pose risks. Overall, parcel security is the same as with other lockers.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Yes, a key need is clarity on responsibility. Who is liable for parcels at each stage—public transport or logistics provider? Particularly when vehicles go to depots and parcels remain onboard.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
Locker size, accessibility, and integration without interfering with normal passenger flow. Secure systems to manage opening and closing during transit are also essential.

12. Do you think technology like real-time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Yes, especially real-time tracking. It helps users know where their parcel is and coordinate retrieval, even if they miss the vehicle. Digital access codes are a baseline requirement.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
It depends. In urban areas, onboard lockers might increase costs due to installation, maintenance, and vehicle modification. In remote areas, it could reduce costs by combining freight and passenger transport, avoiding duplicate trips.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Again, the impact is more positive in remote areas. Reducing the need for a separate delivery vehicle in hard-to-reach areas can significantly cut emissions. In urban zones, the effect might be negligible.

15. How would you propose measuring or benchmarking these impacts?
Compare the integrated system against the baseline case where logistics and public transport operate separately. Metrics could include total distance traveled, vehicle-kilometers saved, and carbon emissions avoided.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
Logistics companies, public transport operators, and local government or regulators need to work together. The collaboration should define roles and responsibilities clearly.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?

Clear business models with financial agreements (e.g., per parcel delivery fees), and clarity over roles such as who monitors parcel safety, manages drop-off points, and handles customer queries.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?
For public transport: direct financial returns from logistics providers. For users: rewards for choosing lockers. For logistics firms: cost savings from fewer failed deliveries and fewer vehicle trips.

19. What are the most significant challenges in integrating on-board parcel lockers?
Time and space coordination, passenger-parcel match failures, user inflexibility, and increased operational complexity.

20. What are the key enablers that would ensure widespread acceptance?
Data sharing and real-time tracking, shared infrastructure, and clear stakeholder benefits (especially financial).

21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
Success: remote or low-density areas where buses can deliver packages efficiently. Failure: dense urban areas with high ridership, space scarcity, and complex schedules.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
A hybrid model combining onboard and station lockers could offer flexibility. Flexibility in pickup time is a key behavioral concern. Onboard lockers may limit this. Solutions should aim to balance logistics efficiency with user convenience.

Extra Themes Discussed (in first person):

- **Behavioral Trade-Off: Flexibility vs. Convenience**
  I personally don't like being tied to a specific time and place to retrieve a parcel. If a package doesn't fit in my mailbox, I prefer picking it up from a station locker at my convenience. With onboard lockers, I'd have to adjust my schedule to match the bus or train timing, and that loss of flexibility could be a dealbreaker for many users.
- **Contingency Through Real-Time Re-Routing**
  I see potential in using real-time tracking not just to inform users, but to actively manage exceptions. If I miss my parcel on the bus, maybe I could have it dropped off at the last stop or transferred to a fixed locker nearby. These kinds of fallback options could make the system more resilient and user-friendly.
- **Lockers as Part of Public Transport Business Models**
  One idea I find promising is making parcel delivery a formal part of public transport operations. If transport companies could earn a fee per delivered parcel—especially on remote routes—they might be more motivated to integrate lockers and ensure service quality.
- **Locker Ownership and Investment Risks**
  Something not often discussed is who actually owns the lockers. If they're mounted on moving buses or trains, it complicates maintenance, increases capacity requirements, and

potentially raises investment costs. The business case changes a lot depending on whether the lockers are owned by the logistics provider, the transport operator, or a third party.

Transcript of interview N°3

1. Could you describe your role and experience in the public transportation/logistics sector?
I have experience in both research and the industry side of urban mobility. I co-founded and currently lead a mobility-focused startup that emerged from a major technical university. Our work covers various aspects of urban transportation, with a key innovation involving the use of drones to study mobility patterns. Beyond that, we also engage in simulation, optimization, safety, and other challenges related to urban transportation systems.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Yes, I've come across this concept through a European research project we're participating in. It introduced the idea of integrating parcel lockers into existing transport systems and optimizing their use through modeling and mathematical formulation. We also explored the legal and regulatory issues that such a system would trigger, particularly when considering lockers on vehicles versus at stations.

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
First, it reduces the number of delivery vehicles on urban roads, which in turn eases congestion. Second, it takes advantage of underutilized public infrastructure. And third, it provides consumers with more flexible delivery options. Both from a business and end-user perspective, the potential for improved service flexibility is a major benefit.

4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
The most evident issues are the reduction of available space inside the vehicles, potential safety or security problems, and the complexity involved in integrating this new process. In general, launching such solutions before they are fully mature can risk long-term adoption, as poor early implementation tends to linger in the public or institutional memory.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
I expect a positive reception from logistics companies and consumers. However, public transport operators might be less enthusiastic initially. Introducing a new technology into a traditionally structured agency can disrupt established processes and face resistance.

6. What incentives or disincentives might attract or deter such stakeholders from using on-board parcel lockers?
Operational and technical barriers are the main disincentives. Even if the concept is positive, its real-world complexity might lower stakeholders' confidence. Poor performance at launch could hurt the project's future. The stakes are high, especially for public acceptance.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
If lockers are installed at stations, logistics personnel would need to transfer parcels from trucks to the appropriate lockers, requiring human labor, ramps, trolleys, and designated parking zones. These changes could disrupt existing traffic flows, particularly at busy stations. If the lockers are onboard vehicles, challenges include reduced space—especially during peak hours

and the need to ensure secure transport. Theft or mishandling could occur if lockers are placed near entryways.

8. How can these logistical issues be tackled?
I wouldn't propose specific solutions for each challenge, but I think inclusive design processes are key. Stakeholders, especially those involved in day-to-day operations, not just C-level staff, should be consulted. Their insights can help anticipate and mitigate practical issues from the start.

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit? If yes which one?
Yes. Currently, EU regulations prohibit packages in public transportation vehicles, which would directly block onboard lockers.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Absolutely. It's only a matter of time before these regulations adapt. Given the trends and growing interest, it's likely that policies will evolve to allow integration of freight and passenger transport.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
The most critical technical considerations include locker size, accessibility, and security. These impact both usability and integration feasibility.

12. Do you think technology like real-time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
For the consumer, yes real-time tracking and digital interfaces will be crucial. For operators, I'm less convinced, since many current processes are still hybrid (cloud and paper-based). It could be a challenge to synchronize all systems across diverse stakeholders.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
Logistics providers will benefit by reducing the number of trucks on the road, lowering their operating costs. However, they will likely need to pay public transport operators to use their infrastructure, creating a new revenue stream for the latter. Overall, cost impact could be neutral or positive.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Positively. Fewer delivery vehicles mean fewer emissions, especially in urban centers.

15. How would you propose measuring or benchmarking these impacts?
By tracking the number of delivery vehicles removed from circulation and/or the total kilometers traveled by those vehicles that are no longer needed.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
The key stakeholders are delivery companies, public operators, and governmental authorities responsible for legislation.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
They should clearly define specific roles and ensure transparent communication during the early phases. This will help streamline integration and troubleshoot issues proactively.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?
I wouldn't frame it as "incentives" but rather as a financial relationship. The delivery company should pay the public transport operator for using the infrastructure—simple and fair.

19. What are the most significant challenges in integrating on-board parcel lockers?
Space and safety are the key challenges. Also, public resistance or operational disruptions during peak hours could make deployment more difficult in large cities.

20. What are the key enablers that would ensure widespread acceptance?
Clear demand and stakeholder alignment. Also, starting small—perhaps in a smaller city—could allow smoother testing and scaling.

21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
I see this working better in smaller cities, where the operations are simpler and easier to manage. A big city like London would pose far more logistical and operational challenges.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
Yes—ownership is also an important aspect. If we define ownership in terms of intellectual property, I believe it should be held by either a startup or delivery company. But the physical infrastructure (i.e., the lockers) should be owned by the public transport operator, while the operations could be handled by third parties (startups, delivery firms).

Extra themes discussed:

- **Technology Maturity and Timing**
  If we launch this kind of solution before it's ready—before the tech or legislation is mature—we risk it failing early and leaving a negative impression that's hard to overcome later. Timing matters for adoption.
- **Operational Design Should Include Frontline Workers**
  In my view, you can't just involve managers or executives when designing how this works. The low-level staff—the people who deal with the vehicles or locker handling daily—will know what the real problems are.
- **Industry vs. Consumer Trade-off Based on Locker Placement**
  To me, the placement defines the audience. Lockers at stations are for consumers—they prioritize flexibility. Lockers on vehicles are more of an industry solution to reduce logistics costs.
- **Concerns with Alternative (Station Locker + Bus Loader) Model**
  That model introduces new issues: ramps might not support the equipment needed, safety becomes a concern during accidents, and even during off-peak hours, bus space can be

limited. I've had trouble boarding with just a stroller—imagine trying with a full parcel trolley.

Transcript of interview N°4

1. Could you describe your role and experience in the public transportation/logistics sector?
Sure. I have a background in engineering, specialized in transportation and logistics. Over the years, my research has focused on operations research and the development of mathematical models and algorithms—both exact and heuristic—for complex, NP-hard problems like routing and packing. Recently, I've worked on container transportation, inland movement by ship or truck, air cargo, and also offshore wind logistics.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
No, not exactly. I knew about the idea of using public transport to move goods—there are already studies on that. But from a regulatory standpoint, I think it's currently not allowed. I saw that some union representatives raised this issue during your interviews.

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
Well, lockers in high-traffic areas—like near or inside stores—are already popular, for example here in the Netherlands. But regarding this new type of locker onboard vehicles, I think it's quite difficult to implement. You'd need additional coordination between the transport operator and whoever receives the parcel. Since public transport is already subject to variability and randomness, introducing package delivery would require a lot of flexibility—adding cost.

4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
Say I arrive at the office every day at 9:30, but sometimes I'm early or late—not necessarily by my own fault. This would make planning deliveries unpredictable. Traditional lockers are fixed—you drop off the package, and the customer picks it up whenever. With mobile lockers, there's much more variability and complexity.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
You'd definitely need a platform to coordinate everything. From the customer's side, they'd need to know exactly where their parcel is and which vehicle it's on. But aligning all the actors—transport operators, couriers, customers—is complex. Even if the bus passes by your house at a set time, delays can occur, or picking up a parcel might slow down the entire service, causing a domino effect.

6. What incentives or disincentives might attract or deter such stakeholders from using on-board parcel lockers?
It depends on how many stakeholders are involved. Everyone wants to make a profit. So customers would expect a discount, transport providers would want to be paid for the service, and logistics firms would aim to preserve their margins. Adding another player reduces profitability. In theory, reducing delivery vans on the road is a good idea, but traditional centralized lockers already achieve that with fewer complications.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
First, where do you place the lockers? On buses, the only free space is usually the area reserved

for wheelchairs, which obviously you can't repurpose. Trains might be more feasible—maybe dedicating an entire carriage to lockers. But in buses or trams, especially during rush hour, it's unrealistic. You can't ask passengers to move so someone can pick up a package. Trains, on the other hand, are more flexible in this regard.

8. How can these logistical issues be tackled?
The concept came up that it's rare for someone to miss the Frecciarossa, so the risk is low. But the reality is there's a fleet of identical trains—one day the train might be earlier or later. So the packages should be loaded early in the morning before the train or bus leaves the depot.

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit? If yes which one?
In the Netherlands, mixing public and private use of transport infrastructure is prohibited. I'm not sure about the situation in Italy.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Beyond regulation, I still think coordination would be the most significant cost driver, and the profit margins wouldn't justify it. Also, maintaining consistent train fleets and routes for synchronization is nearly impossible.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
No specific response recorded under this question, but prior responses imply that key technical considerations would include platform coordination, locker location on board, and compatibility with existing passenger needs.

12. Do you think technology like real-time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Not directly answered, but implicitly, yes. The interviewee mentioned that customers need to know exactly where their parcel is and which vehicle it's on.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
The idea is to reduce costs by minimizing home deliveries. If there's sufficient demand, operational costs could decrease slightly. However, emergency situations—like failed deliveries—are expensive. One failed delivery can offset ten successful ones. That's a big risk.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Not significantly. The current system already allows people to choose between home delivery and centralized pickup points. Adding lockers to public transport wouldn't be a game changer, especially considering many delivery vans are already electric. Also, we need to think about where electricity comes from and how batteries are disposed of.

15. How would you propose measuring or benchmarking these impacts?
No direct response recorded.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?

Ownership should probably lie with whoever operates the transport network. They could partner with Poste or Amazon, but another viable model would be to use unused cargo capacity on vehicles to move parcels between stops.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
You'd definitely need a platform to coordinate everything. Aligning all the actors is complex.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?
It depends on how many stakeholders are involved. Everyone wants to make a profit. Customers would expect a discount, transport providers would want to be paid for the service, and logistics firms would aim to preserve their margins.

19. What are the most significant challenges in integrating on-board parcel lockers?
Coordination is the most significant cost driver. Also, space limitations on vehicles, unpredictability in schedules, and the need to align multiple stakeholders are major challenges.

20. What are the key enablers that would ensure widespread acceptance?
Using the capacity for movement, not just storage, is key. Especially if you're leveraging empty space that would otherwise go unused.

21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
Definitely. In Italy, cities are less structured than in the Netherlands. Here, everything is more organized and evenly distributed. In cities like Rome, it's more chaotic. Also, in smaller cities, demand may be too low to justify the investment.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
People often feel more secure knowing their package is in a fixed place. If it's moving around with others on public transport, it may feel less safe—especially for high-value items. So the solution would likely only apply to low-value items, which already limits its applicability. Possibly it could promote public transport, but in Italy it's often seen as a last resort with social stigma. Revaluing public transport could be a positive outcome, but the barriers are high. A startup model could work if it manages to capture value from coordination. But it depends on the context. Public or semi-public models (like Poste) might also work better in some cases. Amazon could make it happen if they see an opportunity, but integrating with public transport adds complexity.

Extra Themes Discussed

- **Emergency Logistics Cost Offset**
  If something goes wrong—like a missed delivery—emergency fixes cost far more than routine ops. One failure can wipe out the savings of ten successful runs; high variability makes the model risky.
- **Use of Public Transport for Parcel Movement, Not Storage**
  I'd rather exploit empty kilometres to shuttle parcels between hubs than keep lockers onboard. Movement creates value without disrupting passengers.

- **Ownership Model—Operator-Owned Lockers, Lean Platform**
  Lockers should belong to the transport operator (not the city). Logistics firms pay a fee, while a slim external platform handles booking and tracking. Pure Amazon ownership is unlikely; a public-operator + startup hybrid is the most workable mix.

Transcript of interview N°5

1. Could you describe your role and experience in the public transportation/logistics sector?
I currently serve as the Chairman of the Freight Leaders Council, an organization focused on promoting sustainable logistics solutions in Italy. Alongside that, I am also the founder and Chairman of FIT Consulting, a transport consultancy firm with a strong focus on sustainable mobility, green logistics, and intermodal freight transport. My experience includes work with the European Commission, various ministries, and local authorities. I also hold the position of Secretary General at the Observatory T.C.R., where I focus on lobbying and transportation policy. I have been involved in logistics, particularly urban logistics, for about 30 years.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Yes, we are currently running an experimental project with the Metropolitan City of Turin. It's not exactly about lockers on board public transport, but rather lockers located at bus stops. These are specifically for suburban transport, in low-demand areas such as valleys. So the concept is familiar, though our focus is slightly different.

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
To be honest, I have serious doubts about the real feasibility of installing lockers directly on transport vehicles. The first issue is that they would reduce the space available for passengers. Secondly, the very concept of a mobile locker is problematic. If you install the locker at a stop, it can be accessed by both public transport users and non-users, which broadens the potential user base. In contrast, if the locker is on a train or bus, only passengers on that specific vehicle can access it—and that vehicle would need to consistently follow the same route. From a business model perspective, this makes the idea significantly more complicated.

4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
Yes, several issues arise right away. One major drawback is that buses often operate on different routes and do not consistently follow the same path. This means you would need to equip more vehicles than necessary just to ensure coverage. Additionally, public transport companies are unlikely to sacrifice revenue-generating space—lockers would take up areas meant for seating or standing passengers. There are also important concerns related to the nature of the goods being transported. For instance, carrying electronics raises fire safety issues. Overall, the implementation becomes quite complex when all these factors are taken into account.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
The perception among stakeholders can vary. For distribution companies, the idea might be appealing in certain scenarios, such as delivering packages to the end of a bus route, where another operator or mode of transport can take over. This could simplify delivery in remote areas. However, the situation becomes more complicated when it comes to international couriers, who are contractually required to deliver to specific branded lockers. In order for onboard lockers to work, they would need to be what we call agnostic lockers—that is, unbranded and accessible to all couriers. Otherwise, the concept becomes unworkable, as you would theoretically need separate buses for each courier, like one for Amazon, one for UPS, another for GLS, and so

on. This is clearly not feasible. Moreover, major players like Amazon are unlikely to deposit packages in generic lockers. These contractual and branding constraints add a significant level of complexity to the business model, both organizationally and commercially.

6. What incentives or disincentives might attract or deter such stakeholders from using on-board parcel lockers?
The main disincentives are operational and organizational. You would need an additional staff member just to manage the lockers, which introduces high costs. Also, transportation companies are unlikely to provide this service for free. On the other hand, logistics providers might adopt it if it saves them time and effort.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
One challenge is that public buses do not consistently run the same route. This means equipping multiple vehicles for a small benefit. Also, the practicality of someone navigating through a crowded bus to access a locker is questionable, especially with privacy concerns and limited space.

8. How can these logistical issues be tackled?
To tackle these challenges, you'd need additional personnel at the end of the line to move parcels from the mobile locker to a fixed location. But again, this increases costs significantly and might not be feasible from a business standpoint.

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit? If yes which one?
Yes, several regulatory constraints exist. Couriers are contractually obligated to deliver directly to recipients and cannot use intermediaries. Bus drivers also have protected contracts that prevent them from performing any task beyond driving. Additionally, buses are currently only approved for transporting people, not freight.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Implementing this service on a regular basis would require new, ad hoc regulations. Without changes in existing policies, especially those regarding contracts and vehicle certifications, it's not legally feasible.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
Technically, the biggest issue is the placement of the locker. A full bus makes it difficult to access the locker, open it, and retrieve items without disturbing other passengers. Also, there is a complete lack of privacy.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
Operational costs would definitely increase. You would need to hire an extra person per vehicle, and this is not sustainable. There are also indirect costs from losing passenger space.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
The idea is environmentally sound in theory. However, most logistics companies are already

shifting to electric vehicles. So the environmental advantage of using public transport lockers might be marginal in practice.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
Local governments, logistics companies, and transport operators must all be aligned. Coordination with courier companies like UPS, FedEx, and Amazon is also necessary, especially if the lockers are to be agnostic..

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?
For logistics companies, just having the option might be enough—they are always looking for efficiency. For transport companies, financial compensation would likely be necessary.

19. What are the most significant challenges in integrating on-board parcel lockers?
The challenges are numerous: inconsistent routes, added staffing costs, loss of passenger space, lack of driver participation, regulatory barriers, and technical impracticalities.

20. What are the key enablers that would ensure widespread acceptance?
One key enabler could be using agnostic lockers placed at bus stops rather than inside vehicles. This model avoids many of the issues linked with on-board integration.

21. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
While the concept is fascinating, it seems unfeasible. There are too many obstacles—technical, legal, organizational, and economic. Fixed lockers at bus stops are a much more viable alternative.

Extra themes discussed

- **The Turin Pilot Project**
  Right now we're testing agnostic lockers at suburban bus stops around Turin's valleys. Couriers load them at dawn; residents grab parcels whenever they pass the stop. Early data show good turnover and—crucially—no loss of passenger space. The trial confirms my view: lockers fixed at stops work; lockers rolling around inside vehicles don't.
- **Ownership & Agnostic-Locker Requirement**
  For onboard—or even stop-based—lockers to fly, they must be agnostic, unbranded, and neutral. One entity—ideally the transport operator or a third-party platform—owns the hardware; all couriers rent slots. If lockers carry an Amazon logo, UPS won't touch them (and vice-versa). Neutral ownership is the only way to avoid the absurd scenario of "one bus for Amazon, another for GLS, another for DHL."
- **Runaway-Parcel Risk**
  Miss the bus that's carrying your package and the item just keeps looping the route. Hunting down these "runaway parcels" means extra tracking tech, customer-service calls, and manual interventions—costs that can wipe out the savings from ten flawless deliveries.
- **Electric-Fleet Charging Bottleneck**
  Couriers tell me, "We're already going electric." Great—but city substations aren't sized to fast-charge an entire zero-emission fleet. Until the grid is beefed up, shifting parcels

onto public transport won't yield the massive carbon cuts everyone hopes for; the actual environmental edge is modest at best.

Transcript of interview N°6

1. Could you describe your role and experience in the public transportation/logistics sector?
I direct the Real Estate Development and Enhancement Department at FS Sistemi Urbani, a subsidiary of Ferrovie dello Stato Italiane. My team takes disused rail property—freight yards, surplus land, vacant buildings—and brings it back to life through urban regeneration projects. A flagship case is the Milan rail yard programme: we are transforming 1 million m², of which 65 % becomes green space, 6 000 social housing units, linear parks, craft hubs for fashion and design, an arts campus for the Brera Academy, plus mixed residential and office stock.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Until today I had never heard of lockers installed inside rolling stock or buses. Within the FS Group we do pursue rail based freight and last mile concepts—Mercitalia Logistics shifts goods from road to rail, and I am exploring station or yard space for urban logistics hubs—but on vehicle lockers are new to me.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
It fits the Smart City vision: citizens can retrieve parcels while commuting, using sustainable public transport. Coupled with real time tracking in an app, it offers flexibility and extends low impact mobility from people to goods.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
The primary drawback is space: lockers would displace passenger seats or standing area. We would need a transport sustainability analysis to see if spare capacity exists.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
Commuters would welcome easier access to services. Transport companies aim to deliver seamless journeys; an added service could attract users—but only if punctuality and comfort hold. Logistics operators might like an extra option yet remain protective of their customer relationship.

6. What incentives or disincentives might attract or deter such stakeholders from using on board parcel lockers?
The big incentive is ESG performance—lower CO□ and better sustainability reporting. Start up grants or EU funding could ease pilots. Disincentives include lost seating revenue, capital cost, and the fear of operational complexity.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?
Beyond space, the barrier is fragmentation: each courier guards its own client data. A viable system needs an agnostic hub that serves all operators without favour.

8. How can these logistical issues be tackled?
Create a neutral “hinge” operator and anchor the concept inside strong urban governance that pushes high impact vans out of the core and obliges a sustainable last mile.

9. Are there regulations or policies that exist to impact the utilisation of parcel lockers on public transit? If yes which one?
Security rules loom large. Luggage storage vanished from many stations in the 1990s because lockers were seen as terror risks. Re introducing volume inside vehicles will face similar scrutiny, though modern surveillance helps.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
EU level sustainability programmes could fund trials, and city mayors could restrict polluting freight at the perimeter, indirectly creating demand for public transport freight.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
Never touch the legally protected wheelchair/mobility space. Lockers would therefore require removing additional seats. We must maintain universal accessibility.

12. Do you think technology like real time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Absolutely. Public transport vehicles already broadcast real time positions; linking each package to a vehicle ID is straightforward, provided data privacy protocols cover sender, courier, and recipient.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
Transport operators would lose fare revenue proportional to the seating removed. A financial plan must weigh that loss against environmental gains and any locker rental income.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Potential savings equal the kilometres that courier vans no longer drive. Yet station based pick up points already capture much of that; the incremental gain of on vehicle lockers needs proof.

15. How would you propose measuring or benchmarking these impacts?
Compare van kilometres and emissions under business as usual vs the locker scenario, then net out the seating reduction and any modal shifts.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
Local government (who sets access rules), public transport operators, logistics companies, and a neutral locker operator must all cooperate.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
City governance has to force high impact freight out of the core—only then will demand appear. The neutral operator coordinates couriers; the transport company supplies space.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last mile delivery methods?
Policy sticks (low emission zones), ESG carrots (lower Scope 3 emissions), and perhaps discounted vehicle fees or grants during the pilot phase.

19. What are the most significant challenges in integrating on board parcel lockers?
Seat loss, security vetting, data sharing reluctance, and the operational puzzle of loading lockers without delaying services.

20. What are the key enablers that would ensure widespread acceptance?
Digital MaaS platforms integrating passenger and parcel flows; strong municipal policy; and a neutral, multi courier locker operator.

21. In your view, are there any particular contexts or use cases where on board parcel lockers are more likely to succeed (or fail)?
Only in large metropolitan areas—Milan, Rome, Naples, Turin, Bologna, Florence—where parcel pressure is high. Small provincial towns lack the volume to justify it.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilising mobile parcel lockers in public transportation?
The concept must plug into a MaaS style digital layer so citizens manage mobility and parcels in one interface. Technically feasible; economically still unproven.

Extra themes discussed

- **Digital city vision.** I emphasised that true smart city operation requires a single digital infrastructure where mobility and logistics merge; eventually the person becomes the device.
- **2050 urban forecast.** By mid century, 70 % of the world's population will live in cities generating 80 % of energy use; freight sustainability is therefore crucial.
- **Real time vehicle data.** Trenitalia and most bus agencies already share live positions, so coupling packages to those feeds is easy.

Transcript of interview N°7

1. Could you describe your role and experience in the public transportation/logistics sector?
I manage research and innovation projects for Spain and Portugal, focusing on European funded urban logistics and supply chain initiatives. That means I'm hands on with pilots and demonstrations that test new distribution models in real cities.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Absolutely. My team is already running two pilots in Madrid. Important distinction: our pilots place grouped parcels in lockers at metro stations, not inside the rolling stock, because today's safety rules make passenger-freight mixing tricky. We preload cages at the metro depot overnight, the trains bring them into town before service starts, and staff transfer the parcels into the station lockers for later pickup.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
I see four clear gains:
• 60–80 % CO□ cut by removing diesel vans from door-to-door work.
• Extra revenue and a greener brand for the transit operator.
• Lower fleet and labour costs for logistics providers—we move more parcels with fewer vehicles and hours.
• Time savings for commuters, who combine parcel pick-up/return with their normal ride.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
Yes, the tricky part is mixing passengers and freight. Current safety rules demand strict separation, so I have to load and unload during windows when vehicles are empty or dedicate whole runs to freight only.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
Logistics operators and retailers are pushing hard for it. Commuters like the convenience. Public transport bodies are keen but cautious because they must tick every safety box.

6. What incentives or disincentives might attract or deter such stakeholders from using on board parcel lockers?
Incentives: lower costs, new income, sustainability metrics, and positive publicity.
Disincentives: added operational complexity, regulatory liability, and the need for robust data sharing.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?
The biggest logistical hurdle for me is capacity planning, matching the number of parcels to locker space and to the trains' time table. If I misjudge, parcels pile up or travel on the wrong train.

8. How can these logistical issues be tackled?
I need a shared digital platform that gives every actor real time visibility, allocates slots per

station, and automates scanning at each hand off.

9. Are there regulations or policies that exist to impact the utilisation of parcel lockers on public transit? If yes which one?
There's no Europe wide rule yet. I still have to respect general safety codes that ban freight where passengers ride unless I physically separate them. Operators also set their own dynamic rules, for example, banning items after a battery incident.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Yes, once pilots mature I expect guidance on passenger freight segregation and on standardising data exchange.

11. From a technical point of view, what might be the most important considerations when parcel lockers have to be incorporated into public transportation?
• Modular locker modules sized to vehicle geometry.
• Roller-cage workflow: parcels grouped into wheeled cages with brakes; a quick strap or tie-down secures them to the car floor. Loading/unloading must fit the short layover window.
• Fast, tool-free tie-down rails inside the vehicle.

12. Do you think technology like real time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Definitely. Barcode or QR scans at every transfer plus API integration between retailer, logistics provider, and operator are non negotiable if I want reliability.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
In Madrid I calculated that once I move about 4 000–5 000 parcels a day on a metro line, ten vans driving six hours shrink to one van driving one hour. Fuel, labour, and congestion costs plunge.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Using metro capacity instead of diesel vans slashes emissions by roughly 60–80 % against today's door to door model, and the savings grow as rail remains electric.

15. How would you propose measuring or benchmarking these impacts?
I start with a baseline: vans, kilometres, and fuel needed to move X parcels today. Then I run the locker flow, measure the same metrics, and compute the Δ CO□ with standard emission factors.

16. Which stakeholders must align to successfully implement the onboard parcel lockers?
Retailers (gatekeepers—if Amazon or Vinted say no, nothing moves), logistics operators, public transport operators, and city authorities.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
I'd set up service level agreements plus a shared IT platform and a revenue sharing model, for instance, €1 per parcel to the metro operator and €2 to the logistics provider.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last mile delivery methods?
Financial savings, tax breaks for low emission delivery, and visible green branding all help.

19. What are the most significant challenges in integrating on board parcel lockers?
Coordinating data between companies, clearing regulatory approvals, securing vehicle space, and hitting the volume needed to break even.

20. What are the key enablers that would ensure widespread acceptance?
Multi brand locker networks, open data standards, credible demand forecasts, supportive city policy, and successful pilots.

21. In your view, are there any particular contexts or use cases where on board parcel lockers are more likely to succeed (or fail)?
They work best in dense urban corridors with reliable metro or BRT systems—Madrid or northern Italian cities are perfect. In smaller towns I could pair bus based lockers with bicycle couriers. They fail where public transport is sparse or unreliable.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilising mobile parcel lockers in public transportation?
I'm happy to share pilot data and connect you with the colleague who built our parcel demand algorithm, just let me know when you start the technical phase of your thesis.

Extra themes discussed

- **Vehicle-loading windows.** To comply with safety rules, parcels are loaded only while the vehicle is empty—typically on the first outbound trip from the depot before passenger service, or on entirely freight-only runs.
- **Securing cages inside the train.** Grouped parcels travel in roller cages that are braked once on board; a simple strap/belt is added for extra stability. No further securing is needed because no passengers are present during these moves.
- **End-to-end scanning procedure.** Each package is linked to a bag/cage ID in the warehouse. At every hand-off (warehouse → truck, truck → metro depot, depot → train, train → locker) only the bag/cage barcode is scanned, giving real-time location of all enclosed parcels while minimising handling.
- **Examples of operator-specific rules.** Public-transport operators can impose additional bans (e.g., Madrid Metro's recent prohibition of e-scooters after a battery-fire incident). These dynamic rules sit on top of general EU safety codes and must be monitored continuously.
- **Madrid scale reference.** Madrid's network has 12 metro lines; one line equipped with lockers at 6–7 stations yields capacity for roughly 300–400 parcels per day, illustrating the scalability of the concept once volumes rise above the 4 000–5 000-parcel break-even.

Transcript of interview N°8

1. Could you describe your role and experience in the public transportation/logistics sector?
I work on corporate strategy—that is, the long term vision—inside Ferrovie dello Stato Italiane (FS Group). The holding covers Trenitalia for passengers, Mercitalia for freight, the infrastructure company that owns tracks and stations, and several foreign rail subsidiaries in the UK, France, Spain, Germany, and (to a lesser extent) Romania. I also look at how to repurpose disused real estate assets around stations.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Lockers inside trains, buses, or trams are new to me; I had never heard of that set up before your thesis. What I have seen is Deutsche Bahn's model: they installed parcel lockers in stations, not on the rolling stock. That seems more realistic to me.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
Among the three variants you outlined, the only one that looks remotely promising to me is the third: trams, buses, or regional trains become Amazon's very last mile. Amazon would drop everything at a central hub and we would load the packages onto public transport vehicles. Even there I feel I'm "missing a piece," because I can't yet see a clear benefit that outweighs the complexity.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
Integration between Amazon's supply chain and operators such as Trenitalia, ATAC, or local bus companies strikes me as really difficult for marginal gains. Service delivery cannot be compromised: if a tram line needs four runs per hour, you must run four—no skipping one to load parcels. Crowding, punctuality, and the sheer number of departures (5 400 trains leave daily in Italy) make the risk of delay unacceptable.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
I see three core stakeholders: logistics providers, the transport company, and the end user. For a shipper like Amazon a single drop off point could be attractive if we then handle the last mile ourselves. Transport companies are conservative; they might consider the idea only if it brings margin and does not interfere with their core schedule. Passengers might find it novel, but I struggle to see a big advantage over current home delivery or the dense network of pick up points.

6. What incentives or disincentives might attract or deter such stakeholders from using on board parcel lockers?
End users: convenience—so long as the price stays low.
Passenger operators: extra margin, but only in market based businesses; regulated services cannot keep commercial revenue.
Amazon: better customer service, provided costs do not explode.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?

You must know the exact vehicle that will carry each package, load every bus or tram correctly in the morning, and still cope with inevitable delays. On subways I'd say absolutely not: too crowded, too frequent, impossible to manage loading. Even on buses you would fight your way through passengers to retrieve the parcel. And most commuters collect on the return trip, which means the packages either ride around full day or someone reloads at midday—both bad options.

8. How can these logistical issues be tackled?
Honestly, I don't have a solution; the logistics look chaotic. That is why station lockers seem far more feasible.

9. Are there regulations or policies that exist to impact the utilisation of parcel lockers on public transit? If yes which one?
Yes. Italian rail has two regimes. Market based services such as Frecciarossa receive no subsidy; profit or loss is ours. Regulated services like regional trains or Intercity receive public funding, and any extra profit theoretically reverts to the State. Local public transport (buses, trams, metro) is similar. Installing lockers on a regulated service would therefore be much harder.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
If the idea ever proved genuinely advantageous, I imagine public authorities would promote it for sustainability reasons, but right now it feels premature.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
Vehicles would need structural changes—removing seats or standing areas—to fit lockers. On high speed trains the restaurant car is the only plausible space; on Intercity trains I see no obvious area. On trams and buses the loss of passenger capacity would be serious.

12. Do you think technology like real time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Coordination with couriers would have to be extremely precise—any loading error or small delay would create chaos—so yes, advanced tracking would be mandatory, but again I doubt it solves the bigger issues.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
Operating costs would rise because the logistical coordination is so fine grained. A single tram delay or a mis loaded parcel derails the whole chain. Capital expenditure to adapt vehicles would also be significant.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Emission savings would have to be counted against the kilometres a courier van no longer drives, but traditional pick up points already capture much of that efficiency.

15. How would you propose measuring or benchmarking these impacts?
I didn't propose a methodology; my point is that existing pick up networks are already highly efficient, so the incremental gain might be small.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g.,

local government, transport operators, logistics firms)?
Logistics providers, the transport operator, and public authorities (because of regulated services) must all agree, plus of course the final users.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
Above all, the new service must not interfere with punctuality: 5 400 trains have to depart each day; a three minute slip can cascade into seven delayed trains.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last mile delivery methods?
Passenger operators would need a clear, risk free margin. Users need convenience at no extra cost. Amazon needs better service without excessive cost.

19. What are the most significant challenges in integrating on board parcel lockers?
Regulatory barriers on subsidised services; logistical complexity; loss of passenger space; risk to punctuality; crowding.

20. What are the key enablers that would ensure widespread acceptance?
If any, they would have to come from the market side—high speed trains looking for ancillary revenue—or from public authorities pushing a sustainability agenda. Neither is happening yet.

21. In your view, are there any particular contexts or use cases where on board parcel lockers are more likely to succeed (or fail)?
Station based lockers are far more promising. On vehicle lockers look unworkable on subways, risky on buses, and irrelevant on long distance trains.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilising mobile parcel lockers in public transportation?
At present I do not see a context where the advantages outweigh the disadvantages. Innovative ideas often look hard at first, but here the obstacles—especially regulatory—seem to trump the gains.

Extra themes discussed

- **Clarifying the thesis frame.** I asked whether you are graduating in economics or engineering, and whether the thesis aims to solve a business problem or a technological one. Understanding that context would help me judge the feasibility of public-transport lockers and the depth of your logistics knowledge.
- **Precedents to investigate.** I recommended looking at Deutsche Bahn's station-based parcel-locker programme—lockers are installed in stations, not on rolling stock—as the closest real-world analogue.
- **FS Group's broader strategy remit.** Beyond trains and tracks, my work involves redeveloping disused railway real-estate assets (e.g., vacant buildings adjacent to stations) for alternative commercial uses.
- **Regulated vs market rail services.** I explained Italy's two revenue regimes: market-based services (e.g., Frecciarossa high-speed trains) keep any profit, whereas regulated services

(regional and Intercity) receive subsidies and must return surplus to the State—making commercial locker revenue far harder on the latter.

- **Operational fragility.** With 5 400 trains departing daily, even a three-minute delay can ripple across seven subsequent trains, so any locker process must never compromise punctuality.
- **Potential cargo spaces.** I noted that, if anything, the restaurant car on high-speed trains could host parcels (similar to airlines filling belly space), whereas refitting buses, trams, or metro cars would remove needed passenger capacity.
- **Station lockers vs on-vehicle lockers.** In my view, fixed lockers at stations offer a much cleaner, less disruptive solution than loading packages directly onto moving vehicles.

Transcript of interview N°9

1. Could you describe your role and experience in the public transportation/logistics sector?
I am a Program Manager in the construction operations area of a large company: I steer multiple projects that jointly deliver medium term supply chain objectives. My remit is less "last mile logistics" and more the upstream infrastructure—overseeing contractors that build and maintain the operational backbone our company relies on.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?
Until this conversation I had never encountered lockers installed on buses, trams, or trains. The notion is new to me; my exposure is limited to conventional courier pick up points.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
For commuters the prime gain is time optimisation: workers ride the same line daily and could collect parcels "en route" instead of carving out extra time. For delivery firms it converts expensive door to door drops into one central hand off, potentially cutting costs and attracting customers who value convenience.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
Two big drawbacks: (i) lockers eat into passenger capacity; (ii) service reliability hinges on the customer catching that exact vehicle—miss the 15:54 bus and your parcel vanishes until the loop completes.

5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
Logistics companies see fewer trips but risk diluting their core "delivery" value. Consumers gain convenience yet shoulder the punctuality burden. Public transport benefits environmentally yet must safeguard capacity and timetable integrity. Municipalities would welcome lower congestion and emissions.

6. What incentives or disincentives might attract or deter such stakeholders from using on board parcel lockers?
Leverage sustainability metrics and potentially charge a storage fee that shares revenue with the transit operator. Conversely, locker space competes with fare revenue, and home delivery remains extremely convenient, so the consumer value proposition can be weak.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?
Everything rides on timing: couriers must load the correct vehicle at its depot; consumers must be punctual. Vehicle depots vary, batch size must justify effort, and missed loads undermine efficiency.

8. How can these logistical issues be tackled?
I don't yet see an easy fix beyond sophisticated scheduling and perhaps limiting the system to predictable terminus loading.

9. Are there regulations or policies that exist to impact the utilisation of parcel lockers on

public transit? If yes which one?
Space reserved for wheelchair users is legally untouchable; lockers must not infringe accessibility. Privacy rules demand anonymous packaging; secure, tamper proof lockers are mandatory.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Yes—rules ensuring anonymity, prohibiting tampering, and setting dimensional limits (only small/medium parcels) would be required.

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
Installation must be quick and modular: fleets differ by city and model, so lockers need configurable footprints. Keeping vehicles out of service for fitting would create gaps in timetables.

12. Do you think technology like real time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Absolutely. Real time vehicle tracking lets customers plan and providers monitor. Random digital codes replace physical keys for security. Without both, the system fails.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
If batching works, delivery costs decline because one drop replaces many. Transit operators might earn rental fees, though fare revenue could fall if seat capacity shrinks.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
Emissions drop by the kilometres not driven by vans; public transport runs anyway. The scale of benefit depends on how many parcels the limited locker space can handle.

15. How would you propose measuring or benchmarking these impacts?
Track "kilometres avoided" from hub to recipient address, convert to CO□ via standard factors, and monitor locker dwell time to gauge utilisation.

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
Producers/retailers, courier companies, transit operators, municipal authorities, and the consumers themselves—because user behaviour is the lynch pin.

17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
Delivery firms must hit depot slots; transit keeps to schedule; consumers collect promptly. If municipalities designate central loading hubs and set clear windows, accountability becomes shared yet structured.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last mile delivery methods?
Show cost savings to retailers, CO□ cuts to the city, and convenience metrics to end users. Possible locker rental or environmental credits could sweeten participation.

19. What are the most significant challenges in integrating on board parcel lockers?
Locker installation and space trade off; consumer punctuality; coordinating loading windows;

ensuring scalability.

20. What are the key enablers that would ensure widespread acceptance?
Concrete cost savings for logistics, demonstrable emissions reduction for municipalities, and iron clad convenience for riders.

21. In your view, are there any particular contexts or use cases where on board parcel lockers are more likely to succeed (or fail)?
High frequency, punctual networks in safe metropolitan areas—e.g., London, Milan, Copenhagen—offer the best odds. Low density or unreliable systems will struggle.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilising mobile parcel lockers in public transportation?
The idea is innovative but may serve a narrow slice of parcels; limited locker volume and consumer discipline could cap impact.

Additional themes discussed outside the guide

- **Scalability concern.** Locker capacity and missed pickups can quickly saturate the system, limiting real world impact.
- **Large item limitation.** Bulky goods (e.g., suitcases) are incompatible with vehicle space; the model only suits small/medium parcels.
- **Installation logistics.** Workers may need to hop on/off moving fleets or sideline vehicles, complicating rollout.
- **Customer behaviour dependency.** The entire value proposition hinges more on end user punctuality than provider performance.

Transcript of interview N°10

1. Could you describe your role and experience in the public transportation/logistics sector?
I am currently working as a researcher at the LINKS Foundation within the "Future Cities & Communities" domain, in collaboration with GTT (Gruppo Torinese Trasporti). Since February 2024, I have been involved in a joint project aimed at facilitating the transition toward a more sustainable and efficient transport system for the city of Turin. In this context, I focus on the analysis of innovative solutions, including the integration of urban logistics with public transport, with particular attention to environmental sustainability and the optimization of urban services.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain your idea of it?
Until you mentioned it I had never heard of putting parcel lockers on buses or trams. The closest comparison I could think of was mail that travels on inter city coaches in remote regions, but in Europe this would be completely new.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
I picture it as a way to make one vehicle do two jobs at once: the bus is already moving, so why not let it carry small freight too? That would let both the transit operator and a company like Amazon polish their green image and tap into an extra revenue stream. As a rider myself I'd enjoy combining my commute with an errand—picking up lunch, stationery, or a gift without adding an extra trip.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
The first thing that worries me is space. Our buses are often packed, so taking over the wheelchair or pram area for lockers would trigger complaints and might breach accessibility rules. Even if space is found, the boarding time would lengthen when someone fishes out a parcel, and that slows the entire line. Customers would also lose flexibility because they'd have to be at a specific stop at a precise moment. Security is another headache: thieves could ride the bus expressly to grab parcels, and a locker that breaks mid route can't be repaired on the fly. Finally, the locker adds weight and drains power—those kilometres really matter on the new electric fleet.

5. How would stakeholders (for example, transit bodies, logistics companies, commuters) view this technology?
I think a public transport agency would be cautiously intrigued by the extra cash and publicity but push back hard on anything that complicates operations or reduces passenger space. A logistics firm would like the sustainability label, while regular riders who already board that bus every day might welcome the convenience; others would call it inflexible and crowded.

6. What incentives or disincentives might attract or deter such stakeholders?
Money always talks: paying an operator to keep marginal evening runs, selling advertising on the locker surface, or promising full logistical responsibility would draw interest. On the other hand, labour negotiations, liability for theft or damage, regulatory exposure, and the loss of accessible floor area could very quickly scare the same stakeholders away.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?

We would have to decide where the lockers fit, how and when they get restocked, and how they interact with depot traffic at night when buses are cleaned and refuelled. Electric buses complicate things because their range is already tight. On trams with high steps the courier would need a ramp or a stair climbing trolley. And every boarding passenger would have to dance around someone unlocking a box.

8. How can these logistical issues be tackled?
My instinct is to start small: pick one tram or BRT line that already has continuous power and high frequency, load lockers during off peak hours, maybe let a dedicated courier ride the route, and see what breaks. Solar assisted or purely mechanical locks could spare the traction battery, and we can test stair climbing equipment on the steep board vehicles.

9. Are there regulations or policies that exist to impact the utilisation of parcel lockers on public transit? If yes which ones?
Weight limits, mandatory wheelchair spaces, emergency exit clearances, hazardous goods restrictions, union rules about drivers' duties, and the whole insurance framework would all kick in the moment a locker is bolted to a bus.

10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
Green deal style incentives for low emission last mile delivery, municipal ordinances that formally allow freight on transit vehicles, clear data sharing clauses for real time GPS, and updated collective agreements that spell out extra tasks for drivers could all smooth the path.

11. From a technical point of view, what might be the most important considerations when parcel lockers have to be incorporated into public transportation?
The locker has to be light yet strong, secure in a crash, easy to remove for maintenance, resistant to vandalism, and miserly in power consumption.

12. Do you think technology like real time tracking, digital access codes, or software integration is crucial?
Absolutely. Without live GTFS feeds a rider couldn't tell where the locker is, and a simple digital code is the quickest way to open a compartment. Some agencies delay their GPS data by thirty seconds because they treat it as a trade secret, but with the right contract that barrier can be removed.

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
Fewer van kilometres could save money for the courier, but someone still has to load and unload lockers, potentially at overtime rates, and the transit agency will invoice for space and risk. Insurance premiums might climb, so the net cost picture is not automatically better.

14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability?
If lockers cut out several diesel vans, emissions drop and city streets see less congestion—especially when the host vehicle is already electric. Yet the extra weight and tyre wear push emissions slightly upward, and an electric cargo bike network might do even better, so the comparison depends on the specific context.

15. How would you propose measuring or benchmarking these impacts?

I would take two years of baseline data—vehicle kilometres, fuel or electricity use, staff hours—and then run a pilot, tracking the same indicators plus parcel throughput, locker turnover speed, failed or stolen deliveries, and cost per parcel. That before and after study would show the real delta.

16. Which stakeholders must align to successfully implement the onboard parcel lockers?
We'd have to bring the municipality, the transit company, the logistics operator, the labour unions, the locker supplier, disability advocates, police and fire authorities, regulators, and—very importantly—the riding public to the same table.

17. How should collaboration be structured?
I'd launch with a transparent cost benefit analysis and an advisory committee where every stakeholder has a seat. The city can steer, the operator can voice operational limits, the courier can commit resources, and disability groups can flag access issues before hardware is ordered.

18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over traditional methods?
Revenue sharing, subsidies for service extensions, the right to exploit locker advertising, free upgrades of passenger information screens, or reduced congestion fees for the logistics firm could all act as carrots.

19. What are the most significant challenges in integrating on board parcel lockers?
Finding space that doesn't impair accessibility, overcoming union resistance, managing liability and theft risk, protecting electric bus range, fitting locker operations into busy depots, satisfying regulators, and convincing passengers that the bus is still primarily for them—all of that forms a formidable bundle of challenges.

20. What are the key enablers that would ensure widespread acceptance?
Clear evidence of benefits, a strong public private dialogue, a supportive sustainability policy framework, positive branding, and a successful pilot on a high frequency electric corridor would all build momentum.

21. Are there any particular contexts or use cases where on board parcel lockers are more likely to succeed (or fail)?
They are most promising in dense, fast moving cities like New York and at the suburban termini of high frequency lines where services are scarce; they are least convincing on overcrowded or infrequent routes, in rural areas, or in places where tobacconists and convenience stores already provide lockers every few hundred metres.

22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilising mobile parcel lockers in public transportation?
I genuinely like the idea because I enjoy squeezing more efficiency out of existing systems, but I would probably start by turning buses into after hours delivery vans that top up fixed lockers at the stops. That sidesteps the space issue and still yields most of the environmental gain. From a transport equity angle mobile or bus replenished lockers could bring services to peripheral neighbourhoods that lack them today. The real hurdle is persuading risk averse public sector actors; once that cultural barrier falls, the technical piece looks solvable.

Extra themes discussed

- **Privacy and the risk of misuse**
  I love the idea that I could pick up a parcel without anyone knowing what it is; that discretion is perfect for surprise gifts ... but the same secrecy could tempt people to move "a kilo of drugs" or worse, so we'd need strict rules on what can travel through the lockers.
- **Social visibility on board**
  Honestly, I'd feel pretty awkward opening a locker in a packed bus and suddenly becoming the centre of attention. A fixed street-side locker lets me collect my stuff quietly, which makes it more comfortable for everyday use.
- **Safety of the courier**
  Picture a courier jumping off at 10 p.m. with a trolley full of parcels: thieves could be waiting, and it would take "two minutes" for them to clear out the load. That personal-safety angle means we'd need better-protected terminals or police presence.
- **Real world precedents**
  I keep thinking of Switzerland's AutoPostale buses that once carried mail and that Basel tram which even collects household waste—proof that multipurpose public-transport vehicles can work and give us a template to study.
- **Fixed lockers at stops & stations restocked by buses**
  The alternative I kept coming back to is placing lockers directly at bus or tram stops, or in nearby stations, and then using off-peak buses as "after-hours delivery vans" to restock them along the route. This setup avoids all the on-board accessibility and space issues, allows for larger locker capacity, and could even help justify keeping some evening or low-demand runs. You'd still cut van mileage and get most of the environmental benefits—without the operational headaches of cramming lockers onto passenger vehicles.

Transcript of interview N°11

1. Could you describe your role and experience in the public transportation/logistics sector?
I'm the Director of the Mobility Service of the Molise Region. We manage regional public transport—not the urban system, but the service that connects all towns and villages in the region.

2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain your idea of it?
No, I wasn't familiar with this idea before. But once it was explained to me, I understood the concept and started thinking about how it might work, especially in the context of our regional transport system.

3. In your view, what would be the possible benefits of on board parcel locker installation on public transportation?
In a region like Molise, this could be very useful. It could serve all the inland municipalities, which are already connected by public transport. That means parcels could reach remote areas easily. It would also help reduce delivery costs for residents, lower emissions, and even support efforts to prevent rural depopulation by bringing more services to people who live far from urban centers.

4. Are there any short term disadvantages or issues that are immediately apparent with on board parcel lockers?
The biggest issue is that the user would have to catch the right vehicle—the one carrying their parcel. This might get complicated if there are multiple runs along the same route. In our regional system, this is manageable, but I see how it could be a challenge. Also, drivers might not be happy about having additional responsibilities unless they're compensated.

5. How would stakeholders (for example, transit bodies, logistics companies, commuters) view this technology?
If transport operators are paid for the service, they'll likely support it. As for logistics companies, they might see it as competition unless they are directly involved. If they collaborate, it might save them from making long trips. The Region would definitely be open to the idea, especially since it adds value for citizens.

6. What incentives or disincentives might attract or deter such stakeholders?
A good incentive would be a small payment per delivery for either the driver or the public transport company. That would make the additional responsibility more acceptable.

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day to day operations?
The biggest logistical issue is knowing which bus has the parcel. Since there might be several buses running the same route, we'd need some system to help users identify the right one. Real-time tracking seems essential.

Q8. How can these logistical issues be tackled?
As I said, real-time tracking would help. Also, making use of the luggage compartment is a good idea—it's typically empty here in Molise because most people don't travel with large bags. That space could definitely be used for parcel delivery.

Q9. Are there regulations or policies that exist to impact the utilization of parcel lockers on

public transit? If yes which one?
As far as I know, there's no regulation in Molise that prohibits carrying goods and passengers together. I've personally sent parcels by bus just by giving them to the driver and paying a small fee. It's common practice here.

Q10. Do you envision some new policies or regulatory developments that would be able to bring in this service?
I'm not sure what national regulations might say, but regionally we've never had issues. If the service grows or becomes formalized, some policy updates might be needed, but I don't think it would be a major barrier.

Q11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
It depends on the parcel size. Smaller items could potentially be stored on the bus, but larger ones should go into the luggage compartment. That said, an IT system to manage everything would be essential.

Q12. Do you think technology like real-time tracking, digital access codes, or software integration is crucial to successfully implementing lockers on public transportation?
Yes, absolutely. Real-time tracking, digital access codes, and software to coordinate everything would be critical for making this work.

Q13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
I think it would reduce costs for the end-user. If buses are already traveling the route, there's no need for an additional delivery van. That's where the savings come in.

Q14. How can parcel lockers on public transportation impact carbon emissions or environmental sustainability on public transportation?
It would definitely reduce emissions. Right now, delivery vans sometimes drive out to a remote town for just one or two deliveries. If the bus is already going there, that trip becomes unnecessary.

Q15. How would you propose measuring or benchmarking these impacts?
This wasn't discussed in detail.
→ Not explicitly covered in the interview.

Q16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
You'd need alignment between the Region or local government, logistics companies, and transport operators. They all play a role.

Q17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
In my view, the logistics company should manage the lockers. They're already structured for it. Public transport companies—especially since we have 29 different concessionaires in Molise—should act as subcontractors. That would simplify things.

Q18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?

A fair revenue-sharing model would help. Giving the public transport provider 20–30% of the delivery fee could be a good starting point.

Q19. What are the most significant challenges in integrating on-board parcel lockers?
It's the vehicle identification issue again—making sure users find the right bus. Also, ensuring driver participation and coordination among all the stakeholders, especially given the number of transport operators we work with in the region.

Q20. What are the key enablers that would ensure widespread acceptance?
Financial incentives for operators and drivers, the availability of luggage space, and solid IT systems are the key enablers. The fact that this aligns with environmental goals makes it even stronger.

Q21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
This system would work well in rural or regional areas like Molise. In big urban cities like Milan, though, it would be difficult. The buses are too crowded, and there's no room to access lockers. The space issue would be a serious limitation.

Q22. Do you have any other comments regarding the viability, potential benefits, or drawbacks of utilizing mobile parcel lockers in public transportation?
I think it's a really interesting concept. I'll personally look into the legal side to better understand what's possible. I'd be happy to see it move forward, especially in regions like ours where the benefits could be significant.

Extra Themes Discussed

- **Distinction between urban vs. regional context:**
  I believe this kind of solution might work well in a rural region like Molise, but it would be much harder to implement in a big city like Milan. In urban settings, buses are often full, and there's no space to place lockers or allow people to access them during a crowded ride. In contrast, here we usually have more space available, and the structure of the routes is simpler to manage.
- **User behavior and interaction with drivers:**
  From my experience, especially in smaller communities, the handover of a package would likely involve some direct interaction with the driver. That's quite normal around here—people are used to informal exchanges and services. So I think that's something to keep in mind, particularly where the digital locker infrastructure might not be fully developed or widespread.

B

Open coding

Table B.1: Open coding interview N°1

#	Code label	Brief description	Literal source text
1	Logistics-manager perspective	The interviewee is a logistics-manager	**Q1** "I'm a manager, and I work in the logistics sector. Specifically, I'm responsible for relationships with our courier providers..."
2	Outsourced-courier coordination	Interviewee manages the interactions with external courier providers	**Q1** "...we use external companies, so I manage those interactions."
3	Concept unfamiliarity	The idea of lockers on PT is new to the expert	**Q2** "Honestly, no. I'd never heard of the idea before this conversation..."
4	Niche traveller segment	The main targets could be always-moving customers	**Q3** "...could serve a niche group of customers—people who travel often and might not be home to receive deliveries."
5	Space constraints	It might be difficult to fit lockers on vehicles	**Q4** "Where would you actually put these lockers on a train or a bus? ... space is always a major issue."
6	Passenger-capacity trade-off	Reduce seats capacity	**Q4** "You might have to sacrifice a cabin or a section of it, which would reduce capacity for passengers."
7	Wheelchair-space conflict	The placement of lockers inside PT could compete with accessible area	**Q4** "On buses, maybe you'd put them where wheelchair users sit, but then you're creating another problem."
8	Schedule-alignment challenge	The parcel and customer must be in the same vehicle	**Q4** "If I'm on a specific train at a specific time, the parcel has to be there too—and that's not easy."
9	Delivery unpredictability	Traffic and road issues can cause delays	**Q4** "We often don't meet scheduled time slots because of traffic or road issues."
10	Perceived environmental benefit	Fewer kilometres done by vans	**Q5** "If it helps reduce carbon emissions by replacing van trips with existing public transport routes, that's potentially positive."

#	Code label	Brief description	Literal source text
11	Innovation image	Idea seen as "cool/innovative"	**Q5** "…could be seen as innovative…"
12	Operational complexity	The implementation of this idea has been judged as "very complex"	**Q5** "That said, operationally it's very complex."
13	Work-force reluctant	Drivers would be reluctant to abandon vans	**Q5** "…getting our delivery drivers to switch from vans to taking public transportation. People are resistant to change, especially in this sector."
14	Union-opposition risk	Strong unions could resist	**Q5** "In Lombardy, for instance, there are strong unions, and changes like this could be extremely delicate."
15	Business-model fit	This solution has to align with existing operations	**Q6** "…whether this kind of solution fits into our business model and operational processes."
16	Feasibility & CBA required	Needs to be understood if there is a positive cost-benefit analysis	**Q6** "We'd need to do a thorough feasibility and cost-benefit analysis."
17	Morning terminus loading feasible	Load the packages in the morning is doable	**Q7** "…be at the terminus at a specific time … and load the packages. That part is manageable."
18	Night re-processing cost	Unclaimed parcels increase cost	**Q7** "If parcels aren't picked up, we'd have to collect and reprocess them during the night shift."
19	High bus no-show risk	Bus riders often miss the ride and consequently do not pick up the parcel	**Q7** "On buses, it's far more unpredictable."
20	Lower no-show risk on trains	Train riderds are more reliable	**Q7** "On high-speed trains, this risk is lower, because people are more committed to those trips."
21	Smart design needed	A careful design of lockers is required	**Q11** "Integrating them into buses or trains will require careful design."

#	Code label	Brief description	Literal source text
22	Public-access rule	Lockers must meet opening-hours regulations	**Q9** "They have to be in locations that are publicly accessible and open for a minimum number of hours."
23	Locker-failure problem	If the access is denied, the delivery fails	**Q9** "If the locker is on a train and the customer can't retrieve the package ... it becomes a big problem."
24	Customer-dissatisfaction	The worst possible outcome for a retailing company is the customer-dissatisfaction	**Q9** "Customer dissatisfaction is one of the worst outcomes for us."
25	Locker bulkiness	Units are large and awkward	**Q11** "Lockers are bulky and hard to fit, even in retail locations."
26	Reliable process needed	Robust process for loading, monitoring and collecting	**Q11** "...we'd need reliable processes for loading, monitoring, and collecting the packages..."
27	Real-time tracking necessity	Live tracking is crucial	**Q12** "...we'll need robust tech—real-time tracking..."
28	Secure digital access	Digital codes for pickup	**Q12** "...secure access..."
29	Systems integration	Software must easily fit with the current backend	**Q12** "...software that integrates seamlessly with our systems."
30	Cost efficiency depends on pickups	Viability strongly relies on pickup rate	**Q13** "If packages are consistently picked up, it could be efficient."
31	High possible costs for parcels lockers on buses	If pickups fail, the costs sharply raise	**Q13** "...especially buses, the risk of failed pickups is high. If that happens often, we face higher costs in returns and reprocessing."
32	Unplanned retrieval burden	Off-schedule retrieval increase the operational strain	**Q13** "...managing unscheduled retrievals adds operational strain."
33	Trains mitigate cost	More predictable service reduces costs	**Q13** "On trains, though, where schedules are more predictable, these costs could be minimized."

#	Code label	Brief description	Literal source text
34	Van-trip substitution	PT legs replace van kilometers, having a positive impact on the environment.	**Q14** "Using existing transport infrastructure to deliver parcels has environmental value."
35	Environmental-value	Municipalities might be interested given the green appeal	**Q16** "Municipalities might be interested if it fits within a smart city strategy. It could also appeal to environmentally conscious citizens."
36	Successful-delivery KPI	A key metric could be % picked-up	**Q15** "One of the main metrics we'd look at is the percentage of successful deliveries…"
37	Track the cause of return	Reason behind returns	**Q15** "We'd also track returns caused by technical issues, timing problems, or missed pick-ups."
38	Stakeholders alignment	Logistics, PT and local government alignment	**Q16** "You'd definitely need alignment between logistics companies, public transport operators, and local governments."
39	Transparent communication	Early open dialogue is crucial	**Q17** "There should be direct and transparent communication, especially in the beginning."
40	Proactive problem-solving	Proactive approach towards issues	**Q17** "Problems need to be addressed proactively before they escalate."
41	Incentives are secondary to feasibility	Incentives matter less than feasibility	**Q18** "…for us it's not about incentives it's about feasibility."
42	Cost-viability challenge	Is it worth it?	**Q19** "Then there's the question of cost. Is it worth it? From both a financial and operational perspective?"
43	Demand-research necessity	Must understand demand first	**Q20** "Understanding the actual demand is essential."
44	Customer-interest enabler	User interest drives adoption	**Q20** "If customers show interest, then companies will be more willing to explore the solution."

#	Code label	Brief description	Literal source text
45	High PT-usage context	The success of this solution is likelier where PT use is high	**Q21** "In Northern European countries, where public transportation is more heavily used, this idea might succeed."
46	Geographic suitability	Bologna given as Italian example	**Q21** "…cities like Bologna where people drive less and use bikes or public transport more could be a good fit."

Table B.2: Open coding interview N°2

#	Code label	Brief description	Literal source text
1	Transportation modelling expertise	Interviewee's professional focus	**Q1** "I work with transportation models, mostly focused on optimization over transport networks."
2	Data-driven optimisation	Integration of data-driven learning techniques	**Q1** "Recently, we've also integrated data-driven learning techniques when historical data is available."
3	Customer-behavior integration	Focus on the inclusion of user preferences	**Q1** "...incorporating customer behavior into these models. For example, understanding whether customers prefer improved reliability, reduced time..."
4	New to the concept	Lockers on PT is new to the interviewee	**Q2** "I had not encountered the specific idea of placing them inside public transportation vehicles until now."
5	Reduction of vans in traffic	Reduction of redundant vans	**Q2** "I think lockers can reduce redundant delivery van traffic..."
6	Solve failed home deliveries	Benefit of increasing successful deliveries	**Q2** "...and solve the problem of unsuccessful home deliveries."
7	Effectiveness in using it in remote-areas delivery efficiency	Potential benefit in making it in low-density zones	**Q3** "There may be some benefit for remote areas where dedicated delivery is inefficient."
8	Reduction of freight trips	Combines freight and passengers	**Q3** "This could reduce the need for separate freight trips."
9	Driver drop-off interaction	Need of bus drivers to interact at drop-off points	**Q3** "...if drivers can interact with local drop-off points or individuals, it might make sense."
10	Timing–passenger synchronization issue	Disadvantages related to time and spatial coordination	**Q4** "Timing and spatial coordination between the parcel and the passenger is problematic."

#	Code label	Brief description	Literal source text
11	Inaccessibility in retiring the package	Missed bus/train → lost access	**Q4** "If someone misses a crowded train or bus, the package could be lost or inaccessible."
12	Space limitations on vehicles	Locker volume reduce available seats	**Q4** "There are also space limitations…"
13	Loading/unloading complexity	Extra operational step	**Q4** "…operational complexity of loading/unloading packages on public vehicles."
14	PT-operator punctuality burden	Risk of loosing punctuality	**Q5** "Public transport operators may see it as an operational burden, particularly if it affects punctuality…"
15	Service complexity concern	Increase complexity for operators	**Q5** "…or increases service complexity."
16	Commuter convenience	Commuters avoid extra trip	**Q5** "Regular commuters might benefit, particularly if the service helps them avoid going to another location."
17	Logistics companies prefer station lockers	Less complex alternative	**Q5** "Logistics providers may not see a clear advantage, especially if station-based lockers provide similar benefits with less complexity."
18	Financial incentive for transit operators	Burden reduction with fee per parcel	**Q6** "For transit operators, a financial incentive per parcel could make the solution viable…"
19	Reduction of logistics cost	Failed home deliveries reduced	**Q6** "Logistics providers might benefit if home delivery is reduced…"
20	User discount incentives	Incentives encourage adoption	**Q6** "Users could be encouraged with discounts or loyalty rewards…"
21	Peak-hour space problem	Space issues if too crowded	**Q7** "…managing space onboard (especially during peak hours)…"
22	Need to monitor parcel	Need to track locker activity	**Q7** "…and monitoring parcel activity."

#	Code label	Brief description	Literal source text
23	Unpicked-package retrieval	Need of relocation or retrieval of items	**Q7** "There's also the issue of what happens when packages are not picked up someone needs to retrieve or relocate them."
24	Real-time tracking need	Essential update to resolve synchronization error	**Q8** "Real-time tracking is critical."
25	Communication with operators	User ↔ operator info flow	**Q8** "…track their parcels, communicate with operators…"
26	Possibility of rerouting parcel	Redirect parcel to nearby stop	**Q8** "…or divert packages to a nearby station or stop…"
27	Hybrid locker system	Mix on-board & station lockers	**Q8** "A hybrid system (on-board and at-station lockers) could offer more flexibility."
28	Lack of regulation barrier	No known blocking rules	**Q9** "I'm not aware of specific regulations that would block this."
29	Safety concern in transit	Passengers using lockers on moving vehicle	**Q9** "However, safety could be a concern—e.g., passengers accessing lockers while in transit could pose risks."
30	Parcel security parity	Same security of existing stationary lockers	**Q9** "Overall, parcel security is the same as with other lockers."
31	Explicit liability	Policy must define responsibility	**Q10** "…clarity on responsibility. Who is liable for parcels at each stage—public transport or logistics provider?"
32	Locker size & accessibility	Physical/ergonomic design factors	**Q11** "Locker size, accessibility, and integration without interfering with normal passenger flow."
33	Non-interference with passenger comfort	Must not block passenger movement	**Q11** "Locker size, accessibility, and integration without interfering with normal passenger flow."
34	Secure access in motion	Open and close safely on route	**Q11** "Secure systems to manage opening and closing during transit are also essential."

#	Code label	Brief description	Literal source text
35	Digital access baseline	Codes = minimum tech	**Q12** "Digital access codes are a baseline requirement."
36	Urban cost increase	Installation in urban environments raises costs	**Q13** "In urban areas, onboard lockers might increase costs due to installation, maintenance, and vehicle modification."
37	Remote cost savings	Combining trips saves money	**Q13** "In remote areas, it could reduce costs by combining freight and passenger transport…"
38	Emission reduction in hard-to-reach areas	Bigger CO_2 benefit are in remote areas	**Q14** "Reducing the need for a separate delivery vehicle in hard-to-reach areas can significantly cut emissions."
39	Negligible urban impact	Little green gain in dense cities	**Q14** "…In urban zones, the effect might be negligible."
40	Comparison metric	Evaluate against the current system	**Q15** "Compare the integrated system against the baseline case where logistics and public transport operate separately."
41	Distance/VKT/emission KPIs	Suggested measurement set	**Q15** "Metrics could include total distance traveled, vehicle-kilometers saved, and carbon emissions avoided."
42	Stakeholder triad alignment	Logistics + PT + government need to work together agree	**Q16** "Logistics companies, public transport operators, and local government or regulators need to work together."
43	Business model with parcel fee	Financial agreement structure	**Q17** "Clear business models with financial agreements (e.g., per parcel delivery fees)…"
44	Customer-interest is vital	User interest drives adoption	**Q20** "If customers show interest, then companies will be more willing to explore the solution."
45	Public-transport returns	Direct revenue for PT	**Q18** "For public transport: direct financial returns from logistics providers."

#	Code label	Brief description	Literal source text
46	User rewards	Incentive for customers	**Q18** "For users: rewards for choosing lockers."
47	Logistics savings via fewer fails	Incentive for carriers	**Q18** "For logistics firms: cost savings from fewer failed deliveries…"
48	Time-space coordination challenge	Principal integration hurdle	**Q19** "Time and space coordination, passenger-parcel match failures…"

Table B.3: Open coding interview N°3

#	Code label	Brief description	Literal source text
1	Research–industry dual experience	The intervieew shows hybrid expertise	**Q1** "I have experience in both research and the industry side of urban mobility."
2	Startup founder role	Entrepreneurial point of view	**Q1** "I co-founded and currently lead a mobility-focused startup…"
3	Drone-based mobility research	Tech innovation background	**Q1** "…a key innovation involving the use of drones to study mobility patterns."
4	Simulation & optimisation expertise	The interviewee shows modelling skill set	**Q1** "…we also engage in simulation, optimization, safety, and other challenges…"
5	EU-project	Familiarity with the concept	**Q2** "I've come across this concept through a European research project we're participating in."
6	Locker on PT modelling & formulation	Mathematical formulation of lockers on PT	**Q2** "…integrating parcel lockers…and optimizing their use through modeling and mathematical formulation."
7	Focus on regulatory aspects	Early awareness of legal and regulatory isseus	**Q2** "We also explored the legal and regulatory issues … particularly when considering lockers on vehicles versus at stations."
8	Delivery-vehicle reduction benefit	Core environmental benefit	**Q3** "First, it reduces the number of delivery vehicles on urban roads…"
9	Reduction of traffic congestion	Traffic benefit	**Q3** "…which in turn eases congestion."
10	Use of under-utilised infrastructure	Better use of assets	**Q3** "it takes advantage of underutilized public infrastructure."
11	Flexible delivery options	Consumer convenience	**Q3** "…provides consumers with more flexible delivery options."

#	Code label	Brief description	Literal source text
12	Service-flexibility value	Business appeal	**Q3** "Both from a business and end-user perspective, the potential for improved service flexibility is a major benefit."
13	Vehicle space reduction	Key physical drawback	**Q4** "...reduction of available space inside the vehicles..."
14	Safety / security risk	Risk perception	**Q4** "...potential safety or security problems..."
15	Integration complexity	The integration of this new process could be complicated	**Q4** "...the complexity involved in integrating this new process."
16	Premature launch risk	Adoption could be hindered	**Q4** "Launching such solutions before they are fully mature can risk long-term adoption..."
17	Logistics positive view	Stakeholder positive attitude	**Q5** "I expect a positive reception from logistics companies..."
18	Consumer positive view	End-user attitude	**Q5** "...and consumers."
19	PT operator reluctant	Adoption barrier	**Q5** "...public transport operators might be less enthusiastic initially."
20	Resistance to innovation	Disturb established processes	**Q5** "Introducing a new technology into a traditionally structured agency can disrupt established processes and face resistance."
21	Operational & technical barriers	Main disincentives	**Q6** "Operational and technical barriers are the main disincentives."
22	Complexity lowers confidence	Stakeholder reluctant due to complexity	**Q6** "...its real-world complexity might lower stakeholders' confidence."
23	Public acceptance stakes	Reputation risk	**Q6** "The stakes are high, especially for public acceptance."
24	Required human labor and equipment	Added handling effort	**Q7** "...transfer parcels...requiring human labor, ramps, trolleys, and designated parking zones."

#	Code label	Brief description	Literal source text
25	Disruption in busy stations	Possible congestion in busy stations	**Q7** "These changes could disrupt existing traffic flows, particularly at busy stations."
26	Peak-hour lost of space onboard PT	Capacity issues	**Q7** "…reduced space—especially during peak hours…"
27	Secure transport needed	Safety during transportation	**Q7** "…the need to ensure secure transport."
28	Theft / mishandling risk	Security threat	**Q7** "Theft or mishandling could occur if lockers are placed near entryways."
29	Inclusive design process	Mitigation approach	**Q8** "I think inclusive design processes are key."
30	Consult operational staff	Use insights from the front line	**Q8** "Stakeholders, especially those involved in day-to-day operations… should be consulted."
31	EU ban on parcels onboard	Regulatory issues	**Q9** "Currently, EU regulations prohibit packages in public transportation vehicles…"
32	Expect regulatory evolution	Future policies	**Q10** "It's only a matter of time before these regulations adapt."
33	Locker size critical	Tech specification	**Q11** "The most critical technical considerations include locker size…"
34	Locker accessibility critical	Tech specification	**Q11** "…accessibility…"
35	Locker security critical	Tech specification	**Q11** "…and security."
36	Real-time tracking vital (consumer)	Tech enabler	**Q12** "For the consumer, yes real-time tracking…will be crucial."
37	Digital interfaces baseline	Tech enabler	**Q12** "…and digital interfaces will be crucial."
38	Operator hybrid systems	Integration could be a problem due to the mix of cloud and paper processes	**Q12** "…many current processes are still hybrid (cloud and paper-based)."

#	Code label	Brief description	Literal source text
39	Synchronization challenge	Multi-party IT challenge	**Q12** "It could be a challenge to synchronize all systems across diverse stakeholders."
40	Logistics cost saving	Financial upside	**Q13** "Logistics providers will benefit by reducing the number of trucks on the road…"
41	New revenue stream for PT	Business model	**Q13** "…they will likely need to pay public transport operators to use their infrastructure, creating a new revenue stream…"
42	Net cost neutral / positive	Overall cost outlook	**Q13** "Overall, cost impact could be neutral or positive."
43	Urban-emission reduction	Sustainability gain	**Q14** "Fewer delivery vehicles mean fewer emissions, especially in urban centers."
44	Metric: delivery vehicles removed	Impact measurement	**Q15** "…tracking the number of delivery vehicles removed from circulation…"
45	Metric: kilometres saved	Impact measurement	**Q15** "…and/or the total kilometers traveled by those vehicles that are no longer needed."
46	Stakeholder triad alignment	Collaboration need	**Q16** "The key stakeholders are delivery companies, public operators, and governmental authorities…"
47	Define roles & transparent comms	Governance rule	**Q17** "They should clearly define specific roles and ensure transparent communication during the early phases."
49	Space & safety top challenges	Greatest hurdles	**Q19** "Space and safety are the key challenges."
50	Demand clarity & small-city pilot	Key enablers	**Q20** "Clear demand and stakeholder alignment. Also, starting small—perhaps in a smaller city—could allow smoother testing and scaling."

Table B.4: Open coding interview N°4

#	Code label	Brief description	Literal source text
1	Engineering & logistics background	Interviewee's core expertise	Q1: "I have a background in engineering, specialized in transportation and logistics."
2	Mathematical modelling for NP-hard problems	Focus on exact & heuristic algorithms	Q1: "...development of mathematical models and algorithms—both exact and heuristic—for complex, NP-hard problems like routing and packing."
3	Multimodal expertise	Experience in container, air and offshore wind logistics	Q1: "Recently, I've worked on container transportation, inland movement by ship or truck, air cargo, and also offshore wind logistics."
4	Unfamiliar concept and regulatory ban	New to the idea of lockers on PT and "currently not allowed"	Q2: "No, not exactly... from a regulatory standpoint, I think it's currently not allowed."
5	Concern towards union	Union representatives raised	Q2: "I saw that some union representatives raised this issue during your interviews."
6	Dutch locker popularity	Fixed lockers already common	Q3: "Lockers in high-traffic areas—like near or inside stores—are already popular, for example here in the Netherlands."
7	Complexity in coordinating the implementation	Extra coordination raises costs	Q3: "...introducing package delivery would require a lot of flexibility—adding cost."
8	PT variability	Public transport subject to variability	Q3: "Since public transport is already subject to variability and randomness..."
9	Unpredictable planning	Arriving early/late breaks schedule	Q4: "Say I arrive at the office every day at 9:30, but sometimes I'm early or late... This would make planning deliveries unpredictable."

#	Code label	Brief description	Literal source text
10	Fixed vs mobile lockers	Mobile = "much more variability and complexity"	Q4: "Traditional lockers are fixed… With mobile lockers, there's much more variability and complexity."
11	Need of a platform to coordinate	Digital platform prerequisite	Q5: "You'd definitely need a platform to coordinate everything."
12	Tracking is requirement	Users must know the location of the parcel & vehicle	Q5: "…they'd need to know exactly where their parcel is and which vehicle it's on."
13	Alignment complexity	Multi-actor synchronisation is complex	Q5: "…aligning all the actors—transport operators, couriers, customers—is complex."
14	Domino-effect delay risk	Parcel pickup may slow down the PT service	Q5: "…picking up a parcel might slow down the entire service, causing a domino effect."
15	Stakeholder profit expectations	Discounts / fees / margins	Q6: "Customers would expect a discount, transport providers would want to be paid … logistics firms would aim to preserve their margins."
16	Extra player cuts profitability	Each added actor reduces profit	Q6: "Adding another player reduces profitability."
17	Centralised lockers already solve the problem of vans	Simpler existing alternative	Q6: "Traditional centralized lockers already achieve that with fewer complications."
18	Wheelchair-space conflict	Bus free zone can't be reused	Q7: "On buses, the only free space is usually the area reserved for wheelchairs, which obviously you can't repurpose."
19	Dedicated train carriage viable	Trains are more flexible for lockers	Q7: "Trains might be more feasible—maybe dedicating an entire carriage to lockers."
20	Peak-hours issues	It's not possible to ask to passengers to move	Q7: "…especially during rush hour, it's unrealistic. You can't ask passengers to move so someone can pick up a package."

#	Code label	Brief description	Literal source text
21	Early-morning depot loading	Operational tactic	Q8: "...packages should be loaded early in the morning before the train or bus leaves the depot."
22	Train variability	Same-fleet but timing still varies	Q8: "...there's a fleet of identical trains—one day the train might be earlier or later."
23	NL public-private mix is banned	Regulatory blocker	Q9: "In the Netherlands, mixing public and private use of transport infrastructure is prohibited."
24	Coordination main cost driver	Biggest cost element	Q10: "I still think coordination would be the most significant cost driver..."
25	Profit margins not justified	Low economic appeal	Q10: "...and the profit margins wouldn't justify it."
26	Consistent fleet impossible	Synchronization challenge	Q10: "Maintaining consistent train fleets and routes for synchronization is nearly impossible."
27	Operational cost risk of failures	1 failed cancels 10 successive	Q13: "One failed delivery can offset ten successful ones. That's a big risk."
28	Modest cost-reduction potential	Need for high demand	Q13: "If there's sufficient demand, operational costs could decrease slightly."
29	Minimal sustainability impact	Not a "game changer"	Q14: "Adding lockers to public transport wouldn't be a game changer..."
30	Electric van baseline	Electric vans already have low-emission	Q14: "...considering many delivery vans are already electric."
31	Battery lifecycle concern	Upstream environment constraint	Q14: "...we need to think about where electricity comes from and how batteries are disposed of."
32	Operator ownership model	PT operator should own	Q16: "Ownership should probably lie with whoever operates the transport network."
33	Partnership with PosteNL/Amazon	Possible business allies	Q16: "They could partner with Poste or Amazon..."

#	Code label	Brief description	Literal source text
34	Use unused cargo capacity	Move parcels between stops	Q16: "…use unused cargo capacity on vehicles to move parcels between stops."
35	Coordination platform reiterated	Alignment still complex	Q17: "You'd definitely need a platform to coordinate everything. Aligning all the actors is complex."
36	Incentive = profit split	Same profit-expectation logic	Q18: "Everyone wants to make a profit…"
37	Coordination + space + schedule = top challenges	Triple-challenge summary	Q19: "Coordination is the most significant cost driver. Also, space limitations on vehicles, unpredictability in schedules…"
38	Movement capacity enabler	Use vehicle motion, not storage	Q20: "Using the capacity for movement, not just storage, is key."
39	Netherlands vs Italy structure	Importance of context	Q21: "In Italy, cities are less structured than in the Netherlands… In cities like Rome, it's more chaotic."
40	Low demand in small cities	Scale challenge	Q21: "In smaller cities, demand may be too low to justify the investment."
41	Security perception fixed vs mobile	Users feel safer with fixed lockers	Q22: "People often feel more secure knowing their package is in a fixed place."
42	Suitable for low-value items	Low value items	Q22: "So the solution would likely only apply to low-value items, which already limits its applicability."
43	PT revaluation potential	Could boost PT image	Q22: "Possibly it could promote public transport… Revaluing public transport could be a positive outcome…"
44	PT stigma in Italy	Cultural barrier	Q22: "…but in Italy it's often seen as a last resort with social stigma."
45	Startup coordination model	New-venture opportunity	Q22: "A startup model could work if it manages to capture value from coordination."

#	Code label	Brief description	Literal source text
46	Public / semi-public operator model	Poste style option	Q22: “Public or semi-public models (like Poste) might also work better in some cases.”

Table B.5: Open coding interview N°5

#	Code label	Brief description	Literal source text
1	Freight leaders chairman role	Senior point of view in sustainable logistics	Q1: ”I currently serve as the Chairman of the Freight Leaders Council...”
2	Transport consultancy founder	Consultancy expertise	Q1: ”...founder and Chairman of FIT Consulting, a transport consultancy firm...”
3	30 years of urban logistics experience	Long exposure in the logistics experience	Q1: ”I have been involved in logistics, particularly urban logistics, for about 30 years.”
4	Pilot program of lockers at bus stop	Pilot program in Turin	Q2: ”we are currently running an experimental project with the Metropolitan City of Turin... lockers located at bus stops.”
5	Low demand with a focus on valley	Rural use case context	Q2: ”...specifically for suburban transport, in low-demand areas such as valleys.”
6	Doubts regarding the feasibility of on-board lockers	Scepticism regarding this innovation	Q3: ”I have serious doubts about the real feasibility of installing lockers directly on transport vehicles.”
7	Reduction of space for passenger	Physical constraint	Q3: ”The first issue is that they would reduce the space available for passengers.”
8	Limited access to mobile lockers	Only riders can access	Q3: ”...if the locker is on a train or bus, only passengers on that specific vehicle can access it...”
9	Need of consistent route	Vehicle must follow same route	Q3: ”...and that vehicle would need to consistently follow the same route.”
10	Complex business model	Mobility complicates economics	Q3: ”From a business model perspective, this makes the idea significantly more complicated.”
11	Bus might have variable routes	Buses hardly follow the same path	Q4: ”buses often operate on different routes and do not consistently follow the same path.”

#	Code label	Brief description	Literal source text
12	Need to equip more fleet	Need many vehicles to cover the entire network	Q4: ”This means you would need to equip more vehicles than necessary just to ensure coverage.”
13	Revenue rider space trade-off	PT operators won’t lose paying space	Q4: ”public transport companies are unlikely to sacrifice revenue generating space…”
14	Fire safety electronics	Dangerous goods	Q4: ”carrying electronics raises fire safety issues.”
15	Agnostic locker requirement	Need for unbranded lockers	Q5: ”they would need to be what we call agnostic lockers that is, unbranded and accessible to all couriers.”
16	Branded courier contract barrier	UPS/Amazon branding obstacle	Q5: ”international couriers… are contractually required to deliver to specific branded lockers.”
17	Separate bus absurdity	Multiple buses for each brand is infeasible	Q5: ”you would theoretically need separate buses for each courier… This is clearly not feasible.”
18	Additional staff cost	Need more staff for lockers on board	Q6: ”You would need an additional staff member just to manage the lockers… introduces high costs.”
19	Need of a service fee for PT	Operators won’t do it free	Q6: ”transportation companies are unlikely to provide this service for free.”
20	Crowded bus access impractical	Privacy & space issues in the center of the bus	Q7: ”the practicality of someone navigating through a crowded bus to access a locker is questionable, especially with privacy concerns and limited space.”
21	Need for transfer at the end of line	Must move parcels to fixed point	Q8: ”you’d need additional personnel at the end of the line to move parcels from the mobile locker to a fixed location.”

#	Code label	Brief description	Literal source text
22	Staff cost too high-> infeasibility	An additional cost kills business feasibility	Q8: "...this increases costs significantly and might not be feasible from a business standpoint."
23	Courier must direct delivery to customer	Legal barrier for courier	Q9: "Couriers are contractually obligated to deliver directly to recipients and cannot use intermediaries."
24	Driver task restriction	Bus drivers can't handle parcels	Q9: "Bus drivers also have protected contracts that prevent them from performing any task beyond driving."
25	Bus allows people only	Vehicle type approval limit	Q9: "buses are currently only approved for transporting people, not freight."
26	Need new and ad-hoc regulation	New rules are required	Q10: "Implementing this service... would require new, ad-hoc regulations."
27	Access to locker challenge	Opening a locker in full bus is complicate	Q11: "A full bus makes it difficult to access the locker, open it, and retrieve items without disturbing other passengers."
28	Privacy absence	No private space on board	Q11: "Also, there is a complete lack of privacy."
29	Extra-person cost per vehicle	OPEX spike	Q13: "You would need to hire an extra person per vehicle, and this is not sustainable."
30	Passenger space lost of opportunity	Indirect financial hit	Q13: "There are also indirect costs from losing passenger space."
31	Marginal environmental gain	EV fleets already make the last-mile green	Q14: "most logistics companies are already shifting to electric vehicles. So the environmental advantage... might be marginal."
32	Triple stakeholder alignment	Government + logistics + PT must agree	Q16: "Local governments, logistics companies, and transport operators must all be aligned."

#	Code label	Brief description	Literal source text
33	Agnostic locker as enabler	Unbranded lockers at stops solves issue	Q20: ”One key enabler could be using agnostic lockers placed at bus stops rather than inside vehicles.”
34	Efficiency seeking couriers	Option itself could be attractive	Q18: ”For logistics companies, just having the option might be enough they are always looking for efficiency.”
35	PT needs financial compensation	Payment requirement	Q18: ”For transport companies, financial compensation would likely be necessary.”
36	Multi- challenge summary	Inconsistent routes, staffing and regulations	Q19: ”The challenges are numerous: inconsistent routes, added staffing costs, loss of passenger space, lack of driver participation, regulatory barriers, and technical impracticalities.”
37	Bus-stop locker alternative	Fixed stop model is preferred	Q20: ”agnostic lockers placed at bus stops... avoids many of the issues linked with on-board integration.”
38	Overall unfeasible judgement	Concept is unrealistic	Q21: ”While the concept is fascinating, it seems unfeasible. There are too many obstacles—technical, legal, organizational, and economic.”

Table B.6: Open coding interview N°6

#	Code label	Brief description	Literal source text
1	PT real estate leadership	Interviewee's current role	Q1: "I direct the Real-Estate Development and Enhancement Department of PT company…"
2	Urban-regeneration mission	Reviving disused rail infrastructure	Q1: "…takes disused rail property—freight yards, surplus land, vacant buildings—and brings it back to life through urban regeneration projects."
3	Milan railyard flagship	Large green-space project	Q1: "A flagship case is the Milan railyard programme: we are transforming 1 million m², of which 65% becomes green space…"
4	Novelty of the concept	Locker on PT new to the interviewee	Q2: "Until today I had never heard of lockers installed inside rolling stock or buses."
5	Station as urban-logistics hubs	Familiar with last-mile approach	Q2: "…I am exploring station or yard space for urban-logistics hubs…"
6	Smart-city parcel retrieval	Benefit the idea of s SmartCity	Q3: "It fits the SmartCity vision: citizens can retrieve parcels while commuting…"
7	Real-time tracking flexibility	Tech enabled convenience	Q3: "…Coupled with realtime tracking in an app, it offers flexibility…"
8	Passenger space trade-off	Lockers reduce seats	Q4: "The primary drawback is space: lockers would displace passenger seats or standing area."
9	Capacity analysis need	Must study spare capacity	Q4: "We would need a transport-sustainability analysis to see if spare capacity exists."

#	Code label	Brief description	Literal source text
10	Stakeholder views diverge	Commuter vs logistics vs PT	Q5: "Commuters would welcome… Transport companies aim to deliver seamless journeys… Logistics operators might like an extra option yet remain protective…"
11	ESG incentive	Sustainability as incentive	Q6: "The big incentive is ESG performance lower CO□ and better sustainability reporting."
12	EU-funding	Public money for pilots	Q6: "Startup grants or EU funding could ease pilots."
13	Lost-seating revenue	Financial disincentive	Q6: "Disincentives include lost seating revenue…"
14	Operational complexity	Barrier to adoption	Q6: "…and the fear of operational complexity."
15	Courier data fragmentation	Major logistical barrier	Q7: "Beyond space, the barrier is fragmentation: each courier guards its own client data."
16	Agnostic-hub	Neutral system for all couriers	Q7: "A viable system needs an agnostic hub that serves all operators without favour."
17	Neutral 'hinge' operator	Proposed governance fix	Q8: "Create a neutral "hinge" operator…"
18	Urban-governance push	Policy lever to bar polluting vans	Q8: "…anchor the concept inside strong urban governance that pushes high-impact vans out of the core…"
19	Security and possible terrorist attacks	Locker safety scrutiny	Q9: "Security rules loom large. Luggage storage vanished… lockers were seen as terror risks."
20	Surveillance mitigation	Modern tech eases security	Q9: "…though modern surveillance helps."
21	EU could fund trials	Policy pathway	Q10: "EU-level sustainability programmes could fund trials…"
22	City freight-restriction driver	Local policy creates demand	Q10: "…city mayors could restrict polluting freight at the perimeter, indirectly creating demand…"

#	Code label	Brief description	Literal source text
23	Protect wheelchair space	Accessibility mandate	Q11: “Never touch the legally protected wheelchair/mobility space.”
24	Seat removal requirement	Locker install needs seat removal	Q11: “Lockers would therefore require removing additional seats.”
25	Universal-accessibility priority	Inclusion principle	Q11: “We must maintain universal accessibility.”
26	Data-privacy protocols	Tech integration caveat	Q12: “…provided data-privacy protocols cover sender, courier, and recipient.”
27	Fare-revenue loss vs locker rent	Cost-benefit question	Q13: “A financial plan must weigh that loss against environmental gains and any locker-rental income.”
28	Incremental sustainability gain	Needs proof vs station lockers	Q14: “…station-based pickup points already capture much of that; the incremental gain of on-vehicle lockers needs proof.”
29	Metric of van-kilometre	Impact metric suggestion	Q15: “Compare van kilometres and emissions under business-as-usual vs the locker scenario…”
30	Seating reduction	Need to offset lost capacity	Q15: “…then net out the seating reduction and any modal shifts.”
31	Quad-stakeholder alignment	Government + PT + logistics + neutral operator	Q16: “Local government… public-transport operators, logistics companies, and a neutral locker-operator must all cooperate.”
32	City-forced demand creation	Governance must ‘force’ freight change	Q17: “City governance has to force high-impact freight out of the core—only then will demand appear.”
33	Neutral operator coordinates couriers	Role specification	Q17: “The neutral operator coordinates couriers; the transport company supplies space.”

#	Code label	Brief description	Literal source text
34	Policy sticks & ESG carrots	Incentive combo	Q18: "Policy sticks (low-emission zones), ESG carrots (lower Scope 3 emissions)..."
35	Seat-loss as main challenge	Physical constraint reiterated	Q19: "Seat loss, security vetting, data-sharing reluctance..."
36	Security vetting challenge	Screening issue	Q19: "Seat loss, security vetting, data-sharing reluctance..."
37	Data-sharing reluctance	Courier privacy obstacle	Q19: "Seat loss, security vetting, data-sharing reluctance..."
38	Loading-without-delay puzzle	Operational timing issue	Q19: "...operational puzzle of loading lockers without delaying services."
39	MaaS platform enabler	Digital integration key	Q20: "Digital MaaS platforms integrating passenger and parcel flows..."
40	Strong municipal policy enabler	Local authority role	Q20: "...strong municipal policy; and a neutral, multi-courier locker operator."
41	Metro-area suitability	High-volume cities only	Q21: "Only in large metropolitan areas—Milan, Rome, Naples, Turin, Bologna, Florence—where parcel pressure is high."
42	Small-town infeasibility	Low volume in provincial towns	Q21: "Small provincial towns lack the volume to justify it."
43	MaaS-layer integration vision	One interface for mobility & parcels	Q22: "The concept must plug into a MaaS-style digital layer so citizens manage mobility and parcels in one interface."
44	Technically feasible, economically unproven	Final verdict	Q22: "...Technically feasible; economically still unproven."

Table B.7: Open coding interview N°7

#	Code label	Brief description	Literal source text
1	EU R&I project lead	Manages EU urban-logistics pilots	Q1: "I manage research and innovation projects for Spain and Portugal, focusing on European-funded urban-logistics and supply-chain initiatives."
2	Hands-on city pilots	Runs real-city demonstrations	Q1: "…hand-on with pilots and demonstrations that test new distribution models in real cities."
3	Familiarity with the concept via pilots	Already doing pilots at metro	Q2: "My team is already running two pilots in Madrid."
4	Station-locker focus	Lockers at stations, not on board	Q2: "Important distinction: our pilots place grouped parcels in lockers at metro stations, not inside the rolling stock…"
5	Safety rule constraint	Mixing passenger and freight is an issue	Q2: "…because today's safety rules make passenger-freight mixing tricky."
6	Overnight preload	The parcels are loaded at the depot overnight	Q2: "We preload cages at the metro depot overnight…"
7	Train line haul to town	Trains bring goods in town before service	Q2: "…the trains bring them into town before service starts…"
8	Staff transfer to station locker	Final hand-off procedure from train to locker	Q2: "…and staff transfer the parcels into the station lockers for later pickup."
9	CO_2 cut 60–80 %	Important environmental benefit	Q3: "60–80 % CO_2 cut by removing diesel vans from door-to-door work."
10	Extra revenue & green brand PT	Benefit for transport operator	Q3: "Extra revenue and a greener brand for the transit operator."
11	Savings on fleet labor logistics	Benefit for carriers	Q3: "Lower fleet and labor costs for logistics providers—we move more parcels with fewer vehicles and hours."

#	Code label	Brief description	Literal source text
12	Commuters save time	Combination of pick-up with ride	Q3: "Time savings for commuters, who combine parcel pick-up/return with their normal ride."
13	Passenger-freight problem	Core disadvantage	Q4: "the tricky part is mixing passengers and freight."
14	Safety window loading	Must load when vehicles empty	Q4: "I have to load and unload during windows when vehicles are empty…"
15	Run only for freight	Dedicated trips	Q4: "…or dedicate whole runs to freight only."
16	Retailer & logistics push	Strong demand side	Q5: "Logistics operators and retailers are pushing hard for it."
17	Convenient for commuters	Positive user view	Q5: "Commuters like the convenience."
18	PT are cautious over safety	Operator attitude	Q5: "Public transport bodies are keen but cautious because they must tick every safety box."
19	Incentive basket	Lower costs, new income and green PR	Q6: "Incentives: lower costs, new income, sustainability metrics, and positive publicity."
20	Disincentive: operational complexity	Extra process step	Q6: "Disincentives: added operational complexity…"
21	Disincentive: liability	Risk exposure	Q6: "…regulatory liability…"
22	Disincentive: need for data-sharing	IT barrier	Q6: "…and the need for robust data-sharing."
23	Capacity planning complication	Match parcels, lockers and timetable	Q7: "The biggest logistical hurdle for me is capacity planning…"
24	Pile-up / wrong-train risk	Outcome of misplanning	Q7: "If I misjudge, parcels pile up or travel on the wrong train."
25	Shared digital platform	Need for real-time visibility for everyone	Q8: "I need a shared digital platform that gives every actor real-time visibility…"

#	Code label	Brief description	Literal source text
26	Slot allocation & auto-scan	Platform functions	Q8: "…allocates slots per station, and automates scanning at each handoff."
27	No EU-wide rule	Regulatory gap	Q9: "There's no Europe-wide rule yet."
28	Passenger-freight issue	Must separate freight and riders	Q9: "…safety codes that ban freight where passengers ride unless I physically separate them."
29	Operator bans	E-scooter battery example	Q9: "Operators also set their own dynamic rules, for example, banning items after a battery incident."
30	New policies	Policy evolution	Q10: "once pilots mature I expect guidance on passenger-freight segregation and on standardising data exchange."
31	Modular locker design	Must fit in the vehicle geometry	Q11: "Modular locker modules sized to vehicle geometry."
32	Roller-cage	Grouped parcels in wheeled cages	Q11: "Roller-cage workflow: parcels grouped into wheeled cages with brakes…"
33	Quick tie-down strap	Simple securing method	Q11: "…a quick strap or tie-down secures them to the car floor."
34	Quick transfer loading	Process must fit dwell time	Q11: "Loading/unloading must fit the short layover window."
35	Tool-free tie-down	tie-down	Q11: "Fast, tool-free tie-down rails inside the vehicle."
36	Scan-at-every-handoff rule	Reliability via bar/QR codes	Q12: "Barcode or QR scans at every transfer… are non-negotiable."
37	Need for API integration	Systems must connect	Q12: "…plus API integration between retailer, logistics provider, and operator…"
38	Van-reduction cost effect	10 vans → 1 van example	Q13: "ten vans driving six hours shrink to one van driving one hour."

#	Code label	Brief description	Literal source text
39	60–80 % emission cut	Carbon benefit quantified	Q14: "slashes emissions by roughly 60–80 %..."
40	Baseline vs Δ method	Impact measurement approach	Q15: "I start with a baseline... then ... compute the Δ CO_2..."
41	Retailers have gatekeeper role	Amazon/Vinted power	Q16: "Retailers (gatekeepers—if Amazon or Vinted say no, nothing moves)..."
42	Revenue-sharing model	Example of €1 to metro and €2 to logistics	Q17: "...revenue-sharing model, for instance, €1 per parcel to the metro operator and €2 to the logistics provider."
43	Tax-break incentive	Policy lever	Q18: "Financial savings, tax breaks for low-emission delivery..."
44	Data-coordination challenge	Main barrier	Q19: "Coordinating data between companies..."
45	Regulatory-approval hurdle	Need permits	Q19: "...clearing regulatory approvals..."
46	Vehicle-space securing challenge	Physical constraint	Q19: "...securing vehicle space..."
47	Volume break-even challenge	Need parcel scale	Q19: "...and hitting the volume needed to break even."
48	Multibrand locker network enabler	Shared infrastructure	Q20: "Multibrand locker networks..."
49	Dense-corridor context	Urban metro/BRT ideal	Q21: "They work best in dense urban corridors with reliable metro or BRT systems—Madrid or northern Italian cities are perfect."
50	Scarce PT service brings failure	Concept fails where service poor	Q21: "...They fail where public transport is sparse or unreliable."

Table B.8: Open coding interview N°8

#	Code label	Brief description	Literal source text
1	PT strategy role	Senior point of view shaping long-term rail vision	Q1: "I work on corporate strategy—that is, the long-term vision—inside PT company"
2	Multisubsidiary scope	Covers PT, Logistics scopes and foreign operations	Q1: "The holding covers PT for passengers, and logistics for freight... and several foreign rail subsidiaries in the UK, France, Spain, Germany..."
3	Real-estate repurposing role	Focus on disused rail assets	Q1: "I also look at how to repurpose disused real-estate assets around stations."
4	On-vehicle lockers unfamiliar concept	Concept new to interviewee	Q2: "Lockers inside trains, buses, or trams are new to me; I had never heard of that setup before your thesis."
5	Station-locker	Deutsche Bahn station lockers seen as realistic	Q2: "What I have seen is Deutsche Bahn's model: they installed parcel lockers in stations, not on the rolling stock."
6	Hub-to-vehicl promising	Only hub-to-vehicle model "remotely promising"	Q3: "the only one that looks remotely promising to me is the third: trams, buses, or regional trains become Amazon's very last mile."
7	Complexity outweighs benefit	Missing clear advantage	Q3: "...I can't yet see a clear benefit that outweighs the complexity."
8	No-skip schedule	PT can't skip departures to load parcels	Q4: "Service delivery cannot be compromised: if a tram line needs four runs per hour, you must run four—no skipping one to load parcels."
9	Scale risk	Delay risk unacceptable	Q4: "...5 400 trains leave daily in Italy) make the risk of delay unacceptable."

#	Code label	Brief description	Literal source text
10	Conservative approach	PT adopts only if it brings margin and there is no disruption	Q5: "Transport companies are conservative; they might consider the idea only if it brings margin and does not interfere with their core schedule."
11	End-user small benefit	Passengers would face little gain over home delivery	Q5: "Passengers might find it novel, but I struggle to see a big advantage over current home delivery or the dense network of pickup points."
12	Low-price incentive	Users are driven only by convenience	Q6: "End users: convenience—so long as the price stays low."
13	Regulated-service barrier	Commercial income restricted	Q6: "regulated services cannot keep commercial revenue."
14	Amazon cost-service condition	Shipper needs better service not higher cost	Q6: "Amazon: better customer service, provided costs do not explode."
15	Exact-vehicle allocation	Must map each package to a vehicle	Q7: "You must know the exact vehicle that will carry each package, load every bus or tram correctly in the morning…"
16	Not working on subway	Too crowded & frequent to manage	Q7: "On subways I'd say absolutely not: too crowded, too frequent, impossible to manage loading."
17	Return-trip pickup problem	Packages ride all day or require reload	Q7: "…most commuters collect on the return trip, which means the packages either ride around full day or someone reloads at midday—both bad options."
18	Logistics "chaotic" verdict	Station lockers deemed feasible	Q8: "Honestly, I don't have a solution; the logistics look chaotic. That is why station lockers seem far more feasible."
19	Dual rail regimes Italy	Market vs regulated services	Q9: "Italian rail has two regimes. Market-based services … Regulated services … receive public funding…"

#	Code label	Brief description	Literal source text
20	Locker revenue harder on regulated	Profit reverts to State	Q9: "…any extra profit theoretically reverts to the State."
21	Premature sustainability policy	Authorities may promote later	Q10: "…public authorities would promote it for sustainability reasons, but right now it feels premature."
22	Seat/standing removal impact	Structural modification needed	Q11: "Vehicles would need structural changes—removing seats or standing areas—to fit lockers."
23	Restaurant opportunity on high-speed train	Only plausible on HS-train	Q11: "On high-speed trains the restaurant car is the only plausible space…"
24	Capacity loss on buses	Passenger capacity reduction	Q11: "…On trams and buses the loss of passenger capacity would be serious."
25	Precise tracking is mandatory	High coordination requirement	Q12: "advanced tracking would be mandatory…"
26	Tracking doesn't solve bigger issues	Tech is insufficient alone	Q12: "…but again I doubt it solves the bigger issues."
27	OPEX rise due to coordination	High cost of detailed chain	Q13: "Operating costs would rise because the logistical coordination is so fine-grained."
28	CAPEX vehicle adaptation	Significant capital spend	Q13: "…Capital expenditure to adapt vehicles would also be significant."
29	Pickup-point efficiency	Existing network already efficient	Q14: "traditional pickup points already capture much of that efficiency."
30	Small incremental gain	Additional benefit is marginal	Q15: "…existing pickup networks are already highly efficient, so the incremental gain might be small."
31	Multi-stakeholder alignment	Logistics, PT, authorities and users	Q16: "Logistics providers, the transport operator, and public authorities … must all agree, plus of course the final users."
32	Punctuality is mandatory	Trains can't be late	Q17: "…a three-minute slip can cascade into seven delayed trains."

#	Code label	Brief description	Literal source text
33	Operator needs risk-free	PT needs revenue without risk	Q18: "Passenger operators would need a clear, risk-free margin."
34	User no-extra-cost requirement	Price sensitivity	Q18: "Users need convenience at no extra cost."
35	Regulatory barrier highlight	Sub-services obstacle	Q19: "Regulatory barriers on subsidised services…"
36	Passenger-space loss challenge	Physical space constraint	Q19: "…loss of passenger space…"
37	Punctuality risk challenge	Delay threat reiterated	Q19: "…risk to punctuality…"
38	Crowding challenge	Bus/tram crowding obstacle	Q19: "…crowding."
39	Market-side enabler	Ancillary revenue on HS trains	Q20: "they would have to come from the market side—high-speed trains looking for ancillary revenue…"
40	Sustainability agenda enabler	Authority push possible	Q20: "…or from public authorities pushing a sustainability agenda."
41	Subway failure context	On-vehicle lockers unworkable	Q21: "On-vehicle lockers look unworkable on subways…"
42	Bus risk context	Risky on buses	Q21: "…risky on buses…"
43	Long-distance irrelevance	Irrelevant on LD trains	Q21: "…irrelevant on long-distance trains."
44	Station-locker preference	Fixed lockers cleaner solution	Q21: "Station-based lockers are far more promising."

Table B.9: Open coding interview N°9

#	Code label	Brief description	Literal source text
1	Program manager role in a logistics company	Focus on up-stream supply chain	Q1: "I am a Program Manager in the construction operations area ... my remit is less 'last mile logistics' and more the upstream infrastructure—overseeing contractors..."
2	Novelty of the concept	Unfamiliar to the idea of lockers on vehicles	Q2: "Until this conversation I had never encountered lockers installed on buses, trams, or trains."
3	Time-optimisation	Commuters save time	Q3: "...the prime gain is time optimisation: workers ... could collect parcels 'en route'..."
4	Central-handoff reduce costs	Courier drop packages to one place	Q3: "...converts expensive door-to-door drops into one central handoff, potentially cutting costs..."
5	Loss of passenger capacity	Lockers reduce space onboard	Q4: "lockers eat into passenger capacity"
6	Punctuality challenge	Must catch the exact vehicle	Q4: "...service reliability hinges on the customer catching that exact vehicle—miss the 15:54 bus and your parcel vanishes..."
7	Logistics company losing their core value	Couriers might fear brand erosion	Q5: "Logistics companies see fewer trips but risk diluting their core 'delivery' value."
8	PT timetable risk	PT must safeguard schedule	Q5: "...public transport benefits environmentally yet must safeguard capacity and timetable integrity."
9	Sustainability leverage	ESG metric as incentive	Q6: "Leverage sustainability metrics..."
10	Storage-fee	Fee split with PT operator	Q6: "...potentially charge a storage fee that shares revenue with the transit operator."
11	Fare-space competition	Locker and seat revenue trade-off	Q6: "...locker space competes with fare revenue..."

#	Code label	Brief description	Literal source text
12	Criticality of loading on time	Courier must be on time	Q7: "Everything rides on timing: couriers must load the correct vehicle at its depot…"
13	Batch-size viability	Loads must justify the effort	Q7: "…batch size must justify effort…"
14	Missed load inefficiency	Late parcels undermine the business model	Q7: "…missed loads undermine efficiency."
15	Need for sophisticated scheduling	No possibility fixing it so far	Q8: "I don't yet see an easy fix beyond sophisticated scheduling…"
16	Limit of terminus loading	Restrict to depot start	Q8: "…perhaps limiting the system to predictable terminus loading."
17	Wheelchair-space protection	Legal accessibility barrier	Q9: "Space reserved for wheelchair users is legally untouchable; lockers must not infringe accessibility."
18	Privacy needed	Anonymous packaging needed	Q9: "…Privacy rules demand anonymous packaging; secure, tamper-proof lockers are mandatory."
19	Dimension of parcels	Only small/medium parcels	Q10: "…setting dimensional limits (only small/medium parcels) would be required."
20	Modular quick-fit design	Design needs to fit in a variety of fleets	Q11: "Installation must be quick and modular: fleets differ by city and model…"
21	No downtime	Keep vehicles in service	Q11: "…Keeping vehicles out of service for fitting would create gaps in timetables."
22	Realtime tracking essential	Vehicle and parcel visibility	Q12: "Realtime vehicle tracking lets customers plan and providers monitor."
23	Digital codes	Secure access for users	Q12: "Random digital codes replace physical keys for security."
24	Batching reduce costs	One drop VS many	Q13: "If batching works, delivery costs decline because one drop replaces many."

#	Code label	Brief description	Literal source text
25	Lockers vs seat trade-off	Locker rent vs seat loss	Q13: "…fare revenue could fall if seat capacity shrinks."
26	Emission-kilometre connetcion	Benefit depends on the number of parcels carried	Q14: "Emissions drop by the kilometres not driven by vans … benefit depends on how many parcels the limited locker space can handle."
27	Km-avoided metric	Impact measurement	Q15: "Track 'kilometres avoided' … and convert to CO_2…"
28	Multi-actor alignment	From producers to consumers	Q16: "Producers/retailers, courier companies, transit operators, municipal authorities, and the consumers themselves…"
29	Municipality loading hubs	Policy coordination idea	Q17: "…If municipalities designate central loading hubs and set clear windows…"
30	Cost-saving / CO_2 / convenience	Tailored incentives	Q18: "Show cost savings to retailers, CO_2 cuts to the city, and convenience metrics to end users."
31	Locker-space trade-off challenge	Seats vs lockers central issue	Q19: "Locker installation and space tradeoff…"
32	Consumer punctuality risk	Behaviour dependency	Q19: "…consumer punctuality…"
33	Loading-window coordination	Must synchronized courier & PT	Q19: "…coordinating loading windows…"
34	Scalability uncertainty	Hard to expand system	Q19: "…ensuring scalability."
35	Cost-saving logistics enabler	Core requirement for uptake	Q20: "Concrete cost savings for logistics…"
36	Emissions-reduction enabler	Proof point for cities	Q20: "…demonstrable emissions reduction for municipalities…"
37	Convenience enabler	User adoption hinge	Q20: "…ironclad convenience for riders."

#	Code label	Brief description	Literal source text
38	High-frequency network success	Context where the idea could work	Q21: "High-frequency, punctual networks in safe metropolitan areas—e.g., London, Milan, Copenhagen—offer the best odds."
39	Low-density failure	Rural/unreliable PT won't work	Q21: "…Low-density or unreliable systems will struggle."
40	Narrow-slice of parcels	Limited parcel segment served	Q22: "…may serve a narrow slice of parcels; limited locker volume and consumer discipline could cap impact."

Table B.10: Open coding interview N°10

#	Code label	Brief description	Literal source text
1	LINKS researcher role	Academic perspective in PT logistics	Q1: "I am currently working as a researcher at the LINKS Foundation within the 'Future Cities & Communities' domain..."
2	GTT collaboration	Works jointly with Turin transit agency	Q1: "...in collaboration with GTT (Gruppo Torinese Trasporti)."
3	Sustainable-efficient transport focus	Research goal	Q1: "...facilitating the transition toward a more sustainable and efficient transport system for the city of Turin."
4	Urban-logistics with PT lens	Investigates integration	Q1: "...integration of urban logistics with public transport, with particular attention to environmental sustainability..."
5	New to the concept	Lockers on vehicle idea is new	Q2: "Until you mentioned it I had never heard of putting parcel lockers on buses or trams."
6	Remote-coach mail comparison	Similar precedent	Q2: "The closest comparison ... was mail that travels on intercity coaches in remote regions..."
7	Green-image & revenue benefit	Dual brand + income gain	Q3: "...let it carry small freight too? That would let both the transit operator and a company like Amazon polish their green image and tap into an extra revenue stream."
8	Commuter convenience	Rider benefit	Q3: "As a rider myself I'd enjoy combining my commute with an errand—picking up ... without adding an extra trip."
9	Wheelchair space threat	Space drawback	Q4: "...taking over the wheelchair or pram area for lockers would trigger complaints and might breach accessibility rules."

#	Code label	Brief description	Literal source text
10	Longer boarding time	Operational delay	Q4: "...the boarding time would lengthen when someone fishes out a parcel, and that slows the entire line."
11	Customer inflexibility	Must be at stop on time	Q4: "Customers would also lose flexibility because they'd have to be at a specific stop at a precise moment."
12	Theft risk	Security concern	Q4: "...thieves could ride the bus expressly to grab parcels..."
13	Locker breakdown risk	Repair impossible in service	Q4: "...a locker that breaks mid-route can't be repaired on the fly."
14	Weight–battery penalty	An extra mass reduce the e-bus range	Q4: "...the locker adds weight and drains power—those kilometres really matter on the new electric fleet."
15	PT cautious	Operator attitude	Q5: "A public transport agency would be cautiously intrigued by the extra cash and publicity but push back hard on anything that complicates operations or reduces passenger space."
16	Logistics sustainability appeal	Courier view	Q5: "A logistics firm would like the sustainability label..."
17	Rider split opinion	Convenience vs crowding	Q5: "...regular riders ... might welcome the convenience; others would call it inflexible and crowded."
18	Monetary incentives	Pay, ads, full responsibility	Q6: "Money always talks: paying an operator ... selling advertising on the locker surface, or promising full logistical responsibility..."
19	Labour and liability issues	Barriers	Q6: "...labour negotiations, liability for theft or damage, regulatory exposure... could very quickly scare ... stakeholders away."

#	Code label	Brief description	Literal source text
20	Accessible floor loss	Space disincentive	Q6: "…and the loss of accessible floor area could very quickly scare the same stakeholders away."
21	Locker fitting and restock	Where and when to refill	Q7: "We would have to decide where the lockers fit, how and when they get restocked…"
22	Depot-night traffic clash	Locker operations vs cleaning/refuel	Q7: "…how they interact with depot traffic at night when buses are cleaned and refuelled."
23	E-bus range	Range constraint	Q7: "Electric buses complicate things because their range is already tight."
24	Tram high-step access	Ramp/trolley need	Q7: "On trams with high steps the courier would need a ramp or a stair-climbing trolley."
25	Passenger constraint	Locker use disrupts flow	Q7: "…every boarding passenger would have to dance around someone unlocking a box."
26	Start-small pilot	Limited BRT/tram test	Q8: "My instinct is to start small: pick one tram or BRT line … and see what breaks."
27	Off-peak loading	Timing mitigation	Q8: "…load lockers during off-peak hours…"
28	Courier on board pilot	Dedicated staff idea	Q8: "…maybe let a dedicated courier ride the route…"
29	Solar/mechanical locks	Power-saving tweak	Q8: "Solar-assisted or purely mechanical locks could spare the traction battery…"
30	Stair-climber test	Equipment prototype	Q8: "…we can test stair-climbing equipment on the steep-board vehicles."
31	Wheelchair-space mandatory	Legal constraint	Q9: "mandatory wheelchair spaces… would all kick in the moment a locker is bolted to a bus."
32	Emergency-exit mandatory	Safety rule	Q9: "…emergency-exit clearances…"

#	Code label	Brief description	Literal source text
33	Hazardous goods restriction	Dangerous items rule	Q9: "…hazardous-goods restrictions…"
34	Union duty limits	Driver-task barrier	Q9: "…union rules about drivers' duties…"
35	Insurance framework	Liability regime	Q9: "…and the whole insurance framework would all kick in…"
36	Green-deal incentives	Policy enabler	Q10: "Green-deal style incentives for low-emission last-mile delivery… could all smooth the path."
37	Freight-on-PT ordinance	Municipal legal change	Q10: "…municipal ordinances that formally allow freight on transit vehicles…"
38	Realtime location	Data policy	Q10: "…clear data-sharing clauses for realtime GPS…"
39	Updated collective agreement	Labour-policy need	Q10: "…updated collective agreements that spell out extra tasks for drivers…"
40	Crash secure locker	Tech requirement	Q11: "The locker has to be light yet strong, secure in a crash…"
41	Vandal-resistant build	Durability need	Q11: "…resistant to vandalism…"
42	Low-power consumption	Energy constraint	Q11: "…and miserly in power consumption."
43	GTFS live-feed necessity	Tracking for users	Q12: "Without live GTFS feeds a rider couldn't tell where the locker is…"
44	30-second GPS delay barrier	Data-release issue	Q12: "Some agencies delay their GPS data by thirty seconds … but with the right contract that barrier can be removed."
45	Invoice for space & risk	PT cost recovery	Q13: "…the transit agency will invoice for space and risk."
46	Insurance premium rise	Cost uncertainty	Q13: "…Insurance premiums might climb…"

#	Code label	Brief description	Literal source text
47	Diesel-van cut vs tyre wear	Mixed environmental effect	Q14: "…extra weight and tyre wear push emissions slightly upward…"
48	Before-after pilot metrics	Evaluation method	Q15: "…then run a pilot, tracking the same indicators plus parcel throughput…"
49	Multi-stakeholder alignment	Actors to align	Q16: "…municipality, the transit company, the logistics operator, the labour unions, the locker supplier, disability advocates, police and fire authorities, regulators, and—very importantly—the riding public…"
50	After-hours bus replenishment	Alternative hybrid model	Q22: "…I would probably start by turning buses into after-hours delivery vans that top up fixed lockers at the stops. That sidesteps the space issue…"

Table B.11: Open coding interview N°11

#	Code label	Brief description	Literal quotation
1	Regional-mobility director	Government perspective & viewpoint	Q1: "I'm the Director of the Mobility services of the Italian region of Molise."
2	Inter-town PT scope	Inter-town focus	Q1: "We manage regional public transport — not the urban system, but the service that connects all towns and villages in the region."
3	Concept unfamiliar	Locker-on-PT idea was new to the interviewee	Q2: "No, I wasn't familiar with this idea before."
4	Remote-area application	Could reach remote municipalities	Q3: "It could serve all the inland municipalities, which are already connected by public transport."
5	Cost saving	Lower delivery costs for citizens	Q3: "It would also help reduce delivery costs for residents…"

#	Code label	Brief description	Literal quotation
6	Emission reduction	Sustainability benefit	Q3: "…lower emissions…"
7	Anti-depopulation benefit	Supports people that want to stay in rural areas	Q3: "…support efforts to prevent rural depopulation by bringing more services to people who live far from urban centers."
8	Right-bus challenge	The user must catch the specific vehicle with onboard the parcel	Q4: "The biggest issue is that the user would have to catch the right vehicle—the one carrying their parcel."
9	Multi-run increase complexity	Several runs along the same route make everything more complicated	Q4: "…might get complicated if there are multiple runs along the same route."
10	Increase in driver's work	Extra work for the driver can create issues	Q4: "Drivers might not be happy about having additional responsibilities unless they're compensated."
11	Extra compensation for drivers	PT operators can receive a fee to do an extra service	Q5: "If transport operators are paid for the service, they'll likely support it."
12	Need for logistics companies' involvement	Couriers need to be involved to accept the service	Q5: "…logistics companies, they might see it as competition unless they are directly involved."
13	Region positive vision	Public authority welcomes ideas if they create value for citizens	Q5: "The Region would definitely be open to the idea, especially since it adds value for citizens."
14	Per-delivery incentive	Monetary incentive for PT	Q6: "A good incentive would be a small payment per delivery for either the driver or the public transport company."
15	Identification of the correct bus	Core logistical issue	Q7: "The biggest logistical issue is knowing which bus has the parcel."
16	Real-time tracking needed	Technology integration needed	Q7: "Real-time tracking seems essential."
17	Use of empty luggage bay	Physical solution available	Q8: "…the luggage compartment is a good idea—it's typically empty here in Molise…"

#	Code label	Brief description	Literal quotation
18	No local legal barrier	Goods-with-passengers allowed	Q9: "As far as I know, there's no regulation in Molise that prohibits carrying goods and passengers together."
19	Informal parcel by bus practice	Existing precedent	Q9: "I've personally sent parcels by bus just by giving them to the driver and paying a small fee."
20	Minor policy changes	Formalisation may require some adjustments in the formalized service	Q10: "If the service grows or becomes formalized, some policy updates might be needed, but I don't think it would be a major barrier."
21	Storage rules	Where parcels go depends on the size	Q11: "Smaller items could potentially be stored on the bus, but larger ones should go into the luggage compartment."
22	IT platform essential	An IT platform is crucial to manage the service	Q11: "…an IT system to manage everything would be essential."
23	Technology needs	Tracking, codes, software	Q12: "Real-time tracking, digital access codes, and software to coordinate everything would be critical…"
24	User-cost saving	Lower cost to final customer are reduced	Q13: "I think it would reduce costs for the end-user."
25	Van-kilometre avoidance	Bus substitute a van trip in a remote area	Q14: "If the bus is already going there, that trip becomes unnecessary."
26	Stakeholders alignment	Collaboration between region or local government, logistics companies, and transport operators is crucial	Q16: "…alignment between the Region or local government, logistics companies, and transport operators."
27	Lockers ownership	Lockers should be managed by logistics companies	Q17: "…the logistics company should manage the lockers… Public transport companies… should act as subcontractors."

#	Code label	Brief description	Literal quotation
28	20–30 % fee share	Proposed revenue split	Q18: "Giving the public transport provider 20–30% of the delivery fee could be a good starting point."
29	Bus identification challenge persists	Biggest ongoing obstacle	Q19: "It's the vehicle identification issue again—making sure users find the right bus."
30	Driver engagement challenge	Need driver participation	Q19: "…ensuring driver participation…"
31	Many operators coordination	29 concessionaires presents in Molise region	Q19: "…especially given the number of transport operators we work with in the region."
32	Financial incentive	Money are central in the acceptance of the service	Q20: "Financial incentives for operators and drivers… are the key enablers."
33	Spare luggage space	Physical space in inter-urban buses exists	Q20: "…the availability of luggage space…"
34	Alignment with environmental goal	Green agenda support this solution	Q20: "The fact that this aligns with environmental goals makes it even stronger."
35	Rural-region success	In rural-region this idea could work	Q21: "This system would work well in rural or regional areas like Molise."
36	Crowded-city failure	This solution fails if urban buses are too full	Q21: "…In big urban cities like Milan … The buses are too crowded…"
37	Luggage bays are typically empty	Unused space on public transport	Q8: "…it's typically empty here in Molise because most people don't travel with large bags."
38	Service reaches remote areas	Supports remote connectivity	Q3: "parcels could reach remote areas easily."
39	Public-transport baseline	Buses already cover the entire territory	Q3: "…which are already connected by public transport."
40	Substitution of logistics long-trip	Couriers save remote runs	Q5: "…might save them from making long trips."

C

Data Grouping

Data grouping of interview N°1

Theme	Associated Codes	What Binds These Codes
Expertise and novelty to the concept	#1, #2, #3	The interviewee is a logistics expert who is responsible for the couriers ' external company relationships. This helps give the perspective from which the interview will be conducted. The idea is new to the expert.
Market target & Demand	#4, #43, #44, #45, #46	The interviewee thinks this idea could target a niche segment of customers that keeps moving. However, interest is dictated by customer adoption and whether the use of PT is high.
Vehicle Space & Physical-Integration constraints	#5, #6, #7, #21, #25	Due to reduced space, it can be difficult to fit in vehicles, and in that case, you would have to reduce the seat capacity and accessible areas. So, a careful design is needed, given that the current lockers are large and hard to fit.
Timing, pick-up & return risks	#8, #9, #17, #18, #19, #20, #30, #31, #32, #33, #36, #37	The parcel and customer must be in the same vehicle; however, there can be traffic issues. Moreover, loading packages in the morning is doable, but reprocessing them at night is very expensive. Given the high no-show risk on buses, this needs to be considered, but the lower no-show risk on trains makes it more suitable.

Operational complexity & labor resistance	#12, #13, #14, #15, #16, #41, #42	The interviewee introduces the possible labor resistance, union risk, and the need for benefits in the costs.
Technical & digital requirements	#26, #27, #28, #29	A robust process for loading and monitoring everything, with real-time tracking, digital access, and integration with back-end systems, is needed.
Governance, regulation & stakeholder alignment	#22, #38, #39, #40	Lockers should meet open-hours regulations, and this solution needs to align all stakeholders. Transparent communication and proactive problem-solving are needed. Incentives are secondary to feasibility.
Environmental benfit	#10, #34, #35	The reduction of km by vans is an environmental benefit, which can be a green appeal for municipalities.

Data grouping of interview N°2

Theme	**Associated Codes**	**What Binds These Codes**
Expertise and novelty to the concept	#1 #2 #3	The interviewee is an expert in transportation models, focusing on optimization and integrating data-driven techniques. The interviewee is new to the concept of lockers on PT but not stationary lockers.
Perceived benefits and context effectiveness	#4 #5 #6 #7 #8 #9 #16 #37 #38	The expert highlights the effectiveness of this solution in remote areas and the effectiveness of combining freight and people; however, the interaction of the bus driver is needed.
Operational & logistical challenges	#10 #11 #12 #13 #14 #15 #21 #22 #23 #48	The interviewee highlights the problem of synchronizing the schedule of PT and passengers. Other risks related to space during peak hours, unpicked package retrieval, and the need for communication.
Technical & data enablers	#24 #25 #26 #27 #35	The expert defines the technical infrastructure needed and how to mitigate the drawbacks highlighted in theme section 3.
Regulatory, safety & design requirements	#28 #29 #30 #31 #32 #33 #34	The interviewee has doubts about the safety of this innovation, the accessibility of lockers, and the need for clear liability.

Business model & incentives	#18 #19 #20 #43 #45 #46 #47	Financial mechanisms are needed to align the different interests of transit, logistics providers, and end-users.
Environmental & economic impact	#36 #39 #41	Focus on possible metrics to be used to evaluate the cost-effectiveness and environmental performance of this innovation.
Stakeholder coordination	#40 #42 #44	Highlights how to reach shared implementation and accountability using institutional and coordination tools.

Data grouping of interview N°3

Theme	Associated Codes	What Binds These Codes
Academia and industry perspective	#1 #2 #3 #4	The interviewee has a blended academic and entrepreneurial background, with knowledge in simulation and optimization.
Prior Exposure to parcel-locker research	#5 #6 #7	The experts indicate prior involvement in locker projects, with a strong focus on the legal side.
Expected benefits	#8 #9 #10 #11 #12 #40 #42 #43	It captures the main benefits related to more innovative use of existing PT, reduction of logistics costs, and greener cities.
Operational, Capacity & Security Risks	#13 #14 #15 #16 #21 #22 #23 #24 #25 #26 #27 #28 #48	Describes a variety of constraints, such as physical, logistical, and social, that can threaten the deployment of the solution.
Technical & digital enablers	#33 #34 #35 #36 #37 #38 #39	Specific physical and digital systems need to work to make the locker system efficient and trustworthy.
Stakeholder attitudes	#17 #18 #19 #20 #41	Stakeholder alignment can be shifted by the perception of the different actors given the financial and strategic incentives.
Regulatory landscape	#31 #32 #46 #47	Highlight current policy constraints and expect regulations and governance to evolve.
Co-design	#29 #30 #49	The expert proposes an iterative and collaborative rollout, with specific testing including worker input and localized experimentation.
Impact Measurement	#44 #45	KPIs are needed to evaluate the effectiveness.

Data grouping of interview N°4

Theme	Associated Codes	What Binds These Codes
Professional expertise and novelty of the concept	#1, #2, #3, #4	The interviewee has a background in engineering and specializes in logistics and transportation, with a focus on multimodal transportation. The expert is also new to the concept
Existing locker landscape & regulatory issues	#5, #6, #23	Describes the barriers related to policy and labor that shape what is possible.
Operational & capacity challenges	#7, #8, #9, #10, #14, #18, #19, #20, #21, #22, #26, #27, #37, #41, #42	The expert identified the main obstacles related to logistical, spatial, and temporal obstacles, which include complications in coordination, planning, delays, and vehicle design.
Digital coordination requirements	#11, #12, #13, #24, #35	Highlights the "nervous system" that is needed to make the concept viable
Business model, incentives & stakeholder economics	#15, #16, #17, #25, #28, #32, #33, #36, #45, #46	The interview shows the complications behind cost-sharing and the possible structure of stakeholders to balance the risk and profit.
Environmental considerations	#29, #30, #31, #34, #38	The environmental benefits are minimal because of the small impact and the pre-existing electric van infrastructure.
Market fit & adoption factors	#39, #40, #43, #44	The adoption potential is influenced by national culture, city size, and perceptions of public transport in different countries.

Data grouping of interview N°5

Theme	Associated Codes	What Binds These Codes
Professional expertise	#1, #2, #3	The interview has a senior point of view on sustainable logistics. Moreover, the candidate has been exposed to the logistics field for a long time and has consultancy experience.
Existing pilot	#4, #5, #33, #37	Knowledge about an ongoing pilot program with fixed lockers (agnostic) at bus stops, which is the benchmark compared to mobile parcel lockers.
Spatial constraints & passenger experience on vehicles	#6, #7, #8, #9, #11, #12, #13, #19, #20, #27, #30	Practical issues related to the space on board, boarding flow, and route variability with strong concern regarding the interference with passenger service.

Staffing, coordination & delay risks	#18, #21, #22, #24, #29, #36	Focuses on the coordination and labor challenges brought by the use of onboard lockers. Specifically, it addresses concerns related to chain delays, the need for more staff, and feasibility.
Regulatory & safety barriers	#14, #23, #25, #26	Additional barriers include existing legal constraints on fire safety, vehicle certification, courier rules, and the rigidity of driver roles.
Branding conflict & the "Agnostic" lockers	#15, #16, #17	Emphasizes the need for agnostic lockers and the difficulties of introducing them into a market dominated by powerful courier brands with exclusive delivery contracts.
Business model	#10, #18, #19, #32, #34, #35	The operational and financial model must balance the costs that PT and couriers face while guaranteeing user adoption and the system's sustainability.
Environmental impact limited	#31	Given the widespread of EV vehicles, the possible environmental advantages are seen as minimal.
Overall feasibility verdict	#36, #38	It places all the cumulative problems in one, leading the interviewee to a conclusion: the onboard concept is too complex to be put into practical use.

Data grouping of interview N°6

Theme	**Associated Codes**	**What Binds These Codes**
Professional experience and concept novelty	#1, #2, #3, #4	The interviewee is a manager in the real-estate development of PT company, transforming green land into mixed-use assets.
Existing station-hub project	#5, #28	The PT company it works for is planning station-based logistics hubs that already capture most of the environmental benefits.
Smart-City concept	#6, #7, #11, #18, #34, #39	According to the expert, this idea fits in the SmartCity vision; however, real-time tracking and digital integration are crucial to offering flexibility.
Vehicle-space & accessibility constraints	#8, #9, #23, #24, #25, #35	Highlight how onboard lockers reduce seat availability, threaten wheelchair access, and can cause legal and service quality concerns.

Revenue trade-off	#13, #27, #30, #44	The expert highlights the loss of seating revenue and the uncertainty about cost-benefit because seat reduction needs to be offset.
Operational Complexity	#14, #38	AThe barrier to adoption displays the difficulties due to the operational complexities and the load without delays of PT.
Data fragmentation	#15, #16, #17, #26, #33, #37, #43	The data protection implemented by couriers blocks interoperability, so a neutral operator with privacy protocols needs to be introduced to facilitate the multi-actor system.
Governance & funding needs	#10, #12, #18, #21, #22, #31, #32, #40	The actual implementation will be unlocked by EU grants, municipal policy alignment, and buy-in from all four actors: city, transit, logistics, and coordinator.
Security & safety barriers	#19, #20, #34, #36	The expert highlights the concerns related to security (terrorism, fire); however, current modern surveillance helps reduce the risks.
Scalability	#41, #42, #44	The viability depends on the high demand; otherwise, the seating loss is not justified.
Impact-assessment metrics	#29, #30	There is a need for robust measurement of parcel-mile savings vs. seat losses.

Data grouping of interview N°7

Theme	**Associated Codes**	**What Binds These Codes**
Interviewee expertise & Existing demonstration	#1, #2, #3, #4, #6, #7, #8	The interviewee manages EU urban logistics pilots and runs real-city demonstrations. The locker concept is not new; however, the project currently running is lockers at stations using PT as freight transport.
Environmental, cost & user-convenience value propositions	#9, #10, #11, #12, #38, #39	Quantification of the environmental, economic, and time-saving benefits that are the core interests of stakeholders.
Passenger–freight mix risks	#5, #13, #14, #15, #23, #24, #34, #46	Issues in mixing freight with passengers related to scheduling, safety, and spatial issues show the risks of disruptions and complexity.

Digital platforms	#22, #25, #26, #31, #32, #33, #35, #36, #37, #44	Provide details on how the IT and hardware should be done(APIs, slot allocation, barcode scans, modular lockers) to reduce risk and improve integration.
Absence of rules and liability issues	#21, #27, #28, #29, #30, #45	The absence of EU rules and liability issues inhibits the deployment.
Business Model	#16, #17, #18, #19, #20, #41, #42, #43	Description of incentive and mix needed to increase adoption. In particular, the drivers and blockers logistics/retail push and commuter benefits vs PT safety caution and complexity.
Scale economics	#47, #49, #50	The context in which this innovation could work is dense urban corridors with high PT frequency and parcel volume.
Impact Assessment	#40, #36	Description of how the success should be measured baseline-vs-Δ metrics, particularly CO_2 savings, and scan-traceable parcel flow.

Data grouping of interview N°8

Theme	**Associated Codes**	**What Binds These Codes**
Interviewee experience and novelty of the concept	#1, #2, #3, #4	The interviewee is a strategist inside a PT company who works in rail operations, freight flows, and real-estate development, defining a long-term, multi-subsidiary view. Onboard lockers are new to the expert.
Station-locker precedent	#5, #6, #44	On-board lockers are assessed in comparison to existing station-locker models. Of three variants, only one (hub-to-vehicle) is viewed as conditionally viable.
Punctuality non-negotiables	#8, #9, #32, #37	Punctuality is essential; deviation from it is unacceptable because of the interdependence of the national rail network.
Vehicle space & passenger-capacity constraints	#22, #23, #24, #36, #38, #41, #42	Highlight the space lost because of lockers and the possible reduction in customer comfort. Only restaurant carriages inside trains are considered a potential fit.
Logistical complexity & coordination cost	#15, #16, #17, #18, #25, #26, #27, #28	This solution's complexity, which includes logistical precision, tracking, and modifications, is expensive, and it would undermine the fluidity of the service.

Economic viability barriers	#7, #10, #11, #12, #13, #14, #20, #27, #28, #29, #30, #33, #34, #39	Possible challenges in the business case include regulated operators' inability to retain the new revenue, users' expectation of free service, and the logistics partner's desire for a cost-efficient solution.
Regulatory regimes	#19, #21, #35, #40	The expert maintained that there are premature sustainability policies and legal barriers. Furthermore, there are different regimes regarding how PT works in Europe and whether it can keep the revenue or not.
Stakeholder alignment & incentive requirements	#31, #33, #34, #39, #40	The model would work only if all the stakeholders fully buy-in, requiring aligned incentives and zero disruption.

Data grouping of interview N°9

Theme	**Associated Codes**	**What Binds These Codes**
Interviewee expertise and novelty of the concept	#1, #2	The interviewee is an expert in the upstream supply chain, and the concept of lockers on PT is new.
Perceived benefits	#3, #4, #9, #24, #26, #30, #35, #36	The expert thinks that the combined benefits of commuter time savings, emissions reduction, and ESG gains could justify the adoption.
Vehicle-space & accessibility constraints	#5, #11, #17, #31	The space for lockers competes with the space for seating and wheelchair zones.
Timing, punctuality & user punctuality risks	#6, #8, #12, #14, #15, #16, #21, #32, #33	Critical aspects are punctuality and coordination, which could be operationally fragile. Furthermore, missed loading windows or late riders could delay the service.
Operational design	#20, #21	Crucial is the design, which needs to fit in a variety of fleets, but the vehicles need to be kept in service.
Legal, privacy Rules	#17, #18, #19, #47	The expert highlights the rules on protected space, tamper-proofing, privacy, and item-size limits to define what can ride onboard.
Digital & security tech requirements	#22, #23	The interviewee underlines tech needs: real-time tracking and one-time codes for secure, traceable, and user-friendly delivery access.

Business Model, incentives & stakeholder alignment	#7, #10, #11, #25, #28, #29, #30, #35	There is a need for a multi-actor deal, especially on how the revenue must be shared.
Environmental Metrics	#26, #27	The metrics relate to concrete KPIs, such as the number of parcels carried or the km avoided.
Scalability & context fit	#34, #38, #39, #40	The idea could be viable in dense, punctual metro networks. In rural or low-demand areas, however, the model fails.

Data grouping of interview N°10

Theme	**Associated Codes**	**What Binds These Codes**
Interviewee expertise and concept novelty	#1, #2, #3, #4, #5,	The interviewee, with his expertise in PT and logistics, is working to facilitate the transition toward a more sustainable and efficient transport system for the city of Turin. The concept of lockers on PT is new.
Closest precedents	#6	On-board lockers are entirely new to the interviewee; the only analogue cited is coach-based parcel delivery in rural settings.
Perceived benefits	#7, #8, #16, #36, #47	Highlights green branding, extra revenue, and commuter convenience—offset by awareness that extra weight may limit the environmental upside.
Physical space, energy & accessibility constraints	#9, #14, #20, #24, #25, #31, #32, #40, #42, #47	Locker installation affects wheelchair access, e-bus range, and boarding flow, and requires lightweight, crash-safe, low-energy designs.
Service-flow & timing risks	#10, #11, #21, #22, #23, #25, #26, #27, #28, #50	Coordinating depot ops, bus range, and passenger schedules is complex; piloting off-peak and at night is proposed to mitigate these risks.
Security, liability & labour barriers	#12, #13, #18, #19, #34, #35, #41, #46	Locker theft, breakdowns, and liability ambiguity drive union resistance and raise insurance costs—pricing and responsibility must be shared.
Digital infrastructure	#29, #38, #40, #41, #42, #43, #44	Success hinges on sub-30-second GPS data, vandal-resistant hardware, and energy-efficient, integrated tech for smart lockers.

Regulatory framework	#31, #32, #33, #36, #37, #38, #39	Accessibility law, goods handling codes, live-data clauses and city regulations form the legal boundary for any locker deployment.
Business model	#15, #16, #17, #18, #45, #49	A workable model must share space and liability costs fairly; PT operators want margin-neutral deals, couriers want green PR, and riders are divided.
Evaluation Metrics	#27, #34, #41, #47, #48	Pilots must track van-km cuts and parcel throughput, but risks of locker saturation from missed pickups or union duties loom large.

Data grouping of interview N°11

Theme	**Associated Codes**	**What Binds These Codes**
Interviewee expertise and concept novelty	#1, #2, #3, #31, #39	The interviewee is the director of mobility services for the Italian region of Molise. The expert is new to the idea.
Perceived value & societal benefits	#4, #5, #6, #7, #24, #25, #34, #38, #40	The benefits highlighted by the expert are related to the new service that would also reach the remote areas, the delivery costs that would be reduced, the support for anti-depopulation, and the reduction of km of delivery vans.
Vehicle space & capacity constraints	#10, #17, #21, #33, #36, #37	The problem of space persists in crowded urban buses, while for inter-urban buses, this problem does not persist because of the empty luggage bays.
Operational-coordination challenges	#8, #9, #15, #29, #30	One big problem is that users must identify the correct bus, and the multiple departures increase the complexity. Moreover, especially in rural areas, the engagement between client and driver is crucial.
Technology requirements	#16, #22, #23	Given the big problem of identifying the correct bus, real-time vehicle tracking becomes essential. Also, a dedicated IT platform and secure one-time access are crucial to the successful deployment of this solution.

Legal & policy framework	#18, #19, #20	The region of Molise already allows for mixing goods with passengers; however, this informal precedent would need more formalization and, consequently, more policy updates.
Business model, incentives & stakeholder alignment	#11, #12, #13, #14, #26, #27, #28, #32	Possible incentives to convince drivers/operators to do it could be financial. However, couriers' involvement and ownership of lockers are crucial.
Context fit	#35, #38	Rural or regional networks, with their different types of buses and broad territorial coverage, can be an ideal context for starting.

D

Interview guide for logistics and public transportation expert

The interviews were conducted in a semi-structured format in order to have comparability across participants while still allowing the participants some freedom in their answers. The core structure of the interview covered a variety of topics; however, to facilitate the reconnection with the original subquestions, they are traced back to them. First of all, it asks about the participants' background and whether they are familiar with parcel lockers; after, it switches to the general perception of lockers on PT (SubQuestion 3) after the questions focus on the key logistical, regulatory, and technical factors (SubQuestion 1), the impact on a performance indicator (SubQuestion 2), and finally with the stakeholder collaboration acceptance (SubQuestion 3) and the challenges, enablers and final reflections. Their order does not follow the order of the subquestions, for the simple thing is that they try to create a logical flow throughout the interview. Moreover, in this research, the initial idea was to have another set of questions that were on the ownership model to implement with this solution; however, experts in many times didn't have time, so it has been usually compressed in and out of the structured interview question in which has been asking the preference among the public, private, startup-led, and hybrid ownership model.

The base transcript used by the interviewer has been always the same with some freedome given the semi-structure nature of the interviews:

Participant background and familiarity with lockers

1. Could you describe your role and experience in the public transportation/logistics sector?
2. Is the concept of parcel lockers on public transportation vehicles familiar to you? If yes, can you explain to me your idea of it?

General perceptions of lockers on public transportation (SQ3)

SubQuestion 3 – Stakeholder Perceptions
"How do stakeholders—public transportation authorities, logistics providers, and end-users—

perceive parcel lockers on public transport?"

3. In your view, what would be the possible benefits of on-board parcel locker installation on public transportation?
4. Are there any short-term disadvantages or issues that are immediately apparent with on-board parcel lockers?
5. How would stakeholders (e.g., transit bodies, logistics companies, commuters) view this technology?
6. What incentives or disincentives might attract or deter such stakeholders from using on-board parcel lockers?

Key logistical, regulatory, and technical factors (SQ1)

SubQuestion 1
"What are the key logistical, regulatory, and technical factors that enable or inhibit the acceptance of mobile parcel lockers on public transportation systems?"

Logistical Factors

7. What logistical issues or challenges can the integration of parcel lockers on public transportation bring to day-to-day operations?
8. How can these logistical issues be tackled?

Regulatory Factors

9. Are there regulations or policies that exist to impact the utilization of parcel lockers on public transit? If yes which one?
10. Do you envision some new policies or regulatory developments that would be able to bring in this service?

Technical Factors

11. From a technical point of view, what might be the most important considerations to do when parcel lockers have to be incorporated into public transportation?
12. Do you think technology like real-time tracking, digital access codes, or software inte- gration is crucial to successfully implementing lockers on public transportation?

Impact on performance indicators (SQ2)

SubQuestion 2
"To what extent do on-board mobile parcel lockers impact key performance indicators such as operational costs and carbon emissions compared to conventional last-mile delivery meth- ods?"

13. How can this innovative solution affect the operational costs for logistics providers or public transport operators?
14. How can parcel lockers on public transportation impact carbon emissions or environ- mental sustainability on public transportation?
15. How would you propose measuring or benchmarking these impacts?

Stakeholder Collaboration and Acceptance (SQ3)
(Additional considerations on stakeholder perceptions)

"How do stakeholders—public transportation authorities, logistics providers, and end-users—perceive parcel lockers on public transport?"

16. Which stakeholders must align to successfully implement the onboard parcel lockers (e.g., local government, transport operators, logistics firms)?
17. How should the collaboration between these stakeholders be structured to ensure a successful and smooth implementation?
18. Which incentives should be implemented to motivate stakeholders to adopt this new solution over the traditional last-mile delivery methods?

Challenges, Enablers, and Final Reflections
Ties back to the main RQ:
"What are the key potentials and possible challenges for the integration of on-board mobile parcel lockers into the public transportation network?"

19. What are the most significant challenges in integrating on-board parcel lockers?
20. What are the key enablers that would ensure widespread acceptance?
21. In your view, are there any particular contexts or use cases where on-board parcel lockers are more likely to succeed (or fail)?
22. Do you have any other comments regarding the viability, potential benefits, or draw- backs of utilizing mobile parcel lockers in public transportation?

However, to experts who demonstrated to have enough free time and availability other questions have been proposed related to the ownership model.

E

Extended quantitative analysis of open questions

E.1. Desired features

The questionnaire included a question on the desired features. The 83 answers were then grouped into other bigger categories. It was possible to list more than a single feature, and every one of them was considered as such.

Table E.1: Thematic grouping of desired features

#	Category (Feature)	Mentions	Share of Respondents
1	Real-time tracking	43	≈ 52%
2	Surveillance / security	24	≈ 29%
3	24/7 / flexible access	14	≈ 17%
4	Ease of use / app integration	4	≈ 5%
5	Guarantee if delayed / missed pick-up	4	≈ 5%
6	Damage / loss reimbursement	3	≈ 4%
7	Reliability & service quality	1	≈ 1%
8	Larger lockers / size options	1	≈ 1%
9	Environmental benefit	1	≈ 1%

#	Category (Feature)	Mentions	Share of Respondents
10	Lower cost	1	≈ 1%

Note: The percentages have been calculated using 83 interpretable answers. If multiple features were present in one answer, they were assigned to each relevant category.

Key take-aways:

The answers to this open question highlight the characteristics that are prioritized by the user.

1. **Real-time tracking** is the most important feature highlighted by the users (52%). This indicates that they expect complete visibility and transparency when they use a mobile parcel locker system. This has also emerged in the interviews, that real-time tracking is essential for a successful deployment.
2. **Security and surveillance** is the second most requested characteristic, cited by 29% of respondents. The return citation of "video surveillance" and "advanced security" underline concern about the perceived vulnerability of unsecured packets in a mobile or shared context. These findings validate that without apparent protection—e.g., camera monitoring, secure authentication, and theft-prevention mechanisms—most individuals will be unwilling to use the system.
3. **24/7 or flexible access** is the third quoted by 17%. Even though it is less central than tracking and monitoring, whether the locker is constantly available indicates that the users want the service to adapt to the varying schedules. However, lockers in transit have to align with the working hours of the PT vehicles, so this is in contrast with that. This is the strongest argument of the experts against this solution (interviews 4 and 5), who believe that onboard lockers would remove flexibility from the customer, whereas stationary lockers offer the greatest flexibility.
4. **Features such as ease of use, app integration, locker size, missed pick-up and sustainability** are relatively marginal in the share of responses. Even though they can be influential in long-term user satisfaction, they are secondary to the main concerns highlighted above related to tracking, security, and access. Basically, users need basic functionality before having additional features. All these themes also emerged during interviews, specifically because the missed pick-up was a big issue, as well as the app integration.

To conclude, the acceptance of mobile lockers is based on attributes that minimize uncertainty and maximize control. Only when these foundational needs are met will the secondary features improve the perceived value of the service

E.2. Concerns and Mitigation

E.2.1. Safety, Privacy & Space

A total of 87 valid answers were cleaned, translated where necessary, and coded line-by-line. Because a few respondents provided requests for mitigation rather than direct concerns, a new

category has been created: the conditional-mitigation category. These are not concerns in themselves but rather signify that acceptance is conditional on additional safeguards.

Table E.2: Thematic grouping safety, privacy & space

#	Category (Feature)	Mentions	Share of Respondents
1	Conditional-mitigation (surveillance / tracking / 24 h)	35	40 %
2	Safety / theft / malicious use	15	17 %
3	No concern / neutral	20	23 %
4	Space / crowding	7	8 %
5	General unease (unspecified)	9	10 %
6	Usability / service disruption	6	7 %
7	Privacy	2	2 %

*Percentages sum to more than 100 % because some answers raised multiple points.

Key take-aways:

1. **Four out of the respondents did not articulate a problem but asked for more protections.** Terms such as ”video surveillance”, ”real-time tracking”, and ”24-hour access” indicate that these people can become customers if intensive monitoring is implemented.
2. **Concrete safety fears remain the single biggest true concern.** Many respondents have mentioned theft, tampering, and even terrorism scenarios (”you could send an explosive to a crowded train”), this underly the need of efficient security measures.
3. **Roughly a quarter of participants see no issue at all.** The 23% see no concerns and this segment represents ready to adopt user base.
4. **Space worries are real but secondary.** In the answers are present phrases such as ”space is valuable at rush hours” and ”spaces may constrict” . This suggest modular arrangements or off-peak arrangements.
5. **General unease & usability frustrations round out the picture.** A smaller part of the clusters is worried about missing packages, reduced boarding pace, or missing a pick-up. However, fallback procedures (e.g., automated re-routing) can mitigate this.

In short, public acceptance hinges on visible security measures and space-sensitive installation, with transparent operating policies to convert conditional supporters into confident users.

E.2.2. Integration without disruption

The answers were 81 in total, and they were translated (where needed), cleaned, and coded line-by-line. However, in this question, many answers were proposed design solutions rather

than concerns. As a consequence, the categories are preferred integration strategies, plus two residual groups ("Opposed" and "Unsure").

Table E.3: Thematic grouping of integration without disruption)

Rank	Integration Strategy / Position	Mentions†	% of 81 resp.
1	Dedicated carriage / compartment / zone	24	29.6 %
2	Station-based only (not onboard)	10	12.3 %
3	Use "dead" or under-utilised space inside the vehicle	9	11.1 %
4	Conditional safeguards (monitoring, scheduling, peak-hour rules)	10	12.3 %
5	Limit size / quantity	2	2.5 %
6	Opposed / negative	3	3.7 %
7	Unsure	18	22.2 %
–	Misc. single suggestions	–	–

† Multiple ideas in the same answer were counted in each relevant category.

Key take-aways:

1. **Spatial separation**: Nearly 30% think lockers should be placed in a dedicated carriage or partitioned zone to avoid disruption. This would keep users and parcels out of the standard seating and standing areas.
2. **Station-based lockers over onboard installation.** Ten people mentioned that lockers should be placed at stops or hubs instead of onboard to avoid disruption.
3. **Use of wasted space.** To avoid disruption onboard, people suggested placing lockers under seats, overhead, or in luggage compartments to preserve aisle width and seating capacity.
4. **Operational measures** Around 12% of the respondents requested monitoring, time-slot reservation, or off-peak access to avoid queues, ensure security, and consequently reduce disruption.
5. **Rejection of the concept** Few people refused to accept the innovation due to its added weight, increased energy use, or general impracticality.
6. **Unsure regarding the integration of the solution** 22% of the sample were unable to imagine how the lockers on PT solution could have been deployed, indicating a possible need for visual mock-ups and pilot demonstrations.

To conclude, end-users think that mobile lockers on public transportation can be efficiently integrated and disruption avoided if they are secure and sensibly integrated into the vehicle or station environment without creating comfort or capacity problems.

E.3. Desired features at stop-based lockers

In total, the question gave 54 interpretable answers, which were also translated (where needed), cleaned, and coded line-by-line. The majority of the answers were listed in concrete categories, "make it better" features, while two others captured rejection ("Opposed") and uncertainty ("Unsure") regarding the innovation.

Table E.4: Thematic grouping of desired features at stop-based lockers

Rank	Requested Feature / Position	Mentions†	% of 54 resp.
1	Convenience / proximity	21	38.9 %
2	Security & safety measures	11	20.4 %
3	24/7 availability	4	7.4 %
4	Lower cost / discounts	4	7.4 %
5	Tech / app integration & smart access	2	3.7 %
6	Already appealing (no extra need)	6	11.1 %
7	Opposed / negative	6	11.1 %
8	Unsure / no idea	9	16.7 %

† Multiple ideas in the same answer were counted in each relevant category.

Key take-aways

1. **Proximity** Almost 40% of the sample indicate proximity as a crucial characteristic for increasing the attractiveness of lockers. In particular, proximity is intended as being close to home, work, or regular transit routes.
2. **Safety** Security is still a crucial aspect highlighted. In fact, almost 20% of the sample would like to have cameras or other surveillance measures to feel safe leaving packages in street lockers.
3. **Accessibility** The 24/7 availability is requested as much as cost incentives; this indicated the need for automation of the service.
4. **Prices** Around 7 % want the service to be cheap or wants a discount compared to the traditional home delivery.

5. **Digital integration** A small group asked for an app-based service which allowed to unlock the locker and real-time notifications.
6. **11 % already "sold", 11 % opposed, and 17 % unsure.** The percentage of people opposed and unsure is comparable to the percentage of people who were also opposed to lockers on public transportation, as highlighted in section 7.5.2.2.

Implications for design and characteristics of stop-based lockers: to conclude, this was the analysis of the variant idea of installing lockers at public transportation stops near your home. After analyzing the responses, it is possible to extrapolate some implications for the design. First, given the importance of proximity, it is crucial to understand where to locate the lockers, for example, where passengers already walk and stop in residential areas and along major commute corridors. Include safety measures in the service and make people feel safe when using it. However, the service must be available 24/7, and discounts and fees lower than traditional home delivery can make users more sensitive to costs. In short, bus-stop and tram-stop lockers are more appealing when in close proximity, being seen as secure, always available, and reasonably priced—with clever technology to improve the customer experience.

E.4. Thematic grouping of concerns on the integration of parcel lockers on public transport

There were 72 open-ended responses to answers related the concerns of lockers on public transportation. Nearly, two-thirds of the respondents reported specific issues, while others answered "No" (no issue) or "Yes" (favorable without remark).

Table E.5: Thematic grouping of concerns on the integration of parcel lockers on public transport

Rank	Concern Theme	Mentions	% of Responses
1	Space / crowding	13	18 %
2	Security / theft / privacy	11	15 %
3	Reliability of retrieval & lost-parcel worries	8	11 %
4	Time pressure when boarding/alighting	6	8 %
5	System feasibility & pilot quality	4	6 %
6	Finding the right vehicle/locker	4	6 %
7	Extra weight & fuel use	1	1 %
8	Less convenient than shop pickup	1	1 %

Note: Percentages use the full sample size (72). *Twenty-four respondents explicitly wrote "No/None/Nothing," and six wrote only "Yes," so 48 answers expressed a concrete concern or desired improvement.*

Key-take aways:

The concern that has been nominated the most was related to space and overcrowding (18%), meaning that many respondents noted that lockers would occupy space otherwise used by passengers and add to congestion, especially in already crowded buses or trains. Security, theft, and privacy concerns were the second biggest category (15%), with respondents concerned both during transit and at pickup. A high percentage indicated the system's reliability, specifically in terms of delayed delivery, missing packages, or delay (11%).

Time pressure at boarding or alighting is another constraint that worries respondents (8%), as is eventual lack of knowledge regarding using the correct carriage or vehicle (6%). Finally, a minority reported other feasibility issues, such as successful implementation of pilot projects or environmental trade-offs.

E.5. Increasing the appeal of lockers on public transport vehicles

This questionnaire wanted to explore the possible characteristics that increase the appeal of mobile parcel lockers. It had 60 answers in total, which were translated as needed and coded line by line.

Table E.6: Thematic grouping of increasing the appeal of lockers on public transport vehicles

Rank	Theme (unique respondents who mention it)	Mentions	% of 60 resp.
1	Accessibility / Convenience	21	35 %
2	Nothing / Unsure	14	23 %
3	Security / Theft-proofing	12	20 %
4	Location integration (at stations, on regular route, fixed point)	10	17 %
5	Tracking & real-time information	7	12 %
6	24/7 or extended access windows	5	8 %
6	Speed / Time-saving	5	8 %
8	Reliability / Trust in the system	3	5 %
8	Cleanliness / Size & space management	3	5 %
10	Lower cost / Incentives	2	3 %
11	Environmental benefit	1	2 %

Rank	Theme (unique respondents who mention it)	Mentions	% of 60 resp.
11	Tech integration (phone / watch)	1	2 %

*Percentages sum to more than 100 % because respondents could mention multiple themes.

Key-take aways:

Accessibility and Convenience (35%), was the most important category, indicating that the ease of access and the integration of the service in the day to day communiting is crucial for the widespread of this solution. Another substantial part of the respondents (23%) did not have an opinion nor were sure about possible concerns; this might indicate that they were unfamiliar with the concept before the questionnaire or lacked a strong opinion on this solution because they were unfamiliar with it. **Security and theft-proofing** with 20% indicates a strong concern for the safety of packages in a PT setting. **Location integration**, in the sense of installing the lockers at major stations or on regular, predetermined routes, has also been nominated many times, indicating the user's interest in the place of lockers. **Track and real-time info** (12%), **24/7 access** (8%) and **time-saving features** (8%) accounted for a total of 28%. Characteristics such as **system reliability**, **space management**, **cost incentives**, **environmental benefits**, and **tech integration** (like smartphones or smartwatches) show the diversity of needs that each client might want from the service. Overall, the dominant sense is that the solution has to trade off performance in operations against user-focused issues like accessibility, security, and convenience of location.

E.6. Final open-ended feedback: additional comments or suggestions

The final question of the questionnaire was on the additional comments from the respondents, and it attracted 36 comments, which were translated as needed and coded line by line.

Table E.7: Thematic frequency table of additional comments

Rank	Feedback Theme	Mentions	% of responses
1	No suggestion / unsure / neutral	23	64 %
2	Concerns about mobile lockers on transit vehicles (timing, risk, stress)	4	11 %
3	Preference for fixed lockers (station or stop)	4	11 %
4	"Never heard of this before"	2	6 %

Rank	Feedback Theme	Mentions	% of responses
5	Cautious support if it doesn't disrupt passengers	1	3 %
6	Incentives / pricing ideas	1	3 %
7	Operational logistics / staffing / discretion	1	3 %

*Percentages may not sum to 100 % due to rounding. Multiple issues raised in the same answer were coded in each relevant category.

Key-take aways:

The largest single group is the 40% of responses, encompassing those that did not provide suggestions. A significant portion of respondents (around 11%) expressed **concerns about lockers being placed on moving public transport**;, according to them, it would create stress (especially in case someone misses their stop) and more in general impractical and too risky. They expressed discomfort regarding the idea of chasing the parcel on the route and the risk of traveling without it. The 11% expressed **preference for fixed locker locations** such as stations, bus stops, or central areas near home; in particular, respondents emphasized that lockers should remain static and easily accessible—preferably not on the vehicle itself. Moreover, they suggested that distributing lockers across different stations would be more convenient than locating them on buses or trains. Another 3% expressed **logistical or operational concerns** saying that the system might require additional staff, planning, or needs to be less visible (e.g., underground station lockers). The same proportion gave **cautiously positive feedback**, saying that this idea might work and can be made work if it does not disturb travelers or take up space. Only a few of the interviewees (6%) said they never heard about this model. Lastly, 3%, **incentive-related suggestions**, e.g., providing product price discounts on products transported via this mode. Overall, the major themes view a trend toward stability, security, and simplicity—favoring fixed lockers over mobile ones—and indicate that implementation ease and user convenience will be most important in broader acceptance.

Table E.8: Conclusions by section

Section / Sub-section	Main conclusion per section / sub-section
1. Age-group distribution	Sample mainly composed of people in the age group between 18–25 years ($\approx 56\%$); results represent mainly digital-natives, yet older segments still reveal usability/accessibility problems.
2. Education level	Two-thirds possess a bachelor's degree or more, suggesting good tech-literacy and environmental awareness—not necessarily representative of the total population.

Section / Sub-section	Main conclusion per section / sub-section
3. Place of residence	93 % live in towns or large cities → end-user perspective is therefore most relevant in dense, urban last-mile contexts.
4. Online-shopping frequency	Purchases are sporadic (most are "few times / month"); lockers must accommodate irregular rather than high-frequency demand.
5. Public-transport usage	The majority ride PT only occasionally; the service should appeal to travellers who can integrate parcel pick-up naturally into their journeys.
6. Perceived usefulness by nationality	Usefulness varies widely (most useful: English, French, Greek, Iraqi; least useful: German, Portuguese, Chinese, Icelandic) ⇒ roll-out must be culturally tailored.
7. Perceived usefulness by PT usage	Positive correlation between PT use frequency and perceived usefulness; largest gains perceived by the most frequent travellers.
8. Perceived usefulness by online-ordering	Frequent online shopping → higher perceived usefulness.
9. Willingness to use by age group	Enthusiasm diminishes steeply after 45; < 35 yrs show $\sim 85\%$ openness, whereas ≥ 46 yrs show more hesitation.
10. Trust in on-board lockers	38 % already trust the concept, 33 % are neutral, 29 % distrust → transparency and security messaging are needed.
11. Perceived advantages	Greatest benefits: lower delivery cost (26 %), convenience (26 %), environmental impact (21 %); cost and ease drive appeal.
12. Desired features (on-board locker)	Highest priorities: real-time tracking (52 %), security/surveillance (29 %), 24 / 7 or flexible access (17 %).
13. Safety, privacy & space concerns	Conditional mitigation dominates (40 % want added safeguards); concrete concerns focus on theft and crowding.
14. Integration without disruption	Preferred mitigations: dedicated carriage/zone (30 %), station-based lockers instead of on-board (12 %), use of under-utilised space (11 %).
15. Desired features at stop-based lockers	Proximity to home/work (39 %), security (20 %), and 24 / 7 access & lower cost (each 7 %) make stop-based lockers attractive.

Section / Sub-section	Main conclusion per section / sub-section
16. Concerns for parcel-locker integration	Biggest worries: space/crowding (18 %), security/privacy (15 %), retrieval reliability (11 %).
17. Features to boost mobile-locker appeal	Accessibility/convenience (35 %) and security (20 %) outweigh all other enhancements; nearly one-quarter still unsure.
18. Additional open comments	Fixed, station-level lockers favoured by 11 %; 64 % had no further suggestions, indicating limited familiarity but little outright rejection.

F

AI Statement

The use of AI in this thesis has been limited to specific functions. It has been used to help create the graphs, specifically in cases where errors arose, and to improve their aesthetics. Additionally, as already mentioned, it has been used to have the interview transcript. Another supporting instrument, although not fully AI-driven, is Grammarly, which is used to check grammar and rephrased if needed. However, it is essential to note that all the content in this thesis has been created by the researcher and not generated by AI.