

D2.5.5 Curb management framework for regulations and accessibility



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GRETA Website

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GRETA Project



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More information about GRETA can be found on <https://www.interreg-central.eu/greta/>



Abbreviation table

| Abbreviation | Definition |
|--------------|---|
| CE | Central Europe |
| FUA | Functional Urban Area |
| SUMP | The Sustainable Urban Mobility Plan (SUMP) |
| ZTL | Limited Traffic Zone |
| KPI | Key Performance Indicator |
| IoT | Internet of Things |
| LoRaWAN | Long Range Wide Area Network |
| CO2 | Carbon Dioxide |
| IT | Information technology |
| IP | Ingress Protection (referring to device protection standards, e.g. IP68/IP69) |
| AMT3 | Azienda Mobilità Trasporti Traffico Verona |
| EU | European Union |



1. The GRETA project

GRETA project aims to decarbonise the last mile delivery in Functional Urban Areas (FUAs) in Central Europe (CE) and create liveable and accessible cities for all by 2030. The project seeks to implement joint sustainable solutions in CE FUAs using zero-emission vehicles and cargo bikes and reorganise urban spaces with curb management. The pilot actions in the cities of Maribor, Reggio Emilia, Verona, Poznan, and Budapest (with Berlin FUA as an observer) have the potential to quickly deploy as pop-up measures in combination with existing measures. GRETA provides capacity-building activities, strategies, action plans, and tools for public authorities, enterprises, and relevant organisations to ensure financial, environmental, and social sustainability beyond the project's lifetime.

Last-mile delivery generates negative impacts, including emissions, noise, and congestion. Due to the COVID-19 crisis, global parcel distribution volume nearly doubled, further increasing inefficiencies in the peripheral areas. GRETA's FUAs recognise the problems that generate pollution, nuisance, noise, congestion, and have jointly recognised three main problems: the lack of use of green zero-emission last-mile vehicles, conflicts between freight and public vehicles, and the lack of knowledge and strategies for a flexible and shared use of the curb and public space. Despite having SUMP/SULPs, FUAs struggle to activate fitting measures while keeping their centres attractive and alive for residents and tourists.

GRETA addresses the common challenges of all CE FUAs by creating the conditions to promote ZE logistics using micro-hubs, cargo bikes, light e-vehicles, and curb management strategies. Additionally, the project also focuses on paving the way to innovative concepts such as regional collaborative logistics, physical internet, and freight curb management. GRETA facilitates the dialogue towards the acceptance of a business and governance as a service model, where cities must equip themselves with a network of innovative services to guarantee seamless experiences for their users and a mobility plan considering different functions and priorities of the services.

GRETA's objective is to support the urban mobility transition in CE FUAs by jointly developing solutions and strategies with a huge potential for decarbonisation of the last mile in line with the EU Green Deal and the Urban Mobility Package, abating congestion, pollution, and nuisance. The project's success relies on capitalising on previous experiences, exploiting synergies with ongoing initiatives, testing innovative pilots, improving competences and knowledge among PPs and stakeholders.



2. Executive summary

The Verona pilot action, implemented within the framework of the GRETA project, aimed to test and validate a digital curbside management solution designed to improve the organisation, regulation, and efficiency of loading and unloading parking slots in a dense urban context. The pilot focused on the Functional Urban Area of Verona, with particular attention to the Limited Traffic Zone and areas characterised by high competition for curbside space and complex logistics operations. The core objective of the pilot was to demonstrate how digital tools and sensor-based technologies can support municipalities in managing freight-related curbside activities more effectively, while simultaneously improving operational conditions for logistics operators and reducing negative externalities such as congestion, double-parking, and unnecessary vehicle circulation. To achieve this objective, the pilot combined the installation of IoT sensors under loading and unloading parking slots with the development of a digital platform enabling real-time monitoring and advance booking of curbside space. The pilot was developed through close cooperation between ZAILOG, the Municipality of Verona, and AMT3, following a progressive and adaptive approach. Initial phases focused on strategic alignment with local mobility policies, including the Sustainable Urban Mobility Plan (SUMP), and on the definition of technical and organisational requirements. Subsequent phases involved procurement procedures, technical design, infrastructure preparation, and system implementation. During the project, key decisions were taken to revise and strengthen the implementation strategy, including the expansion of the pilot scope and the reinforcement of the LoRaWAN network to ensure reliable data transmission across the Functional Urban Area. The implemented solution enabled the Municipality of Verona to gain improved visibility and control over the use of loading and unloading parking slots, supporting monitoring and enforcement activities. At the same time, logistics operators were provided with a dedicated digital tool, allowing them to plan deliveries more efficiently, reduce uncertainty, and improve the predictability of operations. The integration of sensor data and booking functionalities represented a shift from a static and fragmented management of curbside space to a data-driven and coordinated approach. Monitoring activities carried out during the pilot demonstrated tangible operational and environmental benefits. The introduction of the digital curbside management system contributed to a reduction of double-parking episodes and empty vehicle trips, leading to smoother traffic conditions and measurable CO₂ savings. Although the pilot was implemented on a limited scale, the results confirmed the effectiveness of the approach and highlighted its potential for wider deployment. Beyond local impacts, the Verona pilot provided valuable insights for developing a transferable framework for digital curbside management. The experience demonstrated the importance of strong municipal involvement, robust digital infrastructure, and close coordination between public authorities and private operators. It also highlighted the need for adaptive implementation strategies capable of addressing technical and organisational challenges as they emerge. Overall, the Verona pilot action confirmed that digital curbside management solutions can play a key role in supporting more sustainable, efficient, and liveable urban freight systems. The results achieved contribute directly to the objectives of the GRETA project and provide a solid basis for replication and scaling-up in other Functional Urban Areas facing similar urban logistics challenges.

3. Solution

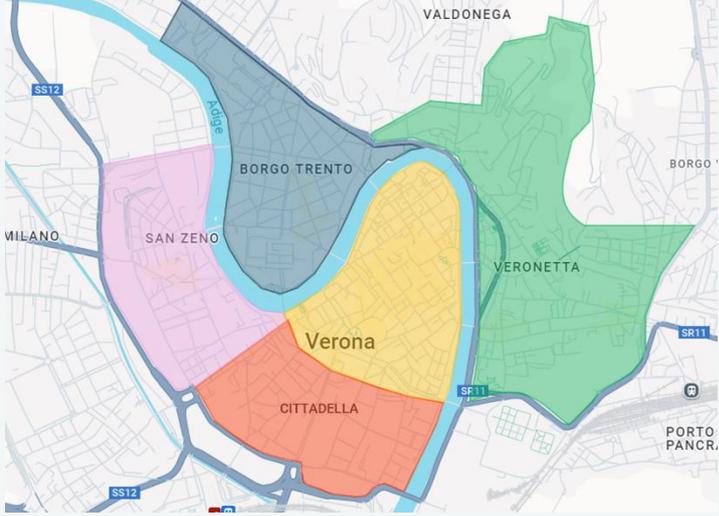
3.1. General information

Firstly, ZAILOG will contribute to the development of the strategy and action plans to improve the Verona Sustainable Urban Mobility Plan (SUMP) with logistics solutions by applying a new curbside management system. More specifically, ZAILOG will closely cooperate with the Municipality of Verona to set up an efficient curbside management system, solving many traffic issues. The municipalities of the surrounding villages operating in the Verona FUA agreed on this sustainable approach.



Verona, located in the Veneto region, is a city with a population of approximately 260,000¹ inhabitants. Verona faces pressing challenges in its urban logistics and transportation systems, particularly in the crucial last-mile deliveries. The Functional Urban Area (FUA) of Verona experiences notable traffic congestions, often aggravated by irregularly parked vehicles and inefficient use of available curb spaces. To address these challenges and pave the way for a more sustainable and efficient future, the scope of ZAILOG in the GRETA project is to implement innovative solutions in Verona's logistics landscape. The vision is to create a sustainable last-mile delivery system that not only reduces emissions but also enhances the overall quality of life for Verona's citizens.

Table 1 General information

| | |
|--|---|
| Location | Verona city center and surroundings, Veneto Region |
| Map (general map of the municipality + detailed map of the city centre) |  <p data-bbox="596 1301 847 1330">Figure 1: Map of the city</p> |
| Area characteristics | <p data-bbox="596 1429 1262 1458">Brief outline the main characteristics of the pilot area:</p> <ul data-bbox="596 1480 1430 1648" style="list-style-type: none"> area type: city center zone that has a high population density. area size: 4,529 squared kilometres access restrictions: some cameras prevent the entrance of no authorized vehicles in the Limited Traffic Zone |
| Additional information | <p data-bbox="596 1724 1430 1892">The SUMP was approved in October 2023 and identified the need to enlarge and enforce access restrictions in the city centre. Starting in October 2024, only residents and freight vehicles will be allowed to access the city centre, with some streets restricted to pedestrians. This is expected to significantly reduce congestion and pollution.</p> |

¹ <https://public.tableau.com/app/profile/ufficio.statistica.comune.di.verona/viz/shared/4N2665S6X>



3.2. Strategy description

The Municipality of Verona aims to rearrange the use of parking spaces in the city. For instance, some parking slots in the FUA area will become only for citizens' use, while other slots (that are currently free) can be used only for paying a toll. It is clear the scope of this SUMP amendment: to reduce the use of vehicles in the FUA area with a consequent increase in sustainability. This is why the Municipality agreed to cooperate in the GRETA project, since it will be possible to have a better arrangement of the deliveries in the FUA with a consequent decrease in empty running.

Through the pilot action, ZAILOG aims to introduce an advanced curb management system, optimizing the allocation of curb spaces for deliveries and reducing traffic bottlenecks. Thanks to the close collaboration with the Municipality of Verona, ZAILOG plans to implement these solutions with local stakeholders. The goal is to face logistics challenges as well as to create a sustainable and scalable model that can be replicated in other cities.

Within this framework, ZAILOG's pilot action is set to become a touchstone of innovation, demonstrating how smart logistics and sustainable transportation can transform urban spaces.

3.3. Governance model

Local policies and regulations:

Currently, in the city centre, there is an access restriction for motor vehicles. In particular, only residents and freight vehicles can easily access this area. Residents do not have any time limitations, while freight operators have time windows to access the city centre. The other vehicles can access only in specific time slots.

The SUMP, approved in October 2023, identified the need to enlarge and enforce the access restrictions in the city centre. In this perspective, from October 2024, there will not be time slots for other vehicles, so only residents and freight vehicles can access the city centre. In addition, in some streets the access is allowed only for pedestrians. In this way, there will be a significant reduction in congestion and pollution.

Regional policies and regulations:

THE AIR QUALITY PLAN OF THE VENETO REGION

The European directives 2008/50/EC² and 2004/107/EC,³ along with Legislative Decree 155/2010, designate regions as authorities responsible for assessing air quality and developing Remediation Plans in areas where air quality standards have been exceeded. Regional planning defines the methods for intervening to control and reduce air pollutants.

The Veneto Region was one of the first Italian regions to develop the Regional Plan for the Protection and Remediation of the Atmosphere (PRTRA).

National policies and regulations:

Free access in limited traffic zones to BEVs, PEHVs and MHEVs due to national legislation. Currently, the national government aims to change Road Traffic Act, but the timeline and variations are not clear.

EU policies and regulations:

European Commission Transport White Paper setting the goal of a 'carbon-free urban freight distribution', i.e., zero direct carbon dioxide (CO₂) emissions by 2030; the proposed revision of TEN-T Regulation is followed with great attention from the cities, especially the part related to the definition of the Urban

² <https://eur-lex.europa.eu/legal-content/IT/ALL/?uri=CELEX%3A32004L0107>

³ <https://eur-lex.europa.eu/legal-content/IT/ALL/?uri=CELEX%3A32004L0107>



Nodes, which will influence also city logistics planning, as well as the ambitious target of phasing out ICE vehicle sales by 2035.

It supports EU goals for sustainability, decarbonisation of transport, and improved urban mobility while contributing to environmental and public health objectives. By aligning with the EU's Green Deal, urban mobility frameworks, Clean Vehicle Directive⁴, and vision zero for road safety⁵, the project can help meet broader EU targets for a greener, safer, and more efficient transportation system.

3.4. Digital and physical infrastructure

In addition to the elements already described, the Verona pilot strengthened its digital and physical infrastructure through concrete measures that enhanced the quality of the service and the reliability of the data collected. The deployment of six new LoRaWAN antennas across the pilot area significantly increased signal coverage, addressing one of the main shortcomings identified at the beginning of the project. This improvement ensured stable communication between the sensors installed in the loading parking slots and the central platform, even in narrow streets or areas where buildings could interfere with signal propagation.

The real-time monitoring of loading parking slots, enabled by IoT sensors and interactive dashboards, has allowed operators and municipal authorities to access reliable information on the availability, occupancy and reservation status of each parking slot. This dynamic visibility has contributed to reducing operational inefficiencies, particularly those related to double parking and unnecessary circulation. Moreover, the digital platform developed for the pilot provided delivery companies with optimised routing indications and updated traffic information, enabling them to plan their operations with greater accuracy.

Overall, the integrated physical and digital infrastructure created through GRETA constitutes a scalable and low-maintenance system that can support future developments in urban logistics, including regulatory updates, the introduction of road-pricing schemes, or integration with existing ITS solutions.

4. Impact

4.1. Environmental, economical and social impact assessment of the solution

The impact generated by the Verona pilot reflects improvements from an environmental, economic and social perspective, demonstrating the added value of digitally supported curb management solutions even when applied on a limited scale.

From an environmental point of view, the reduction of 115 empty trips per month and the decrease in double-parking episodes resulted in a measurable saving of approximately 32 kilograms of CO₂ per month. While this value may appear modest in absolute terms, it is significant when considered in relation to the limited geographical scope of the pilot and the short monitoring period. The results clearly indicate the potential for substantially higher emission reductions if the solution is extended to a wider area and adopted on a permanent basis. Moreover, improved circulation conditions contributed to reducing local air pollutants and noise levels, particularly in sensitive areas of the historic city centre where congestion and stop-and-go traffic previously amplified negative environmental impacts.

⁴ DIRECTIVE (EU) 2019/1161 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles

⁵ European Commission: Directorate-General for Mobility and Transport, *Next steps towards 'Vision Zero' - EU road safety policy framework 2021-2030*, Publications Office, 2020, <https://data.europa.eu/doi/10.2832/391271>



From an economic perspective, the pilot supported greater efficiency in freight operations. Logistics operators benefited from reduced time spent searching for available loading and unloading bays, fewer unnecessary kilometres driven and improved predictability of delivery schedules. These factors contributed to lower fuel consumption and operational costs, while also improving overall service reliability. In addition, the availability of structured and reliable data on curbside usage provided the Municipality of Verona with a clearer understanding of traffic dynamics related to freight transport, supporting more informed decision-making and the evaluation of future policy measures. The reduction of empty trips was particularly relevant, as it directly addressed one of the main inefficiencies affecting last-mile delivery operations.

From a social perspective, the decrease of 67 double-parking cases per month had a positive effect on safety, accessibility and urban liveability. The reduced presence of vehicles obstructing road space improved traffic flow and visibility, creating safer conditions for pedestrians, cyclists and other road users. The more orderly use of loading and unloading bays also helped mitigate conflicts between commercial vehicles and residents, contributing to a more balanced coexistence of different urban functions. Furthermore, the pilot raised awareness among operators and local stakeholders about the importance of regulated and shared use of limited curbside space.

Overall, the results obtained in Verona demonstrate that even a relatively small-scale and non-invasive intervention can generate meaningful and multidimensional benefits. The pilot confirmed the effectiveness of the curb management approach promoted by GRETA in improving efficiency, reducing negative externalities and supporting more sustainable and liveable urban environments, while also highlighting its strong potential for scaling up and replication in other cities.

5. Lessons learnt

The implementation of the pilot in Verona provided valuable insights into the scalability and transferability of smart curb management solutions, as well as into the organisational conditions required for their successful deployment. One of the most significant lessons concerned the central role of governance and enforcement. The strong involvement of the municipal administration, and in particular of the Local Police and in-house mobility management bodies, proved essential to ensure correct use of the booking system and to prevent the misuse of reserved loading and unloading bays. The pilot clearly showed that technological solutions alone are not sufficient if they are not accompanied by adequate enforcement mechanisms and clear operational responsibilities. Governance frameworks and regulatory practices therefore need to evolve in parallel with technological innovation.

Another important lesson emerged in relation to the behaviour and engagement of logistics operators. The pilot demonstrated that operators are generally open to adopting new digital tools when the benefits are tangible and directly linked to daily operations, such as reduced waiting times, fewer detours, improved access to curbside space and more predictable delivery schedules. However, the experience also highlighted that adoption cannot be taken for granted and requires targeted communication and training activities. Providing clear information on how the system works, explaining its advantages and offering practical support during the initial phases were key factors in fostering acceptance and long-term use of the platform.

From a technological perspective, the project highlighted the critical importance of reliable data transmission and digital infrastructure readiness. Early challenges related to incomplete or delayed data synchronisation revealed that connectivity issues can significantly affect system performance and user trust. Addressing these challenges required additional investments in telecommunications infrastructure, including the installation of supplementary LoRaWAN antennas. These upgrades proved to be a fundamental



prerequisite for ensuring stable system operation, accurate real-time information and overall platform reliability.

The pilot also showed that close and continuous coordination between public authorities, technology providers and operators is essential throughout all phases of implementation. Regular exchanges and feedback loops allowed emerging technical and organisational issues to be identified early and addressed effectively, reducing the risk of delays or system malfunctions.

Overall, the experience in Verona confirmed that smart curb management systems are most successful when they are embedded within a supportive governance framework, underpinned by robust digital infrastructure, designed with user-friendly interfaces and accompanied by ongoing stakeholder engagement. These lessons provide valuable guidance for future implementations and for the potential scaling-up and replication of similar solutions in other urban contexts.

6. Transnational Cooperation

6.1. Scaling-up

The experience gained in the city centre of Verona demonstrates that the solution can be scaled to the entire Functional Urban Area, provided that the necessary governance, technological, and infrastructural adjustments are carried out. The modular nature of the IoT sensors and the LoRaWAN communication technology allows the system to be extended progressively to new neighbourhoods, commercial districts, and suburban municipalities. The six antennas installed during the pilot significantly strengthened the network and can serve as the foundation for broader expansion.

Scaling up the system also means integrating the curb management platform into the wider mobility and logistics planning framework of the FUA. This includes aligning the solution with the Sustainable Urban Mobility Plan, coordinating with neighbouring municipalities, and adapting the digital tools to different regulatory contexts. The scaling process will require the development of a shared regulatory approach across municipalities, especially where access restrictions, time windows, or road-pricing measures differ.

Potential risks associated with scaling, such as inconsistent network coverage, heterogeneous local regulations, or resistance from logistics operators, can be mitigated through early stakeholder engagement and by ensuring that the system remains flexible and easy to adapt. The strong results achieved in the pilot area demonstrate that once adequate conditions are in place, the expansion of the system can generate significant benefits at a larger territorial scale.

Table 2 Scaling up – plans and recommendations

| | |
|---|--|
| Plans for scaling up the solution in the pilot area. | Adaptation of the technological infrastructure to other cities. |
| Suitability for scaling-up | The pilot can be developed in other similar cities that have a complex situation in their central districts. The aim is to significantly reduce the pollution and congestion produced by freight vehicles, especially in the narrow streets. The use of a similar platform in other city centres will allow an increase in the punctuality of deliveries thanks to the overview provided by the IT infrastructure. In this way, all these cities will produce benefits for their citizens and for the shippers operating in the central districts. |



| | |
|---|---|
| <p>Identified risks for scaling up and solutions to overcome them (risk mitigation).</p> | <p>One of the main challenges in scaling up the solution is adapting it to the specific infrastructure of different cities. Ensuring compatibility with existing systems and technologies can be difficult. The mitigation measures are:</p> <ul style="list-style-type: none"> - stakeholders’ engagement and collaboration with local authorities - the flexibility and adaptability of the solution to accommodate various logistics requirements. |
|---|---|

6.2. Transfer

The solution tested in Verona is highly transferable to other European cities, particularly those with historic centres, narrow streets, and intense commercial delivery activity. The challenges addressed during the pilot (double parking, congestion caused by commercial vehicles, and the lack of real-time visibility over loading bays) are common across many urban contexts. The corrective actions taken in Verona, such as increased enforcement and reinforcement of the LoRaWAN network, provide a clear roadmap for other cities interested in adopting similar tools.

Transferability also depends on adapting the solution to local regulatory frameworks. Cities adopting the Verona model should ensure that rules governing loading and unloading parking slots are clearly defined and enforceable. They should also consider communication campaigns to familiarise operators with the benefits of the system and to encourage consistent use of the digital platform. Technological transfer is facilitated by the low cost and open-standard nature of the LoRaWAN technology, which does not require heavy infrastructure and can be installed quickly.

The experience of Verona, therefore, shows that the combination of digital innovation, targeted enforcement, and strong institutional coordination can be reproduced elsewhere with relatively limited adjustments, offering a viable pathway toward more sustainable and efficient urban logistics.

Table 3 What to expect - problems and solutions

| Problems and solutions | |
|---------------------------------|--|
| <p>Problems faced</p> | <p>Problem 1: Reserved Parking Slot illegitimately occupied</p> <p>During the implementation phase of the GRETA solutions, an issue can be related to a reserved parking slot illegitimately occupied. For instance, a user might park in a space already booked by another user, thus occupying the reserved spot. This situation can cause inconvenience for users who had booked the time slot, finding themselves without an available parking space upon arrival.</p> <p>Problem 2: Data Synchronization</p> <p>One of the main issues affecting the implementation of a new IT platform is the lack of data synchronization. Due to the delays in the transmission of information, the data exchanged could be occasionally inaccurate. This led to inefficiencies in route planning, delays in deliveries, and confusion among drivers.</p> |
| <p>Corrective actions taken</p> | <p>Corrective Action 1:</p> <p>To effectively address this issue, immediate corrective actions must be taken. Specifically, the Municipality of Verona must enhance checks and surveillance by local police. This measure aims to prevent improper occupation of designated parking spaces.</p> <p>Corrective Action 2:</p> |



| | |
|-----------------------|---|
| | Thanks to the GRETA project funds, it is possible to invest in the upgrade of the communication infrastructure between the central logistics hub and the fleet of delivery vehicles. This included the installation of high-speed data transfer devices and improved connectivity solutions. |
| What to watch out for | Recommendation 1: Based on the experience gained, it is essential to establish a sort of penalty for the vehicles occupying illegitimately the parking slot. In this way, these vehicles will be added to a blacklist, and, in case of further violations, they will receive a fine. Recommendation 2: All users of the platform must be aware of the benefits coming from the synchronization of data. Therefore, a dedicated advertising campaign is strictly recommended. |

7. Conclusions

The GRETA pilot implemented in Verona demonstrated that smart curb management can play a crucial role in addressing some of the most persistent challenges affecting last-mile deliveries in urban environments, including congestion, emissions, and operational inefficiencies. By introducing a digitally supported system combining sensor-based monitoring and a booking platform for loading and unloading bays, the pilot showed how the management of existing curbside infrastructure can be significantly improved without the need for extensive physical interventions. The results achieved during the pilot, such as the reduction of double-parking occurrences, the decrease in empty trips, the saving of CO₂ emissions, and the reinforcement of network coverage, highlighted the effectiveness of integrating IoT technologies within a well-structured governance framework. Beyond the quantitative outcomes, the pilot also demonstrated qualitative improvements in the organisation of freight operations, the predictability of deliveries, and the overall coordination between public authorities and logistics operators. These aspects proved essential in building trust in the system and ensuring its operational viability. The experience in Verona confirmed that digital management of curb space, when supported by adequate connectivity and strong municipal commitment, can significantly enhance urban liveability and safety while contributing to improved environmental performance. More orderly use of loading and unloading bays reduced conflicts between different road users, improved traffic flow, and supported a more balanced coexistence of freight activities with residential and commercial functions in the city centre. Importantly, the pilot also showed that the implemented solution is not limited to a single pilot area but can be scaled up to cover larger portions of the urban territory and adapted to different regulatory and spatial contexts. The modular nature of the digital platform and sensor infrastructure, combined with the lessons learned during implementation, provides a solid basis for replication in other cities facing similar urban logistics challenges. Overall, the Verona pilot positioned the city as a concrete example of how municipalities can modernise their urban freight systems in line with the objectives of the European Green Deal and broader urban mobility strategies. By embedding digital innovation within existing policy frameworks and governance structures, the pilot offers a replicable and pragmatic model for other Functional Urban Areas seeking to decarbonise freight transport while improving efficiency, safety, and quality of urban life.

