Developing a Methodological Framework for Effective Stakeholder Collaboration and Data Sharing in Last Mile Mobility

A Case Study in Zeeland

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TU Delft

Thesis

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Preface

This thesis marks the culmination of my Master of Science research, conducted in close collaboration with Siemens Mobility, focusing on one of the most critical and persistent challenges in modern urban planning: the last mile of a journey. This final segment, connecting transport hubs to the user's ultimate destination, is crucial for effective public transit yet remains hindered by systemic inefficiencies. The real deal the core problem that drove this research was the fragmented nature of data sharing and the frequent misalignment of objectives among the diverse public and private stakeholders involved in last-mile solutions. This complexity creates a system that is often expensive, inefficient, and poorly integrated for the end-user.

The foundation of this work was a deep-dive case study into the Siemens Demand Responsive Transport (DRT) project in Zeeland, Netherlands. This real world initiative provided the necessary, practical insights to move beyond theoretical analysis. The Zeeland project allowed for a comprehensive examination of existing collaborative dynamics, challenges, and successes in a Mobility as a Service (MaaS) environment. My research sought to move past merely describing this problem by addressing the fundamental knowledge gap: the lack of a structured, actionable process for effective cooperation and data sharing among stakeholders regarding last mile mobility.

The result is a comprehensive, five-step collaborative framework designed to act as a governance tool. This framework provides a practical blueprint for stakeholders to overcome data silos, align their competing interests (such as public welfare versus commercial profitability), and establish clear operational boundaries and standardized data formats. Its successful validation against the Zeeland DRT project demonstrated its utility in transforming ad-hoc, conflict-prone interactions into a more analytical, efficient, and results-driven process for developing integrated, user-centric mobility solutions.

This journey would not have been possible without the guidance of my supervisory team. I extend my sincere gratitude to my academic supervisors at TU Delft, Mr. Jan Anne Annema and Van Ort, whose critical feedback and rigorous academic standards were instrumental in shaping the methodology and ensuring the highest quality of research. Equally, I am thankful for the invaluable practical guidance from my supervisor at Siemens Mobility, who provided the necessary industry context and access to the real world case study, ensuring the framework remained grounded and relevant. Their combined expertise successfully bridged the gap between academic theory and industry reality. May the insights developed here contribute to unlocking the full potential of last-mile mobility, paving the way for a more integrated, efficient, and sustainable urban transport future.

Summary

The thesis is situated within the last mile mobility sector. Its central problem is the fragmented data and unaligned stakeholder interests. This core issue creates significant challenges, as stakeholders including municipalities, private mobility providers, and public transport agencies operate in silos due to competitive interests and the desire to protect proprietary data. This fragmentation ultimately results in inefficiencies, redundant planning, and prevents a holistic understanding of mobility patterns. The research therefore aims to develop a comprehensive framework to solve this by facilitating effective collaboration and data sharing.

The central issue in last mile mobility encompassing services like e-scooters, shared bikes, and on-demand transit systems is the lack of a unified framework for data sharing and collaboration. Stakeholders, including municipalities, private mobility providers, and public transport agencies, often operate in silos due to competitive interests and a desire to protect proprietary data. This fragmentation results in poorly synchronized transit schedules, redundant planning, and a fragmented landscape that prevents a holistic understanding of mobility patterns.

To address this, the research sets out to answer several key questions:

- Problem Analysis: What are the consequences of data fragmentation and unaligned stakeholder interests for the mobility sector?
- Data Comprehension: What are the key attributes of mobility data, and what are the challenges and standards for sharing it?
- Framework Development: How can a structured framework be developed to integrate stakeholder insights and technological requirements?
- Framework Validation: How can this framework be applied and tested in a practical case study to validate its effectiveness?

The research uses a qualitative case study approach to provide an in depth analysis of a real world initiative. The study's focus is the Siemens Demand Responsive Transport (DRT) project in Zeeland, Netherlands, which serves as a case study for stakeholder collaboration in a Mobility as a Service (MaaS) environment. The primary method for data collection was a series of nine semi-structured interviews with professionals involved in the Zeeland project. This approach was chosen to gather rich, qualitative insights into the opinions, experiences, and challenges faced by stakeholders. The data from these interviews was then used to validate and refine the proposed framework. The study found that while the value of collaboration is recognized, significant barriers persist, especially concerning data sharing and communication protocols.
Key findings from the case study include:

- Missing Central Governance: There is a critical absence of a dedicated, central governmental body with the authority to manage the coordination, set consistent standards for data sharing, and enforce accountability across all private and public stakeholders.
- Trust is fundamental: Successful collaboration hinges on mutual trust and strong relationships, not just advanced technology. Systemic shifts led by visionary leadership are required to foster shared value.
- Divergent Sector Goals: Fundamental conflicts exist between the private sector's focus on profit/market competition (viewing data as an asset) and the public sector's focus on welfare and accessibility.

- Fragmented Data Standards: Data sharing is blocked by the inconsistent implementation of standardized interfaces (GTFS, GBFS, etc.) and a general lack of agreed upon legal and ethical data governance frameworks.
- Weak Feedback Loop: A major weakness is the absence of formal, continuous mechanisms for gathering and analyzing feedback from end users and non core partners, hindering adaptive governance and continuous improvement.
- Conflict Prevention Need: Frequent conflicts arise from unclear expectations. Solutions require formalizing relationships (e.g., via NDAs) and establishing mechanisms for proactive conflict resolution and shared goal setting.

The thesis provides a detailed understanding of data exchange and sharing in last mile mobility. It highlights the need for a unified MaaS data standard at a European level to streamline sharing processes, while also noting that a vast amount of mobility data remains highly fragmented due to proprietary interests. The main contribution of the thesis is the five step collaborative framework designed to address these challenges:

1. Foundational Scrutiny: This step involves the comprehensive identification and characterization of all relevant stakeholders, including their organizational scale, resources, and core mandates.
2. Boundary Setting and Data Evaluation: This phase assesses the data landscape, identifying data sets, their quality, and formats to understand what data can be shared and what is required.
3. Current State Evaluation: This step synthesizes insights and quantifies existing deficiencies, translating qualitative observations into actionable findings.
4. Solution Design, Governance, and Implementation Strategy: The focus here is to develop strategic solutions that meet the diverse needs of all stakeholders, using feedback mechanisms like pilot tests to refine the approach.
5. Feedback: Feedback loops are established at each stage of the project to ensure continuous engagement, responsiveness to changing conditions, and alignment with real world relevance.

Stakeholders are motivated to move from ad hoc interactions to a strategic approach because the existing fragmentation directly harms their goals. The public sector is incentivized by the framework's ability to improve operational efficiency and address the fragmented nature of urban mobility, fulfilling their mandates for welfare and accessibility and leading to more effective, sustainable solutions. For the private sector, strategic collaboration and data sharing eliminate inefficiencies and redundant planning, offering a clearer path to profitability within an integrated network. Ultimately, the framework offers a practical blueprint to overcome silos, build mutual trust, and ensure all parties benefit from a holistic understanding of mobility patterns.

Despite being derived from a single case study, the framework is generally applicable but requires further development and validation. Future research must apply its principles across multiple, varied contexts to confirm its robustness and adaptability. The research successfully establishes an academic foundation and provides a direct, actionable response to last mile mobility complexities by offering a five-step collaborative blueprint. This systematic approach, if adopted, is shown to improve operational efficiency and facilitate more effective and sustainable solutions.

List of Abbreviations

Abbreviation	Definition
ACES	Automated, Connected, Electric, and Shared (Technologies/Vehicles/Mobility)
AI	Artificial Intelligence
DRT	Demand-Responsive Transport (or Transit)
EMDS	European Mobility Data Space
ESS	Energy Storage System (or Emergency Stop Signal, in a vehicle context)
EU	European Union
GBFS	General Bikeshare Feed Specification
GTFS	General Transit Feed Specification
MaaS	Mobility as a Service
NDA	Non-Disclosure Agreement
TOMP-API	Transport Operator to MaaS Provider API

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1. Introduction

The urban landscape is constantly evolving, with a growing focus on sustainable and efficient transportation solutions. Last mile mobility refers to the final leg of a journey, connecting people from a transportation hub to their ultimate destination (Zellner et al., 2016). This is not a single service but a diverse ecosystem comprising public transit, shared vehicles (e.g., car sharing, ride hailing), micromobility (e-bikes, e-scooters), and on demand delivery services. This crucial phase is often the most challenging, inefficient, and costly part of the journey. While innovations in shared mobility, micromobility, and Mobility as a Service (MaaS) have provided new options, the full potential of these solutions is often hindered by significant challenges related to data.

A key problem lies in the fragmented nature of data exchange among different stakeholders. Municipalities, private mobility providers, and public transit agencies all collect vast amounts of data on rider behavior, vehicle usage, traffic patterns, and infrastructure. However, this data often exists in silos, with a lack of standardized formats, protocols, and willingness to share. This creates a critical knowledge gap, preventing a holistic understanding of the mobility ecosystem. Without integrated data, stakeholders cannot effectively coordinate services, optimize routes, or develop policies that address urban mobility challenges in a comprehensive way.

This lack of effective data exchange is a fundamental problem because it leads to inefficient service provision, missed opportunities for collaboration, and a failure to meet the evolving needs of city residents. This inability to share data prevents a unified approach to urban planning and management, which in turn leads to a sub optimal user experience across the entire mobility network.

1.1 Problem Statement and Knowledge Gap

The last mile is the final and often most challenging leg of a journey, covering the distance from a transportation hub to the passenger's final destination. The central issue hindering progress in this field is the lack of effective data sharing and collaboration among stakeholders. This is primarily driven by competitive commercial interests and a deep protectiveness over proprietary data. This inherent competitive structure leads to inconsistent cooperation, resulting in companies relying on restrictive Non Disclosure Agreements (NDAs) that limit the broader application of shared data. This lack of transparent and open collaboration ultimately impedes the development of truly integrated and efficient last mile transportation solutions and represents the fundamental knowledge gap this research addresses

The rapid integration of last mile mobility services, such as shared e-scooters and autonomous delivery systems, creates a fundamental need for sophisticated data exchange to ensure public safety, regulatory alignment, and efficient urban planning. However, the core challenge is not technical, but rather a systemic governance deficit in the ecosystem: the lack of a standardized, trust-based procedural framework for collaboration between municipal authorities and private operators. This friction leads directly to fragmented regulatory oversight and sub-optimal city

planning, resulting in missed opportunities for traffic reduction and regulatory uncertainty. The core of the problem lies not just in a lack of data, but in the fragmented and siloed nature of existing data exchange. This disconnect creates significant inefficiencies, from redundant planning to a lack of coordinated service provision. The absence of a unified, collaborative framework means that stakeholders such as municipal governments, private mobility providers, and public transport authorities operate in isolation. This fragmented landscape prevents a holistic understanding of mobility patterns and user needs, ultimately hindering the development of truly sustainable and user centric last mile solutions.

Public transport services are increasingly dependent on digital information systems to ensure efficient operations and provide accurate information to passengers. In the transport sector, data sharing plays a crucial role as it leads to outcomes that can benefit the wider population. By unlocking new insights, data sharing fosters the development of more efficient processes and the creation of new products that can cater to society's evolving needs, such as providing real time location tracking, optimizing routes to reduce travel times, and enabling seamless multimodal trip planning and integrated ticketing systems.

Tight, Rajé & Timms (2016) discuss the limited effective range for public transport, typically about one mile (1.6 km), beyond which public transport becomes less attractive, posing accessibility issues (Lesh, 2013). Innovative and green transport solutions are transforming last mile mobility by introducing sustainable and eco friendly options such as electric vehicles, bike sharing, and micro mobility solutions like e-scooters, all aimed at reducing the environmental impact of urban transportation (Shaheen & Cohen, 2019). Alongside these advancements, social and behavioral studies are shedding light on user preferences and decision making processes, exploring how factors like accessibility, convenience, and safety influence the adoption of last mile solutions. To further enhance connectivity, multimodality is emerging as a key trend, integrating various transport modes, such as public transit, bikes, scooters, and ride sharing into seamless and flexible systems that bridge gaps between different transportation networks (Papa & Lauwers, 2015). Together, these trends highlight a holistic approach to last mile mobility, combining sustainability, user centric design, and intermodal connectivity to create more efficient and inclusive urban transport systems.

Despite these positive trends, the mobility landscape in the Netherlands continues to face significant challenges, fuelled by urbanization, an increase in passenger kilometers, and the urgent need for sustainable solutions. This scenario has led to a dynamic and complex mobility environment where transportation demands fluctuate throughout the day, necessitating innovative approaches to management. In response, stakeholders from various sectors including government, education, and the business community have launched initiatives aimed at optimizing mobility solutions. However, a critical barrier remains, the lack of a unified framework for managing and sharing data amongst these stakeholders. Without a cohesive approach, there is a persistent gap in aligning objectives and addressing distinct challenges, leading to missed opportunities for enhanced efficiency and effectiveness in last mile mobility solutions.

The literature review underscores significant gaps in aligning diverse stakeholder objectives, such as those of local governments, transport operators, and private companies, due to often competing interests. This lack of a unified framework for data management among stakeholders obstructs effective last mile mobility solutions, as it leads to fragmented data standards and proprietary APIs, ultimately impeding the integration of real time information systems and coordinated services (Hoffmann & Otero, 2021). While digital platforms are

recognized for their ability to enhance decision making and efficiency, integrating them into cohesive frameworks remains a significant challenge. The importance of shared data and digital platforms is further highlighted by Gonzalez Feliu et al. (2018), who show how real time data from various sources can be used to inform evidence based policy decisions. Despite the promising advances in micromobility solutions and Mobility as a Service (MaaS) platforms, persistent challenges like infrastructure limitations, safety concerns, and scalability across different urban settings hinder their widespread adoption (Puspitasari et al., 2025). Effectively aligning these varied stakeholder objectives in such a complex and diverse ecosystem therefore requires strategic coordination and collaboration. As demonstrated by Kostiainen & Tuominen (2019), adopting structured approaches for stakeholder collaboration, with a focus on a shared vision and clear roles, is essential to mitigate conflicts and foster effective partnerships.

The lack of a unified framework for data management among stakeholders obstructs effective last mile mobility solutions. This issue manifests in two distinct, yet interconnected, ways.

First, on a practical and technical level, the absence of a unified framework leads to fragmented data and the creation of data silos. Public and private actors often employ their own proprietary APIs and protocols, making it technically difficult and costly for different systems to communicate, share information, or work together seamlessly. As highlighted by Hoffmann & Otero (2021), this practice results in data silos, missed synergies, and increased transaction costs, ultimately impeding the integration of real time information systems.

Second, the misalignment of diverse objectives and conflicting interests among stakeholders such as municipal governments focused on public good and private companies driven by profit is a core issue. Without a shared framework, these competing goals lead to missed synergy opportunities and a complex ecosystem that hinders progress despite technological advances. The literature review shows that while digital platforms can enhance decision making, their integration remains challenging (Gonzalez Feliu et al., 2018). Similarly, despite advances in micromobility solutions and Mobility as a Service (MaaS), challenges like infrastructure limitations, safety concerns, and scalability persist (Puspitasari et al., 2025). Effective alignment, therefore, requires strategic coordination and collaboration, with structured approaches being outlined by scholars like Kostiainen & Tuominen (2019) to mitigate conflicts and foster effective partnerships.

1.2 Research Goal

The objective of this research is to create a comprehensive framework that facilitates effective collaboration and data sharing among stakeholders, with the ultimate goal of enabling more effective, sustainable, and user centered last mile mobility solutions. This approach aims to align diverse objectives and manage competing interests. The framework will be informed by insights from a case study in Zeeland, Netherlands, where effective stakeholder collaboration has already been implemented. The research process involves identifying stakeholder objectives and understanding the associated challenges and knowledge gaps. This will be achieved through interviews to gain deeper insights. Ultimately, the goal is to develop a framework that provides practical insights into how stakeholders can address their knowledge questions, using a concrete use case to analyze the "last mile" mobility challenges based on the case study findings.

The actual problem in last mile mobility is the lack of a unified framework for data sharing and collaboration among stakeholders. This leads to fragmented data silos and a failure to align

competing objectives, ultimately impeding the integration of systems and preventing the development of efficient, sustainable, and user centric solutions. This research seeks to address the existing fragmentation by proposing a comprehensive and practical framework aimed at fostering greater coherence and integration. By outlining a structured approach for data sharing and stakeholder collaboration, this thesis offers a practical blueprint for creating a more integrated and efficient urban mobility ecosystem. The framework's objective is to enable all parties to move beyond their operational silos, fostering a new era of cooperation that unlocks shared value and leads to smarter, more adaptive last-mile mobility solutions.

1.3 Research Questions

Main Research Question: What are the key elements of a collaborative framework for stakeholder data sharing in last mile mobility?

Sub Research Questions:

1. **Problem Analysis: Stakeholder Conflicts and Data Fragmentation in Last Mile Mobility**

What are the consequences of data fragmentation and unaligned stakeholder interests for the mobility sector?

2. **Data Comprehension: Attributes, Benefits, and Challenges of Mobility Data**

What are the key attributes and benefits of mobility data, and what are the existing challenges and standards for sharing it among stakeholders?

3. **Framework Development: A Framework for Collaborative Data Sharing**

How can a structured framework be developed to integrate stakeholder insights and technological requirements to facilitate data sharing for last mile mobility solutions?

4. **Framework Validation: Testing the Framework in a Practical Case Study**

How can the developed framework be applied and tested in a practical case study to validate its effectiveness in addressing last mile mobility challenges?

1.4 Scope

This graduation project, in collaboration with Siemens Mobility, tackles the "last mile" mobility challenge, a key aspect of urban transportation. The project's scope is specifically focused on the final segment of a journey, which involves connecting people or goods from a transportation hub to their ultimate destination. Therefore, while acknowledging the role of large scale transport systems like trains and long distance buses, this research does not delve into their operational or data related challenges, as they fall outside the last mile ecosystem. The project's focus is to address the challenge of data fragmentation in last mile mobility by developing a structured collaborative framework for stakeholders. The scope of this thesis is explicitly focused on Last-Mile Transportation within urban environments. This research exclusively examines the movement of people specifically, the passenger journey involving solutions such as micro-mobility (e.g., e-scooters), Mobility as a Service (MaaS) platforms, and Demand Responsive Transport (DRT). By concentrating on this precise segment of

passenger movement, the study provides a deep, targeted analysis of collaboration and data sharing challenges within the last mile passenger ecosystem.

The research aims to address the data fragmentation among stakeholders by proposing a structured collaboration framework. Objectives include identifying stakeholder goals, framing key questions, and using insights from a case study in a running project in Zeeland, Netherlands, to find solutions for a safe and sustainable urban setting. Ultimately, the research presents a framework that helps stakeholders address various knowledge questions by leveraging insights from real life examples of successful collaboration in last mile mobility. The framework proposes improvement scenarios based on these insights, offering a strategic blueprint for analyzing and enhancing the last mile of a journey.

1.5 Structure

This thesis is divided into nine parts. It begins by establishing the research problem and goals. The following section provides a theoretical analysis of existing research on stakeholder collaboration and mobility solutions. The next part outlines the qualitative case study approach, including a specific case and semi-structured interviews. The findings from these methods are then presented, covering topics like stakeholder objectives and data sharing tools. The analysis then shifts to a deeper look at the attributes and standards of mobility data. The main contribution of the research is presented next, outlining a five-step process for effective collaboration and data sharing. This framework is then validated by applying it to real world challenges. The thesis concludes with a broader discussion of the study's findings, and a final summary that confirms the successful development of a comprehensive methodology.

2. Literature review

The literature review incorporated articles from peer-reviewed journals accessed through academic databases such as Scopus and Google Scholar. The searches employed precise keywords and search strings to ensure a focused and relevant selection of studies. These included, but were not limited to, combinations such as: "last mile mobility" and "stakeholder collaboration," "data sharing" and "urban transportation," "mobility as a service" and "MaaS," and "micromobility" and "policy framework." Studies were selected based on their relevance to urban mobility, stakeholder collaboration, data sharing, and the specific challenges associated with last mile solutions. Priority was given to recent publications and those providing empirical evidence or comprehensive frameworks. Each of the 20 papers identified was thoroughly read and analyzed, with particular attention paid to the most relevant sections of each article. This comprehensive approach allowed for the synthesis of a detailed and cohesive literature review, integrating key findings and insights from the selected studies to provide a robust foundation for the research proposal.

The comprehensive initial pool was then subjected to a two stage screening process based on specific inclusion and exclusion criteria. The primary goal was to ensure a contemporary review, leading us to prioritize and retain references as close to the present day as possible, with a general inclusion cutoff of 2018 for high impact studies. However, the search strategy was designed to be rigorous: any older papers, such as the single reference from 2000, were retained only if they were fundamental, seminal works that established core conceptual frameworks or critical theories directly underpinning modern stakeholder collaboration or urban mobility standards. The final inclusion criteria required all papers to provide empirical evidence, case studies, or comprehensive regulatory/technical frameworks. This systematic screening ultimately refined the extensive initial references down to the final 20 papers that form the basis of this literature review, ensuring they collectively cover the four key research areas.

The literature review examines four key aspects of urban mobility and last mile solutions stakeholder collaboration and data sharing, micromobility solutions, Mobility as a Service (MaaS) platforms, and regulatory frameworks because they are essential for understanding the complexities and developing effective strategies to address last mile challenges. These elements are interconnected and form the core of the problem and its potential solutions. Stakeholder collaboration and data sharing are crucial for aligning diverse objectives and enhancing decision making, which in turn supports the integration of micromobility solutions. These solutions offer flexible alternatives for short distances and are further enhanced by MaaS platforms, which integrate various transportation modes into a seamless user experience. Finally, regulatory frameworks govern these services, ensuring safety and sustainability. By exploring these four interconnected aspects, the review provides a solid rationale for the research focus on a collaboration framework.

2.1 Stakeholder Collaboration and Data Sharing

Stakeholder collaboration and data sharing are critical in addressing urban mobility challenges, particularly in last mile solutions. Research highlights that effective collaboration among local governments, transport operators, and private stakeholders can enhance decision making and efficiency in urban transport systems (Clement et al., 2022). Larger stakeholder ecosystems provide diverse resources but often face coordination challenges, whereas smaller ecosystems

are easier to manage but may lack necessary diversity and resources. Digital platforms have emerged as essential tools for facilitating stakeholder engagement, ensuring transparency, trust, and efficient decision making. These platforms integrate IoT and smart technologies, alongside training programs, to promote data driven decision making in smart city development. Further advancing the discourse on data sharing, Chevallier et al. (2023) introduce the MobiData Lab platform, an EU wide initiative designed to integrate diverse datasets while adhering to FAIR principles. The platform offers open, interoperable, and privacy preserving data access, enabling seamless data exchange via APIs. It also addresses compatibility issues with existing EU mobility projects like GAIA-X, thereby fostering collaboration among public and private stakeholders.

The significance of data sharing in urban transport collaboration is further emphasized by Gonzalez Feliu et al. (2018). Their study demonstrates how real time data from transport operators and residents' private vehicle usage can inform evidence based policy decisions, leading to optimized transport services. By fostering a collaborative ecosystem, data sharing reduces duplication of efforts and enhances overall efficiency. Public private partnerships and community initiatives allow stakeholders to leverage their complementary expertise and resources to achieve common mobility goals.

In the context of Mobility as a Service (MaaS), Kostiainen & Tuominen (2019) outline structured approaches for stakeholder collaboration. They emphasize the necessity of a shared vision, clear roles, and open communication channels to align objectives and mitigate conflicts. Standardized data formats and APIs are essential for service integration, and incentives such as revenue sharing agreements further align stakeholder interests. Regulatory frameworks should be flexible to accommodate new mobility services, while user feedback mechanisms ensure continuous service improvement. A broader framework for stakeholder collaboration in sustainable urban mobility is proposed by Hamdan, Andersen, and de Boer (2021). Their model underscores the importance of early stakeholder identification and engagement, mapping diverse stakeholder objectives, and addressing tensions between private and public interests. Their structured approach includes problem conceptualization, preparation using data analytics, implementation through shared mobility hubs, and systematic evaluation of outcomes. Such an approach ensures adaptive and effective collaboration in last mile mobility solutions.

In today's interconnected world, the sharing and collaboration of mobility data among stakeholders are crucial for driving innovation and efficiency across Europe. The vast amount of data generated by daily movements of people and goods has the potential to significantly reduce environmental impacts and enhance the quality of life. Through intelligent and resilient planning, transport infrastructure and services can be optimized, resulting in smoother traffic flows, more competitive logistics, and seamless cross border travel. The challenge lies not only in gathering this data but also in safely and securely sharing it to convert it into actionable insights. This transformation is essential for advancing AI and frontier technologies and is a key focus of the EU Data Strategy, which aims to create common European data spaces, including mobility, providing governance and infrastructure for secure data access and sharing (European Commission, n.d.).

The creation of a unified technical and governance framework like the European Mobility Data Space (EMDS) highlights the importance of stakeholder collaboration in overcoming barriers to data interoperability and access. By building on existing and emerging transport data ecosystems, EMDS supports businesses and governments in effectively utilizing data to drive

progress in transportation technologies and services. Such collaboration is crucial for harnessing the full potential of data driven innovation, enhancing both company and individual efficiency through initiatives such as real time navigation, which could save public transport users over 27 million hours and reduce labor costs for drivers by up to €20 billion annually (European Commission, n.d.).

Effective data sharing and collaboration require the development of sustainable business models, clear stakeholder engagement guidelines, and long term partnerships. These elements ensure that data sharing aligns with stakeholders' motivations and risk allocations. Public Transport Authorities (PTAs) often play a central role in largescale projects like citywide Mobility as a Service (MaaS); however, smaller projects may not necessitate their involvement. The transport data sharing ecosystem is multifaceted, involving various stakeholders, and requires each to understand their role. As Montero Pascual, Finger, and Serafimova (2022) point out, a unified MaaS data standard at the European level is vital to reducing market fragmentation and enhancing data sharing processes, adding value through deeper insights into mobility behaviors and facilitating the development of sustainable transportation solutions.

The literature review demonstrates that effective stakeholder collaboration and data sharing are crucial for overcoming fragmentation in urban mobility. The primary challenge lies in aligning the diverse and often conflicting interests of public and private actors. Ultimately, a lack of standardized frameworks and an over reliance on proprietary data lead to inefficiencies, missed synergy opportunities, and increased transaction costs.

2.2 Micro Mobility and Shared Mobility Solutions

Building upon the role of stakeholder collaboration and data sharing, micro mobility and shared mobility solutions have emerged as viable strategies for enhancing last mile connectivity. These solutions, including bike sharing, e-scooters, and ride sharing services, reduce reliance on private vehicles, promote sustainable transport, and improve accessibility in urban and suburban areas.

Public attitudes toward smart mobility solutions have been extensively studied by Butler et al. (2022), who examine suburban growth in Australian cities like Brisbane, Sydney, and Melbourne. Their findings suggest that micro mobility solutions, such as e-scooters and bike sharing, effectively address first and last mile connectivity issues. MaaS, which integrates multiple transport modes, including public transit and ride sharing, into a single digital platform, is highlighted as a key approach to enhancing accessibility.

Despite this idealized vision, the practical implementation of MaaS has faced significant challenges, leading some industry observers and academics to question the concept's long-term viability. Critics argue that the original MaaS model is fundamentally challenged by competitive friction, low user willingness to pay for comprehensive packages, and a lack of cooperative political support (Jittrapirom et al., 2017). This tension, particularly the reluctance of private operators to fully share proprietary data, highlights the governance barriers that prevent true integration. Therefore, the research focus has shifted to how to overcome these commercial and data-sharing impediments rather than simply promoting the concept.

Examining shared mobility options in the Netherlands, van Kuijk et al. (2022) explore first and last mile solutions in Utrecht. Their study finds that shared bicycles and e-scooters are particularly preferred by younger commuters traveling to suburban destinations. However,

despite the availability of these solutions, a significant portion of public transport users still avoid shared mobility, influenced by personal travel patterns, age, and cycling habits. This underscores the need for better integration of user behavior insights into last mile transport planning.

The role of bike sharing in enhancing metro accessibility is further examined by Campbell et al. (2016) and Guo & He (2020), who find that both station based and dockless bike sharing systems help bridge first and last mile gaps. Liu & Miller (2022) reinforce this argument by demonstrating how dockless bike sharing expands mobility options, particularly in transit deserts. However, challenges such as infrastructure limitations, safety concerns, and regulatory constraints remain barriers to widespread adoption (Puspitasari et al., 2025).

Yang et al. (2019) provide an in depth case study of dockless bike sharing in Nanchang, China, illustrating its effectiveness in improving last mile connectivity. Their findings reveal a 28% increase in bike demand near metro stations after the introduction of a new metro line, showcasing the importance of integrating micro mobility with existing public transit networks. Urban planners are encouraged to prioritize bike parking near transit hubs to optimize last mile connectivity. Additionally, Baek et al. (2021) explore electric scooter sharing (ESS) as an alternative to traditional last mile transport modes. Their research suggests that ESS is a competitive option in urban environments where walking is less feasible. Similarly, Zuo et al. (2020) demonstrate how bicycling enhances transit accessibility, particularly benefiting low income and minority groups in suburban areas, thus promoting transportation equity.

Micromobility solutions, such as bike sharing and e-scooters, are a key component of modern last mile transport. While they offer flexible and sustainable alternatives, their successful integration requires addressing significant challenges. The literature highlights issues with safety, infrastructure limitations, and scalability across different urban contexts.

2.3 Mobility as a Service platform

Building upon the role of micro mobility and stakeholder collaboration, Mobility as a Service (MaaS) platforms offer a holistic approach to integrating various transport services into a single digital interface. Effective collaboration among stakeholders is essential to ensure seamless integration and service efficiency.

The paper about Mobility as a Service Stakeholders' Challenges and Potential Implications (Kostiainen & Tuominen, 2019) highlights the need for a shared vision, clear roles, open communication, and standardized data sharing. Incentives like revenue sharing agreements and adaptable regulatory frameworks further support collaboration, while user engagement and performance monitoring ensure a sustainable, user centric MaaS ecosystem. Expanding on this, "Building Trust and Collaboration Among Stakeholders in a Mobility as a Service (MaaS) Ecosystem" (Kandanaarachchi et al., 2024) emphasizes trust, transparency, and synergy identification in stakeholder collaboration. It explores data sharing and regulatory support as key enablers, particularly for last mile solutions. By identifying synergies, fostering innovation, and considering contextual factors like user behavior and policy frameworks, stakeholders can create effective MaaS solutions, as demonstrated by case studies like the Sydney MaaS trial and Whim.

MaaS platforms are a critical technological solution for integrating various transport modes into a seamless, user centric service. The review shows that while MaaS holds great promise, its full potential is hindered by the complexities of platform integration. For these platforms to succeed, there must be a move away from operational silos towards a structured, collaborative ecosystem.

2.4 Regulatory and policy framework

The success of MaaS depends on the broader regulatory and policy landscape. Suck et al. (2023) highlight the need for stakeholder collaboration in integrating Automated, Connected, Electric, and Shared (ACES) technologies. City planners, transport operators, and private companies must work together to address congestion, accessibility, and sustainability challenges while overcoming regulatory barriers and conflicting priorities. Faherty et al. (2024) examine stakeholder collaboration in sustainable urban mobility, emphasizing data driven approaches and systems thinking to balance diverse objectives. Shared mobility hubs, community engagement, and inclusivity play key roles in promoting sustainability and reducing car dependency. Hamdan, Andersen, and de Boer (2021) propose a structured framework for stakeholder collaboration in sustainable mobility, focusing on early engagement, balancing interests, and addressing regulatory delays. Their systematic approach while conceptualizing challenges, developing tools, implementing initiatives, and evaluating outcomes ensures adaptive and effective collaboration in urban mobility.

Existing studies highlight the importance of stakeholder collaboration, data sharing, and micro mobility integration. However, while there are some frameworks that provide general support, there is limited research on systematically aligning diverse stakeholder objectives, such as those of municipalities, transport operators, and private companies, while balancing competing interests. Although digital platforms are emphasized, a comprehensive methodology for integrating these tools into a cohesive framework for specific knowledge questions, like the effectiveness of shared mobility hubs, remains lacking. Furthermore, despite the promise of micro mobility solutions, there is inadequate guidance on scaling them to various urban contexts. Practical challenges such as regulatory barriers and conflicting priorities are often overlooked in these frameworks.

Table 1: Synthesis of Key Literature on Last Mile Mobility and Stakeholder Collaboration

REFERENCE	RESEARCH TOPIC	KEY FINDINGS	CONTRIBUTION
HAMDAN, H. A. M., ANDERSEN, P. H., & DE BOER, L. (2021)	Systematic Literature Review focusing on the factors impacting stakeholder collaboration across the four development stages	Synthesis of 20 themes and factors drives collaboration complexity in sustainable projects. A clear, stage based process is critically needed.	The systematic review is limited to explicitly defined empirical based research..
CLEMENT, MANJON, & CRUTZEN (2022	Factors for intensive collaboration in Smart Cities; Local government perspective (Contingency)	Smart city strategy is crucial; managers facilitate collaboration in large, complex ecosystems	High level governance focus; lacks specific data sharing mechanisms for last mile mobility conflicts.
CHEVALLIER ET AL. (2023)	EU MobiDataLab project creating a Transport Cloud for mobility data sharing	Provides a technical, privacy preserving cloud infrastructure adhering to FAIR principles (Findable, Accessible, Interoperable, Reusable)	The framework requires future deployment and testing in real world scenarios. ,lacks a procedural or collaborative governance framework for stakeholder alignment.
GONZALEZ-FELIU, PRONELLO, & SALANOVA GRAU (2018)	Collaboration state of the art in urban transport; classifies stakeholders functionally	Collaboration exists at transactional, informational, and decisional levels; identifies MaaS as a key topic	lacks focus on last mile mobility data governance
KOSTIAINEN & TUOMINEN (2019)	MaaS stakeholder collaboration challenges and conflict mitigation.	Shared vision, clear roles, and data standards are needed in MaaS.	Conceptual paper; proposed collaboration processes need empirical validation.
EUROPEAN COMMISSION (2020-2023	EU strategy to unlock mobility data potential; creating the Common European Mobility Data Space (EMDS)	Establishes governance/technical framework (EMDS) using FAIR principles; backed by Data Governance Act.	High level policy document; requires localized, specific framework for last mile stakeholder collaboration
MONTERO, FINGER, & SERAFIMOVA (2022)	Policy brief on EU wide Intermodal Ticketing; promoting integrated, multimodal transport solutions.	EU wide Multimodal Digital Mobility Services (MDMS) initiative is needed to facilitate payment/booking across modes.	Focuses on intermodal passenger ticketing/payment; doesn't address the data sharing framework for last mile operational conflicts.
BUTLER, YIGITCANLAR, PAZ, & AREED (2022)	Public attitudes toward smart mobility, MaaS, and the last mile gap in Australia.	Private vehicle use, aversion to sharing/multimodality are major user adoption barriers	Findings are based on survey data from major Australian cities only.
VAN KUIJK, CORREIA, VAN OORT, & VAN AREM (2022)	User preferences for shared mobility connecting to public transport last mile in Utrecht, Netherlands.	Explores how walking time, waiting time, and cost influence user choice for shared last mile modes.	Uses Stated Preference experiment; findings need validation with observed behavior.

CAMPBELL, CHERRY, RYERSON, & YANG (2016)	Factors influencing shared bicycle and e-bike choice modeling in Beijing	E-bikeshare replaces buses; is less weather sensitive than bikeshare but sensitive to user demographics	Uses Stated Preference survey data; findings may not reflect actual rider behavior.
GUO & HE (2020)	Built environment effects on dockless bike sharing (DBS) integration with metro (Shenzhen)	Mixed land use and residential/industrial areas positively affect DBS use for metro connection.	Focuses on urban planning/user behavior; lacks a collaboration or data sharing framework for operators.
LIU & MILLER (2022)	Measuring dockless micro mobility impacts on public transit accessibility (First/Last Mile).	Dockless scooters significantly increase transit accessibility; first mile improvement outweighs last mile improvement.	Analysis based on hypothetical trips in Columbus, Ohio; limits generalizability.
PUSPITASARI, YUEN, & IBRAHIM (2025)	Bibliometric review mapping First and Last Mile (FMLM) themes in public transport research	Identified six key FMLM research clusters: efficiency, micro mobility, equity, and technology.	High level overview; lacks a data governance and collaboration framework for last mile providers
YANG, HEPPENSTALL, TURNER, & COMBER (2019)	Dockless bike sharing (DBS) patterns, spatiotemporal analysis, and urban flows over the last mile.	New metro service boosted bike demand nearby; DBS flow structures are resilient and adaptable	Uses dockless bike data from Nanchang, China only; results need broader validation.
BAEK, LEE, CHUNG, & KIM (2021).	Analyzing user preference and value of travel time (VOTT) for e scooter last mile trips.	E-scooters are a competitive last mile mode; VOTT for riding is greater than walking.	Findings are based on survey data from a specific region (Seoul); future research needs real world data.
ZUO, WEI, CHEN, & ZHANG (2020)	Bicycling as a first/last mile solution to improve transit accessibility and transportation equity.	Bicycling access distance triples walking distance, increasing job accessibility and equity for minorities	Findings are based on 2009-2010 travel survey data and the case study of Hamilton County, Ohio.
KANDANAARACHCHI, NELSON, & HO (2022)	Factors building trust and collaboration among stakeholders in two MaaS ecosystems.	Trust is antecedent and catalyst for collaboration; capability, prior relationships are key constructs.	Findings are based on two qualitative case studies and may lack generalizability to other contexts.
SUCK, L., BECKER, N., EILERS, M., & VÖLCKNER, F. (2023).	Stakeholder alignment and expectations for the market creation of ACES (Automated, Connected, Electric, Shared) vehicles.	Proposes a shared brand understanding for ACES to align conflicting expectations and foster productive co creation/collaboration.	Study is limited by small expert sample size (n=28); the findings have limited statistical generalizability.
FAHERTY, MCARDLE, & TAFIDIS (2024)	Stakeholder views and system dynamics modeling for sustainable urban mobility challenges in Dublin.	Identified systemic challenges (e.g., funding, conflicting policy) and need for holistic planning/cross sectoral task forces	Study is limited by the qualitative nature of semi structured interviews and is a case study on Dublin
HAMDAN, ANDERSEN, & DE BOER (2021)	Systematic literature review on stakeholder collaboration in sustainable neighborhood projects; finding common ground.	Identified 20 main themes impacting collaboration; stakeholders/issues change as the project develops	The systematic review is limited to explicitly defined empirical based research.

The literature emphasizes the importance of stakeholder collaboration, data sharing, and micro mobility solutions in addressing urban mobility challenges, particularly for last mile solutions. Effective collaboration among governments, transport operators, and private stakeholders, supported by digital platforms, enhances decision making and operational efficiency. Micro mobility solutions, such as bike sharing and e scooters, improve last mile connectivity, though challenges like infrastructure and safety persist. Mobility as a Service (MaaS) platforms require structured approaches, including shared vision and flexible frameworks, to align stakeholder interests and ensure user centric improvements. The research begins by mapping stakeholder objectives, identifying challenges, and formulating knowledge questions, a framewok will be developed to guide stakeholders in answering their knowledge questions. Ultimately, a holistic approach integrating collaboration, data driven decision making, and adaptive policies is key to creating sustainable, inclusive, and efficient urban mobility ecosystems.

In summary, the literature demonstrates that effective stakeholder collaboration and robust data sharing practices are critical to addressing the complexities of last mile mobility. Micro mobility options and MaaS platforms expand transportation possibilities, but their success relies on integrated approaches, clear communication, and supportive regulatory frameworks. While digital tools and platforms offer promising solutions, research highlights continued challenges in aligning diverse stakeholder objectives, ensuring interoperability, and scaling solutions to varied urban contexts. Although significant progress has been made, further work is needed to develop integrated approaches that fully realize the benefits of stakeholder collaboration and data sharing in last mile mobility. This literature review therefore establishes a strong academic foundation. The subsequent validation of its findings and frameworks through practical application is anticipated to yield significant insights, further advancing effective and sustainable last mile mobility solutions.

3. Methods

Cases are typically selected based on their relevance to the research question, theoretical significance, or practical considerations. They may be chosen because they are typical examples, extreme instances, test sites for theory, or due to unique opportunities. The selection process should be deliberate and justified, ensuring the case aligns with the research objectives. Practical considerations, such as convenience, may also play a role, but they should not be the sole criterion for selection. The researcher must provide a clear rationale for the choice of the case, including how it represents the broader category of phenomena being studied (Denscombe, 2014).

The Siemens Demand Responsive Transport (DRT) project in Zeeland, Netherlands, was utilized as a pivotal case study for this research. This project provides a unique opportunity to gain insights from a currently operating initiative, allowing for a real world examination of stakeholder collaboration in a mobility as a service environment. To this end, a series of semi structured interviews were conducted with key professionals and stakeholders directly involved in the Zeeland project. These interviews served as the primary method for gathering qualitative data, offering a comprehensive understanding of the collaborative dynamics, challenges, and successes within a complex and active project.

In addition to providing valuable qualitative data, the Zeeland case study was instrumental in the validation of a proposed framework for collaboration among different stakeholders. The insights gathered from the interviews were systematically analyzed to assess how well the theoretical framework aligns with the practical realities of the project. By comparing the framework's principles with the experiences and feedback of the professionals, this research aimed to refine and strengthen the framework, ensuring its applicability and effectiveness for future last mile mobility initiatives. The validation process confirmed the framework's robustness and highlight any necessary adjustments to better facilitate data sharing and cooperation.

3.1 Case Study Approach

The case study approach is a versatile research methodology that delves into a few instances of a phenomenon to provide an in depth analysis of events, relationships, experiences, or processes within a specific context. This method is particularly adept at exploring complex social situations and is well suited for both theory building and theory testing, making it valuable in various research contexts. For instance, in last mile mobility, a case study can illuminate the intricate data sharing dynamics among stakeholders like urban planners and technology vendors, revealing friction points and highlighting stakeholder dependencies. This comprehensive understanding of real world interactions supports informed decision making and leads to improved system design and service delivery (Denscombe, 2014).

Using a single case study for this research was a deliberate and necessary choice. Instead of broadly examining many projects, this method allowed for a deep, detailed investigation into one specific initiative: the Siemens Demand Responsive Transport (DRT) project in Zeeland. This approach was essential for understanding the full, complex picture of stakeholder collaboration and data sharing in a real world setting. By focusing on a single case, the research was able to uncover the specific challenges and nuances like data silos and conflicting interests that might be missed in a broader study. This depth of understanding was crucial for developing

a practical and realistic framework that is directly grounded in authentic experiences, ensuring it can be a useful tool for industry professionals and policymakers.

As highlighted in Table 2, the case study method is a powerful qualitative tool for gaining a deep, contextual understanding of a complex issue. The table demonstrates that while this approach is excellent for producing rich, qualitative insights and can aid in theory building, it is also constrained by limitations. A key weakness is that findings from a single case study may not be easily generalizable, and there is a risk of researcher bias influencing the interpretation of data. Overall, the table presents a balanced view of the case study approach, which is a crucial element for a robust methodology section.

A "case" in this approach refers to a bounded system or phenomenon, such as an individual, organization, event, or policy, with clear boundaries that distinguish it for focused analysis. While centered on specific instances, case studies can contribute to broader generalizations. The generalizability of findings is enhanced when the studied case shares significant features with other phenomena in the same category, allowing researchers to draw broader implications (Denscombe, 2014). For example, the ongoing Siemens project in Zeeland served as a pertinent case study, offering insights into mobility and data sharing that can inform general theories and practices in transportation and data management.

Table 2: Advantages and Disadvantages of Case Study Approach (Denscombe, 2014).

Advantages of the Case Study Approach:
1.Holistic Analysis: Focuses on complex social intricacies, allowing deeper investigation into relationships and processes.
2.Multiple Research Methods: Encourages diverse methods to capture complex realities effectively.
3.Multiple Data Sources: Uses various data sources, enhancing validation through triangulation.
4.Natural Settings Suitability: Ideal in scenarios where researcher control is limited, observing natural occurrences.
5.Small-Scale Research Compatibility: Concentrates efforts on a limited number of sites, suitable for small-scale studies.
6.Theory Development: Supports both building and testing theories effectively.
Disadvantages of the Case Study Approach:
1.Generalization Credibility: Needs careful justification for the generality of conclusions.
2.Perception of 'Soft' Data: Often seen as lacking rigor with a focus on qualitative, process-oriented data.
3.Boundary Definition Issues: Challenges in clearly defining case boundaries, influencing data inclusion.
4.Access Negotiations: Difficulties in obtaining and maintaining access can impact research.
5.Ethical Concerns: Raises ethical issues related to confidentiality and privacy.
6.Observer Effect: Potential behavior alteration of subjects due to the awareness of being studied.

The Siemens Demand Responsive Transport (DRT) project in Zeeland, Netherlands, was utilized as a pivotal case study for this research. This project provides a unique opportunity to gain insights from a currently operating initiative, allowing for a real world examination of stakeholder collaboration in a mobility as a service environment. The Province of Zeeland and the Ministry of Infrastructure and Water Management initiated this demand driven, flexible public transport solution, and Siemens won the European tender to deliver the advanced digital solution. This solution includes a dynamic journey planner and a user friendly app, which enables travelers to request a public transport vehicle with a driver and receive real time updates

for regular public transport routes. By examining this initiative, crucial insights into stakeholder collaboration and technological integration were gained, supporting broader implications in mobility solutions.

The Zeeland Demand Responsive Transport (DRT) project was chosen as a unique and pertinent case study. In this initiative, the Ministry of Infrastructure and Water Management, working closely with the Province of Zeeland and its municipalities, contracted Siemens to provide the DRT solution software. The core goal of this project is for the province and municipalities to combine their regular transport services with dedicated transport for specific user groups. These integrated services are dispatched by the same fleet with the help of the Siemens DRT Dispatching software. This allows for a better grouping rate of passengers and a reduction in the number of vehicles, all while upholding the strict conditions of the services. This innovative approach ensures that the business case for demand responsive transport in Zeeland remains a viable one. To successfully implement this service, extensive stakeholder management is necessary between the ministry, the Province of Zeeland, its municipalities, and the organizations involved in providing the necessary data and system functionalities.

Effective stakeholder collaboration, therefore, becomes paramount in the Zeeland project, precisely because of the inherent difficulties in data sharing and the complexities of aligning diverse interests. It's through coordinated efforts among all parties from public transport authorities to private solution providers that the formidable barriers of fragmented data and siloed system integrations can truly be overcome. This active cooperation is vital not only for the successful implementation of advanced digital mobility solutions but also for creating a unified understanding and shared vision that ultimately drives more efficient, sustainable, and user centric last mile services.

The Zeeland project serves as a crucial running case study precisely because it embodies real life situations with active participants striving for collaboration while adhering to strict deadlines. This ongoing, dynamic environment ensures that the insights gained are exceptionally valuable. The involvement of numerous individuals in various capacities within a live project provides a rich source of authentic experiences, making the collected information invaluable for developing a robust methodology for stakeholder collaboration in last mile mobility, particularly concerning data sharing.

3.2 Interviews

Interviews are an exceptionally effective research method for delving into complex, nuanced, or sensitive subjects. They are perfectly suited for understanding stakeholder perspectives on projects such as the Siemens Demand Responsive Transport System (DRT) in Zeeland. This approach allows researchers to gather detailed insights into opinions, feelings, and experiences, revealing subjective phenomena that simpler data collection methods often miss. Interviews are particularly valuable for discussing sensitive issues empathetically and for gaining unique knowledge from key informants or experts.

However, a critical review of this methodology is essential. While interviews excel at providing rich, contextual information crucial for understanding stakeholder engagement (Denscombe, 2014), they are not without their drawbacks. As noted by Denscombe (2014), they can be time consuming and resource intensive, requiring significant effort for transcription and data analysis. The data collected can also be less reliable due to its highly subjective nature and the

potential for the "interviewer effect," where the informant's responses may be influenced by the researcher's presence or questions. This method was chosen for this study despite these challenges because it offers a flexible framework, particularly through semi structured interviews, that supports the discovery of hidden or emerging themes, which is vital in complex policy analysis (Denscombe, 2014; Varvasovszky & Brugha, 2000).

3.2.1 Interviews Conduction process

To ensure comprehensive and unbiased insights into the last mile mobility challenges faced by stakeholders, the interviews were conducted with a strong emphasis on anonymity and the protection of personal information. All collected data focused solely on participants' professional experiences, allowing to tailor questions specifically for engineers and managers to gain the most relevant insights.

Two primary methods for conducting these interviews were utilised.

The first method involved in person, live conversations with participants. These sessions were voice recorded to ensure accurate transcription. The recordings were securely stored within a personal, protected space on the TU Delft web platform and were permanently erased upon the completion of this thesis. The second method involved sending written interview questions to stakeholders, who provided their responses in written form, distinct from a typical survey. This approach also guaranteed complete anonymity and protection of personal data.

As illustrated in Figure 1, the interview flowchart provided a clear and systematic overview of the data collection and analysis process. We see that it maps the journey of data from two distinct sources in, person and written interviews, through to a unified analysis phase. The figure demonstrates the structured approach taken to ensure consistency and rigor in identifying key themes and patterns, showing how these insights were then used to develop the final framework of the thesis. This visual representation serves to validate the methodological steps taken to ensure the credibility of the research findings.

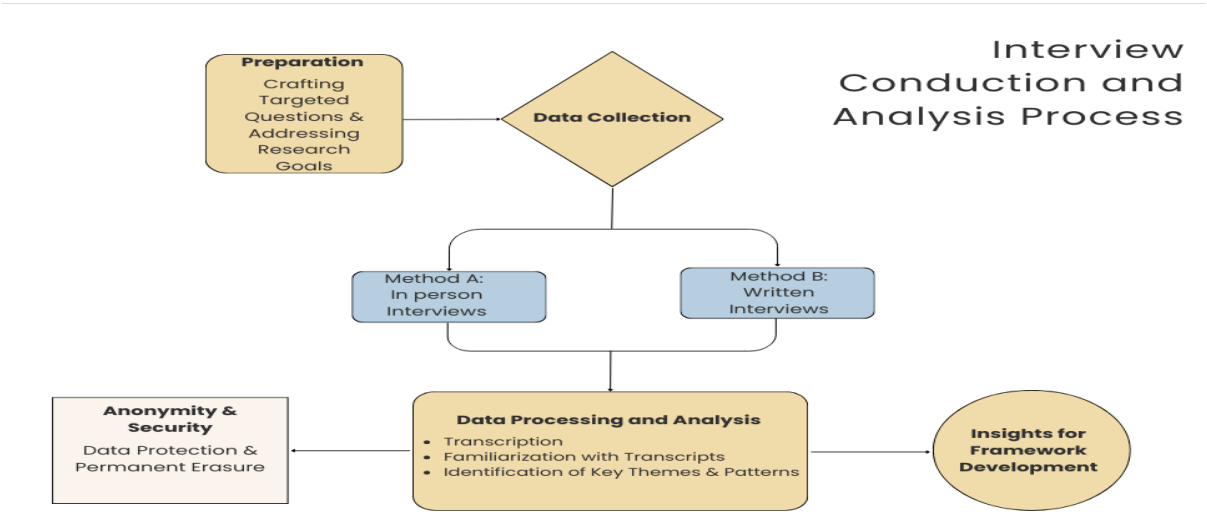

Figure 1: Interview Flowchart

The interview questions are carefully crafted with the explicit purpose of addressing the main research question and its sub questions. They are designed not only to elicit targeted information but also to encourage reflection on real life situations encountered by professionals in active projects, with a primary focus on the ongoing Zeeland initiative. In addition, insights were gathered from other professionals working within the last mile mobility sector, as well as from academics whose research focuses on transportation and last mile solutions, thereby providing a richer and more comprehensive understanding of the field. This approach enabled a deeper understanding of how theoretical challenges manifest in practice, using the interview process itself as a lens to closely examine real world dynamics such as collaboration, conflict resolution, and data sharing practices. During the analysis, particular attention was paid to how professionals articulate their roles, challenges, and strategies, offering a grounded perspective on last mile mobility beyond abstract concepts. Nine individuals were interviewed, including not only professionals actively involved in the ongoing Zeeland project, but also other experts working within the broader last mile mobility sector. The selection of these specific functions is strategic and designed to gather both deep, case specific insights and a broader, more generalized understanding of the problem.

- **Professionals from the Zeeland project:** This group included project managers, data analysts, and municipal liaisons. They were chosen to provide a detailed, firsthand perspective on the practical challenges and successes of a real world last mile mobility project. Their insights are essential for understanding the specific dynamics of stakeholder collaboration and data sharing within the chosen case study.
- **Broader last mile mobility experts:** This group included urban planners and regulatory experts. They were chosen to provide a wider context. Their perspectives helped validate and generalize the findings from the Zeeland case study, identifying broader trends, challenges, and best practices across the industry. This ensures the proposed framework is not limited to a single project but is applicable to the wider mobility ecosystem.

While their roles may differ, their shared involvement in an active project provided a rich tapestry of experiences regarding collaboration and last mile mobility, and by engaging with individuals in diverse positions, a wide array of insights into the multifaceted challenges and experiences within the sector is anticipated.

When processing the interviews, the key focus was uncovering stakeholder objectives. The primary interests and objectives of companies regarding data sharing in last mile mobility were explored. By understanding these goals, it becomes possible to identify how effective the current data sharing processes are and uncover the reasons behind any shortcomings. It is vital to pinpoint where the primary responsibility for ongoing data sharing and collaboration issues lies, as well as the frequent points of disagreement or conflicting interests among stakeholders in implementing last mile mobility initiatives.

In examining conflict insights, the aim was to understand what early warning signs or indicators signal potential conflicts among stakeholders. Any encountered conflicts in the context of data sharing within last mile transportation were explored, along with how they have been resolved. Interviewees shared effective approaches or strategies utilized in resolving such conflicts and provided suggestions on improving situations regarding data sharing and collaboration.

The interviews also delved into the tools and data sharing platforms currently in use for collaboration in last mile mobility. Understanding these tools helps to highlight data sharing

practices that have fostered seamless collaboration across stakeholders. Furthermore, potential new digital tools and functionalities that could enhance future collaboration among stakeholders were considered. Feedback is a critical component of the process. The exploration included how stakeholders and user feedback is incorporated into strategic planning and continuous improvement processes. Strategies used to gather input and feedback from stakeholders and users were also discussed, ensuring that the insights gained are both practical and actionable, ultimately contributing to enhanced strategies for last mile mobility.

To effectively analyze interview results, recording each session using audio or video devices is essential to accurately capture the conversation. Following the recordings, interviews should be transcribed verbatim to preserve as much detail as possible. Once transcriptions are completed, it is important to familiarize with the data by meticulously reading through the transcripts multiple times to gain a comprehensive understanding of the content. During this initial review, it is crucial to note any interesting points, recurring themes, or unexpected insights. In the analysis phase, examining the organized data helps identify patterns, similarities, and differences in responses. This method allows for the highlighting of key insights, such as recurring issues, unique solutions, or prominent disagreements, facilitating an understanding of how different pieces of information relate to the research questions.

3.3 Practical Application and Framework Validation

Beyond the case study and interviews, a practical application was used as a methodological tool to validate the proposed framework. The framework, which was developed based on the insights from the interviews and the literature review, was a structured framework for facilitating stakeholder collaboration and data management.

The practical application involved testing this newly developed framework against a use case identified within the Zeeland project. This step was crucial for transforming a theoretical model into a verified, actionable tool. It served a dual purpose:

- **To Validate:** By applying the framework, the framework 's effectiveness in addressing the real world challenges and knowledge gaps identified in the case study was assessed. This step provides empirical evidence of the framework’s utility and robustness.
- **To Refine:** The application process revealed potential limitations, unforeseen complexities, and areas for improvement. Feedback from this hands on test was used to refine and enhance the framework, ensuring it is practical and scalable for other urban contexts.

This practical application is a critical component of the framework as it moves the research beyond a purely descriptive or theoretical discussion. It demonstrates the direct utility of the study's primary output and ensures that the final framework is not only by academic perspective but also practically relevant for industry professionals and public policy makers.

4. Case Study Insights on Current Last Mile Mobility Collaboration

This chapter presents the empirical findings derived from the qualitative interviews conducted with key stakeholders in last mile mobility. These interviews serve as a crucial component of this research, directly contributing to answering the main research questions and sub questions by providing real world insights and perspectives. The findings presented here build upon the theoretical foundations established in previous chapters, particularly concerning stakeholder collaboration, data sharing, and last mile mobility challenges. The detailed methodology for these interviews, including participant selection, interview conduction, and analysis procedures, is thoroughly described in Chapter 3 (Methodology).

This chapter is based on insights gathered from 9 interviews (1 written – 8 live) conducted with professionals involved in various capacities within the last-mile mobility sector with a focus on a running project of Siemens mobility in Zeeland. The data was analyzed using a thematic analysis approach, as detailed in Chapter 3, to identify recurring patterns and key insights across the interviews. Interviews were conducted with representatives from various stakeholder groups actively involved in last mile mobility initiatives. These include individuals from municipal authorities, public transport operators, and private mobility service providers. While their specific roles and organizations varied, all interviewees possessed significant experience and insights into the complexities of data sharing and collaboration within the last mile sector, particularly within the context of the Zeeland Demand Responsive Transport (DRT) project and broader last mile mobility initiatives. To ensure anonymity and confidentiality, specific names of individuals and organizations are not disclosed generally.

4.1 Zeeland Case Study Elaboration

The Zeeland project represents a significant transformation of public transport in the Dutch province of Zeeland through the introduction of an innovative Demand Responsive Transport System (DRT), or "public transport on demand." This initiative is a strategic collaboration between the Province of Zeeland (through the Ministry of Infrastructure & Waterstaat) and Siemens Mobility, along with its subsidiaries. The core objective of the Zeeland DRT system is to create a more flexible, efficient, and sustainable public transport network that specifically meets the diverse mobility needs of the region's residents, visitors, and tourists. By moving away from fixed routes and schedules, the system is designed to increase the accessibility of the public transport network, encourage people to leave their cars at home more often, and ultimately boost local tourism.

The project involves a full scale rollout across all 13 municipalities of the province of Zeeland. Previously, on demand public transport was primarily restricted to specific groups, such as individuals with a Wmo (Social Support Act) assessment and schoolchildren/students. A key change enabled by the new DRT system is that it is now accessible to everyone. The projected operational scale is substantial. Once fully implemented by 2026, the digital solution will be able to process up to 10,000 journeys (or rides) per day. The fleet supporting the service will eventually comprise approximately 300 Flex vehicles operating throughout the province, with a commitment to include electric vehicles among the types used to directly contribute to more environmentally friendly traffic.

Siemens Mobility acts as the technology partner, providing the **advanced digital solution** that makes the demand-driven system possible. This solution is built through the expertise of its software business unit subsidiaries.

This technological provision includes two core elements:

1. A **dynamic journey planner** and **dynamic routing engine**. This intelligent tool enables the dynamic management of routes, facilitating seamless, multimodal, and intermodal journeys. This component is crucial for determining the most efficient routes and optimizing the vehicle fleet's operation.
2. An **efficient booking system** and the technology behind the **user facing application**. This component is involved in realizing the overall solution, handling user requests, and managing the flexible on-demand service.

The technological platform is anchored by a user friendly app (often referred to as the DRT app) that serves as the primary interface for travelers. Through this app, users can request a chauffeured public transport vehicle for pick up at a pre arranged location and time. The app integrates technology to provide real time updates and information about both the flexible DRT service and regular public transport with fixed routes. The platform is designed to be highly adaptive, supporting various operating models, including door to door and stop to stop options, with a door to stop configuration also planned for introduction. Crucially, the system ensures equitable access by intelligently distinguishing between 'Regular' DRT users and passengers with a WMO indication, allowing it to cater to specific needs for the latter group, such as requirements for special equipment or specialized assistance. Payment methods available through the service include IDEAL, credit card, and onboard payment options.

The introduction of the DRT system is being managed through a phased, gradual rollout. The service began its initial operation on February 17, 2025, in the municipality of Schouwen Duiveland. This was followed by an expansion to a second area, the Noord-Beveland Islands, in June 2025. The service is now expanding across the remaining municipalities, with full deployment anticipated to be completed by 2026. Initial feedback indicates a high degree of user satisfaction. As of June 2025, the service boasted an impressive 4.9/5 overall user rating based on over 1,000 ratings and was already serving over 8,700 casual and recurring regular passengers, underscoring the positive reception of this new approach to public transport in Zeeland.

4.2 Stakeholder Objectives

This section explores the diverse goals and perceived obstacles different stakeholders face in data sharing within last mile mobility. It begins by highlighting the importance of understanding stakeholder objectives and the inherent complexities of data sharing in this space. It then outlines the motivations behind data sharing, such as improving efficiency, enhancing user experience, meeting sustainability targets, or complying with regulations, while noting both overlaps and differences across stakeholder types. The section also examines stakeholder views on the effectiveness of current data sharing mechanisms, pointing to issues like lack of standards, technical and legal barriers, trust concerns, and limited resources. Interviewees' views on who holds responsibility for these challenges, ranging from government policies and private sector practices to poor cross sector coordination and tech limitations are also discussed. Finally, the most common points of friction, such as

disagreements over data ownership, quality, costs, or strategic goals, are analyzed, supported throughout by anonymized quotes that illustrate the nuances of stakeholder perspectives.

Stakeholders across the mobility sector consistently identify data sharing as fundamental for advancing last-mile transportation. A primary objective is to achieve seamless integration and enhanced interoperability among various mobility services (Interviewee 1, Question 1; Interviewee 6, Question 1; Interviewee 3, Question 1), aiming to improve overall service efficiency through real time and predictive analytics, optimizing last mile mobility. This collaborative approach seeks to deliver a superior user experience (Interviewee 2, Question 1) by enabling more comprehensive travel advice and optimizing service availability, for instance, by providing effective demand response applications or transportation systems at transfer points (Interviewee 6, Question 1), ensuring seamless transitions from major transport hubs to final destinations through readily available options like public transit or micro-mobility solutions. Beyond internal operational efficiencies, a broader goal involves aligning diverse systems to understand general trends from other providers, which supports smarter operations and the development of intelligent, data driven solutions (Interviewee 2, Question 1; Interviewee 5, Question 1). The overarching interest is to facilitate multi-modal travel for passengers, align with urban management policies (Interviewee 3, Question 1), and provide added value through sophisticated interfaces and algorithms (Interviewee 4, Question 1), viewing data sharing as a standard and essential component for implementing effective mobility tools.

Despite the recognized benefits, the current data sharing process for last mile mobility initiatives is widely perceived as not fully effective (Interviewee 3, Question 2). A significant impediment is the inherent protectiveness organizations exhibit over their data, often considering it proprietary knowledge and a source of competitive advantage (Interviewee 5, Question 2). This reluctance stems from concerns about potential vulnerabilities or misuse by competitors, leading to difficulties in establishing open data exchange. As one interviewee indicated, companies are "highly protective of their data, viewing it as their intellectual property, knowledge, and power," which necessitates restrictive agreements that limit broader data application (Interviewee 2, Question 2). Further shortcomings arise from misaligned priorities, a lack of clear commitments among parties, and inconsistencies in collaboration (Interviewee 1, Question 2). Legal restrictions on sharing sensitive user or business-sensitive information (Interviewee 3, Question 2; Interviewee 7, Question 2), coupled with an unclear understanding of the overall benefits and protocols for data processing, also contribute to the challenges, making the initial steps toward increased sharing particularly difficult (Interviewee 3, Question 2).

Pinpointing primary responsibility for data sharing and collaboration issues within the last-mile mobility ecosystem is complex, often attributed to systemic factors rather than individual entities. Interviewees highlight the inherent competitive structure of the market (Interviewee 2, Question 3), where organizations prioritize self-preservation, making data protection a natural measure. The issue is seen as a "system thing" involving various governmental tiers and market participants (Interviewee 4, Question 3; Interviewee 5, Question 3), each with their own objectives. While certain technology providers are recognized for their role in facilitating communication (Interviewee 3, Question 3), there is a strong consensus on the need for greater coordination and a unifying framework from overarching bodies (Interviewee 5, Question 3; Interviewee 6, Question 3, Interviewee 7, Question 3 Interviewee 8, Question 3, Interviewee 9, Question 3). This leadership is deemed crucial for establishing common principles that enable data exchange without undermining individual organizational stability, bridging the gap

between commercial interests and the collective good (Interviewee 5, Question 3; Interviewee 7, Question 3). Ultimately, the situation is not about assigning blame but rather recognizing the need for systemic changes to foster a more collaborative environment.

The most frequent points of disagreement or conflicting interests among stakeholders primarily arise from misaligned commercial interests and disparate strategic roadmaps (Interviewee 1, Question 4). Organizations often pursue their distinct visions, and collaborative efforts do not always perfectly align with these individual objectives, thereby limiting willingness to share data or fully engage. A significant conflict noted is between public sector entities and private operators concerning demand-responsive services (Interviewee 4, Question 4; Interviewee 7, Question 4). Private operators may have incentives tied to operating more vehicles, which can clash with public sector goals of cost efficiency and optimized service for specific user groups. This fundamental clash of priorities, combined with entrenched contractual arrangements and a lack of shared understanding, hinders the standardization of data sharing practices. The competitive nature of the market and the need for organizations to protect their data also inherently lead to friction when transparency or extensive data exchange is required, as the perceived immediate commercial implications can outweigh the collaborative advantages (Interviewee 2, Question 4).

To consolidate the empirical findings discussed in this section, Table 2 provides a comprehensive overview of the key themes. It summarizes the primary objectives of stakeholders, the perceived responsibilities for collaboration challenges, and the most frequent points of disagreement.

Table 3: Summary of Findings on Stakeholder Objectives

	Key Findings	**Associated Challenges & Conflicts**
Stakeholder Objectives	**Seamless Integration:** Improve interoperability for service efficiency. **Enhanced User Experience:** Optimize multi-modal journeys. **Smarter Operations:** Use data for intelligent, data-driven solutions.	**Data is proprietary:** Organizations are highly protective, viewing it as a competitive asset. **Legal & Technical Barriers:** Restrictions on sensitive data and unique implementations of technical standards.
Responsibility	**Systemic Factors:** The issue is a "system thing" stemming from a competitive market. **Overarching Bodies:** There is a strong consensus on the need for a central, independent body to provide a unifying framework and bridge commercial interests.	**Lack of Coordination:** Poor cross-sector coordination and misaligned priorities among different governmental and market participants.
Most Frequent Disagreements	**Misaligned Commercial Interests:** Organizations pursue distinct visions that don't always align with collaborative efforts. **Clashing Roadmaps:** Public sector goals (e.g., cost-efficiency) often conflict with private operator incentives (e.g., more vehicles).	**Data Ownership:** Disputes over who owns the data, its quality, and the costs associated with sharing it. **Friction over Transparency:** The need for extensive data exchange is hindered by the perceived commercial implications.

4.3 Analysis of Stakeholder Conflict

This section examines the nature of conflicts in last mile mobility data sharing and the strategies used or proposed to address them. It begins by recognizing that conflicts are inevitable in multi stakeholder settings and that understanding their dynamics is key to effective collaboration. Interviewees identified early warning signs of conflict, such as communication breakdowns, misinterpretations of agreements, or resistance to change. Specific conflict examples are discussed, detailing their causes and the resolution methods applied. The most effective approaches such as mediation, negotiation, clear governance structures, open communication, and shared goals are synthesized from the interviews. Recommendations for preventing or better managing future conflicts are also included. Anonymized quotes are integrated throughout to illustrate the types of conflicts, warning signs, and resolution strategies in context.

Early warning signs of potential conflicts in last-mile mobility collaborations often manifest as a palpable lack of willingness to engage, particularly concerning data sharing (Interviewee 1, Question 5). This can appear as unresponsiveness in meetings, overly brief answers (Interviewee 2, Question 5), or a general reluctance to provide sufficient reciprocal input, signaling that a partnership might be stalling. Conversely, an overly eager approach without transparent communication of mutual benefits can also raise suspicion. Stakeholders frequently require extensive clarifications regarding data usage and purpose, and any perceived risks can lead to quick disengagement (Interviewee 3, Question 5; Interviewee 8, Question 5), indicating that underlying misalignments or a fundamental reluctance to fully commit are present. This protective stance often stems from a fear of being exploited or a desire to safeguard perceived assets (Interviewee 4, Question 5). To mitigate these issues, clear articulation of shared goals and transparency from the outset are consistently highlighted as crucial for establishing a collaborative, rather than competitive, intent.

Conflicts related to data sharing in last-mile transportation are a recurring challenge. Common scenarios include situations where a stakeholder verbally agrees to share data but becomes unresponsive when concrete requests are made, leading to significant delays (Interviewee 1, Question 6). Other instances involve fundamental differences in vision between collaborating entities, sometimes resulting in a withdrawal from the partnership if alignment cannot be achieved (Interviewee 1, Question 6). Initial skepticism about the business benefits of participation can also lead to conflict (Interviewee 3, Question 6), which has been resolved through further discussions that clarify long term strategic advantages. Additionally, disagreements can arise between different organizational layers, such as when a larger entity is reluctant to cede budget or control to a broader governing body, fearing a loss of service quality or financial resources (Interviewee 4, Question 6). Resolution often involves persistent, transparent dialogue to clarify mutual benefits, establishing formal agreements, leveraging existing strong relationships, and participating in coordinated, often externally funded, projects that encourage collaboration even among competitive entities (Interviewee 2, Question 6; Interviewee 5, Question 6; Interviewee 6, Question 6).

Effective strategies for resolving conflicts among stakeholders involve a multi faceted approach. Implementing confidentiality agreements, such as Non Disclosure Agreements (NDAs), helps build trust and creates a more secure environment for information exchange

(Interviewee 1, Question 7), though understanding deeper underlying reluctance can remain challenging. On an interpersonal level, transparency through extensive calls and clear explanations is paramount for building trust and facilitating data sharing (Interviewee 2, Question 7). On a broader scale, coordinated initiatives that bring together diverse organizations, even competitors, can significantly foster collaboration by providing a framework for collective goal advancement. Furthermore, a clear plan detailing the specific inputs and expected benefits for each party is crucial (Interviewee 3, Question 7), and this discussion should be thoroughly documented and formally agreed upon before project commencement. A "carrot and stick" approach, which involves demonstrating both the gains from adapting to new practices and the potential losses from resisting change, is also seen as effective (Interviewee 4, Question 7), alongside facilitating conversations where individuals can openly share their fears and needs to find creative, win-win solutions. Anonymization is a highly effective strategy for resolving data related conflicts, as it involves aggregating information and removing personally identifiable details (e.g., specific times, exact locations) while preserving useful insights like overall traffic flow (Interviewee 6, Question 7). This approach helps alleviate concerns about privacy and competitiveness, encouraging stakeholders to share and contribute their data.

To significantly improve data sharing and collaboration in last mile mobility, several key areas are identified. Firstly, clearly defining and emphasizing a shared, higher level goal at the very beginning of any collaboration is essential (Interviewee 1, Question 8), as it provides a consistent reference point for realigning efforts when individual interests diverge. Secondly, fostering a culture of transparency through sharing success stories from effective collaborations and organizing interactive workshops can inspire other organizations and cultivate a more collaborative environment (Interviewee 2, Question 8). Such events, even if brief, can shift mindsets and build personal connections that help solve shared problems. Thirdly, there is a strong need for standardized protocols or templates that simplify the process of secure data exchange (Interviewee 3, Question 8), addressing concerns about data safety and protecting against leaks. Fourthly, to enhance data sharing and collaboration, it is essential to establish a highly reputable, independent body with significant authority (Interviewee 6, Question 8; Interviewee 5, Question 8). This entity would ensure the integrity and transparency of the data exchange process, fostering trust and encouraging active stakeholder participation. Finally, improving the situation requires understanding the gains and losses for stakeholders, fostering open dialogue about fears and needs (Interviewee 4, Question 8), and often involves a political dimension where skilled individuals are needed to clearly outline beneficial solutions and apply necessary pressure to drive change.

The following table synthesizes the empirical findings on conflicts in last mile mobility data sharing, organizing the insights gathered from the interviews. It provides a clear overview of the nature of conflicts, including their early warning signs, and details the strategies used to effectively manage and resolve them. This structure allows for a quick and comprehensive understanding of the dynamics of stakeholder disagreements.

Table 4: Summary of Findings on Conflict Management and Resolution in Last-Mile Mobility

	Key Findings	Resolution & Prevention Strategies
Early Warning Signs	**Lack of engagement:** Unresponsiveness, overly brief answers, and reluctance to provide input. **Suspicion:** Extensive clarification requests and quick disengagement due to perceived risks. **Protective stance:** Fear of exploitation or a desire to safeguard perceived assets.	**Clear communication:** Articulate shared goals and establish transparency from the outset. **Build trust:** Focus on a collaborative, not competitive, intent.
Common Scenarios	**Broken agreements:** Verbal commitments without follow-through on data sharing. **Misaligned visions:** Fundamental differences that threaten or dissolve partnerships. **Organizational clashes:** Larger entities reluctant to cede budget or control.	**Transparent dialogue:** Clarify mutual benefits through persistent discussions. **Formal agreements:** Establish formal commitments and leverage existing relationships. **Coordinated projects:** Participate in externally funded projects that encourage collaboration.
Effective Resolution	**Confidentiality:** Utilize NDAs to build a secure environment. **Anonymization:** Aggregate data to alleviate privacy and competitiveness concerns. **Incentives:** Use a "carrot and stick" approach to demonstrate gains and losses. **Dialogue:** Foster conversations where stakeholders can openly share their fears and needs.	**Implement standards:** Use protocols or templates for secure data exchange. **Establish authority:** Create a reputable, independent body to oversee data exchange. **Set goals:** Define a clear, high-level shared goal from the beginning. **Inspire collaboration:** Share success stories and organize workshops to foster a positive culture.

The reason something has not yet been implemented despite a strong consensus on the problem is not a lack of knowledge, but a persistent deficiency in the existing institutional and commercial architecture. Specifically, two systemic barriers prevent self-correction: 1) a lack of neutral, mutually trusted governance to enforce sharing; 2) the immediate financial and competitive risk associated with unilaterally surrendering proprietary data. The pervasive reluctance to share data, as evidenced by interviewee comments on unresponsiveness and fear of exploitation, stems from a fundamental asymmetry of perceived risk versus reward. Private stakeholders view their operational data as a core competitive asset; sharing it exposes them to high risk regulatory scrutiny, loss of market edge, and proprietary compromise with often vague or low reciprocal benefit from the public sector. The missing link is a neutral, authoritative governance structure that can act as a binding data arbiter. Without a formal framework that clearly delineates data usage, guarantees protection from misuse, and ensures the return of valuable, aggregated insights, stakeholders rationally prioritize non-participation to safeguard their interests. This deep-seated organizational reluctance, more than any technical obstacle, is the primary systemic failure preventing effective collaboration.

Beyond the fundamental deficit of trust, the process of data sharing is severely impeded by basic operational constraints. Organizations struggle with the immense friction of technical incompatibility, as disparate systems cannot communicate or exchange data efficiently. This technological challenge combines with a severe lack of sustained resources, meaning many partners lack the dedicated expertise or budget necessary to consistently manage and maintain high data quality streams. Simply put, the cost and daily effort of reliable participation routinely outweigh the perceived strategic value, leading to collaboration failure.

4.4 Tools and data sharing

This section explores the technological and practical dimensions of data sharing in last mile mobility, focusing on how tools and practices either support or hinder collaboration. It outlines the specific platforms and technologies currently used by stakeholders from dedicated MaaS systems to general communication and data management tools and highlights the data sharing practices interviewees found most effective, such as standardized formats, clear governance policies, routine data exchanges, or cross-organizational teams. It also presents interviewees' visions for future improvements, including desired tools or features like AI powered analytics, more integrated platforms, or advanced visualization capabilities. Anonymized quotes are used throughout to illustrate current technologies, effective practices, and aspirations for future advancements.

Organizations involved in last mile mobility currently aim to utilize standardized interfaces for collaboration wherever possible, specifically mentioning GTFS (General Transit Feed Specification), GBFS (General Bikeshare Feed Specification), and TOMP-API (Transport Operator to MaaS Provider API) (Interviewee 1, Question 9; Interviewee 3, Question 9; Interviewee 5, Question 9). These common specifications are designed to support interoperability across various services. However, a practical challenge observed is that despite the adoption of these common protocols, individual providers frequently implement the standards in unique ways, which can still lead to integration difficulties in practice (Interviewee 1, Question 9).

Regarding practices that foster the most seamless collaboration, the use of standardized interfaces like GTFS, GBFS, and TOMP-API is acknowledged for significantly enhancing technical integration and interoperability. Yet, interviewees emphasize that these technical standards alone do not automatically translate into seamless cooperation. True and effective collaboration fundamentally depends on mutual trust, transparency, and a shared willingness to work together among all parties involved (Interviewee 1, Question 10; Interviewee 3, Question 10; Interviewee 4, Question 10). Beyond technical aspects, fostering a mindset of shared problem-solving and establishing personal connections through collaborative events are highlighted as key practices that lead to more seamless collaboration, moving beyond mere technical data exchange (Interviewee 2, Question 10).

Looking ahead, stakeholders believe that additional functionalities and new digital tools could further enhance collaboration. A crucial element identified for effective collaboration is trust, and therefore, digital tools designed to support transparency and shared accountability are seen as highly beneficial (Interviewee 1, Question 11). Examples of such tools include platforms for

joint goal-setting or for tracking progress, which could potentially help in strengthening this essential element of trust among collaborating parties (Interviewee 1, Question 11).

The following table provides a condensed overview of the empirical findings on data sharing, highlighting the current tools and practices used by stakeholders, as well as their vision for future improvements to enhance collaboration.

Table 5: Insights for Data Sharing Tools and Practices

Current Tools & Practices	**Desired Future Improvement**
Standardized APIs (GTFS, TOMP-API)	AI analytics
Inconsistent implementation	Integrated platforms
Collaboration based on trust	Tools for accountability
Personal connections	Joint goal-setting platforms

4.5 Feedback

This part will examine how feedback from stakeholders and end users is gathered and integrated into strategic planning and continuous improvement processes. It emphasizes the importance of feedback loops for adaptive governance in dynamic mobility projects. The discussion will detail the processes and methods organizations employ to collect input, such as surveys, workshops, public consultations, or dedicated feedback platforms. Finally, the perceived impact of incorporating this feedback will be discussed, highlighting how it leads to improvements or adjustments. Quotes will illustrate the feedback mechanisms, challenges, and perceived benefits.

Stakeholder and user feedback is integrated into strategic planning and continuous improvement by treating it as essential data for system optimization (Interviewee 5, Question 12). Organizations gather input directly from clients and partners, often through informal means like ongoing calls and meetings, though some use formal surveys (Interviewee 1, Question 12; Interviewee 2, Question 12). For end users, immediate issues are promptly addressed. Feedback is incorporated through a stepwise project approach (Interviewee 3, Question 12), involving discussions with relevant teams at each stage (Interviewee 3, Question 13). Strategies for gathering input include active questioning in meetings and direct engagement with potential customers to understand needs and emotional responses (Interviewee 4, Question 12). This holistic approach emphasizes systematic analysis of insights to inform recommendations and refine overall efficiency.

In collaborative projects, participants generally view initiatives positively, with many initial concerns being addressed. However, there is often no formal mechanism for continuous feedback and reporting, despite its importance (Interviewee 6, Question 12). Regular updates to data providers showing how their contributions are used and the outcomes achieved are key to sustaining engagement and building trust (Interviewee 6, Question 12).

4.6 Summary of key findings

In Table 5, we can see the most important findings from the interviews which were conducted. The interviews revealed that while stakeholders in last mile mobility broadly recognize the value of data sharing for improving service integration, operational efficiency, and user experience, actual collaboration remains limited by competing interests, technical barriers, and a lack of trust. Stakeholders often see data as a strategic asset, leading to hesitance around open exchange. Differences in strategic priorities, especially between public and private actors, and the absence of a unifying governance framework further complicate effective collaboration. Despite these challenges, there is a strong collective desire to move toward more interoperable systems, with stakeholders calling for greater standardization, clearer data governance policies, and stronger coordination from overarching authorities.

Table 6: The most important findings of the interviews conduction

Category	**Most Important Findings**
Stakeholder Objectives	• Divergent goals between public and private sectors • Private companies view data as a competitive asset. • Lack of standards and legal barriers hinder data sharing. • Conflicts over data ownership and strategic goals.
Conflict Insights	• Conflicts stem from misaligned expectations, limited transparency, and resistance to sharing control. • Early warning signs include unresponsiveness and passive disengagement • Resolution strategies involve clear goal setting, formal agreements (like NDAs), and open dialogue.
Tools and Data Sharing	• Technology is supportive, but trust and relationship building are the most critical factors. • Standardized interfaces (GTFS, GBFS, TOMP-API) are often implemented inconsistently. • The need for a shared problem-solving mindset is highlighted as key to success.
Feedback	• Feedback from stakeholders and end users is crucial for continuous improvement. • This input informs strategic planning and helps in adaptive governance. • A lack of formal, continuous feedback mechanisms is a significant issue.

Conflicts within these multi stakeholder environments are common and typically stem from misaligned expectations, limited transparency, or resistance to sharing control. Interviewees emphasized the importance of early warning signs such as communication breakdowns or passive disengagement and outlined strategies for managing conflict, including clear goal setting, formal agreements, open dialogue, and trust building measures like NDAs. Technological tools play a supportive role in enabling data exchange, but trust, mindset alignment, and relationship building remain the foundation of successful cooperation.

Feedback loops with stakeholders and end users are increasingly used to inform strategy and implementation, with a focus on continuous improvement and adaptive governance. Overall, advancing collaboration in last-mile mobility will require both technical enhancements and systemic shifts in how trust and shared value are cultivated across sectors.

5. Comprehension of Data

The purpose of this chapter is to provide a comprehensive understanding of the existing situation of data exchange and sharing within last mile mobility. It is essential for completely understanding the data sharing procedure, the data format, and the specific data types required for effective collaboration. By meticulously analyzing the formal requirements and recommendations suggested by organizations like the European Investment Bank and others, this chapter lays the groundwork for promoting and improving data sharing protocols among stakeholders. This foundational knowledge serves as the direct evidence and strategic direction, which, when combined with the insights from Chapter 4, allows for the development of a well justified and actionable framework in Chapter 6. This ensures the final framework is not merely a theoretical model, but a robust and practical solution that addresses the real world complexities of fostering effective data sharing.

The vast amounts of data generated in the last mile ecosystem include several key types crucial for effective mobility management. This includes real time operational data from micromobility fleets (e.g., location, battery status, and usage patterns of e-bikes and e-scooters), infrastructure data (e.g., parking availability, charging station locations, and traffic flow), and user generated data (e.g., travel demand, trip origin destination information, and feedback on service quality). Furthermore, transactional data (e.g., payments and ride history) and planning data (e.g., urban planning blueprints and public transport schedules) are also essential. Unlocking the potential of this data requires a framework that allows for secure, structured, and controlled sharing across all stakeholders to transform these fragmented datasets into a cohesive source of actionable insights (European Investment Bank, 2021).

In today's increasingly interconnected society, vast amounts of data generated by the daily movements of people and goods present enormous potential for innovation and efficient mobility management. Mobility data serves as a key driver for enhancing quality of life, promoting environmental sustainability, and supporting technological advancements across Europe. Leveraging this data intelligently can enable the design of more resilient transport infrastructures and services, smoother cross border travel, optimized logistic networks, streamlined reporting, and reduced congestion. Yet, the core challenge in mobility is not merely the collection of data itself, but rather enabling secure, structured, and controlled data sharing to effectively transform raw data into actionable insights. Unlocking the untapped strength within transport data holds critical importance for the widespread uptake of artificial intelligence (AI) and other frontier technologies in urban mobility.

Recognizing this significant potential, the EU Data Strategy has introduced the creation of common European data spaces, including a dedicated European Mobility Data Space (EMDS). This aims at providing the necessary governance, infrastructure, interoperability, and secure mechanisms to facilitate controlled access, pooling, and data exchanges. However, despite the extensive mobility data generated across Europe, fragmentation remains prevalent. Many European companies still struggle with data access and sharing, while dominant foreign technology providers exploit European generated data commercially. Addressing these challenges, the EMDS specifically seeks to establish harmonized technical and governance frameworks to overcome existing barriers, enhance interoperability, and foster closer collaboration across the transport data ecosystem. Through the EMDS, EU institutions aim to enable businesses and public authorities to fully harness mobility data, significantly bolstering Europe’s transport innovations, efficiency improvements, sustainability objectives, and economic competitiveness (European Commission, n.d.).

According to the European Commission, improving data sharing across sectors has measurable benefits, providing efficiencies for individuals, companies, and societies more broadly. For instance, effective use of mobility data could generate annual time savings exceeding 27 million hours for public transport passengers and could reduce labor costs amounting to €20 billion per year for drivers through real time navigation assistance (European Commission, n.d.).

5.1 Attributes and Understating of Mobility Data

Data possesses unique characteristics and ramifications that significantly contribute to its value across various sectors. One defining feature is that data is non rivalrous, allowing numerous users to simultaneously access and utilize it without restricting others. This attribute can yield both beneficial and adverse effects. On the positive side, sharing research data across industries can expedite innovations, such as the rapid development of vaccines. On the downside, sharing consumer information can lead to privacy infringements and data misuse (UITP, 2021).

(UITP, 2021) emphasizes the significance of real time data in providing immediate insights essential for informed decision making. While the long term accumulation of data is valuable for fostering forward looking perspectives when combined with real time analytics, the quality and accuracy of data are crucial for optimal results. Merging diverse data sets generates unique insights not possible from single sources. However, acquiring data involves costs related to its collection, storage, and preparation, and its value can vary with technological advancements that enhance infrastructure and discover new data sources.

Data sharing lacks a 'one size fits all' solution and can be categorized into several business model types. Building a sustainable business model for data sharing involves several key elements: establishing clear engagement guidelines among stakeholders, which clarify each stakeholder's role, risk allocation, and motivation alignment in data sharing; the capacity to value data as an asset; and fostering long term partnerships to justify the investments in data sharing. The transport data sharing ecosystem involves various stakeholders who can engage in multiple ways. Figure below shows the government's broad role in regulating and overseeing these stakeholders within each model. While Public Transport Authorities (PTAs) are viable candidates for the central role in largescale projects like city wide Mobility as a Service (MaaS), where alignment with urban mobility goals is crucial, this is not always necessary. Smaller data sharing projects, particularly those involving private organizations, might not need PTAs to take a central position. Additionally, not every city has a robust and well equipped transport regulatory body to perform this role, and imposing such a responsibility on PTAs might be counterproductive.

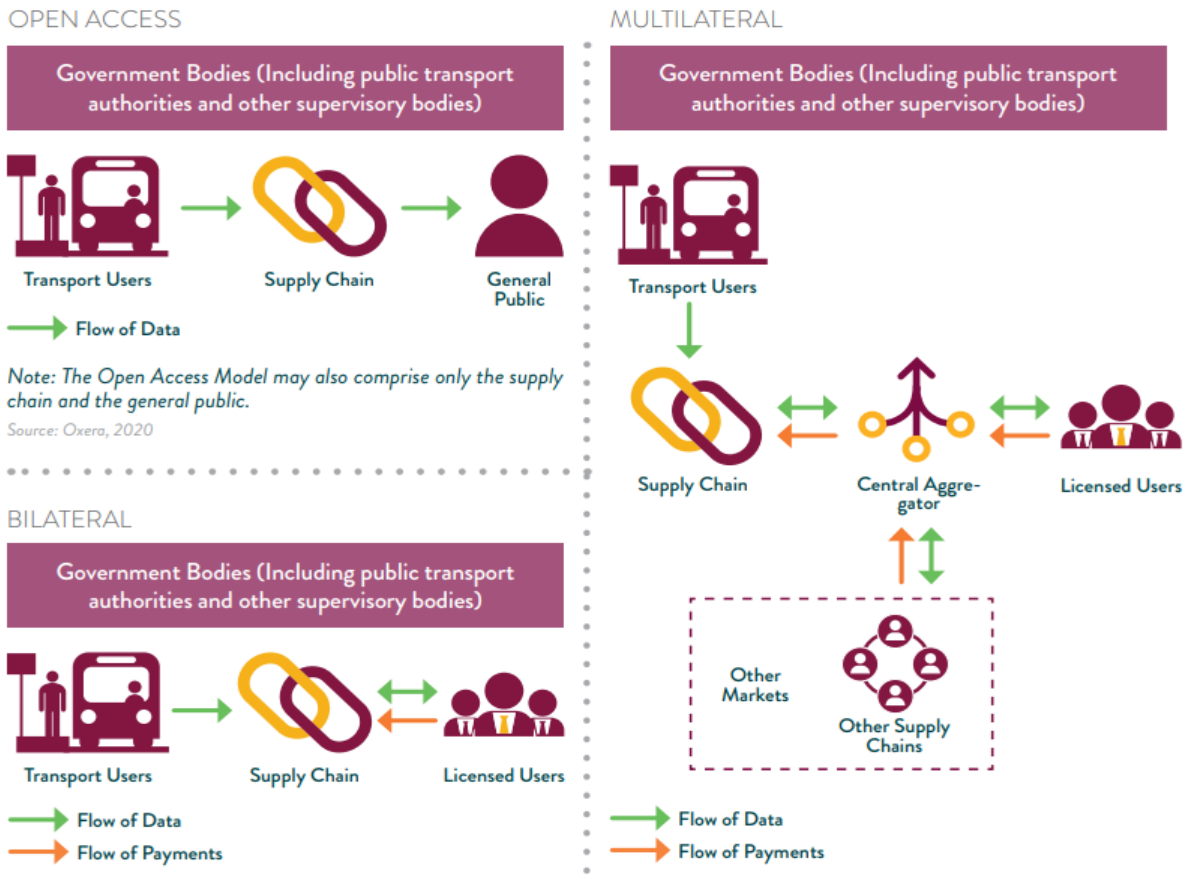

Figure 2: Stakeholder's Partnerships (UITP, 2021)

`5.1.1 Key Benefits and Challenges of Mobility Data sharing

Data sharing amplifies both long term and immediate benefits, achieving several positive outcomes. These insights, as outlined in a key report by the UITP (International Association of Public Transport) from 2021, highlight several advantages. Firstly, it bolsters economic competitiveness by enhancing efficiencies and unlocking new monetization opportunities through innovative business models. Within the transport sector, data sharing optimizes planning and network operations, leading to increased productivity and cost efficiency. This opens up new user benefits and innovative last mile mobility services such as ride hailing and bike sharing. Additionally, data sharing fosters greater harmony between public and private stakeholders, aligning their diverse motivations and improving overall productivity. Finally, the ability to respond swiftly to recovery planning during disruptions and crisis management is another advantage of data sharing (UITP, 2021).

Despite these substantial benefits, data sharing does come with its own set of risks and barriers. These challenges, such as the risk of losing competitive advantage, were a primary consideration in designing the governance and trust building components of the framework**.** One key risk is liability and potential reputational damage, as organizations may fear accountability for other parties' wrongdoings, particularly in cases of data protection breaches or misuse. There is also the risk of losing competitive advantage or market share, impacting public transport modal shares and the market position of individual operators or mobility providers. Additionally, when third parties release inaccurate or misleading information, it can weaken relationships between the organization and its customers, partners, and the broader

community. These challenges, such as a fear of losing competitive advantage, were a primary consideration in designing the governance and trust building components of the framework

The figure that follows effectively illustrates that data is a central enabler of value creation, impacting every aspect of an organization. It shows that by leveraging data, companies can not only generate new revenues through innovative services and business models but also significantly reduce costs by improving productivity and operational efficiency. Furthermore, data enhances the customer experience by enabling personalized products and services, while optimizing production and internal processes for better outcomes.

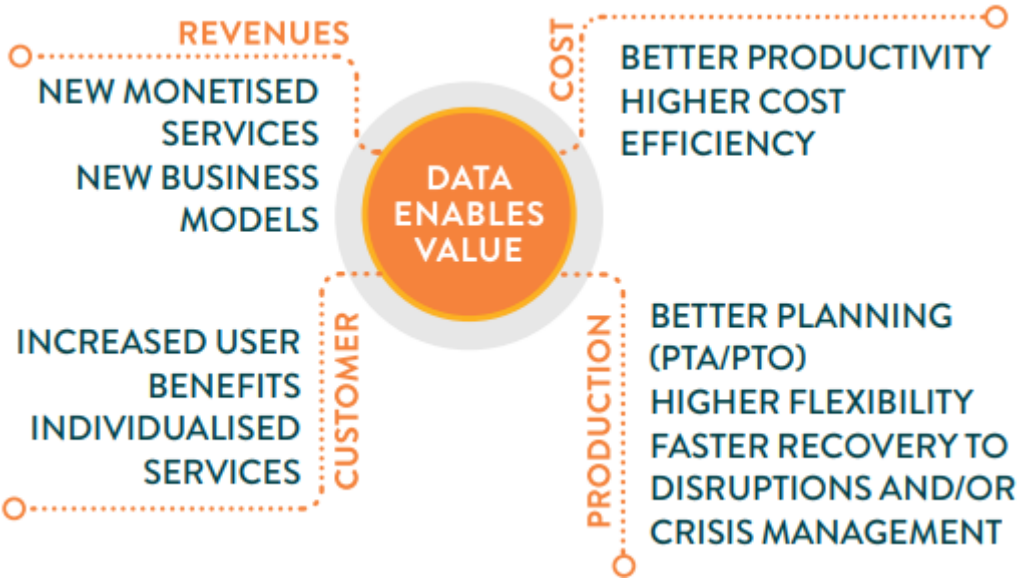

Figure 3: Advantages of Data Sharing (UITP, 2021)

Understanding the goals of data sharing is crucial in valuing its significance. By systematically assessing the outcomes of data sharing, stakeholders can better align their incentives and motivations. This involves recognizing how to quantify the value of sharing data beyond the inherent benefits and risks. Different parties may cultivate value from data in various ways, which introduces uncertainty regarding its utilization. Therefore, it is essential to comprehend the use cases between potential partners and incorporate these into the terms and conditions of contracts or agreements. The valuation process connects the factors influencing each stakeholder's approach, based on their objectives, to better understand the positioning of data sharing's value within the broader spectrum. For instance, an organization concerned with data sharing costs will emphasize these expenses in its valuation, whereas one aiming to maximize social value will focus on the ultimate impacts enabled by sharing data (UITP, 2021).

It is important to acknowledge that data, despite its value, comes with a cost. This includes the direct "financing of data operations," which can have a negative impact on an organization's financial capital. While data sharing can create value for stakeholders, the valuation process must also consider the costs associated with these actions. For instance, an organization concerned with the costs of data sharing will focus its valuation on the expenses associated with it (UITP, 2021).

Figure 4 illustrates the data sharing process in four steps: first, identifying internal and external data to share; second, recognizing stakeholders involved and their objectives; third, understanding how stakeholders might use the data, the impacts, and related costs; and fourth, calculating the value of data sharing from different perspectives. It highlights that effective

data sharing requires not only technical exchange but also alignment of stakeholder goals, cost considerations, and clear valuation of benefits.

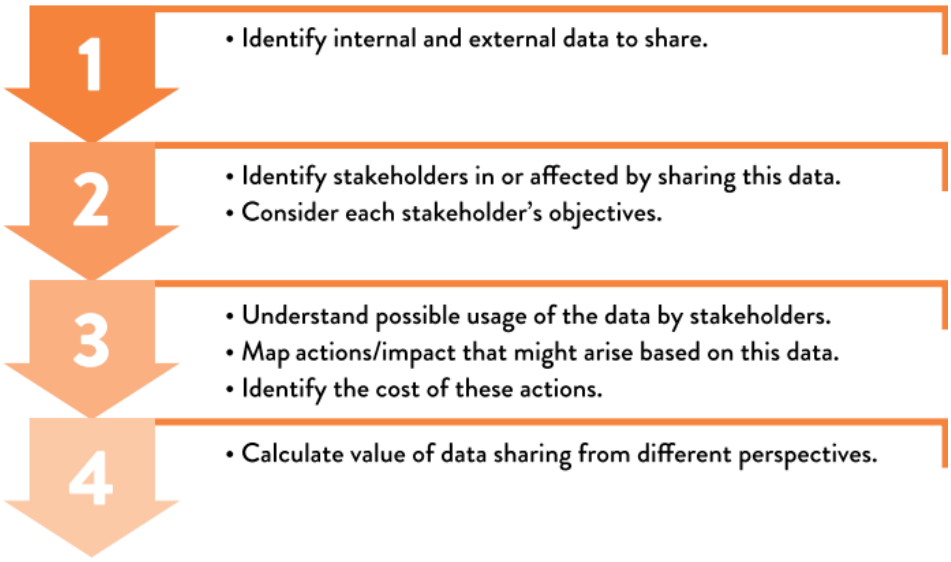

Figure 4: Data Sharing Process (UITP, 2021)

The concept of Mobility as a Service (MaaS) fundamentally relies on effective data sharing between partners. However, this critical aspect is faced with numerous challenges, such as the existence of various integration standards and differing data requirements across partnerships and markets. Additionally, as Member States consider designing national standards for MaaS integrations, the risk of market fragmentation increases. This underscores the necessity for a unified MaaS data standard at the European level, which would streamline data sharing processes, enhance market predictability, and reduce technical burdens for all stakeholders. Establishing such a standard would simplify the adoption and implementation of MaaS, making it more likely to become a widespread or best practice throughout the mobility industry (MonteroPascual, Finger, & Serafimova, 2022). This specific need for a unified standard directly informed a key component within the developed framework in the next chapter, which is designed to address technical fragmentation.

Moreover, beyond integration focused data sharing, the exchange of mobility insights within MaaS platforms holds the potential for substantial value creation by offering a deeper understanding of citizens' mobility habits and their preferences for sustainable transportation options. However, the current ecosystem is hindered by limited data collection and sharing practices among MaaS aggregators, which obstructs the ability to fully assess the sustainable impact of MaaS initiatives. As the industry evolves alongside technological advancements in data collection capabilities, it will be imperative to establish guidelines for efficient data exchanges among MaaS partners. These guidelines will facilitate the evaluation of multimodal transportation adoption and allow progress tracking toward MaaS's sustainability objectives (MonteroPascual, Finger, & Serafimova, 2022).

5.1.2 Data can be shared

This section provides an overview of the data sources commonly used by cities to map and manage mobility flows. By examining various mobility dashboards implemented by cities, we

can identify the most relevant data sources for effectively monitoring traffic and transportation. Notably, motorized vehicles have historically generated more data due to widespread use of navigation services, onboard units, and enforcement systems. However, in recent years, there has been a shift towards collecting more data on public transport and bicycles, largely facilitated by the proliferation of smartphone applications. While pedestrian data acquisition has traditionally been limited, this too is gradually improving. Given the nature of dashboards, which are designed to present dynamic information, there is a strong emphasis on real time, streaming, or live data to meet user expectations for updated and current insights into mobility trends (European Investment Bank, 2021).

5.2 Data Standards

I. Data types

Data sharing in urban mobility encompasses several key types that provide valuable insights for effective management and planning. One important category is data on volumes, which includes the number of cars, pedestrians, cyclists, and public transport users. This data helps cities monitor how infrastructure is utilized over time and understand the impact of events or policies. Speeds and travel times are also crucial, offering information on traffic flows, congestion, and public transport service levels, which can support decisions on speed reduction measures and accessibility planning. Origin destination data provides insights into travel patterns, aiding in urban planning and infrastructure development, while individual trip information from mobile and app data reveals routes taken, helping to identify missing links in transportation networks (European Investment Bank, 2021).

Additionally, shared data on parking usage and contextual factors such as weather, events, and holidays further enhance urban mobility management by informing policy planning and adaptation to changing conditions. Data on human behavior, such as the reasons behind travel decisions, is essential for shaping policies that influence mobility choices and promote sustainable alternatives. Lastly, system and infrastructure data from roadside electronic systems provide operational information that ensures safety and efficiency, while service provisioning data from concession contracts or mandatory regulations offers a comprehensive view of mobility patterns and operator performance. Together, these diverse data sources enable cities to design more effective and responsive mobility systems that cater to the needs of their populations (European Investment Bank, 2021). The diversity of these data types, from volumes to travel times and origin destination information, emphasizes the need for a standardized approach to data classification and sharing, a core principle of the framework presented in Chapter 6.

II. Data sources

In today's transport sector, the sharing of diverse datasets is of paramount importance as it provides insights that can lead to more efficient processes, cater to society’s changing needs, and benefit the wider population. Some of the key types of data that can be shared include mobile phone application location data, in vehicle data, Bluetooth and Wi-Fi tracking, mobile/telco data, inductive loops, floating vehicle data, cameras and license plate recognition, ticketing systems and smart card data, automatic vehicle location systems, air quality, weather, and data collected by the public (European Investment Bank, 2021).

Mobile phone application location data has evolved beyond navigation apps to include various applications like Strava and Run keeper that actively track user activity, while some apps collect location data less transparently. In vehicle data comes from sensors connected to the car's main platform, providing information on vehicle function and context. Bluetooth and WiFi tracking use sensors to detect enabled devices and can reveal speeds and routes. Mobile/telco data logs smartphone connections, providing detailed origin destination information. Inductive loops detect vehicles via changes in road surface electrical fields, and floating vehicle data captures real time vehicle location through devices. Cameras and license plate recognition systems offer vehicle related information, while ticketing systems record smart card usage for transport. Automatic vehicle location systems track public transport vehicles, air quality data measures the impact of mobility, and weather data informs about conditions affecting transport. Lastly, data collected by the public through IoT devices contributes significantly to crowdsourced data acquisition models.

Together, these datasets offer extensive potential for transforming urban mobility, though it is vital to address challenges such as data privacy and ensure sustainable sharing practices tailored to specific needs and goals (European Investment Bank, 2021). The wide range of these data sources highlights the need for a flexible and adaptable framework that can integrate different types of information

The figure 5 below illustrates the layered process of using transport related data for urban mobility. At the foundation are multiple data sources ranging from mobile phone applications and in-vehicle sensors to ticketing systems, air quality monitors, and crowdsourced contributions. These raw datasets are funneled into a processing and integration hub, where tools such as GIS, real time dashboards, analytics platforms, and Mobility as a Service (MaaS) frameworks organize and analyze the information. The insights generated then support a wide range of applications and outcomes, including transport planning, service optimization, improved user experience, sustainability tracking, and stronger governance. Together, these layers highlight how effective data sharing and digital tools can drive smarter, safer, and more sustainable last-mile mobility solutions.

To conclude, considering what has been discussed above data and digital tools are crucial for thoroughly understanding travel behaviors, demand patterns, and usage trends related to last mile mobility. For instance, anonymized mobile phone and GPS data, collected via smartphone applications and location based services, can illustrate how, when, and why users travel during the final segment of their journeys. This aids planners in accurately mapping daily commuter flows and pinpointing popular travel corridors as well as underserved areas, ultimately guiding targeted interventions and optimal resource allocation to improve last mile connectivity.

Leveraging digital tools such as Geographic Information Systems (GIS), floating vehicle data, Bluetooth sensors, and camera based analytics further helps identify infrastructure gaps and measure the quality of existing transport systems. These tools empower cities to visualize spatial patterns clearly, highlighting connectivity issues and revealing inequities in accessibility, such as barriers experienced by vulnerable or less mobile citizens. This detailed awareness allows for precise infrastructure enhancements, well informed decisions in infrastructure investments, and safer, smoother passenger experiences.

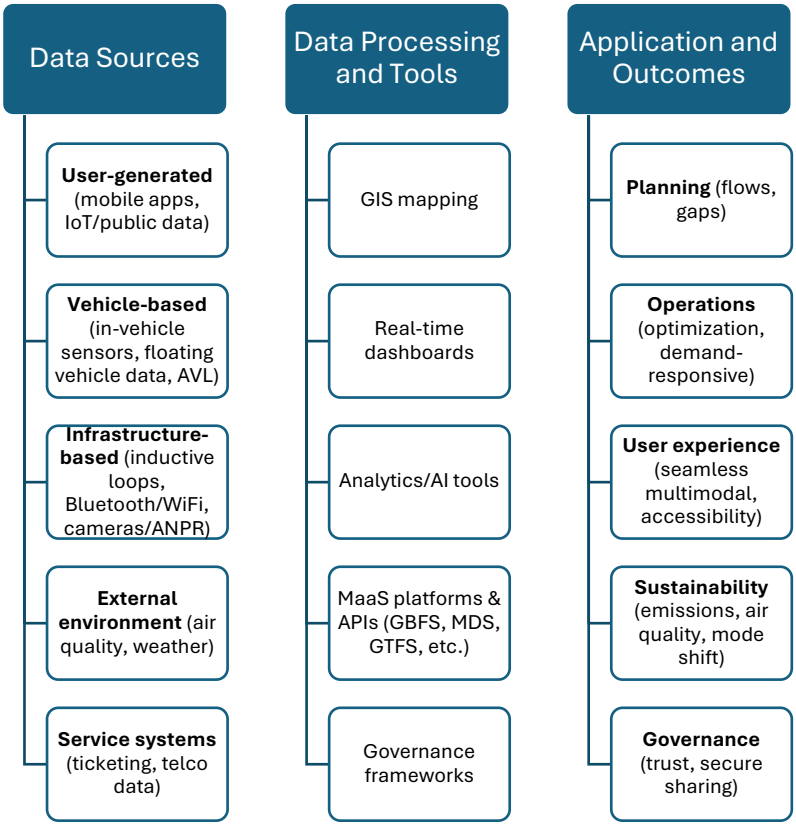

Figure 5: Overview of transport data sources, processing, and applications.

Important questions around service provision, usage trends, operations optimization, and user satisfaction can be addressed by platforms and tools that aggregate and analyze operational data generated by shared mobility services (e.g., bike sharing, ride hailing, scooter sharing) and demand responsive transport solutions. Real time dashboards and data integration tools from intermediaries allow urban mobility stakeholders quickly and easily to obtain a holistic understanding and respond dynamically to shifting user preferences and operational conditions. Data driven insights support informed decision making, resource allocation, and more effective management of last mile services.

Additionally, integrating services into coherent multimodal last mile solutions can be facilitated by Mobility as a Service (MaaS) platforms, APIs, and standardized data exchange protocols (including GBFS, MDS, GTFS, NeTEx, and SIRI). Efficient integration of various data streams and services enables seamless planning, ticketing, booking, and transfers between transport modes, supporting greater usage convenience. Such effective integration mechanisms have the potential to increase user adoption of sustainable transport methods, substantially reducing reliance on single occupancy cars.

To measure the environmental impacts and align with sustainability goals, data from air quality sensors, environmental monitoring stations, and digital analytics platforms play a pivotal role. Cities can track improvements in emissions, mode shift towards sustainable options, and identify areas for additional interventions. Digital dashboards communicate these measurable outcomes transparently to citizens, businesses, and policymakers, reinforcing and validating environmentally oriented transport policies, initiatives, and behavior change strategies.

Finally, ensuring successful and sustainable last mile mobility demands clear and secure data sharing among stakeholders. Secure digital platforms, governance frameworks, clearly defined

agreements, and privacy protection practices are essential components needed to build trust and alignment within this diverse ecosystem. Proper digital governance and transparent data sharing agreements clearly represent stakeholder rights, responsibilities, and expected usage patterns, thus overcoming friction and legal complexities. Collaborative environments supported by digital governance frameworks empower seamless and responsible data sharing, unlocking synergies and innovation in last mile mobility.

The comprehensive analysis of data types, sources, and challenges in this chapter is what makes the subsequent framework possible. This chapter served as an attempt to fully understand the barriers in data sharing, the format of the data, and the data exchange situation, all of which were examined and justified according to established standards and references. By taking this deep dive, the research gained a complete understanding of the problem's nature, which provides the direct evidence and the strategic direction for each element of the collaborative framework. This ensures that the framework is not a theoretical model, but a well justified and actionable tool that directly addresses the real world complexities of fostering effective collaboration in last mile mobility.

6. Developing a Collaborative Framework for Stakeholder Data Sharing in Last Mile Mobility

6.1 Stakeholder definition

A stakeholder in an interorganizational information system refers to any individual, group, or organization that can impact or be impacted by the system being examined. Their influence on the system's requirements can be either direct or indirect, and this influence can be positive or negative (Ballejos & Montagna, 2008).

Strand and Freeman (2015) describe Stakeholder Theory as a compilation of concepts, expressions, and metaphors centered on the idea that the primary goal of a company is to generate maximal value for its stakeholders. Achieving social and environmental sustainability requires collaboration between companies and their stakeholders. This approach is frequently used by researchers to explore the interplay of diverse stakeholder interests and the potential to create additional value for more stakeholders (Öhman & Samuelsson, 2020). It is crucial to consider diverse perspectives at various levels, as this helps identify critical issues and constraints, set relevant objectives, and ensure transparency in the planning process. Pira (2018) argues that the optimal solution may not be the most technically advanced one but rather the one that best satisfies the needs of all stakeholders. Moreover Shivanagouda (2024) notes that striking a compromise between stakeholder driven evaluations and technical analyses can be challenging.

6.2 Stakeholder Involvement

It is crucial that stakeholders should be involved as early as possible which is useful for stakeholder analysis and decision making (Reed, 2008 & Erkul, Yitmen, & Çelik, 2016) .When conducting a participatory process, it is crucial to consider stakeholder involvement from the very beginning, starting with concept development and planning, and continuing through to implementation, monitoring, and evaluation of outcomes. Engaging with stakeholders as early as possible in the decision making process is often cited as vital for achieving high quality and sustainable decisions. Usually, stakeholders are only involved during the implementation phase of the project cycle, rather than during the earlier stages of project identification and preparation. There is also a growing trend of involving them in monitoring and evaluating the outcomes of the decision making process.

Utilizing the insights from the literature review (Chapter 3) and the empirical data from the case study interviews (Chapter 4), this chapter will analyze and develop a systematic framework for effective stakeholder collaboration and data sharing in last-mile mobility. The framework will integrate theoretical concepts with practical findings to provide a clear and actionable blueprint. The proposed approach will identify and elaborate distinct stages and key steps necessary to facilitate successful collaboration, aligning stakeholder interests, mitigating potential challenges, and ensuring sustainable outcomes.

Strategies for effective stakeholder collaboration may differ in some aspects, but as observed in both Tomlinson and Parker (2021) and Krick et al. (2005), they often adhere to the same foundational principles. As a result, many corporations now view engaging with diverse

individuals and entities on social, environmental, and economic issues as a crucial part of managing their operations. Initially, the first generation of stakeholder engagement was often driven by external pressures, executed in a spontaneous manner, and focused mainly on addressing issues that led to conflicts with stakeholders. Recognizing the advantages of a more proactive, comprehensive, and continuous dialogue, businesses began to adopt more sophisticated and systematic approaches to stakeholder engagement. These second generation activities have proven effective in enhancing understanding, managing risks, and resolving conflicts. In recent times, leading companies have realized that stakeholder engagement can contribute to learning and innovation in both products and processes, and improve the sustainability of strategic decisions both within and outside the company. Third generation stakeholder engagement enables companies to synchronize their social, environmental, and economic performance with their core strategy. These processes involve resource sharing, such as expertise and financial, human, or operational resources, which helps all parties involved gain insights, solve problems, and achieve goals that were unattainable independently (Krick et al., 2005).

Figure 6 illustrates the three generations of stakeholder engagement, showing the shift from reactive, conflict driven approaches, to proactive, structured communication, and finally to strategic, integrative collaboration embedded in core strategies that drive innovation and align social, environmental, and economic goals.

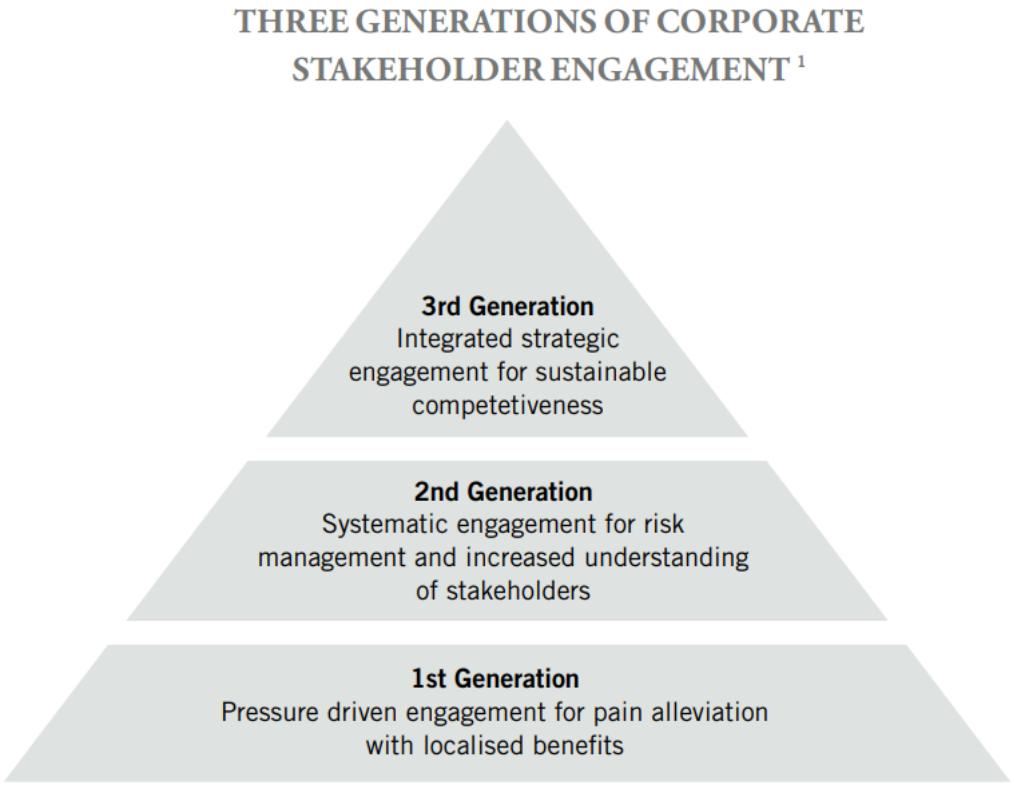

Figure 6: Schematical representation of the three generations of stakeholder engagement (Krick et al., 2005)

First Generation Stakeholder Engagement ("Reactive"): Defined as reactive and issue driven engagement mostly initiated due to conflicts or external pressures. Second Generation Stakeholder Engagement ("Proactive/Systematic"): Defined as a proactive, structured process aimed at improving communication, reducing risks, managing conflicts early, and achieving mutual understanding between stakeholders. Third Generation Stakeholder Engagement ("Strategic/Integrative"): Defined as a fully strategic and integrative collaboration where

stakeholder engagement integrates deeply into enterprise strategy, driving clear innovation in product and process and aligning environmental, social, and economic performance. Stakeholders actively participate and clearly provide strategic value.

Table 6 highlights the benefits of stakeholder engagement, emphasizing how meaningful collaboration can lead to improved risk management, stronger trust and relationships, better decision-making, innovation, and more sustainable outcomes. It underlines that engagement is not just a compliance exercise but a value creating process that benefits both organizations and stakeholders.

Table 7: Benefits of Stakeholder Engagement (Krick et al., 2005)

The Benefits of Stakeholder Engagement
Effective and strategically aligned stakeholder engagement can: – Lead to more equitable and sustainable social development by giving those who have a right to be heard the opportunity to be considered in decision-making processes; – Enable better management of risk and reputation; – Allow for the pooling of resources (knowledge, people, money and technology) to solve problems and reach objectives that cannot be reached by single organisations; – Enable understanding of the complex business environment, including market developments and identification of new strategic opportunities; – Enable corporations to learn from stakeholders, resulting in product and process improvements; – Inform, educate and influence stakeholders and the business environment to improve their decision-making and actions that impact on the company and on society; – Build trust between a company and its stakeholders;

The stakeholder engagement framework developed within this research draws upon the theoretical framework of Krick et al. (2005), explicitly moving from reactive engagement (first generation) through systematic and structured stakeholder approaches (second generation), to ultimately reach a highly integrated, strategic third generation engagement aimed at continuous improvement, innovation, and robust collaboration. This evolution in stakeholder engagement is clearly necessary according to the empirical insights gained from stakeholder interviews, which emphasized proactive communication, trust building through structured dialogue and collaborative scenario development, and data sharing measures to practically enable strategic multi stakeholder value.

While stakeholder engagement offers significant benefits, it is not a cost-free process. The most immediate costs are financial and human resources. This includes the time and labor required for planning, organizing, and conducting meetings or workshops, as well as the cost of dedicated staff or consultants. Additionally, there are opportunity costs, as the time and resources allocated to engagement might otherwise be used for other operational tasks. Finally, there is the potential for increased complexity and slower decision making if the process is not managed effectively, which can be seen as an indirect cost. Acknowledging these expenses provides a more balanced and realistic view of the engagement process.

6.3 Procedure of Developing the Framework

The insights gleaned from the interviews and the understanding of data dynamics discussed in previous chapters serve as the foundation for this methodology. This section outlines the development of a structured framework designed to facilitate effective stakeholder collaboration and data sharing in last mile mobility. This framework provides a step by step roadmap that stakeholders can use to continuously unlock the maximum potential of their data and collaborative efforts. It is designed to move beyond theoretical discussions by offering a practical, actionable guide. By following the steps outlined in this methodology, organizations can overcome fragmentation, build trust, and ensure they are utilizing all available resources to create a more efficient and sustainable urban mobility ecosystem

6.3.1 Step 1: Foundational Scrutiny of Context, Stakeholders, and Objectives in Collaborative Data Sharing

The initial phase of the proposed framework, designated as "Step 1," represents the critical diagnostic and strategic alignment stage for establishing robust collaborative data sharing frameworks within the complex domain of last mile mobility. This phase is not merely a procedural formality but a rigorous analytical undertaking, the meticulous execution of which is paramount for the subsequent efficacy and sustainability of the entire data sharing initiative. Any superficiality or oversight at this foundational stage risks developing a technically sophisticated, yet ultimately misaligned and ineffectual, collaborative ecosystem.

Drawing on the insights from Chapter 5, which emphasized the importance of aligning stakeholder objectives and overcoming initial barriers to data sharing (UITP, 2021), this framework begins with a foundational step. The first analytical imperative within Step 1 is the comprehensive identification and granular characterization of all relevant stakeholders. This extends beyond a rudimentary enumeration of entities, demanding a multi dimensional assessment of every actor possessing a direct or indirect interest in, or potential impact on, the last mile mobility landscape and its associated data flows. This encompasses a broad spectrum of participants, including, but not limited to, public sector bodies (e.g., municipal and regional transport authorities, urban planning departments), private mobility service providers (e.g., micro mobility operators, ride hailing services, logistics companies), technology developers, research institutions, and critically, community advocacy groups and end users. For each identified stakeholder, a detailed profile must be constructed, scrutinizing what can be termed their "dynamic character." This analytical dimension encompasses:

- **Organizational Scale and Operational Reach:** This involves assessing the magnitude of their operations, such as the demographic size of a municipality they serve, the geographic expanse of a transport network they manage, or the volume of vehicles or users a private entity commands. This quantitative understanding provides insight into the potential scale of data generation and consumption.
- **Resource Endowments and Constraints:** A critical evaluation of available resources, including financial capacity (e.g., budgetary limitations), human capital (e.g., availability of specialized data scientists, IT infrastructure personnel), and technological maturity (e.g., existing data management systems, analytical tools, digital

infrastructure). This assessment illuminates potential gaps and requirements for capacity building.

- **Core Mandate and Strategic Drivers:** Understanding the fundamental purpose and guiding principles of each organization. For a public entity, this might revolve around public welfare, equity, or environmental sustainability. For a private enterprise, it typically centers on market share, profitability, and operational efficiency. This analysis reveals inherent biases and priorities influencing data engagement.
- **Existing Infrastructure and Assets:** An inventory of tangible and intangible assets, such as vehicle fleets, charging networks, data collection points, existing data repositories, and established digital platforms. This provides a baseline understanding of their current operational and data-generating capabilities.

By dissecting these "dynamic characteristics," a nuanced understanding of each stakeholder's unique capabilities, limitations, and potential points of synergy or conflict emerges. This analytical depth is indispensable for anticipating their individual contributions, identifying potential bottlenecks, and designing tailor made engagement strategies.

A core focus here is to comprehensively understand the specific objectives and priorities of each stakeholder, as illuminated through the stakeholder interviews. These direct insights from the field revealed the immense diversity of goals ranging from governmental bodies prioritizing accessibility and sustainability, to private operators focused on efficiency and profitability. Understanding these varied objectives, including their organizational mandates and resources, is paramount because it directly uncovers potential conflicts of interest and proprietary data concerns. This foundational scrutiny ensures that the framework anticipates contributions, identifies bottlenecks, and ultimately designs tailored engagement strategies that align disparate objectives towards a unified, measurable, and effective data collaboration initiative for last mile mobility.

This step is crucial in the systems engineering (SE) process, as omitting stakeholders could undermine the outcomes of the decision making by causing dissent and obstacles from those excluded. Conversely, involving a larger number of stakeholders can elevate the costs associated with SE. Stakeholders often have differing, and sometimes conflicting, objectives, and increasing their number generally raises the expenses for implementing the SE process. Additionally, as noted by Giordano et al. (2020), variations in the stakeholders participating in the process can alter the emphasis placed on various objectives, potentially influencing the most favorable final decision (Pagliara, ElAnsari). The overall purpose of this engagement plan is to facilitate and systematically enable effective data sharing collaboration among prioritized stakeholders involved in sustainable last mile urban mobility solutions. It identifies suggested strategic steps that can be undertaken in a clear, structured, and achievable way, guided explicitly by SMART (Specific, Measurable, Achievable, Relevant, Timebound) objectives according to (Krick et al., 2005).

Overall SMART Objectives for Stakeholder Collaboration:

- Specific: Facilitate collaboration through stakeholder engagement aimed at generating agreements on practices, standards, and pilot data sharing initiatives.
- Measurable: Achieve clearly articulated agreements, jointly defined technical frameworks, stakeholder consultations, collaborative pilots, and transparent communication.

- Achievable: Provide suggestions feasible within the stakeholders' expertise, resources, and operational capacities.
- Relevant: Ensure relevance towards thesis/project research goals and clearly defined strategic objectives for sustainable urban mobility.
- Time specific: Recommend general target timelines, focusing on overall feasibility and practicality rather than mandatory enforcement.

Concurrently with this exhaustive stakeholder characterization, Step 1 necessitates a precise analytical articulation of the overarching objective of the data collaboration. Instead, it must be deconstructed into clearly defined, measurable, achievable, relevant, and time bound (SMART) goals. For instance, a broad aim such as "improving last mile accessibility" would be refined into a quantifiable target like "increasing public transport mode share for first/last mile segments by X% within Y urban zones over a Z-month period," or "reducing average last mile journey times by A% for B user segments." This analytical precision in objective definition necessitates a thorough understanding of the specific urban challenges or market opportunities that the shared data aims to address. It requires asking: What precise problem is this data collaboration designed to solve? How will the integration and analysis of diverse datasets directly contribute to a measurable improvement against a predefined metric?

Table 8 outlines Step 1: Stakeholder Identification, emphasizing a foundational review for collaborative data sharing. It highlights identifying stakeholders across public, private, and community sectors, assessing their scale, resources, mandates, and infrastructure, and aligning their objectives with SMART goals to anticipate synergies and conflicts.

Table 8: Schematic representation of Step 1

Step 1: Stakeholder Identification
Purpose: Identify and analyze stakeholder data for a collaborative framework.
Description: - Identify relevant stakeholders across public, private, and community sectors. - Assess dynamic characteristics through: • Organizational Scale & Operational Reach • Resource Endowments & Constraints • Core Mandate & Strategic Drivers • Existing Infrastructure & Assets - Align objectives with SMART goals, mapping stakeholder contributions and data needs.
Outcome: Establish a strategic framework for robust collaborative data sharing, anticipating synergies and addressing potential conflicts.

Furthermore, a crucial analytical link must be established between each stakeholder's "dynamic character" and their specific objectives within the broader collaborative framework. This involves understanding how their individual strategic goals align with, or diverge from, the collective objective, and consequently, what particular data sets they would require, and what data they could potentially offer, to achieve both individual and collective aims. For example, a municipality's objective of reducing urban congestion might necessitate real time vehicle

movement data from private operators, while the operators themselves might seek data on infrastructure availability or public demand patterns to optimize their services. This reciprocal understanding, derived from the "dynamic character" analysis, is fundamental. It enables the identification of specific data needs and potential data contributions, concurrently revealing latent concerns such as the protection of proprietary business information or sensitive user data. Without this intricate mapping of individual motivations to data requirements and potential contributions, the collaborative framework risks being perceived as imbalanced or commercially disadvantageous, leading to reluctance in data provision.

In conclusion, Step 1 functions as the analytical bedrock upon which the entire collaborative data sharing framework rests. It provides the essential contextual intelligence by deeply understanding the ecosystem's actors and their individual operational realities. Simultaneously, it establishes the strategic clarity necessary to ensure that all subsequent data collection, sharing protocols, and analytical endeavors are purposeful, aligned with quantifiable objectives, and directly responsive to the unique dynamics of the last-mile mobility landscape. An inadequate or superficial execution of this initial phase inevitably leads to misdirected efforts, stakeholder disengagement, and ultimately, a compromised capacity to realize the transformative potential of data-driven collaboration in urban mobility.

6.3.2 Step 2: Boundary Setting and Data Evaluation

Following the initial scrutiny, this step focuses on meticulously defining the boundaries of the collaborative initiative and rigorously evaluating the data at hand, encompassing its scope, relevance, granularity, and format. The insights from Chapter 4.1 and 4.3 revealed that despite aims to utilize standardized interfaces like GTFS, GBFS, and TOMP-API, "individual providers frequently implement the standards in unique ways," leading to practical integration difficulties. Stakeholders commonly highlighted "issues like lack of standards, technical and legal barriers, trust concerns, and limited resources" that hinder current data sharing. The pervasive "restrictive Non Disclosure Agreements (NDAs)" further exemplify the challenges in establishing open data exchange. This empirical understanding directly informs the necessity for robust data governance protocols and clear data sharing agreements, thereby shaping the method framework ology's emphasis on meticulous boundary definition and comprehensive data quality assessment.

The first imperative of Step 2 is to define the clear boundaries and scope of the data sharing initiative. This involves establishing the operational parameters that will govern the data exchange:

- **Geographic Scope:** Precisely delineating the spatial extent of the data collaboration (e.g., a specific urban district, an entire municipality, or a broader metropolitan region). This defines the 'where' of the data relevance.
- **Temporal Scope:** Specifying the timeframes for data collection and sharing, distinguishing between the need for real time data streams, historical archives for trend analysis, or specific periodic snapshots.
- **Modal Scope:** Identifying which last mile mobility modes (e.g., public transport, ride-hailing, micro mobility, logistics, cycling infrastructure) are included in the data sharing ambit.
- **Data Granularity and Aggregation Levels:** Determining the level of detail required for data. This is a critical point where analytical needs must be balanced with privacy

considerations and commercial sensitivities. For instance, is individual trip data necessary (with appropriate anonymization), or will aggregated, zonal-level data suffice for the defined objectives?

Table 9 presents Step 2: Scope Definition and Data Assessment, focusing on setting the geographic, temporal, and modal boundaries of data sharing, balancing data granularity with privacy, and evaluating availability, quality, formats, and governance. The outcome is a clear picture of current data gaps and requirements.

Table 9: Schematic representation of Step 2

Step 2: Scope Definition & Data Assessment
Purpose: Boundary Setting and Data Evaluation
Criteria: - Define Geographic, Temporal, and Modal Scope - Determine Data Granularity and Balance Privacy Description: - Inventory and assess data availability, quality, formats, and governance - Evaluate performance of key mobility services (focus on Public Transport) • Operational Efficiency • Service Quality and Ridership • Coverage and Accessibility
Outcome: Analyze current 'as is' state to align framework with strategic goals, identifying specific data gaps and technological requirements for bridging to desired outcomes in mobility solutions

Following the boundary definition, a comprehensive assessment of existing data assets and their current state is undertaken. This involves a meticulous inventory and qualitative evaluation, directly addressing questions such as: "Do you have data?" and "Where is it missing or incomplete?" This diagnostic process critically examines:

- **Data Availability and Access:** Identifying which stakeholders currently collect, possess, or control relevant data, and assessing the existing mechanisms, or lack thereof, for accessing this information. This probes the current state of data silos.
- **Data Quality and Reliability:** Evaluating the accuracy, consistency, completeness, and timeliness of available datasets. Poor data quality can undermine even the most sophisticated analytical efforts, leading to erroneous conclusions and distrust among collaborators. This analytical step is further informed by the insights from Chapter 5, which underscore that the quality and accuracy of data are crucial for optimal results, as poor data can undermine even the most sophisticated efforts (UITP, 2021).
- **Data Formats and Interoperability:** Ascertaining the current formats in which data is stored and exchanged (e.g., proprietary formats, common industry standards like GTFS, GTFS-RT, or MDS). This identifies the technical challenges related to data harmonization and integration, which are crucial for enabling seamless analysis across diverse sources.

- **Data Ownership and Governance:** Clarifying existing agreements (or the absence thereof) regarding data ownership, usage rights, and responsibilities. This unveils potential legal or contractual hurdles to data sharing.

A particularly salient analytical component of this step, stemming from the initial objectives, is the performance assessment of key mobility services, specifically focusing on public transport (PT), as indicated by "public transport how does it perform?" This involves leveraging any existing data or reports to establish baseline performance metrics. This can include:

- **Operational Efficiency:** Metrics such as on-time performance, average speeds, vehicle utilization rates, and operational costs.
- **Service Quality and Ridership:** Data on passenger waiting times, service frequency, passenger load factors, customer satisfaction, and overall ridership trends.
- **Coverage and Accessibility:** Analyzing where PT services exist and, critically, "where it doesn't exist" or performs inadequately. This identifies spatial and temporal service gaps in last-mile connectivity.

This detailed performance analysis provides crucial empirical evidence for the "Score" phase. It quantifies existing challenges and validates the necessity of data driven interventions aligned with the objectives defined in Step 1. The insights gained from this comprehensive data landscape assessment highlighting data availability, quality, format, and the performance of existing services form the analytical basis for understanding the current 'as is' state. This informs the subsequent identification of specific data gaps, technological requirements, and the overarching needs that the collaborative framework must address to bridge the chasm between the current reality and the desired future state of last mile mobility.

6.3.3 Step 3: Current State Evaluation: Quantifying Gaps and Performance Baselines

Following the comprehensive understanding of stakeholder dynamics and the detailed assessment of the existing data landscape (as elaborated in preceding sections), the framework proceeds to a critical Current State Evaluation phase. This step rigorously synthesizes the insights derived, quantifying existing deficiencies and establishing performance baselines to inform subsequent solution design. It fundamentally addresses the 'score' of the current operational and data environment, translating qualitative observations into actionable findings. Organize stakeholders into categories and subgroups that are likely to share similar perspectives. Generic categories previously highlighted can be used. This level of differentiation is crucial, as it makes stakeholder identification more meaningful and detailed, enabling decisions on their materiality and potential next steps. At this stage, focus only on general groups (Krick et al., 2005).

Many stakeholder groups may fall into multiple dimensions and can be positioned in the overlapping areas of these categories. A stakeholder map is not meant to be analytically exhaustive; rather, it is a tool to illustrate the spectrum of stakeholders and aid in developing an engagement plan. All the stakeholder groups will be included at this stage, even if the current relations are not strong or if they might be unwilling to engage. The stakeholder map is expected to be evolved throughout the engagement process as we gain deeper insights into the stakeholders (Krick et al., 2005).

Each type of stakeholder is vital to the project's success. Despite their importance, there is often a lack of clarity regarding stakeholder types and identifying the ideal candidates. Bittner and Spence recommend involving stakeholders by first identifying their different types, which are defined by factors such as problem domain, environment, and organization. Evaristo et al. emphasize the need for stakeholder classification to optimize performance in managing distributed software projects. Stakeholder types can be seen as groups of individuals sharing common attributes relevant to the project context (Ballejos & Montagna, 2008).

In the process of assigning stakeholder roles, it's critical to associate as many roles as possible with identified stakeholders. This association helps in eliciting crucial requirements that may otherwise remain undiscovered until late in the project. The roles are tied to each stakeholder's specific responsibilities and participation, guiding their influence on the project's outcomes. Moreover, selecting stakeholders involves rigorous analysis of criteria across various dimensions, ensuring that chosen individuals align with the project's needs and characteristics. The task requires a thorough understanding of organizational and interorganizational dynamics, project structure, and availability of Human Resources Information Systems (HRIS) to facilitate the selection process effectively (Ballejos & Montagna, 2008).

This phase is dedicated to a rigorous synthesis of insights to quantify existing deficiencies and establish clear baselines through the establishment and evaluation of Key Performance Indicators (KPIs). The findings from Chapter 4.1 on "Stakeholder objectives" clearly indicate that the "current data sharing process for last mile mobility initiatives is widely perceived as not fully effective," with a "lack of a unified framework for managing and sharing data" among stakeholders. Furthermore, insights from Chapter 4.2 on "Conflict insights" identified early warning signs of collaboration stalling, such as "lack of willingness to engage" and "unresponsiveness in meetings." These empirical observations directly inform the necessity to establish relevant KPIs and for comparing current performance against desired targets, transforming qualitative observations into tangible evidence of the collaborative and data-sharing challenges that the framework must address.

To effectively address the challenge of stakeholder differentiation and engagement, will be leveraged insights from the previous steps to categorize stakeholders into groups with similar levels of challenges or comparable goals. This approach aims to enhance clarity and precision in stakeholder identification, making it a more meaningful process. By utilizing these strategies, stakeholders are grouped according to shared challenges or goals, optimizing their contribution toward achieving collective objectives.

Table 10 summarizes Step 3: Current State Evaluation, which uses stakeholder categorization and KPIs (efficiency, service quality, accessibility, environmental impact) to quantify performance gaps. This provides measurable evidence of deficiencies and informs targeted interventions for last mile mobility improvements.

Table 10: Schematic representation of Step 3

Step 3: Current State Evaluation
Purpose: Rigorous synthesis of insights to quantify deficiencies and establish baselines for solution design
Stakeholder Categorization Key Performance Indicators (KPIs): Operational Efficiency, Service Quality, Passenger waiting times, service frequency, customer satisfaction, Environmental Impact Emissions reductions, energy consumption Compare current performance with desired KPI targets from Step 1.
Outcome: - Provide quantifiable measures of existing challenges and performance gaps. - Inform the design of targeted interventions aligned with identified gaps to enhance last-mile mobility. - Ensure that stakeholder contributions are optimized towards achieving collective objectives, leading to measurable improvements.

A central component of this phase is the establishment and evaluation of Key Performance Indicators (KPIs). Drawing upon the data assessed, baseline values are determined for critical metrics relevant to the last mile mobility objectives (e.g., efficiency, accessibility, environmental impact, user experience). For each identified KPI, a rigorous comparison is made between its current performance and the desired targets established in Step 1. This comparative analysis explicitly addresses whether current "KPIs are performing well or poorly," providing a quantifiable measure of the existing challenges and highlighting specific areas requiring strategic intervention. This assessment transforms qualitative observations into tangible evidence of performance gaps.

- **Operational Efficiency:** Includes onvtime performance, vehicle utilization rates, and average speeds. These indicators assess how efficiently transportation modes are operating.
- **Service Quality:** Looks at passenger waiting times, service frequency, and customer satisfaction levels, aiming to enhance user experience.
- **Environmental Impact:** Evaluates metrics such as emissions reductions, energy consumption, and sustainability practices, aligning with broader environmental goals.
- **Accessibility and Coverage:** Focuses on service reach, areas of coverage, and the convenience and connectivity provided to users, ensuring that mobility solutions are inclusive and comprehensive.
- **Safety and Reliability:** Considers the frequency of incidents, maintenance response times, and feedback on perceived safety, ensuring that services meet high safety standards.

In essence, this Current State Evaluation phase serves as the methodical quantification of the problem space. It precisely articulates *what data is missing*, *what analytical capabilities are lacking*, and *how current performance deviates from desired objectives*. The outcomes of this systematic evaluation directly inform the subsequent design of targeted, effective solutions, ensuring that interventions are strategically aligned with the identified gaps and capable of

driving measurable improvements in the last-mile mobility ecosystem. The framework now moves into the strategic design and enablement of solutions. This step, highlights the crucial role of a central, facilitating entity in translating identified needs into tangible actions utilising at the maximum level the isnights from the interviews and the insights from the real world scenarios.

6.3.4 Step 4: Solution Design, Governance, and Implementation Strategy

Upon the rigorous identification of specific data needs and analytical requirements (as detailed in the preceding section), the framework progresses to Solution Design, Governance, and Implementation Strategy. This pivotal phase involves conceptualizing, structuring, and preparing for the deployment of the collaborative data sharing framework. It fundamentally addresses *how* the identified needs will be met, acknowledging the often necessary role of a central orchestrating body.

This pivotal phase involves conceptualizing, structuring, and preparing for the deployment of the collaborative data sharing framework, fundamentally addressing how identified needs will be met. The difficulties encountered in the Zeeland project, particularly in overcoming collective action problems, fostering trust, and integrating data due to competitive interests, directly underscore the necessity for a Central Coordinating Body and robust governance. Interview insights on "Conflict insights" and "Tools and Data Sharing" were paramount, providing direct guidance on building conflict resolution mechanisms and informing the selection of practical solutions for data exchange architectures, technological tools, and standardization initiatives, ensuring the proposed frameworks align with real-world needs and challenges.

Table 11 details Step 4: Solution Design, Governance, and Implementation, emphasizing the role of a Central Coordinating Body. It includes selecting tailored solutions, establishing governance and legal frameworks, and delivering a comprehensive implementation strategy that bridges current gaps to a sustainable future state of data sharing.

Table 11: Schematic representation of Step 4

Step 4: Solution Design, Governance, and Implementation
Purpose: Translate identified needs into strategic, actionable solutions
Central Coordinating Body: • **Role:** Overcomes collective action problems and builds trust. • **Function:** Facilitates solution selection and customization, formalizes agreements, and provides support for stakeholders. • **Company's Solution Catalogue (in the absence of a Central Coordinating Body):** • **Role:** An internal strategic guide for a company's data sharing efforts. • **Function:** Outlines potential technical, operational, and legal solutions to streamline collaborations.

Outcome:
- Deliver a comprehensive implementation strategy detailing solutions, governance structures, and operational frameworks.
- Strategically bridge gaps from the current data landscape to the desired future state of last mile mobility.

This step typically recognizes the critical function of a **Central Coordinating Body**.

A collaborative platform can be created to apply new digital tools to critical urban domains like mobility, public space, and housing. This type of ecosystem aims to contribute to the intelligent and sustainable design of cities, ultimately enhancing urban environments. By bringing together a diverse range of stakeholders, including governments, businesses, and knowledge institutions, these platforms foster a collective approach to addressing complex urban challenges. In its operational capacity, such a platform actively facilitates stakeholder collaboration with a strong emphasis on data sharing and digital technology. By promoting the effective use of data and digital tools, the goal is to improve policy development, enhance urban management, and support the creation of more livable and sustainable metropolitan areas.

This entity is instrumental in overcoming collective action problems, fostering trust, and ensuring coherence across diverse stakeholders. Its responsibilities analytically extend to:

- **Facilitating Solution Selection and Customization:** Drawing upon a comprehensive "Solution Catalogue," this body guides the selection of appropriate interventions tailored to the specific needs identified. This catalogue is not merely a list of off-the-shelf products but represents a repository of potential strategies, technologies, and operational models for data sharing. These might include:
    - **Data Exchange Architectures:** Deciding on centralized data platforms, decentralized peer to peer exchanges, or hybrid models.
    - **Technological Solutions:** Identifying specific software, APIs, or data management tools required for data ingestion, processing, storage, analysis, and visualization.
    - **Standardization Initiatives:** Promoting or developing common data models and formats (e.g., establishing "NOA Standards" or adapting existing industry wide protocols) to ensure interoperability and semantic consistency across diverse stakeholder datasets. As established in Chapter 5, a significant barrier to effective collaboration is the lack of a unified data standard (Montero-Pascual, Finger, & Serafimova, 2022).
    - **Analytical and Simulation Capabilities:** Providing or endorsing tools for "simulation" and "evaluation" that allow stakeholders to model the potential impact of data sharing scenarios, assess the effectiveness of proposed interventions, and forecast future mobility trends. This supports evidence based decision making and de risks deployment.

- **Establishing Robust Governance and Legal Frameworks:** A cornerstone of sustainable collaboration is the development of clear, enforceable agreements. The Central Coordinating Body plays a critical role in formalizing these through:
    - **Framework Agreements:** Developing overarching legal instruments (Memoranda of Understanding, Data Sharing Agreements) that delineate the terms of engagement, data ownership, access rights, permitted uses, and dispute

resolution mechanisms. These agreements provide the necessary legal certainty and build trust.
    - **Non-Disclosure Agreement (NDA) Standards:** Establishing standardized protocols and templates for NDAs, particularly for commercially sensitive or proprietary data, ensuring that confidentiality is maintained while enabling controlled data exchange.
    - **Contact Protocols and Communication Channels:** Defining clear lines of communication and points of contact to streamline information flow, facilitate problem-solving, and ensure ongoing engagement among all participants. This operationalizes the collaborative network.

- **Capacity Building and Support:** This phase also implicitly includes strategies for empowering stakeholders. The Central Coordinating Body may facilitate knowledge transfer, provide training on new tools or standards, and offer technical assistance to ensure all participants have the necessary capabilities to engage effectively in the data-sharing ecosystem.

The analytical output of this phase is a comprehensive implementation strategy that details not only *what* solutions will be adopted but also *how* they will be governed, *who* will be responsible, and *what legal and operational frameworks* will underpin the collaborative effort. This structured approach to solution design, heavily informed by the needs identified previously, ensures that the proposed interventions are not arbitrary but are strategically targeted to bridge the gap between the current data landscape and the desired future state of last-mile mobility, thereby laying the groundwork for effective and sustainable data collaboration.

Assessing a project's complexity is crucial for determining the appropriate level of governmental engagement. For straightforward projects that adhere to standard practices, extensive involvement from governmental bodies might be unnecessary; established protocols are often sufficient to ensure effective collaboration. However, complex projects, involving numerous stakeholders and demanding intricate coordination, greatly benefit from governmental oversight. In such cases, leveraging governmental bodies provides essential integration capabilities and governance, ensuring diverse needs are met efficiently. This differentiated approach allows for a tailored engagement strategy and optimal resource allocation, striking a balance between operational simplicity and comprehensive project governance.

6.3.4.1 Company's Solution Catalogue: Driving Collaboration in the Absence of a Central Coordinating Body

If a Central Coordinating Body does not exist or is not a participant, a company must still develop its own Solution Catalogue to guide its collaborative efforts. This catalogue serves as an internal strategic document that outlines potential technical, operational, and legal solutions the company can use to engage in data sharing initiatives. It is a critical tool for ensuring the company is prepared to enter a collaboration, knows its capabilities, and can advocate for its specific needs and preferred solutions.

This internal catalogue should detail a range of pre approved or "ready to deploy" data exchange architectures and technological solutions that align with the company's business model and security protocols. For example, it might outline the company's preferred APIs for

real-time data exchange, specify which data standardization initiatives it supports (e.g., General Transit Feed Specification), and list approved data management tools. It should also include templates for legal agreements, such as NDAs and data sharing agreements, to streamline the formalization process with partners. Having this catalogue in place allows the company to move quickly and confidently when opportunities for collaboration arise, without having to design a new solution from scratch for every potential partnership.

The company's solution catalogue should also incorporate a clear implementation strategy that details its internal capacity building needs. This could include a plan for training staff on new data tools, a budget for necessary technological upgrades, and a list of key personnel responsible for managing data-sharing projects. This proactive preparation ensures the company is a ready and capable partner, which can be a key competitive advantage in a complex and rapidly evolving urban mobility market. The development of this catalogue effectively shifts the responsibility of solution design and governance from a central body to the company itself, empowering it to drive collaborations on its own terms and ensure its contributions are both strategic and secure.

6.3.5 Step 5: Feedback

Integrating stakeholder feedback effectively begins at the very start of the project. In the initial phase, it is crucial to establish clear communication about how the feedback process will work. By setting explicit expectations early on, stakeholders are informed about the methods and timing of data collection, which not only fosters transparency but also lays the groundwork for a collaborative environment. This early engagement builds trust and ensures that everyone understands their role in contributing valuable insights throughout the project lifecycle.

A diverse mix of feedback channels is essential for capturing a comprehensive range of insights. Utilizing both qualitative methods, such as interviews, focus groups, and workshops, alongside quantitative tools like surveys ensures gathering rich, multilayered data. Qualitative inputs provide in depth perspectives on stakeholder sentiments, while quantitative measures offer objective data points. This combination allows for triangulating information, making it easier to identify common trends and nuanced issues that might otherwise be overlooked. During the implementation phase, the ability to capture feedback in real time is particularly valuable. Establishing digital platforms or dedicated applications allows stakeholders to report observations or issues as they occur. This immediacy in receiving feedback enables the project team to make quick adjustments, potentially preventing minor issues from escalating into major problems. Real time feedback supports a dynamic and responsive project environment, where continuous improvement is an inherent part of the process.

In this step, the focus is on evaluating the methods and activities adopted during the stakeholder engagement process. This assessment is critical as it determines the effectiveness of the strategies employed and identifies areas for improvement. The evaluation involves collecting and analyzing feedback from stakeholders to understand their experiences and perceptions. Tools such as surveys, interviews, and focus group discussions may be employed to gather qualitative and quantitative data. The overall aim is to create a feedback loop that informs future engagement efforts, ensuring that they are more aligned with stakeholder needs and expectations (Jaanso, 2019).

Once feedback is collected, standardizing the process of aggregating and categorizing it becomes vital. By developing a clear, standardized framework to sort feedback into logical themes, such as operational challenges, communication barriers, or technological issues, it can be identified which areas require immediate attention. This structured analytical approach facilitates the prioritization of actions based on factors like impact, urgency, and feasibility, ensuring that the most critical issues are addressed promptly and effectively.

Following the assessment, it is essential to respond to the results obtained. This step emphasizes taking actionable insights from the assessment to enhance engagement activities in real time. By reacting to feedback promptly, organizations can demonstrate their commitment to stakeholder needs and improve trust and collaboration. This could involve modifying engagement approaches, addressing concerns raised by stakeholders, and communicating changes made as a result of their feedback. This proactive stance not only fosters a culture of continuous improvement but also strengthens the relationship with stakeholders (Jaanso, 2019). Closing the feedback loop is also essential for maintaining and strengthening stakeholder trust. After analyzing the data, communicating the outcomes and subsequent actions back to stakeholders demonstrates accountability and respect for their contributions. This transparent communication not only affirms that their input is valued and acted upon but also encourages ongoing engagement.

Feedback is integrated as a continuous and vital component throughout the framework, designed as a dynamic mechanism embedded in every stage of stakeholder engagement. This approach is strongly informed by the ongoing nature of the Zeeland project and the real-time insights gathered from the interviews, which highlighted the necessity for constant responsiveness to evolving needs and challenges. Interviewees frequently expressed the need for adaptive approaches in complex, dynamic environments, directly underscoring that a static framework would fail to account for real world shifts. This emphasizes the critical role of continuous feedback loops in ensuring the framework 's flexibility, its capacity to evolve based on lived experiences, and its sustained real-world relevance and impact.

6.3.5.1 Feedback Integration Points:

Throughout Stakeholder Engagement (Step 1): The primary purpose of this initial phase is to continuously gather stakeholder feedback. This ensures that objectives remain aligned and are refined according to real-time insights from all parties involved. To achieve this, regular feedback sessions or surveys are implemented, specifically designed to capture stakeholder concerns, priorities, and any suggestions they may have for improvement. This ongoing and active engagement is crucial for tailoring strategies effectively, ensuring they consistently meet the evolving needs of the stakeholders.

Figure 7 illustrates the feedback integration points across all four steps of stakeholder engagement. It shows how feedback is gathered continuously during stakeholder identification, used to validate data in the assessment phase, applied to refine KPIs in the evaluation stage, and incorporated through pilot tests and trials during solution design and implementation. Feedback loops at each stage ensure ongoing alignment, adaptability, and continuous improvement throughout the project lifecycle.

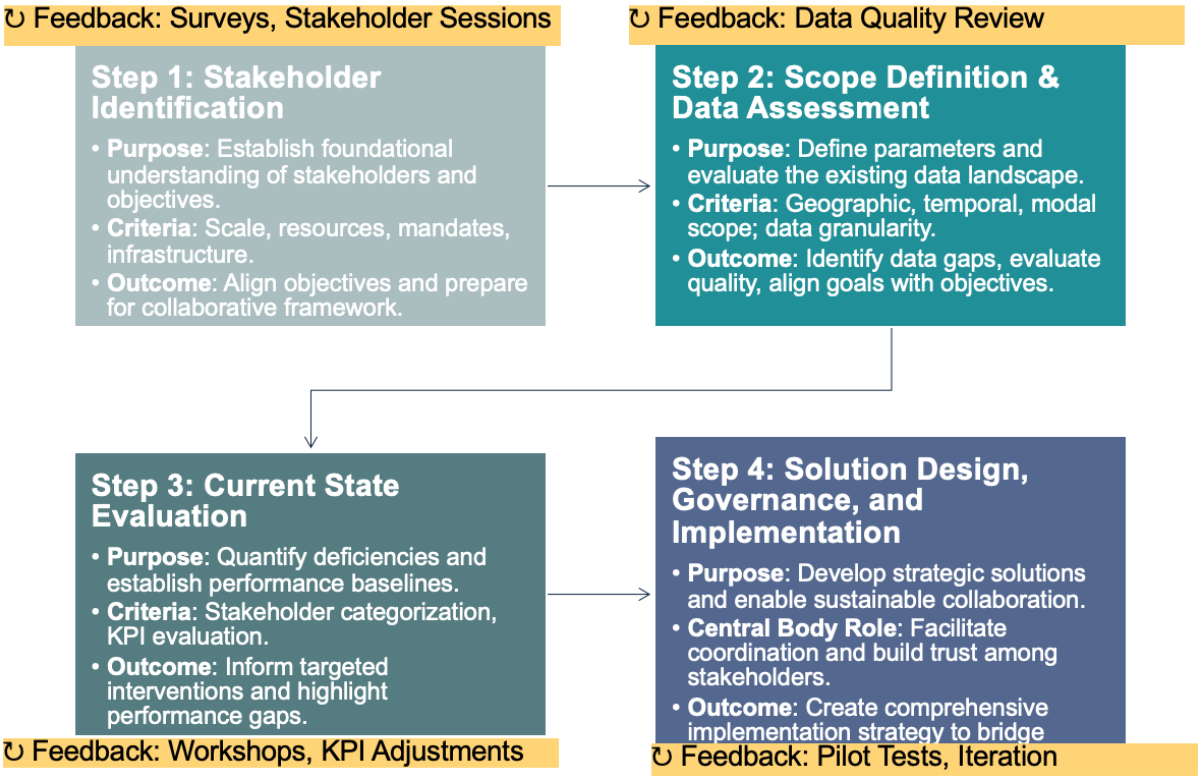

Figure 7: Feedback Integration Points

Post Data Assessment (Step 2): At this stage, the core focus shifts to validating the accuracy and adequacy of the collected data, specifically in alignment with the identified stakeholder needs. Feedback mechanisms are critically employed here to pinpoint any additional data requirements that may emerge and to identify areas where the quality of existing data might need enhancement. The input received during this phase is vital for adapting scope definitions as necessary, ultimately ensuring that any data driven decisions made are robust, comprehensive, and well-supported by reliable information.

During Current State Evaluation (Step 3): The aim of this phase is to adjust Key Performance Indicator (KPI) settings and evaluations based on the insights directly derived from stakeholders. Workshops or focused discussions are conducted to ensure that the chosen KPIs remain relevant, realistic, and truly reflective of the project's evolving goals. This ensures a strong alignment between performance metrics and strategic objectives, which is essential for facilitating accurate assessments of progress and guiding targeted interventions where they are most needed.

Throughout Solution Design, Governance, and Implementation (Step 4): In this comprehensive phase, the central purpose is to verify that the strategic solutions being developed effectively meet the diverse needs of all stakeholders. To achieve this, various feedback mechanisms, such as pilot tests and trial runs, are meticulously set up with active stakeholder participation. This direct involvement allows for a thorough assessment of the solution's effectiveness in a practical context. The insights gathered during this critical stage are vital for refining approaches and ensuring that the implemented solutions are both practical and impactful in addressing the identified challenges.

Implementation Feedback Loops: Feedback loops are strategically established at each stage of the project, creating continuous and iterative points of engagement for all stakeholders. These loops are designed to enable stakeholders to regularly and effectively communicate their observations, experiences, and any emerging issues. This structured approach ensures that the framework remains dynamic, highly responsive to changing conditions, and consistently aligned with real-world relevance. Ultimately, this robust feedback structure fosters a culture of agility and promotes continuous improvement across all stages of the project lifecycle.

After systematically following the proposed framework, we move beyond a vague understanding of fragmentation to a concrete, evidence based analysis of the specific data and collaboration challenges within the last mile ecosystem. The framework serves as a foundational tool, providing a clear and structured way to identify stakeholders, map their data assets, and articulate their core objectives and motivations. This process leads to a precise articulation of the problem, highlighting the specific barriers whether technical, legal, or organizational that have hindered effective data sharing.

The primary outcome of this chapter is not a theoretical model, but a practical blueprint that stakeholders can use to address their unique challenges. The framework's sequential steps provide a clear guide for implementation. It shows how to transition from reactive, ad hoc interactions to a proactive, systematic, and ultimately strategic approach to stakeholder engagement. By creating a structured process, the framework enables all parties to collaboratively develop solutions that are tailored to their specific needs, fostering greater trust and a shared sense of purpose.

Furthermore, the framework provides a strategic roadmap specificially a step plan for action. By guiding stakeholders through a structured process of identifying their data assets, clarifying their objectives, and understanding their barriers, it outlines specific, tailored solutions. These solutions such as a standardized API or a joint governance committee are designed to move a fragmented mobility landscape toward a cohesive and integrated ecosystem, fostering greater cooperation and unlocking shared value.

7. Testing of the Developed Framework

The objective of the framework validation was to move beyond theoretical development and establish the practical utility and feasibility of the proposed governance model. The overall outcome indicates that the Collaborative Data Sharing Framework is operationally feasible and procedurally robust for governing last mile data exchange, offering a clear methodological structure where previously none existed.

This chapter presents the validation of the proposed collaborative methodology through a practical application. The framework, developed in Chapter 6, was designed to address the data sharing and collaboration challenges identified through interviews and in the Zeeland case study. To demonstrate its real world utility, the framework was applied to the existing Siemens Mobility Demand Responsive Transport (DRT) project in Zeeland. This application followed the framework's principles, with some adjustments to account for the complexities of a real world project. This section outlines the validation process and the results achieved when the framework was partially implemented.

7.1 Detailed Application of the Framework in Zeeland

The framework's implementation was not about replacing existing systems but about integrating them more effectively to unlock new potential. As many core components were already in place, the methodology served as a tool for analytic fine tuning and optimization, allowing stakeholders to go beyond the basics and achieve a new level of success.

Step 1: Foundational Scrutiny of Context

In alignment with the first step of the framework, it can be inferred that the project began with a comprehensive customer discovery phase which validated the necessity of early stakeholder alignment. This inference is based on the highly specific nature of the tender, which would have necessitated the gathering of significant information to precisely define the existing transport problems in the region. This phase likely involved a series of structured interviews with various stakeholders, including regional authorities, local transport operators, and community representatives. Through this direct engagement, the team would have gained a nuanced understanding of the customers' true objectives and specific needs, such as the low utilization of existing public transport and the need for more flexible travel options.

Siemens' role in this ecosystem was clearly defined as the provider of the technological platform for managing the DRT service. This meant their initial customer discovery was focused on understanding the technical and operational requirements of the project partners, rather than the end users. The core objective of the overall DRT project, however, was a broader initiative to offer an optimized transport solution. This was aimed at encouraging more people to use a single shared vehicle, directly addressing the significant issue of low public transport ridership and promoting more sustainable travel habits.

The main application in this project is the "Reizen door Zeeland" (Traveling through Zeeland) app, which serves as the user interface for the public transport system across the Zeeland province in the Netherlands. It's designed to bring all travel options into a single, seamless platform. The app's primary function is to integrate traditional public transport with the new Demand Responsive Transport (DRT) service, called "De Flex." This allows users to easily plan multimodal trips, view real-time information, and access the flexible transport on demand.

The ultimate goal is to enhance accessibility, especially in rural areas and during off-peak hours (evenings and weekends), where fixed route services are often limited or non-existent.

The application's core function is the management and operation of "De Flex," which is a flexible, on-demand transport service using small buses or taxis. Instead of relying on a fixed timetable, a traveler uses the app to book a ride (Flex-rit) between a dedicated hub or, outside of urban areas, for door to door service. The app's dynamic routing engine calculates the most efficient route and time, often pooling multiple travelers going in the same direction. In addition to booking, the app provides a full range of travel planning features, including timetables for all public transport, the location of "Flex" pick up points (hubs), and the ability to pay directly for the "Flex" ride. This creates a more personalized and flexible public transport experience that aims to be as convenient as using a personal car.

Siemens Mobility is the central technology partner engaged in delivering the digital solution for this project. Their involvement, through their subsidiaries, focuses entirely on the sophisticated software that powers the entire system. Siemens provides the Demand Responsive Transport (DRT) System and the underlying Mobility as a Service (MaaS) components. This includes the development of the smart travel planner and the efficient booking system that forms the technical foundation of the "Reizen door Zeeland" app. By supplying this advanced digital platform, Siemens is crucial to the successful roll out of "De Flex," ensuring the platform can effectively manage up to 10,000 rides per day after full deployment and transform Zeeland's public transport into a flexible, integrated network.

A critical and explicit objective that emerged from the tender phase was to integrate regular public transport with various dedicated transport services for different user groups. The project's goal was to combine these services including those for people with disabilities and youth care, among others while maintaining the high quality of service for each group. By doing so and leveraging the Siemens DRT Dispatching software, the project could achieve a better grouping rate of passengers and reduce the overall number of vehicles. This strategic integration makes DRT a viable and sustainable service for the province and its municipalities by lowering the overall cost of ownership. The project's commitment to this goal became a central pillar of the solution, demonstrating how a detailed problem definition, guided by stakeholder input, can lead to more inclusive and impactful outcomes.

Step 2: Data Mapping and Technological Integration

The project’s second step, which focused on establishing clear operational boundaries, required a highly adaptive application of the framework. A significant number of separate requirements were part of the solution to account for these boundaries, all to meet the ambitious goal of integrating these services for the first time in the Netherlands. For this, a great deal of pre-discussion had to be held with multiple stakeholders. However, talks during the execution and implementation phase revealed that the team still had to improve the solution for the initial goals to be met. The key lesson learned here is that a boundary cannot be stated SMART enough from the outset. This was a crucial phase for transforming vague aspirations into concrete project specifications, a task made challenging by the numerous variables involved in a new mobility service.

To understand the full scope of the project, the team considered all relevant factors. This involved detailed inquiries into operational boundaries, such as geographical service areas and hours of operation, as well as desired functionalities of the platform, including booking and routing capabilities. The team also had to prepare for potential change requests, as the dynamic nature of DRT services meant that initial requirements would likely evolve. This foresight was essential for building a flexible and resilient solution that could adapt to future needs without compromising service quality.

To support this broad analysis, the team gathered both operational and dynamic traffic data. This was a data intensive effort that required collaboration with a subcontractor to collect and analyze the information. This data served as the basis for modeling and simulation, allowing the team to test different operational scenarios and refine the boundaries of the service. The central goal of this step was to at least maintain the existing quality of the transport service while simultaneously improving overall operational conditions, a clear benchmark for success that was defined through a combination of stakeholder input and data analysis.

The initial difficulties in defining boundaries "SMART enough" tangibly validated the framework's core function in governing data quality and boundary definition. The framework's mandated, data-intensive modeling phase empirically proved that data quality is directly dependent on precise operational and geographical boundaries. By forcing the team to confront and refine these definitions through iteration, the framework acted as a necessary procedural tool, ensuring the quality of the incoming operational data was sufficient to meet the stated performance benchmarks. This confirms the theoretical importance of formalized governance in translating vague stakeholder aspirations into precise, reliable data requirements.

Step 3 & 4: KPI Identification and Solution Selection

Consistent with the framework, the project proceeded to identify key performance indicators (KPIs) before selecting a solution. The primary operational KPIs were focused on maintaining high levels of service availability and quality, ensuring that the DRT service was reliable and met the expectations of its users. These included metrics such as on time performance, vehicle utilization rates, and the number of successfully completed trips, all essential for gauging the operational health of the new service while reducing the number of vehicles to lower the overall cost of ownership

Concurrently, the project explicitly considered customer centric KPIs. This involved specifically measuring user satisfaction with the precision and consistency of the application that handles all service data, from booking to real time tracking. Metrics like app ratings, user feedback scores, and the number of support inquiries related to the application were monitored to ensure a positive user experience. This dual focus on both operational efficiency and customer satisfaction was a key strength of the project, ensuring that the solution was not only technically sound but also aligned with the needs and expectations of the end-users.

Following a thorough analysis of all requirements and KPIs, the Siemens team proceeded by selecting a suitable solution from their internal solution catalogue. This catalogue offers a range of pre-vetted solutions, and based on the analysis, a solution could be adopted with minor modifications. This approach minimized development time and risk by leveraging existing, proven technology. However, if no suitable option was found, the project could have been discontinued, demonstrating a pragmatic and risk averse approach to solution implementation

based on a rigorous, data driven analysis. The balance achieved between operational efficiency and customer satisfaction tangibly validated the framework's hypothesis that value driven design requires a structured KPI phase prior to selection. By imposing this balance, the framework empirically proved its ability to mitigate the risk of prioritizing only cost reduction metrics, ensuring the solution remains holistically aligned with the needs of both the public and private partners.

Step 5: Iterative Refinement and Scalability

The final step of the methodology, focused on feedback and continuous improvement, was implemented through a robust system of constant feedback loops. The project established a schedule of weekly meetings to collect and review feedback from all stakeholders, including Siemens' internal teams, project partners, and transport operators. This regular, formal process ensured that any issues or opportunities for improvement were identified and addressed in a timely manner, preventing minor problems from escalating into major project risks.

Operational and customer centric KPIs are also continuously monitored to track the project's ongoing performance. This real time data provided a quantitative measure of the service's health, complementing the qualitative feedback gathered in the weekly meetings. By comparing actual performance against the established KPIs, the team could make data informed decisions to optimize routing, adjust fleet size, or fine tune other operational parameters, ensuring the service remained efficient and effective. This structure empirically confirmed that formalized feedback loops which translate both qualitative stakeholder input and quantitative KPI data into actionable adjustments are critical for establishing a self correcting and enduring data sharing ecosystem.

7.2 Conclusion and Future Work

A key insight from this project is that even when not followed rigidly, the proposed methodology consistently improved the situation. This demonstrates the framework's adaptability and robustness in a real world environment. This organic, albeit non linear, progression led to smoother and more efficient data exchange and a more collaborative working environment. A key aspect of this data exchange is Siemens' commitment to sharing data in a specific format, the TOMP API, as suggested by the European Investment Bank. This practice is also extended to sharing data with the main governmental body, reinforcing a structured and open approach to data collaboration that ultimately contributes to the overall success of the project and the broader transport ecosystem.

Despite Siemens already implementing some of the steps outlined in the developed framework, and only partially applying others, the framework's structured approach enhanced the entire process. Its partial application in the Zeeland project demonstrates its significant value in improving collaboration and data sharing in last mile mobility. The framework provided a clear structure that allowed stakeholders to move beyond informal, ad-hoc interactions and engage in a more analytical, results driven process. The framework's utility lies not in its full, rigid application, but in its ability to serve as a guiding blueprint that, even when partially adopted, substantially increases operational efficiency and improves cooperation. This partial, implementation in Zeeland proves that the framework is a powerful tool for addressing the fragmented nature of urban mobility, paving the way for more effective and sustainable solutions.

The project demonstrated that the framework's partial application still yielded positive outcomes, a sentiment shared by those involved. Stakeholders came to believe that the framework's primary value was in providing a structured, systematic way to think about collaboration. They found it an efficient tool for optimization, enabling them to move beyond basic operational requirements and achieve a further level of success. This perspective highlights that the framework's strength lies in its conceptual guidance, which even when selectively applied, catalyzes a more analytical and results oriented approach to project implementation. The key finding is that the framework acts as an effective governance tool that injects structure into fragmented operational environments. This confirms that the solution to the systemic governance deficit lies in adopting formalized, analytical procedures for collaboration, transitioning the thesis from theory to practical proof.

The feedback from specialists at Siemens, confirms that the framework improves the existed situation because it addresses and resolves key systemic flaws in their existing collaboration process. The specialists reported that the framework indeed worked and improved the project situation by tackling the conflict prone, ad-hoc nature of previous interactions. The improvement was achieved primarily by mandating a value driven approach. This forced the team to move beyond a narrow focus on cost efficiency (like maximizing vehicle utilization) and instead compelled them to define a holistic set of Key Performance Indicators (KPIs). By requiring commitment to both operational efficiency and customer satisfaction (e.g., measuring app ratings alongside on-time performance), the framework validated its ability to drive a balanced, partnership focused, and ultimately more successful outcome.

The specialists further highlighted that the framework improved the data sharing situation by enforcing a structured, formalized procedure where ambiguity had previously caused issues. To govern the collaboration, the framework demanded the institutionalization of clear, procedural mechanisms for data exchange. This required the Siemens team to commit to sharing data using a standardized data format (the TOMP API) with the main governmental body. This commitment to standardization replaced vague agreements with a clear, reliable data exchange commitment. This act of formalization enhanced trust, ensured data compatibility, and empirically confirmed the framework’s ability to establish a robust, reliable, and self-correcting data ecosystem for the last mile mobility project.

The Collaborative Data Sharing Framework’s primary role is to transition last mile projects from fragmented, ad-hoc interactions to a cohesive, analytical, and results oriented process. It achieves this by instituting mandatory governance steps for aligning diverse public and private interests. By forcing stakeholders to formally define shared objectives, meticulously establish operational boundaries, and agree on precise data quality metrics, the framework reduces ambiguity. The empirical result of this process is a quantifiable improvement in cooperation, data efficiency, and resource allocation, ultimately ensuring that mobility solutions are not only technically improved but also sustainably aligned with the long term strategic goals of all partners.

8. Conclusion and Discussion

The culmination of this research offers a comprehensive and validated perspective on the critical need for a collaborative and data driven Last Mile Transportation ecosystem. The findings from the case study unequivocally demonstrate that despite theoretical acknowledgment of collaboration's value, the current landscape remains deeply fragmented. Stakeholders including city municipalities, private micromobility operators, and public transit agencies continue to operate in informational silos, driven by disparate objectives and often competing priorities (Chapter 4.2). This fragmentation aligns with existing literature on urban mobility partnerships (Mokhtarian, 2013) and is fundamentally rooted in a lack of institutional trust and a reliance on reactive communication protocols.

Data sharing is currently ad hoc and lacks standardized protocols, confirming the knowledge gap identified in the problem statement (Chapter 1.1). Fragmented feedback systems also hinder a holistic understanding of user and stakeholder needs. A key element in overcoming these challenges is fostering a data sharing culture led by strong leadership, which shifts organizations from a compliance-focused mindset to one where data sharing is seen as a means to benefit end users and create value (UITP, 2021). Building trust is essential, requiring continuous consultation and transparent communication to align divergent interests and resolve conflicting objectives (Erkul, Yitmen, & Çelik, 2016). This discussion is also extended by the concept of integrating digital twins, where the dynamic interaction between physical systems and representative data models (Figure 8) creates a continuous feedback loop that promotes a more sustainable and efficient urban mobility ecosystem (EIT Urban Mobility, 2023).

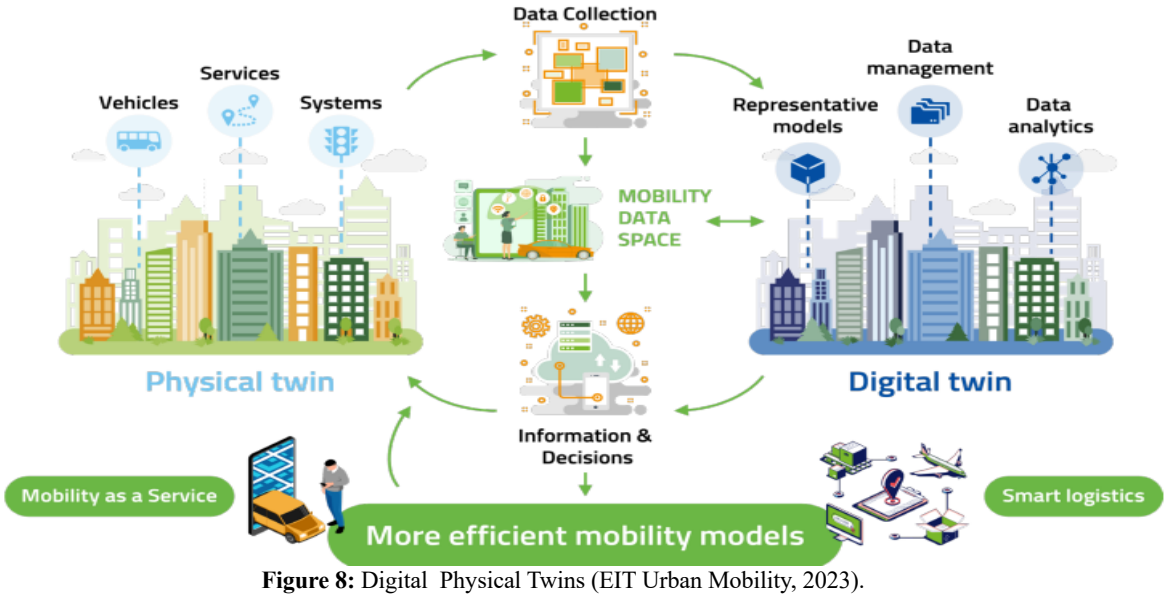

Figure 8: Digital Physical Twins (EIT Urban Mobility, 2023).

The primary goal of this research was to develop a practical framework for collaboration and data sharing among diverse stakeholders. The conceptual framework presented in Chapter 6 is a direct and actionable response to this goal and the case study insights.

The consequences of data fragmentation and unaligned stakeholder interests are the creation of data silos, missed synergies, a failure to align competing objectives, and ultimately, the inability to develop integrated, efficient, sustainable, and user-centric last mile solutions. Mobility data is diverse, including vehicle volumes, travel times, origin-destination information, parking usage, and system/infrastructure data, which are all essential for designing

effective and responsive mobility systems. However, key challenges include the lack of standardized formats and protocols, competitive interests leading to proprietary data protection, and a lack of willingness to share among actors. The research identified that a standardized approach, such as adhering to standards like the TOMP API, is necessary to overcome these barriers.

The development and validation phases provided the final synthesis. A structured framework was developed as a comprehensive, five-step roadmap to overcome fragmentation and facilitate data sharing: (1) Foundational Scrutiny of Context, Stakeholders, and Objectives; (2) Boundary Setting and Data Evaluation; (3) Current State Evaluation and Gap Quantification using KPIs; (4) Solution Design, Governance, and Implementation Strategy; and (5) Feedback. This process integrates diverse stakeholder insights and technological requirements to move beyond ad-hoc collaboration. The framework was applied and tested in a practical case study (the Zeeland DRT project) to validate its effectiveness. This validation confirmed its utility and robustness, demonstrating that even the partial application of the structured approach "consistently improved the situation".

The key elements of a collaborative framework are its five structured and systematic steps, which serve as a governance tool to formally define shared objectives, establish operational boundaries, agree on data quality metrics, and enforce the use of standardized data formats (e.g., TOMP API). The framework's efficacy was made tangible through feedback from specialists involved in the case study, who confirmed that it improved the situation. By replacing conflict-prone, ad-hoc interactions with a formalized, analytical procedure, the framework immediately resolved key systemic flaws. This was achieved by mandating a value-driven approach that defined a holistic set of KPIs and, critically, by enforcing a commitment to standardized data sharing with the main governmental body, thereby enhancing trust, ensuring data compatibility, and empirically establishing a more robust and reliable data ecosystem for last-mile mobility.

The most significant contribution of this research is this conceptual framework, which moves beyond theoretical advocacy to provide a practical, actionable blueprint specifically tailored for the Last Mile Transportation of people.

This study is subject to several limitations that should be considered when interpreting the findings. First, the research is based on a single qualitative case study, which means the insights gathered are context-specific and not fully generalizable to all urban contexts. While the findings provide a foundational model applicable to public private partnerships facing similar data and collaboration challenges, contextual factors such as regulatory differences, company cultures, and technological readiness must be considered for successful adaptation. A further limitation is that the framework’s validation involved a preliminary, non-conforming test rather than a full-scale, rigorous implementation; therefore, these findings should be viewed as indicative rather than conclusive.

Future research should aim to address these limitations. First, a comparative case study involving multiple cities with differing regulatory frameworks would provide a more robust understanding of generalizable challenges. Furthermore, a longitudinal pilot study is highly recommended to rigorously test the proposed framework's effectiveness in a real world setting. This would provide empirical evidence of the framework's ability to foster a more sustainable and integrated Last Mile Transportation system. The successful application of this

methodology will demonstrably improve last mile mobility by facilitating data driven decisions that directly address the pain points of urban commuters.

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Appendix 1: Full Interview Transcripts

The part contains all the questions asked during the interviews. For each question, all of the corresponding answers from each interviewee are provided. For the sake of anonymity, the interviewees are identified only by a number.

Question 1: What are the primary interests or objectives of (your company) when it comes to data sharing in last mile mobility?

(Interviewee 1) At Siemens Mobility, data sharing is seen as crucial for enabling seamless integration across shared mobility and Demand Responsive Transport (DRT) services. Their main objectives are to enhance interoperability, improve service efficiency through the use of real time and predictive analytics, and ultimately deliver a better user experience. By effectively leveraging shared data, Siemens Mobility aims to optimize availability, support smarter operations, and differentiate itself through intelligent, data-driven solutions in the last-mile mobility sector.

(Interviewee 2) In the context of last-mile mobility, Siemens' primary objective for data sharing, beyond their internal collaboration with another company for DRT services where the municipality owns the data, is to align systems better in a general sense. This means understanding trends from other companies, such as scooter providers, to enable Siemens to offer more informed travel advice through MaaS (Mobility as a Service) applications. The overall aim of this collaborative data sharing is to provide a smoother and more seamless experience for the end customer.

(Interviewee 3) The primary interests and objectives regarding data sharing in last-mile mobility focus on facilitating multi-modal travel for passengers, which involves various stakeholders such as government bodies, municipalities, public transport operators, and shared micro-mobility companies. Additionally, a key objective is to align with the city management policies and broader city development goals, involving government, municipalities, and last-mile mobility companies.

(Interviewee 4) Siemens' strategy has shifted from providing closed, siloed solutions that made customers dependent on their products to offering more open solutions, particularly in the software realm. Within last-mile mobility, their products, like the DRT solution, allow all transactions to be exported and queried by the customer. Siemens' primary interest is to provide added value through smart interfaces and algorithms, viewing data sharing as a necessary commodity or a standard functionality within their software for implementing any tool anywhere.

(Interviewee 5) The primary interests revolve around leveraging data sharing to optimize transportation systems and enhance overall efficiency in last-mile mobility. The objective is to facilitate seamless integration across various mobility modes and improve service delivery through data driven insights. By analyzing shared data, the aim is to support smarter operations and ensure a smoother, more effective experience for the end user, aligning with the core principles of transportation engineering and logistics.

(Interviewee 6) From an academic perspective, the primary objective of data sharing in last-mile mobility is the optimization of last-mile services. This aims to enhance the traveler's experience by providing effective demand response applications or transportation systems at

transfer points, ensuring seamless transitions from major transport hubs to final destinations through readily available options like public transit or micro-mobility solutions.

(Interviewee 7) Primarily, as a researcher and educator, our key interest lies in data since data acts as our fundamental resource, or 'oxygen', for research. At Delft and particularly within the Smart Public Transport Lab, most research initiatives are data-driven. We mainly utilize two significant data sources in public transport: AVL (automatic vehicle location data), which is fortunately an open database, and smart card data, which captures origin destination patterns along with passenger boarding and alighting events. Smart card data remains restricted primarily due to privacy concerns and business interests, as companies are hesitant to share commercially sensitive information. This makes it challenging for our research. For last mile mobility, data access is even more problematic data related to walking, cycling, and shared mobility services often demands specialized agreements with private operators, who are generally cautious about sharing due to business sensitivities. Without sufficient data access, our ability to understand user behavior, develop accurate models, and improve the overall transportation system is limited.

(Interviewee 8) As a transportation engineer, my primary objectives for data sharing in last-mile mobility are to enhance the efficiency, sustainability, and safety of the transportation network. This includes optimizing routes to reduce congestion and travel times, and promoting the use of sustainable modes like public transit and shared micro-mobility to lower carbon emissions. I also aim to ensure that data is used to improve accessibility for all users, including those with disabilities, and to support city planning for future infrastructure needs, such as new bike lanes, charging stations, or improved pedestrian walkways.

(Interviewee 9) Our primary objective is to ensure the sustainability of our business and grow our user base. Data sharing, for us, is a tool to achieve this by optimizing our fleet's efficiency, identifying new service opportunities, and improving the overall user experience. While we recognize the value of public private partnerships, our core focus remains on leveraging data to gain a competitive edge and grow our business, thereby ensuring our long-term viability in the market.

Question 2: How effective is the current data sharing process for last mile mobility initiatives, and what are the primary reasons for its shortcomings?

(Interviewee 1) The effectiveness of the current data sharing process for last-mile mobility initiatives varies considerably. The interviewee noted that while some stakeholders engage in open and efficient collaboration, others may become unresponsive or fail to follow through on commitments. These inconsistencies are often attributed to misaligned priorities or a lack of clear commitments among parties, which makes the overall process inconsistent and, at times, challenging to manage effectively.

(Interviewee 2) The interviewee believes the current data sharing process for last-mile mobility initiatives is not effective. This is largely due to companies being highly protective of their data, viewing it as their intellectual property, knowledge, and power. Sharing data can make them vulnerable, as competitors might identify and exploit service gaps. This protectiveness makes data sharing difficult for projects, often requiring restrictive Non-Disclosure Agreements (NDAs) that strictly limit how the data can be used within a specific project context, preventing its broader application.

(Interviewee 3) The current data sharing process for last-mile mobility initiatives is described as "not very effective". While there is a strong desire among parties to increase sharing, taking the initial step proves difficult. The primary reasons for these shortcomings include legal concerns, such as restrictions on sharing sensitive and private user information, and business-sensitive information, to prevent it from leaking to competitors. Furthermore, the general roadmap and the benefits of data sharing are not immediately visible to companies, leading to confusion about how to use the data and the protocols for its processing.

(Interviewee 4) The current data sharing is not entirely effective because local taxi companies, for instance, often lack open software or an incentive to share their data. There's even an incentive against it: if taxi companies, which are paid per van they operate, were to share data with municipalities, simulations might show that 50% fewer buses could be used, thus reducing their earnings. Current contracts and working methods are ingrained, and municipalities or governmental institutions often lack the knowledge or consulting expertise to address this.
(Interviewee 5) Based on my understanding and experiences, the current data sharing process in last-mile mobility initiatives often lacks comprehensive effectiveness. A significant reason for this is the inherent protectiveness organizations have over their data, viewing it as proprietary knowledge. This can create reluctance to share, fearing competitive disadvantages or misuse of sensitive information. Without clear incentives or standardized, secure protocols, the process becomes inconsistent, hindering the potential for broader collaboration and optimization.

(Interviewee 6) Currently, data sharing in this sector is highly problematic. A significant hurdle is the reluctance of public bodies to share data, often requiring extensive non-disclosure agreements. The most crucial shortcomings stem from a lack of reliability and clear incentives for participating entities, particularly public transport advisors. Without transparency and a tangible benefit for their efforts, stakeholders are disinclined to share data.

(Interviewee 7) The current data sharing process is quite ineffective, primarily because the data is mostly owned by private companies. These companies are typically reluctant to share due to privacy concerns and competitive business interests. Additionally, the market for shared mobility services is fragmented and unstable, with multiple providers continually entering and leaving the ecosystem. For instance, in a city like Delft, bike-sharing companies frequently change, leading to a lack of continuity and no consistent long-term data collection. This scattered and continuously shifting landscape makes the accumulation of comprehensive longitudinal data nearly impossible.

(Interviewee 8) The current data sharing process often provides effective, basic operational insights, but it falls short in two key areas: interoperability and standardization. The primary reasons for these shortcomings are a lack of common data formats and protocols across different private companies and public agencies, which makes it difficult to aggregate and analyze data holistically. For example, one company might use a certain file format for ridership data while another uses a different one, making it challenging to combine the two for a comprehensive analysis. Additionally, there are often legal and privacy concerns that create barriers to sharing certain types of data, such as real-time user location information, which is a common point of conflict among stakeholders.

(Interviewee 9) The current data sharing process is often inefficient and costly. The primary reason for this is the lack of standardized protocols across different cities and municipalities. We are frequently required to provide data in unique formats and through different channels

for each jurisdiction we operate in. This forces us to dedicate significant resources to administrative tasks and custom software development, which ultimately drives up our operational costs.

Question 3: Where does the primary responsibility for these ongoing data sharing and collaboration issues in the last mile mobility ecosystem typically lie?

(Interviewee 1) From Siemens Mobility's perspective, they do not believe they are the direct cause of the data sharing and collaboration issues within the last-mile mobility ecosystem. They aim to maintain transparency and cooperation, especially when Non Disclosure Agreements (NDAs) are in place with involved parties. However, the interviewee acknowledged the importance of self reflection and suggested that this research could provide valuable insights into how Siemens Mobility can further enhance its role in the collaboration process.

(Interviewee 2) Pinpointing primary responsibility for data sharing and collaboration issues is challenging, as the interviewee attributes it largely to the inherent competitive structure of the market. Companies protect their data as a self preservation measure, as sharing it might expose vulnerabilities. Therefore, the issue is not about blaming individual companies but rather a consequence of the market's design. The interviewee suggests that better coordination might be a solution, ensuring data is used for collective development rather than cannibalizing other businesses, though acknowledging the difficulty of such coordination.

(Interviewee 3) Responsibility for data sharing and collaboration issues primarily lies with MaaS platforms, and MaaS Information Technology companies and builders such as Siemens Mobility and Rivier, as they are tasked with facilitating communication among stakeholders regarding data sharing. Additionally, municipalities or last-mile mobility companies sometimes initiate contact with each other and with universities for research collaboration projects to explore data sharing possibilities.

(Interviewee 4) The responsibility for data sharing and collaboration issues in the last-mile mobility ecosystem is primarily a "system thing". It involves various governmental layersmmunicipalities, provinces, and the Ministry of Infrastructure and Waterways all of whom have responsibilities related to transport provision. Taxi companies also want to make money. The Ministry, or at least the government, needs to establish governing principles to enable better solutions. Initiatives like DMI, where the Ministry funds pilots and environments for stakeholders to collaborate and share knowledge, are good examples. Ultimately, no one is to blame, but the Ministry has the greatest potential for impact in changing the situation.

(Interviewee 5) I believe the primary responsibility for these data sharing and collaboration issues lies within the systemic structure of the ecosystem itself, rather than with any single entity. It's a complex interplay between various levels of governance, market participants, and their individual objectives. There's a clear need for greater coordination and a unifying framework that can bridge the gaps between commercial interests and public good. Leadership from overarching bodies could be crucial in establishing common principles that facilitate data exchange without undermining individual organizational stability.

(Interviewee 6) The primary responsibility for these issues lies with governmental bodies at all levels national, supra local, and local. Given the increasing involvement of the private sector in transportation, a simple solution would be to implement mandatory data sharing clauses in

public tenders. Any company winning a tender or operating within a defined geographical area should be obligated to provide data using specific protocols. This legislative intervention, along with national initiatives, is seen as the only way to facilitate meaningful change.

(Interviewee 7) Ultimately, the primary responsibility lies with the government. Data sharing and collaboration in last mile mobility are fundamentally linked to societal benefits, such as sustainability, inclusiveness, and efficient urban space usage, rather than purely financial incentives. Since private companies naturally prioritize financial profitability, they generally avoid investing in activities with no clear financial return. Local public transport and micromobility require governmental intervention and financing due to their societal, non-financial benefits. Hence, the effective management and facilitation of data sharing should be viewed as a governmental responsibility. If governments fail to address this need, it is unlikely that private companies will take these initiatives independently.

(Interviewee 8) The primary responsibility for these ongoing data sharing and collaboration issues in the last-mile mobility ecosystem typically lies with the government. Governments are often slow to create and enforce clear, standardized policies for data sharing, leaving private companies to operate with conflicting protocols and without a unified framework. This lack of clear governmental guidance on data formats, security standards, and privacy regulations creates a fragmented system where collaboration is difficult to achieve, ultimately hindering the progress of last mile mobility initiatives.

(Interviewee 9) The primary responsibility for these issues lies with the government. There is a notable lack of leadership and vision from governmental bodies to create a clear, universal framework for data sharing. Instead of developing a single, mandatory standard, they have created a patchwork of conflicting regulations, leaving companies like ours to navigate a complex and fragmented landscape that hinders our ability to collaborate effectively.

Question 4: What are the most frequent points of disagreement or conflicting interests among stakeholders when it comes to implementing last mile mobility initiatives or sharing data?

(Interviewee 1) The most frequent points of disagreement or conflicting interests among stakeholders primarily stem from commercial interests. Many stakeholders operate with their own distinct strategic roadmaps, and collaboration efforts do not always align perfectly with these individual visions. When joint initiatives are perceived as inconsistent with a stakeholder's long-term objectives, it often limits their willingness to share data or fully engage in the collaborative process.

(Interviewee 2) The most frequent points of disagreement or conflicting interests among stakeholders were not explicitly detailed as separate from the broader market structure. However, the interviewee implied that the competitive nature of the market and companies' need to protect their data, as discussed in the answer to question 3, inherently lead to conflicting interests when it comes to sharing data and collaborating on last-mile mobility initiatives. Companies prioritize their strategic roadmaps, and collaboration doesn't always align with their long-term commercial goals, thus creating friction.

(Interviewee 3) The most frequent points of strategic disagreement or conflicting interests among stakeholders are linked to the challenges mentioned in Question 2. These issues make it difficult to establish data sharing as a standard practice within the industry, which

consequently impacts overall project success by hindering the widespread adoption and seamless integration of data sharing protocols.

(Interviewee 4) Two major conflicting interests are identified. The first is between municipalities and local taxi companies regarding DRT or flex traffic. Taxi companies have a wrong incentive, aiming to operate as many vehicles as possible to earn more money, while municipalities face high costs for specific user groups who cannot organize their own mobility. While Siemens' DRT dispatcher could improve service or include public transport with the same budget, local contracts and taxi company incentives currently prevent this. Taxi companies need education and assistance to establish appropriate contract formats for future periods that could become a standard for all municipalities.

(Interviewee 5) The most frequent points of disagreement often stem from fundamental conflicts between individual organizational interests and the broader collaborative goals. Companies naturally prioritize their own strategic roadmaps and profitability, which can clash with the perceived risks or lack of direct benefits from sharing data. This can lead to resistance when implementing initiatives that require high levels of transparency or data exchange, as the immediate commercial implications may seem to outweigh the collaborative advantages.

(Interviewee 6) The most frequent points of disagreement revolve around space allocation and data sharing itself. In last-mile operations, securing space for picking up and dropping off passengers at transfer hubs is a major point of contention among competing service providers. Furthermore, the reluctance to share proprietary data with potential competitors or platforms remains a significant conflict.

(Interviewee 7) The most frequent strategic disagreements stem from conflicting motivations: private companies primarily seek financial gains, whereas governments and society aim at broader societal objectives such as sustainability, space efficiency, and inclusiveness. This fundamental difference in motivation leads to disagreements about who should finance and facilitate data sharing and related initiatives. Companies are understandably unwilling to invest in initiatives without perceiving clear and immediate financial returns, undermining long-term development and innovation. Such conflicting interests directly impact overall project success, limiting investment, innovation, and sustained commitment to shared mobility and data sharing initiatives.

(Interviewee 8) The most frequent points of disagreement or conflicting interests among stakeholders often revolve around data ownership, privacy, and commercial value. Private companies may be reluctant to share proprietary data that they see as a competitive advantage, such as information on their most popular pickup and drop-off locations, or how their routing algorithms work. Public agencies, on the other hand, need this data to effectively manage the public right-of-way and make informed decisions about infrastructure. There are also conflicts over how to ensure user privacy while still collecting enough data to make informed decisions about infrastructure and service planning.

(Interviewee 9) The most frequent points of disagreement revolve around the commercial value and ownership of our proprietary data. We consider our operational data such as our routing algorithms, user demand patterns, and real time fleet analytics to be a valuable asset. Stakeholders often demand access to this information without understanding its commercial importance to our business, leading to conflicts over how the data is used, who owns it, and whether we should be compensated for its provision.

Question 5: What early warning signs or indicators do you look for that signal potential conflicts?

(Interviewee 1) An early and significant warning sign that indicates potential conflicts among stakeholders is a lack of willingness to collaborate, particularly concerning data sharing. The interviewee noted that when this openness is absent from the initial stages of a project or partnership, it typically suggests deeper underlying misalignment or a fundamental reluctance to engage fully, which can foreshadow future disagreements.

(Interviewee 2) Early warning signs of potential conflicts include a lack of responsiveness from collaborators in meetings or very brief, unextensive answers, which indicate that the collaboration might be stalling due to insufficient reciprocal input. Conversely, an overly friendly demeanor from a company can also be a signal, as they might be subtly trying to extract information that conflicts with Siemens' interests without upfront disclosure. However, the lack of openness is the more common indicator. To mitigate this, clear articulation of the shared goal and transparency from the outset are crucial to establish a collaborative, rather than competitive, intent.

(Interviewee 3) In previous collaborations, many conversations were built on existing connections among stakeholders. However, new collaborations are difficult to establish because stakeholders require a very clear indication of all data to be used and its specific purposes. The main indicator of potential conflict, though not necessarily negative, is the need for extensive clarifications to keep the conversation going. If any aspect sounds less safe or presents risks, new partners tend to end discussions quickly, unwilling to invest further budget in exploring solutions if the plan isn't clear from the outset.

(Interviewee 4) Conflicts arise because people are trying to protect what they perceive as their own, fearing they might be taken advantage of. Therefore, a framework or mechanism is needed to divert risks and clearly demonstrate benefits, often requiring "early adopters" to convince others. The interviewee believes that what is heard in one municipality regarding these conflicts will likely be similar in others, suggesting that the industry is already facing a "worst case" scenario for many services, implying that the only direction from here is improvement. However, a risk remains that some services might cease if they don't secure adequate funding or better contracts, especially as budget cuts for transport become more common.

(Interviewee 5) As an analytical professional, I look for several early warning signs that signal potential conflicts. A key indicator is a lack of openness or responsiveness from stakeholders during initial discussions, particularly regarding data requirements. This often suggests underlying reservations or misalignments that need to be addressed proactively. Conversely, an overly eager approach without sufficient clarity on mutual benefits could also raise suspicion. Transparent communication and a clear articulation of shared goals from the outset are crucial to mitigate these potential conflicts.

(Interviewee 6) Initially, a strong negative reaction from service providers regarding data sharing is a clear early warning sign. They often express a desire to understand the exact nature of the collaborative scheme, what each entity will contribute, and what benefits they will receive. Over time, however, as mutual understanding and transparency are established, this

initial negativity tends to relax, and willingness to share some data emerges. The presence of a trusted, guaranteeing "hand-holder" can significantly mitigate these initial conflicts.

(Interviewee 7) One crucial early warning indicator for potential conflicts is the short duration of contracts between companies and governments or municipalities. Short term contracts, such as those lasting only two years, discourage companies from investing in long term commitments, collaborative data sharing, or innovation, as they are unable to recover their investment within the short contractual period. This scenario pushes companies toward significant cost reduction and immediate economic outcomes rather than focusing on societal contributions and innovation. The lack of longer-term commitment thus clearly signals potential upcoming conflicts and strategic disagreements.

(Interviewee 8) I look for early warning signs by monitoring for inconsistencies in reported data, a lack of participation in collaborative initiatives, and public complaints or negative feedback about last-mile services. For instance, if a mobility provider's reported data on ridership doesn't align with my own observations of network usage or public feedback, it's a red flag that there may be an issue with data accuracy or an underlying disagreement. I also pay close attention to stakeholder meetings and project updates, watching for any signs of reluctance to share information or engage in joint problem solving.

(Interviewee 9) I look for early warning signs by monitoring for a lack of willingness from stakeholders to engage in constructive dialogue or to negotiate in good faith. For example, when a city refuses to even consider our feedback on a new ordinance, or unilaterally imposes new fees or regulations without any consultation, it's a clear indicator that they are not willing to collaborate. These actions suggest that they are making decisions in a vacuum, which almost always leads to practical conflicts and operational challenges for our business.

Question 6: Have you encountered any potential conflicts among stakeholders in the context of data sharing in last mile transportation and how have these been resolved?

(Interviewee 1) Siemens Mobility has encountered potential conflicts related to data sharing in last-mile transportation. In one specific last-mile project, a stakeholder verbally agreed to share data but subsequently became unresponsive when concrete requests were made, leading to significant delays and highlighting the critical need for clear commitments early on. In another project, outside of last-mile transport, fundamental differences in vision between stakeholders led Siemens Mobility to ultimately withdraw, as alignment with the consortium's direction could not be achieved.

(Interviewee 2) Yes, potential conflicts related to data sharing have been encountered. One specific example involved a difficult situation with a company where extensive calls, transparency, and signing an NDA were required to gain access to their data. A more general solution observed to foster data sharing in this environment involves participating in EU-funded "horizon projects." These projects bring together companies, even competitors, into a consortium, and the EU funding encourages collaboration, providing a level of coordination that helps advance last-mile mobility.

(Interviewee 3) Yes, potential conflicts have been encountered. In one collaboration with a shared micro-mobility company, the company was initially unconvinced of the business benefits of participating in a pilot study. This conflict was resolved when the interviewee's

partner company, which had a long-standing collaboration with the micro-mobility company, engaged in another round of discussions. During these conversations, they shared more long-term business insights, ultimately convincing the micro-mobility company to join the pilot.

(Interviewee 4) Another conflict arises when combining services like "Yerrechzor," "Reimo," and public transport at a provincial level, as provinces must deal with municipalities that fall within their jurisdiction. For example, a large municipality like Omer, which has well-organized transport services and dedicated resources, is reluctant to cede its budget to the province. They fear losing service quality or money if the provincial level manages dispatching for all services, especially if it means their funds are used to improve transport in other, less cared-for areas. This creates a fight between municipalities and provinces. Solutions require ways to facilitate good collaboration between these layers, potentially by learning from regions like Zeeland where this is already happening at a provincial level, and through knowledge transfer initiatives like DMI.

(Interviewee 5) In my experience with complex projects, I've observed that potential conflicts in data sharing often arise when the perceived value or risks are not clearly communicated. For instance, a stakeholder might verbally agree to data exchange but become unresponsive when concrete steps are required, highlighting a need for stronger initial commitments. Resolution typically involves persistent, transparent dialogue to clarify mutual benefits, and establishing formal agreements that build trust and define parameters. Collaborative environments where overarching objectives are funded or clearly defined can also encourage cooperation by providing a shared incentive.

(Interviewee 6) Yes, reluctance to share data is a common conflict. Initially, stakeholders may offer only small, sample datasets. This reluctance can be overcome over time through repeated meetings where a transparent plan is presented to all players. Consistent dialogue and clear communication help to build trust and overcome initial hesitation.

(Interviewee 7) Yes, conflicts frequently arise among stakeholders due to differing priorities between societal benefits and private financial gains. Usually, such conflicts have been effectively resolved through governmental intervention. The government utilizes contractual frameworks and regulatory mandates that explicitly require companies to share their data as a fundamental condition for operating within particular regions or cities. Establishing clear contractual obligations ensures compliance and significantly reduces stakeholder conflict.

(Interviewee 8) Yes, I've encountered conflicts, especially concerning the deployment of new micro-mobility services, where a company's desire for a large-scale rollout conflicts with a city's need for a controlled rollout to prevent sidewalk clutter and safety issues. We resolved these conflicts by establishing a clear framework and a pilot program that defined the number of vehicles, geo-fenced operating areas, and data sharing requirements. This collaborative approach allowed us to test the service under controlled conditions and make adjustments based on real-world data and feedback before a city-wide expansion.

(Interviewee 9) Yes, we've encountered conflicts, particularly regarding vehicle parking and designated service areas. For example, a city might suddenly decide to restrict where our scooters can be parked without prior notice, which can create user frustration and operational challenges. We have resolved these by proactively engaging with city officials to establish clear rules and communicate those changes to our users. This direct engagement allows us to make

adjustments based on real-world data and feedback, thereby building trust and preventing future conflicts.

Question 7: What approaches or strategies have you found effective in resolving conflicts among stakeholders?

(Interviewee 1) One effective strategy employed by Siemens Mobility for resolving conflicts among stakeholders is the implementation of Non-Disclosure Agreements (NDAs). These agreements are used to ensure that shared information is treated confidentially, which helps to build trust and create a more secure environment for collaboration. However, even with NDAs in place, it can still be challenging to fully understand the underlying reasons why some stakeholders may remain reluctant to cooperate.

(Interviewee 2) Two key approaches have been found effective in resolving conflicts among stakeholders. On a company-to-company level, transparency is paramount, often involving many calls and clear explanations to build trust and facilitate data sharing, along with signing NDAs. On a broader scale, coordination, particularly at the level provided by EU-funded projects (like Horizon projects), significantly helps. These projects encourage collaboration even among competitors by forming consortia, demonstrating that external coordination can effectively advance collective goals in last-mile mobility.

(Interviewee 3**)** Effective strategies for resolving conflicts among stakeholders involve having a clear plan that details the specific inputs and efforts required from each party for data sharing and processing. It is crucial to present a clear picture of the project, its expected outcomes, and how each party will benefit. This entire discussion should be thoroughly documented, reviewed, and formally signed through agreements like NDAs or project proposals before the project commences.

(Interviewee 4) Effective strategies involve a "carrot and stick" approach. The "carrot" is understanding what stakeholders can gain from changing their way of working, contracting, dispatching, or servicing different user groups. This requires thorough stakeholder analysis to understand everyone's goals. The "stick" is making them understand what they will eventually lose if they resist change. It's also crucial to facilitate conversations where people can share their fears and needs as human beings. Conflict resolution, in essence, is about understanding another person's needs and finding creative, win-win solutions. This often involves "Critear Markers" or "Quartermakers" individuals skilled at lobbying and clearly outlining the benefits of solutions while also applying necessary pressure, which is inherently political.

(Interviewee 5) Effective strategies for resolving conflicts among stakeholders involve a multi-faceted approach. Firstly, establishing clear and mutual understanding of project goals and individual contributions is vital. I've found that open communication and detailed planning, outlining expectations and benefits for all parties, can prevent many disagreements. Formalizing these understandings through agreements helps too. Secondly, identifying and articulating the "win-win" scenarios for each stakeholder, demonstrating how collaboration serves their interests, is crucial. This often requires careful analysis of individual needs and a focus on collective optimization.

(Interviewee 6) The most effective strategy for resolving data related conflicts is anonymization. By aggregating data and removing personally identifiable information (e.g.,

specific times, exact locations of individuals) while still providing useful insights (e.g., aggregated traffic flow within a zone), stakeholders are more inclined to share. This initial step of anonymization can be crucial in convincing entities to participate and contribute their data, as it addresses concerns about competitiveness and privacy.

(Interviewee 7) One highly effective approach in resolving stakeholder conflicts within data sharing contexts is for the government to enforce mandatory data sharing conditions explicitly stated within service contracts. This strategy clearly mandates that any operating company must comply with predefined data sharing obligations as part of their authorization to provide services. Binding data sharing conditions from the onset considerably reduce conflicts and ensure companies align with broader societal objectives rather than exclusively focusing on their financial interests.

(Interviewee 8) The most effective approach I've found for resolving conflicts is to establish a clear, neutral forum for discussion and to focus on shared goals. By bringing all stakeholders to the table including private companies, public agencies, and community groups and framing the conversation around the collective benefit, such as improving overall urban mobility or reducing carbon emissions, we can often move past individual interests. Using data and objective analysis to support our arguments also helps to depoliticize the decision-making process.

(Interviewee 9) The most effective strategy I've found is to proactively engage with city officials and be transparent about our operations. We demonstrate how our data and services can help them achieve their own goals, such as reducing traffic congestion or improving public transit connectivity. By framing our proposals in terms of mutual benefit and presenting them with clear, data-driven evidence, we can often find common ground and avoid protracted disputes.

Question 8: What can we do to improve this situation regarding data sharing and collaboration in last mile mobility?

(Interviewee 1) To improve data sharing and collaboration in last mile mobility, the interviewee suggested that it would be beneficial to clearly define and emphasize a shared, higher level goal at the very beginning of any collaboration. Committing to this common objective from the outset creates a reference point that can be utilized throughout the project to realign efforts when challenges or individual interests diverge, thus keeping all parties focused on the broader picture.

(Interviewee 2) To improve data sharing and collaboration, transparency is seen as key. The interviewee suggests sharing success stories from successful collaborations as a marketing tool on platforms like LinkedIn to inspire other companies and create a collaborative environment. Another helpful initiative is Siemens' "Connected Mobility Day," where companies (excluding direct competitors but including shared mobility providers, municipalities, and portfolio partners) are invited for workshops to discuss common challenges. Such events, even if short, can change mindsets, foster personal connections, and ultimately help solve shared problems.

(Interviewee 3) To improve data sharing and collaboration in last-mile mobility, it would be beneficial to create a standardized protocol or template that facilitates the type of clear conversations outlined in Question 7. Additionally, addressing data safety is a major concern,

so developing a well designed tool for secure data sharing is essential. Such a tool should protect shared data from leaks and ensure it is not used for purposes outside of what was agreed upon.

(Interviewee 4) Improving the situation requires understanding what stakeholders can gain from changing their current practices (the "carrot") and what they stand to lose if they don't adapt (the "stick"). This involves fostering conversations where people can share their fears and needs, as conflict resolution aims to find win-win solutions by understanding each other's perspectives. The solution itself, if beneficial (e.g., combining services through a single dispatcher for more effective service and reach with the same budget), serves as the "carrot," requiring initial collaboration and investment. It needs skilled individuals to clearly outline this path and apply pressure, which is political in nature.

(Interviewee 5) To significantly improve data sharing and collaboration, I believe two key areas need focus. Firstly, there's a need for more standardized frameworks or protocols that simplify the process of secure data exchange. This would reduce ambiguity and perceived risks. Secondly, fostering a culture of collaboration through shared success stories and interactive workshops can be highly effective. By demonstrating tangible benefits and facilitating direct human connection, we can shift mindsets from competitive isolation to collaborative problem solving, showcasing how collective effort leads to better outcomes for everyone involved.

(Interviewee 6) To improve data sharing and collaboration, it is essential to establish a highly reputable, independent body with significant authority. This entity would guarantee the integrity and transparency of the data exchange process. Without such a weighty player to co-create and oversee the data exchange plan, stakeholders are likely to engage with limited commitment. This authoritative body would foster trust and encourage active participation, leading to more effective collaboration.

(Interviewee 7) To significantly improve the situation, it is necessary to clearly articulate the objectives and societal contributions of shared micromobility services. Once these benefits such as sustainability, accessibility, and efficient urban space utilization are clearly recognized and politically supported, the government must actively assume a significant coordination and leadership role. Governments must facilitate balanced cooperation between private markets and societal interests, ensuring that societal benefits remain prioritized alongside commercial incentives. Strong governmental leadership can effectively ensure that markets do not exclusively focus on financial profit but also help secure broader societal benefits for the community.

(Interviewee 8) To improve the situation, a dedicated governmental body or regulatory authority is needed to oversee the last-mile mobility ecosystem. This body would be responsible for developing and enforcing a common, open-source data standard that all providers must adhere to, which would simplify technical aspects and enable easier data integration. Furthermore, this body could establish and manage a centralized data trust, where information could be securely shared, anonymized, and accessed by authorized parties, which would build trust among stakeholders and address privacy concerns.

(Interviewee 9) To improve the situation, a national or regional government body is needed to establish a unified framework. This entity should be tasked with creating a mandatory, open source data standard that all mobility providers and public agencies must adopt. By centralizing the governance of data sharing, this body can eliminate the fragmented landscape of local

regulations, making it easier for companies to operate and for public agencies to access the data they need in a consistent format.

Question 9: What data sharing tools and platforms does your organization currently use for collaboration in last mile mobility?

(Interviewee 1) Siemens Mobility aims to utilize standardized interfaces wherever possible for collaboration in last-mile mobility, specifically mentioning GTFS (General Transit Feed Specification), GBFS (General Bikeshare Feed Specification), and TOMP-API (Transport Operator to MaaS Provider API). These standards are intended to support interoperability across various mobility services. However, in practice, it is often observed that providers implement these standards in their own unique ways, which can still lead to integration challenges despite the adoption of common protocols.

(Interviewee 8) My organization currently uses a combination of tools for collaboration in last-mile mobility. We rely on GIS (Geographic Information System) software, like ArcGIS or QGIS, to visualize and analyze spatial data, such as ride origins and destinations. We use API (Application Programming Interface) connections to pull real time data directly from different mobility providers, allowing us to monitor service levels. We also use project management platforms, like Asana or Trello, to track tasks and ensure all stakeholders are on the same page.

(Interviewee 9) We primarily use proprietary APIs for real- ime data sharing and fleet management, which allow us to track vehicle locations, battery levels, and user trips. Internally, we use advanced data analytics platforms and cloud services to process and store our operational data. When we do share data with external stakeholders, we do so through a standardized API endpoint, which is a significant improvement over manual file exchanges.

Question 10: In your experience, what data sharing practices have fostered the most seamless collaboration across different stakeholders?

(Interviewee 1) From Siemens Mobility's experience, the use of standardized interfaces such as GTFS, GBFS, and TOMP-API has significantly enhanced technical integration and interoperability among different stakeholders. While these technical standards are highly beneficial for the mechanics of data sharing, the interviewee emphasized that they do not automatically translate into seamless collaboration. True and effective cooperation still depends fundamentally on mutual trust, transparency, and a shared willingness to work together among all parties involved.

(Interviewee 2) While the specific question about "seamless collaboration practices" was answered in conjunction with improvement strategies, the interviewee emphasized that transparent communication and proactive engagement (as discussed in question 8) contribute to better collaboration. The underlying sentiment is that fostering a mindset of shared problem-solving and establishing personal connections through initiatives like the "Connected Mobility Day" (as detailed in question 8) are key practices that lead to more seamless collaboration, moving beyond mere technical data exchange.

(Interviewee 8) In my experience, data sharing practices that have fostered the most seamless collaboration are those that are transparent, standardized, and automated. Providing stakeholders with a clear data dictionary, regular data quality audits, and an automated process for data submission and retrieval has significantly reduced friction. Practices that focus on sharing anonymized and aggregated data have also been successful in mitigating privacy concerns and encouraging participation from private companies.

(Interviewee 9) In my experience, the most effective data sharing practices are those that minimize our administrative burden while still meeting our obligations. This is best achieved through a standardized, automated API for data exchange. This approach reduces the need for manual reporting and custom development for each city, allowing us to focus on our core business. Sharing aggregated and anonymized data has also been crucial, as it allows us to protect our proprietary information while still providing the transparency needed for public agencies.

Question 11: Looking ahead, are there additional functionalities or new digital tools that could further enhance stakeholder collaboration?

(Interviewee 1) The interviewee expressed that trust is an essential element for effective collaboration. Looking ahead, they believe that digital tools designed to support transparency and shared accountability could further enhance stakeholder collaboration. Examples of such tools include platforms for joint goal setting or for tracking progress, which could potentially help in strengthening the crucial element of trust among collaborating parties.

Question 12: How do you incorporate stakeholder and user feedback into strategic planning and continuous improvement processes?

(Interviewee 1) As a B2B (business-to-business) company, Siemens Mobility primarily incorporates feedback into its strategic planning and continuous improvement processes by gathering input directly from its clients and partners. For instance, they regularly conduct Net Promoter Score (NPS) surveys among their customers to assess satisfaction levels and identify specific areas that require improvement in their services and offerings.

(Interviewee 2) Feedback is incorporated at different levels. For end users, immediate issues like booking difficulties in an application are taken seriously and integrated into improvements. For company-to-company feedback, especially in areas like DRT, observed patterns can lead to proposals for schedule changes or governmental adjustments. The interviewee noted that companies might sometimes withhold feedback if it goes against their commercial interests. Beyond application-specific buttons for end-users, feedback from stakeholders is primarily collected through ongoing calls and conversations, rather than formalized tools, surveys, or forms, suggesting a more organic, dialogue based approach.

(Interviewee 3) As an algorithm designer, the interviewee incorporates feedback using a stepwise approach throughout the project. This process includes stages such as a 'Project proposal,' 'data sharing template and data engineering preparation,' 'algorithm design and experimentation with sample data,' 'applying the algorithm to real-time/full datasets and generating full analysis reports,' 'communicating the algorithm with data engineers to improve the product,' and 'central documentation of code and reports for data processing and modeling'.

(Interviewee 4) The interviewee and their team incorporate stakeholder and user feedback by actively asking questions in meetings to understand needs. They also engage directly with potential customers to identify their needs and emotional responses, which then prompts further inquiry. This proactive approach to gathering input is part of their strategic planning and continuous improvement processes, indicating a direct engagement model rather than formalized feedback loops.

(Interviewee 5) I incorporate stakeholder and user feedback into strategic planning and continuous improvement by treating it as essential data for system optimization. My approach involves systematically analyzing input to identify patterns and root causes of issues, much like I've done with data anomalies in past projects. This feedback directly informs the development of recommendations and innovative solutions. I then integrate these insights into the planning process, often creating visualizations and testing models to refine and enhance overall efficiency and effectiveness of the proposed strategies.

(Interviewee 6)Within collaborative projects, feedback from participating members indicates that the initiatives are positively received, and many initial constraints are addressed. However, a formal, explicit mechanism for continuous feedback loops and reporting back to stakeholders is often lacking in practice, despite its recognized importance. A crucial element for sustaining engagement is providing regular reporting to data providers, demonstrating the value and impact of their contributions. This reporting can highlight how their shared data is being utilized and what outcomes have been achieved, which encourages continued participation and builds credibility.

(Interviewee 8) I incorporate stakeholder and user feedback into strategic planning by establishing formal channels for feedback and analyzing it alongside quantitative data. We use public surveys and workshops to gather qualitative insights from users, while also analyzing quantitative data on ridership and service usage. We then use this combined information to identify areas for improvement and to prioritize projects, such as adding new bike lanes or adjusting the placement of e-scooter parking zones. This ensures that our planning is not just data-driven but also responsive to community needs and concerns.

(Interviewee 9) We incorporate stakeholder and user feedback by analyzing it to drive product and service improvements that increase user satisfaction and loyalty. Our strategic planning is heavily informed by a combination of qualitative feedback and quantitative data. By identifying pain points mentioned in feedback such as issues with app usability or vehicle availability and cross-referencing them with our operational metrics, we can prioritize changes that will have the biggest positive impact on our user base, thereby securing our business growth.

Question 13: What strategies do you use to gather input and feedback from stakeholders and users?

(Interviewee 1) Currently, Siemens Mobility does not follow a formalized strategy for systematically gathering stakeholder feedback. Instead, input and feedback are typically collected through more informal means. These include ongoing collaborations, various project meetings, and direct, informal conversations that occur throughout their engagement with stakeholders and users.

(Interviewee 3) Strategies for gathering input and feedback involve discussions about the strategic level of the project with the entire group of stakeholders. Furthermore, regular feedback and task-specific discussions are held with particular teams at different project stages. For example, during the coding stage, feedback is gathered from data engineers, while at the product stage, discussions are held directly with customers.

(Interviewee 4) Strategies for gathering input and feedback from stakeholders and users involve actively asking questions during meetings to identify their needs. The team also makes efforts to approach potential customers directly to understand their requirements and observe their emotional responses, which guides further detailed questioning. This suggests a more conversational and direct approach to collecting feedback.

(Interviewee 5) My strategies for gathering input and feedback focus on direct engagement and comprehensive analysis. I actively seek input through collaborative discussions and meetings to understand strategic needs, leveraging my communication and team collaboration skills. For specific project stages, I'd engage relevant teams to gather task specific feedback. On the user side, while direct application feedback mechanisms are useful, I also prioritize understanding the underlying requirements and challenges through qualitative insights, aiming for a holistic view that informs continuous improvement.

(Interviewee 8) We use a variety of strategies to gather input and feedback from stakeholders and users. This includes public online portals, town hall meetings, and social media channels to engage with the general public. For our partners in the last-mile ecosystem, I rely on regular stakeholder meetings and dedicated communication channels to ensure a continuous flow of information. I also work with our community engagement team to conduct targeted surveys and interviews with specific user groups, such as people with disabilities, to ensure their needs are being met and incorporated into our planning.

(Interviewee 9) We use a multi channel approach to gather input, starting with in app surveys and user forums to directly engage with our customers. For our municipal partners, we maintain a dedicated communication channel and conduct regular meetings to solicit their feedback on our service's impact on the city. We also closely monitor social media mentions and online reviews, which provides us with real-time feedback that we can use to make quick adjustments to our service.