Interreg CENTRAL EUROPE

Co-funded by the European Union

GRETA

D2.3.5 Pilot action in FUAs:Verona

Version 1

05 2025

GRETA Website

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Deliverable revision			
Version	**Date**	**Changes**	**Author (Organization)**
0	28/04/2025	Template and ToC draft	Alice Benini and Fahad Anwar (ITL)
0.1	05/05/2025	Review	Luca Simone and Riccardo Maratini (OE)

GRETA Project

1	08/05/2025	Template and ToC updated version	Alice Benini and Fahad Anwar (ITL)

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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 organizations 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 recognize the problems that generate pollution, nuisance, noise, congestion and have jointly jointed 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 SUMPs/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 capitalizing 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 was conceived as a progressive and adaptive process aimed at testing a digitally supported curb management system within the Limited Traffic Zone (LTZ) and, subsequently, across the entire Functional Urban Area of Verona. The pilot focused on the development and implementation of a digital platform enabling freight operators to book loading and unloading parking slots through a dedicated application, combined with the installation of sensors under each loading and unloading parking slot to monitor real-time occupancy.

The pilot was developed through close and continuous cooperation between ZAILOG and the Municipality of Verona. Starting from an initial agreement on objectives and scope, the project evolved through several implementation phases, including technical definition, procurement procedures, system redesign and infrastructure upgrades. Throughout the process, the pilot was progressively refined to ensure technical robustness, economic efficiency and full compatibility with the existing urban and regulatory context.

The final phase of the pilot included on-field testing of the platform, engagement with logistics operators and the first collection of operational data. This structured approach allowed the project partners to validate the feasibility of a city-wide digital curb management solution and to assess its readiness for long-term integration into municipal mobility and logistics policies.

The pilot achieved concrete and measurable results during the testing phase. The introduction of the digital curb management system contributed to a reduction of double-parking episodes by 67 cases per month and a decrease of 115 empty vehicle trips per month, leading to an estimated saving of approximately 32 kg of CO_2 per month. In parallel, the reinforcement of the digital infrastructure resulted in the installation of six additional LoRaWAN antennas, significantly improving network coverage and system reliability. These results confirmed the operational effectiveness of the solution and its readiness for scaling up and long-term integration into urban mobility and logistics policies.

3. Pilot action set up

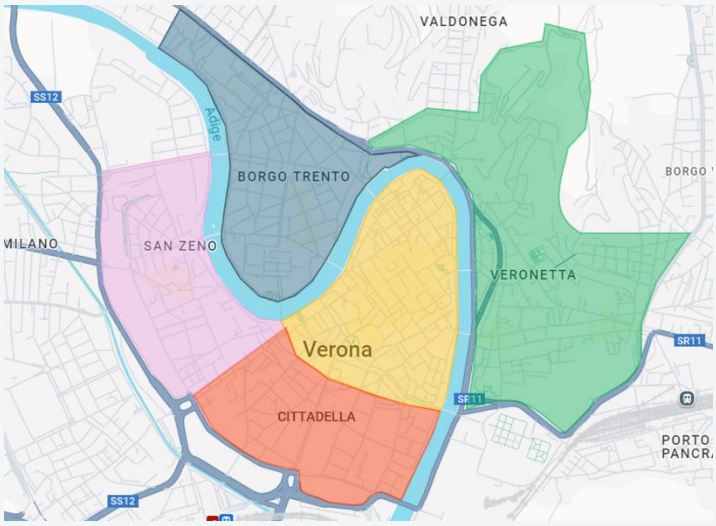
3.1. General information

The Verona pilot action was implemented within the administrative boundaries of the Municipality of Verona, with an initial focus on the loading and unloading parking slots located within the Limited Traffic Zone and a subsequent extension to cover all such slots across the urban area. Verona is characterised by a dense historic city centre, high levels of commercial activity and limited road space, which together create significant pressure on curbside areas used for freight operations.

The pilot was coordinated by ZAILOG in close cooperation with the Municipality of Verona and its in-house parking and mobility management company, called AMT3. From the outset, the pilot was conceived as a digital solution aimed at improving the management of existing infrastructure rather than introducing new physical elements into the urban environment. This approach was considered particularly suitable for a historic city context, where physical interventions are often constrained by space limitations and cultural heritage considerations.

Table 1 General information

Location	Verona city center and surroundings, Veneto Region
Map (general + detailed)	One map of the pilot area:

	 *Figure 1 Map of the city*
Area characteristics	Brief outline the main characteristics of the pilot area: 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	The SUMP was approved in October 2023 and identified the need to enlarge and enforce the 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.

3.2. Vision and problems/needs to be addressed in GRETA

3.2.1. Pilot action objectives

The primary objective of the Verona pilot action was to test the feasibility and effectiveness of a digital curb management system covering loading and unloading parking slots across the functional urban area. Specific objectives included improving the predictability of freight operations, reducing inefficient vehicle movements, supporting municipal enforcement activities, and generating reliable data on curb usage patterns.

A further objective was to design a solution that could be economically sustainable and scalable, allowing for gradual expansion and long-term integration into municipal mobility policies. The pilot also aimed to strengthen cooperation between public authorities and logistics operators by providing a shared digital tool that supports operational planning and transparency.

3.2.2. Specific vision & ambition and the pilot action problems/needs to be addressed by GRETA

The needs to be addressed by Verona pilot are the following:

- **Need for knowledge about good practices for deliveries into city centres / exchange of experiences**. The experience of other city centres is essential to design a smooth delivery network. In fact, the previous tests carried out by the Municipalities of other cities can be reduced if the knowledge is shared. In this way, it is possible to speed up the implementation process as well as to reduce the development costs. Then, to provide suggestions and good practices to the shippers can produce relevant benefits in terms of less congestions and an improved coordination of vehicles when are travelling inside the city centre.
- **Need for guidance/process knowledge related to the allocation and design for public space functions, specifically for mobility and logistics functions**. The space in city centres is limited and often congested. This is why a specific plan for its proper allocation must be drafted. Dedicated rules and an efficient IT platform are mandatory to reduce the double-parking phenomena and traffic jams since it is often difficult to realize new parking slots in the city centre. In addition, the use of technology can help the shippers to have a full overview of parking slots available and decrease empty running.

3.2.3. Governance analysis

3.2.3.1. Local, regional, national and EU government policies and regulations that influence the pilot action

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/EC[1] and 2004/107/EC,[2] 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:

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

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

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 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 directive[3],and vision zero for road safety[4], the project can help meet broader EU targets for a greener, safer, and more efficient transportation system.

3.2.4. Solution description and technical specifications

The Verona pilot action was centred on the design and implementation of a digitally supported curb management solution aimed at improving the regulation, monitoring, and operational efficiency of loading and unloading parking slots across the Verona Functional Urban Area. The solution was conceived to operate within a complex and highly constrained urban environment, characterised by a historic city centre, limited availability of public space, and high competition among different road users. The technical approach has been adopted for the pilot combined sensor-based monitoring technologies with a centralised digital platform, enabling real-time data collection, processing, and visualisation, as well as the implementation of a booking system for freight operators. The objective was to transform traditionally static and poorly regulated curbside infrastructure into an actively managed and data-driven system, capable of supporting both daily operations and long-term policy decisions.

At the core of the technical solution was the installation of dedicated IoT sensors under each selected loading and unloading parking slot. The sensors adopted for the pilot were single-space devices based on tri-axial magnetometric detection technology, specifically designed for urban smart parking applications. This technology allows the sensor to detect variations in the Earth's magnetic field caused by the presence of a vehicle, ensuring reliable occupancy detection even when the sensor is installed beneath the asphalt surface. The sensors were fully autocalibrating, allowing them to adapt to local environmental conditions and minimise the risk of false detections. Detection accuracy was designed to reach levels above 95%, ensuring the reliability of occupancy data used by both operators and municipal authorities. Particular attention was paid to robustness and durability, as the devices were designed to withstand constant mechanical stress, temperature variations, and exposure to water and dust, with protection levels compliant with IP68/IP69 standards. From an energy perspective, the sensors were optimised for low power consumption, allowing an expected battery lifetime of up to seven years under normal operating conditions. This aspect was considered essential to limit maintenance requirements and ensure long-term operational sustainability of the system. Installation was carried out using minimally invasive techniques suitable for historic urban contexts, through precise core drilling operations directly under the asphalt surface of the parking slots, typically requiring holes of limited diameter. This approach ensured minimal visual impact,

[3] 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

[4] 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

rapid installation times, and full compatibility with existing road surfaces, without requiring major reconstruction works.

Data transmission from sensors relied on LoRaWAN (Long Range Wide Area Network) technology, selected for its suitability for large-scale urban deployments and low energy requirements. Each sensor periodically transmitted occupancy data to nearby LoRaWAN gateways operating on the 868 MHz frequency band. Communication parameters were configured to ensure an optimal balance between data update frequency, network reliability and battery consumption. The LoRaWAN network architecture consisted of multiple gateways distributed across the Municipality of Verona. During the implementation phase, a detailed assessment of network coverage was carried out, revealing the need to reinforce the existing infrastructure. As a result, additional gateways were installed to ensure stable and continuous coverage across the entire Functional Urban Area. Adequate network coverage was identified as a critical prerequisite, particularly because sensors installed beneath parked vehicles may experience signal attenuation if gateways are located too far away. All transmitted data were routed securely from the gateways to a central cloud-based platform, where they were processed, stored and made available for visualisation and analysis.

The central digital platform represents the backbone of the Verona pilot solution. It was designed to aggregate real-time data from all sensors, manage reservations and provide a comprehensive overview of the status of loading and unloading parking slots. The platform architecture is modular and scalable, allowing future expansion in terms of geographical coverage, number of sensors or additional functionalities. Core technical features of the platform include secure user authentication, role-based access management, real-time dashboards, historical data storage and data analytics functionalities. For municipal authorities, the platform provides dedicated interfaces enabling continuous monitoring of curbside usage, supporting enforcement activities and facilitating the evaluation of urban logistics policies. The platform was designed to ensure high levels of data reliability and availability, with mechanisms in place to handle temporary communication delays or network disruptions. Data security and compliance with applicable data protection regulations were integrated into the system design from the outset.

A key component of the solution was the introduction of a remote booking system allowing freight operators to reserve loading and unloading parking slots in advance. This functionality was integrated directly into the digital platform and made accessible to operators through a dedicated web-based application. The application allows operators to consult real-time information on slot availability, select time windows for deliveries and manage reservations according to operational needs. User interface design prioritised simplicity and usability, ensuring that the system could be adopted by operators with varying levels of digital familiarity. Real-time synchronisation between sensor data and booking information ensured consistency between physical occupancy of parking slots and their digital status. The operator application was fully integrated with the Municipality of Verona's existing digital portal, ensuring interoperability with municipal systems and facilitating user access through a familiar environment.

The overall technical solution implemented in Verona was designed with scalability and long-term integration in mind. The modular architecture allows the system to be extended to additional parking slots, areas or user groups without requiring fundamental redesign. The integration of hardware, network infrastructure and software components demonstrated the technical feasibility of deploying a city-wide digital curb management system within a complex urban environment. In conclusion, the technical solution implemented through the Verona pilot action combined robust sensor technology, reliable LoRaWAN connectivity and an integrated digital platform to support real-time monitoring and regulated use of loading and unloading parking slots. This approach provided a solid technological foundation for improving last-mile delivery efficiency, supporting municipal governance and enabling future scaling-up of the solution.

3.2.5. Transnational Cooperation

Table 2 Information on joint development

Main implementor of the pilot action	ZAILOG
Contributor[2]	L-PIT and City of Poznan (PL)
Process of joint development	*The joint development process of the Verona pilot action was based on a close and continuous collaboration between ZAILOG, the Municipality of Verona and Municipia Spa. The decision to involve Municipia was motivated by several factors related to experience, technical expertise and institutional familiarity. Municipia had a long-standing working relationship with the Municipality of Verona and was already developing and managing other digital platforms and software solutions both for the City of Verona and for other Italian municipalities. This previous experience ensured a strong understanding of public-sector requirements, administrative procedures and integration with existing municipal systems. Municipia was selected also due to its proven experience in the implementation of complex digital solutions in urban environments and its capacity to manage both software development and the coordination of hardware installation activities. This background was considered particularly relevant given the technical complexity of the pilot and the need to integrate sensor-based infrastructure with a digital booking platform. Collaboration throughout the implementation phase was intensive and structured. Regular online coordination meetings were organised between ZAILOG, the Municipality of Verona, AMT3 and Municipia to define technical requirements, monitor progress and address emerging issues. These meetings were complemented by technical exchanges and document reviews aimed at refining system architecture, functionalities and implementation timelines. Site visits and on-field coordination were also carried out during the installation phase to address practical constraints related to specific loading and unloading bays. The cooperation with Municipia proved to be particularly effective during the installation of sensors in challenging locations. Despite the presence of occupied bays or ongoing roadworks in some areas, Municipia was able to adapt installation procedures and coordinate closely with municipal services to ensure that sensors were successfully deployed. As a result, the implementation proceeded in line with the initial expectations and planned scope. Overall, the joint development process benefited from a high level of trust, frequent communication and a shared problem-solving approach. This collaborative framework played a key role in ensuring the successful implementation of the pilot and contributed to delivering a technically robust and operationally feasible solution.*

Input received from contributor	*The collaboration with the Poznan Institute of Technology provided a clear strategic added value to the development of the Verona pilot. Building on their previous experience in city logistics projects, including a successful implementation in the city of Kalisz, Poznan contributed technical knowledge, methodological guidance and best practices relevant to the optimisation of urban curbside management. This experience proved particularly valuable in supporting the design and refinement of the digital platform and its operational logic. Throughout the project, Poznan provided continuous technical input and recommendations, supporting ZAILOG, Municipia and the Municipality of Verona in identifying appropriate system functionalities and implementation approaches. This exchange of expertise contributed to improving the efficiency of both the software architecture and the overall management framework of the solution, helping to ensure that the platform was aligned with real operational needs and international best practices in urban logistics. Thanks to the collaboration with Poznan and the technical suggestions received, ZAILOG, Municipia and the Municipality of Verona were able to implement the digital platform in a more effective and structured manner. All the necessary technical functionalities were successfully integrated, contributing to a robust and operationally sound solution. The steady cooperation also ensured a dynamic exchange of ideas throughout the implementation process, reinforcing the quality and maturity of the final outcome.*
Value of collaboration	*The joint development process, and in particular the cooperation with the Poznan Institute of Technology, played a key role in improving the implementation of the Verona pilot action. The technical guidance and methodological feedback provided through transnational cooperation helped the project partners identify and avoid potential implementation errors at an early stage, reducing the need for corrective actions during later phases. This support contributed to a smoother and more efficient development of the digital platform, allowing technical choices related to system architecture and functionalities to be validated against previous experiences and best practices. As a result, the pilot benefited from a more streamlined implementation process, with reduced staff effort and shorter implementation timelines compared to what would have been expected in the absence of transnational cooperation. Overall, the contribution of external expertise enhanced the quality and robustness of the solution, enabling the project partners to achieve the expected results while making more efficient use of available resources.*

4. Stakeholders and their role

Following is the list of the stakeholders involved:

- MUNICIPALITY OF VERONA: it is the managing authority of the city of Verona.

- AMT3: it is the in-house company of the Municipality of Verona that manages all the parking slots of the city.
- MUNICIPIA SPA: it is a software house company with a long-term experience in the field of public works, especially IT upgrades.

Table 3 Stakeholders' list

Organisation	Stakeholder type[5]	Role	Stakeholders' priority[6]	Engagement level[7]	Engagement activity		Feedback from stakeholder	Comments
					When	What		
Municipality of Verona	Public Institution	Strategic planning and policy formulation. The Municipality of Verona plays a pivotal role.	High	1	15/05/2024 27/09/2024	Meeting	1st meeting: Availability of the Municipality of Verona to install sensors on the loading/unloading slots in the city centre as well as to create a software to manage the information received. 2nd meeting: The Municipality of Verona made an	The Municipality of Verona has been directly engaged in the project. This is due to the longstanding collaboration between the Municipality and the Verona

[5] Public institutions and authorities, local administration, neighbouring municipalities, regional administration, national and state administration, association and intermediaries, Chamber of Commerce, business association, private sector, other members and representatives, educational institutions and research institutes, local media and general public.

[6] High, medium, low.

[7] Engagement level 1 or 2, as reported in the stakeholders' mapping file

							evaluation of the quotes received in close cooperation with AMT3. They agreed to14 prepare and launch two separate tenders for the IT platform's hardware (sensors) and software parts.	freight village.
AMT3	In-house company of the Municipality of Verona	Strategic planning and policy formulation. AMT3 manages the parking slots of Verona City Center	High	1	15/05/2024 27/09/2024	Meeting	1st Meeting: Availability of AMT3 to manage the new platform that will be developed within GRETA project. 2nd Meeting: AMT3 made an evaluation of the quotes received in close cooperation with The Municipality of Verona. They agreed to prepare and launch two separate tenders for IT platforms' hardware (sensors) and software parts	AMT3 has been directly engaged in the project. This is due to the longstanding collaboration between the Municipality and the Verona freight village

Shipping Companies		These stakeholders bring expertise in delivery operations to enhance the efficiency and effectiveness of the platform implemented.	Medium	2	05/11/2025 17/12/2025	Meeting	1st meeting: The road operators engaged in the first meeting demonstrated a deep interest on this new platform and provided suggestions to adjust the functionalities already implemented. 2nd Meeting: In the second meeting, these logistics operators provided a feedback regarding the use of this platform, suggesting improvement to implement.	In the same way, the shipping companies have been engaged directly. This level of engagement ensures a steady cooperation with these stakeholders.
MUNICIPIA Spa		This stakeholder will install the sensors under the asphalt and develop a software to elaborate all the informati	Medium	1	12/02/2025	Meeting		The IT provider has been engaged directly. This level of engagement ensures a steady cooperation with the

		on received. The scope is to provide a booking system to the logistics operators that deliver goods in the Verona FUA.						stakeholders.

5. Pilot action implementation

5.1. Timeline

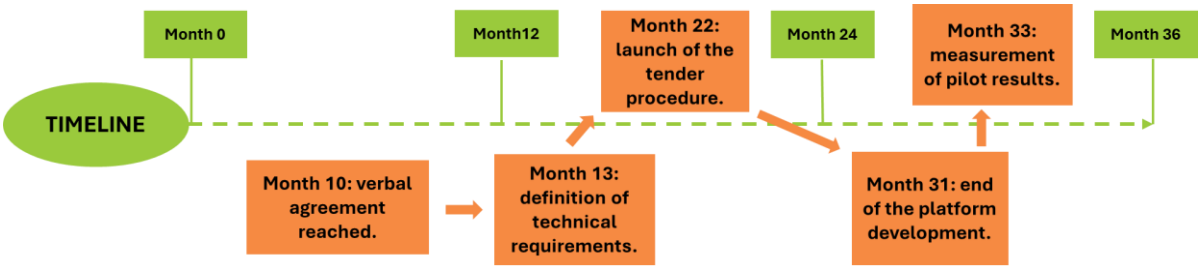
In February 2024, the Municipality of Verona and Zailog reached an agreement on the steps to follow to implement the pilot activities. This agreement has been reached after several meetings.

In May 2024, the Municipality of Verona and AMT3 defined a list of technical requirements that are mandatory for the proper functioning of the curb management IT platform. Then, they started to list the companies that can be invited to the tender.

In February 2025, the tender has been launched, and the contract has been awarded in a couple of weeks. Then, the Municipality of Verona, Zailog and Municipia (the IT provider selected) met to define in detail all the implementation phases.

In October 2025, the pilot action implementation has been concluded, and the logistics operators started to use this platform.

In December 2025, the first results of the implementation have been measured to make an evaluation of the pilot impact.



5.2. Planning

The planning phase of the Verona pilot action was conceived as a comprehensive and structured process aimed at translating strategic objectives into a technically and operationally feasible implementation framework. Given the complexity of the urban context and the innovative nature of the proposed digital curb management solution, particular attention was paid to aligning technical, regulatory and organisational aspects from the earliest stages. The planning activities began with an in-depth analysis of the urban logistics context within the Municipality of Verona, with a specific focus on the management of loading and unloading parking slots in the Limited Traffic Zone and, subsequently, across the wider Functional Urban Area. This analysis highlighted several critical issues, including inefficient use of curbside space, frequent double-parking phenomena, limited turnover of loading and unloading parking slots and a lack of real-time information for both operators and public authorities. These challenges provided the rationale for adopting a digitally supported approach to curb management. In parallel, the planning phase included a thorough review of the existing policy and regulatory framework, with particular attention paid to ensuring consistency with the Sustainable Urban Mobility Plan (SUMP) of the Municipality of Verona, existing access regulations for freight vehicles and enforcement practices managed by municipal services. This step was essential to ensure that the pilot action would complement ongoing urban mobility policies rather than operate as a stand-alone or experimental initiative disconnected from local governance structures. A key component of the planning phase concerned the definition of the technical concept of the pilot, including the identification of appropriate sensor technologies, the selection of LoRaWAN as the communication standard for data transmission, and the definition of the functional requirements of the digital platform and booking system. Early assumptions regarding network coverage, data reliability, and system scalability were discussed and documented, forming the basis for subsequent technical design and procurement activities. Organisational and administrative aspects were also carefully addressed during the planning phase. Roles and responsibilities were clearly defined among ZAILOG, the Municipality of Verona, and AMT3, ensuring transparency and effective coordination throughout the project lifecycle. Particular attention was paid to procurement planning, including the definition of technical specifications and evaluation criteria for the selection of IT providers capable of delivering both hardware and software components. Risk identification and mitigation planning represented an integral part of the planning process. Potential risks related to procurement complexity, technical integration, network coverage limitations, and user adoption were identified at an early stage. For each risk, preliminary mitigation measures were discussed, including contingency planning for infrastructure upgrades, flexibility in implementation timelines, and the involvement of stakeholders during the testing phase. Throughout the planning phase, continuous coordination with municipal departments and AMT3 ensured that the pilot action was fully embedded within existing administrative and operational processes. Regular exchanges allowed assumptions and planning choices to be validated against practical constraints and local knowledge, contributing to the definition of a realistic and robust implementation roadmap and laying the foundations for the subsequent implementation and monitoring phases of the pilot action.

5.3. Implementation

The implementation phase of the Verona pilot action was articulated as a multi-step and adaptive process, reflecting both the technical complexity of the digital curb management solution and the specific constraints of the urban context. Following the completion of the planning phase and the definition of technical and organisational requirements, implementation activities were launched in close coordination between ZAILOG, the Municipality of Verona, AMT3, and the selected IT provider (called Municipia). The implementation strategy combined the deployment of sensor-based infrastructure, the development of a digital platform, and the integration of these components within the existing municipal IT ecosystem. The first implementation steps focused on preparatory activities required to enable the deployment of the sensor infrastructure. These activities included detailed site inspections of loading and unloading parking slots,

verification of pavement conditions, and coordination with municipal technical services to schedule works on public roads. Particular attention was paid to minimising disruption to traffic flows and daily urban activities, especially within the Limited Traffic Zone and other highly sensitive areas of the city. From a technical perspective, installation planning also considered the optimal positioning of sensors to ensure accurate detection and reliable data transmission. An important milestone in the implementation process concerned the procurement procedures. Following an initial selection process, a second procurement procedure was launched in November 2024 to improve both the technical and economic efficiency of the solution. This decision allowed the project partners to revise the implementation strategy and expand the scope of the pilot, increasing the number of sensors to be installed and extending coverage across the Verona Functional Urban Area. The revised approach aimed to ensure greater representativeness of the system and to test its scalability under more realistic conditions. The contract was awarded between the end of January and the beginning of February 2025 to Municipia Spa, an IT company with extensive experience in the development of digital solutions for public administrations. Following the contract award, Municipia initiated implementation activities in close cooperation with the Municipality of Verona and AMT3, establishing regular coordination meetings to align technical development, infrastructure deployment, and implementation timelines. These meetings addressed both software development aspects and on-field deployment requirements. A central and technically critical component of the implementation phase was the assessment of LoRaWAN network coverage across the Verona Functional Urban Area. This activity, carried out between June and July 2025, aimed to verify whether the existing network infrastructure could reliably support data transmission from sensors installed beneath parked vehicles. Signal strength and data reliability were assessed in different urban conditions, including narrow streets and areas characterised by high building density. The assessment revealed coverage gaps in several zones, highlighting the need for infrastructure reinforcement. To address these limitations, the Municipality of Verona undertook the installation of additional LoRaWAN gateways, significantly strengthening network coverage across the pilot area. This intervention ensured stable signal reception and reduced the risk of data loss or delayed transmission, which could have compromised real-time monitoring and booking functionalities. Although this activity was not foreseen in the initial implementation schedule, it proved essential to guarantee the robustness and reliability of the system. Once adequate network coverage had been ensured, Municipia proceeded with the installation of the sensors under the selected loading and unloading parking slots. The sensors were installed using minimally invasive core drilling techniques, allowing devices to be placed beneath the asphalt surface without altering the visual appearance of the street. Following installation, each sensor was configured and tested to verify the correct detection of vehicle presence and successful data transmission to the central platform. Installation activities required flexible and adaptive solutions, particularly in locations affected by temporary occupation, ongoing roadworks, or limited accessibility, and close coordination with municipal services was necessary to manage these constraints.

In parallel with hardware deployment, the digital platform and the operator application were developed, tested, and progressively integrated with the Municipality of Verona's existing digital portal. This phase included configuration of data flows from sensors to the cloud-based platform, validation of sensor–platform communication, implementation of booking functionalities, and testing of user interfaces. Particular attention was paid to ensuring real-time synchronisation between physical occupancy detected by sensors and the digital status displayed to users. Iterative testing cycles were conducted to verify system stability, data accuracy, and responsiveness under operational conditions.

Throughout the implementation phase, continuous coordination among ZAILOG, the Municipality of Verona, AMT3, and Municipia played a key role in addressing emerging technical and organisational challenges. Regular technical meetings, progress reviews, and on-field coordination activities allowed the implementation to be adjusted as needed, ensuring alignment between hardware deployment, network infrastructure, software development, and governance requirements. The implementation phase concluded

with the preparation of the system for operational testing and monitoring under real conditions, marking the transition from system deployment to performance evaluation and impact assessment.

5.4. Monitoring

The monitoring phase represented a crucial step in which the solution was tested under real operating conditions within Verona's urban environment. During the implementation of the pilot activities, a dedicated team observed the performance of the system in daily operations, focusing on the functionality of the digital platform, the reliability of data transmission, and the interaction between users and the booking system. In parallel, qualitative feedback was collected from key stakeholders, including municipal staff and logistics operators involved in the pilot, in order to assess the usability and operational effectiveness of the solution. These inputs provided valuable insights into how the platform supported delivery planning, improved predictability and facilitated compliance with curbside regulations, particularly within the Limited Traffic Zone.

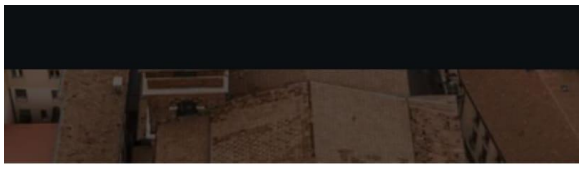
The monitoring activities also allowed the project partners to assess the concrete effects of the pilot in operational terms. The data collected during the testing period showed a reduction of double-parking phenomena and a decrease in empty vehicle runs, contributing to smoother traffic conditions in the pilot area. In particular, the system supported a reduction of 67 double-parking cases per month and 115 fewer empty trips per month. These operational improvements resulted in an estimated saving of approximately 32 kg of CO_2 per month, confirming the positive environmental impact of a more efficient management of loading and unloading parking slots. In addition, the reinforcement of the digital infrastructure led to an increase in LoRaWAN network coverage, with the number of active antennas rising from four to ten, significantly improving data reliability and system scalability. Overall, the monitoring phase served as an important checkpoint within the project, allowing the partners to evaluate the maturity and robustness of the implemented solution. The observations and feedback gathered during this phase contributed to refining the main features of the platform and to assessing its suitability for potential scaling-up and replication in other cities facing similar urban logistics challenges. With regard to risks and mitigation measures, one identified risk concerned the possibility that some operators could carry out deliveries without using the platform, potentially leading to continued double-parking issues. To address this risk, the system design included the possibility of introducing alerts and warning mechanisms to inform users of non-compliance and the potential consequences in terms of penalties. Another risk related to network reliability, including potential crashes, data synchronisation delays or temporary connection losses, which could affect the real-time accuracy of information displayed on the platform. To mitigate these risks, regular system updates, technical checks and continuous monitoring of network performance were carried out throughout the pilot implementation.

6. Digital and physical infrastructure

Regarding consolidation and infrastructure, a remote booking system for loading and unloading parking slots was introduced as a core component of the Verona pilot action. The system enabled freight operators to schedule delivery time slots in advance through a dedicated digital platform, reducing uncertainty and improving the organisation of last-mile operations. The platform provided full and transparent visibility of the status of each loading and unloading parking slot, clearly indicating whether a slot was free, reserved or occupied. This functionality supported more efficient delivery planning and contributed to a more orderly use of curbside space. In parallel, IoT devices and sensors were installed under the selected loading and unloading parking slots to detect vehicle presence and provide real-time updates on availability. The sensors continuously transmitted occupancy data to LoRaWAN antennas

installed across the Municipality of Verona, allowing both municipal authorities and system users to access a comprehensive and up-to-date overview of curbside space usage. The integration of sensor data into the digital platform enabled real-time monitoring and improved the reliability of information provided to users. Ensuring adequate LoRaWAN network coverage proved to be a critical prerequisite for the proper functioning of the platform. Sensors installed under parked vehicles are particularly sensitive to signal strength, and insufficient coverage can lead to data transmission delays or losses. For this reason, the Municipality of Verona took targeted action to reinforce the LoRaWAN network by installing additional antennas, ensuring stable connectivity and full coverage across the pilot area. This infrastructure upgrade significantly improved data reliability and supported the scalability of the solution. A dedicated web application for freight operators was also developed as part of the pilot. The application was designed to support the optimisation of delivery operations by providing intuitive access to booking functionalities, real-time information on the availability of loading and unloading parking slots and operational notifications related to curbside usage. The development of the application was closely coordinated with the deployment of the sensor infrastructure and the municipal digital systems to ensure full interoperability between hardware and software components, as well as ease of use for end users. In summary, the GRETA pilot action in Verona contributed to upgrading last-mile delivery practices through a holistic and integrated approach. By combining advanced digital technologies, sensor-based monitoring, reinforced telecommunications infrastructure and collaborative governance between public authorities and logistics operators, the pilot laid the foundations for a more efficient, transparent and scalable management of urban curbside space, while actively engaging local stakeholders throughout the implementation process.


obilita.comune.verona.it
Comune di Verona
Prenotazione stalli di carico/scarico
GRETA APP
Questa applicazione è stata sviluppata pensando agli operatori logistici che ogni giorno vanno a consegnare le merci nel territorio comunale della città di Verona. Attraverso questa piattaforma, è possibile visualizzare in tempo reale lo status degli stalli e prenotarne uno per un lasso di tempo, in modo da consentire all'operatore di parcheggiare velocemente senza allungare la propria tabella di marcia giornaliera. L'applicazione è stata finanziata dal programma Interreg Central Europe e nello specifico dal progetto europeo GRETA il cui obiettivo è quello di decarbonizzare le consegne nell'ultimo miglio dei centri urbani.



Autoveicoli

Accedi all'area dedicata alla tua flotta. In questa sezione è possibile consultare l'anagrafica completa dei mezzi registrati e procedere con l'inserimento e la configurazione di nuovi veicoli nel sistema.

Prenotazioni Stalli

Accedi all'area dedicata alle tue prenotazioni. In questa sezione è possibile consultare le tue prenotazioni, inserire nuove prenotazioni ed effettuare Check-in e Check-out sugli stalli prenotati.

GRETA APP

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7. Evaluation/Impact assessment and results of implementation

7.1. Primary and secondary quantitative and qualitative KPIs

Primary indicators:

- Available space - operational space (e.g. size of hub - storage, parking), indoor and outdoor (sqm) 2,637.5 sqm occupied by loading bays in the Verona FUA.
- Utilization of public spaces (sqm): Although the physical surface of public space remained unchanged, the pilot significantly improved the quality of its utilisation. The introduction of booking functionalities and real-time monitoring contributed to a more orderly, regulated, and efficient use of loading and unloading parking slots, reducing informal occupation and improving turnover.
- Investment costs (€) 85,000.00
- Operational cost: Operational costs were mainly related to system maintenance, platform management, and network monitoring. These costs remained limited due to the low-energy consumption of the sensors and the integration of the platform within existing municipal IT systems.
- Forecast on revenues 0 €
- Estimated Impact on carbon emissions - Based on monitoring data collected during the pilot phase, the reduction in empty vehicle trips resulted in an estimated saving of approximately **32**

kg of CO_2 per month, confirming the positive environmental impact of optimised curbside management.

Secondary quantitative indicators:

- Estimated Number of vehicles using the hub per day: During the pilot testing phase, a limited but representative number of freight vehicles used the system on a daily basis, allowing the partners to assess system functionality and operational impacts under real conditions.
- Fermi-estimate on number of deliveries / number of possible deliveries: The improved organisation and booking of loading and unloading parking slots increased the potential turnover of curbside space. While precise figures were not calculated, qualitative observations indicate that a higher number of deliveries could be accommodated within the same time windows compared to pre-pilot conditions.
- Additionally created job (as stated by operators): No
- Number of operators: A selected group of logistics operators participated in the pilot testing phase, contributing to system validation and providing operational feedback.
- Reduction of Traffic Jams - The introduction of advance booking and real-time information supported a decrease of approximately **115 empty vehicle trips per month**, reducing unnecessary circulation within the pilot area.
- Decrease of Double-Parking phenomena: Monitoring activities showed a reduction of approximately **67 double-parking cases per month**, indicating improved compliance with curbside regulations and more orderly use of public space.

Secondary qualitative indicators:

- Impact of Neighbourhoods quality of life: The more orderly use of curbside space reduced conflicts between freight vehicles, pedestrians, and other road users, contributing to improved liveability in residential and commercial areas.
- Benefits for shops and other retail businesses: More predictable and regulated delivery operations, reduced disruptions during opening hours, and improved accessibility for supply activities.
- Satisfaction of the service users (drivers, micromobility device users, etc.): Qualitative feedback collected during the pilot phase indicated a generally positive perception of the system, particularly regarding predictability, reduced waiting times, and easier access to loading and unloading parking slots.
- Increase of Time Savings (better arrangement of the shipments): The availability of real-time information and booking functionalities supported better organisation of delivery routes and schedules, resulting in time savings for logistics operators.
- Enhanced Safety (reduction of car accidents, extension of pedestrian zones, ..): The reduction of double-parking and improved regulation of curbside space contributed to enhanced road safety by improving visibility, reducing obstructions, and limiting unsafe manoeuvres.

7.2. Results

The implementation of the pilot action resulted in the creation, activation, and operational testing of a digital platform for the management of loading and unloading parking slots within the Verona Functional Urban Area. The platform enabled a more structured and coordinated management of curbside space by integrating a booking system for freight operators with real-time monitoring of parking slot occupancy through sensor-based technologies. This combination allowed the transition from a static and fragmented use of curbside infrastructure to a data-driven and transparent management approach. The system was progressively developed, tested, and put into operation during the final phase of the pilot. Throughout this phase, the platform proved capable of supporting both public authorities and freight

operators in their respective roles. The Municipality of Verona gained improved and continuous visibility over the use of loading and unloading parking slots, supporting monitoring and enforcement activities, while freight operators were provided with a dedicated digital tool to plan deliveries more efficiently, reduce uncertainty and improve predictability of operations. The implementation process also confirmed the technical feasibility of integrating sensor infrastructure, digital platforms and municipal governance processes within a complex urban environment such as Verona's historic city centre. Despite challenges related to connectivity, infrastructure constraints and coordination among multiple actors, the pilot demonstrated that a city-wide digital curb management system can be successfully deployed when supported by adequate telecommunications infrastructure and strong institutional cooperation. Overall, the pilot action successfully demonstrated the potential of digital curb management solutions to optimise the use of existing loading and unloading parking slots, reduce operational inefficiencies and support compliance with access regulations. The experience laid a solid foundation for future scaling-up of the system and for its long-term integration into urban mobility and logistics planning, both within Verona and in other cities facing similar challenges.

7.3. Summary of the environmental and social impact assessment of GRETA pilot actions and solutions

The environmental and social impact assessment of the GRETA pilot action in Verona highlighted the potential benefits of digitally supported curb management solutions in dense urban contexts. By improving the organisation and governance of loading and unloading parking slots, the pilot contributed to more efficient freight operations and a better use of existing public space, without requiring additional physical infrastructure in the historic city centre.

From an environmental perspective, the pilot supported a reduction in unnecessary vehicle circulation by enabling freight operators to plan deliveries more accurately and access loading and unloading parking slots through a structured booking system. The improved visibility of curbside availability and the reduction of irregular parking behaviours created conditions for smoother traffic flows, which are associated with lower emissions, reduced noise and improved air quality in sensitive urban areas.

From a social perspective, the pilot contributed to enhanced urban liveability and safety. The more orderly use of loading and unloading parking slots helped reduce conflicts between freight vehicles, private cars, pedestrians and cyclists, particularly in areas with limited road space. The introduction of a transparent and predictable system also improved the working conditions of delivery drivers by reducing uncertainty and stress related to searching for available curbside space.

Overall, the assessment confirmed that the GRETA pilot action in Verona generated positive environmental and social effects by promoting more efficient, predictable and regulated last-mile delivery practices. The experience demonstrated that digital curb management solutions can support sustainable urban mobility objectives while improving the quality of life for residents, businesses and transport operators, providing a solid basis for future scaling-up and replication.

8. Lessons learnt

The preparation and implementation of the Verona pilot action provided several important lessons related to governance, technical design, and implementation processes. One of the main lessons concerned the importance of early alignment between technical solutions and local regulatory and administrative constraints. Initial ideas related to visible signaling solutions for loading and unloading parking slots were reconsidered after discussions with relevant public authorities, highlighting the need to involve all competent bodies at an early stage when introducing innovations in sensitive urban areas.

Another key lesson emerged from the procurement and implementation phases. The initial selection process revealed that revisiting technical and economic assumptions can lead to more effective solutions. The decision to launch a second procurement procedure allowed the project partners to significantly improve both the technical scope and cost-efficiency of the pilot, resulting in a broader coverage of loading and unloading parking slots across the city. This experience demonstrated the value of maintaining flexibility in procurement strategies and being open to revising initial implementation plans when better options emerge.

From a technical perspective, the pilot highlighted the critical role of digital infrastructure readiness. The lack of adequate LoRaWAN network coverage across the Municipality of Verona was identified only during the implementation phase and required additional time and coordination to be addressed. This underlined the importance of assessing network coverage and connectivity conditions at an early stage, particularly for solutions relying on sensor-based data transmission in dense urban environments.

The implementation process also showed that close and continuous cooperation between public authorities, in-house municipal companies and technology providers is essential to manage complex interdependencies between hardware installation, software development and network infrastructure. Regular coordination meetings proved crucial to address emerging issues and adapt implementation timelines accordingly.

Finally, the pilot confirmed the importance of stakeholder engagement during the operational phase. Early interactions with logistics operators helped identify usability aspects and practical requirements that could not be fully anticipated during the design phase. This feedback was essential to refine the platform and to ensure that the solution was aligned with real operational needs.

Overall, the lessons learned from the Verona pilot emphasised the need for adaptive planning, strong governance cooperation and early technical assessments when implementing digital curb management solutions. These insights provide valuable guidance for future pilots and for the potential scaling-up and replication of similar solutions in other urban contexts.

9. Conclusion

The Verona pilot action demonstrated that a digitally supported curb management solution can be effectively designed, implemented and tested within a complex urban environment such as a historic city centre. Through a phased and adaptive approach, the pilot addressed long-standing challenges related to the management of loading and unloading parking slots, including inefficient use of curbside space, limited visibility on slots availability and difficulties in coordinating freight operations.

The pilot was developed through close cooperation between ZAILOG and the Municipality of Verona and evolved progressively over time. Initial planning and technical definition phases were followed by procurement procedures, system redesign, and infrastructure upgrades, allowing the solution to be refined and strengthened in response to emerging technical and organisational challenges. This adaptive process proved essential to ensure the robustness and feasibility of the final system.

The implementation resulted in the deployment of a digital platform combining a booking system for freight operators with sensor-based monitoring of curbside occupancy. The system provided public authorities with improved oversight of loading and unloading parking slots usage and supported more predictable and organised delivery operations. On-field testing and early operational use confirmed that such a solution can be integrated into existing regulatory and governance frameworks without requiring significant physical interventions in the urban environment.

From a governance perspective, the pilot highlighted the importance of strong institutional collaboration, clear allocation of responsibilities, and continuous coordination between public authorities, in-house municipal companies, and technology providers. The experience also underlined the need for adequate

digital infrastructure, particularly in terms of network coverage, as a prerequisite for the successful deployment of sensor-based solutions.

Overall, the Verona pilot action provided valuable insights into the practical implementation of digital curb management systems and laid the foundations for their potential integration into long-term urban mobility and logistics planning. The experience confirmed that data-driven and transparent management of curbside space can represent an effective tool to support more efficient, regulated, and sustainable last-mile delivery practices in urban contexts like Verona.