Transportation Research Interdisciplinary Perspectives 36 (2026) 101897

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives

From experimentation to learning and routinization: A long-term trial framework for cargo bike and light electric vehicle integration in Germany☆

Johannes Gruber *, Martin Plener, Daniel Weiss

German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR), Institute of Transport Research, Rutherfordstrasse 2, 12489 Berlin, Germany

ARTICLE INFO

Keywords:
Fleet transformation
Cargo bikes
Light electric vehicles
Organizational learning
Adoption barriers
Long- term trials
Commercial transport

ABSTRACT

In light of rising sustainability demands in commercial transport, cargo bikes and light electric vehicles (LEV) offer promising alternatives to conventional fleets. However, despite increasing vehicle diversity and supportive policies, adoption remains limited due to organizational inertia, sunk costs, and resistance to change. Short-term pilot projects, while useful for testing feasibility, often fail to capture the evolving and context-specific dynamics of fleet integration. To address this gap, we introduce and evaluate a novel long-term trial framework implemented across multiple German regions over a 12-month period. The framework embeds vehicle trials into daily operations and combines tailored onboarding, sustained engagement, and structured reflection phases. This article makes three core contributions. First, it advances both academic and practical understanding by introducing a reliable and transferable framework for long-term fleet transformation that functions as an organizational learning device. Second, it uncovers context-specific and time-sensitive challenges of integrating LEVs and cargo bikes, as shown through five stylized cases across logistics, manufacturing, services, and craft sectors. Third, it conceptualizes three learning-based pathways of organizational commitment to fleet transformation: fleet expansion, vehicle substitution, and purchase prevention, through which long-term trials can support learning-based fleet reconfiguration, including normative learning reflected in the strategic reframing of alternative vehicles. The findings highlight the value of long-term trials in supporting adaptive and real-world transitions that extend beyond the scope of short-term studies. By fostering deeper organizational learning and aligning vehicle solutions with operational realities, the framework establishes critical conditions for sustained adoption and contributes to the broader transition toward more sustainable transport practices.

Introduction

In light of the ongoing sustainability transition in the mobility sector, cargo bikes and light electric vehicles (LEV) have gained increasing relevance as environmentally friendly alternatives for commercial transport, particularly since the early 2010s (Lenz and Gruber, 2021; Assmann et al., 2024). This trend is reflected in rising sales figures and a growing diversity of vehicle models, ranging from compact two-wheelers to heavy-duty cargo bikes (ZIV, 2025). However, despite rising parcel volumes and supportive decarbonization policies (Menge et al., 2024), cargo bike sales show signs of stagnation and decline since 2021, with a sharper drop in 2023 (ZIV, 2025). This highlights their continued status as a niche technology and the persistent barriers to adoption (Sherriff et al., 2023). These barriers go beyond technical or economic feasibility and are deeply rooted in internal organizational dynamics. Companies must often overcome established routines and sunk investments that contribute to organizational inertia, alongside challenges such as high upfront costs, limited internal expertise, and resistance to change (Cowan and Gunby, 1996; Schreyögg and Sydow, 2011; Lesáková et al., 2017; Beyer, 2022). Therefore, fleet transformation requires more than the substitution of vehicles; it entails a fundamental reconfiguration of workflows, staff involvement, and implementation strategies that are aligned with long-term organizational goals (Gruber and Narayanan, 2019; Lenz and Gruber, 2021).

Building on research into experimental innovation and technology adoption (Müür et al., 2020; Axsen and Pickrell-Barr, 2024; Büttner,

☆ This article is part of a special issue entitled: 'Transforming Freight' published in Transportation Research Interdisciplinary Perspectives.

* Corresponding author.
E-mail address: johannes.gruber@dlr.de (J. Gruber).

https://doi.org/10.1016/j.trip.2026.101897
Received 31 May 2025; Received in revised form 19 December 2025; Accepted 11 February 2026

2025; Müür and Karo, 2025), our study examines how organizational learning explains the evolution of fleet transformation over time. This process extends beyond mere technical familiarization with cargo bikes and LEVs to encompass shifts in organizational routines, coordination mechanisms, and strategic priorities. To capture these dynamics, we employ the organizational learning framework developed by McFadgen and Huitema (2017), which identifies three distinct but interrelated dimensions: cognitive, relational, and normative learning. Cognitive learning encompasses the acquisition and restructuring of knowledge, including technical, operational, and regulatory insights, that inform vehicle integration decisions (Pisano, 2001). Relational learning involves changes in trust, cooperation, and mutual understanding among organizational actors, which prove essential for coordinating workflows and resolving implementation challenges (Webler et al., 1995; Pahl-Wostl, 2006). Normative learning entails reflection on and revision of underlying assumptions, strategic goals, and priorities, ultimately shaping how organizations assess sustainability objectives and long-term fleet strategies (Haug et al., 2011). Notably, in line with McFadgen and Huitema (2017) and other studies applying this learning framework (Kivimaa and Rogge, 2022; Baatz and Ehnert, 2023; Müür and Karo, 2025; Shrestha et al., 2025), we do not privilege one form of learning over another ex-ante. This is distinctive to other learning frameworks, such as single- and double-loop learning, which implicitly prioritize certain forms of learning over others (Argyris, 2003; Knudsen, 2008; Nelson et al., 2018).

To address the multidimensional challenges of fleet transformation, pilot projects and trial schemes have become key instruments for supporting transitions toward more sustainable transport options. Unlike one-time subsidies, trials enable hands-on experimentation that addresses multiple organizational and operational barriers while fostering learning, user acceptance, and early technology stabilization (Geels, 2002; Geels et al., 2018). From an organizational learning perspective, trials can be understood as collective activities through which organizations not only test new vehicle technologies but also develop, adapt, and stabilize operational routines that structure day-to-day practices (Nelson and Winter, 1982; Knudsen, 2008; Nelson et al., 2018). Crucially, changes in these routines shape whether experimentation translates into sustained organizational change and long-term fleet transformation. In this sense, trials function as learning environments in which organizations navigate the tension between exploration (i.e., experimenting with new vehicle technologies and use cases) and exploitation (i.e., the gradual stabilization and routinization of operational practices) (March, 1991). Through repeated application and adjustment, both technical knowledge about vehicle performance and organizational knowledge related to coordination and service integration are progressively embedded in day-to-day routines (Rerup and Feldman, 2011; Müür and Karo, 2025).

Across Germany and internationally, numerous cargo bike and LEV trials have been conducted across sectors and urban contexts, generating valuable evidence on feasibility, early adoption barriers, and operational boundary conditions (Bogdanski et al., 2018; NYC DOT, 2021; Knese et al., 2023). Importantly, these initiatives span a wide range of trial formats and durations. Some are clearly short-term operational deployments, such as the four-week cargo bike trial reported for Stargard, Poland (Nürnberg, 2019). Others extend over several months, including the six-month "Mir sättlä um" initiative in Bern, Switzerland (Schmid and Stawicki, 2017), or multi-month trial and evaluation designs such as the City of London logistics trial (Leonardi et al., 2012). In the German context, longer implementation-oriented projects also exist, for example the Nürnberg micro-depot practice phase (March–October 2017), which is reported to have triggered more sustained operational changes beyond the formal project period (Bogdanski et al., 2018). However, despite these variations, the dominant evidence base remains shaped by project-based trial logics and evaluation designs that primarily capture early feasibility and performance impressions rather than longer-term organizational integration dynamics, with discontinuation after funding periods reported in related city logistics pilot schemes (Kin et al., 2016).

From an organizational learning perspective, the key gap is therefore not simply a lack of "more pilots," but a lack of long-term trial frameworks that systematically operationalize learning over time and enable observation of how alternative vehicles become embedded in day-to-day operations. As fleet transformation depends not only on technical familiarization, but on the gradual development and stabilization of routines, roles, coordination mechanisms, and external relations. These processes require repeated task execution, cumulative experience, and the capacity to respond to disruptive events as they occur. Short-term trials rarely capture systematically full maintenance cycles, shifts in staffing and responsibilities, changing workloads, or the renegotiation of subcontracting and coordination arrangements. As a result, they tend to overemphasize early feasibility impressions while underrepresenting later-stage challenges such as routinization failures, declining engagement, or context-dependent reconfiguration of practices and partnerships, and, thus, ultimately fall short of facilitating the full range of necessary learning processes (Pisano, 2001; Müür et al., 2020; Müür and Karo, 2025).

Taken together, prior trials provide important feasibility evidence, but they offer limited empirical leverage for theorizing how organizations move from initial experimentation to stabilized integration and sustained organizational commitment, due to the aforementioned limitations inherent in their relatively short duration. To address this gap, this paper introduces a long-term fleet transformation framework and examines its implementation across diverse organizational contexts in Germany. The framework is explicitly designed to function as an organizational learning device: it structures prolonged experimentation through iterative feedback loops and reflection phases, enabling organizations to adapt routines and to make informed decisions about cargo bike and LEV integration. The study addresses the following research questions:

1. How can the limitations of previous short-term trials be addressed, and what key elements should be considered in the conceptualization and practical implementation of a long-term trial scheme for cargo bike and LEV fleet integration?
2. What challenges and usage patterns emerge during the implementation of a long-term trial framework for integrating cargo bikes and LEVs into commercial fleets?
3. How does the introduced long-term trial framework shape organizational learning processes and subsequent fleet transformation scenarios regarding the integration of cargo bikes and LEVs?

This paper makes three contributions to research on sustainable commercial transport and organizational change: First, we conceptualize and implement a novel 12-month trial framework as an organizational learning setting. Extending existing notions of piloting as experimentation, the framework specifies elements that structure how learning can unfold over time, through micro-fleet segmentation, iterative feedback loops, and structured reflection phases. In essence, this aims to facilitate the gradual stabilization of routines, enabling a shift from exploration toward exploitation in vehicle integration (Nelson and Winter, 1982; March, 1991; McFadgen and Huitema, 2017). Second, we provide empirically grounded insights into time-sensitive and context-specific fleet integration dynamics that short-term pilots typically miss. Combining utilization trajectories across the full sample with five analytically selected company cases across logistics, manufacturing, service, and craft contexts, we show how barriers and enabling conditions emerge, change, and interact over the course of prolonged experimentation. Furthermore, the cases show how learning takes different forms (cognitive, relational, or normative) depending on sectoral constraints and intra-organizational development. Third, we show how sustained learning translates into distinct modes of organizational commitment and post-trial implementation pathways. Notably, in our empirical context, the pathways that entail more substantial fleet transformation appear to be strongly shaped by extended time horizons, as they require a broader range of learning processes that are difficult to realize in short-term trials. Thus, rather than treating fleet transformation strategies as a typology of firms or as system-level transition mechanisms, we frame fleet expansion, direct substitution, and prevention of new conventional vehicle acquisitions as learning-based pathways that reflect increasing maturity of routines.

Finally, an additional contribution lies in the conceptional and methodological value of the long-term framework for empirical and practice-oriented research. By generating robust longitudinal process evidence on vehicle integration, organizational change, and user behavior, our study demonstrates the added value of long-term trial frameworks for understanding fleet transformation. While arguably being more resource-intensive and dependent on sustained organizational engagement, such frameworks complement short-term pilots by enabling deeper organizational learning and more informed, context-sensitive fleet reconfiguration beyond early feasibility impressions.

Long-term fleet transformation framework – concept and implementation

Background

Our novel framework builds on over a decade of experience with cargo bike and LEV pilot projects and trials conducted at the German Aerospace Center's (Deutsches Zentrum für Luft- und Raumfahrt, DLR) Institute of Transport Research, primarily in Germany and also in other European countries. These included a wide range of companies and vehicle types, such as battery-electric and fuel cell-powered cargo bikes. In the project *Ich ersetze ein Auto* ("I substitute a car", 2012–2014), 125,000 B2B deliveries were carried out by professional bicycle couriers, demonstrating the competitiveness of cargo bikes in urban transportation (Gruber et al., 2014). The project *TRASHH* (2016–2020) focused on municipal cleaning and developed first approaches for long-term restructuring among a supposedly less bicycle-affine workforce (Gruber and Peters, 2023). Project *Fuel Cell Cargo Pedelecs* focused on the fuel cell innovation and its applicability to municipal users in France, Scotland and Germany (Damer et al., 2026). With project Ich entlaste Städte ("Taking the load off cities", 2017–2020), one of the most extensive cargo bike trials in Europe was created. 755 companies participated Germany-wide and across all business sectors, each testing a cargo bike for a three-month period, generating valuable insights into key success factors for implementation (Gruber, 2024). The current concept was developed and is being implemented in the project Ich entlaste Städte 2, the successor project with a runtime from December 2021 until January 2026.

Concept of the long-term trial framework

The integration process of cargo bikes and LEVs within a long-term test can be represented as a sequential model (Fig. 1) with the overall goal to create adaptable solutions for converting commercial combustion engine vehicle fleets to emissions-free alternatives sustainably. We refer to the framework as "adaptive" because it incorporates repeated feedback and structured reflection phases that allow companies to iteratively adjust use cases, coordination routines, and vehicle allocation over time. In doing so, the framework aims to support broader learning processes over time, rather than one-off assessments that are more typical of short-term trials (Müür et al., 2020; Müür and Karo, 2025).

The focus of integrating cargo bikes and LEVs revolves around specific usage scenarios where traditional vehicles could be replaced. This requires a detailed understanding of existing route profiles, freight characteristics, and workforce structure. As a first step, the current commercial fleet and organizational structure are identified to capture the status quo in terms of vehicle inventory, operational demands, and intended use-cases. This status-quo analysis provides the basis for an initial segmentation of the fleet into subparts ("micro-fleets"), enabling a preliminary assignment of test vehicles to potentially feasible use-cases, matching transportation tasks and other functional requirements with the capabilities of the vehicles. This results in various combinations of the respective tasks or use cases, a dedicated mixture of existing and alternative vehicles and, if necessary, a spatial assignment.

While test configurations are intended to run for a 12-month trial period in total, it is realistic to assume that adjustments will have to be made and therefore actively facilitate them. Early adaptations as well as potential barriers, e.g., on organizational, operational, technical, or behavioral level, can be identified among both management and employees during the early-stage testing phase. To monitor the status of vehicle integration and to address emerging challenges during the trial, the framework includes follow-up consultations. The goal is to iteratively optimize and restructure the use of test vehicles so that all stakeholders arrive at workable, operational solutions within the test configuration applied to the use cases. Feedback loops enable targeted

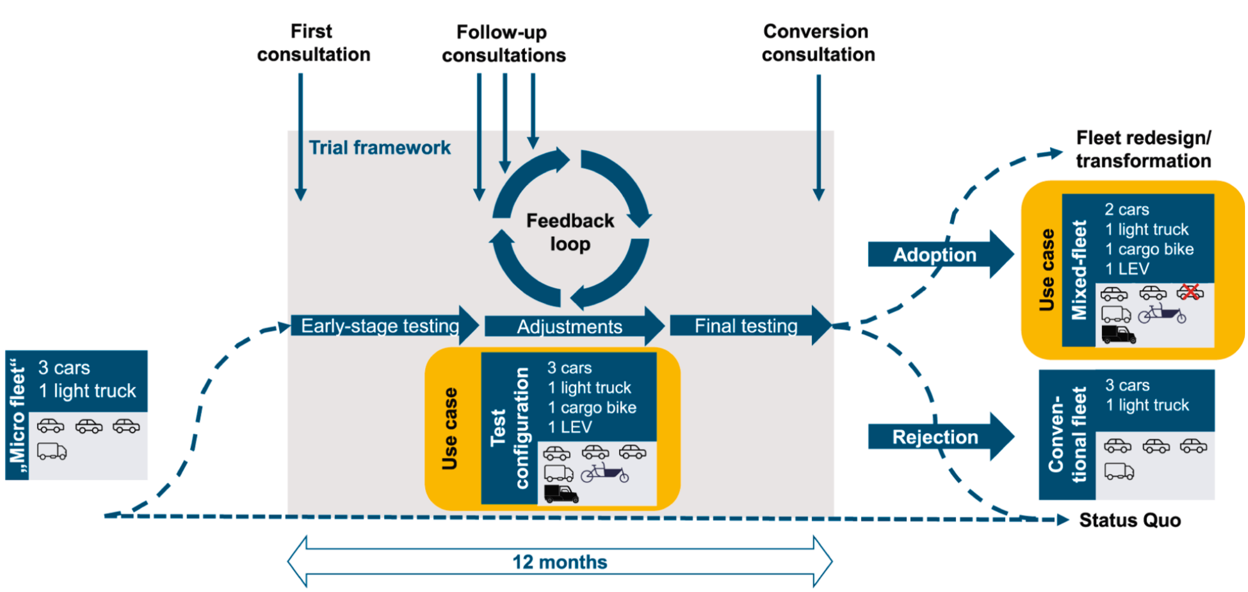


Fig. 1. 12-month fleet transformation framework.

and iterative adjustments throughout the trial period, with durations and intensities of adjustments varying by company. Companies have sufficient time to trial all aspects of vehicle integration in everyday contexts, considering industry-specific seasonality and various times of the year.

At the end of the final testing phase structured conversion consultations are conducted with the participating companies. These serve to evaluate the experiences of the test period and to assess the likelihood of adopting cargo bikes and LEVs as a permanent component of the operational fleet. This phase marks the phase-out of the trial period, culminating in one of two outcomes: adoption or rejection. In the case of adoption, the insights gained lead to a redesign of the commercial fleet, resulting in a mixed-fleet configuration that integrates cargo bikes and LEVs alongside conventional vehicles. In that case mid-term corporate goals and concrete implementation pathways are defined to support long-term integration of the tested vehicles and scale-up opportunities. To support a possible transition beyond the trial, companies receive support such as vehicle procurement options, market contacts, and strategic advice. Conversely, if the trial revealed persistent obstacles, whether logistical, organizational, or cultural, the result may be a rejection, with a return to the previous fleet composition and therefore to the status quo. From an organizational learning perspective, the different elements of the framework, namely micro-fleet segmentation, iterative feedback loops, and structured conversion consultations, are designed to consolidate experiences accumulated over the trial period and to render them actionable for future decision-making. In this sense, the framework functions as a structured learning environment that supports reflection on operational feasibility, organizational fit, and strategic alignment beyond short-term experimentation. The distinctive learning effects associated with our framework are further examined and discussed together with the empirical results of the conducted trials.

Practical conditions for implementing the concept

Implementing the framework in practice requires not only a structured rollout but also the creation of a supportive environment that enables participating companies to concentrate fully on vehicle operations and facilitate the different forms of learning over long periods of time. For this purpose, the trial includes the coordination of vehicle logistics and handovers, driver training, and the provision of a support hotline throughout the trial. An intermediary contractor took care of the handling of vehicle insurance, maintenance, and repairs in cooperation with local service partners.

With the exception of downtimes in the event of accidents or waiting times for unusual spare parts, an uninterrupted operation time was made possible for the testers. These measures reduce administrative and operational burdens for participating companies, creating low-threshold conditions for real-world vehicle testing conditions. These conditions were also financially attractive for the test companies, as little time and expenses had to be spent on the additional requirements of vehicle integration. However, to mitigate deadweight loss and free-rider problems, a monthly usage fee between €50 and €80 was charged.

Methods and data

As we emphasized in the introduction, the variability of positive and negative impact factors and their effects on cargo bike and LEV use is high. To capture this complexity beyond purely technical or operational aspects, we applied a mixed-methods, longitudinal accompanying research design.

Data collection and timing: Data were collected in multiple waves. First, an online screening survey was used during recruitment to document basic company characteristics (e.g., fleet size, prior experience, intended use cases) and to support matching of vehicles and operational contexts. After selection, companies completed a more detailed questionnaire covering organizational decision structures and implementation conditions. In addition, we conducted in-depth onboarding consultations and repeated follow-up conversations over the 12-month period with key organizational actors (e.g., management, logistics managers) and, where accessible, additional internal roles such as departmental coordinators ("champions"), drivers/users, or other functions (e.g., marketing). Companies provided supplementary information where available (e.g., service territories and vehicle characteristics). Operational incidents such as maintenance, repairs, downtime, and accidents were documented throughout the trial.

GPS trip data and usage metrics: Trip data for test vehicles (and, where available, baseline conventional vehicles) were recorded using DLR's data collection tool MovingLab (DLR, 2025). For this paper, the GPS data were primarily used to derive descriptive utilization indicators (e.g., mileage over time). The plots shown in Fig. 2 represent aggregated recorded distances per week.

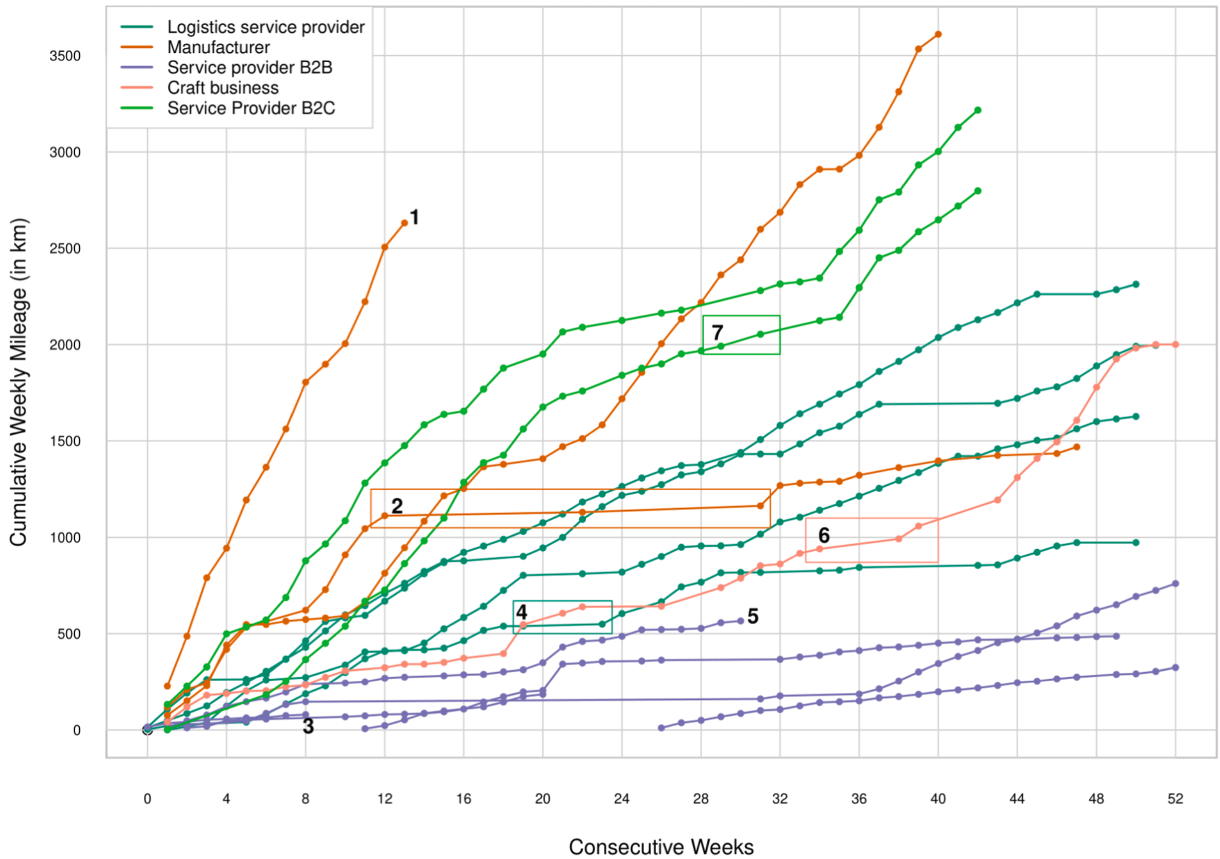
Analytical procedures: Patterns were derived through triangulation across (i) utilization traces, i.e. mileage trajectories, (ii) documented events (e.g., downtime, repairs), and (iii) qualitative material from surveys and interviews/consultations. Qualitative material was analyzed through thematic pattern building focused on operational challenges, adaptations, and different forms of organizational learning.

Participants acquisition & criteria of case study selection

In principle, participation in the project was open to all companies in Germany. To ensure socio-spatial heterogeneity while enabling intensive project support, recruitment was concentrated in seven pilot regions: Berlin, Düsseldorf/Rhineland, Leipzig, Frankfurt/Rhine-Main, Munich, Bremen and Flensburg/Kiel. In the period from October 2021 to November 2024, 274 applications were received, 101 of which were classified as first choice candidates and originating from the pilot regions. Onboarding discussions were held with all selected companies to determine the conditions of participation and mutual expectations, and the basic suitability of small vehicle integration.

Ultimately, 42 companies participated in two waves of a 12-month real-world trial. The sample was intentionally designed to reflect a broad range of economic sectors and operational logics. Prior experience from earlier pilot projects (Gruber, 2024) had shown that logistics providers, service businesses, craft enterprises, and municipal organizations differ markedly in their operational routines, decision-making structures, and expected use cases for cargo bikes. In order to capture a substantial amount of variation we included firms from various business sectors, i.e., parcel logistics (6 companies), manufacturing and shipping (4), consumer-oriented service providers (6), B2B-oriented service providers (8), craft businesses (9), municipal companies (6), and other sectors (3). This heterogeneity provides a robust foundation for identifying both sector-specific and cross-sectoral adoption processes. Sectoral distribution and fields of application are summarized in Appendix A, including the five companies selected for in-depth analysis.

The case studies presented in this paper are based on individual companies drawn from this heterogeneous sample. Selection followed a set of empirical and analytical criteria. We identified five use-case types that reflect the spectrum of operational requirements, organizational structures, and vehicle usage patterns observed across the 42 participants. For each type, a company was chosen that represents typical conditions within its sector and displays a characteristic implementation pathway. Furthermore, all selected cases exhibited clear intra-organizational development over the trial period, including adjustments to operational routines, responses to shock events (e.g., vehicle failures, staff shortages), and evolving managerial or employee engagement. These dynamic developments made them particularly suitable for examining organizational learning and change processes. The selected cases do not claim statistical representativeness, but instead serve as analytically illustrative examples of how firms in different sectors experiment with, adapt to, and eventually integrate small vehicles into their operations.



No.	Business sector	Event	Outcome
1	Manufacturer	Rear wheel damage due to heavy payloads	Replacement of vehicle
2	Manufacturer	Employee resigned	Non-usage and acquisition issues, followed by successful employment
3	Service provider B2B	Vehicle does not manage to ascend a steep ramp from the parking garage	Replacement of vehicle
4	Logistic service provider	Spoke breakage on the vehicle	Resumption of use after repair
5	Service provider B2B	Electric light-duty vehicle demonstrates limited flexibility and inadequate range for touring purposes.	Usage was discontinued, LEV not feasible for use-case
6	Craft business	Rear wheel damage	Non-usage period due to lack of maintenance network, successful continued use
7	Service provider B2C	Damage to the oil system and drivetrain of the cargo bike	Resumption of use after repair

Fig. 2. Cumulative weekly mileage of tested vehicles by presented 5 case study companies, as well as relevant events impacting the course of the long-term trial.

Tested vehicles

The aim in compiling the test fleet was to meet the requirements of the selected companies with the given financial resources of around €600 thousand, while at the same time allowing flexibility for changing operating conditions. Table 1 provides an overview of the 47 selected test vehicles within 5 categories (Long John, Long John with trailer, Heavy-duty cargo bike, LEV and Electric light-duty vehicle), including the number of different models and corresponding attributes (e.g., max. speed, dimensions, payload, and transport volume).

Results

While the implementation of our trial framework yielded a wide range of diverse results, this study focuses on novel insights derived from distinctive empirical observations and stylized cases of cargo bike and LEV integration and organizational learning (section 3.1). In addition, we demonstrate how the long-term nature of the framework enabled

Table 1
Key parameters of the vehicle classes provided (photo credits: DLR).

	Long John	Long John + trailer	Heavy-duty cargo bike	Light Electric Vehicle (LEV)	Electric light-duty vehicle
EU vehicle class	**Bicycle**	**Bicycle**	**Bicycle**	**L6e/L7e**	**N1**
Typical model					
Different models	4	1	7	3	4
No. of vehicles	15	2	19	6	5
Max. speed (km/h)	25*	25*	25*	40–70	85
Driving license	none	none	none	moped / car	car
Market price (€)	6,000–8,000	10,000	6,000–24,000	17,000–21,000	15,000–30,000
Width (cm)	50–70	65	100–120	120–130	160
Length (cm)	240–280	550	270–340	230–330	360–470
Height (cm)	105–120	150	170–210	170–190	170–200
Transport volume (l)	185–260	1750	1,400–2,100	600–2,000	2,000–4,700
Max. payload (kg)	155–180	260	170–280	420–530	530–1,100

*Electrically assisted

different modes of organizational commitment to fleet transformation in comparison to short-term trials (section 3.2).

Key insights of framework implementation

We begin our results by outlining general insights from all 42 participating companies, highlighting shared usage patterns, challenges and adaption strategies. This provides an overview of how organizations with diverse backgrounds and objectives engaged with our trial framework. In the first subchapter (3.1.1), we describe and group the use of the test vehicles before focusing on the long-term observation of five company case studies (3.1.2).

Vehicle utilization and mileage trajectories

The companies participating in the long-term trial exhibited a range of expertise levels with regard to cargo bikes and LEV. Some were already acquainted with them, while for most of the other there was no previous experience with these types of vehicles. Also, their needs, use cases, and objectives differed. Consequently, the implementation processes varied in terms of how frequently and how long the vehicles were used, as well as how occurring challenges during the trial were addressed. These diverse usage trajectories highlight distinct restructuring patterns. Although all companies operated within the same trial framework, their engagement levels, internal dynamics, and adaptation strategies evolved in markedly different ways, which will be examined in more detail. Based on the collected empirical data, distinctive patterns of diverse usage biographies and implementation strategies were found to have emerged among the participating companies.

In general, frequency of use and cumulative mileage varies significantly across companies, ranging from a few hundred to around 8,000 km. However, low cumulated mileage does not necessarily indicate unsuccessful usage. In fact, observations show that even if a vehicle is not used daily or does not cover a significant daily distance, it can still be considered as a "successful" usage by decision-makers and drivers alike. This is due to the specific operational needs it fulfills, such as integrating staff without driver's license or replacing high-consumption vehicles for short trips.

Looking at the development of test vehicle mileage over time, three empirically observed utilization trajectories can be distinguished: We refer to these categories as *jump-starters*, *ascendants*, and *heavy-users*. The categories can be understood as descriptive labels for recurring implementation trajectories, rather than normative or exhaustive classifications, capturing differences in how organizations learn to integrate cargo bikes and LEVs into daily operations over time, shaped by initial organizational readiness, operational pressure, and adaptive capacity.

One usage type can be called *jump-starters*, i.e., companies that had ideal initial conditions for adopting cargo bikes and LEVs into their operations. These companies typically exhibit consistently high daily mileage starting from the beginning of the trial. Another group can be referred to as a*scendants*. Craft businesses can often be assigned to this type, requiring more time at the beginning to effectively integrate the new vehicles into their existing workflows. This may involve redefining routes, recruiting new personnel or convincing existing staff, or simply becoming familiar and comfortable with the new type of vehicle. Furthermore, weekly mileage values are more heterogeneous among craft businesses and service providers compared to logistics service providers. This reflects the more diverse range of use cases for cargo bikes in the non-logistics sector, as well as the lower cost pressure of having to fully utilize the vehicles. In contrast, tested cargo bikes and LEVs play a more prominent and consistent role among the participants from logistics branches, especially parcel delivery. All participating logistics companies in the trial exhibit a relatively homogeneous usage pattern. Moreover, they not only use the vehicles more frequently, but also achieve partly higher mileage. Due to the high level of competition in the logistics sector, vehicles must demonstrate strong performance, even during the pilot phase, and are pushed to the limits of operational capacity. For this reason, logistic service provider can be seen as *heavy-users*.

Importantly, these trajectories do not merely reflect operational differences in mileage or frequency of use. They also indicate different modes and speeds of organizational learning, ranging from rapid stabilization under favorable initial conditions to gradual learning through experimentation and adjustment, as well as routinized high-intensity use under competitive pressure.

Long-term experimenting and learning: five company cases

To deepen our understanding of the operational and organizational processes involved in integrating cargo bikes and LEVs, we present five company case studies that reflect distinct implementation pathways observed during the 12-month trial. Each case represents a single firm, yet the challenges encountered, the strategies employed, and the learning processes that unfolded resonate with patterns frequently observed in comparable companies within the same sectoral context. The cases therefore offer singular narratives that simultaneously illustrate typical sector-related constellations.

The extended observation period proved essential for uncovering how companies adjust their routines, experiment with vehicle allocation and task suitability, cope with setbacks, and recalibrate expectations over time. Unlike short-term pilots, the long-term design exposed firms to seasonality, changing workloads, staff turnover, and disruptive events such as accidents or repairs (see Fig. 2). All these factors can strongly shape companies' assessment of vehicle suitability. In some instances, cargo bikes opened opportunities, for example by enabling employees without a driving license to take on new tasks; in others, they triggered frustration and temporary withdrawal from the experiment.

The five cases cover a wide range of motivations (from conservative to progressive), organizational readiness levels, and operational roles for cargo bikes and LEV. They also illustrate different aspects of organizational learning (cognitive, relational, and normative) which were activated in response to both sector-typical constraints and firm-specific experiences emerging throughout the trial (McFadgen and Huitema, 2017). In addition, the long-term design allows us to observe how organizations navigate the tension between exploration and exploitation over time (March, 1991), moving from experimentation toward adoption or, in some cases, rejection. Table 2 provides an overview of the five case studies before they are presented individually.

Parcel logistics service provider. The parcel industry is a highly competitive, cost-driven sector that is also committed to growing sustainability goals. One company, an international parcel delivery service with an extensive network across multiple European countries, sought to enhance their cargo bike business model by trialing heavy-duty cargo bikes. During the trial, they utilized existing subcontractors and depot-based logistics. The cargo bikes were centrally loaded and then distributed throughout the city, with delivery routes specifically designed to optimize their use.

Throughout the test, the company encountered several challenges, including dissatisfaction with one subcontractor. This service provider, whose processes and personnel are optimized for Diesel vehicles, lacked experience with bicycle logistics, which revealed limits of established operational routines when applied to cargo bike delivery. Further issues were related to the cargo bike and recurring maintenance issues, such as frequent repairs and extended downtime (see Fig. 2, event 4). These operational hurdles provided insights, particularly given the highly competitive nature of the parcel delivery sector, where cost pressure is an omnipresent concern. Despite the challenges faced, the trial offered critical lessons helping the company's future efforts in expanding cargo bike usage with their urban logistics network. Upon completion of the trial, the company identified several success factors that, although not fully realized during the test phase, emerged as highly relevant for subsequent implementation: restructuring of operations, adaptation to local traffic conditions, and the need for efficient and easy maintenance processes. Most importantly, however, was the newly established cooperation with a service provider specializing in bicycle logistics, a young company with around 30 cargo bike couriers, with which the company intends to expand the urban parcel logistics use case. At a normative level, the trial contributed to a reassessment of cargo bikes as a meaningful alternative to conventional delivery vans rather than merely a supplementary solution. At a relational level, it prompted the company to reconsider the existing subcontracting arrangement and to deliberately engage the specialized bicycle logistics provider.

Manufacturing industry (self-organized logistics). This manufacturer of frozen food products acts as shipper with in-house logistics planning. The factory is located at the outskirts of a large metropolitan area. A diverse set of customers (e.g., small kiosks, restaurants, but also supermarket chains) is being served with the majority of locations within the metropolitan area, but also in the wider region. Their logistics system involves a diverse range of tours with tour weights adjusted for cargo bikes generally up to 200 kg. The company shows a strong commitment to environmental sustainability and is driven by ambitious management goals. There have been first experiments with cargo bikes and electric vans prior to the long-term trial.

During the test period, vehicle utilization varied significantly across the fleet. While some vehicles matched operational needs well and had suitable drivers, others experienced extended idle times due to mechanical failures (see Fig. 2, event 1), which necessitated replacement. These failures were primarily caused by overloading or poorly planned routes. In another case, an employee resigned (event 2) due to lack of interest and acceptance issues, resulting in prolonged vehicle inactivity. This was successfully addressed by explicitly hiring a new employee through a job posting focused on cycling. Additionally, the company's less-than-ideal location on the city outskirts results in long deadhead distances, sometimes up to 15 km, to reach customers. The feasibility of setting up a micro-depot was estimated and discussed. However, an implementation cannot be prioritized due to employer shortage and an ongoing construction project at another company location. As a result of the trial, the manufacturer decided not to integrate the tested vehicles into the company fleet, mainly due to their unreliability. Thanks to the long-term test, the company gained cognitive insights, revealing that operating on difficult road surfaces with the usual payload requires extremely robust vehicles. Therefore, new cargo bikes were acquired from a specialized provider that offer particularly durable models tailored to such conditions. These have been in permanent use ever since.

Replacement of water and heat meters (B2C service provider). This case represents a successful example of cargo bike integration in the service sector, based on a metering service company with less than 10 employees located in an outskirt of a metropolitan area. Specialized in the replacement and installation of water and heat meters, the company

Table 2
Overview of selected case studies.

	Logistics service provider	Manufacturer (self-organized logistics)	Service provider (B2C)	Service provider (B2B)	Craft business
Business sector	Parcel logistics	Manufacturer of frozen food product	Replacement of water/ heat meters	Facility management	Plumbing and heating
Integration goal (ex-ante)	Conservative	Progressive	Progressive	Conservative	Conservative
Type of learning	Normative, relational	Mostly cognitive	Cognitive, normative	Cognitive, relational	Cognitive
Challenges	Cost pressure Existing contractor lacks know-how	Payload requirements Staff shortage	Minor vehicle downtimes	Top-down decision is not initially implemented in middle management	Payload requirements
Strategies	Commissioning of a cargo bike specialist Restructuring of operations	Purchase of heavy-duty cargo bikes Urban hub solution (discussed)	Vehicle allocation to bike-enthusiastic employees Recruiting of staff without license	Relocation of vehicles to a more suitable location Trialing in several departments Assignment of dedicated contact persons	Purchase of heavy-duty cargo bikes More flexibility for staff without license
Outcome after 12 months	Clear advantages Expansion of business together with new contractor	Moderate advantages Cargo bikes remain niche solution	Clear advantages Replacement of conventional car	Clear advantages Generation of new business (that would not be economically viable using cars)	Clear advantages Replacement of conventional light truck

traditionally relied on a fleet of conventional vehicles (owned cars and leased vans). Due to the standardized service, the time spent on site with customers is very homogeneous. Therefore, tour planning is relatively easily and done few weeks in advance. The initiative to test cargo bikes was launched top-down by the managing director. Despite his personal preference for large combustion engine vehicles, he adopted a pragmatic approach to improving operational efficiency. The company's service structure with homogenous transported goods and predictable time windows provided ideal conditions for testing cargo bikes.

During the trial, two cargo bikes were deployed. One was equipped with an additional battery to recharge the vehicle, enhancing its range by around 25 km. The goal was to reduce mileage by ICE vehicles. Therefore, both bikes were used intensively, which led to a total mileage of around 3,000 km for each cargo bike. The heavy-duty bike acted as a full substitute on a one-to-one basis, while the Long John cargo bike partially replaced another vehicle. The cargo bikes proved effective in this context, offering key advantages such as flexible parking and the ability to assign tours to staff without a driver's license. Because of an overall positive attitude towards new vehicle concepts and bicycle affinity of the employees, the company responded positively to the new mode of transport from the beginning. The smooth and widely accepted implementation was primarily driven by the intrinsic motivation of the small team. Even technical issues, such as temporary downtime due to oil system and drivetrain damage see Fig. 2, event 7), did not hinder long-term usage. Quite the contrary, cargo bike usage resumed. Economically, the shift proved to be cost-neutral, with no major challenges encountered. Given the positive outcomes, the company sees strong potential for further integration of cargo bikes into its fleet. Despite his personal preference for large combustion engine vehicles, the managing director ultimately adapted his approach and embraced the potential of cargo bikes, reflecting normative learning within the organization.

Facility management (B2B service provider). As a representative of a business-related service, a facility management company tested cargo bikes across multiple departments, including building cleaning, maintenance, and green space maintenance. Traditionally reliant on leased vans and cars, the company initiated the shift from the top down, led by senior management. However, the transformation faced early challenges due to a conservative industry setting, low-skilled work environments, and a lack of middle-management engagement, resulting in suboptimal vehicle-task assignments of the cargo bikes. For example, seasonal changes like leaf collection required more volume than initially expected, making some deployments less effective. In total, five cargo bikes (Long Johns and heavy-duty types) and one LEV were deployed across various use cases in total. Initial implementation faced setbacks due to charging issues and low usage. One cargo bike vehicle didn't manage to ascend the ramp (see Fig. 2, event 3) therefore it was replaced by a different type of cargo bike, which experienced afterwards usage and consistent use. After reassigning the other vehicles and adjusting scenarios, usage increased steadily, with average daily distances of 4–6 km and some bikes reaching over 1,600 km total.

Use cases were gradually restructured and responsibilities clarified during the trial. Departments with predominantly outdoor work were more successful in recruiting cargo bike users as employees are already used to the effects of the weather during their work. However, the limited range of the LEV conflicted with established practices, such as employees commuting home with the vehicle or transporting bulky green waste (see Fig. 2, event 5), which ultimately led to the discontinuation this vehicle. Over time, usage stabilized, and key benefits emerged: emissions-free operations, avoidance of van purchases, and greater flexibility in urban deployment. By the end of the test period, three cargo bikes out of six test vehicles were permanently integrated into the fleet. The company now sees cargo bikes as a viable and expandable part of its operations, with the pilot marking a meaningful step in its broader transformation.

In terms of organizational learning, the trial offered important cognitive insights, showing how employees respond to the introduction of cargo bikes, how resistance can be managed, and how alternative use cases can be explored to ensure adoption. At the same time, relational learning emerged as the company identified departmental "champions" and coordinators who could guide colleagues, facilitate usage, and help integrate cargo bikes into daily routines, reinforcing both acceptance and consistent application across departments.

Plumbing and heating services (craft business). Almost 80 % of craft businesses in Germany have fewer than 10 employees (Destatis, 2024), with a high degree of decision-making power allocated to the owner and a traditional reliance on conventional cars or light trucks for their business and also for employee commuting to their place of residence. This business sector proved to be one of the more challenging field for fleet transformation. Many companies participated in the trial, testing various types of cargo bikes and LEV. However, implementation, and in some cases even regular use, was difficult. Only few craft business managed to integrate these vehicles into their operations, and not all of them are planning to continue the transition. One of the successful trials in this business sector was conducted by a plumbing company that tested a heavy-duty cargo bike for pipe-cleaning tasks in an inner-city setting. Both the managing director and the driver were open-minded from the very beginning. Due to the high transport demands, the company carefully assessed its options, gaining valuable insights into the capabilities and limitations of the cargo bike. Ultimately the company identified a certain heavy-duty bike as the only suitable option, particularly valuable for involving an employee without a driver's license.

The trial still revealed clear limitations in payload and volume, but within its operational range, the bike proved practical and cost-effective for urban deployment. One factor that continues to cause concern is the lack of a nearby service and maintenance network. After rear-wheel damage occurred (see Fig. 2, event 6), the vehicle remained unused for an extended period due to delays in repair. Despite this, the company views the overall trial positively and now plans to acquire a similar heavy-duty model with greater payload capacity, informed by the cognitive learning gained through the trial.

Cross-case synthesis. Overall, the five cases illustrate how long-term trials make it possible to trace fleet transformation as an evolving process shaped by sectoral constraints, firm-specific issues, and repeated adaptation. Across cases, we observed how organizations identified context-specific challenges and developed responses through organizational learning, for instance by refining recruitment and role allocation, reconfiguring external partnerships, or iteratively adjusting task/vehicle fit. Importantly, the trial revealed emergent transformation patterns in which initial expectations frequently diverged from actual outcomes once vehicles were exposed to routine operations and disruptive events. From an organizational learning perspective, the cases display different balances between exploration, understood as experimenting with new vehicle technologies and use cases, and exploitation, understood as the gradual stabilization and routinization of operational practices (March, 1991). While some organizations rapidly stabilized cargo bike use under favorable initial conditions, others remained in prolonged exploratory phases or reverted to conventional vehicles following negative experiences. These dynamics underline the analytical value of long-term trial designs: they allow organizations to encounter disruptive events, revise routines, and reassess expectations beyond early feasibility impressions. These conditions are rarely observable in short-term pilots.

Modes of organizational commitment in long-term fleet transformation

This section explores how the long-term trial framework supported organizational learning processes that led companies to develop higher levels of commitment to fleet transformation. It highlights three types of scenarios: fleet expansion, vehicle substitution, and prevention of new acquisitions, which are conceptualized not merely as descriptive outcomes but as stylized pathways of fleet restructuring. These scenarios are not intended as a typology of fleet strategies or system-level transition mechanisms; rather, they serve as analytical learning pathways that reflect different levels of organizational commitment and increasing maturity of routines over time. In contrast to short-term trials, our framework enabled learning at a greater depth, providing companies with a structured environment to explore and reflect on alternative vehicle integration over an extended period. In practice, companies are often hesitant to invest in such restructuring due to unclear cost structures, and the addition of a cargo bike as a supplementary vehicle is frequently not economically viable. Outside of a trial setting or even in a short-term trial, companies rarely have the opportunity to observe the long-term dynamics of integrating alternative vehicles into their fleet. Against this backdrop, the long-term trial provided a window of opportunity to explore how the integration of a cargo bike or LEV as an additional fleet component affects overall fleet operations. By testing the configuration over time, companies reduced cost-related uncertainty and developed a more differentiated understanding of fleet-related costs and operational trade-offs.

The following sections describe each scenario in detail, showing how companies applied insights from the long-term trial to progressively restructure their fleets.

Scenario 1: expansion of the existing vehicle fleet

In this case, the company expands its capabilities by adding a cargo bike or LEV to its fleet, rather than replacing existing vehicles. This is the most common case of conversion, when this occurs on the company's own initiative or as part of short-term tests. The additional vehicle is used for smaller, local transport tasks that can be completed more efficiently and sustainably, while conventional vehicles remain in use for larger or more complex or higher payload or distance deliveries. While this strategy can lead to a measurable reduction in the mileage of conventional vehicles by shifting specific transport tasks to the more suitable and environmentally friendly mode, this configuration is frequently identified as a less viable option due to higher costs. This scenario is frequently perceived as economically challenging because it increases fleet size and fixed cost exposure; therefore, it often remains an exploratory configuration rather than a long-term solution unless additional benefits or supporting conditions apply (e.g., subsidies, flexibility gains, soft advantages such as company image or employee health). However, Scenario 1 plays a crucial role as an exploratory phase: it allows companies to gain first-hand insights into operational practices, cost parameters, and vehicle suitability. This experience can create conditions that may enable a shift toward Scenarios 2 or 3, depending on context, readiness, and learning outcomes. These more advanced forms of fleet restructuring, including direct substitution (Scenario 2) and prevention of new conventional vehicle acquisitions (Scenario 3), will be presented in the following.

Scenario 2: direct substitution of a conventional vehicle

With this type, a cargo bike or LEV fully replaces a conventional vehicle in the fleet. This decision is typically based on an analysis of transport needs, usage patterns, and operational requirements. The ratio of cargo bikes or LEVs needed to replace one conventional vehicle depends on the vehicle class, delivery volume, and typical route characteristics. In the case of low-mileage passenger cars with limited transport requirements, a 1:1 substitution is often feasible. In contrast, replacing light commercial vehicles with higher transport demands may require multiple cargo bikes or LEVs to fully cover the same operational scope. This setup, however, allows for more targeted route planning and can improve delivery efficiency at the destination. Through the long-term trial, companies gained greater familiarity and confidence with the vehicles and gradually established routines for their use. Future replacement decisions are made with consideration of practical factors, such as remaining service life or maintenance schedules of existing conventional vehicles, rather than being abruptly discontinued. Over time, this process enabled companies to develop a more differentiated understanding of relevant cost factors, including maintenance, vehicle lifetime, and suitability. As a result, economic feasibility could be assessed more reliably, and in several cases, direct substitution emerged as a viable and informed option. In learning terms, Scenario 2 indicates a shift from exploratory testing toward stabilized, routinized deployment, supported by clearer role allocation, task/vehicle matching, and more informed cost-related assumptions.

Scenario 3: prevention of the purchase of a new conventional vehicle

In this third variant, a company that had planned to expand its fleet with an additional conventional vehicle decides instead to integrate a cargo bike or LEV. This shift occurs following an evaluation that reveals the cargo bike or LEV can adequately cover the additional transport tasks. Similar to Scenario 2, time and repeated engagement allowed companies to develop routines, reflect on operational practices, and consider strategic expansion, such as opening new business areas or taking on new customer assignments. Scenario 3 differs from the additive logic of scenario 1, even if the resulting fleet composition appears similar. The key distinction lies in timing and organizational context: Scenario 3 unfolds at critical moments of fleet development or business expansion (e.g., entering new areas or service lines), when prior learning enables organizations to reassess planned trajectories and avoid adding a conventional vehicle. Through accumulated learning, companies were able to reconsider planned investments and prevent the acquisition of new conventional vehicles. This pathway reflects a higher level of organizational commitment, as prior experimentation and reflection reduced uncertainty and enabled cargo bikes or LEVs to be evaluated as strategic alternatives rather than merely supplementary options. Moving toward this scenario was not automatic and, in some cases, learning led to an informed decision not to proceed beyond exploratory use, i.e., returning to using conventional vehicles only. Scenario 3 required context-specific learning outcomes, organizational readiness, and a well-informed understanding of operational costs and trade-offs. By enabling companies to explore these alternatives over time, Scenario 3 demonstrates the potential of cargo bikes and LEVs not only to complement existing fleets but also to serve as a sustainable alternative to new conventional vehicle investments, contributing to a long-term transformation of fleet composition.

Taken together, the three scenarios reflect different stages of organizational learning and commitment in the integration of cargo bikes and LEVs into everyday operations. They did not necessarily unfold fully within individual companies during the trial but emerged as recurring patterns across participants, illustrating how learning outcomes informed post-trial fleet restructuring. Importantly, learning also involved reducing cost-related uncertainty and developing more differentiated assumptions about operational trade-offs and indirect expenses. From a process perspective, the scenarios illustrate how firms balance exploratory experimentation with the gradual stabilization and routinization of new practices, consistent with the exploration – exploitation tension (March, 1991). While short-term trials often remain confined to additive experimentation (Scenario 1), the sustained engagement and reflective structure of the long-term trial enabled organizations to consider more stabilized and commitment-intensive fleet configurations (Scenarios 2 and 3). However, progression was context-dependent and not automatic, underlining that learning expands decision options rather than prescribing outcomes.

Discussion

In this section, we revisit our research questions and discuss how the findings advance current debates on fleet transformation by specifying how long-term trials enable organizational learning and routine change.

Given our first research question, the study demonstrates that overcoming the limitations of short-term pilots requires a design that actively structures learning. We therefore conceptualize the framework as an organizational learning device that combines (i) integration of cargo bike and LEV use into day-to-day operations, (ii) micro-fleet segmentation to link vehicle capabilities to concrete operational profiles, and (iii) iterative feedback loops and structured reflection that repeatedly connects observed performance to adaptations in routines, roles, and coordination, consistent with routine-based accounts of organizational change (Nelson and Winter, 1982; Knudsen, 2008; Rerup and Feldman, 2011). Conceptually, this design refers to the exploration and exploitation dynamic (March, 1991): the trial initially enables broad exploration of tasks, tour configurations, and staffing arrangements, while recurring feedback loops and consultation phases support the selective stabilization and routinization of practices. In doing so, the framework moves beyond a procedural tool by specifying *how* long-term experimentation can generate knowledge and therefore, but not necessarily, translate into organizational change under conditions of uncertainty and heterogeneous operational contexts (Shrestha et al., 2025) and in line with accounts of organizational inertia and path dependence (Cowan and Gunby, 1996; Schreyögg and Sydow, 2011). Notably, these insights correspond to and extend discussions on short- versus long-term trials in the broader literature by providing detailed empirical results from our conducted long-term trials.

In response to our second research question, the results underline that cargo bike and LEV integration is characterized by pronounced heterogeneity in both utilization trajectories and organizational adaptation. Across the presented five cases, this heterogeneity becomes visible in recurring cross-case patterns of challenges and learning dynamics. The descriptive categories of utilization trajectories highlight differences in initial readiness, operational pressure, and adaptive capacity, but their analytical value lies in revealing different speeds and modes of learning rather than stable adopter "types." Across sectors, barriers were not static; instead, they emerged and shifted as organizations moved from first trials to repeated execution, gradually developing routines (Bogdanski et al., 2018; Knese et al., 2023). Recurring constraints, which align with process-oriented learning accounts emphasizing evolving knowledge, relations, and norms (McFadgen and Huitema, 2017), included cost pressure, subcontracting arrangements, varying levels of staff acceptance, concerns regarding vehicle robustness, and uneven access to maintenance and service networks. Early phases were often dominated by basic feasibility questions and initial acceptance, while later phases revealed constraints that only become salient under prolonged exposure, such as routinization challenges, maintenance-related interruptions, coordination bottlenecks, or the cumulative effects of disruptive events. The five case studies reinforce this temporal perspective by showing how cognitive learning (task vehicle fit and operational knowledge), relational learning (coordination within departments and with external partners), and normative learning (strategic reframing of the vehicles' role) functioned as typical learning responses to these challenges, unfolding in different combinations depending on sectoral context and internal dynamics. Importantly, the long-term perspective also makes visible that "low mileage" does not necessarily equal failure; in several contexts, selective and task-specific deployment was evaluated as successful because it addressed specific operational needs and stabilized a workable niche within existing service delivery.

Regarding the third and final research question, we show that the long-term trial framework influenced fleet transformation not primarily through deterministic economic optimization, but through learning-enabled reductions in uncertainty and the gradual maturation of routines and organizational commitment. Notably, in our empirical context, the pathways associated with more substantial fleet transformation are closely tied to extended time horizons, as they depend on the accumulation of multiple forms of learning that are difficult to realize within short-term trials. The three scenarios (fleet expansion, direct substitution, and prevention of new conventional vehicle acquisitions) should therefore be interpreted as learning-based pathways that reflect increasing organizational commitment and routine maturity over time. This interpretation builds on the idea that sustained change depends on how new practices become routinized and stabilized through repeated enactment and learning (Nelson and Winter, 1982; McFadgen and Huitema, 2017). Scenario 1 typically functions as an exploratory configuration: organizations can test operational fit with limited immediate disruption to established fleets, but the additive nature often exposes coordination and resource trade-offs that trigger further learning. Scenario 2 reflects a stronger stabilization of routines, where organizations translate accumulated knowledge into replacement decisions aligned with operational requirements and maintenance realities. Scenario 3 represents the highest level of commitment observed, where accumulated learning enables organizations to treat cargo bikes or LEVs as credible strategic alternatives at moments of operational growth (e.g., entering new areas or expanding service portfolios), thereby preventing planned conventional vehicle acquisitions. Importantly, the framework does not imply that learning automatically leads to Scenario 3. Rather, it specifies conditions under which sustained experimentation and reflection can enable organizations to proceed from exploration toward routinized integration and more consequential restructuring choices.

In sum, beyond practical insights into fleet transformation, the long-term trial framework offers clear value as a distinctive methodological approach for research by operationalizing long-term trials as an organizational learning device, extending arguments on experimentation and learning under uncertainty in organizational settings (Pisano, 2001; Müür et al., 2020; Müür and Karo, 2025). Compared to short-term pilots, the extended duration enables the observation of non-linear implementation trajectories, the emergence and coping with disruptive events, and the gradual stabilization of routines, thereby providing richer evidence on cognitive, relational, and normative learning processes as well as on the exploration–exploitation tension in real-world fleet integration. The study yields design principles for trial schemes and analytically grounded insights that can inform intermediaries such as policy-makers, industry associations, and mobility service providers. At the same time, long-term trials are resource-intensive. Both researchers and participating companies invest substantial effort in preparation and ongoing coordination (e.g., understanding workflows, matching vehicles to use cases, and maintaining reflective feedback loops). This raises the risk that early discontinuation or implementation breakdowns result in disproportionate effort relative to outcomes. Moreover, maintaining engagement over twelve months is challenging. Participation in tracking and dialogue may decline over time, and organizational dynamics can remain partially opaque due to limited access, confidentiality constraints, or shifting strategic priorities. Long-term engagement also increases the likelihood of selection effects, as firms willing to participate may be more innovation-oriented than the broader population.

From a conceptual perspective, the identified trajectories can be interpreted as process-oriented patterns of organizational learning and adaptation, illustrating that the integration of cargo bikes and LEVs is neither linear nor uniform, but contingent on sectoral context, organizational structure, and exposure to operational constraints. These patterns also relate to empirically observed groups of utilization patterns ("jump starters", "ascendants", and "heavy users"), highlighting heterogeneous speeds and modes of learning across organizations. To avoid reifying these labels as firm types, we use them as descriptive heuristics for contrasting learning speeds and utilization dynamics under different operational conditions.

From a broader transition perspective, these findings highlight that organizational learning in fleet transformation is situated and processual, shaped by organizational routines as well as technology-specific and institutional contexts. Accordingly, the scope of our empirical insights is bounded by the focus on cargo bikes and light electric vehicles and by the German regulatory and market environment. While the conceptual framing of long-term trials as organizational learning devices appears transferable, the learning dynamics and restructuring pathways identified here should be understood as analytically illustrative rather than universally generalizable. This underscores the need for further empirical research that applies and adapts the framework across different technologies, sectors, and national contexts and examines how firm-level learning processes interact with broader socio-technical transition dynamics beyond the organizational level, which would require additional designs linking firm-level learning to system-level transition processes (Geels, 2002; Geels et al., 2018).

Conclusion

This study addressed the limitations of short-term pilots by developing and implementing a 12-month trial framework for cargo bike and light electric vehicle integration across 42 companies in Germany. Conceptually, we frame the framework as an organizational learning device that structures how experimentation generates knowledge. These learning outcomes can translate into organizational change through iterative feedback loops, collective reflection, and the gradual stabilization of routines, making the exploration–exploitation tension observable in real-world fleet transformation settings (March, 1991).

Empirically, the findings show that implementation pathways are heterogeneous, non-linear, and time-dependent. Utilization trajectories and five company cases illustrate how barriers and enabling conditions evolve over time and how learning processes shape whether experimentation translates into sustained practice, context-sensitive scaling, or informed discontinuation. Building on this, we conceptualize fleet expansion, direct substitution, and prevention of new conventional vehicle acquisitions as learning-based pathways that reflect increasing organizational commitment and routine maturity, rather than firm typologies or system-level transition mechanisms.

For trial design and policy, our results suggest that long-term trials should not be evaluated solely through short-term utilization metrics or immediate adoption decisions. Their distinctive value lies in enabling structured learning under operational uncertainty, supporting routine adaptation, and surfacing trade-offs that remain latent in shorter pilots, even when adoption does not occur. At the same time, the findings are bounded by the technological focus and the German regulatory and market context, and by the resource intensity and engagement requirements of long-term trials.

As discussed, future research should test the framework in other national contexts and vehicle domains in order to validate and potentially extend the observations presented here. In this vein, further studies should also examine how organizational learning trajectories interact with broader socio-technical transition dynamics beyond the firm level, including regime- and landscape-level processes and their interactions (Geels et al., 2018). From a practice-oriented perspective, future research could translate and stylize the empirical insights to lower entry barriers and support uptake by developing a self-assessment tool that complements the framework as a scoping instrument, helping firms formulate testable hypotheses for long-term trials and align expectations with implementation requirements.

Funding sources

Generation and publication of the shown results were made possible by the project “Ich entlaste Städte 2” (funding code 67KF0154) of the German National Climate Initiative, funded by the Federal Ministry for the Environment.

CRediT authorship contribution statement

Johannes Gruber: Writing – original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Martin Plener:** Writing – original draft, Project administration, Methodology, Investigation, Data curation. **Daniel Weiss:** Writing – original draft, Validation, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Participants of long-term trial.

Main category	Business sector	Municipality size	Case study
Logistics service provider	Green logistics	>1million	
	Green logistics	>1million	
	Express deliveries for retail client	>1million	
	Parcel logistics	100,00–500,000	x
	B2B courier logistics	500,000-1million	
	B2B courier logistics	500,000-1million	
Manufacturer / shipper (self-organized logistics)	Manufacturing industry (frozen product)	>1million	x
	Manufacturing industry (beverage)	100,00–500,000	
	Grocery store chain (home delivery)	100,00–500,000	
	Grocery store chain (home delivery)	<10,000	
Service provider (B2C)	Replacement of water/heat meters	>1million	x
	Funeral services	>1million	
	Sustainable heating solutions	>1million	
	Tree care	500,000-1million	
	Tree care	>1million	
	Replacement of water/electricity meters	100,00–500,000	
Service provider (B2B)	Facility management	>1million	x
	Illuminated advertising	>1million	
	Commercial cleaning	500,000-1million	
	Telecommunications infrastructure	500,000-1million	
	Commercial cleaning	500,000-1million	

(continued on next page)

Table A1 (*continued*)

Main category	Business sector	Municipality size	Case study
	Event production	500,000-1million	
	Facility management	100,00–500,000	
	Interior finishing	50,000–100,000	
Craft business	Drainage and sewerage	>1million	
	Plumbing and heating	500,000-1million	x
	Metal construction	500,000-1million	
	Carpentry	500,000-1million	
	Carpentry	500,000-1million	
	Painting	500,000-1million	
	Electrician	100,00–500,000	
	Carpentry	50,000–100,000	
	Metal construction	10,000–50,000	
Public organization	Waste management	>1million	
	Municipal energy supplier	>1million	
	Healthcare authority	500,000-1million	
	Municipal energy supplier	50,000–100,000	
	Municipal administration	10,000–50,000	
	Municipal administration / bike rental scheme	10,000–50,000	
Other	Art institute	>1million	
	Pharmacists' association	>1million	
	Restaurant	>1million	

Data availability

The authors do not have permission to share data.

References

Argyris, C., 2003. A life full of learning. Organ. Stud. 24 (7), 1178–1192. https://doi.org/10.1177/01708406030247009.

Assmann, T., Seissler, M., Braun, L., 2024. Die Renaissance des Lastenrads. In: Assmann, T., Bürklen, A., Gruber, J., Knese, D., Mayregger, P., Rudolph, C. (Eds.), Radlogistik. Grundlagen zu Logistik und Wirtschaftsverkehr mit Lasten- und Transporträdern. Springer Fachmedien Wiesbaden, Wiesbaden, pp. 51–65.

Axsen, J., Pickrell-Barr, J., 2024. What drives fleets? Organizations' perceived barriers and motivators for alternative-fuel vehicles. Transp. Res. Part D: Transp. Environ. 132, 104220. https://doi.org/10.1016/j.trd.2024.104220.

Baatz, A., Ehnert, F., 2023. Reframing places, communities and identities: social learning in urban experimentation. Sustainability: Sci., Pract. Policy 19 (1). https://doi.org/10.1080/15487733.2023.2207369.

Beyer, K., 2022. Barriers to innovative activity of enterprises in the sustain development in times of crisis. Procedia Comput. Sci. 207, 3140–3148. https://doi.org/10.1016/j.procs.2022.09.372.

Bogdanski, R., Bayer, M., Seidenkranz, M., 2018. Pilotprojekt zur Nachhaltigen Stadtlogistik durch KEP-Dienste mit dem Mikro-Depot-Konzept auf dem Gebiet der Stadt Nürnberg. https://opus4.kobv.de/opus4-ohm/frontdoor/index/index/docId/2623.

Büttner, C., 2025. Transformation: acceptance factors for electrifying corporate fleets in service companies—an extension of the UTAUT and an empirical study with decision-makers. Eur. Transp. Res. Rev. 17 (1). https://doi.org/10.1186/s12544-025-00738-5.

Cowan, R., Gunby, P., 1996. Sprayed to death: path dependence, lock-in and pest control strategies. Econ. J. 106 (436), 521. https://doi.org/10.2307/2235561.

Damer, L., Weiss, D., Gruber, J., 2026. Barriers to fuel cell cargo bike adoption in urban logistics: a multi-level transition analysis. Front. Sustainable Cities. https://doi.org/10.3389/frsc.2025.1701390 (in print).

Destatis, 2024. Anteile kleiner und mittlerer Unternehmen beim Handwerk 2022. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Handwerk/Tabellen/kleine-mittlere-unternehmen-handwerk.html (accessed 29 May 2025).

DLR, 2025. DLR MOVING LAB. https://movinglab.dlr.de/dlr-moving-lab (accessed 25 May 2025).

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy 31 (8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8.

Geels, F.W., Schwanen, T., Sorrell, S., Jenkins, K., Sovacool, B.K., 2018. Reducing energy demand through low carbon innovation: a sociotechnical transitions perspective and thirteen research debates. Energy Res. Soc. Sci. 40, 23–35. https://doi.org/10.1016/j.erss.2017.11.003.

Gruber, J., 2024. Results and learnings from Europe's largest cargo bike testing program for companies and public institutions. Transp. Res. Procedia 79, 146–153. https://doi.org/10.1016/j.trpro.2024.03.021.

Gruber, J., Kihm, A., Lenz, B., 2014. A new vehicle for urban freight? An ex-ante evaluation of electric cargo bikes in courier services. Res. Transp. Bus. Manag. 11, 53–62. https://doi.org/10.1016/j.rtbm.2014.03.004.

Gruber, J., Narayanan, S., 2019. Travel time differences between cargo cycles and cars in commercial transport operations. Transp. Res. Rec. 2673 (8), 623–637. https://doi.org/10.1177/0361198119843088.

Gruber, J., Peters, B., 2023. Lastenräder - ein Baustein beim Umbau kommunaler Flotten. KommunalTechnik (2/2023).

Haug, C., Huitema, D., Wenzler, I., 2011. Learning through games? Evaluating the learning effect of a policy exercise on European climate policy. Technol. Forecast. Soc. Chang. 78 (6), 968–981. https://doi.org/10.1016/j.techfore.2010.12.001.

Kin, B., Verlinde, S., van Lier, T., Macharis, C., 2016. Is there life after subsidy for an urban consolidation centre? An investigation of the total costs and benefits of a privately-initiated concept. Transp. Res. Procedia 12, 357–369. https://doi.org/10.1016/j.trpro.2016.02.072.

Kivimaa, P., Rogge, K.S., 2022. Interplay of policy experimentation and institutional change in sustainability transitions: the case of mobility as a service in Finland. Res. Policy 51 (1), 104412. https://doi.org/10.1016/j.respol.2021.104412.

Knese, D., Fassnacht, L., Künbet, S., Henninger, S., Mashayekhy Fard, Y., 2023. DiMoG–Digitale Schnittstelle zur Förderung klimafreundlicher Mobilitätskonzepte im Güterverkehr: Abschlussbericht. Frankfurt University of Applied Sciences. https://www.frankfurt-university.de/fileadmin/standard/Hochschule/Fachbereich_1/FFin/Neue_Mobilitaet/Veroeffentlichungen/2023/2023-02-08_DiMoG_Abschlussbericht.pdf (accessed 23 May 2025).

Knudsen, T., 2008. Organizational Routines in Evolutionary Theory. In: Becker, M.C. (Ed.), Handbook of organizational routines. Edward Elgar, Cheltenham, Northampton, Mass.

Lenz, B., Gruber, J., 2021. Bicycles for urban freight. In: Vickerman, R. (Ed.), International Encyclopedia of Transportation. Elsevier, pp. 488–494.

Leonardi, J., Browne, M., Allen, J., 2012. Before-after assessment of a logistics trial with clean urban freight vehicles: a case study in London. Procedia. Soc. Behav. Sci. 39, 146–157. https://doi.org/10.1016/j.sbspro.2012.03.097.

Lesáková, Ľ., Gundová, P., Kráľ, P., Ondrušová, A., 2017. Innovation leaders, modest innovators and non-innovative SMEs in Slovakia: key factors and barriers of innovation activity. Organizacija 50 (4), 325–338. https://doi.org/10.1515/orga-2017-0024.

March, J.G., 1991. Exploration and exploitation in organizational learning. Organ. Sci. 2 (1), 71–87. https://doi.org/10.1287/orsc.2.1.71.

McFadgen, B., Huitema, D., 2017. Are all experiments created equal? A framework for analysis of the learning potential of policy experiments in environmental governance. J. Environ. Plan. Manag. 60 (10), 1765–1784. https://doi.org/10.1080/09640568.2016.1256808.

Menge, J., Gehrke, M., Keinath, N., 2024. Lastenräder in der strategischen Planung des Wirtschaftsverkehrs am Beispiel des Landes Berlin. In: Assmann, T., Bürklen, A., Gruber, J., Knese, D., Mayregger, P., Rudolph, C. (Eds.), Radlogistik. Grundlagen zu Logistik und Wirtschaftsverkehr mit Lasten- und Transporträdern. Springer Fachmedien Wiesbaden, Wiesbaden, pp. 375–392.

Müür, J., Karo, E., 2025. Learning from public sector innovation pilots: the case of autonomous bus pilots. Innov.: Eur. J. Soc. Sci. Res. 38 (2), 687–710. https://doi.org/10.1080/13511610.2023.2286438.

Müür, J., Rutanen, E., Ronke, R., 2020. Starting your own pilot – sohjoa baltic: the roadmap to automated electric shuttles in public transport. Metropolia University of Applied Sciences.

Nelson, R.R., Dosi, G., Helfat, C.E., Pyka, A., Saviotti, P.P., Lee, K., Dopfer, K., Malerba, F., Winter, S.G., 2018. Modern evolutionary economics. Cambridge University Press.

Nelson, R.R., Winter, S.G., 1982. An evolutionary theory of economic change. Harvard University Press.

Nürnberg, M., 2019. Analysis of using cargo bikes in urban logistics on the example of Stargard. Transp. Res. Procedia 39, 360–369. https://doi.org/10.1016/j.trpro.2019.06.038.
NYC DOT, 2021. Commercial Cargo Bicycle Pilot: A New Mode for Last Mile Deliveries in NYC. Evaluation Report (5/2021). The City of New York. https://www.nyc.gov/html/dot/downloads/pdf/commercial-cargo-bicycle-pilot-evaluation-report.pdf (accessed 30 May 2025).
Pahl-Wostl, C., 2006. The importance of social learning in restoring the multifunctionality of rivers and floodplains. Ecol. Soc. 11 (1).
Pisano, G.P., 2001. In search of dynamic capabilities: the origins of R&D competence in biopharmaceuticals. In: Dosi, G., Nelson, R.R., Winter, S. (Eds.), The Nature and Dynamics of Organizational Capabilities. Oxford University PressOxford, pp. 129–154.
Rerup, C., Feldman, M.S., 2011. Routines as a source of change in organizational schemata: the role of trial-and-error learning. Acad. Manag. J. 54 (3), 577–610. https://doi.org/10.5465/amj.2011.61968107.
Schmid, J., Stawicki, M., 2017. „Mir sattlä um!": eCargobikes im Berner Wirtschaftsverkehr: Resultate der Begleitforschung. Mobilitätsakademie AG, Bern.
Schreyögg, G., Sydow, J., 2011. Organizational path dependence: a process view. Organ. Stud. 32 (3), 321–335. https://doi.org/10.1177/0170840610397481.
Sherriff, G., Blazejewski, L., Davies, N., 2023. 'Why would you swap your nice warm van, where you can eat your butties and listen to the radio?' Mainstreaming a niche of cycle logistics in the United Kingdom. Energy Res. Soc. Sci. 99. https://doi.org/10.1016/j.erss.2023.103062.
Shrestha, S., Haarstad, H., Rauws, W., Buijs, P., 2025. From experiments to organizational change: learning from urban logistics projects in Groningen and Bergen. Technol. Forecast. Soc. Chang. 213, 124023. https://doi.org/10.1016/j.techfore.2025.124023.
Webler, T., Kastenholz, H., Renn, O., 1995. Public participation in impact assessment: a social learning perspective. Environ. Impact Assess. Rev. 15 (5), 443–463. https://doi.org/10.1016/0195-9255(95)00043-E.
ZIV, 2025. Marktdaten Fahrräder und E-Bikes für 2024. https://www.ziv-zweirad.de/wp-content/uploads/2025/03/ZIV-Marktdatenpraesentation-2025-fuer-GJ-2024.pdf (accessed 14 April 2025).