Combatting Congestion: How Cities and Companies are Innovating First- and Last-Mile Transport

INSIGHT REPORT

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Contents

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Foreword

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Most cities, designed for the past, now struggle with growing populations, higher energy demands and evolving transportation needs. The outdated reliance on single-occupancy vehicles continues to lead to congestion, pollution, longer commutes and road safety concerns, all of which harm productivity and reduce quality of life.

To address these issues, cities must adopt a new mobility model that blends traditional and innovative solutions. Public and shared transport, along with walking, cycling, adoption of electric vehicles, drones and smart warehousing, can play a critical role. As transport systems face mounting pressures, there is a clear need for innovative approaches that ensure efficient and sustainable urban mobility.

A crucial area for intervention is the optimization of the first and last mile of urban journeys. Enhancing the efficiency and sustainability of these segments can provide better access to mobility systems, alleviate congestion, bolster local economies, and improve overall health and quality of life in urban areas.

This report presents unique strategies for improving first- and last-mile transport, showcasing global examples where policy, technology and infrastructure have been used to create less congested and more liveable cities. The case studies highlighted are by no means the only solutions needed to solve congestion, as a range of interventions and approaches are needed. However, these cases highlight the innovative options at the disposal of cities to alleviate congestion through first- and last-mile transport, and the power of public-private collaboration in driving meaningful change.

Also presented in this report are the collective efforts of cities and companies worldwide to confront congestion and foster more sustainable urban environments. Through such collaborations, progress can be made towards creating cities that are not only more navigable, but also better places to live and visit – healthier and more sustainable for all.

Executive Summary

Cities and businesses around the world are adopting innovative solutions to address the challenge of congestion.

Urban transport systems are facing new and growing pressures. Increasing urban populations, changing behaviours and demands around transport, and changing societal patterns such as remote and hybrid working, all pose challenges to the traditional operation of transport in cities. Among the biggest challenges facing urban transport is congestion, underpinned by transport systems dominated by single-occupancy vehicles and limited urban space. Traditional solutions to tackle congestion – such as public transport, shared vehicles, walking, cycling, warehousing and pooled delivery vehicles – remain vital in keeping cities moving. But, with changing societal patterns around transport, innovative solutions are needed to tackle congestion.

This report focuses on the challenge of congestion in cities and explores how addressing the first and last mile of transport can mitigate this pervasive issue. Pioneering approaches are showcased across technology, policy and infrastructure, which demonstrate the necessity of innovative strategies to enhance urban mobility.

Solutions like micromobility, data-driven transport management, autonomous vehicles and innovative infrastructure projects are helping cities deliver efficient first- and last-mile transport and reshape urban mobility. These innovations and many more are not only enhancing the efficiency of existing transport systems, but also future-proofing urban transport and contributing to more sustainable, liveable cities.

The diversity of solutions explored in this report reflects a broad spectrum of interventions, from experimental pilots to proven strategies that significantly ease congestion and enhance first- and last-mile connectivity. These initiatives demonstrate the potential for cities of various sizes and contexts to tackle congestion effectively and highlight the importance of customizing solutions to meet local needs and conditions.

As cities continue to grapple with new challenges and ever-changing transport needs, there is a clear need for collaboration among stakeholders to deliver efficient first- and last-mile transport and address congestion. Investments in infrastructure, the integration of evolving technologies and flexible policies depend on strong public-private cooperation.

This report highlights innovative approaches to first- and last-mile transport, contributing to the reimagining of urban transport. Embracing these solutions can create more accessible, navigable, sustainable and healthier transport systems that meet the demands of modern cities.

Introduction

Addressing congestion demands innovative and focused first- and last-mile solutions for enabling sustainable mobility.

Cities constitute a significant proportion of environmental pollution, accounting for approximately 60-80% of worldwide energy consumption and more than 75% of carbon emissions.[1] One of the primary sources of these emissions is the transport sector, which contributes approximately one-quarter of all energy-related greenhouse gas (GHG) emissions.[2] Since 1970, transport emissions have increased nearly threefold. The sector currently ranks as the second-largest contributor to global carbon emissions,[3] with road-based transport accounting for around 75% of all transport emissions.[4] In many cities, transport accounts for about one-third of total carbon emissions,[5] and with other sectors such as energy rapidly decarbonizing, transport is the largest source of emissions for many cities throughout the world. The continued dependence on internal combustion engine vehicles, coupled with the high use of single-occupancy vehicles, makes tackling emissions from transport a major challenge.

Beyond the challenge of emissions, transport systems characterized by single-occupancy vehicles mean that many cities continue to struggle with the issue of road traffic congestion. Congestion adds hundreds of hours to journey times each year in major cities around the world, causing both longer commute times and delays to the delivery of goods, costing millions of dollars in excess fuel consumption and loss of productivity.[6,7] On top of delays in travel times, congestion puts pressure on cities through infrastructure strain, decreased quality of life, as well as increased emissions and pollution.[8] Solutions are needed to tackle the issue of congestion and advance the transition to more efficient, sustainable transportation models in cities.

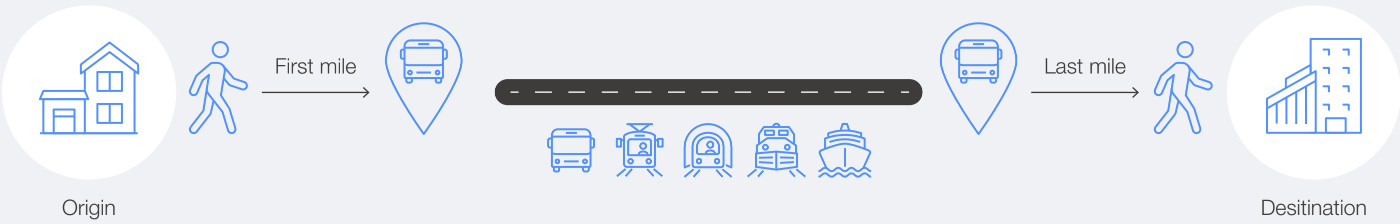
Local and national authorities play a key role in addressing congestion, with one of the most effective strategies being the improvement of first- and last-mile journeys. First and last mile refers to the transportation of goods or people at the beginning or end part of a journey, which in cities, are often major contributors to congestion due to the high number of single-occupancy vehicles typically being used. Intervening in first- and last-mile transport is crucial for reducing congestion and pollution[9] while improving overall transport efficiency in cities.

While shared transport, public transit, walking and cycling are vital for reducing congestion, cities need new solutions to meet evolving urban transport demands. A comprehensive approach across technology, policy and infrastructure is required to deliver efficient first- and last-mile journeys. This report examines a range of innovative solutions, from proven methods with clear impacts to emerging technologies being tested to address congestion. Many of these solutions are the result of public-private collaboration, which is crucial for developing effective first- and last-mile interventions.

First- and last-mile passenger transport

Transport journeys encompass the movement from one's origin to the desired destination, whether it be for work, medical appointments, shopping, educational purposes, or leisure activities. When travelling by public transport, the distance individuals need to travel from the point of origin to a transit stop is commonly referred to as the first mile of the journey, whereas the distance from the arrival transit stop to the destination is referred to as the last mile of the journey. Effective first- and last-mile solutions in passenger transport play a vital role in fostering a seamless, efficient and accessible public transport experience, enabling people to easily access public transport services.

FIGURE 1. **Typical passenger journey**

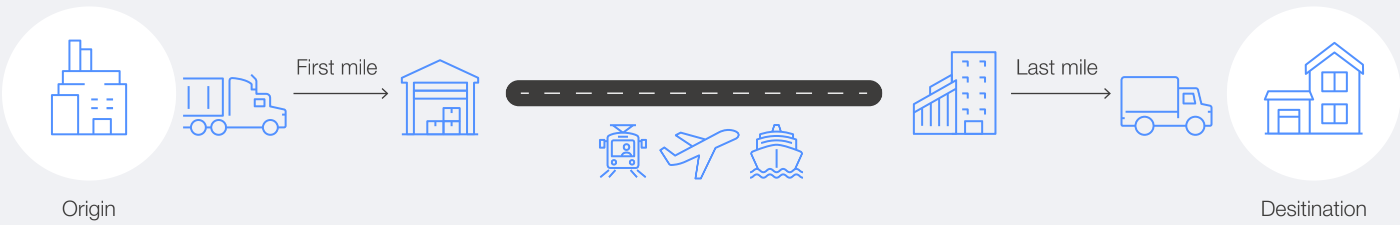


Traditional first- and last-mile solutions encompass walking, cycling, private vehicle use and shared mobility services such as taxis. However, emerging alternatives such as micromobility (e.g. e-scooters), ridesharing and on-demand public transport are increasingly gaining traction globally. In addition, experimental initiatives such as pilot programmes of autonomous vehicles are being explored worldwide, offering potential solutions to alleviate urban congestion.

First- and last-mile delivery in goods/freight transport

The term first-mile delivery refers to the start of the delivery portion of the supply chain and the last mile to the end of the supply chain. First-mile operations get products from the manufacturer via a courier to a carrier. Last-mile operations finish when the order is delivered to the customer.[10]

FIGURE 2. **Typical logistic transportation journey**



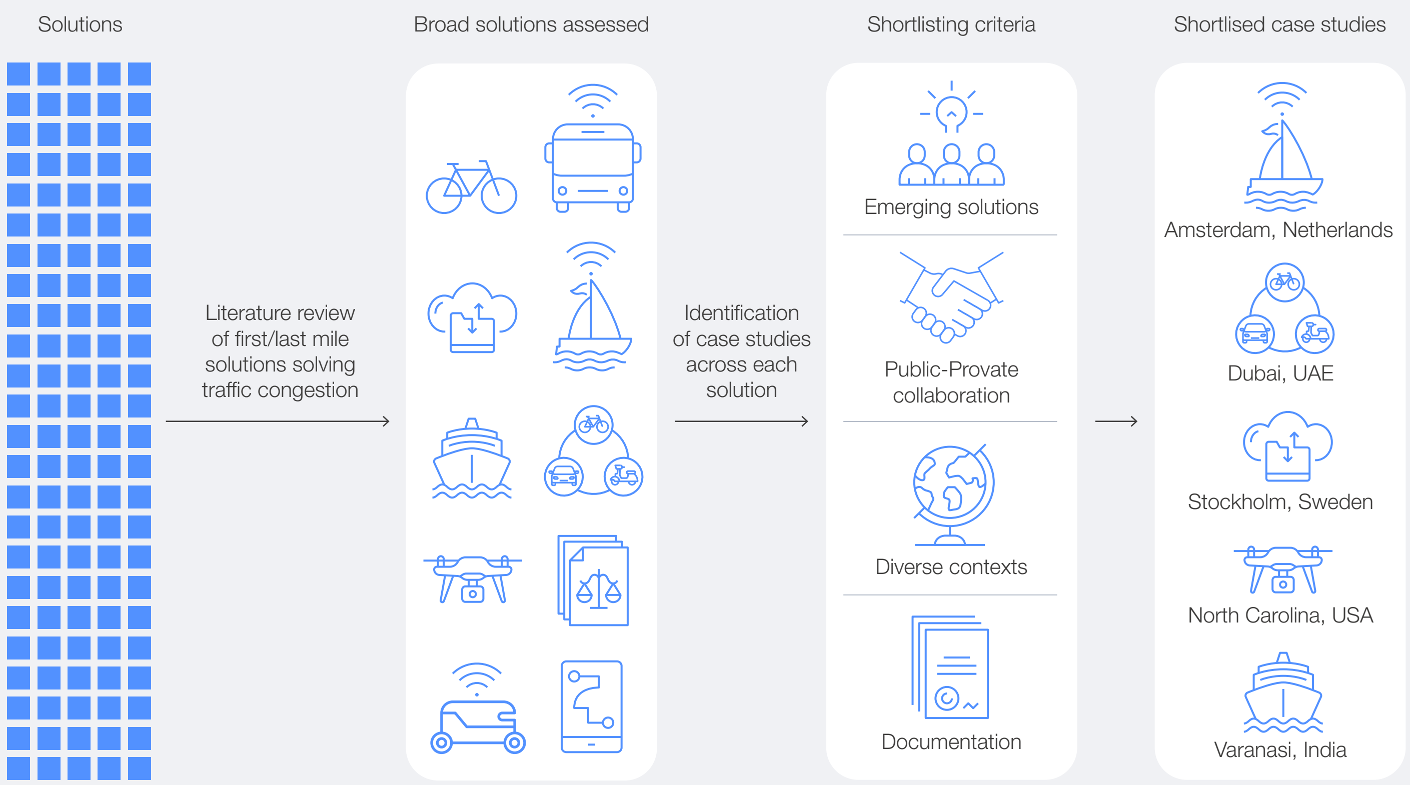
Due to increased trends in online shopping and home deliveries, the number of delivery vehicles on city streets has grown significantly in recent years. Past studies have estimated that in the global top 100 cities, delivery vehicles may increase by 36% by 2030. Consequently, emissions from delivery traffic could increase by 32%, with congestion rising by over 21%, equalling an additional 11 minutes of commute time for each passenger on a daily basis.[11]

Approximately 70% of delivery companies claim that speed and estimated time of delivery (ETD) are the main challenges they face today while managing customer expectations.[12] Urban freight has a disproportionately high impact on congestion and emissions due to the number and size of vehicles. Among the main barriers that prevent meeting speed and delivery time predictions are road congestion, and poor traffic routing strategies. The conventional form of freight deliveries, using high volumes of trucks and minivans, puts significant pressure on traffic congestion, as well as causing local air pollution, emissions and concerns around road safety. A range of solutions is being used to reduce the use of these large vehicles and alleviate congestion, with alternatives such as e-cargo bikes, small electric vehicles and delivery drones holding promise to replace these vehicles. Deploying these solutions, complemented by defined public policies and necessary infrastructure, will enable a more sustainable movement of goods, tackling traffic congestion and reducing the footprint of deliveries on city streets.

The analysis approach

This report aims to showcase innovative and unique solutions that are being deployed by cities to address congestion not solved by traditional first- and last-mile transportation solutions (i.e. walking, cycling, private vehicle use, shared mobility, shared delivery, warehousing, etc). The selection process for case studies followed the approach outlined below:

FIGURE3. **Approach to a selection of case studies**



Through an extensive literature review, a range of solutions for delivering innovative first- and last-mile transport for both passenger and freight transport were identified. Over 20 solutions were shortlisted for investigation, with six cases taken forward for investigation in this report. The five case studies were selected to meet four key parameters: emerging or innovative solutions based on unique technology, policy, or infrastructure; public-private collaboration underpinning the success of the solution; a diverse geographical representation of solutions from differing locations and urban contexts; and information availability on the existing or expected impact of the solution to alleviate congestion and deliver efficient first- and last-mile transport.

It is important to note that the aim of this report is not to present a definitive list of first- and last-mile solutions that solve on-road traffic congestion, but rather to showcase unique, innovative solutions from across the world that have created, or are predicted to create, a positive impact in tackling congestion through interventions to improve the efficiency of first- and last-mile transport. As such, solutions in the case studies cover a range of interventions – from policy and infrastructure to data and new technological responses.

CASE STUDY 1

Autonomous water taxis

Amsterdam, the Netherlands

STATUS **Implemented**

Overview of mobility challenge

The extensive canal system in Amsterdam has historically played a crucial role in the city's development having been built for various purposes, including transportation, trade and defence. However, the historic infrastructure, particularly the walls and bridges around the canal system, is now a significant concern for the city. The age and design of these structures struggle to withstand modern traffic demands, especially heavy delivery vehicles. As a result, parts of the city's legacy infrastructure are deteriorating. This issue has prompted the need for mobility solutions that can shift some of the city's traffic from the road to the waterways and also reduce the burden of deliveries in the city.

Another key challenge exists for waterways – a lack of skilled shippers. So while many manned boats currently operate on Amsterdam waterways, scaling these operations, or making them more on-demand and flexible in routing, requires driverless solutions.[13]

Solution: Roboat autonomous water taxi and sustainable inner-city logistics centres

The Roboat initiative was a collaborative research effort led by the AMS Institute, involving scholars from the Massachusetts Institute of Technology, Delft University of Technology, and Wageningen University and Research supported by Waternet, the City of Amsterdam and the City of Boston.[14] The project sought to leverage emerging technology to optimize Amsterdam's canal system for both freight and public transport. Central to the project was the development of modular, zero-emission, autonomous boats, aimed at revitalizing the canals and the significance of the canals within the cityscape.

The five key use cases envisaged for the Roboat project were:

1. **Passenger transport:** The most apparent use of Roboats is as water taxis or passenger shuttle vessels, providing a convenient and eco-friendly mode of transportation for residents and visitors. The navigation component in the system calculates from path A to B using GPS technology with the map of the local environment.

2. **Logistics:** Roboats are to be utilized for logistics and transporting various goods to different parts of the city, reducing the need for heavy trucks on the city's roads.

3. **Data collection:** Roboats equipped with LiDAR technology and sensors could serve as valuable tools for urban data collection. For example, water quality sensors can provide real-time data on the state of Amsterdam's waters, aiding in monitoring and managing water quality and environmental conditions.

4. **Flexible infrastructure:** The modular design of these autonomous boats allows them to self-assemble and form temporary structures, such as bridges. This feature can be especially useful for reducing traffic congestion during rush hours by creating additional pathways for vehicles and pedestrians.

5. **Waste collection:** Replacing current road transport for refuse collection along streets lined by canals will help clean up the street environment and free up space on streets. Replacing current road transport for refuse collection along canal-lined streets will help clean up the street environment and free up space on the streets.

Amsterdam is also innovating sustainable goods deliveries. CTPark in Amsterdam City stands as the pioneering multimodal, multi-level inner-city logistics centre in the country, offering strategic connectivity to urban hubs via both land and water routes. CTPark is strategically designed for last-mile deliveries to densely populated regions in an emission-free manner.[15] With more than 200 charging stations for electric vehicles and other emission-free transportation options, it emerges as an optimal hub for last-mile deliveries.

Deudekom, a removal company with a warehouse in Amsterdam's Duivendrecht area, uses its warehouse as a central hub for consolidating goods deliveries around the city. It also advocates for suppliers to consolidate deliveries to reduce mileage, CO_2 emissions and the number of trips. Research indicates that urban logistics facilities, such as micro hubs, can enhance the cost-effective use of light electric freight vehicles (LEFVs) by reducing the distance to customers.

Energiewacht, based in Heemstede, installs smart energy meters in the Amsterdam region. Due to scarce parking and heavy traffic in Amsterdam, mechanics waste significant time on travel and parking. To address this, a mobile hub is centrally parked in the work area throughout the day for resupply. This system potentially saves 30% on transportation costs and reduces CO_2 emissions by 80%.

Nedcargo, one of the Netherlands' largest logistics service providers, specializes in transporting food and beverages.

Traditionally using lorries for city deliveries, Nedcargo faced challenges due to stricter environmental regulations and safety concerns in narrow city streets. In 2018, students from the Rotterdam University of Applied Sciences established a consolidation centre to deliver goods to Nedcargo's customers in the inner city of Rotterdam by different types of LEFVs. Data revealed a 30% reduction in roundtrip times, and more than 90% reduction in CO_2 and NOx as compared to lorries. Customer surveys also indicated increased satisfaction with the new delivery method.[16]

Impact and takeaways

Since its establishment in 2015, the Roboat project has amassed a substantial body of scientific knowledge through research, visualizations, experiments and prototyping. This plethora of information encompasses autonomous navigation, perception-control systems and potential applications wherein Roboats could serve as an alternative form of public transport. The first prototypes were tested in 2017, with a second demonstration taking place in 2018.[17] In 2021, one water taxi and one waste collection boat were launched for live testing in Amsterdam waterways.[18]

Subsequently, Roboat officially launched as a start-up company in early 2023 with a focus on its autonomous system, which can be installed in new-build boats, as well as in existing vessels. Amsterdam's public transport company GVB uses this system for its ferry services across the IJ river system. Roboat's system can identify all objects in the water and provides this information to the captain to make the crossing safer. The company also supplied its system to a shipping provider and local operator in Paris for the 2024 Olympics to help carry passengers across the Seine.[19] Roboat's prototype vehicle is zero emissions, and the company is seeking to embed electrification as a principle of its plans to scale the technology in the future.[20]

Roboat's ability to operate safely and efficiently in dynamic urban environments with extensive water networks like Amsterdam holds promise for future applications. With many cities across the world still having canals as a key feature of urban form, autonomous river transport solutions such as Roboat could hold promise to alleviate pressure on the road network and provide sustainable, intelligent transport for passengers and freight, strengthening transport connections across cities. The Roboat initiative also highlights the significance of public private collaboration in deploying innovative transportation solutions.

Sustainable delivery solutions and congestion alleviation can be achieved through innovative approaches in urban logistics such as CTPark. By establishing multimodal hubs strategically located within city centres, delivery operations can optimize access to densely populated areas while minimizing environmental impact. Incorporating emission-free vehicles and charging infrastructure, such hubs promote eco-friendly transportation methods. Additionally, by facilitating last-mile deliveries efficiently, they contribute to reducing congestion and improving overall urban mobility.

CASE STUDY 2

Taxi traffic management

Dubai, United Arab Emirates

STATUS **Implemented**

Overview of mobility challenge

Taxi services, as with other shared mobility services, are widely recognized as indispensable first- and last-mile solutions in urban areas, ensuring seamless transportation and reducing dependency on private cars within cities. However, challenges stemming from disorganized passenger demand and unpredictable driver patterns have led to an unbalanced distribution of taxis in many cities, particularly during peak traffic hours. Consequently, passengers can experience longer waiting times and increased fares while taxi drivers navigate through congested traffic lanes, leading to a demand-supply gap, longer commute times and increased stress levels. Such operational inefficiency also hampers the income of taxi service providers and undermines overall passenger satisfaction, primarily attributed to prolonged wait times and the inability to access timely service when required.

In Dubai, a city that has experienced significant growth in recent years and continues to grow rapidly, developing an efficient transport system is a priority. Around 60% of trips in Dubai are made by private vehicles,[21] making the growth of shared and public transport services important to minimize congestion. The use of taxis and shared mobility services is on the rise, with around 114 million journeys taking place in 2023, an 8% increase from 2022.[22] With taxis becoming an increasingly important mode of transport in the city, managing them efficiently is a priority.

Solution: Dynamic heat maps

The Dubai Roads and Transport Authority (RTA) launched the Dynamic Heat Maps Programme for taxis with Trapeze's artificial intelligence (AI) technology, which highlights high-demand areas and potential passenger concentrations. These heat maps are dynamically updated using real-time data analysis through advanced AI within the Enterprise Command and Control Center (EC3) of the city. All taxis are equipped with smart meters that directly connect with the control room. Within the cabs, heat maps utilize three colours: green, yellow and red. Green signifies heightened passenger demand at a specific destination, while yellow suggests sufficient vehicle availability in the vicinity to meet demand. Conversely, red indicates either a scarcity of passengers in the area or an excess of available vehicles, prompting drivers to relocate to another area, optimizing efficiency and reducing wait times for travellers.[23]

FIGURE 4. **Smart meters installed in Dubai taxis[24]**

The dynamic heat maps are meticulously updated through the central control system, closely monitoring the movement of 10,800 taxis and demand fluctuations across Dubai-designated target areas, all powered by advanced AI.[25] This sophisticated control mechanism systematically analyses real-time passenger demand data while gauging the presence of taxis within specific zones. By juxtaposing these insights, the system accurately assesses the overall capacity of the taxi fleet to address the prevailing demand.

FIGURE 5. **Heat maps used for taxi traffic management, Dubai, UAE**[26]

● Area does not require more vehicles ● Demand is neutral ● Area requires more vehicles

Impact and takeaways

The integration of the AI system within the taxi network has yielded remarkable results, notably culminating in a substantial 17% increase in taxi reservation efficiency and 40% reduction in unproductive mileage. Additionally, the system has significantly mitigated unproductive mileage by approximately 40%, consequently fostering a positive impact on both the environmental and economic landscapes. The streamlined implementation of the AI infrastructure has led to a 14% increase in the volume of bookings received, highlighting the system's pivotal role in bolstering operational efficacy and service accessibility.[27]

Dynamic heat maps have helped identify specific locations with high congestion and alleviate the pressure on the road network. These visual representations of real-time and historical data generated from the maps could play a vital role in aiding city planners and traffic management authorities to target areas where interventions are required to remove congestion. The use of heat maps has also facilitated optimized deployment of vehicles to high-demand areas, empowering drivers with a vital resource for passenger acquisition, while concurrently curbing fuel consumption and enabling reduced emissions. Additionally, precise demand indicators displayed on the heat maps result in improved customer experience by providing more information on journey times and helping to reduce waiting times for services.

Overall, making use of cognitive technology solutions such as dynamic heat maps holds the potential to make shared mobility services a key means of reducing congestion and improving first- and last-mile journeys in cities.

CASE STUDY 3

Regulation of micromobility

Stockholm, Sweden

STATUS **Implemented**

Overview of mobility challenge

The electric scooter, or e-scooter, has become widely popular as a form of micromobility in recent years gaining particular momentum in various locations across North America and Europe.

Stockholm, Sweden, emerged as one of the pioneering cities in the adoption of e-scooters, with Voi leading the way by introducing its first e-scooter service in August 2018. Subsequently, numerous other companies followed suit, resulting in more than 10 providers operating in Stockholm by the summer of 2019. These providers varied in fleet size, ranging from a few dozen to several thousand e-scooters totalling more than 20,000 e-scooters in Stockholm.[28,29] However, a local survey conducted in the city presented data that citizens shared mixed opinions about the use of e-scooters as a viable first- and last-mile solution owing to the perception of e-scooters being unsafe for the elderly, and from the experience of accidents due to negligent use of e-scooters on sidewalks, and unauthorized parking.[30]

Solution: Data-driven regulation

In 2020, to analyse the use of e-scooters in the city for better regulation, control and follow-up, city officials ideated a city third-party platform, Cityscope, provided by the French company Vianova, to increase competency in data sharing between cities and micromobility players through practical application of geofencing.[31]

The city provided geo-spatial rules and regulations via an Application Programming Interface (API) to the operators to indicate the appropriate parking and riding locations, which operators could communicate to the users. The companies shared data through Cityscope about the location and movement of e-scooters to monitor compliance and give the city authority an insight into usage behaviours.[32]

Official partners for this project were City of Stockholm (Traffic Administration and Environmental and Health Administration), Voi and Vianova. Many e-scooters providers (Voi, Bolt, Tier, Lime, Bird, Superpedestrian, etc.) participated and provided

data via standardized open-source mobility data formats such as the Mobility Data Specification (MDS). This platform led to a bilateral exchange of information, such as data on the number of e-scooter trips, and information on geofenced regulations including parking zones and curbsides from city administration. Data-sharing via Cityscope continued to be part of normal operations in the City of Stockholm during 2022.[33]

Impact and key takeaways

In Stockholm, utilizing a third-party platform for data sharing was instrumental in overseeing e-scooter operators' adherence to regulations. Through this platform, officials conducted a thorough analysis of e-scooter movements, ensuring compliance with parking and speed regulations. Additionally, this data facilitated trend analysis, aiding in infrastructure planning for a safer and more cohesive mobility environment in the city. Comparisons of Key Performance Indicators (KPIs) between Stockholm and other cities and between operators were conducted, linking complaint levels to fleet sizes. Access to the data-sharing platform also facilitated operators to constructively engage with the city, ensuring compliance with regulations.[34]

One of the difficulties encountered was the inadequate precision of shared e-scooter location data. This lack of accuracy poses challenges for authorities seeking to enforce regulations in narrow areas and levy fines on operators based solely on parking violation information. Moreover, operators faced obstacles in controlling speed near restricted zones due to limitations in positioning accuracy.[35]

The above-gained insights resulted in a new form of permits in 2021 for e-scooter rentals, imposing caps for each operator on the number of electric scooters operated in the city and annual charges for each operator. Various other laws, such as prohibition of parking on pavements or cycle paths and mandating that e-scooters be parked solely in designated parking areas, came into effect. These laws make e-scooters equivalent to bicycles with regards to road traffic regulations.[36] These new regulations have helped to deliver a better-managed, more consistent experience with e-scooters in the city which avoid clutter on streets, reducing conflict with pedestrians and other street space demands. While there is some evidence showing that scooter use may have declined in some instances in Stockholm since the introduction of parking regulations, evidence also shows high support for the changes to scooter management and continued use of the scooters.[37]

E-scooters present a promising solution to urban congestion, offering a convenient means of first- and last-mile transport to complement public transport. However, addressing challenges such as irresponsible parking and reckless speeds is crucial for realizing its full potential. Optimizing micromobility fleet size through measures such as managing operations and enforcing strict permit criteria can significantly improve traffic flow and enhance public safety. Data-sharing platforms enable transparency and informed decision-making, supporting effective infrastructure planning and regulation enforcement. Policy-makers, operators and planners in tandem must collaborate to successfully manage and encourage novel shared mobility solutions such as e-scooters to pave the way for a more efficient, connected mobility system.

CASE STUDY 4

Drone delivery services

Holly Springs, Fayetteville, Raeford and Granbury, USA

STATUS **Implemented**

Overview of mobility challenge

Home delivery volume continues to grow as shoppers move from the high street to online. Consumers are not just looking for faster delivery times, but they are also pushing for increased flexibility and visibility. Shoppers increasingly want to be able to select the timing and location of each delivery, tracking deliveries all the way and experiment with frequent orders with smaller quantities. These changing consumer behaviours and preferences around deliveries are leading to companies exploring options for more home deliveries that can be fast, reliable and economical. More delivery vehicles on the road to meet increased demand for rapid home delivery of goods inevitably puts more pressure on transport systems, including for last-mile deliveries, leading to congestion on city roads, particularly in dense urban areas.[38]

In the United States, demand for fast home deliveries has increased significantly in recent years. E-commerce and logistics players are recording huge increases in customers choosing next-day or even same-day delivery options, with these companies putting significant resources into expanding such services.[39,40] Indeed, the market size for same-day delivery is set to increase by around 50% by 2030,[41] and reports suggest that the vast majority of major retail players in the US are planning to offer same-day delivery services by 2025.[42,43] Meanwhile, home food deliveries continue to increase in popularity, with the US meal deliveries market estimated to be worth almost $100 billion by 2029.[44]

With demand for rapid home deliveries set to increase, it is vital to find solutions that can tackle congestion from last-mile deliveries while providing cost-effective, efficient, end-to-end deliveries.

Solution: Flytrex autonomous delivery drones

Aerial delivery drones have emerged as a promising solution in autonomous last-mile delivery services as a way to reduce traffic and emissions. In the US State of North Carolina, the Federal Aviation Administration (FAA) granted a license for drone delivery operations in the towns of Holly Springs, Fayetteville and Raeford as part of a pilot project. The town of Granbury, Texas, was also included in this trial.[45] Drone delivery start-up Flytrex was selected for running delivery operations in these areas, offering fast, safe and cost-effective airborne deliveries directly to customers' front and backyards.[46] Through the trial, the company has been testing food deliveries from restaurants directly to customers' homes in these towns.

When an order is ready for collection at a restaurant, the company's drone travels to the restaurant and hovers above the collection area. It deploys a descending wire, enabling restaurant staff to affix the package directly to the tethered hook. After loading, the drone transports the order to customers' homes, gradually releasing the delivery via a tether system.[47]

Impact and takeaways

Following successful testing and piloting and buy-in from the FAA, Flytrex's operations have grown to a robust operation, with a substantial growth in its eligible customer base in the US – a 138% increase between 2021 and 2022; 2022 saw over 85,000 grocery items delivered through Flytrex's drones.[48] The company grew on this success by delivering to 81% more households in 2023 compared to 2022,[49] and has capitalized on successful trials in North Carolina and Texas to provide drone deliveries in new cities in the US.[50] In 2022, the company carried out over 22,000 flights without any serious crashes or incidents.[51]

The pilots in North Carolina and Texas have shown the potential for drone delivery to provide a reliable, convenient and safe alternative for last-mile deliveries, offering the potential to reduce vehicle numbers and tackle congestion from the deliveries sector. The ability of drones to navigate complex environments effortlessly and offer rapid delivery times, especially for urgent or time-sensitive packages, holds promise for alleviating pressure on road networks in the future. Although the initial setup costs are considerable and may affect adoption rates, operational expenses are often lower due to reduced energy consumption and fewer human resources needed for operation.

However, unlocking the full potential of drones for deliveries hinges on establishing a robust regulatory framework and obtaining necessary certifications. Industry stakeholders and regulatory authorities need to collaborate in creating a framework conducive to safe and efficient drone operations. Social acceptance of drones for deliveries and other purposes will also be a crucial factor; at present, drones do not have widespread public support, particularly regarding operations near or over households.[52]

CASE STUDY 4

Inland waterways and cable car system

Varanasi, India

STATUS **Status: Underway**

Overview of mobility challenge

Located in northern India, Varanasi is one of the world's oldest cities, known for its dense population, cultural sites and narrow streets. In 2023, India's tourism agency reported that more than 53.8 million domestic and international tourists visited the city.[53] This popularity, however, strains its transport infrastructure, with three national and four state highways critical for connectivity yet overwhelmed by traffic. The congestion, especially around major hubs like the Varanasi railway station, hampers movement and complicates transport needs in this historic city. Given the impracticality of conventional public transport solutions like light rail due to space constraints, innovative alternatives are essential to alleviate congestion and enhance traffic flow.

Solutions: Inland waterways and cable car system

Inland waterways

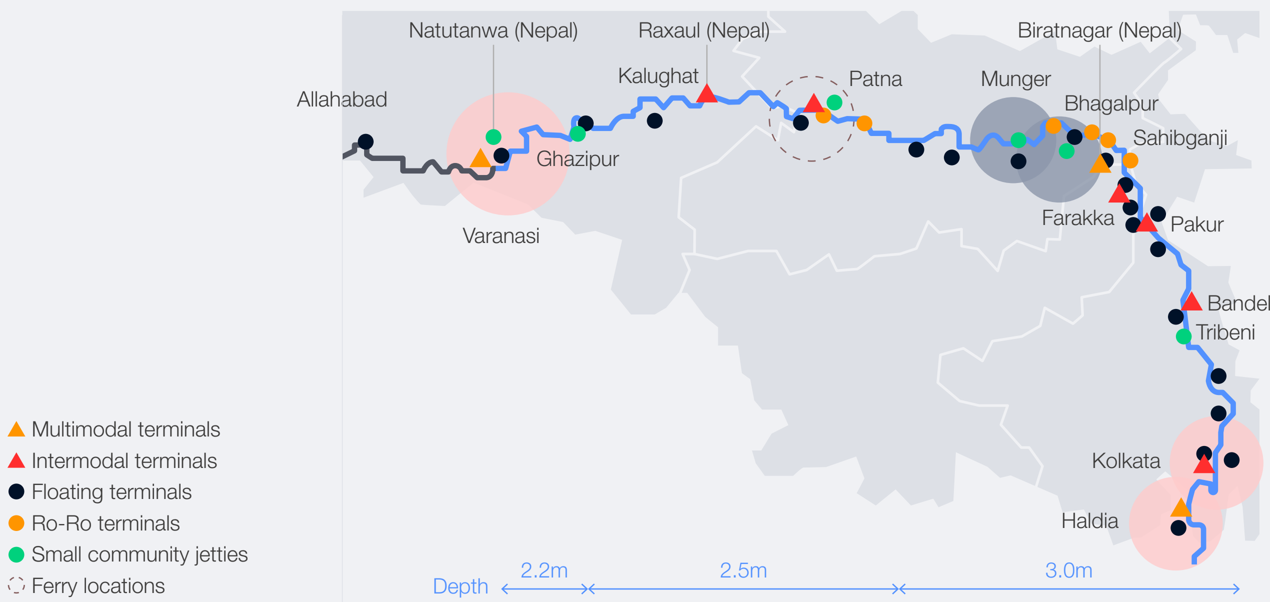
The establishment of inland waterways presents a more cost-effective and environmentally sustainable means of transporting people and goods over both short (within the city) and long distances (inter-city movement), fostering tourism and economic opportunities for communities residing along the riverbanks. The Inland Waterways Authority of India (IWAI), operating under the Ministry of Shipping, serves as the statutory body responsible for overseeing the development and regulation of inland waterways.[54] One noteworthy initiative of the IWAI is the Jal Marg Vikas Project (JMVP), financially supported by the World Bank.[55] This endeavour aims to integrate various modes of transportation, ultimately resulting in the movement of large quantities of goods and passengers in a short time span, thereby reducing congestion on railways and roads, minimizing the carbon footprint and optimizing resource utilization.

Some of the major initiatives taken by this project under the Ministry of Shipping are establishing multi-modal terminals along the Ganga River (Figure 6), with Varanasi being a key location. It also includes the development of jetties within a 250-kilometre stretch between Varanasi and Ballia in Uttar Pradesh state of India.

Completed components: Multi-Modal Terminal (MMT) at Varanasi: Inaugurated on 12 November 2018 by Prime Minister Narendra Modi, this terminal is fully operational, handling cargo and passenger traffic. It marked a milestone with the first cargo vessel arriving from Kolkata in 2018.

Floating terminals: Operational at multiple locations, including Ghazipur, Rajghat (Varanasi), and Prayagraj, facilitating local connectivity and cargo movement.

FIGURE 6. **Arth Ganga masterplan – Multimodal terminals along the Ganga River**[56]



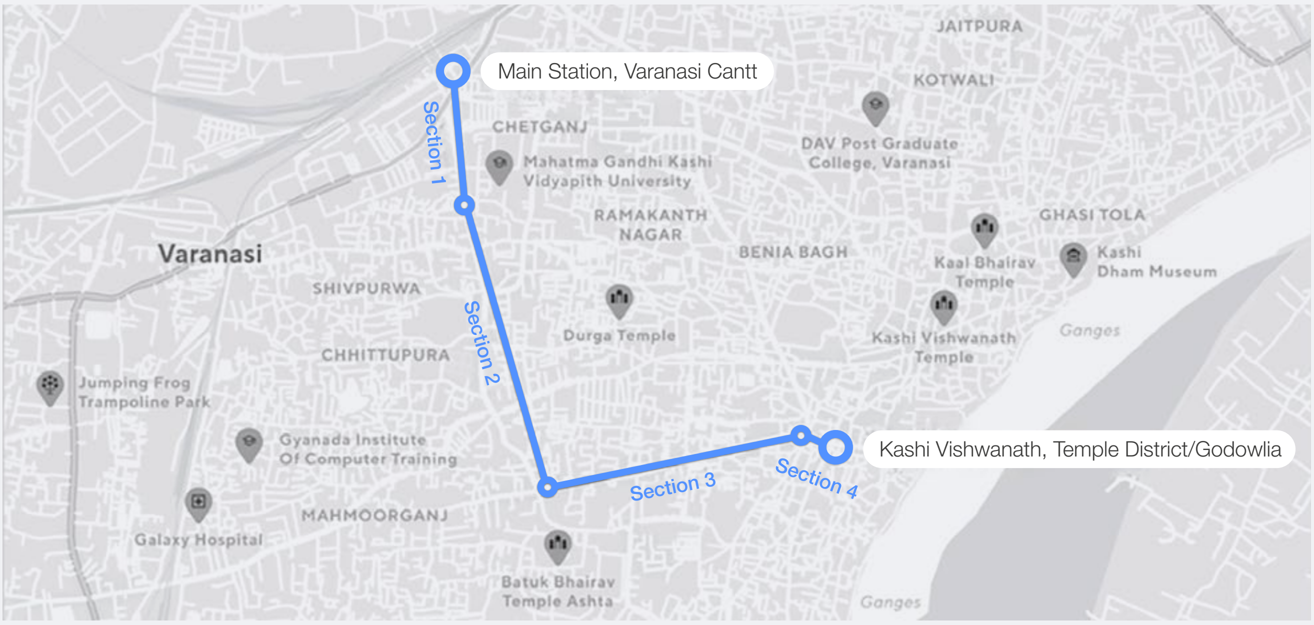
Community jetties: Seven jetties were inaugurated by November 2022 along NW-1 (e.g. Ravidas Ghat, Ramnagar, Kaithi), with eight more under development.

Haldia MMT: Operational to a significant extent, supporting cargo movement toward Kolkata's port ecosystem. These terminals have also facilitated the introduction of roll-on roll-off vessels, ferry and cruise services for tourists. To address environmental concerns, these boats have transitioned from diesel-engine water taxis to compressed natural gas (CNG)-propelled, hydrogen-fuelled and solar-powered water taxis.[57,58,59]

Cable car ropeway system

In 2022, the Varanasi Development Authority approved a cable car ropeway system, with a central terminus at Varanasi Railway Station.[60] The under construction ropeway, which will be the first of its kind in India, aims to strengthen connections throughout the city and provide residents and tourists alike with convenient access to Varanasi Railway Station, as well as key points across the city. The ropeway will provide connections to multiple tourist attractions such as the Kashi Vishwanath Temple and the Ganga River.

FIGURE 7. **Cable car route in Varanasi[61]**



The cable car ropeway will cover about 4 kilometres, with a total of five major stations. The planned operating hours for the Varanasi cable car will be 16 hours per day, promising sustainable relief for traffic congestion and better connectivity to the heavily frequented temple district.[62] The ropeway is anticipated to expand to cover all major city stations in Varanasi. The expanded network will also reach academic institutions, which will help to connect commuting students with the Varanasi Railway station.[63]

Governed by a public-private partnership (PPP), the government tendered the project, opting for the established Swiss technology provided by BARTHOLET. Following completion, the cable car system will be operated by Vishwa Samudra Ropeways for 15 years, ensuring seamless operation and management.[64]

Anticipated impact and key takeaways

Inland waterways

The multi-modal terminal is anticipated to shift local passenger travel within the city away from single-occupancy private vehicles on congested urban roads and onto the Ganga River, as well as reducing intercity passenger and freight traffic from the congested national and state highways within the city to inland waterways. According to a study conducted by the World Bank, one litre of fuel can transport 105 tonne/km via inland water transport, compared to 85 tonne/km via rail and 24 tonne/km via road. Similarly, the carbon emissions per tonne-km are significantly lower for container vessels at 32-36 grams compared to road transport vehicles, which emit 51-91 grams.[65] This redirection will not only reduce the travel time, but will provide a cost-effective and sustainable local solution to first- and last-mile journeys, as well as wider travel within and between cities.

Cities located on riverbanks have recognized inland waterways as a promising sustainable first- and last-mile transportation option. This mode of transport offers advantages such as time and cost savings, decreased road congestion, and improved fuel and energy efficiency.

Cable car ropeway system

The implementation of a cable car system is set to enhance the efficiency of the existing transportation network, particularly improving the convenience and attractiveness of first- and last-mile travel. As revealed in discussions with the Varanasi Development Authority, the ropeway project is envisioned to have a capacity of carrying 2,500 people per hour per direction, totalling 5,000 people in both directions per hour. This capacity is expected to facilitate the transfer of approximately 80,000 people daily. Notably, this shift is anticipated to alleviate congestion and air pollution, particularly for short trips that currently account for nearly more than 60% of the city's transportation as per studies carried out by Banaras Hindu University, mainly reliant on autorickshaws and two-wheelers.[66]

The cable car ropeway project holds potential as a solution to not only tackle congestion issues in Varanasi, but also to reduce air pollution, noise pollution and carbon emissions, all while strengthening first- and last-mile connections to the city's central railway station and beyond. Alongside other initiatives, such as the Nagar Yojana project, which will see a new bus terminal and consolidation zone for freight transport in the city,[67] the ropeway project could help to alleviate pressure on Varanasi's road network and strengthen first- and last-mile connections across the city.

Concluding Thoughts

Tailored solutions catalysed by public-private collaboration can address the challenge of congestion and optimize first- and last-mile transport.

This report has highlighted innovative ways in which cities are finding solutions to the challenge of congestion through optimizing and enabling first- and last-mile transport, and how public-private collaboration can catalyse action on this challenge. By drawing insights from the case studies, government authorities, industry and citizens can enact measures to reinforce policies and investment decisions and societal changes to mitigate congestion, bolstering sustainability efforts and enhancing the overall well-being of residents.

Key takeaways for city authorities

1. Promote public private collaboration:
   - Foster collaborations between academic institutions, private companies and government bodies to innovate and implement advanced transport solutions like Amsterdam's Roboat project and Varanasi's cable car system.
2. Regulate and support technological innovation:
   - Implement regulations that support the deployment of new technologies while ensuring safety and efficiency. For example, adopt AI-driven systems like Dubai's Dynamic Heat Maps for optimizing taxi movements.
   - Facilitate pilot programmes for emerging technologies such as drone deliveries, ensuring they comply with safety standards and gain public acceptance.
3. Incorporate sustainable logistics hubs:
   - Establish and promote multimodal logistics hubs similar to Amsterdam's CTPark to streamline last-mile deliveries using emission-free vehicles, thereby reducing congestion and pollution.
4. Implement data-driven policies:
   - Utilize data-sharing platforms like Stockholm's Cityscope to regulate and monitor micromobility solutions; ensure that data from these platforms is used to inform infrastructure planning and regulatory adjustments.
5. Develop robust regulatory frameworks:
   - Establish clear regulatory frameworks for autonomous and electric vehicles, drones and other innovative transport solutions, ensuring integration into existing urban transport systems.

Key takeaways for Industry

1. Invest in green and autonomous technologies:
   - Develop and deploy zero-emission and autonomous transport solutions, such as the Roboat in Amsterdam and Flytrex drones in the US, to reduce traffic congestion and environmental impact.
2. Create efficient logistics solutions:
   - Innovate in urban logistics by creating consolidation centres and using electric freight vehicles (LEFVs) for last-mile deliveries, reducing the number of trips and emissions, as seen with Deudekom and Nedcargo in Amsterdam.
3. Leverage AI and data analytics:
   - Implement AI-driven systems like Dubai's Dynamic Heat Maps to optimize fleet management, reduce idle times and enhance service efficiency.
4. Collaborate with urban authorities:
   - Work closely with city officials to ensure compliance with regulations and contribute to urban mobility planning, similar to the collaboration between e-scooter companies and Stockholm's city administration.

5. Engage in continuous improvement and scaling:
   - Commit to continuous improvement of transport technologies and services based on real-world testing and feedback, aiming for scalable solutions like the Roboat's progression from prototype to start-up.

Key takeaways for citizens

1. Adopt sustainable transport options:
   - Utilize eco-friendly transport modes such as electric water taxis, e-scooters and public transport options to reduce individual carbon footprints and alleviate urban congestion.
2. Participate in shared mobility:
   - Engage in shared mobility solutions, such as carpooling, ride-sharing and bike-sharing programmes, to optimize transport efficiency and reduce the number of vehicles on the road.
3. Support innovative solutions:
   - Be open to and actively participate in pilot programmes for new transport technologies like autonomous water taxis, drones and AI-driven taxi systems to provide valuable user feedback.
4. Adhere to urban mobility regulations:
   - Comply with city regulations regarding parking, speed limits and designated transport zones for micromobility solutions to ensure safety and smooth integration into the urban transport ecosystem.
5. Promote and advocate for sustainable practices:
   - Advocate for sustainable urban transport solutions within communities and support initiatives aimed at reducing traffic congestion and pollution through public and private efforts.

A range of solutions from technological innovation and infrastructural changes to government policy will be needed to tackle congestion in the short to long term. Importantly, to sustain such solutions, strong public-private collaboration will remain a fundamental feature. Channelling strengths of both the public and the private sector can effectively meet the ever-changing needs of cities and the urgent need to respond to traffic congestion.

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