MOBILITIES FOR EU

2ZERO AND CCAM CO-DESIGNED SOLUTIONS IN MADRID AND DRESDEN

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Please note that this deliverable has been inspired by deliverable D5.1, the “D&C and Exploitation Plan” of the project MULTICLIMACT (GA number 101123538), which has been authored by STEINBEIS as well.

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List of abbreviations

ACRONYM	DESCRIPTION
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AV	Autonomous vehicles
BEV	Battery Electric Vehicles
CCAM	Connected, Cooperative and Automated Mobility
CPU	Central Process Unit
DIH	Data Intelligent Hub
DSSC	Data Space Support Center
DTG	Direction General Traffic
EPS	Expanded polystyrene
ERDF	European Regional Development Fund
ESG	Environmental Social Governance
FCEV	Fuel Cell Electric Vehicles
GDPR	General Data Protection Regulation
HDV	Heavy-Duty Vehicles
IMU	Inertial Measurement Unit
LCA	Life Cycle Approach
LDV	Light-Duty Vehicles
PMN	Private Mobile Network
PV	Photovoltaic
QoS	Quality of Service
RAN	Radio Access Netwotk

RES	Renewable Energy Sources
SA	Stand Alone
SSI	Self-sovereign Identity
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
UT	Urban Transport
UT-Lab	Urban Transport Lab
VRU	Vulnerable Road Users
V2G	Vehicle-to-Grid
WP	Work Package
2ZERO	Towards zero emission road transport

Publishable summary

MOBILITIES FOR EU project intends to deploy innovative urban mobility solutions that can accelerate the transformation of the urban transportation sector, embracing electrification, automation and connectivity in the journey of the cities towards climate neutrality. Furthermore, these solutions can secure co-benefits such as reduced air and noise pollution and improved health and well-being of citizens.

During the project timeline, a set of innovative mobility technologies will be demostrated in real and diverse urban environments in two Lead Cities, Madrid (Spain) and Dresden (Germany) before being upscaled in other areas of these cities or replicated along Europe. A total of 10 actions, split in 5 pilots, will be implemented in two relevant areas of the cities. In the case of Madrid the demonstrations will be deployed in Mercamadrid, the largest market in Spain, and in the nearby facilities of the Municipal Transport Company (EMT) in Entrevías and Carabanchel districts. For the case of Dresden, a total of 6 pilots will be deployed in the Ostra district, an area plenty of sport arenas and other sport facilities plus the city Fair, that presents unique mobility challenges during sports events and fairs.

This deliverable 2.1 "2ZERO and CCAM co-designed solutions in Madrid and Dresden" provides the designs of the mobility actions to be deployed in both cities after fine-tuning of the initial proposals through a co-design process arranged through the Urban Transport labs created in the two lead cities to support participatory processes. During the first 12 months of project, these innovation hubs have contributed to the cooperation between the local administration, the industry, academic partners and citizens for the design of the demonstrative actions according to the needs of local stakeholders, potential users and agents affected for the introduction of new services. Such collaboration will continue throughout the course of the project through these centres for experimentation and innovation to ensure a user-centric and help to integrate the automated and zero-emission solutions and services for people mobility and freight transport in existing ecosystems. A description of the methodology and resources used for this codesign process along this first year of the project are also presented.

The reader of this deliverable will obtain a valuable knowledge on the demonstrative solutions and specifically the technical specifications, the technical and operational requirements for their deployment, the execution plan, some initial financial considerations and potential risks and mitigation measures. Additionally, the agents involved in their implementation and the interaction among project actions are also detailed in this document with the aim to help other cities to gain knowledge on innovative solutions that can contribute to decarbonizate the urban mobility sector.

1. Introduction

1.1. Purpose, scope and target group

MOBILITIES FOR EU project is one of the two projects funded by the European Comission through the Horizon Europe programme under the topic Horizon MISS-2023-CIT-01-01 named as: "Co-designed smart systems and services for user-centred shared zero-emission mobility of people and freight in urban areas".

The project intends the demostration of solutions for mobility of people and freight in real environments in two lead cities (i.e. Madrid and Dresden) and their posterior upscaling and replication across Europe. Additionally, the project aims to assure that the solutions to implement can cover the needs of citizens and stakeholders why the co-design with these agents is a relevant step during the definition of the features of the demostratie solutions.

This document, deliverable D2.1 "2ZERO and CCAM co-designed solutions" describes the designs of mobility actions that will be implemented in the cities of Madrid and Dresden in order to demonstrate their technical and economic feasibility.

A total of 10 actions, split in 5 pilots, will be implemented in two relevant areas from the city of Madrid: Mercamadrid, the largest market in Spain, and in the nearby facilities of the Municipal Transport Company (EMT) in Entrevías and Carabanchel. For the case of Dresden, a total of 6 pilots will be deployed in the Ostra area, plenty of sport facilities and the city Fair. All these actions will foster positive effects in both cities and their citizens by improving the air quality, decarbonizating the transport sector and improving the access to mobility services. Hence, the description of the solutions included in this deliverable can be helpful for other cities that desire to implement innovative mobility solutions in their transition towards climate neutrality.

The document is structured as follows:

- Chapter 2 where 2ZERO and CCAM, the European initiatives that boost the type of solutions deployed in MOBILITIES FOR EU, are introduced.
- Chapter 3 dealing with the description of the methodology applied for the co-design of the solutions via the collaboration among partners from Madrid and Dresden ecosystems and the involvement of citizens. Perceptions on mobility challenges in the demo areas and potential improvements, compiled from workers from Mercamadrid and citizens from Dresden, are also reported in this chapter.
- Chapter 4, devoted to Madrid, and chapter 5 devoted to Dresden, cover the design of the actions to be implemented in each city including their technical specifications, requirements, execution plan, initial financial considerations, partnerships and interactions among project actions as well as potential risks and mitigation measures. Some further activities on co-creation are also detailed in these sections.
- Chapter 6 concludes the deliverable with a narrative of lessons learned by the municipalities of Madrid and Dresden so far along the design phase of the project actions.

1.2. Contribution from Partners

Table below depicts the main contributions from project partners in the development of this deliverable.

Table 1. Partners contributions

PARTNER SHORT NAME	CONTRIBUTIONS

CARTIF	ToC generation. Sections 1, 2 7 main contributor. Responsible for the partners contributions integration and homogeneization. Final review od the document.
MADRID	Description of the Action 1.3 from Madrid, subchapter 4.1 and chapter 6. Review of the deliverable as WP2 leader with special focus on the Madrid's actions description as LC demo leader
MERCAMADRID	Description of subchapter 4.2 and contributor to chapter 3
EMT	Description of the Actions 3.1 and 4.1 from Madrid
ORANGE	Description of the Action 1.4 from Madrid. Initial support in the management of requests for contributions to the different responsible partners.
FERROVIAL	Description of the Action 2.1 and Action 3.2 from Madrid
TSY	Description of the Action 5.1 from Madrid
PLEXIGRID	Description of the Action 2.2 from Madrid
PZGR	Description of the Action 1.2 from Madrid
ALSA	Description of the Action 1.1 from Madrid
DRESDEN	Description of the Pilot 3 (A3.1, A3.2, A3.3) and Pilot 4 (A4.1) from Dresden, subsections 5.1, 5.2 and contribution to chapter 6
VWGI and CARNET	Description of the Pilot 1 (A1.2, A1.2, A1.3) from Dresden
Fraunhofer	Description of the Pilot 2 (A2.1, A2.2) from Dresden
SAP	Description of the Pilot 5 (A5.1, A5.2, A5.3) from Dresden
TUD	Description of the Pilot 4 (A4.2) and Pilot 6 (A6.1, A6.2) from Dresden
RC	Support in the co-desing of solutions for both cities (Madrid and Dresden). Main author of section 3. Document consolidated version reviewer.

2. Demonstration activities: 2ZERO and CCAM mobility solutions

The demonstrative solutions of the project, which are described in this document, are a combination of technologies on electrification, automatization, connectivity and power grid. These actions are at this moment considered key in Europe to contribute to the decarbonization of the transport sector and improving the access to mobility services. However, before a mass deployment of these innovative technologies, a diversity of barriers require to be overcome. To deal with the mentioned situation and address Europe's most pressing challenges, European Partnerships have been established to develop coordinated research and innovation actions bringing private and public partners together.

Below, the key EU partnerships linked to the MOBILITIES FOR EU solutions, 2ZERO and CCAM, are presented. The project and these partnerships have already established a joint collaboration to share knowledge gained during the execution and evaluation of the demonstrative solutions. MOBILITIES FOR EU participates in meetings and events organized by these partnerships and will provide feedback on the evolution of the project an its main metrics to feed the own indicators of 2ZERO and CCAM. The common lines of actuations are detailed here below to show the future exchange of knowledge.

2.1. 2ZERO partnership

Formally launched on 23rd June 2021, the "Towards zero emission road transport (2Zero) partnership" is a co-programmed partnership funded under the Horizon Europe programme that aims at accelerating the transition towards zero tailpipe emission road mobility across Europe and boosting the EU competitiveness and technological leadership.

The partnership has a timeframe for 6 years (2021-2027) and it is built upon the successes of the European Green Cars Initiative (EGCI: 2009-2013) and the European Green Vehicles Initiative (EGVI: 2014-2020). The evolution of the partnership can be observed in figure below.

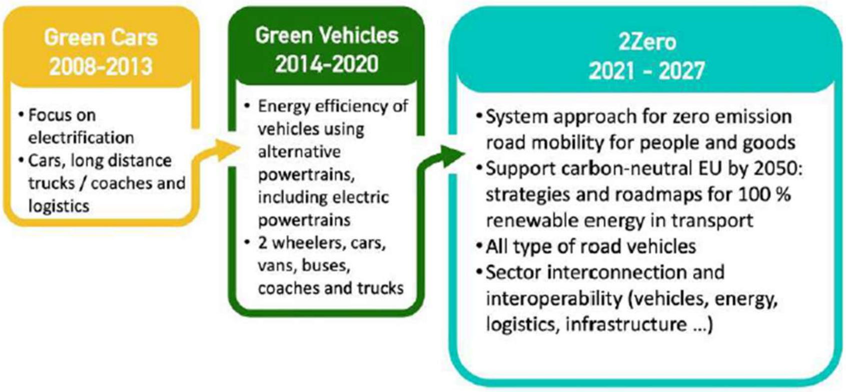

Figure 1. Evolution of the 2ZERO partnership. Source: 2ZERO Partnership SRIA

2ZERO mission

The 2Zero partnership is perfectly in line with the Green Deal and it intends transforming the EU into a modern, resource-efficient and competitive economy, and with the related 'Sustainable and Smart Mobility Strategy", defining an Action Plan of initiatives that will guide the European Commission work for the upcoming years.

2ZERO focus

2Zero focuses on research and innovation for the development of next generation energy-efficient and affordable zero tailpipe emission road vehicles (Battery Electric Vehicles and Fuel Cell Electric Vehicles), mobility solutions and their cost-effective recharging infrastructures (from slow to fast /ultra-fast).

The 2Zero partnership covers all types of vehicles, from passenger cars, trucks and buses to two-wheelers and new vehicles concepts and the activities are organised around four strongly interconnected pillars:

- Vehicle technologies and vehicle propulsion solutions for Battery Electric Vehicles (BEV) and Fuel Cell Electric Vehicles (FCEV).
- The integration of BEV into the energy system and related charging infrastructure.
- Innovative concepts, solutions and services for the zero tailpipe emission mobility of people and goods.
- LCA (Life Cycle Approach) and circular economy approaches for sustainable and innovative road mobility solutions.

2ZERO technologies

ZERO partnership addresses programme objectives stated in the solutions detailed below:

- Development of affordable innovative Battery Electric Vehicles (BEV) and HD Fuel Cell Electric Vehicles (FCEV) concepts and technologies.
- Demonstration of zero emission Light-Duty Vehicles (LDV), passenger cars and commercial use, to reduce total cost of ownership compared to conventional vehicles by 20% for the widest usages.
- Demonstration of zero emission Heavy-Duty Vehicles (HDV) matching the performance and TCO (Total Cost of Ownership) of current vehicles for most of the relevant use-cases, including new usage models.
- Development and demonstration of affordable new vehicle solutions, charging technologies and services for the mass market, to enable 1000km long distance trips with no more than 10% additional time compared to conventional solutions, considering economic and environmental assessment.
- Development and demonstration of solutions for pervasive, user-friendly, low cost and interoperable low-power (<22 kW) and efficient high (~150kW) and/or ultrahigh-power (300 kW) charging infrastructure;
- Development and demonstration of interoperable smart charging and bi-directional energy services and solutions accepted by the users and providing services to the energy grid

Expected 2ZERO outcomes (2030)

It is expected that the demonstrated portfolio of tested and validated use-cases will bridge the existing gap between zero tailpipe emission and conventional vehicles capabilities / costs, making the transition towards zero emission vehicles affordable for citizens and society.

Specifically, it expect to achieve the following outcomes:

- Broad stakeholder consensus on zero emission tailpipe emission vehicles adoption pathways towards 2030, 2040 and 2050. By 2025, identify and propose the most cost-effective and positive impact scenarios and pathways for the deployment of zero tailpipe vehicles in different segments and applications: e.g. transport operations and geographical areas (long-haul, regional, rural, peri-urban and urban) building on previous general roadmaps.
- A broad real-life test and demonstration portfolio of use-cases, applications and solutions for zero emission mobility and logistics is available for a range of segments and applications that address user needs and are suitable for all operative scenarios, from very busy bus lines in cities or freight corridors, where high frequency and high capacity is required, to rural areas.
- New zero emission road shared mobility and logistics concepts and solutions boost the usage of electric vehicles and accelerate their adoption.

- Developed zero tailpipe emission mobility and logistics solutions and services that are interoperable across Europe and beyond.
- Stakeholders have reliable tools for services provision, infrastructure planning, decision making and fleet management regarding zero tailpipe emissions vehicles.

Cooperation with other European Partnerships and Technology Platforms

2ZERO partnership establishes coordination with other co-programmed and institutional Partnerships funded under Horizon Europe to ensure consistency, avoid duplication of activities and disseminate information.

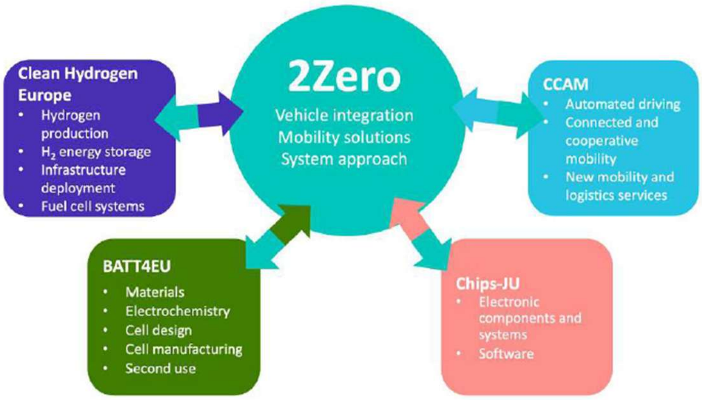

Figure 2. Interaction of 2ZERO partnership with other key partnerships. Source: 2ZERO Partnership SRIA

Furthermore, 2ZERO partnership counts with the support of five Technology Platforms that act as multipliers for the community which are:

- ERTRAC: European Road Transport Research Advisory Council (ERTRAC) is the European Technology Platform (ETP) for Road Transport.
- EPoSS: European Association leading the development and integration of intelligent and green Smart Systems technologies and solutions for a sustainable society.
- ETIP-SNET: European Technology Innovation platform for Smart Networks for Energy Transition.
- ALICE: Alliance for Logistic Innovation through Collaboration in Europe.
- Batteries Europe: This is the platform bringing together all relevant stakeholders in the European batteries research and innovation ecosystem in order to develop and support a competitive battery value chain in Europe.
-

2.2. CCAM partnership

The CCAM (Connected Cooperative Automated Mobility) Partnership is a public private partnership which aligns the research and innovation efforts to accelerate the implementation of innovative CCAM technologies and services in Europe.

This Partnership was officially launched through the signature of the Memorandum of Understanding between the concerned partied in 2021, having as general objectives the following:

- Creation of a more-user centered and inclusive mobility system that increase road safety while reducing congestion and environmental footprint.
- Strengthening competitiveness of European industries.
- Capitalising knowledge to accelerate development and deployment of CCAM solutions

CCAM vision

The vision of the CCAM Partnership for the next 10 years is to make Europe a world leader in the development and deployment of connected and automated mobility and logistics services and systems and thereby provide a significant contribution to European leadership in safe and sustainable road transport.

CCAM focus

CCAM partnership is structured in 7 clusters to organize the necessary Research & Innovation actions to advance towards deployment readiness while aligning perspectives from road users/consumers, public policymakers, road operators, and industry. These clusters are interlinked and the main objectives are detailed below.

- Large scale demostration cluster is continuously implemented results of all other clusters into Large-scale Demostrations in pilots and living labs supporting deployment readiness and a final impact assessment.
- Vehicle technologies cluster aims to deliver the most efficient and effective future solutions which have been proven to be safe and reliable.
- Validation cluster provides the procedures, methodologies and tools which are needed for validating, verifying and rating CCAM systems, in terms of both technology itself and human factors handling the technology.
- Integrating CCAM in the transport system cluster works in the advance of physical and digital infrastructure to support CCAM vehicles and improve connectivity and cooperation between actors.
- Key enabling technologies cluster embed the artificial intelligence, big data and cybersecurity that support the whole mobility sytems.
- Societal aspects and people needs cluster delivers the framework for understanding and taking into account user and citizen needs, and societal aspects of mobility.
- Coordination cluster for the management of all the stakeholders and activities to facilitate the knowledge exchange and enable lessons learned.

Expected outcomes

As MOBILITIES FOR EU project, CCAM Partnership approach has the focal point in the design and development of a user-centred and all-inclusive mobility solution. Demonstration activities close the loop in the co-creation process by proving the match between people needs and societal requirements, providing relevant data for impact assessments, and accelerating the technical development process.

Specifically the expected outcomes from CCAM partnership that also are covered through MOBILITIES FOR EU are:

- Demonstration of inclusive (considering VRU among other aspects), user-oriented, and well-integrated shared CCAM systems and services for people and goods in real traffic conditions.
- Evidence on expected impacts for safety, environment, health, economy, land-use considering of the evolution of mobility services for people and goods through testing of relevant Use Cases that both match society needs and expectations, making the traffic and transport system more efficient.
- New market opportunities and new business models identifying and reflecting on end-users needs for integrated, co-created and convincing business models, leveraging the return-on- investment potential of innovative cross-sector CCAM.
- Inclusion of all relevant stakeholders needed to demonstrate CCAM for individual and shared mobility of persons and goods.
- Strengthen the close link with users and society facilitating co-creation, adoption and up-take ofCCAM addressing risks, reservations and anxieties of citizens.

3. Co-design approach in the project

Co-design is a collaborative design approach that involves engaging stakeholders, end-users, and other relevant participants directly in the design process of the innovative solutions developed in the project to ensure that their needs, ideas, and perspectives shape the final services. Traditional design methods are often led solely by designers or experts in their meeting rooms. Instead, co-design encourages active participation from those who will use or be literally affected by the product, service, or system being developed. By involving their voices, co-design creates solutions that are more user-centered, contextually relevant, and aligned with the real-life experiences of its intended audience, leading to outcomes that are both innovative and practical. This is the reason why it is at the core of the project.

In MOBILITIES FOR EU project, the co-design is structured and organised in the local Urban Transport Labs (UT-Labs) implemented in the cities of Madrid and Dresden as a way that each city integrates the views and experiences of citizens, service providers, local businesses and government agencies in the resulting solutions. This ensures that the designs are not only innovative but also socially sustainable, reducing the risk of resistance to new systems and increasing the likelihood of adoption.

In these labs, new ideas will be prototyped and experienced by citizens in their daily contexts during the project, allowing MOBILITIES FOR EU partners to receive immediate feedback on what works and what doesn't. This hands-on engagement creates a cycle of continuous improvement, with each iteration of testing and feedback leading to more refined and user-centered solutions. As a result, the UT-labs bridge the gap between theoretical design and real-life application, fostering more agile and responsive innovations in mobility and urban logistics.

The role of the UT-Labs in the MOBILITIES FOR EU project is built around five objectives:

- **Proximity:** The UT Labs are established in key urban areas, specifically within the unique contexts of Madrid and Dresden. Each lab functions as a hub for stakeholders—including local authorities, businesses, research institutions, and citizens—to collaborate on sustainable mobility initiatives. They are both located within walking distance of the pilot area. In Madrid, the UT Lab is located in Mercamadrid, focusing on logistics and transport challenges specific to the wholesale market. In Dresden, the Ostra Labor is situated in in the Heinz-Steyer Stadium in the Ostra District, a community-friendly location, emphasizing public engagement and education.
- **Co-design support:** The UT Labs provide a structured environment where various stakeholders can share ideas, discuss challenges, and collaboratively develop innovative solutions. These labs encourage participatory approaches, allowing community members to contribute their perspectives and experiences, ensuring that the solutions created are relevant and tailored to local needs.
- **Collaboration:** By bringing together a diverse range of participants—including local residents, businesses, and government representatives—the UT Labs facilitate a holistic understanding of mobility issues. This integration helps to break down silos between sectors and encourages a comprehensive approach to problem-solving, leading to more effective and inclusive mobility solutions.
- **Testing and Prototyping:** The labs will provide a platform for testing new mobility concepts and technologies. Stakeholders can prototype and evaluate solutions in real-time, allowing for iterative development based on feedback from users. This hands-on approach not only fosters innovation but also builds trust and buy-in from the community, as residents see their input directly influencing the development process.
- **Awareness and Education:** The UT Labs will serve as educational centers, raising awareness about sustainable mobility practices and the importance of reducing carbon emissions. Workshops, exhibitions, and events held in these labs help inform the public about ongoing initiatives and the potential benefits of adopting new transport modes, further encouraging community involvement.

Thus, the UT-Labs in the MOBILITIES FOR EU project supported the design of the pilots with two main pilars, co-design support and collaboration. Later in the project, in the pilot implementation the testing and engagement with local citizens will be crucial for fostering collaborative innovation in urban mobility and logistics.

Why is it important to talk to citizens? Why the co-creation is relevant to introduce innovative solutions in the cities?

When citizens see their ideas, feedback and concerns reflected in the outcomes, they are more likely to support and engage with the proposed changes, whether it involves new public transportation options, sustainable delivery methods, or infrastructure improvements. This empowerment of local voices not only improves the quality of the solutions but also ensures they align more closely with the unique social, economic, and cultural contexts of each urban area.

Co-creation also helps increase user acceptance of advanced technologies, create an early adopter community of engaged users willing to test new solutions and provide feedback. Involving these users regularly builds trust and capture their experiences, which can be showcased to attract broader interest. Using hands-on, interactive activities help familiarize the community with the technology, incorporating gamification and public demonstrations to highlight existing applications and address common concerns. This ensures accessibility and standardization across new technologies, particularly in areas like bidirectional charging, to maintain inclusivity especially for vulnerable road users and build user confidence overall.

For effective co-creation in mobility projects, it is essential to foster open and collaborative environments where a wide range of participants can exchange ideas and discuss potential solutions. This can be achieved through a mix of informal community gatherings and formal engagement sessions that bring together residents, businesses, local government, and service providers. Regular events allow participants to share insights on mobility challenges and potential solutions in a relaxed setting, while structured participation processes—such as district-level workshops, information sessions, and feedback meetings—facilitate ongoing dialogue and ensure transparency. Establishing a clear framework and goals, with public-sector guidance and funding incentives, empowers stakeholders to coordinate efforts effectively and align with shared objectives.

For co-creation events, experts interviewed advise to consider digital citizen participation methods alongside in-person workshops. Digital feedback options can provide insights on local needs, while in-person events focused on specific modes, like cycling or multimodal transport, allow for targeted discussions. Including sessions on business models, financial sustainability, and technical aspects help participants understand how new technologies align with practical goals. Finally engaging all relevant stakeholders from the beginning ensures that co-creation drives effective, inclusive mobility solutions tailored to the needs of the community, especially the vulnerable end users.

3.1. Methodology for the co-design of Madrid and Dresden actions

The co-design of the pilots was structured around three co-design workshops and direct exchanges with local stakeholders and citizens. Three co-design workshops were carried out at M2, M5 and M7-M9 of the project with the final objective of ensuring collaboration of the different stakeholders involved in the pilots. Also, some other activities were organized with citizens during M7-M9.

By bringing together a range of stakeholders—from city planners and policymakers to technologists and residents—the UT-labs foster interdisciplinary collaborations that can result in innovative and unforeseen solutions. The different actions deployed are described below.

3.1.1. WORKSHOPS WITH STAKEHOLDERS INVOLVED IN THE PROJECT

1st Co-design workshop (M2)

The objective of this first workshop was to kick-off the different demos related activities, making all stakeholders putting their ideas together and share their knowledge on the different pilots' actions. The actions of Madrid and Dresden were presented and discussed.

Figure 3. Handouts used on the 1st co-design workshop

The workshop included five handouts for Madrid and six for Dresden. Each action in the pilot had a specific visual template in which different aspects were included to be filled in working in groups:

- **Stakeholder ecosystem map**: the different stakeholders had to be represented in circles and connected with arrows. Each arrow represented a transaction of money, materials or information between partners.
- **Co-design inputs**: the needs for the pilot action in terms of co-design, workshops, support from UT-labs had to be stated in the violet box.
- **Legal requirements:** the group had to identify the initial legal requirements at this stage of the project in the yellow box to start scheduling these actions in the timeline.
- **Tender requirements**: if any tender had to be launched for specific activities in the pilot, this had to be noted in the blue box.
- **Risks**: similarly, the risks identified at this stage had to be listed in the green box.
- **Timeline**: finally, the different activities identified had to be located in the project timeline to have a first overall idea of the activities crom¡nology linked to this pilot action.

2nd Co-design workshop (M5)

Building upon the overview set in the 1st workshop, the objective of this second collaborative activity was to go deeper in the definition of the different activities to make the pilots a reality. The pilots were presented in three phases:

- **Pilot design:** from M1-M12 the design of the pilots for the majority of the pilot actions.
- **Pilot set up:** the period needed for each pilot action to kick off the pilot and start the testing phase, in this case, it was not a specific period because each pilot action has a different timing.
- **Pilot testing:** the testing phase for each pilot actions. Similarly to the pilot set up, each action has its own timing.

The template used is shown in Figure 4 below.

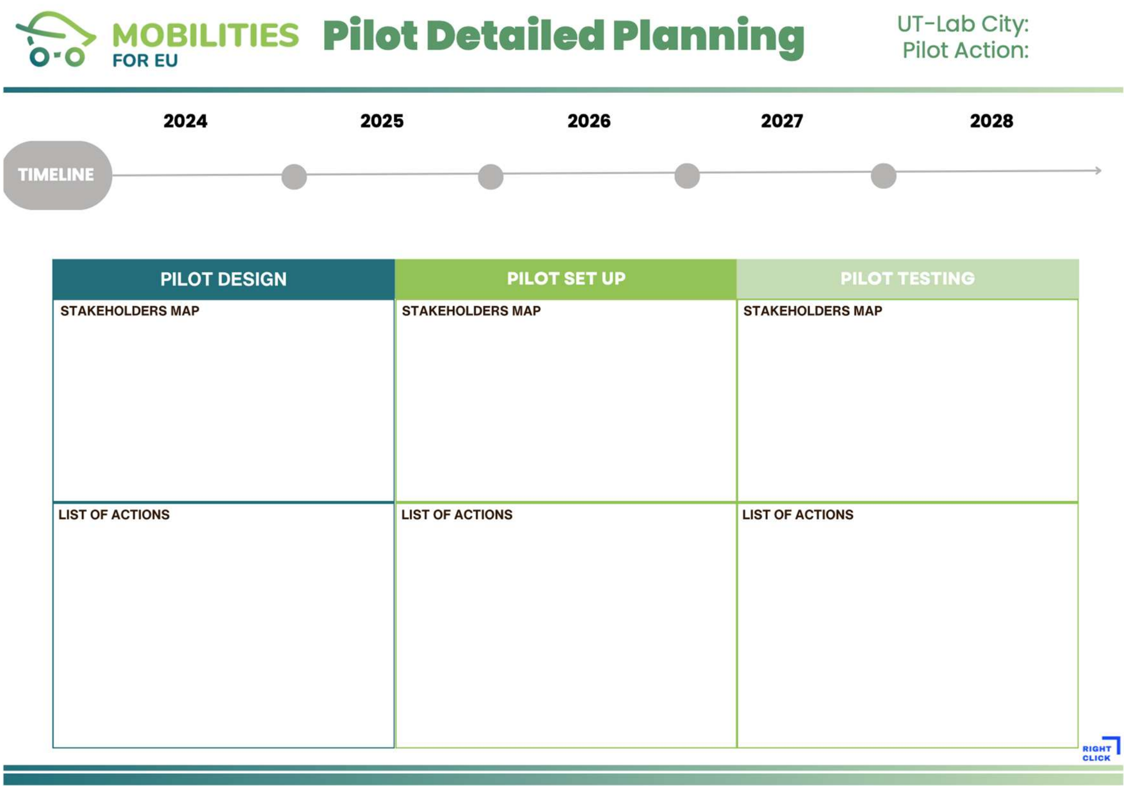

Figure 4. Handouts used on the 2nd co-design workshop

For each phase, two different activities were launched:

- **Stakeholder map**: in the exercise done in M2, there was one map per action, in this case, three different maps were asked, to make stakeholders think about the different interactions in each phase. The exercise helped to better define the exchanges, needs and priorities for each stakeholder involved in the project action.
- **List of actions:** stakeholders were asked to list the different actions linked to the pilot action in each of the project phases. Working in phases helped to better define the actions in each step.

The tables were already pre-filled out with the results obtained in the previous workshop to help the stakeholders start from the work already carried out in M2 and not from scratch.

3rd Co-design workshop (M7-M9)

The objective of the third workshop was to finalise the definition of the different activities linked to each pilot action and end up with an adapted timeline for each action. For this workshop, two exercises were designed:

- **Detailed planning of the pilot's action:** the output of this exercise was a GANTT with a detailed list of actions for each pilot's action. The objective was to identify potential problems, bottlenecks or legal procedures that could take longer than expected. Furthermore, stakeholders had a better idea of the actions under their responsibility and the factors that were depending on other partners.

The printed template used for this exercise is showed in Figure 5 below. It was also provided a digital version to work with directly with the computer.

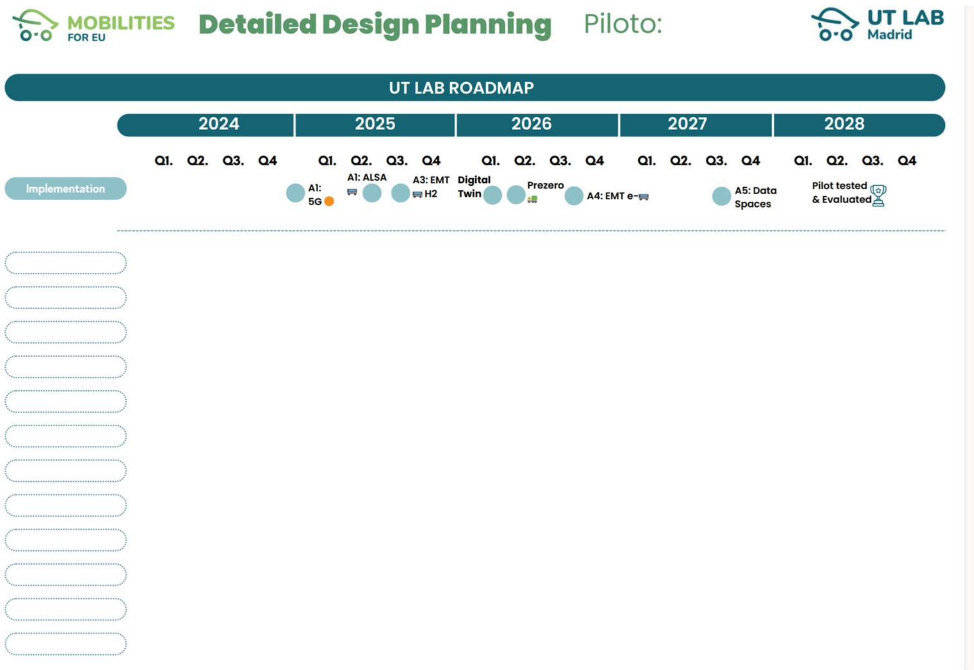

Figure 5. Handouts used on the 3rd co-design workshop

- **Detailed Pilot Design:** A set of seven blocks of questions was drafted to help partners go deeper in the definition of the pilots' actions. The blocks included were: needs and scope, service design and user experience, operational & legal considerations, financial aspects, risk management and contingency planning, feedback and iteration, post-pilot evaluation. The complete questionnaire layout is presented in Figure 6 below.

Detailed Pilot Design

Needs and Scope

1. Primary goal of the mobility service
- What problem are we trying to solve?
- Who are the target users?

2. Geographical area
- Where will the pilot be exactly located?
- What are the specific boundaries?

Service Design and User Experience

3. User journey
- How is the user discovering the service?
- Does he/she need to sign up?

4. Accessibility considerations
- How will we accommodate users with disabilities or special needs?
- What provisions are made for different languages or digital literacy levels?

Operational & Legal Considerations

5. Technology support platform
- What app or software will be used for user interface and backend operations?
- How will data be managed and protected?

6. Requirements for vehicles or devices
- What specifications and regulations/restrictions/licenses/permits must they meet? Technical? Legal?
- Who will be in charge of ensuring the compliance to these regulations?

7. Necessary partnerships
- Do we need to collaborate with local governments, transportation agencies, or private companies?

Financial Aspects

8. Budget for the pilot
- Does every partner have the budget to do their activities?
- Is there any issue with budget?

9. Business model
- Will users be charged? If yes how? And how much?
- If not, how will we test willingness to pay?

Risk Management and Contingency Planning

10. Potential risks and challenges
- How will we address issues like vandalism, theft, or technical failures?

(Pilot Manager, Pilot Management Guide, FAQ,...)

11. Contingency plans
- How will we handle unexpected disruptions?
- Are backup systems needed and available?

Feedback and Iteration

12. User feedback
- What methods will be used (surveys, focus groups, observation, app reviews)?
- How will we ensure that Vulnerable Road Users are taken into consideration?

13. Feedback incorporation
- Are we integrating user feedback during the pilot testing or just at the end?
- Are you planning implementation cycles ?

Post-Pilot Evaluation

14. Plan for evaluating the pilot's success
- What data will be collected?
- For you, at the end of the experimentation, what will you consider a success?

(user satisfaction, efficiency, cost reductions, CO2 emissions reductions...)

15. Next steps after the pilot
- What are the next steps after the pilot?

Figure 6. Questionnaire used on the 3rd co-desing workshop

3.1.2. USER RESEARCH & CITIZEN ENGAGEMENT (M7-M9)

The engagement with citizens in the UT-labs was done through face to face interviews and informal discussions. The method chosen was semi-structured interviews as they combine structured questions with the flexibility for open-ended responses. RC prepared a set of questions focused on the existing transport means, the main challenges regarding mobility and logistics, the potential and most adapted solutions, etc. The format allowed for in-depth exploration of participant responses as the conversation unfolded.

In the end, the UT-labs helped the co-design process enabling collaboration and fostering discussions with structured methodologies. The result was a common view of the specifics of each pilot's action, that allow partners to agree on the main challenges and possible risks, identifying them early in the process and establishing a collaboration environment since the very beginning of the process.

Preliminary User Research for the Madrid Pilots at Mercamadrid

The preliminary research at Mercamadrid entailed discussions with +10 users in the market in July 2024. The profile of participants was varied integrating young and adult workers, a balance between women and men, with a majority of car owners. Later in 2025, qualitative and quantitative research will be carried out to further identify the main mobility needs and priorities for the users of Mercamadrid.

During this preliminary research at Mercamadrid, users highlighted different mobility challenges as well as indicated some possible solutions. The more relevant ones are listed below:

Mobility challenges within the marketplace

- Electric & autonomous vehicles uptake
  - EV infrastructure: Increasing the infrastructure of EV charging stations in Mercamadrid could drive the change. The use of refrigerated trucks in the fish market increases the lack of trust to EVs.
  - Low incentives to change to EV: working in food distribution, they do not trust EV autonomy and the EV truck offer is low.
  - Fear to autonomous vehicles: the pilot has to be well presented to the Mercamadrid buyers and sellers. It should have a continuous service with a respected schedule to deserve areas that are currently non-deserved. With very good signaling it could be very beneficial for Mercamadrid.
- Mobility Within Mercamadrid
  - High Traffic Volume: Peak hours see a diverse mix of vehicles (cars, trucks, pallet trucks, and storage vehicles) converging on the roads.
  - Large Site Size: Due to the vast layout of Mercamadrid, cars are often the only practical way to navigate between providers.
  - Recurring services: there are some services with defined routes that involve different types of vehicles.
- Access to Mercamadrid
  - Limited Public Transportation: There are two bus routes (T32 from Legazpi and 130 from Villaverde Alto and Vicálvaro) service the area, between 4:30 a.m. and 24:00 p.m. There is no service before the market opening.

Suggested Solutions

- Improving Mobility Within Mercamadrid

- Autonomous Loading Platforms: Introduce automated platforms for loading and unloading, with defined routes and designated pickup/drop-off points.
- Internal Shuttle Service: Implement on-demand or scheduled internal buses with hours aligned to peak demand.
- Inclusive solutions: the solutions proposed could support a more inclusive and accessible workplace environment for all employees.
- Larger EV charging infrastructure: More EV chargers could incentivize the use and increase trust and EV use.

- Enhancing Access to Mercamadrid
  - Extended Public Transportation Hours: Expand the operating hours of public bus routes serving Mercamadrid to accommodate early and late shift workers. Besides a train station could reduce car use in the area for logistics and mobility.

These insights and recommendations aim to support safer, more efficient, and accessible mobility within and around Mercamadrid, potentially improving recruitment and operational flow in the marketplace.

Preliminary User Research for the Dresden Pilots at Heinz Steyer Stadium

As the Heinz Steyer Stadium's opening was held last August 2024, the Dresden Ostra Lab team took the opportunity to open the Lab's doors and discuss with the Stadium's visitors, as they are potential users of the mobility services.

During this preliminary research at Heinz Steyer Stadium a survey was answered by 24 visitors on the opening day. Participants were asked to share some of their mobility behaviors and habits, in addition to some suggestions and needs they have identified to better move in the Dresden city.

The profile of survey's respondent and some thoughts about mobility services are described below.

Respondent profile

- Demographics
  - Location: 83.3% live in Dresden city; 12.5% are from the surrounding area.
  - Gender: 58.3% male, 37.5% female, and 4.2% diverse.
- Modes of Transportation
  - Local Public Transport (41.7%) and Cars (39.1%) were the most common ways people travelled to the Heinz Steyer Stadium on the event day.
  - Walking (12.5%) and biking (29.2%) were less frequently used. On other days, the usual choice of mode of transport to the Stadium shows a higher tendency to choose biking (54,2%) than on the survey date.
  - Among public transport, tram (37.5%) and bus (20.8%) were the primary choices, followed by S-Bahn/train (12.5%).
- Vehicle Types
  - Bicycles: Most used "normal bikes" (12/24), with limited e-bike usage (1/24).
  - Cars: Predominantly internal combustion engines (5/24), with minimal hybrid drive usage (1/24).
- Frequency of Visits

- Regular visitors (33.3% visited less often, 16.7% several times a month).
- Few frequent visitors: 8.3% visited weekly, 4.2% several times a week.

- Sharing Services
  - Sharing service usage was very low (4.2%), with rental bikes (MOBIbike) as the only cited service.
- Satisfaction with Transport Connections
  - Satisfied (62.5%) was the dominant sentiment.
  - 16.7% expressed dissatisfaction, while only 12.5% were very satisfied.
- Future Innovations
  - A large majority (75%) supported the idea of using self-driving vehicles between Altmarkt and the stadium.

Related to the perceptions on the challenges and potential improvements compiled from citizens are summarized below.

Mobility Challenges

- Public Transport: More tram connections, bus shuttles, and better connections during peak times were requested.
- Accessibility: Issues with wheelchair access, long walking distances, and high steps were highlighted.
- Traffic at Events: Need for better traffic management during major events.
- Cycling and Pedestrian Infrastructure: Suggestions included improved connections to the northwest of Dresden and an Elbe crossing for cyclists and pedestrians.

Facility Improvements suggestions

- Suggestions included more handrails, better parking, and facilities for disabled sports (e.g., shot put).
- Calls for longer-term, sustainable planning with an expanded focus on infrastructure for competitive sports and multifunctional spaces.

General Feedback

- Positive remarks included "keep it up!" and appreciation for the renovation.
- Specific ideas such as chandeliers in the ballet hall and more integration of sports medicine and rehabilitation facilities were shared.

This feedback highlights a need for better accessibility, enhanced public transport, and long-term infrastructure improvements to cater to diverse user groups, including individuals with disabilities, cyclists, and older visitors. Satisfaction levels with current connections are generally positive but suggest room for targeted improvements.

4. MOBILITIES FOR EU pilots and actions in Madrid

4.1. The city of Madrid

Madrid with 3.460.491 inhabitants (5.726,44 inhabitants/km^2) aspires to be climate neutral by 2030 and has been awarded with EU Mission Label after the submission of its Climate City Contract (CCC). This recognition reflects Madrid's commitment to a fair transition towards a green and digital future, serving as an inspiring example for other cities. Furthermore the city counts with other planning instruments such as "Madrid 360 Sustainable Mobility Plan" (2022-2030) and "Madrid Digital Capital strategy". All these initiatives intend to reduce the air pollution of the city and improve the quality of life of citizens through a series of measures focused on digitalisation, sustainable mobility, energy and waste management. In this way, the aim of the city is to achieve healthier mobility, minimising the pollution generated by the mobility system (emissions of NO_2 and particles), reducing the emissions of GHG by 65% compared to the emissions of the year 1990 and decreasing the fuel energy consumption by using renewable energy sources of at least 32% of the total consumed in 2030. Latest but not less, the optimization of the use of urban space and landscape quality, from the perspective of the mobility system, is also a target of the city.

Figure 7. City of Madrid

To reach the above objectives, Madrid has joined to MOBILITIES FOR EU project to demonstrate and implement 5 pilots with innovative solutions for the mobility of people, goods and waste, prioritizing the co-design of these solutions to ensure a user-centric development. Through this project the city will explore the combined potential of electrification, automation and connectivity with the aim of being pioneers at EU level in climate neutrality and zero pollution by 2030 through intensive use of data and 5G technology, AI, IoT, Digital twins and data spaces.

Madrid's ambition is to use this project as a starting point to replicate several of the pilots in the city and its surroundings. This could be for industrial solutions such as in the Valdemingommez technology park or for urban mobility in new developments in the Smart Urban Spaces. At the same time, the city wishes to increase the participation in European projects with a hyperconnected and interoperable area in MercaMadrid that allows showing the value of using data to generate use cases in all areas of the city (Energy, Mobility, People, Waste, Environment, Greens Zones, ...).

4.2. Overview of the demo areas

The scenarios where the pilots will be implemented are Mercamadrid and in the nearby Operations Centre of the Municipal Transport Company (EMT) in Entrevías and Carabanchel.

Mercamadrid is the largest market in Spain that supplies another 46 markets in the city and many other towns in Spain and it is a significant contributor to the regional and national economy. The area, considered as a small-city itself, comprises over 2.8 million m^2, employs around 8.000 people, including market workers, traders and support staff, and generates an annual turnover of around €2.3 billion. The market is strategically located inside the city, near major transport routes, with easy access to Madrid's ring road and the city's airport.

Mercamadrid handles around 30.000 tons of products per day as one of the busiest wholesale markets in Europe requiring efficient and sustainable mobility solutions to ensure that products can be transported quickly and safely to their destination. The area counts with a road network, internal roads, parking areas and an internal transport and the use of sustainable transport solutions (e.g: electric and hybrid vehicles) to reduce emissions and improve air quality is also promoted in this business area. Regarding logistics optimization, Mercamadrid uses advanced logistics technologies to optimize the movement of goods within the market, reducing unnecessary transportation needs and minimizing the environmental impact. Safety and comfort measures are also addressed to pedestrians and cyclists through sidewalks and dedicated bike lanes. Additionally, other sustainability initiatives are in place, like installation of solar panels, waste reduction measures or water-saving technologies.

Figure 8. Mercamadrid aerial view

MOBILITIES FOR EU project aims to introduce and demonstrate in the area of Mercamadrid innovative passenger mobility and freight transport concepts designed and implemented following participative and user-center principles. These cost-effective and feasible solutions will contribute significantly to the transformation of the city of Madrid towards climate-neutrality, allowing to speed up the process emissions reduction in 2030.

The pilots defined will develop autonomous and electrified mobilitiy in Mercamadrid area that will use 5G technology, and which will circulate on an intelligent urban space with interoperable IoT devices. Three autonomous vehicles will be tested, one for passengers and two ones for goods in an industrial environment with heavy traffic, mainly at night. Autonomous mobility will help in terms of safety, emissions reduction and working conditions. Additionally, the passenger vehicle will offer a new service of transport that will improve the mobility of passengers that use the existing public transport service to go to work to the area of Mercamadrid and need to walk in some ocassions a large distance and cross roads with heavy traffic from trailers and vans. The existing route crosses Mercamadrid from side to side but it does not connect mobility demand points like parkings and main headquarters. Also, a smart grid based on RES will be introduced to decarbonize the vehicle fleet operating in the area supported by a digital twin to improve the grid capacity. Efficient charging infrastructure, which include V2G bidirectional chargers and an intelligent sharing point, will enhance interoperability and efficient use of energy resources in passenger and freight transport.

Apart from Mercamadrid, MOBILITIES FOR EU includes in Madrid two additional actions deployed by EMT (Madrid public transport operator) to help decarbonizing the public transport services: full electrification of Carabanchel bus depot and building and operating of a new Hydrogen fuelling station with 10 hydrogen buses in Entrevías bus depot; both facilities in the viccinity of Mercamadrid. These two measures will help EMT Madrid to achieve the full decarbonization goal by 2030, optimizing zero emission public transport.

Finally, all the above described solutions will provide data that will be integrated in a data space that will help to optimize and rationalize the energy use in mobility and minimize the impact on air quality.

4.3. Technical description of the pilots and actions

The solutions to demonstrate in the city of Madrid are detailed in the table below where it can perceive the solutions that take part of each pilot and the typology of solution.

Table 2. List of actions per pilot in Madrid

Name of the action	Solutions	Type of solution	Pilot
A1-1. Autonomous e-buses in Mercamadrid area for people	Autonomous e-vehicle for passenger	CCAM	Pilot 1
A1-2 Automated Guided Vehicle for waste collection at Mercamadrid	Autonomous e-vehicle for freight	CCAM	Pilot 1
A1-3 Last mile autonomous electric transport for food markets	Autonomous e-vehicle for freight	CCAM	Pilot 1
A1-4 Development of 5G Private Mobile Network (PMN) services in SA (Stand Alone) for CCAM connectivity	5G/IoT standalone network	CCAM connectivity	Pilot 1
A2-1 Distributed Smart Grid for Eco Transportation.	PV panels V2G Battery	RES/Power Grid	Pilot 2
A2-2 Digital Twin and power grid management for flexibility	Digital twin	RES/Power Grid	Pilot 2
A3-1 Electrification of 329 e-buses and full electrification of Carabanchel Bus Depot.	e-buses Charging stations in bus depot	2Zero	Pilot 3
A3-2 Intelligent sharing of charging infrastructure and energy between vehicles for the transport of people and freight EMT	Sharing charging stations for e-buses and e-freight vehicles	2Zero	Pilot 3
A4-1 Implementation of H_2 Refueling Station and 10 H_2 fuel cell buses	H_2 fuel cell buses H_2 refueling station	2Zero	Pilot 4
A5-1 Green Energy Data Space in Mobility for the Decarbonization of Madrid and other Cities	Energy data space	High value / Innovative services	Pilot 5

4.3.1. ACTION 1.1 (PILOT 1): AUTONOMOUS E-BUSES IN MERCAMADRID AREA FOR PEOPLE

Short description of the action and goal

This action aims to demonstrate an automated and zero-emission bus inside Mercamadrid area to extend its use at the same time that to introduce a new public transport service in the area to reduce the use of private vehicles by worker trips made from Madrid. Additionally, one of the biggest innovations is that the vehicle will have more capacity than the ones already deployed worldwide, satisfying a real transport need for mass public transport.

Technical specifications of the action to implement and operational aspects

The vehicle will be an autonomous bus with at least Level 4 autonomy (the maximum level allowed by current Spanish legislation for operation in an open environment), 100% electric and capable of communicating with the various components and devices within the ecosystem where it will operate. Additionally, the service will be designed with a focus on innovation, quality and appeal to all stakeholders in order to make the new operation more attractive to customers.

The bus will follow a specific route during the day and will charge during the night. The schedule and specific path will be determined considering the mobility behaviour of potential users compiled through surveys and local mobility analysis which will be done prior to the implementation. This mobility study will be conducted in Mercamadrid to ensure the integration of the bus into the transportation network, maximizing its usage and social benefits. A first theorical design of the proposed route, open to posterior changes, is shown in figure below.

Figure 9. Possible route of the autonomous bus (Madrid)

The vehicle will be tailored by the manufacturer according to the specifications required since the vehicles available in the market are prototypes in the homologation phase. To identify product alternatives in the market, additionally to the providers set of agreements ALSA has in place, several benchmarking initiatives and visits have been conducted by staff from the company to gather as much insights as possible. To highlight some of them, these companies have been already contacted: top-tier OEMs in Europe such as Mercedes-Benz, Iveco, Scania, Solaris, Karsan, Otokar. Additionally, visits toe operations and developments done under the framework of SHOW project in the public transport services of Manheim (Germany) and Madrid (EMT). [1]

[1] The service provided by the EMT microbus during the project is not longer operating.

Figure 10. Examples of existing autonomous buses in operation or testing

Co-design process

A joint collaboration among partners from Madrid ecosystem has been produced for the identification of needs and requirements of this action. Also citizens were involved in first survey held in July 2024 in Mercamadrid where some insights related to the mobility challenges in Mercamadrid area were compiled as well as suggestions of improvements. In the first quarter of 2025, Alsa will conduct an study for the definition of a Zero Emissions Mobility Plan for Mercamadrid, as well as specific actions to design new customer centric services for the new autonomous bus pilot that will be deployed there.

During the testing phase, logbooks for users will be used to gather feedback and identify improvements in the service, through WP3 activities.

Action deployment requirements and responsibilities

Technical and operational requirements

- The choice of vehicle will be made according to the specific technical needs and objectives of the project which are: demostration of an efficiency vehicle, safe and sustainable. Key factors such as capacity, user satisfaction and adaptability to the existing transportation network will be also considered. Additionally, the selection of bus will be according to the vehicle's availability with the project's timeline as well as the acquisition cost.
- The bus route to select must be suitable from a logistical point of view but also to ensure that the route characteristics are compatible with the bus's technical capacities and the supporting infrastructure such as charging stations and maintenance points. For the definition of the route, various criteria must be considered to ensure both operational feasibility and the satisfaction of user needs and project objectives.

The most relevant factors include transportation demand, infrastructure conditions, bus autonomy and capacity, environmental aspects and cybersecurity.

- The charger for the bus will be deployed by other partners as part of the action 2.1 and must be compatible with other operators such as EMT. Consequently, the definition of their technical requirements has been done jointly to ensure an optimal integration of all the elements to implement in the project.
- The customer focus of the solution will be addressed through continuously measurement of the action's impact through periodic surveys of both users and non-users, evaluating perceived safety, suitability, and service quality. The results will be used to incorporate any unforeseen or initially overlooked improvements, making the final solution more robust in terms of safety, quality, reliability, and innovation.

Legal and Administrative Requirements

Permits for the circulation of the bus will be requested to the Directorate-General of Traffic (Dirección General de Tráfico, DGT). Insurances are also an administrative requirement to enter into service the bus in public roads.

Necessary partnership

ALSA is the main responsible partner for the development of this action, but other partners are also involved in different ways:

- ORANGE as provider of the 5G connectivity infrastructure.
- FERROVIAL as provider of the charging solution.
- MERCAMADRID as manager of the area collaborates on the definition and validation of the routesand the infrastructures adaptation.
- T-Systems (TSY) for the data exchange for the high value services generation.
- Ayuntamiento de Madrid as needed stakeholder for the future uptake of this solutions and link with municipal services.

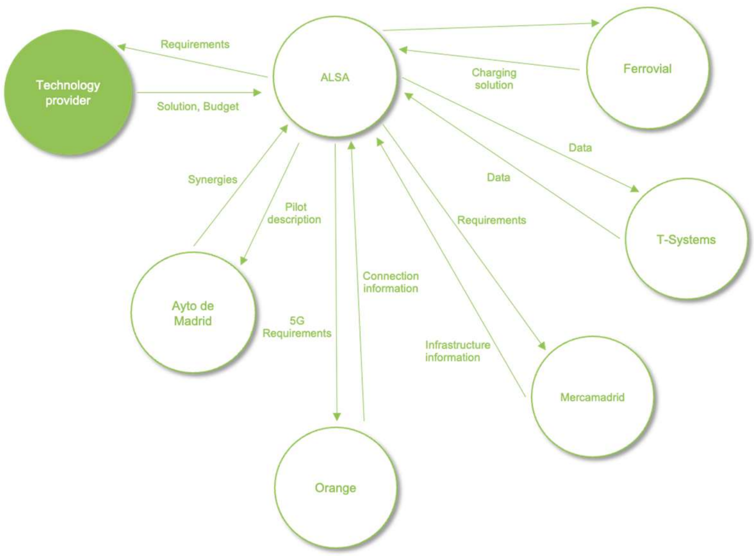

Figure 11. Stakeholders interaction map for action 1.1 in Madrid

Timeline for the deployment and operation of the action

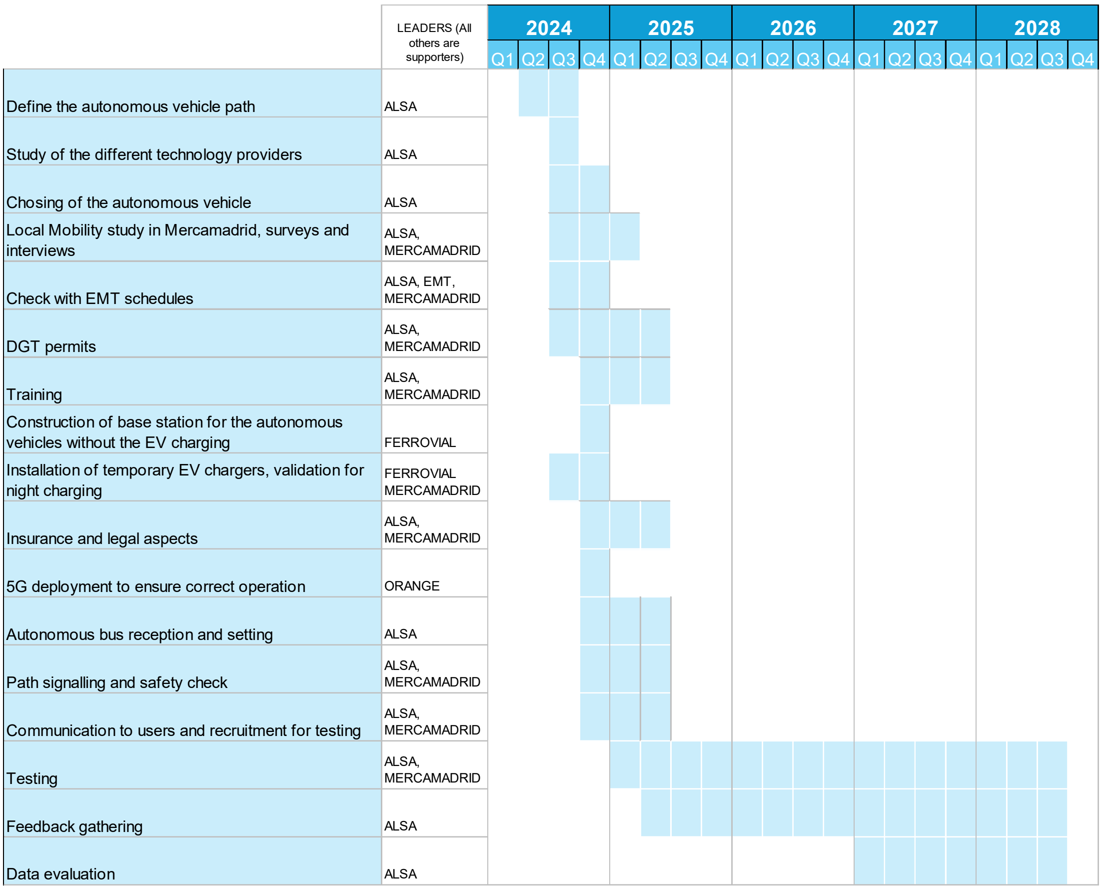

Figure 12. Autonomous e-bus (Madrid) timeline

Initial financial considerations

The costs of this action will be associated to the purchase and the operation of the vehicle. It also includes the installation of additional equipment on board, preventive/corrective maintenance, energy consumption, assistant on board, dissemination costs, etc.

Costs not covered by the project will be assumed by own ALSA resources.

Risk and mitigation measures

- Risk 1: High dense traffic in the area, possible incidents with other road users.
  - Mitigation measure: Level 4-5 autonomous driving technology of the vehicle, assistant on board, additional equipment installed on the vehicle and the own safety programme "ALSA Driving Out Harm".
- Risk 2: Misalignment with EMT public transport lines schedules
  - Mitigation measure: dedicated coordination plan with EMT with periodical reviews of the timetables and adjustments to coordinate services.
- Risk 3: Not achievement of DGT special permits to operate this service
  - Mitigation measure: ALSA has already accomplished to get these permits in other services with autonomous vehicles and has an open channel of communication with DGT authorities. Additionally, the company counts with the support from Madrid City Council and Mercamadrid to deliver the new service with autonomous vehicle.

- Risk 4: Path signalling and safety check
  - Mitigation measure. Alsa has prior experience in designing and implementing these adequations in other services and has an open channel with DGT authorities. Additionally, the company counts with the support from Madrid City Council and Mercamadrid to deliver the new service with autonomous vehicle. Civil works have to be implemented by Mercamadrid, not Alsa.
- Risk 5: Not 5G SA available in the entire route of the bus
  - Mitigation: coordination with Orange, prior to the deployment of the bus, in the definition and testing of the coverage available during the whole route of the vehicle

Interactions with other actions and pilots

- Share of data for Green energy data (Action 5.1)
- Charger of the vehicle will be deployed as part of the action 2.1.

4.3.2. ACTION 1.2 (PILOT 1): AUTOMATED GUIDED VEHICLE FOR WASTE COLLECTION AT MERCAMADRID

Short description of the action, goal and geographical area where is implemented

The proposed solution aims to demonstrate the operation of a zero-emission and Automated Guided Vehicle (AGV) for collecting used EPS (Expanded polystyrene) boxes (waste) at Mercamadrid Central Fish Market. The electric autonomous vehicle will transport EPS boxes collection cages once they are full to the recycling area.

The main goal of the pilot is to get a more effective and sustainable waste collection service. Main benefits of the action are listed below:

- Reduction of emissions and noise, as well as reduction of service's energy demand thanks to the electrification of the diesel vehicle. It is expected to achieve energy savings up to 100 kWh per tonne of waste collected, as well as a reduction of more than 16 teqCO_2/year.
- Contribution to traffic decongestion around the fish market with an on-demand collection solution, thanks to the incorporation of advanced sensors. Specifically, with this solution it is foreseen to halve the distance travelled yearly by the current service vehicle.
- Optimization of human resources and reduction of the risk of accidents by avoiding the need for operators to constantly circulate around the area to identify the filling status of the cages.Specifically, with this solution it is foreseen to halve the distance travelled.

Technical specifications of the action to implement and operational aspects

Every year more than 250 tonnes of EPS used boxes are generated as a waste in the Central Fish Market at Mercamadrid. Nowadays buyers and shop owners bring the boxes to one of the 20 cages distributed in 12 collection points outside the market .

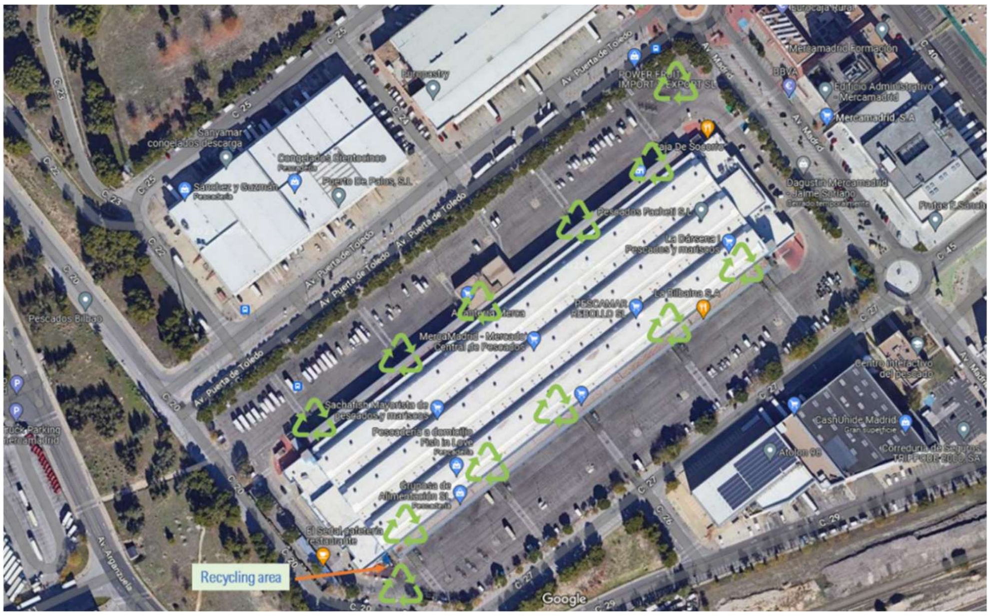

Figure 13. Waste collection points location

An operator is continuously driving a diesel forklift, that can tow up to 2 cages per trip, around the market monitoring the filling status of the cages. Once he detects a full cage, he collects and transfers it to the recycling area. Every day, up to 40 cages are collected and transported to the recycling area. Annually, the diesel vehicle travels more than 11.000 km and consumes about 5.000 litres of diesel. Therefore, 0,057 tonnes of CO_2 are emitted per tonne of EPS waste collected.

Figure 14. Current EPS waste collecting service

For the deployment of the automated service, a solution based on computer vision and Artificial Intelligence will be developed to detect the filling status of the cage and to send a signal to the AGV when the cage is full so that it can proceed to its collection. To do that a set of sensors would be connected by an IoT network, based on a 5G system, that will also connect with the AGV.

- Up to now, contacts with different technology providers, such as GAM, Smarlogy, Drilco and Seevia, have been carried out and the different proposed alternatives for a tow tractor to transport the cages in a similar manner to the current service are being assessed. In this case, each cage must be equipped with safety systems. It would be a semi-autonomous solution since it would need a person to hook the cages to the tow tractor.

- An autonomous tractor head with solidary convoy in the form of a rolling base. The cages would be placed on the base being able to transport up to 4 cages/trip. In this case, safety implementations in the cages are not needed as they are included in the platforms.
- An autonomous forklift transporting the cages on the forks. Up to 2 cages/trip could be transported. In this case, it is a fully autonomous solution.

Once the final solution and technology are chosen, technical specifications and requirements will be defined, as for example needed charging infrastructure, safety signalling, final pathway and route, etc.

Charging requirements and other technical specifications are also about to be defined once the technology is chosen.

Figure 15. Cages for the collection of EPS

Action deployment requirements

Technical and operational requirements

Due to the high circulation of people and vehicles around the working zone in the Fish Market, a dedicated pathway will be delimited in the parking area to reduce the interactions with traffic and people. The dedicated pathway will be designed according to the dimensions of the vehicle and cages once loaded on it.

All solutions being considered include certified and approved systems to guarantee safety and the integrity of the surrounding personnel. However, the deployment of the solution will also require the development of a risk assessment for the entire route, trolleys, transported product, people and other vehicles in the area. Based on the results obtained, the necessary systems and signalling would be installed both in the vehicle and the infrastructure.

Legal and administrative requirements

Permits for the circulation of the AGV shall be requested from the DGT.

Necessary partnership

- Prezero as main partner designing the solution, selecting the provider, acquiring the equipments and devices and implementing and testing it.
- Alsa, collaborating with PreZero in relation to technology identification, circulation permitting, infrastructure adaptation.

- Orange to provide the infrastructure of connectivity.
- Ferrovial to provide the charging solution.
- Collaboration with Ayuntamiento de Madrid for identifying and taking advantages of the synergies with the action 1.3 in which an autonomous vehicle for freight will be implemented.
- Mercamadrid for permitting, infrastructure adaptation and solution validation.
- T-System to data base creation.

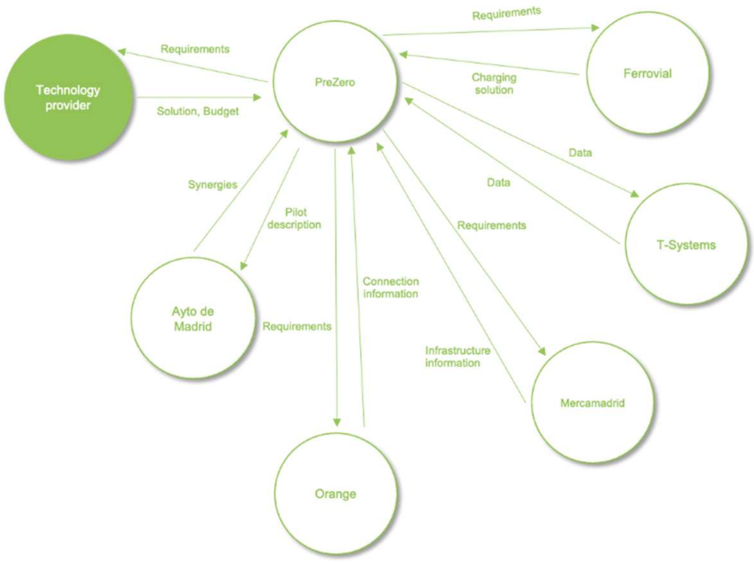

Figure 16. Stakeholders interaction map for action 1.2 in the Madrid pilot

Co-design process

A joint collaboration among partners from Madrid ecosystem has been produced for the identification of needs and requirements of this action. In particular, a close collaboration with Alsa and Ayuntamiento de Madrid has been held for the detection of technology providers. The final selected solution will be validated with them and potential synergies would be identified, mainly in relation to infrastructure adaptation and permit application.

Timeline for the deployment and operation of the action

The solution will be developed following the next planning. The planning will be reviewed once the final solution and the provider are selected.

	LEADERS (All others are supporters)	2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pilot design	PREZERO																				
Contact and selection of technology supplier	PREZERO																				
Identification of synergies with the other pilots for integration with the solution	PREZERO, MERCAMADRID																				
Requirements definition	PREZERO, MERCAMADRID																				
Solution development	PREZERO																				
Pilot set up	PREZERO																				
Application fero permits	PREZERO																				
Infrastructure signaling and adaptation	PREZERO, MERCAMADRID																				
Design of the testing plan and training	PREZERO																				
Pilot testing	PREZERO																				
1st phase	PREZERO																				
2nd phase	PREZERO																				
3rd phase	PREZERO																				
KPIs monitoring	PREZERO																				

Figure 17. Overall AGV (action 1.2) planed timeline

The pilot testing will be developed in different stages to optimize the implementation of the solution.

Figure 18. Implementation stages for action 1.2 in Madrid

- Stage 1: Cages collection in the two centralized collection areas, AP1-AP2. These collecting points represent the 80% of the total EPS volume collected. During this stage, the demonstration of the technical viability of the autonomous solutions would be demonstrated.

Figure 19. Collection area, AP1 for action 1.2 in Madrid

- Stage 2: Cages collection in one collecting point along the building, CP9-CP10. Collection points around the building present the difficulty of high person and vehicle circulation and probably new sensors or safety systems could be required. Therefore, once the solution has been optimized in the previous stage, it will be adapted to the most demandant conditions of CP1 to CP10.

Figure 20. Collecting point along the Fish Market, CP9

- Stage 3: Technical and economic analysis of the feasibility of collecting cages in all the existing points.

Initial financial considerations

The solution would be financed with private budget from PreZero, both acquisition and operational costs.

Challenges for the implementation of the action

Some challenges have been identified and will need to be faced during the design of the pilot:

- AGV connectivity
- Identification of the cages filling status
- Cage-AGV sensor connectivity
- AGV interaction with traffic
- AGV interaction with people
- AGV coupling with cages
- Moving of cages

To address these challenges, permanent contact will be maintained with other pilots and technology providers.

Risks and mitigation measures

Several risks related to the implementation of the solution and its operation have been identified:

Table 3. Risks detected for AGV vehicle

Risks	Mitigation Measures
Permits and licenses delays	Start process early and maintain regular communication with authorities as well as collaborate with other partners (Alsa and Ayto Madrid) to present joint applications. Once the solution is defined, a detailed implementation roadmap and timing plan will be developed to reduce this risks.
Difficulty for the integration of the pilot with the current service due to the implementation in stages	A procedure for the co-existence of both collection services will be defined.
Difficulty of the AGV for loading the cages	It would be assured that all cages are always positioned in an appropriate way for the AGV to pick them up. If needed, some ground stoppers will be installed and a new distribution of cages will be planned.
Difficulty for the operation of the AGV due to a high complex environment	Additional sensors would be installed around the infrastructure and the area to support the autonomous driving of the vehicle.
Low speed of the AGV	Service rescheduling by adding 0.5 or 1 shift, taking advantage of its capacity to work 24/7.
Low level of engagement of staff and buyers at Mercamadrid	Since a new vehicle will be circulating around the area of the Central Fish Market at Mercamadrid, training sessions will be organized with staff to show the capabilities of the vehicle, the area delimited for its circulation and how to act from the safety point of view. Furthermore, the presence of the vehicle will be indicated with several signals.
No acceptance of the technology by operators	Design of a training programme for operators for the maintenance and operation of the solution.

Interactions with other actions and pilots

The solution is expected to be quite similar to the one that will be developed by Pilot 1 (Action 1.3): Last mile autonomous electric transport for food markets since the same kind of autonomous vehicle would be needed; so continuous communications are maintained with the responsible of its implementation. Synergies in the case of use have been identified and common technical requirements related to the specification of the vehicle, connectivity and charging have been analyzed.

As far as charging infrastructure is concerned, requirements related to the typology of the charging station needed and how the vehicle should be connected will be shared with Ferrovial, who is in charge of the implementation of chargers at Mercamadrid, through A2.1.

Close collaboration with Alsa, responsible to deploy the e-autonomous bus through Action 1.1, is also taking place in relation to DGT permitting thanks to their previous experiences in this field.

Regarding connectivity and network requirements, for the correct operation of the action specific needs are communicated to Orange, responsible of the design of the 5G Private Mobile Network for CCAM connectivity (action 1.4 from Pilot 1). Modems to be used in the vehicles must be homologated with the Orange network. Then, the calibration of the connected objects with the frequency/network for their correct operation is required.

Data generated in the implementation and operation of the pilot will be shared with pilot 5 to develop the Green Energy Data Space in Mobility.

4.3.3. ACTION 1.3 (PILOT 1): LAST MILE AUTONOMOUS ELECTRIC TRANSPORT FOR FOOD MARKETS

Short description of the action and goal

The action consists of a zero-emission and Automated Guided Vehicle (AGV) to move merchandise, fish and frozen products in the Mercamadrid Central Fish Market. The electric autonomous vehicle will transport these products between the different warehouses and the central warehouse and along the different commercial stalls within the fish market. The purpose of the action is to deploy a sustainable and scalable solution that will last over time. With this goal, it is aimed to demonstrate that the solution deployed is technically and economically viable. Once the economic impact and business case have been measured, the possibility of replication in similar services in Mercamadrid and in Madrid city and in other cities will be studied.

The main objectives to reach with the deployment of this solutions are:

- Reduction of emissions and noise as well as reduction of service's energy demand thanks to the electrification of the existing diesel vehicle. It is expected to achieve energy savings up to 100 kWh per tonne of waste collected, as well as a reduction of more than 16 teqCO_2/year.
- Contribution to traffic decongestion around the fish market with an on-demand collection solution, thanks to the incorporation of advanced sensors. Specifically, with this solution it is foreseen to half the distance traveled yearly by the current service vehicle.
- Optimization of human resources and reduction of the risk of accidents by avoiding the need for operators to circulate around the area.

Additionally, one of the main strategies promoted by the Madrid City Council is to seek synergies, reduce costs and also guarantee contingency solutions. This is the basis to alignement as much as possible the requirements of the freight and waste transport actions, those described as 1.2 and 1.3 in this document. Therefore, at the level of specifications and implemented technical solutions, the two actions are similar, complementary and aligned. This is not the case at the level of the use case, where each one provides a specific service to a demand.

Technical specifications of the action to implement and operational aspects

Action 1.3 aims to achieve an equivalent service to the current one deployed by a wholesale fish supplier named Congelados Cientocinco. This operator distributes fish, seafood, vegetables and desserts in different formats and an operator is working during the market's operating hours from 2 AM to 10 AM. The goods are moved through a disel forklift and replenish this at the beginning of each shift in the stalls and then according to the demand. The vehicle moves the goods between the auxiliare warehouses outside the fish market and among the different stalls (up to 4) that have in the own market. Every day, more than 10 pallets are transported by the current diesel vehicle and more than 5,000 km are transported yearly, which produces a consumption of 2,200 litres of diesel. Through MOBILITIES FOR EU project, this service will be automated on demand, collecting the pre-established good and moving it between the intermediate warehouses and the fish warehouse.

Figure 21. A1.3 (Madrid): Current operation of the freight service

In a joint with action 1.2, Madrid and PREZERO have contacted and defined requirements for the use cases and contacted with different technology providers, such as GAM, Smarlogy, Drilco and Seevia. At this moment, different alternatives are being evaluated:

- A tow tractor to transport the cages in a manner similar to the current service in which the pallets from frozen fish would be prepared and placed in these cages. In this case, each cage must be equipped with safety systems. The inconvenient of this option is that it would be a semi-autonomous solution since it would need a person to hook the cages to the tow tractor.
- An autonomous tractor head with solidarity convoy in the form of a rolling base. The cages would be placed on the base being able to transport up to 4 cages/trip. In this case, safety implementations in the cages are not needed as they are included in the platforms.
- An autonomous forklift transporting the pallets on the forks. In this case, it is a fully autonomous solution.

Once the final solution and technology are chosen, technical specifications and requirements will be defined, as for example needed charging infrastructure, safety signaling, final pathway and route, etc.

Action deployment requirements

Technical and operational requirements

- Signalling, traffic management and protocol for dealing with different types of users throughout the test environment.

  Although the solution will be autonomous and capable of managing the environment, pre-defined paths will be defined according to the size and characteristics of the vehicle as well as operational parameters, especially in the first phases of the action. Additionally, all solutions under evaluation will include certified and approved systems to guarantee safety and the integrity of the surrounding personnel. A risk plan and an operational plan will be drawn up jointly with Mercamadrid for the entire route and considering all the movements of vehicles and persons. Based on the results obtained, the necessary systems and signalling will be installed.

- Parking area and charging infrastructure.

  The vehicle will have a specific parking area, with specific chargers, security and an optimal level of maintenance for the established requirements.

Legal and administrative requirements

At the regulatory level, all necessary permits and authorizations will be obtained, specifically the permit to circulate the AGV shall be requested from the DGT.

Partnership

- Madrid will be in charge of the design of the solution, selection of the provider, adquisition of the equipment and devices and the implemention and tested of the solution. Additionally, the design of the solution will be done in collaboration with MercaMadrid and Congelados Cientocinco.
- PreZero and ALSA will cooperate with Madrid in relation to technology identification, circulation permitting and infrastructure adaptation.
- Orange will provide the infrastructure of connectivity.
- Ferrovial will provide the charging solution.
- Mercamadrid for obtaining the permits, define the infrastructure adaptation and validation of the final solution.
- T-System to data base creation.
- Congelados Cientocinco will allow to evaluate the impact, savings and economic benefit of this type of solution, comparing the current situation with the target scenario.

Co-design process

One of the fundamental aspects of this project is actions co-design with the different agents involved. For this task, it has counted with the support of Right Click to promote the interaction among project partners to define the actions in a joint way. Additionally, the entire Mercamadrid ecosystem has also been involved in the process by engaging in the co-desing process to suppliers, clients and users of the facilities and services from Mercamadrid. In special, the collaboration with Prezero and Alsa has been essential for the identification of potential synergies, infrastructure adaptation, required charging infrastructure and requests of permits. The bidirectional chargers have been another area of joint work, both with the specific government area of the City Council, as well as with the rest of the vehicles, and with MercaMadrid with the aim that electric car users can utilize and benefit from all the infrastructure deployed.

Timeline for the deployment and operation of the action

The solution will be developed following the next planning. The planning will be reviewed once the final solution and the provider are selected.

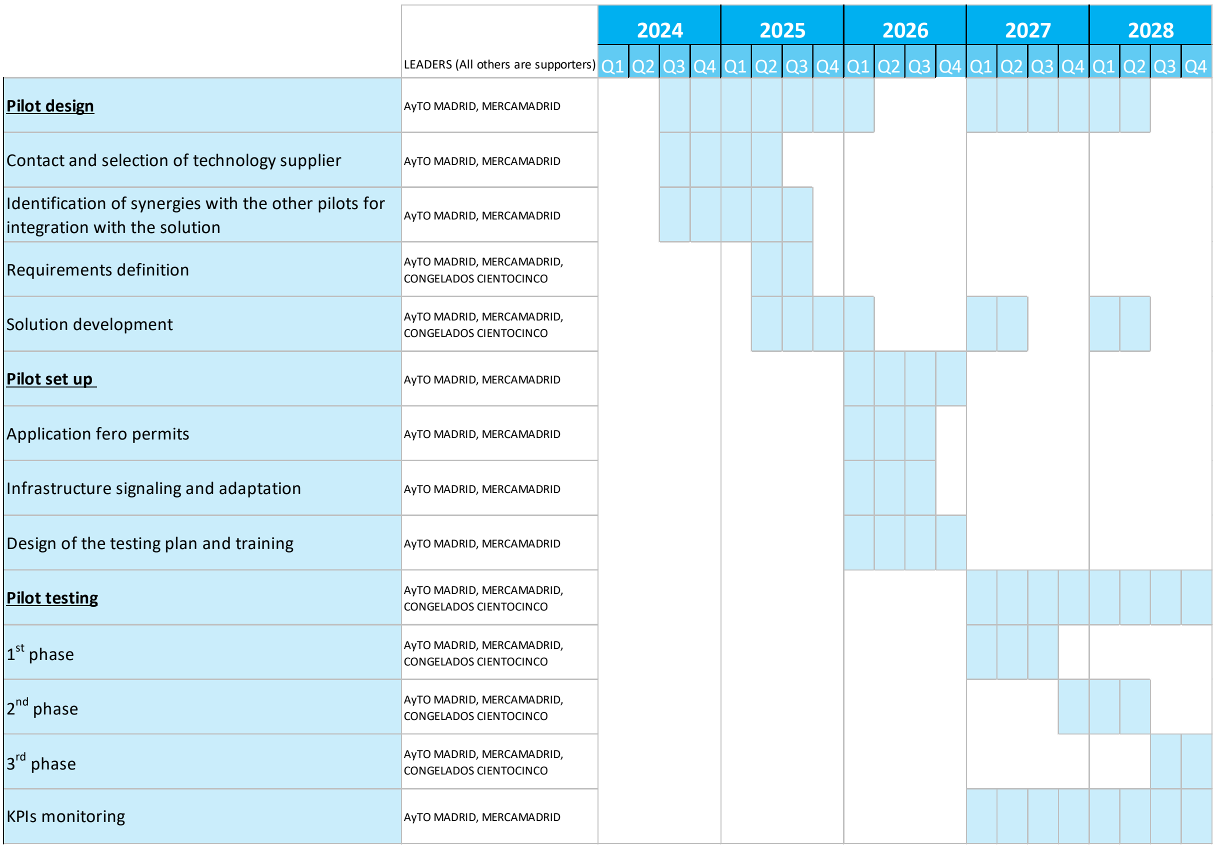

Figure 22. Overall planning for AGV (action 1.3) timeline

The action will be developed in different stages to optimize the implementation of the solution.

- Phase 1: This phase covers the movement of the goods between the warehouse that Congelados Cientocinco has in front of the fish market to reach the stand inside the warehouse. This routes requires to cross the main traffic routes of MercaMadrid to access the market by the nearest ramp, being a critical point of the action since it is needed to collaborate with the traffic management area of the city.
- Phase 2: The second phase cover also the movement of goods between two stands inside the fish market. In this phase, the interaction with the persons working in the market will be critical. This phase, althouth is optional, will allow to determine the viability of autonomous vehicles in a densely populated environment.
- Phase 3: The final phase, also optional, allows the access of the vehicle to the four stalls that Congelados Cientocinco have in the MercaMadrid fish market.

Figure 23. Route of AVG (action 1.3)

Initial financial considerations

The solution is mainly financed through EC funds provided through MOBILITIES FOR EU project, contributing the city of Madrid with those costs not covered by this fund.

Challenges for the implementation of the action

The main challenges for the deployment of this actions are detailed below. These correspond with the challenge faced by the action 1.2.

- AGV connectivity
- Identification of the pallet scenario
- Pallets-AGV sensor connectivity
- AGV interaction with traffic
- AGV interaction with people
- AGV coupling with pallets
- Moving of pallets

To address these challenges, permanent contact will be maintained with other pilots and technology providers.

Risks and mitigation measures

Table 4. Risks detected for AVG (Action 1.3)

Risk	Mitigation measure
High dense traffic in the area, possible incidents with other road users.	Level 4-5 autonomous driving technology of the vehicle, assistant on board, additional equipment installed on the vehicle and the own safety programme.
Permits and licenses delays	Start process early and maintain regular communication with authorities as well as collaborate with other partners (Alsa and Prezero) to present joint applications. Once the solution is defined, a detailed implementation roadmap and timing plan will be developed to reduce these risks.
Difficulty for the operation of the AGV due to a high complex environment	Additional sensors would be installed around the infrastructure and the area to support the autonomous driving of the vehicle.
Low level of engagement of staff and buyers at Mercamadrid	Since a new vehicle will be circulating around the area of the Central Fish Market at Mercamadrid, training sessions will be organized with staff to show the capabilities of the vehicle, the area delimited for its circulation and how to act from the safety point of view. Furthermore, the presence of the vehicle will be indicated with several signals.
Not 5G SA available in the whole route of the bus	Coordination with Orange, prior to the deployment of the bus, in the definition and testing of the coverage available during the whole route of the vehicle.

Interactions with other actions and pilots

The deployment of the three vehicles in Mercamadrid as part of the project will be done in a coordinated manner since all of them have similar requirements.

The vehicle to deploy as part of the A1.3 is expected to be quite similar to the one that will be developed in Action 1.2. A continuous communications with PREZERO, the responsible partner, is needed to define the common technical requirements related to the specification of the vehicle, connectivity and charging infrastructure. Adittionally, requirements of the charging infrastructure of the vehicles are also shared with FERROVIAL, as partner responsible to deploy the chargers through Action 2.1. Finally, the permissions to obtain from DGT for the three vehicles are dealing through a collaboration established among the three responsible partners: Madrid (AVG_Action 1.3) , PREZERO (AVG_Action 1.2) and ALSA (bus_Action 1.1) taking benefit of the previous experience of Alsa in this field.

Regarding connectivity and network requirements for the correct operation of the action, specific needs are communicated to Orange, responsible of the design of the 5G Private Mobile Network for CCAM connectivity (action 1.4 from Pilot 1). Modems to be used in the vehicles must be homologated with the Orange network. Then, the calibration of the connected objects with the frequency/network for their correct operation is required.

Finally, data generated in the implementation and operation of the action will be shared with pilot 5 to develop the Green Energy Data Space in Mobility.

4.3.4. ACTION 1.4 (PILOT 1): DEVELOPMENT OF 5G PRIVATE MOBILE NETWORK (PMN) SERVICES IN SA (STAND ALONE) FOR CCAM CONNECTIVITY

Short description of the action and goal

The solution provides the required mobile connectivity for the correct operation of autonomous vehicles deployed in Mercamadrid through the provision of 5G Private Mobile Network (PMN) services in SA (Stand Alone) mode.

Technical specifications of the action. Technical and operational requirements

A next-generation of 5G Private Mobile Network (PMN) with high-capacity, ultra-reliable and ultra-low-latency to enable reference use cases (uRLL, eMBB, mMTC) associated with the 3GPP/5G SA standard versions 16 and later is deployed, ensuring its evolution and updating during the life of the project.

The PMN cover the mobile connectivity requirements for pilots and is focused on:

- Private network service currently based on state-of-the-art 5G technology;
- With special care for the security and possible future scalability of the proposed solution, anticipating possible scenarios and open to incorporate technological innovations generated throughout the project.
- With coverage, throughput and latency commitments that guarantee high quality communications and the optimal user experience, including FREIGHT services and PEOPLE mobility.

The infrastructure of the solution proposed is composed of three blocks which add value to the project:

- 5G private network core solution.
- Radio access network deployed (existing) at pilot locations.
- Transmission network, linking all elements.
- Key relevant aspects on the solution designed includes: Mean components provided by top of the range carrier grade of the manufacturer Ericsson
- Slicing feature on radio and core to provide QoS (Quality of Service)
- UPF-LBO (User Plane Function – Local Brake Out) in Data Center located in Coslada (Madrid)

Regarding radio access netwotk (RAN), Mercamadrid is served by 2 different 5G sites: MAD0823 and MAD0478 where 5G SA are deployed:

Figure 24. Mercamadrid 5G Sites Coverage

To ensure 5G 3.5GHz coverage in the areas required for the movement of the three autonomous vehicles to implement in the city of Madrid, coverage studies/field measures in Mercamadrid was performed based on walk tests / drive tests made by Orange. These were done according to the routes that will be taken by the vehicles, detecting coverage areas whose level would not cover the project objectives and providing specific solution based on Sectorization coverage solution or ROD coverage solution.

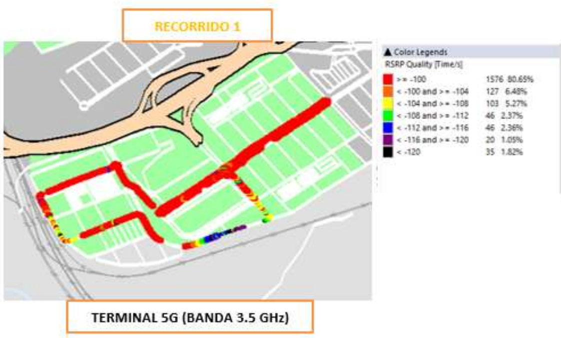

Figure 25. GHz RSRP Quality Route1 based on Site Survey measurements

In terms of efficiency, 5G Private Mobile Netwotk (PMN) services in SA (Stand Alone) is an efficient solution (about 10 times more energy efficient than 4G) due to the higher efficiency of antennas which, for the same consumption as 4G, is able to manage 5 times more bandwidth, with higher throughput and serving many more users simultaneously and the stand-by modes for 5G SA. Additionally, the company to install the solution has accredited that 100% of the consumed energy (included radio nodes) comes from renewable sources. Exactly the electric power are based on both 5G sites by PPA (Power Purcharse Agreement – 100% renewable energy).

Legal and Administrative Requirements

Solution fulfil with the certificates and regulations that currently are in force and responsible of ensuring their compliance:

DOC	ID	Site	Código de Emplazamiento	Código Estación	Tecnología	Estado	Tipología ER	PSI/PSCs	Dirección emplazamiento	Municipio	Provincia
	5051	MAD0478	MADR0478A	MADE0478A	G900	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3.8	MADRID	MADRID
	37742	MAD0478	MADR0478A	MADB0478A	U2100	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3800	MADRID	MADRID
	37767	MAD0478	MADR0478A	MADF0478A	U900	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3800	MADRID	MADRID
	48972	MAD0478	MADR0478A	MADL0478A	L2600	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3800	MADRID	MADRID
	61898	MAD0478	MADR0478A	MADM0478A	L800	APS	ER1	PSC	CL EJE 1-3	MADRID	MADRID
	116600	MAD0478	MADR0478A	MADP0478A	5G3600	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3800	MADRID	MADRID
	147527	MAD0478	MADR0478A	MADQ0478A	5G700	APS	ER1	PSC	CR VILLAVERDE A VALLECAS 3800	MADRID	MADRID
	158531	MAD0478	MADR0478A	MADN0478A	L1800	APS	ER1	PSC	CL CUARENTA Y SEIS 1 E-4	MADRID. MADRID	MADRID
	158532	MAD0478	MADR0478A	MADT0478A	L2100	APS	ER1	PSC	CL CUARENTA Y SEIS 1 E-4	MADRID. MADRID	MADRID

Figure 26. MAD0478 Government certifications

Detailed timeline

	LEADERS (All others are supporters)
5G SA coverage	Orange
Design of the project	Orange
Initial Permits	Orange
Works implementation	Orange
Site survey	Orange
Coverage improvement in warehouse Mercamadrid area	Orange
Service architecture and slicing	Orange
Design of the project	Orange
Service architecture deployment	Orange
Slicing	Orange
Vehicles integration and pilot testing	Orange / Alsa /Prezero / Ferrovial
Solution design	Orange / Alsa /Prezero / Ferrovial
Integration testing	Orange / Alsa /Prezero / Ferrovial
Pilot testing support	Orange

Figure 27. CCAM connectivity in Mercamadrid timeline

Identification of interactions with other pilots & actions. Co-desing process

A collaborative among project partners for the deployment of this action has resulted in a comprehensive that ensures robust protection at multiple levels. The initiative underscores the importance of connectivity, communication, platform security and application-level safeguards. By engaging with the broader community and leveraging their feedback, the project has tailored its approach to address specific risks and enhance the overall connectivity posture.

The co-design process, facilitated through the UT lab, has been instrumental in gathering diverse inputs and validating the solutions from a social perspective. This process not only enhances the technical rigor of the network 5G+ measures but also ensures that they are aligned with the needs and expectations of the end-users.

In conjunction with these efforts, significant strides have been made in identifying and leveraging synergies with other pilots and actions within the broader ecosystem.

Risk and mitigation measures

Thgis action deals with risks related to cybersecurity, and there habe been considered several layers to be covered:

- Connectivity: Security provided by the GSMA standard.
- Communication: Specific solutions taken in consideration the generation of specific private APNs, IPSec tunnels,…
- Platform: Functionalities for data filtering, SIM blocking, traffic limits, ...
- Application: User roles, access policies,…

4.3.5. ACTION 2.1 (PILOT 2): DISTRIBUTED SMART GRID FOR ECO TRANSPORTATION

Short description of the action and goal

The action aims to develop an innovative, distributed and sustainable energy pilot smart grid to drive the decarbonization of last-mile transportation by electrifying vehicles dedicated to transporting people and goods. This system integrates renewable energy sources, energy storage solutions, and bidirectional charging technologies (V2G) to demonstrate efficient and sustainable optimization of energy production, distribution, and consumption.

Figure 28. Example of rooftop PV panels, storage sytems and V2G charger[2]

The action involves creating an experimental pilot of a smart power grid that enables the efficient management of energy flows between the different system components. By optimizing energy production and consumption based on supply/demand, the system will enhance overall efficiency. Additionally, the integration of energy storage technologies, such as batteries, will allow the excess energy generated by the photovoltaic panels to be stored and utilize as needed, thereby increasing the grid's resilience and stability. The bidirectional charging capacity will enable vehicles equipped with this technology to feed energy back into the system, ensuring the most efficient use and storage of energy.

[2] PIctures are only indicative since the pilot has not been deployed yet

In summary, the development of a distributed pilot smart grid for ecological transportation in Mercamadrid involves implementing an experimental advanced energy infrastructure that integrates renewable energy sources, bidirectional charging technologies, storage solutions and sophisticated energy management systems (See Action 2.2). This experimental grid will serve as a foundation for future replication and scaling, to help decarbonize last-mile transportation, optimize energy use, and enhancing the sustainability of the city's transportation system. Additionally, it will demonstrate the functionality of these smart grids when isolated from the main grid, providing auto-consumption solutions for decarbonization.

Technical specifications of the action to implement and operational aspects

The main components of this action and the key specifications are detailed below.

- **Photovoltaic Plant (PV)** with a capacity of 700 kWp to be installed on the rooftop of the fish market at Mercamadrid, covering a significant surface area to capture as much solar radiation as possible. The plant is expected to produce around 1000 MWh per year. The panels are designed to maximize energy efficiency and ensure long-term durability, guaranteeing optimal performance over time. The system will be equipped with efficient inverters to convert the direct current (DC) generated by the panels into alternating current (AC), suitable for use in the experimental grid and the chargers. During the first months of the project Ferrovial analysed together with Mercamadrid the best location for the pilot. After careful analysis of the electric plans and transformers available, it was defined that the solar panels will be installed on the rooftop of the fish market as shown in the image below. It was also noted the need to increase the power of the 400kVA transformer station to 1000kVa in order to be able to connect the PV solar panels, as shown below:

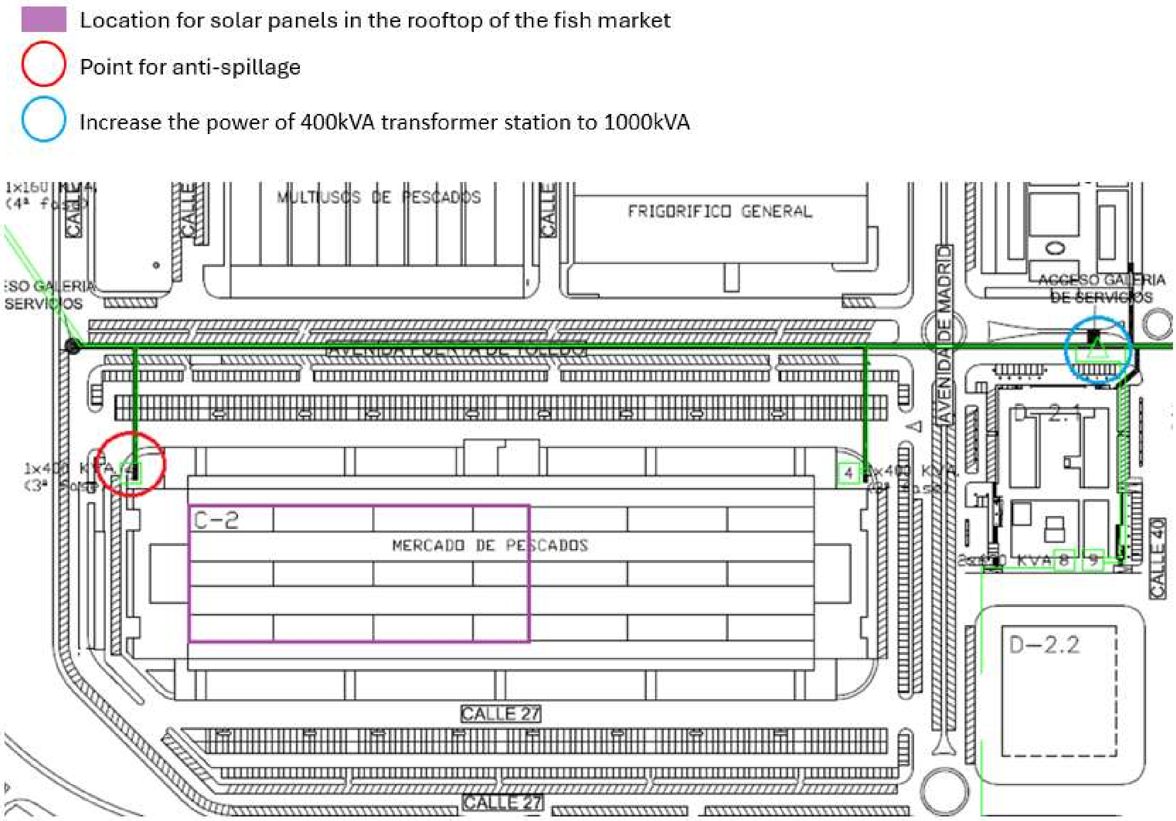

Figure 29. Location for solar panels, anti-spillage and transformer station for connection in Mercamadrid

Bidirectional V2G Chargers (Vehicle-to-Grid): Seven innovative bidirectional fast chargers will be installed, which will be able to charge electric vehicles (EVs) and return energy to the grid when the vehicles are not in use. The bidirectionality allows vehicles to discharge stored energy from their batteries back into the grid, providing energy flexibility and stability. This component is key to managing energy demand in real-time and optimizing consumption based on Mercamadrid's needs. The chargers will be strategically located in Mercamadrid to facilitate access for both distribution center workers and transport vehicles. Specifically, one charger will be used to charge the autonomous Alsa vehicle (See Action 1.1), one charger will initially be designated for two Prezero vehicles (See Action 1.2), and five V2G chargers will be used to charge the vehicles of Mercamadrid users (see specifications below: Action Development Requirements). Several locations for the chargers were analyzed during the initial months of the project between Ferrovial and Mercamadrid. However, the final location will be decided in the coming months, particularly for the chargers dedicated to Alsa's and Pre-zero's vehicles, as they need to be situated in key positions along their autonomous routes.

- *Charging/Discharging Capacity*: Each charger will be able to serve up to 30 electric vehicles (EVs) per day, with enough charging capacity to ensure fast and efficient operation.
- *Energy Consumption:* These chargers are estimated to consume around 300 MWh annually, but thanks to their bidirectional capability, they would also be able to return approximately 500 MWh of green energy back to the grid.

The following characteristics of the V2G chargers have been defined along with possible technological solutions:

- V2G to charge Alsa's vehicle of minimum 120kW.
  - JEMA (EMT supplier): Option V2G 150kW. Delivery time: 32 weeks or Option no V2G 120kW Delivery time: 24 weeks
  - Siemens: Option No V2G 120kW. Delivery time: 14 weeks
  - Orbis: Option No V2G (V2G end of 2024) 160kW. Delivery time: 16 weeks.
- V2G to charge Prezero's vehicle. Power not defined.V2G
- V2G to charge users' vehicle from Mercamadrid.30 kW c.c + 22 kW c.a. V2G
  - Orbis: Option No V2G (V2G end of 2024). Time to supply: 16 weeks.

- **Energy Storage System (Batteries)**: A battery storage system with a capacity of 200 kWh will be installed to store excess energy generated by the photovoltaic panels during periods of low demand or high production. This stored energy can be used to power the V2G chargers when solar energy production is insufficient or energy demand is high, ensuring the system's stability and efficiency. The battery system will store excess solar energy generated during the day for use when needed. The fast response capacity of the batteries will be critical to ensuring there is always enough energy available to charge electric vehicles and maintain the stability of Mercamadrid's energy grid. The batteries will be installed alongside the photovoltaic panels and V2G chargers, facilitating efficient energy transfer between systems and demonstrating through this pilot the feasibility of these type of smart grids.

  Energy flow management between energy systems and renewable energy sources (RES) is a critical aspect. Since the installed photovoltaic panels will be one of the main energy sources, the system must optimize the distribution of this energy among the various users and connected devices. The goal is to ensure efficient use of green energy, minimize dependence on the traditional power grid, and maximize the energy self-sufficiency of the system.

  The energy generated by the photovoltaic plant will be distributed as follows:

- Charging of Electric Vehicles: Solar energy will primarily be used to charge electric vehicles via the 7 bidirectional V2G chargers. Approximately 30 vehicles will be charged daily, consuming around 300 MWh annually.
- Battery Storage: Any surplus energy that is not immediately used will be stored in a battery system with a capacity of 200 kWh. This will ensure the availability of energy during periods of low solar production (e.g., at night or on cloudy days).
- Injection into Mercamadrid's Grid: Any energy not used for vehicle charging or storage will be injected into Mercamadrid's internal grid. This will help reduce dependence on external energy sources, lower costs, and improve grid stability.

For energy flow optimization, a pilot energy management system will continuously monitor and adjust energy flows between the photovoltaic plant, batteries, and V2G chargers (See Action 2.2). This would ensure that renewable energy is prioritized for electric vehicle charging while any surplus is efficiently managed through storage or injection into the internal grid. Additionally, the bidirectional capability of the V2G chargers adds flexibility to the system, allowing vehicles to return energy to the grid when not in use, further enhancing the stability and resilience of Mercamadrid's energy system.

During the initial months of the project Ferrovial and Mercamadrid analysed potential locations for the installation of the battery storage based on available space and electric diagrams of Mercamadrid's grid. The final decision will be made in the coming months. The most probable is the location of the compact container near transformation station as is observed in figure below.

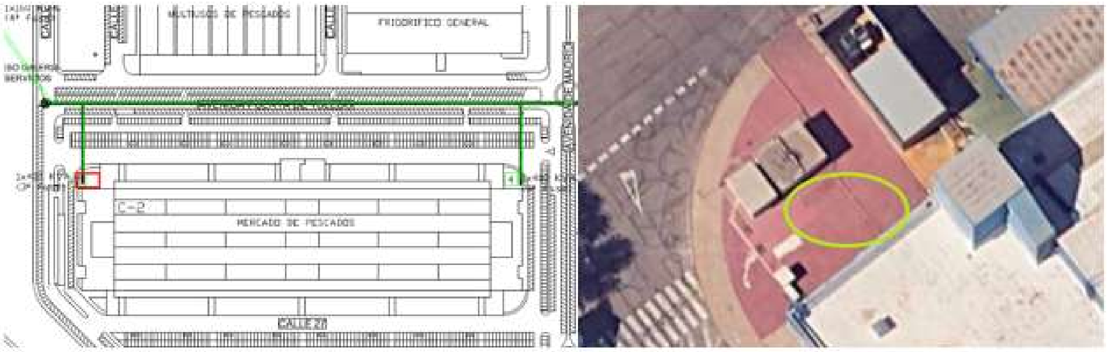

Figure 30. Battery location in Mercamadrid

Also, during the first months of the project, Ferrovial discussed with Plexigrid the data required to feed to feed the energy management system integrated into their Digital Twin (See Action 2.2). It was noted that installing sensors and voltage meters will be necessary to measure electricity from the PV panels, V2G chargers and storage system. This is still to be defined, as it will likely be a collaboration between Ferrovial and UPM.

Action deployment requirements

To ensure the success of the project, a series of technical, operational, legal, and administrative requirements must be met.

Technical and operational requirements

Design and Installation of the Photovoltaic Panels:

- Sizing: The engineering team will design a photovoltaic plant with a capacity of 700 kWp, generating 1000 MWh/year. This involves a thorough analysis of the characteristics of Mercamadrid's rooftops to optimize solar capture.
- Materials Selection: Solar panels, high-efficiency inverters, and suitable mounting structures will be selected to maximize energy production, considering factors such as orientation and tilt.

- Deployment: Complete installation of the solar panels, including electrical wiring and integration with Mercamadrid's energy distribution systems dedicated to the pilot

Installation of V2G Chargers:

- Sizing: Installation of 7 fast chargers with V2G (Vehicle-to-Grid) capability, selected based on the needs of the vehicles and the capacity of Mercamadrid's network.
- Site Evaluation: It will conduct an area assessment to locate the chargers in strategic positions, ensuring easy access for transport vehicles and employees.
- Interconnection: It will handle the connection of the chargers to the internal electrical grid and ensure compatibility with the vehicles that will use this infrastructure.

Installation of the Storage System:

- Sizing: It will install two 100 kWh batteries to store excess energy generated by the photovoltaic plant. The batteries will be located next to the transformer substation, but this will depend on municipal permits as it involves public spaces.

Legal and Administrative Requirements

Permits and licenses required:

- Construction licenses: Municipal permits for the installation of solar panels and charging points, ensuring that all installations meet local requirements.
- Interconnection permits: It will handle the necessary procedures to obtain permits for connecting the photovoltaic plant and V2G chargers to Mercamadrid's internal grid, including the injection of excess energy.

Tenders and contracts required:

- Tender process: It will manage the hiring of suppliers and subcontractors for the acquisition and installation of solar panels, inverters, batteries, and chargers, through a tender process that guarantees the best quality at the best cost.
- Maintenance: It will provide a maintenance plan for the installed experimental infrastructure , ensuring the continuity and operational efficiency of the entire system.

Regulations and certifications

The solution package will ensure compliance with all current regulations and certifications at both European and local levels. Below are the main regulatory requirements for each component:

- Photovoltaic Panels (PV):
  - Certifications: The photovoltaic installation must comply with the European Union Directive 2009/28/EC on the promotion of renewable energy use. Additionally, local construction and safety regulations will be followed to ensure the panels meet rooftop installation requirements.
  - Quality Standards: The photovoltaic panels must comply with European quality standards such as the IEC 61215 certificate, ensuring their efficiency and durability under real operating conditions. The inverters used must meet IEC 62109 standards to ensure operational safety and protection.
- Bidirectional V2G Chargers:
  - Certifications: The bidirectional chargers must comply with European interoperability and safety regulations, such as the 2014/94/EU Directive on alternative fuel infrastructure, which governs the recharging infrastructure for electric vehicles.

  - Quality Standards: The chargers must meet IEC 61851 certifications, ensuring safe and efficient operation, and must be compatible with V2G communication standards (ISO 15118), allowing for the bidirectional flow of energy between the vehicles and the grid.

- Energy Storage System (Batteries):
  - Certifications: The batteries must comply with electrical safety and fire protection standards, as stipulated in IEC 62619, which regulates the safety of lithium batteries for industrial applications.
  - Quality Standards: The storage system must meet IEC 61427 standards for energy storage systems, ensuring safe and efficient operation throughout its life cycle.

Partnerships & Co Design Process

- Mercamadrid: A Key partner in the co-designing this solution, as they own the pilot site. Constant communication and information sharing are essential. During the first months of the project, the locations for the smart-grid components (PV panels, batteries and V2G chargers) were thoroughly analysed in collaboration with Mercamadrid studying their electrical diagrams and understanding their internal grid. From the beginning of the project and throughout all of it, ongoing collaboration will be necessary for permitting and certifications, finalizing the location of the V2G charges (in co-design as well with Alsa and Pre-Zero), determining the final location of the battery systems, completing all necessary installations and connections, and sharing production and electricity data to feed the digital twin that will serve as energy management system for the pilot.
- Plexigrid: A key partner once the smart-grid pilot is deployed, as they will develop and manage the energy management system through their digital twin. During the initial months of the project, the essential data required to feed the system has been defined. In the coming months, extensive collaboration will be necessary to determine the best methods for measuring those data and managing this data, in collaboration with UPM and Mercamadrid. Plexigrid will also play a crucial role testing of the pilot since the analysis of energy production will be performed with the digital twin.
- UPM: A key partner for the definition of the meters and sensors for measuring energy production to provide the necessary data to Plexigrid. In the following months, these systems must be defined, and it must be clarified who will deploy them. UPM will also play a crucial role in the smart-grid data visualization, as they will integrate all energy data in their Home Assistant, which will feed the Energy Management System of the Digital Twin, in collaboration with Plexigrid.
- T-systems and Orange: Key partner to ensure correct interconnection and data communication between the Smart-grid, UPM's home assistant data visualization platform, and Plexigrid's Digital Twin. The requirements for the 4G cards as well as the necessary routers will be defined in the following months.
- ALSA & EMT: Key partner in the definition of the V2G charger that will be dedicated to their autonomous bus. During the last months of the design phase the V2G charger dedicated to their vehicles has been co-designed with Alsa to adapt to the power, capacity and technical specifications of their pilot vehicle. Constant collaboration will be necessary to ensure a correct placement installation along with Mercamadrid, and to ensure vehicle's proper charging capabilities. It was also proposed that this charger should also work with EMT buses. The feasibility of this will be analyzed in the second year of project and, if possible, the charger should be re-defined and co-designed in collaboration with Alsa and EMT.
- Pre-Zero: A key partner in the co-design and definition of the V2G charger that will be dedicated to their autonomous waste collection and other goods vehicles. In the coming months Pre-Zero must provide all technical specifications required from their vehicles to co-design the best charging solution and analyze technical feasibility. The placement of the charger should also be defined in collaboration with Pre-Zero and Mercamadrid to ensure it is in a key location of the pilot's action.

Interactions with other actions and pilots

Actions A2.1 and A2.2 are complementary and support each other to achieve the optimization of the experimental smart-grid in Mercamadrid. Action A2.1 provides the necessary infrastructure, while A2.2 ensures that this infrastructure is used as effectively as possible, creating a robust and resilient energy system.

The relationship between both actions is detailed as follows:

- Common objective: Both actions pursue the goal of maximizing the use of renewable energy and improving the efficiency of the energy system. A2.1 focuses on the installation of generation and charging infrastructure (photovoltaic panels and V2G chargers), while A2.2 aims to actively manage this infrastructure by implementing a management system that ensures efficient use of the network.
- Interaction between components: A2.1 installs the physical components (solar panels, V2G chargers), and A2.2 utilizes a digital system (digital twins and network management) to monitor and manage these components. The information gathered from network management can influence how the chargers operate and how the energy generated by the photovoltaic plant is utilized.
- Network Flexibility: A2.2 deals with managing the flexibility of the network, avoiding bottlenecks and ensuring that the charging capacity of the infrastructure installed in A2.1 is fully utilized. This includes the implementation of demand response methodologies that will optimize how and when energy is charged based on supply and demand.

Monitoring and performance evaluation: The active management of the network, as proposed in A2.2, will allow for the collection of data on the performance of the V2G chargers and the photovoltaic panels installed in A2.1. This data will be essential for performance evaluation and optimization of the systems, as well as for making adjustments that maximize the efficiency of energy use. Additionally, Action A2.1 has multiple interactions with Pilot 1 (Autonomous vehicles within Mercamadrid for goods and people), in which ALSA, PREZERO and Madrid municipallity participate.

- Charging and Energy Infrastructure: Action 2.1 includes the installation of bidirectional V2G chargers that will charge electric vehicles and return energy to the grid when the vehicles are not in use. This is crucial for ALSA and Prezero's autonomous vehicles, as these chargers will allow efficient energy management and ensure that the vehicles are always ready to operate.
- Energy Storage: A2.1 also includes the installation of an energy storage system to store the excess energy generated by the photovoltaic plant. This stored energy will be used to power the V2G chargers when solar production is insufficient or energy demand is high. This will directly benefit ALSA and Prezero's autonomous vehicles, ensuring a constant and reliable energy source.

In summary, Action 2.1 of creating an advanced and sustainable energy infrastructure in Mercamadrid is fundamental to the success of ALSA and Prezero's tasks, as it provides the necessary charging and energy storage infrastructure to operate their autonomous vehicles efficiently and sustainably

Timeline for the deployment and operation of the action

The following timelinereflectsthe timeline for the deployment and operation of the action as today. This timeline is followed by the common actions showed in the timeline of Action 2.2 (See Section 2.2)

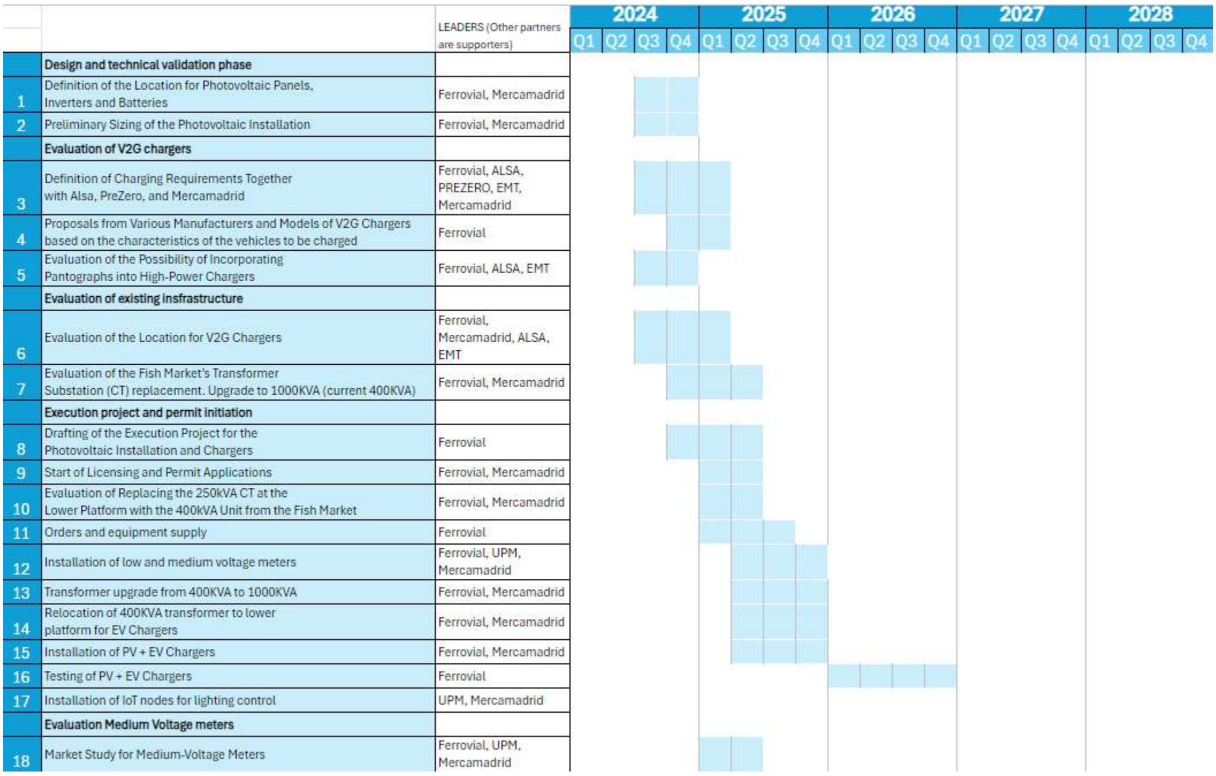

Figure 31. Smart grid for eco-transportation timeline

Initial financial considerations

The purchase costs will be mainly for the acquisition of the three elements of the action: the solar panels, the battery storage and the V2G chargers. During the initial months of the design phase of this action, quotations were requested for the materials necessary for the action. The current quotes align with the action's budget; however, purchases must be made promptly due to the volatile supply chain of energy-related systems, which can cause costs to change drastically from year to year.

The budget of the project for this action, which is an experimental pilot infrastructure, is being accurately categorized in the correct budgeting concepts (a change on accounting cathegories / budget concepts is required) in the Ferrovial's accountability system to cover the needed 70% of the costs. The remaining 30% of the action will be covered by private funding from Ferrovial.

Risks and mitigation measures

The implementation of this solution package in Mercamadrid implies certain risks that must be identified and managed effectively to ensure the viability of the project and the security of the infrastructure. The associated risks, as well as the mitigation measures to be applied, are presented below.

Table 5. Risks detected for Smart grid for eco-transportation action

Type of Risks	Risks	Mitigation Measures
Operational Risks	Interruptions in the operation of the PV plant and the V2G chargers due to technical failures or maintenance problems.	• Establishment of a preventive and corrective maintenance programme for equipment.

		• Regular training of staff to handle operational and technical emergencies.
Financial Risks	Potential for cost overruns during installation or operation.	• Preparation of a detailed and realistic budget, with a contingency margin for unforeseen events. • Constant monitoring of costs and real-time adjustments to prevent significant deviations.
Regulatory and Legal Risks	Regulatory Compliance: Changes in regulations that may affect the operation of PV plant and V2G chargers.	• Active monitoring of legislative changes and regulations in the energy sector. • Legal and regulatory advice to ensure that the installation and operation comply with all current requirements.
Environmental Risks	Environmental impact: Possible negative impacts on the local environment during the installation and operation of the photovoltaic plant.	• Pre-installation environmental impact assessments. • Implementation of sustainable practices to minimise impact during construction and operation.

4.3.6. ACTION 2.2 (PILOT 2): DIGITAL TWIN AND POWER GRID MANAGEMENT FOR FLEXIBILITY

Short description of the action and goal

As previously explained, this action is complimentary of Action 2.1 as here in Action 2.2, the digital twin platform will be deployed to analyse the impact of the new capacities (PV generation, energy storage and chargers) of the Mercamadrid network described in the previous section. Specifically this action will involve integrating data from meters and considering various operational scenarios to perform simulations to identify potential bottlenecks within the grid and explore strategies to enhance the performance of the grid. Additionally, it will also assess the operation, planning and flexibility conditions of the network.

Technical specifications of the action to implement and operational aspects

The digital-twin system will consist in a cloud platform that the users can access via web by means of given credentials. The platform integrates with the systems providing information from Smart meters, SCADA, GIS/NIS and ERP (Enterprise Resource Planning) into a unified data model. The unified data model is based on a Graph Database (GDB) scheme that optimizes data query petitions.

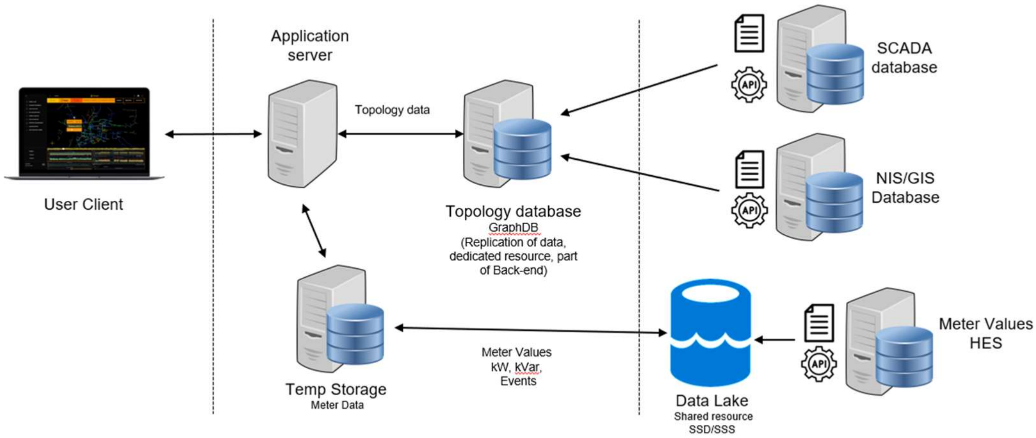

Figure 32. Data sources for Digital-Twin

Action deployment requirements

It is worth to recall that development will be done with high security focus and risk assessments, with a cybersecurity by design approach. In addition, the platform is to be hosted on servers located in a European state member to ensure that data management complies with European Union regulations on data privacy. Additionally, all data (including personal data only if necessary) from clients is not used anywhere outside the mentioned platform, in full compliance with GDPR.

Partnerships

- Plexigrid will lead the implementation of the digital-twin
- Mercamadrid will deploy energy meters and power transformer upgrades on its electrical network, provides meters data and planning scenarios
- Ferrovial will provide meters data related to PV generation, energy storage systems and chargers
- UPM will provide energy data about the lighting system, other meters and integrates data in a hub that will feed the digital-twin.
- T-SYSTEMS to create the Data Space Ecosystem that will use data from this solution.

Co-design process

A joint collaboration among partners from Madrid ecosystem has been produced for the identification of needs and requirements of this action and this collaboration will continue during the next months to concretize pending issues.

Initial financial considerations

Once the aforementioned data is available to feed the digital twin, future expenses are expected to occur regarding the deployment of servers, databases, monitoring and security tools, as well as the utilization of software licenses and other related costs. These financial considerations will be monitored and detailed as the project progresses.

Timeline for the deployment and operation of the action

It can be seen below the agreed planning among the partners linked to the action:

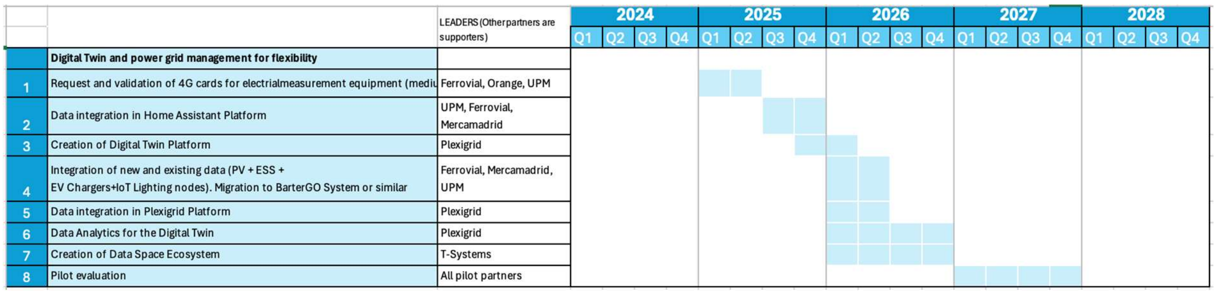

Figure 33. Digital-Twin timeline

Risks and mitigation measures

Once the plan has been stated, it is expected with the partners to perform risk assessment sessions to cope with possible risks materialization in a suitable manner. Nonetheless, below there is an initial risk identification and mitigation that will be further discussed and grounded.

Table 6. Risks detected for Digital-Twin action

Risk	Mitigation meaure
Permits and Licenses delays	Start process early, maintain regular communication with authorities
Transformer Upgrade and relocation delays	Coordinate with suppliers, engage experienced contractors
Data Integration and System Migration Issues	Test migration, use backups, ensure strong team coordination
4G Cards Connectivity Issues	Test 4G cards, secure reliable network providers, have backup options
Digital Twin and Data Quality Issues	Ensure data quality, perform iterative testing and validation
Pilot evaluation challenges when testing	Conduct thorough testing, provide user support, have contingency plans

4.3.7. ACTION 3.1 (PILOT 3): ELECTRIFICATION OF 329 E-BUSES AND FULL ELECTRIFICATION OF CARABANCHEL BUS DEPOT

Short description of the action and goal

The first action of Pilot 3 relates to the full electrification of Carabanchel Bus Depot, which implies adding 329 e-buses more to the existing e-bus fleet that already operates from there. This bus depot (1 of the 5 that EMT owns around the city) is located very close to Mercamadrid. The full electrification will be carried out by using EMT own funds. MOBILITIES FOR EU will help with the impact analysis on emissions reduction at city level due to the implementation of charging infrastructure (by deploying the phase IV of the charging infrastructure with 60 new inverted pantographs) together with the analysis to evaluate the environmental impact of switching 329 buses of the current fleet to electric buses.

EMT Madrid is fully committed to push harder on electrification towards the target of reaching 100% electrified fleet by 2030 (at the moment of preparing the current deliverable electrification accounts around 17%). Since December 2022, 100% of EMT Madrid fleet is considered green according to the European Clean Vehicles Directive (meaning, running on CNG and electricity). The integration of electric buses is a critical part of EMT Madrid's strategy to reduce greenhouse gas emissions and improve air quality in the city. The electric buses, powered by lithium-ion batteries, offer zero-emission transport, contributing to a substantial reduction in urban pollution.

Technical specifications of the action to implement and operational aspects

Technical Specifications of the charging infrastructure deployment are described below.

- **Charging System**: Inverted pantograph system for automated and efficient charging.
- **Charger Capacity**:
  - 100 kW standard for most vehicles, expandable to 450 kW for future requirements.
  - Simultaneous multi-vehicle charging capability (e.g., 120 kW for three buses or 360 kW for a single bus).
- **Energy Source**: Integration of photovoltaic installations supplying 10% of depot energy demand (e.g., 613 panels, 300 kW capacity).
- **Transformer Substations**:
  - For the installation of the 60 pantographs are two transformer substations with two trafos (of 1.6 MVA) ▶ 2x2x1.6 MVA = 6.4 MVA
- **Smart Charging System**:
  - Optimizes charging schedules and minimizes costs.
  - Uses data-driven algorithms for operational efficiency.
- **Communication and Automation**:
  - WiFi-connected pantographs enable remote operation and monitoring.
  - Prepares vehicles overnight for maximum readiness.
- **Safety Measures**:
  - Includes thermographic cameras, gas detection, and automated fire extinguishing systems.

Operational aspects of the action:

- **Charging Schedule**:
  - Nighttime charging to ensure 100% readiness for next-day operations.
  - Automated processes to eliminate manual intervention.
- **Energy Efficiency**:
  - Use of smart grid technologies to manage load and optimize grid interaction.
  - Photovoltaic installations integrated to minimize dependency on external energy.
- **Fleet Management**:
  - Purchase of the articulated e-buses.
  - Supports up to the whole electrified fleet and charging infrastructure.
  - Compatible with all bus manufacturers due to standardized solutions.
- **Scalability and Flexibility**:
  - Chargers designed for future power upgrades to accommodate evolving fleet needs.
  - Modular infrastructure that can be expanded as fleet size increases.
- **Environmental Sustainability**:

  - Renewable energy usage through dedicated solar installations.
  - Reduced energy loss due to efficient design and operations.
- **Workforce Adaptation**:
  - Training programs to ensure depot staff are skilled in operating and maintaining electric vehicle infrastructure.

Action deployment requirements

Electrifying a bus fleet is much more than just buying electric buses. The most challenging aspect is how to deal with the charging of them. That is the reason why EMT is innovating in the infrastructure side, to ensure reliable, safe and optimize charging.

The Carabanchel bus depot is the EMT Madrid flagship in terms of electrification, and has been undergoing a process of complete transformation as set out in the municipal company's Strategic Plan. Divided into four phases, the operations centre aspires, with this process, to position itself as a benchmark for electrified infrastructures that place sustainability at the heart of its operations.

The first phase, carried out between 2018 and 2022, laid the *foundations for the electrification project* by incorporating an initial electric charging solution: 100-120 kW chargers (25 minibus chargers per plug and 65 cable chargers). Since then, EMT has been testing almost every charging solution in the market, including inductive charging, and after a thorough analysis of the pros and cons of each system as well as the operational requirements of the company, the decision is based on:

- DC chargers and inverted pantographs.
- Night charging in bus depots.
- Adopting smart grid technology to optimize energy consumption.

This approach, based on overnight charging at bus depots by using inverted pantograph chargers, allows for quick charging, ensuring minimal downtime for buses and maintaining service efficiency, and also improving safety from the perspective of EMT Madrid employees, setting the most optimal and flexible model for the electrification of 100% of the fleet in the following years.

The list of strengths of this technology is remarkably long; however, one of the biggest advantages of inverted pantographs is that they are universal, requiring only a couple of connecting rods to be installed on top of buses. Thus, it enables a full decoupling of charging infrastructure and buses, allowing the implementation of new operating models. The transfer of the pantograph from the vehicle to the tank represents a significant saving in weight in buses, which translates into better energy consumption. Since the weight of the pantograph is no longer a penalty, they can be designed to be stronger and larger if required.

Subsequently, in February 2023, the second phase was launched, consisting of the commissioning of the first inverted pantograph charging station, which has 52 charging points at 100 kW, together with a powerful photovoltaic installation that will guarantee the supply of 10 % of the charging station's energy for the management of a constantly growing fleet of electric buses.

Figure 34. View of the first 52 inverted pantographs charging infrastructure for e-buses in Carabanchel bus depot (Phase II)

To cope with grid supply, it is necessary to seek the non-captivity of the system, by means of an intelligent charge management system so that all buses with night charging can be 100% available for their operation the next day at the lowest electricity cost.

The new intelligent electric charging systems using an inverted pantograph allow buses to be charged without the intervention of operators or waiting time for the driver, which can be done at the beginning or end of the working day. The system is designed to charge each vehicle in the most versatile way possible, without affecting battery life and optimising the costs associated with the entire operation. The pantographs, connected by wifi with the vehicles, work at a power of 100 kW, which means that the maximum charging time for each bus is between two and three hours. In addition, they would be technically prepared to work, in the future, at a maximum power of 450 kW.

These automated charging solutions are associated with additional installations such as the photovoltaic plant with 613 panels with an installed power of 300 kW, capable of producing approximately 44.5 MWh/year, of which a minimum self-consumption of 90 % is foreseen. This represents at least 10 % of the total energy demand foreseen for this facility. In addition, the infrastructure has a Distribution Centre and a Transformer Substation with different installed power, which are necessary for its operation.

Following this approach, the third phase was deployed in March 2024, which supplies 118 additional e-buses. Developed over a surface area of approximately 221x25 metres, the infrastructure is divided into three levels: at ground level is the canopy that covers the installation, and from which hang the pantographs, the mechanical arms responsible for carrying out the automated recharging process in the vehicles. The canopy also allows for better maintenance of the vehicles, avoiding their direct exposure to inclement weather and thus resulting in less deterioration of the buses.

Figure 35. Aerial view of Carabanchel bus depot with the different electrification phases

With access from the ground via a central pedestrian walkway, two underground transformer substations have been installed in the area of the bus shelter to serve the new chargers. These transformer substations will house two transformers with a total installed power of 10 MVA.

On the next level, located in the structure of the canopy, at a height of approximately 6.5 metres, is the technical corridor where the chargers that supply the energy to the pantographs are located and from where their maintenance and control is carried out. A total of 40 chargers with 360 kW of electrical power have been installed, which can supply a maximum power of 360 kW to a single pantograph - allowing a complete recharge of a bus in just 1 hour - or 120 kW to three pantographs simultaneously - with 3 hours of charging for each bus.

In the side areas there are two large roofs measuring approximately 221x10 metres and, in the upper part of the technical corridor, there is a photovoltaic roof equipped with 1,055 panels that minimise the energy demand of the infrastructure: this photovoltaic installation covers 10 % of the energy required. In addition, all the panels, which are connected in series forming rows, are equipped with PERC technology (a reflective layer to make the most of the radiation) and have an output of 660 Watts peak (Wp) each. The estimated energy output of this installation is 924.6 MWh/year.

All the installations, including the photovoltaic roof, have the capacity to be monitored, which will enable the charging station to be operated using a Smart Charging system, i.e. enabling charging decisions to be determined on the basis of algorithms that establish the service needs.

Last but not least, both charging stations (the 52 and 118 inverted pantographs) have an innovative fire protection system, gas detection systems, thermographic cameras, and extinguishing systems based on water plus encapsulating additive through sprinklers. This set of resources makes it possible to control an incident from the outset, as it prioritises preventive protection (thermal imaging cameras) and early detection (gas detection, even with manual activation of the system), thus facilitating faster protection and minimising possible damage.

With the fourth phase still under execution, it is expected that, when it is finished probably between the end of 2024 and the beginning of 2025, the Carabanchel bus depot will be totally electrified.

Necessary partnerships. Co-design process

- EMT Madrid as the main responsible for the implementation of the action.
- Madrid City Council as the public authority owning EMT Madrid and also financing body.
- Providers: either contractors, providers, technical assistance and support, etc.

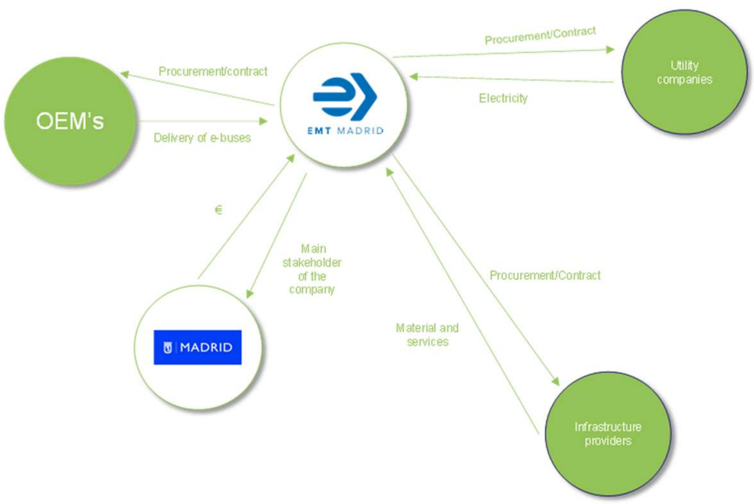

Figure 36. Stakeholders interaction maps for action 3.1 in the Madrid pilot

Timeline for the deployment and operation of the action

		LEADERS (All others are supporters)	2024				2025				2026				2027				2028			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	**Carabanchel Installation of 60 pantographs**	EMT																				
2	Design of the project	EMT																				
3	Initial Permits	EMT																				
4	Tendering of the works	EMT																				
5	Works implementation	EMT																				
6	Legal process and validation	EMT																				
7	Licenses implementation	EMT																				
8	**Acquisition of E-buses**	EMT																				

Figure 37. Bus fleet electrification (Madrid) timeline

Initial financial considerations

The action deployment is not funded by MOBILITIES for EU. The total investment for the different installations (photovoltaic panels and pantographs) has been cofinanced by the European Next Generation funds channelled through the Recovery, Transformation and Resilience Plan.

Risk and mitigation measures

Table 7. Risks detected for bus fleet electrification (Madrid)

Type of Risk	Risk	Mitigation Measures
Operational Risk	Delays in infrastructure construction causing fleet downtime	Phased deployment schedule with clear milestones and contingency planning.

	Incompatibility between buses and charging systems	Standardization of charging equipment by indicating it in the procurement processes.
	Power outages affecting charging operations	Integration of photovoltaic systems and smart grid technology to ensure reliable energy supply.
	Insufficient trained staff to manage and maintain new technology	Comprehensive workforce training programs on EV technology and maintenance.
	Limited charging capacity for expanded fleet	Scalable infrastructure designed for future power upgrades and fleet growth.
Financial Risk	Overrun of allocated budget due to unforeseen costs	Detailed cost analysis and securing diverse funding sources (e.g., EU Next Generation funds).
	High initial capital expenditure on buses and infrastructure	Leveraging public-private partnerships and innovative financing mechanisms.
	Fluctuating energy prices impacting operational costs	Installation of solar panels to reduce dependency on external energy providers.
Regulatory and Legal Risk	Non-compliance with regulations	Regular audits and alignment with legal requirements in all project phases.
	Delays in approvals for infrastructure construction	Early engagement with regulatory authorities and streamlined permitting processes.
	Incompatibility with future regulatory changes (e.g., emission standards)	Future-proofing infrastructure by adopting scalable and flexible technologies (e.g., smart chargers).

4.3.8. ACTION 3.2 (PILOT 3): INTELLIGENT SHARING OF CHARGING INFRASTRUCTURE AND ENERGY BETWEEN VEHICLES FOR THE TRANSPORT OF PEOPLE AND FREIGHT

Short description of the action and goal

As part of Pilot 3, an innovative solution will be implemented to enable intelligent sharing of charging infrastructure between ALSA and EMT transport vehicles in order to enhance interoperability and efficient use of energy resources in passenger and freight transport, promoting synergies between operators and fostering a more sustainable mobility system.

At this moment, the provider of the solution has not been decided but some potential models can be seen in figure below.

Figure 38. Intelligent sharing of charging infrastructure

Technical specifications of the action to implement and operational aspects

To achieve this, an advanced charger will be installed with the following technical specifications:

- Minimum cable length: 10 meters, with the possibility of adapting to shorter dimensions if required by environmental conditions.
- Cable cooling: Non-cooled.
- Minimum power output: 120 kW, ensuring efficient charging for both types of vehicles.
- Location: Outdoor installation, designed to withstand adverse environmental conditions.
- Connector: Combo 2 CCS type, compliant with current charging standards.
- Output voltage: 600 V DC.
- Communication capabilities: Remote and automatic transmission of charging data, optimizing monitoring and analysis processes.
- Communication protocol: Compatible with OCPP 1.6 or higher, ensuring interoperability with various charging management systems.
- Intelligent control: Smart charging system to optimize energy distribution based on demand and availability.
- Preconditioning function: Includes the ability to precondition the vehicle’s heating system during the charging process, improving operational efficiency.

Action deployment requirements

Permits and licenses required:

- Construction licenses: Municipal permits for the installation of charging points, ensuring that all installations meet local requirements.
- Interconnection permits: It will handle the necessary procedures to obtain permits for connecting the V2G chargers to Mercamadrid’s internal grid.

Tenders and contracts required:

- Tender process: It will manage the hiring of suppliers and subcontractors for the chargers, through a tender process that guarantees the best quality at the best cost.
- Maintenance: It will provide a maintenance plan for the installed experimental infrastructure, ensuring the continuity and operational efficiency of the entire system.

Regulations and certifications

The solution package will ensure compliance with all current regulations and certifications at both European and local levels. Below are the main regulatory requirements for each component:

- Bidirectional V2G Chargers:
  - Certifications: The bidirectional chargers must comply with European interoperability and safety regulations, such as the 2014/94/EU Directive on alternative fuel infrastructure, which governs the recharging infrastructure for electric vehicles.
  - Quality Standards: The chargers must meet IEC 61851 certifications, ensuring safe and efficient operation, and must be compatible with V2G communication standards (ISO 15118), allowing for the bidirectional flow of energy between the vehicles and the grid.

Necessary partnerships. Co-design process

- Mercamadrid: A Key partner in the co-design of this solution, as they own the pilot site. Constant communication and information sharing are essential. During the first months of the project, the locations for the V2G chargers were thoroughly analysed in collaboration with Mercamadrid studying their electrical diagrams and understanding their internal grid. In the coming months and throughout the project, ongoing collaboration will be necessary for permitting and certifications, finalizing the location of the V2G charges (in co-design as well with Alsa and EMT).

- ALSA & EMT: Key partner in the definition of the V2G charger that will be dedicated to their autonomous bus. During these last months the V2G charger dedicated to them has been co-designed with Alsa to adapt to the power, capacity and technical specifications of their pilot vehicle. Constant collaboration will be necessary to ensure a correct placement installation along with Mercamadrid, and to ensure vehicle's proper charging capabilities. It was recently requested that this charger also work with EMT buses. The feasibility of this will be analyzed in the coming months and, if possible, the charger should be re-defined and co-designed in collaboration with Alsa and EMT.

Timeline for the deployment and operation of the action

		LEADERS (Other partners are supporters)	2024				2025				2026				2027				2028			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Evaluation of V2G chargers																					
1	Definition of Charging Requirements Together with Alsa and Mercamadrid	Ferrovial, ALSA, EMT, Mercamadrid																				
4	Proposals from Various Manufacturers and Models of V2G Chargers based on the characteristics of the vehicles to be charged	Ferrovial																				
5	Evaluation of the Possibility of Incorporating Pantographs into High-Power Chargers	Ferrovial, ALSA, EMT																				
	Evaluation of existing insfrastructure																					
6	Evaluation of the Location for V2G Chargers	Ferrovial, Mercamadrid, ALSA, EMT																				
	Execution project and permit initiation																					
8	Drafting of the Execution Project for the chargers	Ferrovial																				
9	Start of Licensing and Permit Applications	Ferrovial, Mercamadrid																				
11	Orders and equipment supply	Ferrovial																				
14	Relocation of 400KVA transformer to lower platform for EV Chargers	Ferrovial, Mercamadrid																				
15	Installation of EV Chargers	Ferrovial, Mercamadrid																				
16	Testing of EV Chargers	Ferrovial																				

Figure 39. Intelligent sharing of charging infrastructure timeline

Initial financial considerations

The action deployment will suppose the purchase of the intelligent charging infrastructure.

Risk and mitigation measures

Table 8. Risks detected for Intelligent sharing of charging infrastructure

Type of Risks	Risks	Mitigation Measures
Operational Risks	Interruptions in the operation of the V2G chargers due to technical failures or maintenance problems.	• Establishment of a preventive and corrective maintenance programme for equipment. • Regular training of staff to handle operational and technical emergencies.
Financial Risks	Potential for cost overruns during installation or operation.	• Preparation of a detailed and realistic budget, with a contingency margin for unforeseen events.

		• Constant monitoring of costs and real-time adjustments to prevent significant deviations.
Regulatory and Legal Risks	Regulatory Compliance: Changes in regulations that may affect the operation of V2G chargers.	• Active monitoring of legislative changes and regulations in the energy sector. • Legal and regulatory advice to ensure that the installation and operation comply with all current requirements.

Interactions with other actions and pilots

Action A3.2 interacts with Pilot 1 (Autonomous vehicles within mercamadrid for people), in which ALSA and EMT participate. Action 3.2 includes the installation of bidirectional V2G chargers that will not only charge electric vehicles but also return energy to the grid when the vehicles are not in use. This is crucial for ALSA and EMT autonomous vehicles, as these chargers will allow efficient energy management and ensure that the vehicles are always ready to operate.

4.3.9. ACTION 4.1 (PILOT 4): IMPLEMENTATION OF H_2 REFUELING STATION AND 10 H_2 FUEL CELL BUSES

Short description of the action and goal

The pilot 4 consists in the deployment of one Green H_2 Refuelling Station for refuelling services to buses and the operation of 10 H_2 fuel cell buses in the Entrevías bus depot of EMT (funded by their own investment plans). MOBILITIES will analyse the impact on emission reduction at city level and will evaluate the environmental impact of these very innovative infrastructure and vehicles, also through a life cycle assessment. The measure involves the commissioning of the necessary facilities for the production (by using photovoltaic panels), storage and distribution of green hydrogen.

Technical specifications of the action to implement and operational aspects

The main features of the action are detailed below:

- Hydrogen Production: Proton exchange membrane (PEM) electrolysis system.
- Energy Source: Solar power from 2,780 photovoltaic panels (up to 1.6 MWh).
- Storage: Hydrogen tanks at low and high pressure for flexible supply.
- Compression System: High-pressure compressors for efficient hydrogen handling.
- Dispensing Units: Hydrogen refueling dispensers for quick bus servicing.
- Fleet Support: Infrastructure for 10 hydrogen-powered buses.

Building works have been underway since December 2022 on a surface area of 49,618 m². The Green hydrogen production plant is already supplying the first buses of the Portuguese manufacturer CaetanoBus. This facility produces hydrogen from a water electrolysis process, developed entirely by Spanish companies and whose design, construction and management has been the responsibility of EMT Madrid.

The installation has the following components of national manufacture: a PEM technology electrolyser capable of producing around 18 kg of hydrogen per hour, two compressors, three storage tanks at low, medium and high pressure and two pumps for refuelling the buses. The filling pressure of the green hydrogen tanks is 350 bar, 75 % higher than the pressure of compressed natural gas (CNG) compressors.

In parallel and in order to be able to inject sufficient energy into the hydrogen plant, the project foresees the installation of a total of 2,780 photovoltaic panels distributed on three jetties. The photovoltaic roof generates a maximum power of 1.6 MWh, 550 kW per panel.

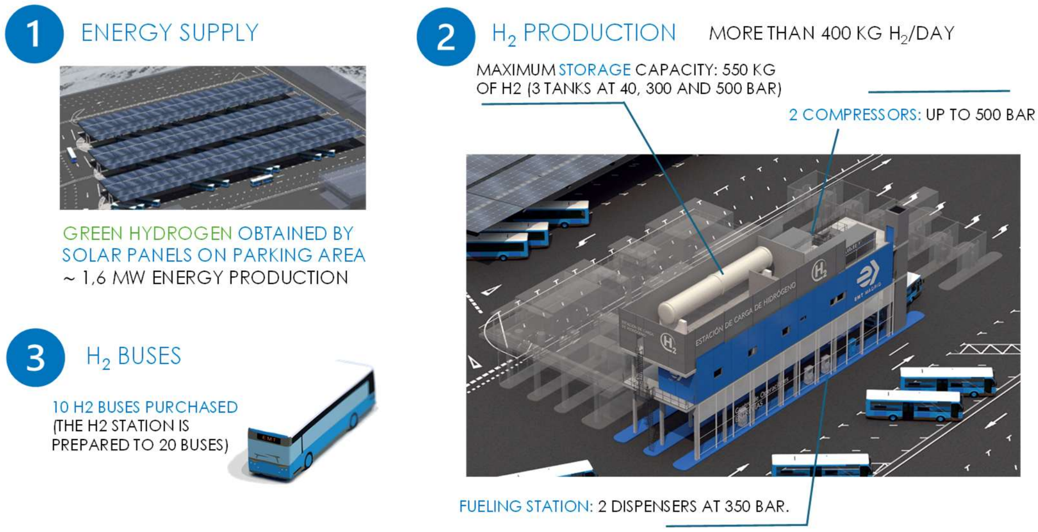

Figure 40. Scheme of the Green Hydrogen plant at Entrevías bus depot

Tresca Ingeniería is the firm awarded the tender for the development of the preliminary project, as well as having carried out consultancy and project management work. The drafting and execution of the project have been awarded to the ENTREVÍAS joint venture, formed by SERVEO SERVICIOS S.A.U. and ALYON SERVICIOS S.A.

The Green Hydrogen fueling station was inaugurated by Madrid Mayor last November 18th, 2024.

Figure 41. View of the Green Hydrogen plant at Entrevías bus depot

Necessary partnerships. Co-design process

- EMT Madrid: as the main responsible of the implementation of the action.
- Madrid City Council: as the public authority owning EMT Madrid and also financing body.
- Providers: either contractors, providers, technical assistance and support, etc.

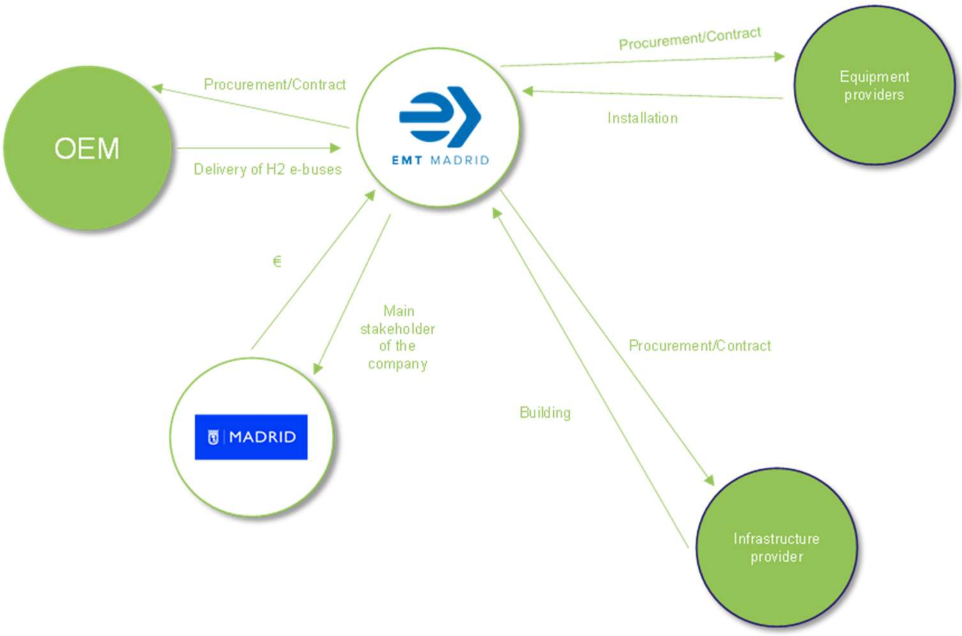

Figure 42. Stakeholders interaction maps for action 4.1 in the Madrid pilot

Timeline for the deployment and operation of the action

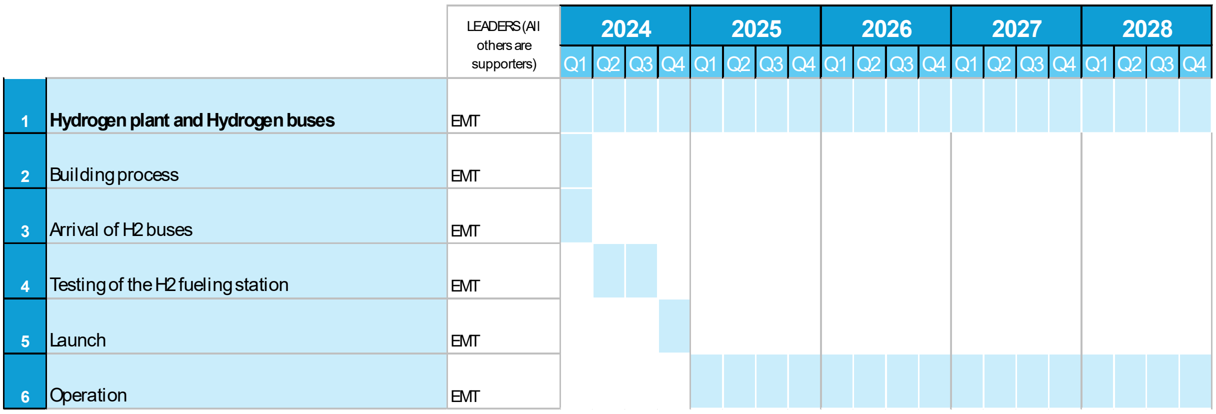

Figure 43. H_2 refuelling station and fuel cell buses timeline

Initial financial considerations

The action deployment is not funded by MOBILITIES for EU. The cost of the work has been cofinanced by the European Regional Development Fund (ERDF), and the acquisition of the first 10 H_2 buses has been cofinanced by European Next Generation funds through the Recovery, Transformation and Resilience Plan.

Risk and mitigation measures

Table 9. Risks detected for H_2 refuelling station and fuel cell buses

Type of Risk	Risk	Mitigation Measures
Operational Risk	Delays in construction of the hydrogen plant leading to fleet downtime	Develop a detailed project timeline with buffer periods and contingency plans.
	Insufficient hydrogen production capacity for fleet operations	Design scalable production systems to accommodate future demand increases, and considering external supply via trailers, injecting H_2 directly.
	Technical failure in hydrogen production or storage systems	Regular maintenance schedules and implementation of redundant critical systems.
	Lack of trained personnel for operating hydrogen technology	Maintenance and operation is subcontracted to a expert and specialized company.
	Safety risks associated with hydrogen handling and storage	Implement robust safety protocols, gas detection systems, and regular safety drills.
Financial Risk	High capital expenditure for plant construction and hydrogen bus acquisition	Seek co-financing opportunities, including EU funds and public-private partnerships.
	Unpredictable operational costs due to fluctuating energy or hydrogen production costs	Integrate renewable energy (e.g., on-site photovoltaic panels) to stabilize energy costs.
	Risk of underutilization of hydrogen plant, increasing cost per unit of hydrogen	Plan for phased fleet expansion to ensure optimal plant utilization over time.
Regulatory and Legal Risk	Non-compliance with hydrogen safety and environmental standards	Engage early with regulatory bodies to ensure design and operations meet all legal requirements.
	Delays in obtaining permits for construction and operation of the plant	Proactively address regulatory requirements and streamline approval processes through consultations.
	Future regulatory changes affecting hydrogen production or usage	Adopt flexible and modular plant design that can accommodate evolving regulations and technologies.

4.3.10. ACTION 5.1 (PILOT 5): GREEN ENERGY DATA SPACE IN MOBILITY FOR THE DECARBONIZATION OF MADRID AND OTHER CITIES

Short description of the action and goal

A data space will be developed for a set of mobility solutions for people, businesses and goods in the Madrid ecosystem, exploiting the combined potential of electrification, automation and connectivity. If the action is succeeded, it can explore its scale-up and replication by adding new solutions and other areas from the city of Madrid and other European cities.

The main purpose of the data space is to promote the use of green energy and improve mobility in the Madrid ecosystem in order to optimize and rationalize the energy use in mobility and minimize the impact on air quality.

Specifically the action intends to:

- Deploy an energy and mobility data space by integrating real-time information about the energy and transport use in Madrid ecosystem. It will facilitate the decision making through objective data and it will help to optimize the resources (energy and space in an urban environment).
- Offering new value services for people and businesses that can use the gathered data.

- Reducing CO_2 emissions in transport by adopting clean energy solutions and promoting sustainability in urban transport.

Main requirements for the desired data space

The mobility and energy data space platform will be deployed as a modular and open based system that integrates different sources of mobility and energy information. It must also ensure compliance with certain regulations, laws, contracts and recommendations of the European Union, such as:

- Interoperability framework & AI ACT
- Data Act & Data Governance
- Privacy: General Data Protection Regulation (GDPR)
- Environmental Social Governance (ESG) values: Green Deal
- Agreements between the parties involved in the data space ecosystem (smart contracts).
- IDSA and GAIA-X compliance

Additionally, as technical requirements, the data space must meet the following requirements:

- Cybersecurity and identity management: based in Self-sovereign Identity (SSI) for decentralized identifications to guarantee the security and trust of the platform (identification, authentication, and authorization).
- Interoperability of the data and the platform through an open connector based on Eclipse, which must offer several standard market options for connecting the most used systems (API-REST, web services…).
- The platform must guarantee the agreement between parties in the use of the data catalogues.
- The platform must be portable, scalable, and replicable.
- Traceable and transparency in the data mechanisms.
- Highly intuitive and friendly user interface.
- The data space does not store or retains any kind of data and must guarantee the sovereignty of the data and the information of the shared data catalogues of every member of the data space.
- Agnostic cloud, preferable for this action in AZURE, in the EU region.

All previous points will be the main technical and functional considerations to take into account when we implement the data space in the Madrid ecosystem, and it to be considered a data space by the European Union.

The platform to be deployed in the Madrid ecosystem as a data space will be based on the Data Intelligent Hub (DIH), which is the T-Systems solution for data spaces platforms. The DIH must be deployed, configured, and aligned with the needs of the MOBILITIES FOR EU project regarding to energy and mobility solutions and the possibilities that the rest of the stakeholders can offer to the ecosystem in terms of data and tentative high value services discovered. Figure below shows the functioning of a data space ecosystem and an example of the DIH solution, provided by T-Systems International, which is probably going to be used as the basis for the MOBILITIES FOR EU data space in Madrid.

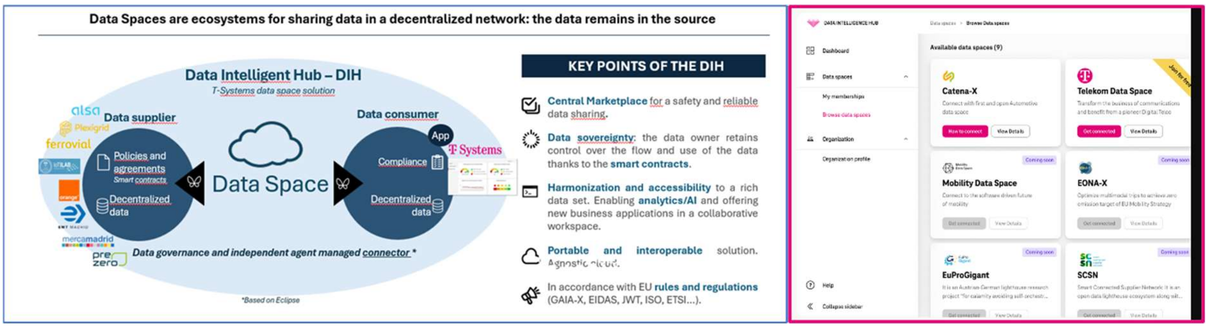

Figure 44. Data space functionalities and DIH

At the same time, the data space, as a platform that will centralize the information of the Madrid ecosystem will provide a dashboard of the overall status of energy and mobility use. There are many possibilities, and it is needed to work with the rest of the stakeholders to see the data catalogues to be shared and the KPIs to be tracked. The main technologies that it are planned are based on Microsoft PowerBI or in Aero (it is a specific dashboard suite for smart cities that also let visualize the status of sensors, smart grids, vehicles in mobility). At this point it is a case of study to be assessed during the project. Below, some examples of dashboards that can implement (1) in PowerBI or (2) in Aero are presented.

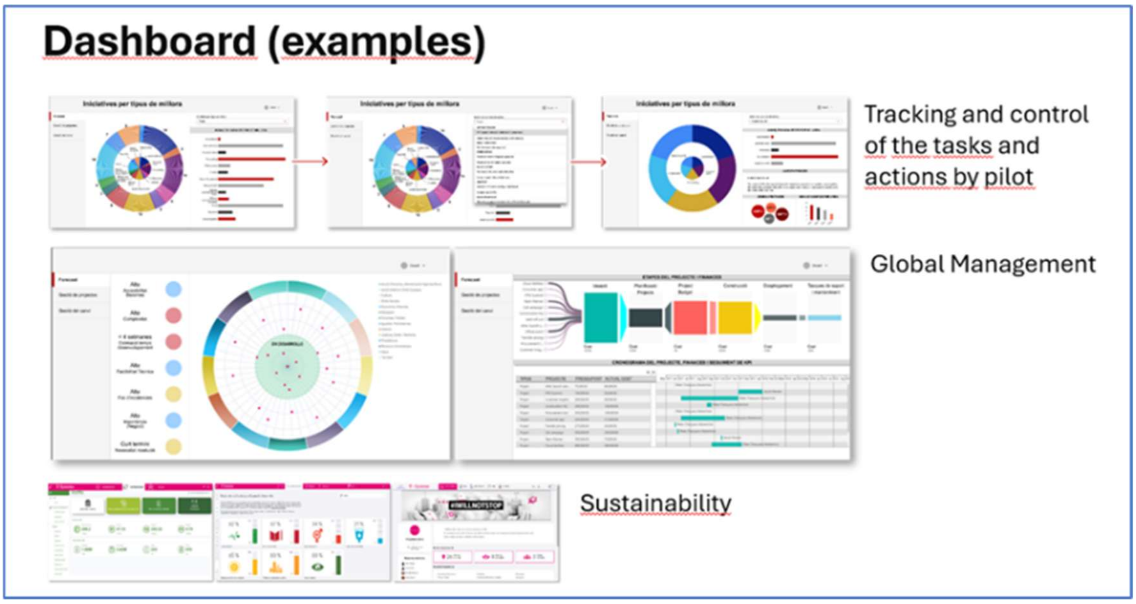

Figure 45. Data space dasboards examples

Partnerships

The main data providers in the mobility and energy data space platform:

- Prezero, Alsa and EMT: Data providers related to the transport of people and goods, contributing to urban transport management and route optimization.
- Plexigrid and Ferrovial: Providers of energy and energy consumption data in real time.
- Orange: Providers of real-time connectivity data for autonomous vehicles.
- Mercamadrid: Provider of logistics and goods data.
- IoTLAB and UPM: Providers of data related to sensors and signage in an urban environment.
- Madrid City Council: Provider of regulatory data, standards regarding sustainability, mobility and energy efficiency.
- Other data sources: external data providers and other open data sources to enrich the set of data.

Co-design process: Open innovation sessions for discovering and exploring high value services

The deployment of high-value services requires the collaboration across all the involved stakeholders in the Madrid ecosystems. Design Thinking methodologies will be used to involve stakeholders in identifying data needs and jointly defining the high value services. This collaborative approach will ensure that solutions are aligned with end-user expectations and needs. Once selected the use cases, it will design technically, develop and implement them over the data space and shared with the citizens or the companies for which they have been designed.

It has identified at least three main groups to do the open innovation sessions:

- Group 1: MOBILITIES FOR EU team in the Madrid ecosystem (Prezero, Ferrovial, Orange, ALSA).

- Group 2: Mercamadrid and companies in the logistic area.
- Group 3: Madrid City Council, EMT and maybe other external organisations in mobility.

An example of one of the open innovation sessions done based on a co-design process follows in figure below.

Figure 46. Co-design process for Data Space

As a result of this process already started some ideas of services have been defined but at this moment are not considered as definitive.

Timeline for the deployment and operation of the action

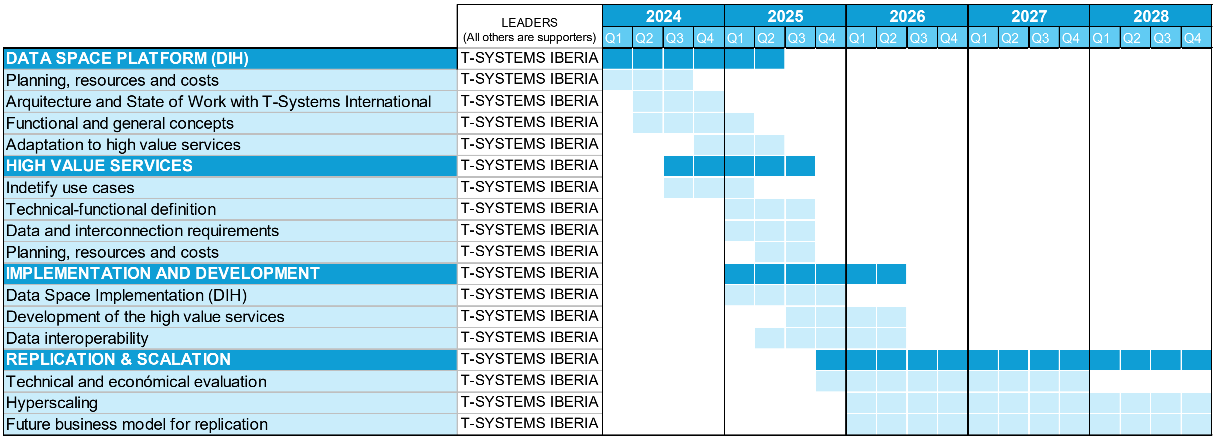

Figure 47. Data Space (Madrid) timeline

Initial financial considerations

An initial economic viability of the action and the costs associated to the project are described below.

Investment cost

The initial elements of investment for the development of the data space platform and the high-value services are as follows:

- Software and hardware licenses for the data space and high-value services.
- Software development.
- Purchase of hardware.

Running costs

The maximum desirable running costs of the solution, to assess the economic viability at the end of the project, are estimated at between 10% and 20% of the total investment of the project. The main activities in this sense are as follows:

- Technical support to ensure that the solution works correctly during the lifecycle.
- Software updates and evolutions to keep applications up to date with the latest technologies, functionalities, and security standards.
- Hardware and software maintenance in order to replacement and fix those technological elements that may fail or become obsolete.

Replication

Once the solution is technically and economically validated, the following aspects will be evaluated:

- Agreements for accessing to data as a consumer and provider.
- Access to sandbox to create new high-value services by third parties.
- Hyperscaling the solution to replicate technological solutions in other cities as a cloud service.
- Business model for replication in other cities.

Risks and mitigation measures

The main risks associated with this action are identified below:

Table 10. Data Space Madrid risks and mitigation measures

Risk	Description	Mitigation Plan
DIH architecture not in line with needs	The DIH architecture does not fit the needs of the project/pilot	Continuous evaluation. Design flexibility. Consultation with stakeholders
Excesive DIH costs	DIH costs may exceed the budget affecting the economic sustainability of the project	Implement a reduced version of the DIH. Reduceoptimization. ROI assessment. Evaluate budget.
Restricted access to the use case data or poor quality of data	Stakeholders' refusal to share deata can hinderthe implementation of high-value solutions	Establish collaboration agreements. Disclose the importance of data in the ecosystem. Implement security and privacy protocols. Implement a data governance model
Costs of high-value services	Development costs for high-value solutions exceed budgets	Implement services with less ambitious functionality. Development in phases. Market analysis to prioritize solutions.

Below it can be seen the typology of the identified risks in a matrix impact vs probability. At this point, none of them are affecting to the project.

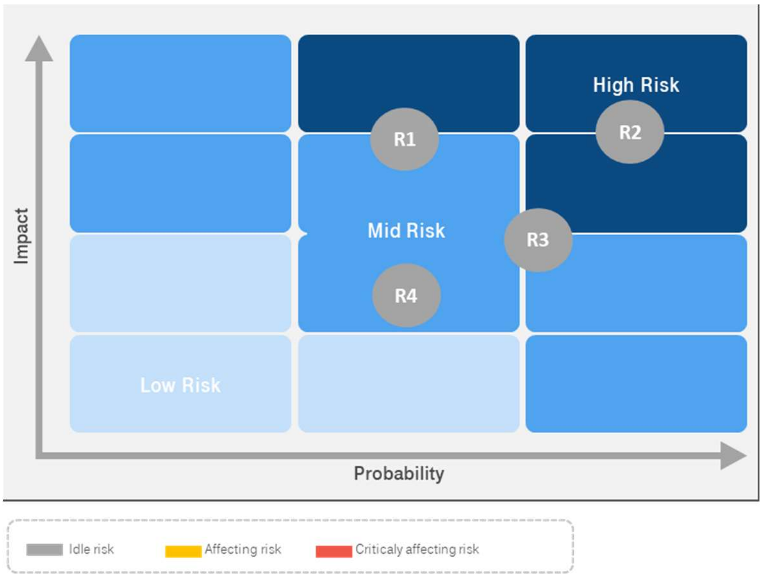

Figure 48. Data Space (Madrid) risks impacts

5. MOBILITIES FOR EU pilots and actions in Dresden

5.1. The city of Dresden

Dresden, located in Germany, is the capital of Saxony and a major urban center in eastern Germany, with an approximate population of 560,000 (as of 2021). Located in the picturesque Elbe Valley, Dresden is renowned for its stunning landscapes and rich cultural heritage. As a center for innovation, technology, and science, the city of Dresden has been at the forefront of dynamic development in recent years. This growth has not only enhanced the urban landscape but also increased traffic demands.

The city faces several environmental and mobility challenges. Air quality issues, particularly during peak traffic periods, highlight the need for improved parking management and measures to alleviate congestion. Dresden is actively working to increase the use of sustainable transportation modes, aiming to lower its CO_2 emissions and pollutant levels in line with European Green Deal targets.

As a designated European city mission, Dresden has set an ambitious target to achieve climate neutrality by 2030. This commitment is reflected in Dresden's comprehensive “Mobility in Dresden 2030” plan, which outlines key measures to support sustainable urban development. The plan includes the expansion of public transport, enhancement of cycling infrastructure, promotion of pedestrianization, and initiatives to encourage the adoption of electric vehicles. These efforts underscore Dresden’s dedication to building a more sustainable and livable city, positioning it at the forefront of urban climate action in Europe.

Dresden, as a Lead City in the MOBILITIES FOR EU project, is implementing innovative mobility solutions in the Ostra area to demonstrate cost-effective and feasible approaches to urban climate-neutrality. The project aligns with Dresden's "Mobility Plan 2030" (SUMP), focusing on sustainable transportation, improved air quality, and reduced congestion through electrification, automation, and connectivity.

5.2. Overview of the demo area

The Ostra district is located in an Elbe bend to the north-west of the city centre, in northern Friedrichstadt and has the character of a peninsula. The area is crossed by the flood channel and is designated as a flood zone. It is bordered by the B6 federal road, which is overloaded on normal working days, and by the Marienbrücke and Flügelwegbrücke bridges, which are also overloaded at peak times. In the area of stationary traffic, there are several unmanaged car parks, some of which are equipped with parking guidance systems. The greatest demand for parking is during sporting events and when congresses, trade fairs and sporting events overlap, which leads to chaotic parking situations and heavy tailbacks.

The Ostra area was selected as the demo area due to its significance as a touristic and event center, presenting unique mobility challenges during sports events and fairs. The area can be split in two zones (A and B) which are described below. Zone A includes the sports arenas like Heinz-Steyer stadion, with a capacity of 15.000 spectators/seats, JoyNext Arena, with a capacity of 5.000 spectators/seats or the Ballsport arena, with a capacity for 3.000 spectators/seats. More sports facilities can be found, like Dynamo Dresden youth academy, and multiple sport clubs and sport facilities (e.g: football, tennis, ice skating, basketball, volleyball, rugby, cricket, parkour, etc.). Zone B includes facilities of Dresden Fair (capacity for concerts up to 12.000 people, capacity for congresses up to 10.000 people, 23.000 m² halls, 13.500 m² open air, 2.500 parking spaces or 8,6 ha Open-Air-Event Facility RINNE). Public

Figure 49. Location of Ostra district (Dresden)

companies owned by the Municipality (Dresden Messe, the public Transport operator DVB) will participate in the pilots via the Municipality (even co-funding externally via public procurement procedures). Private companies based in the zone (NVIDIA, Vodafone) have signed LoI to support technologically the interventions.

Public transport in the Ostragehege is represented by tram line 10, which connects the area with the main railway station, but only indirectly with the city centre. There are four tram stops in the 3 km² Ostra district as well as a multimodal mobility point (MOBIPoint) in the southern part of the area. There is also a well-known tourist cycle route, the Elbe cycle path, which is used by many tourists at weekends and also by citizens to commute. Business travellers and tourists often visit international congresses in the IC Centre, the Dresden Trade Fair Centre or sporting events. There is no direct public transport connection to the hotels in the city centre, which leads to the use of private vehicles and traffic problems and the area counts with only one electric charging station in the Ostra district and one MOBI point on the southern edge of the district. There are no sharing options for cars, bicycles or other vehicles.

The MOBILITIES FOR EU project aims to make Ostragehege a pioneer of climate-neutral urban development. The integration of bidirectional charging stations for electric vehicles and the promotion of sustainable mobility are intended to make the area more attractive. New charging facilities, a car park guidance system and intermodal transport solutions are planned. The Heinz Steyer Stadium is also home to the OSTRA Lab, the urban mobility lab created with the workframe of MOBILITIES FOR EU, a place for interested parties to exchange ideas, share news and offer participation formats.

Figure 50. Dresden Fair (c) Landeshauptstadt Dresden / Jan Hübler

Figure 50. Ostra Area – Sports facilities (c) Landeshauptstadt Dresden / Jan Hübler

The Ostra area faces chaotic parking situations and congestion during sports events and congresses/fairs and needs a set of improvementsi:

- Enhance parking management during high-traffic events
- Reduce congestion and emissions in the area
- Increase sustainable mobility options for visitors and residents

The "MOBILITIES for EU" project is pioneering a testing ground for the mobility of the future in Dresden's Ostragehege and northern Friedrichstadt. In this versatile area, which combines sports facilities, the Flutrinne event venue and the Dresden trade fair center, the state capital is working with various partners to develop innovative solutions to improve transport and sustainability. With these measures, Dresden is taking on a leading role in urban mobility development and shaping the mobility of tomorrow. Specifically, these solutions aim to showcase how innovative mobility concepts can contribute to Dresden's transformation towards climate-neutrality while addressing specific local challenges in the Ostra area.

Solutions to demonstrate consist of:

- Smart parking management systems

- Electric vehicle and charging infrastructure
- Automated and connected mobility solutions
- Integration of public transport with event management
- Real-time traffic management using 5G technology

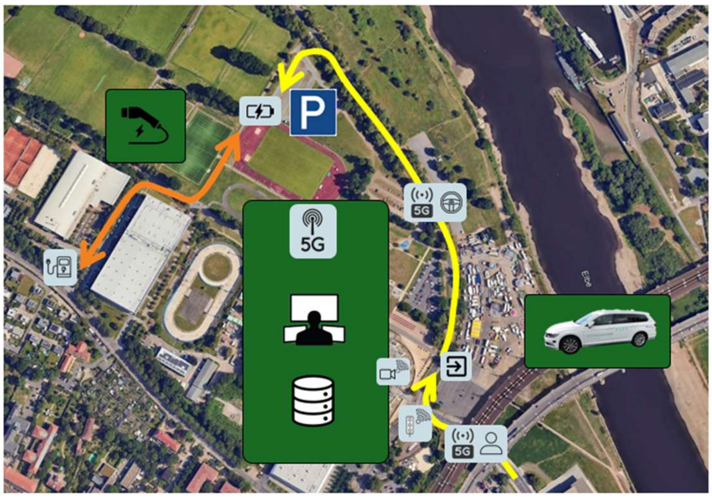

Figure 51. Location of demostrastive actions in Dresden demo area

5.3. Technical description of the pilots and actions

The MOBILITIES FOR EU project in Dresden consists of six interconnected pilots that collectively aim to enhance urban mobility and sustainability in the Ostra district.

- **Pilot 1**, led by VW, focuses on deploying autonomous charging robots for electric vehicles, which are essential for improving the infrastructure needed for electric mobility.
- **Pilot 2**, managed by Fraunhofer, establishes critical infrastructure for autonomous driving and develops a mobility data space that facilitates secure data exchange. This data space is crucial for decision makers.
- **Pilot 3** aims to optimize traffic flow and develop a comprehensive mobility concept tailored to stakeholder needs during events. This pilot also includes the feasibility study for autonomous e-vehicles for passengers and the introduction of autonomous e-vehicles for freight.
- **Pilot 4**, conducted by the City of Dresden and TU Dresden, focuses on introducing 20 e-buses and includes the design and testing of a tuneable, configurable electric vehicle with bidirectional charging capabilities.
- **Pilot 5**, driven by SAP, creates a robust platform that serves as the backbone for all other pilots, enabling seamless communication and coordination among them. This platform facilitates data sharing and service integration across all initiatives, enhancing operational efficiency.
- **Pilot 6** provides a private 5G communication network that ensures reliable connectivity for all pilots, facilitating real-time data exchange. The second part of the pilot, led by TU Dresden, enhances energy demand management and power grid flexibility, providing the necessary optimization logic for charging based on energy consumption patterns. This integration ensures that the electric vehicle infrastructure developed in Pilot 4 operates efficiently within the overall energy framework.

Together, these pilots form an interconnected framework that not only addresses immediate mobility challenges but also aligns with Dresden's long-term goals for sustainable urban development. The collaborative efforts among various partners ensure that innovative solutions are implemented effectively, showcasing Dresden's commitment to becoming a leader in smart mobility.

Table 11. List of actions per pilot in Dresden

Name of the action	Solutions	Type of solution	Pilot and name of the action
Charging robots	Autonomous e-vehicle	CCAM	Pilot 1: A1.2, A1.3, A1.4 *(DoA: same nomenclature)*
Infrastructure assistance Automated Connected Driving (Control Center)	Infrastructure assistance for communication of autonomous vehicles	CCAM connectivity	Pilot 2: A2.1 *(DoA: same nomenclature)*
Mobility Data Space for Automated Connected Driving	Mobility data space	High value / Innovative services	Pilot 2: A2.2 *(DoA: same nomenclature)*
Autonomous e-vehicles for freight	Autonomous e-vehicle for freight Smart Energy Tower as charging infrastructure	CCAM	Pilot 3: A4 *(DoA: Pilot 3. A3.1)*
Feasibility study for 2 routes for autonomous e-vehicle for passengers	Autonomous e-vehicle for passenger	CCAM	Pilot 3: A5 *(DoA: Pilot 3. A3.2)*
Mobility concept for the district with focus on intermodal mobility / bike usage	Intermodal mobility	Intermodal mobility	Pilot 3: A6 *(DoA: Pilot 3. A3.3)*
Electrification of the public bus fleet	e-buses and pantograph	2Zero	Pilot 4: A7 *(DoA: Pilot 4. A4.1)*
Bidirectional charging for cars	One tuneable/configurable e-car with bi-directional charging	2Zero RES/Power Grid	Pilot 4: A8 (DoA: Pilot 4. A4.2)
Platform for servicing events: Estimate traffic flows (predictive) to improve event management via data pooling on a platform	City service through a platform	High value / Innovative services	Pilot 5: A9 *(DoA: Pilot 5. A5.1)*
City App for services including reservations and payment	City service through a platform	High value / Innovative services	Pilot 5: A10.1 *(DoA: Pilot 5. A5.2)*
Enable City App to allow tracking of mobility capacity data and giving wayfinding guidance	City service through a platform	High value / Innovative services	Pilot 5: A10.2 *(DoA: Pilot 5. A5.1)*
Mobility monitoring via image processing and provision via platform for traffic management in Demosite district	City service through a platform	High value / Innovative services	Pilot 5: A11 *(DoA: Pilot 5. A5.3)*
5G private communication network in Ostra district	5G private communication network	CCAM connectivity	Pilot 6: A12 *(DoA: Pilot 6. A6.1)*
Slicing for use case e.g. events	5G network slicing	CCAM connectivity	Pilot 6: A13 *(DoA: Pilot 6. A6.1)*
Power grid-based optimization and control	Small-scale bidirectional charging system	RES/Power Grid	Pilot 6: A14 *(DoA: Pilot 6. A6.2)*

5.3.1. PILOT 1: CHARGING ROBOTS

Short description of the action and goal

The pilot for the autonomous charging robot involves the testing and deployment of robot prototypes designed to autonomously charge electric vehicles in the Dresden Ostragehege area. This pilot will operate at carefully selected deployment sites, which will be agreed upon in collaboration with the City of Dresden, ensuring full compliance with relevant legal requirements. For testing purposes, VWGI will provide electric vehicles, enabling the validation of the charging process in real-world conditions.

The demonstration will be done in a wide range of external conditions (i.e. confined parking garages, open parking areas), in a wide range of temperature scenarios and precipitation conditions (i.e. safe operations will be demonstrated at different times of the year) and with three different models of e-vehicles.

Figure 52. Charging robots

Technical specifications of the action to implement and operational aspects

Two types of robots will be built: an automatic charging robot and a manual charging robot. Both models will have a battery capacity of less than 25 kWh, autonomous navigation capabilities, and the ability to map the operational area. These robots will operate at Technology Readiness Level (TRL) 5. VWGI will provide three vehicles for testing and pilot operations.

The charging robot consists of a driving platform and a design structure. The assemblies are connected via mechanical and electronic interfaces. The driving platform contains the system batteries (48V and 24V), the drive motors and controllers, the steering, control electronics, four wide-angle cameras, and the 3D solid-state lidars.

In the design structure, the robot arm, the traction battery, and the charging management system are housed. Additionally, four wide-angle cameras are installed in the structure.

Using the 3D lidars, GPS, Inertial Measurement Unit (IMU), and odometry, a map of the operational area is created and stored on the control computer. Via an appropriate internet protocol, the charging robot receives the GPS position, vehicle type, license plate, and the capacity to be charged of the vehicle. The robot calculates the trajectory and moves to the GPS position. Using the integrated vehicle recognition, the vehicle to be charged is verified. The robot stops at a defined relative position to the charging flap. The cargo area flap opens, and the plug robot arm extends far enough for the vision system to measure the charging socket and send any positional adjustments to the robot control. Once the plug position is reached, the brakes are activated, and the plugging process begins.

These features will be tested to ensure the robots can perform efficiently, safely, and reliably while operating in dynamic environments. The pilot will focus on demonstrating the robot’s ability to navigate autonomously, interact with vehicles, and perform charging operations with minimal human intervention.

Real-time data from the robots will be transmitted to the cloud, allowing for performance tracking and system optimization.

The following figure shows the various components of the charging robot, especially the battery system.

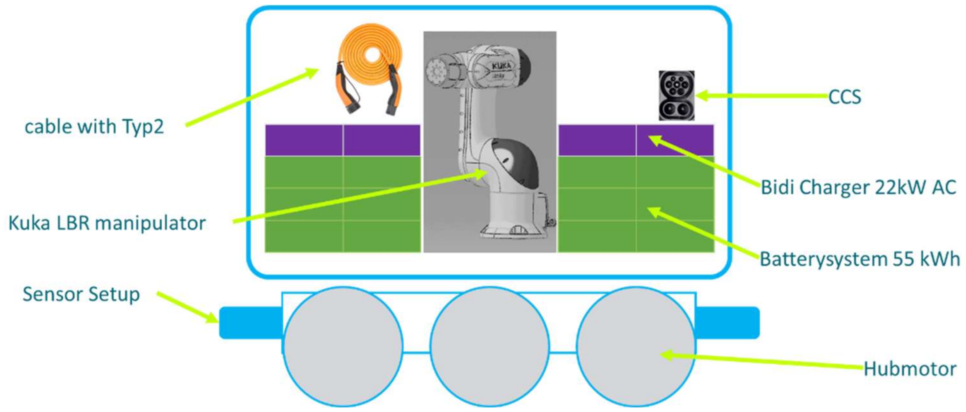

Figure 53. Components of the charging robot

Action deployment requirements

Technical and operational requirements

- Odometry and Localization Requirements: The autonomous vehicle must be capable of robust localization in both global and local contexts. The system should ensure accurate self-positioning within the operational environment to navigate efficiently and safely.
- Obstacle Detection and AI Integration: AI models must be implemented to detect and understand various types of obstacles, including static and moving objects. A tracking algorithm should be developed to track the movement of these obstacles, allowing the robot to make informed decisions and navigate around them.
- Path Planning Capabilities: The system must incorporate machine learning and AI models that understand the behavior of road users. These models should be integrated into the robot's path planning algorithm to enable smoother and more adaptive movements in response to dynamic environments.
- Battery Safety Protocols: Given the substantial battery capacity carried by the autonomous robot, it is crucial to verify that all battery safety protocols are followed. Relevant standards and regulations for battery usage must be reviewed to ensure safety during operation.
- Car Plate Recognition: The robot must employ computer vision algorithms to accurately recognize vehicle license plates, facilitating secure and efficient identification of vehicles for charging.
- Precise Localization for charging: The autonomous robot should be able to position itself with high precision close to the vehicle for charging operations. This ensures that the robot can perform its tasks accurately and safely.
- Automatic Communication: The robot must have the ability to communicate automatically with the vehicle to be charged, enabling the robot to initiate the slap opening process for the charging connection. This will be achieved through V2Cloud communication protocols.
- Automatic Plugging Mechanism: The robot will be equipped with a robotic arm capable of autonomously plugging into the vehicle for charging operations, ensuring seamless interaction with the charging port.
- Operational Monitoring: Continuous monitoring of both the robot's operational status and the charging process is essential.
- Failure Scenario Management: The system must include well-defined strategies and protocols for handling failure scenarios. This includes automated responses for technical malfunctions or emergency situations, ensuring safe operation and minimal disruption to the charging process.

Conversely, the autonomous charging robot requires a variety of data inputs to operate effectively and ensure seamless interaction with vehicles. Key data requirements include the GPS position of both the robot and the vehicles, the license plate of the vehicle to confirm its identity, and the vehicle type to ensure compatibility with the charging system. Additionally, the robot continuously reports its current position and battery capacity to the cloud, enabling real-time monitoring and system optimization.

To support remote operations, particularly in the event of an incident that necessitates human intervention, the robot requires a reliable 4G/5G connection. This high-speed network connectivity is essential for enabling a remote operator to take control of the robot and manage the situation until normal autonomous operations can be resumed. The robust data infrastructure ensures both operational efficiency and safety, facilitating continuous communication and control for effective deployment and troubleshooting.

Legal and administrative requirements

For the autonomous charging robot to operate in public areas, several legal approvals are required to ensure compliance with local regulations and safety standards. Specifically, approval must be obtained from the LASuV (State Office for Traffic and Transport), the Dresden Road Traffic Authority, and the TÜV (Technical Inspection Association), which are responsible for overseeing the safety and regulatory compliance of autonomous vehicles operating in public spaces. These approvals ensure that the robot meets all necessary road safety and operational standards before deployment.

Additionally, it is essential to review the General Data Protection Regulation (GDPR) to assess whether data recorded by the robot's cameras, such as images or videos of vehicles and surrounding environments, complies with privacy regulations. This includes ensuring that any data collection adheres to legal requirements for data protection, user consent, and the secure handling of personal information, to safeguard user privacy and maintain compliance with EU data protection laws.

Partnerships

The implementation of the action need the collaboration of project partners as is detailed below.

- Transportation from VW to Deployment Sites: Organize and coordinate the transportation of the autonomous robots from VWGI to the designated deployment sites. Detailed transportation protocols must be established to prevent any issues with the vehicles during transit.

  Responsible: VWGI + Dresden.

- Permits and Safety Protocols: Secure the necessary permits for the deployment sites and define comprehensive safety protocols to minimize the risk of incidents. These protocols should be clear, covering all aspects of on-site safety.
  Responsible: VWGI + Dresden.

- Mapping of Deployment Sites: Create detailed maps of the deployment sites to facilitate accurate robot navigation. These maps will be essential for ensuring that the robots can operate safely and efficiently within the defined environment.

  Responsible: VWGI – CARNET – Dresden.

- Use Cases Definition: Clearly define the use cases for the autonomous robots, including the location of the vehicle depot and the specific demand that the robots are intended to serve. This will help in aligning operational objectives with real-world requirements.

  Responsible: VWGI – CARNET.

- Operative Domains and Route Optimization: Identify and define the operative domains (e.g., sidewalks, pedestrian areas, bike lanes) where the robots will operate. Use this information to build graphs, ideally using OpenStreetMap data, to optimize the route planning. Conduct in-situ verification to ensure there are no obstacles that could hinder autonomous navigation.

  Responsible: VWGI – CARNET.

- Communication Plan: Develop a communication plan to increase the visibility and impact of the deployment. This should include activities such as social media publications, press releases, and other outreach efforts to engage stakeholders and the public.

  Responsible: VWGI – CARNET – Dresden – Steinbeis.

- Pilot Key Performance Indicators (KPIs) and Objectives: Define the key performance indicators (KPIs) and objectives for the pilot tests. Determine the types of tests to be conducted, the specific metrics to gather, and the overall objectives of the pilot. It is recommended to start with less complex tests and gradually increase complexity as the pilot progresses.

  Responsible: VWGI – CARNET.

- Pilot Results Analysis: Analyze the results of the pilot tests, focusing on user and citizen acceptance of the technology. The analysis will inform the next steps and adjustments to improve the deployment and the robots' operational efficiency.

  Responsible: VWGI – CARNET.

Additionally, the successful deployment and testing of the autonomous charging robot relies on several VWGI **key partnerships** that provide specialized expertise and resources. The company is collaborating with IDMIND in Lisbon, which is responsible for assembling the robot up to the stage where VWGI can install the battery system. This partnership ensures that the robot's assembly meets the necessary technical specifications and is ready for the integration of critical components, such as the battery, which is essential for its functionality.

In addition, VWGI is working with TU Graz, which brings its expertise in autonomous systems. Specifically, TU Graz applies its knowledge and technology to enable the autonomous plugging of the charging connector, a key feature for the robot's operation. Their contributions ensure the robot's capability to perform this task autonomously, without human intervention, enhancing both the efficiency and reliability of the charging process.

Furthermore, the action also requires collaboration with an electricity distributor, which plays a crucial role in providing the necessary infrastructure to support the charging robot's operations. This partnership ensures that the charging system is compatible with existing electrical networks and that all operational requirements for power supply are met, enabling the robot to function effectively within the designated deployment area.

Figure below summarizes the stakeholders interaction map for the pilot 1.

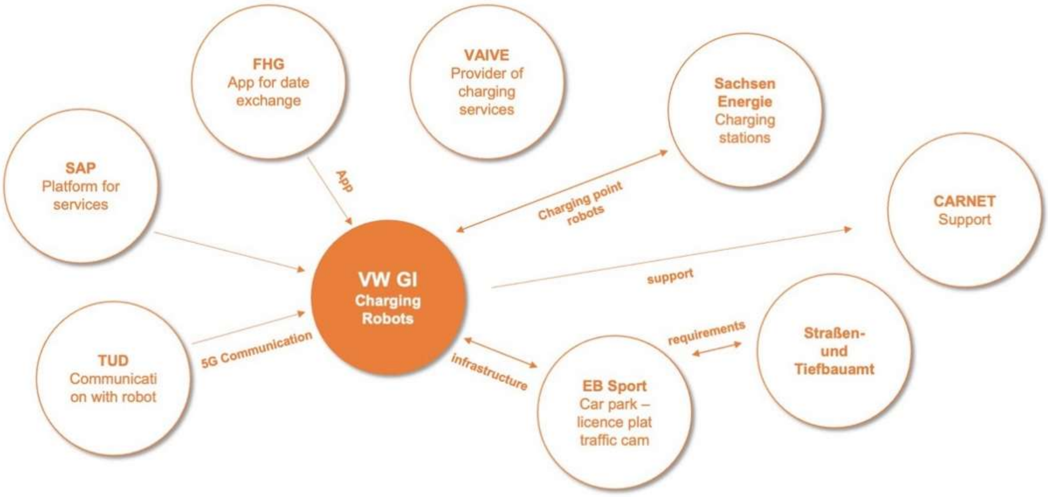

Figure 54. Stakeholders interaction maps for Pilot 1 (Dresden)

Co-design process

The co-design process was carried out in collaboration with the UT Lab of Dresden, which provided essential contributions to the design of the charging robot solution, as described earlier in the co-creation methodology. Additionally, a well-structured public engagement plan, in collaboration with the UTLab, will be implemented to raise awareness, educate the public, test the solution and gather feedback, ensuring transparency and fostering acceptance of the technology in the local community.

These contributions will include comprehensive user feedback, targeted design recommendations, and research insights aimed at improving the robot's functionality, usability, and public acceptance. The UT Lab will utilize robust social validation techniques—such as surveys, focus groups, and user trials—to systematically gather data and ensure that the solution addressed user needs and preferences effectively. Their specialized expertise is instrumental in shaping the final design and guiding the implementation process for the charging robot.

Timeline for the deployment and operation of the action

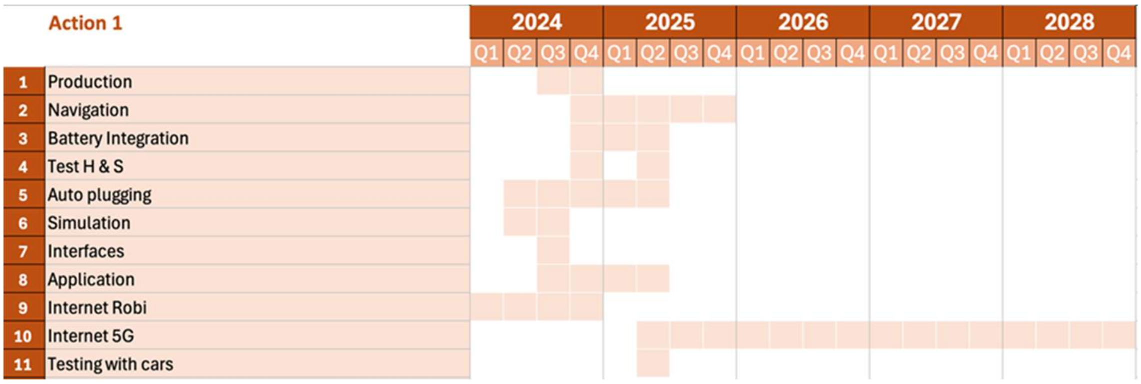

Figure 55. Charging robots timeline

Initial financial considerations

The implementation of the autonomous charging robot pilot requires a detailed evaluation of the associated financial considerations to ensure the feasibility of the project. One of the primary expenses is the production cost of the prototypes, which includes the design, manufacturing, and assembly of the robot to meet the desired functional and operational specifications. Additionally, the cost of the certification process is a critical factor, as regulatory compliance and safety certifications are essential for the deployment and operation of the robot in real-world environments.

The transportation cost of moving the robot from the lab to the deployment site is another important consideration, encompassing logistics, handling, and any associated fees for secure delivery. Once deployed, the action must account for insurance costs to mitigate potential risks and liabilities associated with operating an autonomous robot. Furthermore, the maintenance and repair costs represent an ongoing expense to ensure the robot remains fully operational, reliable, and safe throughout the duration of the pilot project.

Risks and mitigation measures

Table 12. Risks detected for charging robots: vandalism

Risk category	Vandalism
Risk Title	An autonomous robot is destroyed or stolen during the pilots in open urban environments
Risk Likelihood	2
Risk Impact	5
Risk description	Citizen acceptance is a complex issue for autonomous technologies in general. Some persons may be inclined to overreact when observing the robot (named Ona) circulate in open urban environments.
Risk mitigation measure	A fleet of several robots will be deployed during the pilot tests. If one of them is vandalised during one of the pilots, another prototype could be used. The robots will always be supervised by an operator during the duration of the pilots to prevent unexpected behaviours. Stakeholder acceptance will be considered from the early stages of the project to make sure that the use cases which will be developed during

	the course of the project will be accepted by society. The action intends to promote a socially-sustainable deployment of autonomous technologies, in cooperation with cities and citizens. GDPR will always be respected concerning images data treatment from cameras.

Table 13. Risks detected for charging robots: accident

Risk category	Accident
Risk Title	During the tests in open environments, the autonomous robot accidently hits a person.
Risk Likelihood	1
Risk Impact	5
Risk description	At some point of the project, the autonomous robot is intended to be deployed in a fully operational environment, interacting with other road users. During these operations, in case a problem occurs, the autonomous robot may hit a person, resulting in some personal damage.
Risk mitigation	All the operations of the autonomous robot will be covered by liability insurance. In case an accident occurs, the personal damage to the injured person will be covered. Finally, all the pilot tests will be done at a reduced speed, limiting the intensity of the injuries that may be provoked.

Table 14. Risks detected for charging robots: legal

Risk category	Legal
Risk Title	Local legal framework prohibits demonstration
Risk Likelihood	2
Risk Impact	3
Risk description	Depending on use cases / demonstration cases in the targeted cities, the legal framework conditions could prohibit a full demonstration of the autonomous robots in certain areas.
Risk mitigation measure	By working closely with local authorities and municipalities, sufficient time is allowed prior to demonstrations. Concrete benefits of the solutions are communicated to establish living lab conditions and promote legal acceptance of the autonomous robots.

Table 15. Risks detected for charging robots: fire

Risk category	Fire
Risk Title	Incident with the batteries
Risk Likelihood	1
Risk Impact	5
Risk description	Electric batteries are hazardous components which must be manipulated very cautiously. At some points, if the safety norms are not respected, they could generate a fire.
Risk mitigation measure	The design of the autonomous robot will strictly follow the current standards about the manufacturing of electric vehicles. In addition, all the personnel present during the pilot tests will be formed about the risks involving the manipulation of electric vehicles, their correct usage, and the safety protocols that must be implemented in case of an incident.

Cybersecurity will be implemented after the navigation and plugging work to ensure that all foundational systems are properly set up before security measures are added. Once the groundwork is complete, the main Central

Process Unit (CPU) will be equipped with a robust firewall to act as the first line of defense against potential cyber threats. This firewall will help monitor incoming and outgoing traffic, identifying and blocking unauthorized access to maintain data integrity and privacy. By prioritizing the sequence of tasks, the team aims to create a secure and well-organized system architecture that minimizes vulnerabilities and enhances overall system reliability.

Interactions with other actions

The charging robot pilot is strategically integrated with the rest of Dresden actions focused on autonomous delivery systems, data-sharing protocols, and infrastructure development. This integration involves collaborative efforts such as joint testing procedures, seamless data exchange mechanisms, and coordinated operational planning.

These interactions are designed to ensure interoperability across all Dresden pilots on technologies and systems, thereby enhancing the efficiency and functionality of the charging robot pilot. By aligning with these complementary actions, the action aims to maximize its overall impact, fostering a cohesive ecosystem that supports technological innovation and scalable implementation.

Main interactions will be with 5G communication measures and SAP Cloud system.

5.3.2. ACTION 2.1 (PILOT 2): INFRASTRUCTURE ASSISTANCE AUTOMATED CONNECTED DRIVING (CONTROL CENTER)

Short description of the action and goal

Development of infrastructure to address communication challenges in 5G remote automated driving that ensure and allow safe operations as well as efficient 5G remote driving for people. It includes a control center dedicated to advancing automated connected driving capabilities. The infrastructure will be tested and demonstrated in combination with a 5G remote driven vehicle for passengers that will circulate during the demonstration in Ostragehege under real, but safe and controllable boundary conditions.

This action leads to increase protection, better consideration in traffic control, and an increase in the attractiveness of non-motorized road users, which leads to an improvement in the modal splits in urban areas.

Technical specifications of the action to implement and operation of the action

The action consists of three elements to be implemented in the Ostragehege area as are described below.

- Demo scenario: one 5G remote driven automated vehicle will follow the driving commands of the technical supervisor by 5G remote control in a route that is equipped with smart CCAM sensor systems and communication devices (G5/5G) for Car2X-communications.
- Infrastructure assistance: ETSI G5 (Car2X-communication Roadside Unit) and 5G campus (backend) communication equipment for infrastructure assistance will detect current traffic situations and send related information from the infrastructure to the vehicle and the 5G remote control center via a digital dynamic object map. Furthermore, the traffic lights will transmit the signal state information; including prediction to the vehicles and the control center, in order to be able to ideally adapt the speed of the vehicles to the traffic conditions and signal states. For communication, vehicle nearfield information via ETSI G5 and mobile communication to the control center via 5G will be used.
- Control center: a remote workplace with an operator will teleoperate a 5G remote controlled autonomous vehicle. This vehicle will follow the driving commands of the technical supervisor by remote control in a route to be equipped with smart CCAM sensor systems and communication devices (G5/5G) for Car2X-communications. Vehicle videostreams, sensor data and parking request information will be exchanged with the control center via a 5G campus network in upstream of the vehicle. 5G remote control information will pass from the control center to the vehicle downstream.

The action requires the implementation of three stages:

- Within stage 1, the pilot of the action up to TRL4 takes place. This stage will run from 2024-2026.
- Within the second stage, the use case shuttle will be implemented, which will start in 2025/2026 and run until the end of the project.
- In stage 3, the business case will be implemented together with a potential operator from 2027.

Within the first stage, the so called “5G remote driving use case” will be implemented. The action shows the forward-looking possibilities of 5G for teleoperation of automated vehicles. In contrast to previous singular test installations, 5G applications are tested and demonstrated in the pilot side Ostragehege under real, but safe and controllable boundary conditions. A so-called technical supervisor directly takes over the low-latency and uninterrupted vehicle control from the control center. The automated vehicle follows the driving commands of this technical supervisor by remote control. This is monitored by a safety driver in the vehicle. The VW Passat, which is provided externally, will be used as a vehicle for remote driving. The traffic lights affected by the action will be equipped with V2X components. ETSI G5 provides the vehicle with information on the signal status of the system. Furthermore, one of the road network segments, that has yet to be defined, will be supported by infrastructure. Here, the operational design domain will be expanded with the help of infrastructure assistance. The shared responsibility between the 5G remote vehicle on the one hand, the road-sided sensor information with the local sensors, on the other hand, must be implemented.

This action in particular places high demands on the 5G campus network to be built. For the 5G remote driving use case, corresponding data must be transmitted with low latency and broadband. This is the only way for the control center in the cloud and the vehicle in the edge road network to interact securely. To ensure safety, the vehicle is permanently monitored by a safety driver directly in the vehicle as well as the assistance of the infrastructure.

The demo takes place in several steps. In the first step, the remote center receives a request for passenger transport. The approaching vehicle is driven to the passenger via 5G remote driving and drives them to their destination. There, the passenger leaves the vehicle. The vehicle can optionally be driven manually up to that point. In the second step, the passenger leaves the vehicle and a security driver takes over. The control center drives the vehicle, including the security driver, to the parking lot.

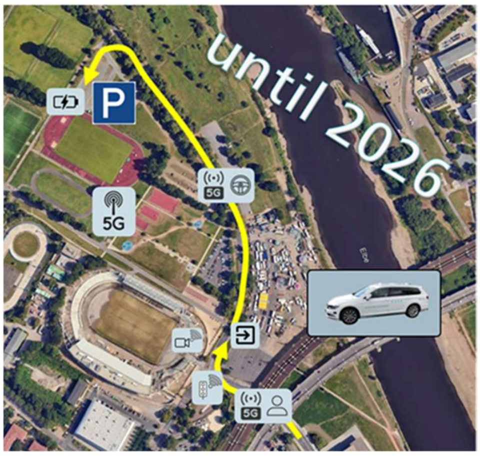

Figure 56. 5G remote automated driving route

While the grant agreement does not explicitly require an autonomous shuttle service, it will ensure that an autonomously driven vehicle is available to support this action. This may potentially lead to establishing a permanent shuttle service in the Ostra area as part of the future business plan of the action; however, this remains a tentative consideration without formal commitment at this stage.

Action deployment requirements and responsibilities

Technical and operational requirements

The technical and operational requirements for the installation of sensor systems and 5G remote driving in public road networks are described as follows:

- Sensor Accuracy to ensure accurate and reliable data for traffic monitoring and management.
- Communication Infrastructure (robust 5G networks) to support real-time data transmission and vehicle communication.
- Interoperability to ensure compatibility between different sensor systems and vehicles for seamless operation.
- Power Supply to provide reliable power sources for sensors, including backup solutions.
- Latency Requirements to maintain low latency in communication to ensure timely responses for autonomous vehicles.
- Compliance with Standards to adhere to industry standards and regulations for both sensor systems and 5G remote vehicle operations.
- Testing and Validation to conduct thorough testing and validation of systems.

Additionally, these tasks are also required for the deployment of the action:

- Stakeholder coordination: engage with local authorities, transportation agencies, and community stakeholders for collaboration.
- Site assessment: conduct thorough assessments of installation sites to identify potential challenges and requirements.
- Resource allocation, including budget, personnel, and equipment for deployment.
- Develop a comprehensive installation plan, including timelines and milestones for project execution.
- Training and capacity building for personnel involved in the installation and operation of sensor systems and vehicles.
- Establish monitoring mechanisms to evaluate the performance and effectiveness of deployed systems.

Legal and administrative requirements

The legal and administrative requirements for the installation of sensor systems in public road networks are described as follows:

- Obtain necessary permits from local or regional authorities before installation of the action.
- Compliance with Data Protection Laws to ensure that the data collected complies with privacy laws and regulations (e.g., GDPR). The aspects of data protection must be clarified in the course of infrastructure assistance through a close coordination with the partners of the project involved in its deployment.
- Safety Standards to adhere to safety regulations for installation and operation of sensor systems.
- Operational Plans to develop plans for ongoing operation of the sensor systems and control center.
- Reporting and accountability to establish reporting mechanisms for data collected and system performance.

Partnerships

- TU Dresden: Provide 5G Campus Network including all interfaces for the communication between control center und 5G remote driven vehicle.
- SAP: Provide Data Platform to get information about traffic conditions and passenger requests.
- City of Dresden: Provide business case and automated shuttles for project stage 2 and 3.
- Dresden mobility provider: Operator for the automated shuttles as daily service for stages 2 and 3 and an autonomous car for stage 1.

Figure below is an interaction map for the action 2.1 with all the required agents to involve in the implementation of the action.

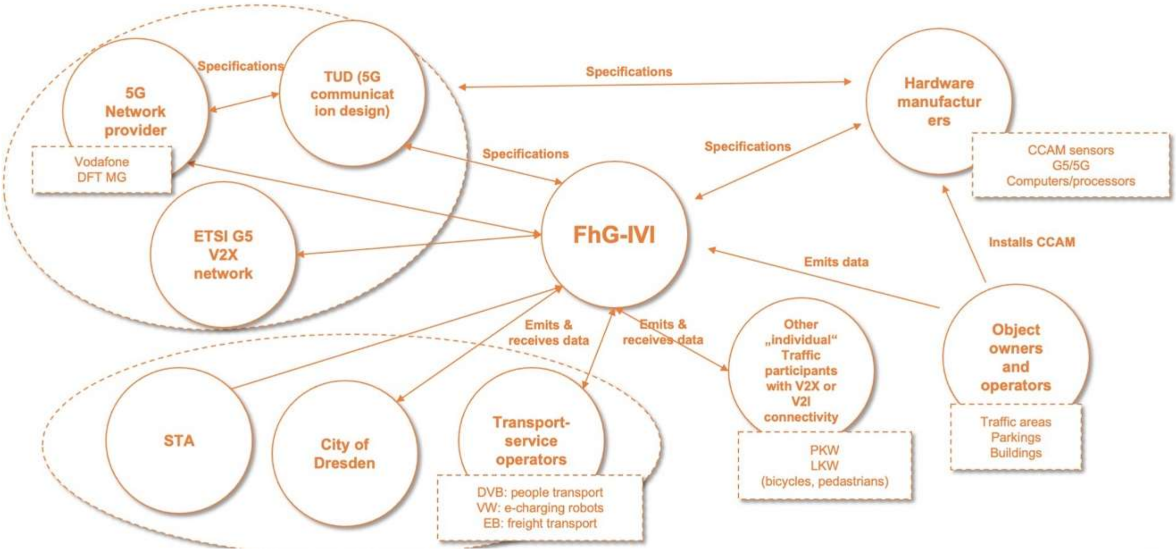

Figure 57. Stakeholders interaction maps for Action 2.1 (Dresden)

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action, in the workframe of the Urban mobility lab of Dresden named “ Ostra Labor”.

Timeline for the deployment and operation of the action

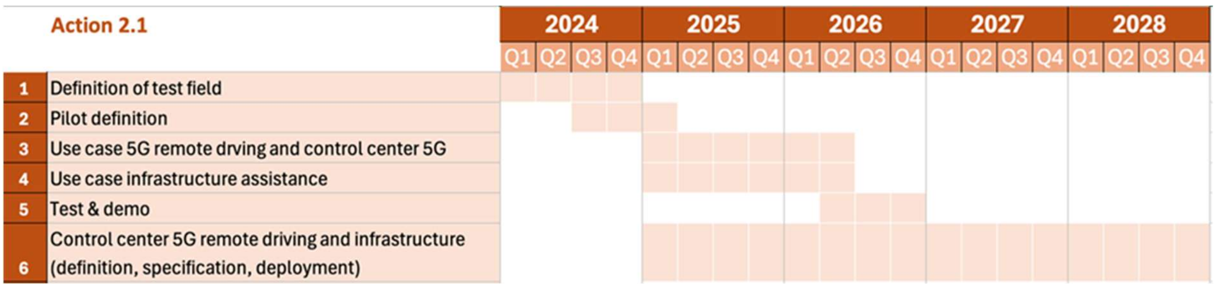

Figure 58. Infrastructure assistance automated connected driving timeline

Interactions with other actions and pilots

Within stages 2 and 3, there is a strong dependence on the future mobility operator of the use case “shuttle“ and the “business case“; being the city of Dresden in conversations with the mobility service provider to proceed in all these actions.

5.3.3. ACTION 2.2 (PILOT 2): MOBILITY DATA SPACE FOR AUTOMATED CONNECTED DRIVING

Short description of the action and goal

Open data space for automated mobility solutions for both people and freight to enable a secure exchange of data involved in automated connected driving. These data relate to the data generated by interconnected vehicles and road infrastructure (sensors). The former are generated by Action 1, Action 3 and Action 4 and considered sensitive data, especially if generated by privately owned vehicles. The latter refers to the data generated by both existing road infrastructure (such as the statuses of the traffic lights), as well as from the intelligent infrastructure for assisted driving that will be implemented through Action 2.1. The main goal of this Action is to prevent data misuse by third parties or use in unapproved purposes. This issue will be addressed within this Action by enabling an exchange of only authorized data between authorized stakeholders within the mobility data space and in authorized purposes (such as in Action 9, Action 10.2, Action 11, but also others).

Technical specifications of the action to implement.

An open data space for driving and operation of automated mobility solutions for both people and freight will be developed and implemented to enable a secure exchange of sensitive data. This Mobility Data Space (MDS) in Dresden will be an open data space that will offer access to, as well as the linkage of, the required data assets for automated mobility solutions. It also includes implementation of data space components like connectors and usage control mechanisms to support a self-sovereign and legally required secure exchange of sensitive mobility data.

The MDS will also offer searching and subscribing to traffic relevant online data, as well as the distribution of online data between data suppliers and data clients for technical supervision for automated driving of different mobility service provider. Data channels will be established, over which the safe operation of self-driving fleets can be monitored.

The following diagram shows the conceptual architecture of the Data Space Support Center (DSSC) of a data space:

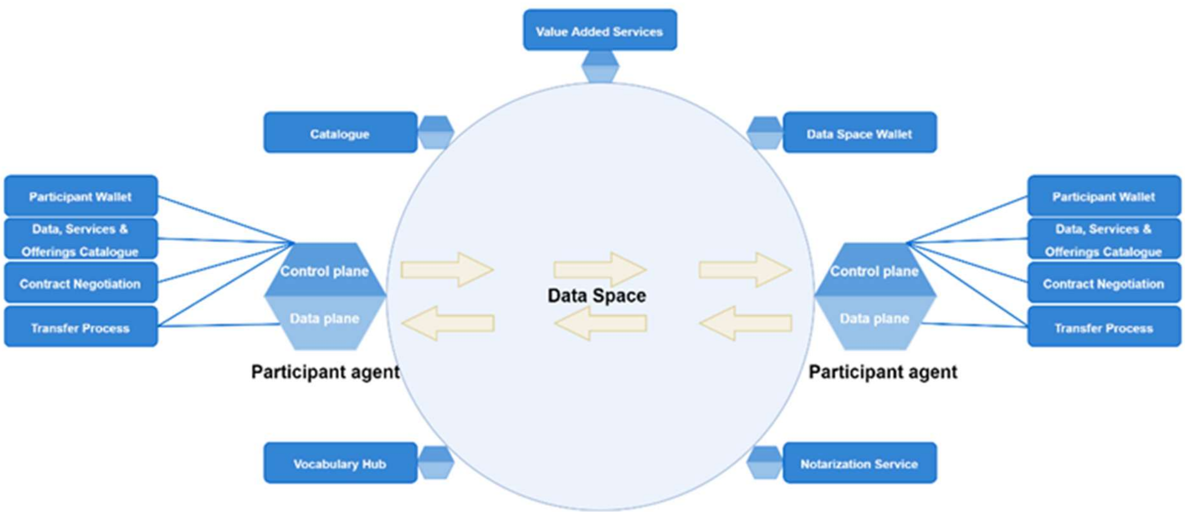

Figure 59. Technical concept of a data space for automated connected driving

This architecture shows a blueprint of the maximal expansion stage of a data space. In the subsequent project months, the team will analyse the use case requirements on the data space components, and it will be decided which of the shown components are needed and which software implementations will best fit these requirements.

Action deployment requirements and responsibilities

Technical and operational requirements

There are already different open source software implementations available that can be used for the technical building blocks of the data space. The requirements analysis will uncover the technical gaps that need to be developed by the project partners or need to be procured.

The data space to be created follows closely the recommendations of the currently running "Data Space Support Centre" project (10/2022-03/2026, URL: https://dssc.eu) – funded by the European Union as part of the Digital Europe Program, with Fraunhofer as a project partner – which regularly publishes and updates the "Data Spaces Blueprint". This blueprint includes a large variety of technical concepts that can enable several businesses requirements. In the first part of the project, it is therefore vital that the stakeholders, their business needs, technical capabilities and technical processes are carefully analysed and technical requirements are derived. Subsequently, a mapping of needed data space concepts can be done, followed by an evaluation of technical software implementations that provide these conceptual functionalities.

On the foundation of these building blocks, the data space enables the linkage of a wide range of different data assets, like vehicle states and sensing, digital maps with different resolutions, traffic flow and incident data, weather, dynamic traffic infrastructure information, occurrence of challenging driving scenarios, etc. The MDS can integrate data from automated mobility provider via a municipal platform, a digital distribution channel for data-driven business models, providing entirely new options of data acquisition, linking and exploitation.

Legal requirements

The MDS will enable the legally required as defined in German law regulations such as Ordinance on the Approval and Operation of Motor Vehicles with Autonomous Driving Function in Defined Operating Areas (AFGBV) and Road Traffic Act (StVG): safe operation of automated fleets in urban areas on the one hand, as well as protection of the data collected by automated vehicles on the other hand. A further relevant regulative that protects personal data and privacy and regulates usage of sensitive data is the European Union General Data Protection Regulation (GDPR).

Necessary partnerships

It is requiring the implementation of the interconnectivity and exchange of data with specific partners of the project: TUD, SAP and VW which lead these actions: Action 1 (VW), Action 4 (EBS), Action 9 (SAP), Action 10.2 (SAP), Action 11 (SAP), Action 12 (TUD). Additionally, the action implementation will require also other agents. Figure below is an interaction map for the action 2.2.

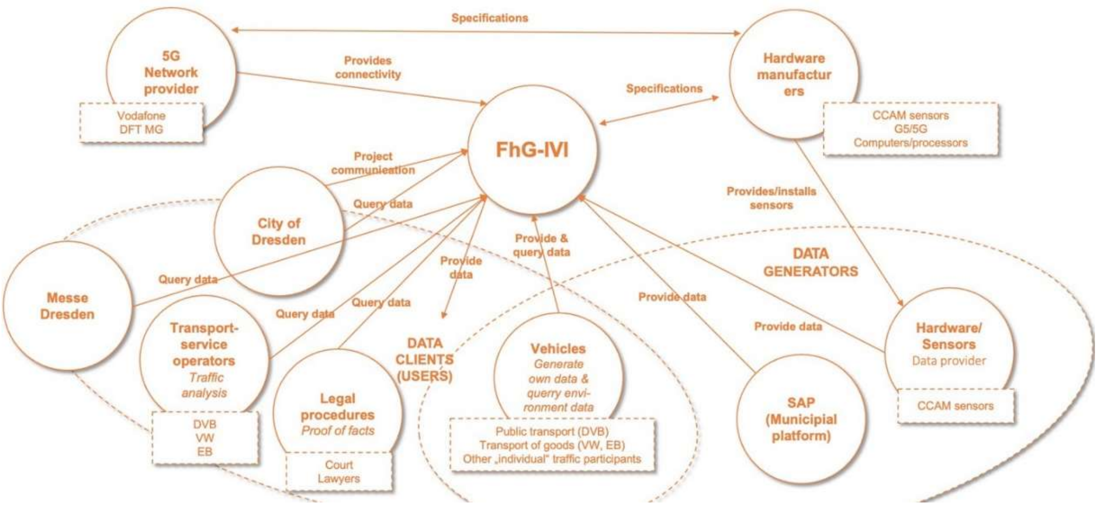

Figure 60. Stakeholders interaction maps for Action 2.2 (Dresden)

Timeline for the the deployment and operation of the action

Action 2.2		2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Definition of data needs, processes and data architectures within the actions that want to use the mobility data space																				
2	Requirements analysis, mapping to conceptual data space concepts																				
3	Development or procurement of data space building blocks																				
4	Operation of the data space																				
5	Implementation of the actions uses cases, test & demo																				
6	Further refinements, adding new data space features																				

Figure 61. Mobility data space (Dresden) timeline

Co-design process

Three co-design workshops were held between January and October 2024 (as described in chapter 3). Within those, the first elements necessary for the Dresen pilots were defined. Among others, a roadmap and a stakeholders' map were created. The latter defined how the Dresden pilots and stakeholders connect to each other, as well as what are the mutual requirements between pilots and stakeholders.

Based on this initial information, working in presence meetings between Dresden partners were organized on a monthly basis, where further requirements for the Dresden pilots, including the services to be developed, were defined in collaboration with project partners. For example, it was clarified that SAP will develop a data platform that will collect and store data and will use the mobility data space developed by FHG for a safe communication with other network components, such as the control centres (Energy Control Centre, Logistics Control Centre and Mobility Control Centre).

Additional monthly presence meetings and direct e-mail correspondence whenever needed were regularly held between FHG and TUD. During those, FHG and TUD pilots were defined on a more detailed level. This resulted in an agreed communication architecture that includes Action 2.2 and demonstrates how the mobility data space and 5G connectivity play roles in the connectivity and communication of interfaces included in the Dresden's part of the project (figure included in Action 12).

The described way of working during 2024, based on regular exchange of information and feedback, proved to be fruitful and the co-design process will continue the same way until a need for adjustment is identified. Interviews or workshops with citizens are not necessary to configure the final design of the solution, as this pilot design is very technical.

Initial financial considerations

Both alternatives described in Risks and Mitigation Measures subsection are currently covered by the granted budget in the project.

Interactions with other pilots and actions

Since the mobility data space service will facilitate collaboration of several interfaces, interactions with multiple other actions are necessary. Planned are minimally interactions with Action 9, Action 10.2 and Action 11.

Furthermore, a exchange of experiences with the data space action that will be developed by T-Systems in the Spanish pilot is planned in order to learn each other. That will be especially interesting on topics like methodology, software implementations to be used and design decisions made.

Risks and mitigation measures

On the level of use cases / actions and their data, it might be the case that due to business model or legal reasons, the needed data will not be shared by the stakeholders. A mitigation measure would be to establish data usage contracts between the stakeholders that formalise the usage and application of the respective data. A further approach would be to lower the detail of the data, removing sensible or confidential information, to an extent that is still usable for the use case.

A further risk could be that existing software implementations do not provide the required technical functionalities. A mitigation measure would be to develop the needed functionalities by the partner or to subcontract a software company that develops this functionality under an open source software license.

5.3.4. ACTION 4 (PILOT 3): AUTONOMOUS E-VEHICLES FOR FREIGHT

Short description of the action and objectives to reach

Two autonomous small-scale freight transport e-vehicles for the logistic of catering products in sport center and 6 Smart Energy Tower/Charging stations for these vehicles will be developed and tested.

The objectives of the action are:

- Improve efficiency of catering logistics in sports facilities.
- Reduce manual labour and operational costs.
- Enhance sustainability through the use of electric vehicles.
- Provide a seamless and unobtrusive service to spectators and staff.

Technical specifications of the action to implement

The two autonomous small-scale freight transport e-vehicles for catering logistics in the sport center will be used for:

- Transporting kitchen items (used cups, tableware) to collection points and dishwashers within the stadium.
- Supplying fresh cups, tableware, and beverages to spectator stands.
- Transporting fresh cooked food between locations, specifically from the kitchen in Joynext Arena to BallsportArena and/ or Heinz-Styer Stadium.

User experience: Staff will interact with the vehicles through a user-friendly interface to schedule and monitor deliveries. Spectators will benefit from improved service without direct interaction with the vehicles.

Action deployment requirements

Technical and operational requirements

- Autonomous navigation system with obstacle detection.
- Electric charging infrastructure at key locations.
- Integration with existing facility management systems.
- Robust communication system for real-time tracking and control.

Legal and administrative requirements

- Obtain necessary permits for autonomous vehicle operation within the facilities.

- Comply with food safety regulations for transportation of catering items.
- Ensure compliance with data protection regulations (GDPR) for any collected operational data.

Data needs

- Real-time location and status data of vehicles.
- Delivery schedules and routes.
- Performance metrics (e.g., delivery times, energy consumption).
- Secure data storage and transmission protocols.

Necessary partnerships

- Local government for permits and regulations
- State Office for Road Construction and Transport (LASUV) and the Federal Motor Transport Authority (KBA)
- Sports facility management (stadium, Joynext Arena, BallsportArena).
- Autonomous vehicle technology providers.
- Catering service providers.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. The collaboration among project partners and the involvement of new agents and citizens is expected to continue during the project timeline as detailed below:

- To gather input on vehicle design and operational requirements: workshops with staff and facility managers.
- To refine the user interface and operational procedures: user testing with prototype vehicles.
- To increase the satisfaction with the vehicle and the service: Simulations of vehicle operations in virtual environments.
- User testing with prototyped vehicles to refine the user interface and operational procedures.

Timeline for the deployment and operation of the action

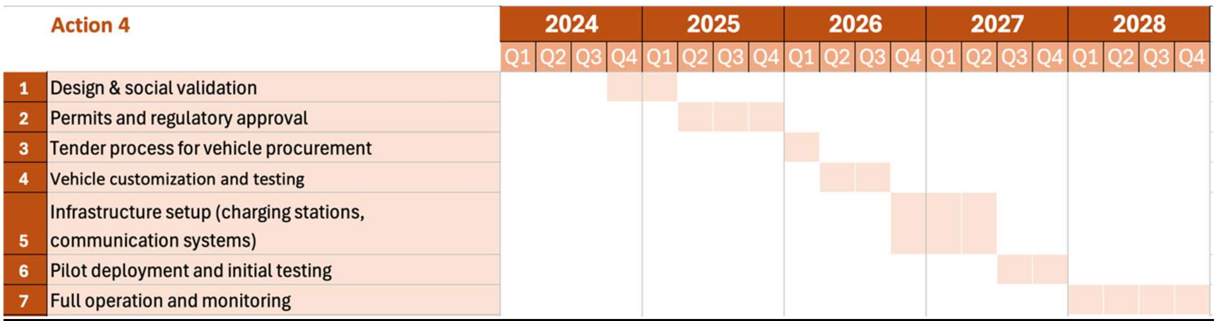

Figure 62. Autonomous vehicle for freight (Dresden) timeline

Initial financial considerations

- Cost of two autonomous e-vehicles (estimate needed)

- Charging infrastructure installation
- Software development and integration
- Operational costs (maintenance, energy, staff training)

Risks and mitigation measures:

Table 16. Risks detected for Autonomous vehicle for freight (Dresden)

Risks	Mitigation Measures
Technical failures	Regular maintenance, redundancy in critical systems.
Safety concerns	Comprehensive safety protocols, constant monitoring.
User acceptance	Staff training, clear communication of benefits.
Cybersecurity	Implement encryption, access controls, and regular security audits.
Regulatory challenges	Early engagement with authorities, flexibility in design to meet evolving regulations.

Interactions with other actions and pilots

- Integration with Smart Energy Tower for efficient charging (Action 14: Power Grid-based Optimization and Control).
- Potential use of 5G network for vehicle communication (Action 12: 5G Private Communication Network).
- Coordination with overall mobility concept for the district (Action 6: Mobility Concept for the District).

5.3.5. ACTION 5 (PILOT 3): FEASIBILITY STUDY FOR 2 ROUTES FOR AUTONOMOUS E-VEHICLE FOR PASSENGERS

Short description of the action and goal

As part of this action, a comprehensive feasibility study will be carried out on routes for autonomous e-buses connecting key points in the city to improve access to different districts and integrate various sports facilities. The aim of the study is to identify possible routes for autonomous shuttles in the city of Dresden from a technical and traffic planning perspective. The test routes in the project area will serve to test the technology in an area with low traffic (and low accident risk) and high demand in the coming years due to planned major events. For the stabilisation of the service and the citywide roll-out after 2028, this feasibility study needs to identify the potential across the city to provide a data base for infrastructure development. The result of the feasibility study will be a detailed mapping of the proposed routes with the technical, economic and administrative requirements, as well as an assessment of the user acceptance of the selected routes and the expected passenger numbers.

Technical specifications of the action to implement

The performance of the study will need to compile the needs and requirements of the deployment of autonomous shuttle as follow.

Technical and operational requirements

- A traffic flow analysis through the collection of traffic data on proposed routes.
- Analysis of public transportation usage patterns together with TU Dresden Chair of Transport Modelling and Simulation.

- Evaluate the potential ridership and user acceptance.
- Assess technical requirements and infrastructure needs for the vehicles to implement.
- An analysis of the cost-benefit of the routes proposed and a risk assessment analysis.

Legal and administrative requirements

- Evaluate regulatory and safety considerations regarding autonomous vehicles together with the State Office for Road Construction and Transport (LASUV) and the Federal Motor Transport Authority (KBA).
- Identification of necessary permits for future implementation with the above-mentioned stakeholders.

Necessary partnerships

The feasibility study will be led by Dresden via subcontracting, requiring also of a collaboration with urban planning department and transportation authorities. Other required agents to be involved are:

- Potential autonomous vehicle providers
- TU Dresden - Chair of Transport Modelling and Simulation
- Subcontractor, probably Institute for Traffic Accident Research (VUFO) to contact a study on VRU (accidents with vulnerable road users)

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. Citizens were also involved in an activity held in Autumn 2024 when they were asked about the satisfaction with existing transport services, challenges in the mobility and required improvements to enhance the mobility of citizens to reach the demoarea and move along different points. Next activities to do in the next months will be workshops and dialogues with stakeholders/citizens to gather input on route selection for e-autonomous shuttles.

Timeline for the deployment and operation of the action

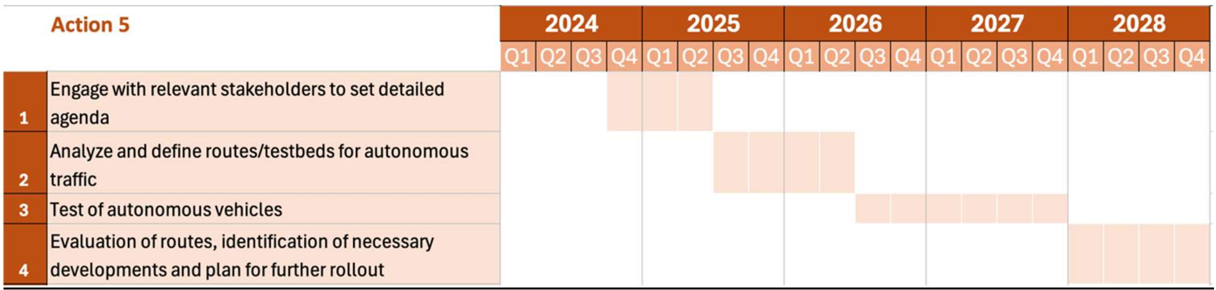

Figure 63. Feasibility study for routes for autonomous vehicle (Dresden) timeline

Initial financial considerations

Dresden will cover the costs of the study as it will benefit its own transport concept. The call for tenders for the sub-contractor will be issued in the year 2025.

Risk and mitigation measures

Table 17. Risks detected for study for routes for autonomous vehicle (Dresden)

Risks	Mitigation Measures
Regulatory challenges	Engage early with relevant authorities

Technical feasibility	Consider a phased implementation approach

Interactions with other actions and pilots

- Coordinate with Pilot 3 (Mobility Concept) for integrated transportation planning (mobility concept needs to be aligned/include autonomous shuttles)
- Align with electrification efforts in Pilot 4

5.3.6. ACTION 6 (PILOT 3): MOBILITY CONCEPT FOR THE DISTRICT WITH FOCUS ON INTERMODAL MOBILITY / BIKE USAGE

Short description of the action and goal

The action aims to promote active mobility in Dresden by exploring app and gamification-based approaches that enable an intermodal mobility concept in the Ostra district. The result of this action will be an intermodal mobility concept that integrates commuter and tourist traffic on the Elbe cycle path, as well as feeder traffic to major events at the Dresden Exhibition Centre and the Dresden canal, into the city's broader mobility network. As an overarching concept, this measure will provide a framework for all existing and new forms of mobility via private car transport, private cycling and walking as well as sharing services, which should sustainably improve the traffic situation in the OSTRA area and beyond in the immediate catchment area.

Technical specifications of the action to implement and operational aspects

This can be achieved through and increased motivation and engagement, behavioural change through new habit formation, encouraging competition and social connection, raising awareness and providing real-time feedback through map-based applications. It is thought to do this by incentivising sustainable modes of transport through app-based cycling and walking challenges, where users earn points for sustainable transport choices and redeem benefits. It is currently explored the option to integrate this into the existing cleema-App that has been developed in another project and already serves as a platform for sustainability challenges in Dresden.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action and citizens were involved in an activity held in Autumn 2024.

Next activities to do in the next months will be:

- Conduct community workshops to gather input on mobility preferences
- Use UT lab to test gamification concepts for encouraging active mobility

Action deployment requirements

Technical and operational requirements

- Analysis of current mobility patterns in the district and needs for seamless urban mobility.
- Assessment of existing cycling and pedestrian infrastructure.
- Analysis of potential intermodal connection points.
- Development of intermodal connection points together with existing mobility concepts from the transport operator DVB such as MobiPunkt (possible collaboration with nextbike, lime scooters, emmy scooter sharing, etc)

Legal and administrative requirements

- Review of existing urban planning regulations.

- Coordination with relevant city departments for infrastructure modifications.

Data needs

- Collection of data on current mobility patterns
- Analysis of potential intermodal connection points

Necessary partnerships

- Sports Facilities of the City of Dresden to lead the development of the mobility concept in the Ostra area and define requirements and needs.
- Urban Mobility department for strategy building.
- Local cycling advocacy groups (Wegebund, etc) for strategy building.
- DVB (public transportation provider) to establish the public transportation connection.
- TU Dresden - Chair of Transport Modelling and Simulation
- Institute for Traffic Accident Research (VUFO) for compiling accident data.

Risk and mitigation measures

Table 18. Risks detected for study for Mobility concept (Dresden)

Risks	Mitigation Measures
Public acceptance	Engage in community outreach and education
Infrastructure challenges	Develop phased implementation plan

Timeline for the deployment and operation of the action

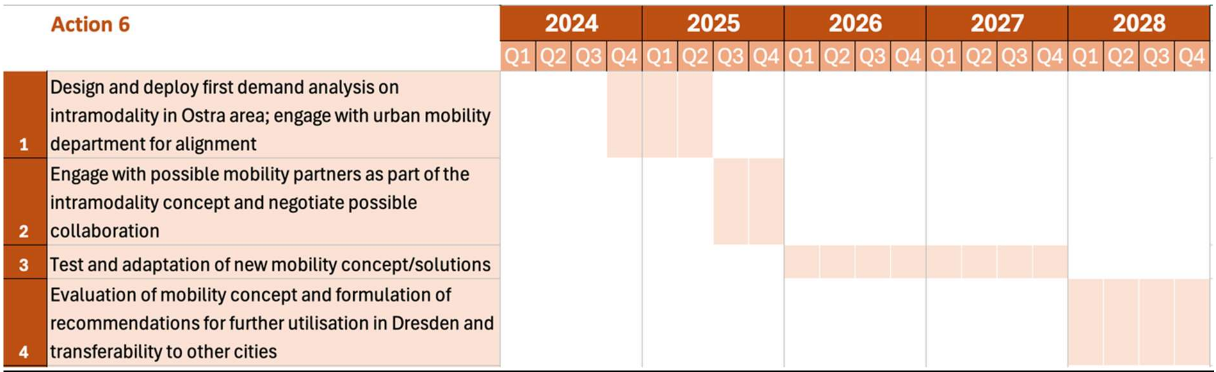

Figure 64. Mobility concept (Dresden) timeline

Interactions with other actions and pilots

- Coordinate with Pilot 3 (Autonomous E-Vehicle Study) for integrated mobility planning
- Align with Pilot 4 (Electrification of Bus Fleet) for comprehensive sustainable transport solutions

5.3.7. ACTION 7 (PILOT 4): ELECTRIFICATION OF THE PUBLIC BUS FLEET

Short description of the action and goal

This action involves the implementation of 20 e-buses in the bus fleet of Dresden to continue contributing to the overall electrification of public transportation in the city and reducing consequently emissions and noise pollution. The buses will be charged through pantograph-based infrastructure.

Technical specifications of the solution to implement and operational aspects

The potential e-buses models to be implemented in the city and the main technical specifications are described in table below.

Table 19. Potential e-buses models for Dresden

Bus model	Key features
Mercedes Benz eCitaro Gelenkbus	▪ Maximum speed 80 km/h ▪ Electric motor, motor output 4 electric motors close to the wheels, each with 125 kW peak and 87 kW continuous output ▪ Energy storage 10 pack NMC total 330 kWh gross ▪ Energy supply en route via a pantograph mounted on the bus roof at the end point with up to 300 kW ▪ Energy supply at the depot/depot via a pantograph mounted on the bus roof with up to 150 kW
Mercedes Benz eCitaro Standardbus	▪ Maximum speed 80 km/h ▪ Electric motor, motor output 2 electric motors close to the wheels, each with 125 kW peak and 87 kW continuous output ▪ Energy storage 8 pack NMC total 256 kWh gross ▪ Energy supply en route via a pantograph mounted on the bus roof at the end point with up to 300 kW ▪ Energy supply at the depot/depot via a pantograph mounted on the bus roof with up to 150 kW
Mercedes Benz Citaro G (C2)	▪ Maximum speed 85 km/h ▪ Engine output 265 kW/360 hp
Solaris Urbino 12 Electric	▪ Maximum speed 65 km/h ▪ Electric motor two wheel-mounted asynchronous motors with 80 KW output power each ▪ Energy storage five 40 kWh battery modules with lithium-iron-phosphate technology from the manufacturer A123 ▪ Energy supply on the track via five-pole current collector on the vehicle roof and stationary charger ▪ Energy supply at the car park via charging cable and semi-mobile charger

More information on e-busses in the website of the local public transportation agency: Busflotte - DVB | Dresdner Verkehrsbetriebe AG

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action.

Action deployment requirements

Technical requirements

- Collection of data on bus routes and usage patterns
- Monitoring of e-bus performance and energy consumption

Co-funded by the European Union

Legal and administrative requirements

- Compliance with public procurement regulations.
- Obtaining necessary permits for charging infrastructure installation.

Data

- Collection of data on bus and usage patterns
- Monitoring of e-bus performance and energy consumption

Necessary partnerships

- DRE to lead the project in collaboration with DVB (local public transportation provider)

Timeline for the deployment and operation of the action

The 20 new electric busses in the public fleet in Dresden will be implemented along the next years; having the year 2028 as target year where all these should be operating.

	Action 7	2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Reach 20 new electric busses to the DVB fleet in Dresden																				

Figure 65. Bus fleet electrification (Dresden) timeline

Initial financial considerations

Covered by the existing municipal public transportation operator

Interactions with other actions and pilots

Coordinate with Pilot 3 (Mobility Concept) for integration with broader mobility plans

5.3.8. ACTION 8 (PILOT 4): BIDIRECTIONAL CHARGING FOR CARS

Short description of the action and goal

This action focuses on implementing a tuneable/configurable e-car with bidirectional charging and network integration capabilities for mobility of people. The objective is to demonstrate the feasibility and benefits of Vehicle-to-Grid (V2G) technology in urban settings and how this can contribute to grid stability and energy efficiency.

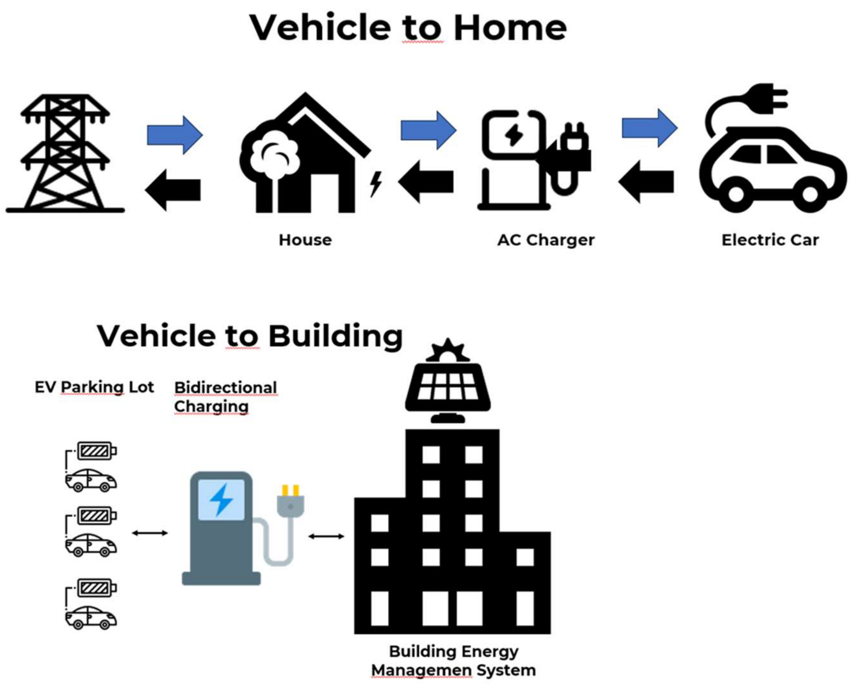

Figure 66. Bi-directional charging functionalities

Technical specifications of the action to implement and operational aspects

Objectives and detailed technical description including the "user experience":

- Implement bidirectional charging technology in an electric vehicle
- Integrate the vehicle with the local power grid
- Demonstrate how V2G can contribute to grid stability and energy efficiency
- Provide users with an intuitive interface to manage their vehicle's energy flow

As part of this action, the communication part to ensure the charging and discharging processes will be provided and the driver will be able to select the mode on which to use the solution (ie. share the vehicle energy to the grid or viceversa). Two critical “add-ons” are developing: the Car2X communication (likely an app) will allow drivers to set up preferences and the protocol between the control centre and the charging station. It is planned to use an e-car from Wolkswagen with bidirectional charging capabilities. The charging stations will have a maximum power output of 50 kW and will be located in a parking lot at Ostra district. The final configuration will be determined based on availability and local grid capacity, with a minimum of 2 EVs and 1 charging station to ensure data validity.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. Also citizens were involved in specific activities performed. Next activities to do in the next months will be:

- Engage local residents in the design of user interfaces
- Conduct workshops to gather feedback on the V2G concept
- Use UT lab for simulations and small-scale testing before full deployment

Action deployment requirements

Technical and operational requirements

- Bidirectional charging hardware installation in the e-car
- Development of control software for managing energy flow
- Integration with local grid management systems

Legal and administrative requirements

- Obtain necessary permits for V2G operations
- Ensure compliance with local energy regulations
- Establish agreements with energy providers for bidirectional energy flow

Data needs

- Real-time data on vehicle battery status
- Grid demand and supply data
- User preferences and charging patterns

Necessary partnerships

- TUD to lead the technical implementation and integration
- Local energy utility companies for grid integration
- Electric vehicle manufacturers for e-car modifications
- Fleet management company (optional)
- Dresden city administration for infrastructure support

Timeline for the deployment and operation of the action

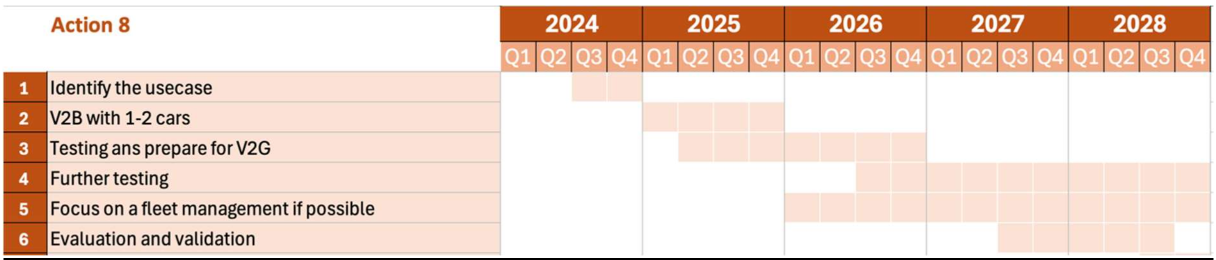

Figure 67. Bidirectional charging for cars (Dresden) timeline

Risks and mitigation measures

Table 20. Risks detected for bidirectional charging for cars (Dresden)

Risks	Mitigation Measures
Cybersecurity risks	Implement robust encryption and access controls
Technical failures	Develop redundancy systems and regular maintenance schedules
User adoption	Conduct user education programs and provide incentives

Interactions with other actions and pilots

- Coordinate with Pilot 6 (Power Grid-based Optimization and Control) for integrated energy management.
- Align with other mobility solutions in the Ostra district for comprehensive transportation planning.

5.3.9. ACTION 9 (PILOT 5): PLATFORM FOR SERVICING EVENTS: ESTIMATE TRAFFIC FLOWS (PREDICTIVE) TO IMPROVE EVENT MANAGEMENT VIA DATA POOLING ON A PLATFORM

Short description of the action and goal

This action is an expandable cloud-based and modular to flexibly integrate diverse data sources and manage the interfaces of the pilots via one unified platform. The main objective of this solution is to reach an effective integration of mobility data into the event planning lifecycle.

Technical specifications of the action to implement and operational aspects

Since the technical foundation of this pilot will be operated by the city, the SAP Business Technology Platform needs to be provided by the city as well. SAP will configure the platform, so that the pilot will be realized. To realize this, the interfaces of the other pilots need to be provided by the project partners and mobility data needs by other city departments.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action and citizens.

Next activities to do in the next months will be:

- Conduct user workshops to gather input on desired features and user interface design.
- Use UT lab facilities for usability testing and iterative design improvements.
- Engage local businesses and service providers in feature prioritization discussions.

Action deployment requirements

Technical and operational requirements

- Access to existing mobility data systems of the City of Dresden
- One unified event planning calendar of the stakeholders in the Ostragehege
- SAP Business Technology Platform (BTP) provided by the City of Dresden
- Parking lot capacity tracking in the Ostragehege

Legal and administrative requirements

- Compliance with GDPR and local data protection laws.
- Agreements with city departments for data sharing and service integration.
- Operation agreements with a third party provider provides the SAP Business Technology Platform to the city.

Data needs

- User account information (securely stored and managed).
- Reservation data for various city services.
- Real-time mobility data from transportation providers.
- Parking lot utilization data.
- Traffic flow data.
- Event calendar data from city and private organizers.

- Data of other pilots that want to/need to be integrated

Necessary partnerships

- SAP to lead the technical development/configuration of the platform.
- City of Dresden to provide/operate the technical foundation via third party provider (SAP Business Technology Platform)
- EBS (sports facilities) to provide local expertise and facilitate integration with city systems.
- Collaboration with various city departments for service integration (e.g., transportation, parks and recreation).
- Event organizers and venue managers.

Timeline for the deployment and operation of the action

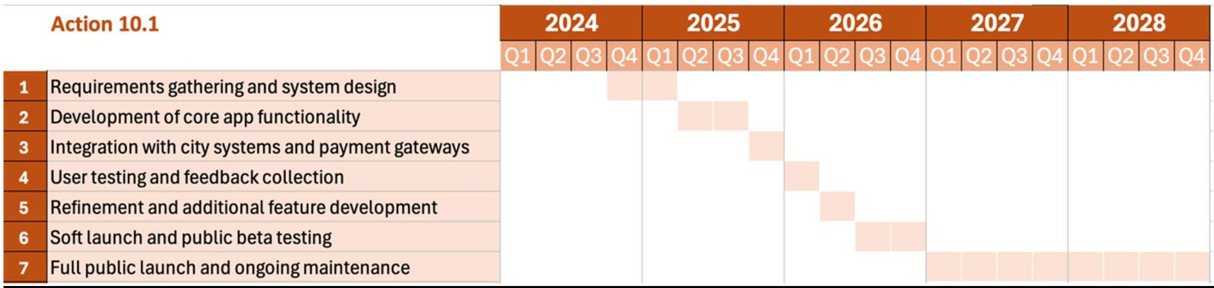

Figure 68. Platform for servicing events timeline

Initial financial considerations

- Costs for the operation/provision of the platform
- Backend infrastructure and hosting expenses
- Licensing fees for third-party services (e.g., payment gateways) and data providers

Risks and mitigation measures

Table 21. Risks detected for services events (Dresden)

Risks	Mitigation Measures
Whole pilot can be blocked by late provisioning of the platform	▪ Buffering timeline with expenses <10.000 EUR and usage of free service plans for development when possible.
Data sharing with several external parties might get difficult	▪ Using multiple data sources to reduce impact of missing data sources.
Interface challenges with city of Dresden / mobility data systems	▪ Early engagement with city IT departments to understand system requirements. ▪ Develop modular architecture to allow for easy integration of different data sources.
Technical issues during scaling:	▪ Conduct thorough load testing before full launch. ▪ Implement scalable cloud infrastructure to handle increased user load.

Interactions with other actions and pilots

- Integration with Action 10.2 for mobility capacity tracking and wayfinding guidance.
- Coordination with Action 11 for incorporating mobility monitoring data.

- Potential integration with Action 8 (Bidirectional Charging for Cars) for EV charging reservations and payments.

5.3.10. ACTION 10.1 (PILOT 5): CITY APP FOR SERVICES INCLUDING RESERVATIONS AND PAYMENT

Short description of the action and goal

This action involves the development and implementation of a comprehensive city app for Dresden, focusing on the Ostra district. The app will enable the users to make reservations and payments for various city services.

Technical specifications of the action to implement and operational aspects

An intuitive and userfriendly mobile application for residents and visitors will be created by integrating reservation systems for city services implementing secure payment features, and incorporating real-time mobility information to enrich the user experience. The platform will provide a seamless interface for users to access multiple city services in one platform.

City services that can be reserved and paid consists of sport facilities located in Ostra distict.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. Next activities to do in the next months will be:

- Conduct user workshops to gather input on desired features and user interface design.
- Use UT lab facilities for usability testing and iterative design improvements.
- Engage local businesses and service providers in feature prioritization discussions.

Action deployment requirements

Technical and operational requirements

- Cross-platform mobile application development (iOS and Android) or website based
- Backend systems for data management and service integration.
- Secure payment gateway integration.

Legal and administrative requirements

- Compliance with GDPR and local data protection laws.
- Adherence to financial regulations for payment processing.
- Agreements with city departments for data sharing and service integration.

Data needs

- User account information (securely stored and managed).
- Reservation data for various city services.
- Payment transaction data.
- Real-time mobility data from transportation providers.
- Event calendar data from city and private organizers.

Necessary partnerships

- SAP to to support the technical development of the app and architectural guidance regarding interfaces and integration.
- EBS (sports facilities) to provide local expertise and facilitate integration with city systems.

- Collaboration with various city departments for service integration (e.g., transportation, parks and recreation).
- Payment gateway providers.
- Event organizers and venue managers.

Timeline for the deployment and operation of the action

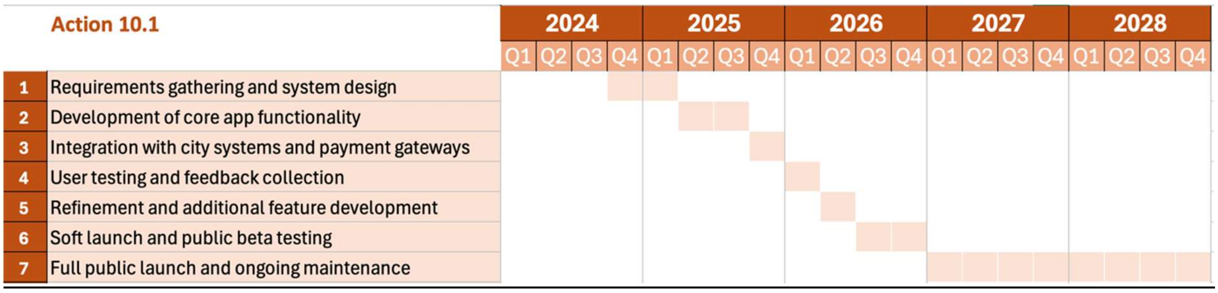

Figure 69. City app for services timeline

Initial financial considerations

- Development costs for the mobile application
- Backend infrastructure and hosting expenses
- Licensing fees for third-party services (e.g., payment gateways)

Risks and mitigation measures

Table 22. Risks detected for City app for services(Dresden)

Risks	Mitigation Measures
Delayed development of Sportpark App (event calendar)	- Mitigation: Develop a flexible API that can integrate with the Sportpark App once available. - Interim solution: Manual input of event data until automated integration is possible.
Interface challenges with city of Dresden/mobility data systems	- Mitigation: Early engagement with city IT departments to understand system requirements. - Develop modular architecture to allow for easy integration of different data sources.
Data privacy and security concerns	- Implement robust encryption and secure data handling practices. - Regular security audits and compliance checks.
User adoption challenges	- Develop a comprehensive marketing strategy to promote app benefits. - Offer incentives for early adopters and regular users.
Technical issues during scaling	- Conduct thorough load testing before full launch. - Implement scalable cloud infrastructure to handle increased user load.

Interactions with other actions and pilots

- Integration with Action 10.2 for mobility capacity tracking and wayfinding guidance.
- Coordination with Action 11 for incorporating mobility monitoring data.

- Potential integration with Action 8 (Bidirectional Charging for Cars) for EV charging reservations and payments.

5.3.11. ACTION 10.2 (PILOT 5): ENABLE CITY APP TO ALLOW TRACKING OF MOBILITY CAPACITY DATA AND GIVING WAYFINDING GUIDANCE

Short description of the action and goal

This action securely links diverse data sources to enable real-time mobility capacity tracking and traffic flow management. Through the integration of existing mobility data, the action intends to enhance the experience of visitors in the area by providing advice on the arrival in the area. A potential wayfinding system will be supported by 15 displays and road guidance systems for disabled people.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. Additionally, cocreation workshops especially with regards to accessibility, will be planned for Q1/Q2 2025.

Action Deployment requirements

Technical and operational requirements

- Access to existing mobility data systems of the City of Dresden
- Wayfinding system with hardware (displays) and software (routing)
- SAP Business Technology Platform (BTP) provided by the City of Dresden
- Parking lot capacity tracking in the Ostragehege

Legal and Administrative Requirements

- Provisioning of BTP by City of Dresden (call for tenders)
- Data sharing agreement with public transport company DVB
- Data sharing agreement with city department for mobility data

Data needs

- Traffic flow data/streets (OSM or City of Dresden, Office for Geodata and Cadastre)
- Parking lot utilization data
- Public transport utilization data (GTFS)
- Event planning data
- Facility Layout & Infrastructure
- User Demographics/Accessibility Needs
- Display Specifications
- Visitor Flows

Necessary partnerships

- SAP
- Collaboration with DVB
- Collaboration with city department for mobility data
- Provider for displays and beacons

Timeline for the deployment and operation of the action

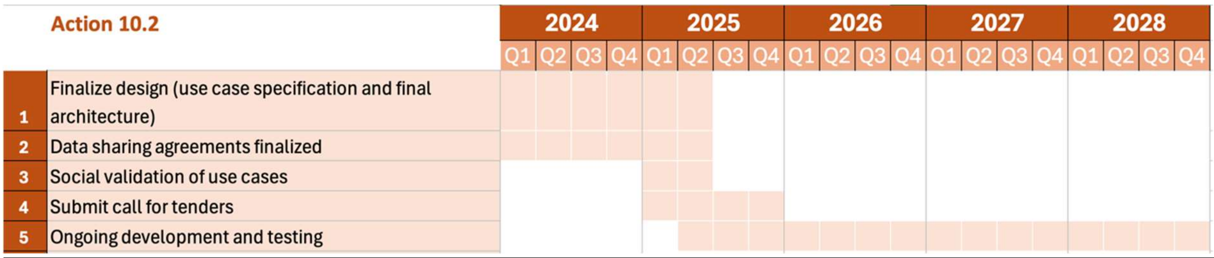

Figure 70. Enable city app timeline

Initial financial considerations

- Provisioning cost for wayfinding navigation system
- Cost for displays
- Platform cost depends on final architecture, mainly backend operation costs like action 9.

Risk and mitigation measures

Table 23. Risks detected for enable city app (Dresden)

Risks	Mitigation Measures
Whole pilot can be blocked by late provisioning of the platform	Buffering timeline with expenses <10.000 EUR
Data sharing with several external parties might get difficult	Using multiple data sources to reduce impact of missing data sources
Wayfinding is not a core competency of the parties involved	The indicated competencies will be sought in different project partners, or even externally.

Interactions with other actions and pilots

- Dependent on Action 11 for measuring parking lot utilization in the Ostragehege
- Similarities to Action 9 regarding data needs
- Optional connection to Action 2.2 as additional data source

5.3.12. ACTION 11 (PILOT 5): MOBILITY MONITORING VIA IMAGE PROCESSING AND PROVISION VIA PLATFORM FOR TRAFFIC MANAGEMENT IN DEMOSITE DISTRICT

Short description of the action and goal

To track parking capacity in the Ostragehege area, this action involves the development and integration of a platform to monitor parking lot occupancy, specifically targeting OSTRA Park, while ensuring compliance with GDPR regulations. The system will utilize cameras or similar technology to monitor parked vehicles in flood-prone areas without requiring ground installations. The collected data will be integrated with the systems outlined in Actions 9 and 10.

Technical specifications of the action to implement and operational aspects

High-resolution camera systems for parking monitoring, integration with the SAP Business Technology Platform (BTP) for data management, compliance with GDPR regulations, and partnerships with third-party hardware providers to ensure effective deployment and operation of the parking occupancy monitoring system.

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. This joint collaboration will continue during the next months.

Action Deployment requirements

Technical and operational requirements

- Camera hardware for parking lot monitoring
- SAP Business Technology Platform (BTP) provided by the City of Dresden
- Optional: Write access to existing mobility data systems of the City of Dresden

Legal and Administrative Requirements

- Provisioning of BTP by City of Dresden (call for tenders)
- Provisioning of hardware by City of Dresden (call for tenders)
- Optional: Data sharing agreement with city department for mobility data
- Ensuring GDPR compliance

Data needs

- Real-Time Camera Feeds
- Parking Layout Maps
- Parking Spot Status

Necessary partnerships

- SAP
- Third party hardware provider – alternatively additional arrangements with FHG

Timeline for the deployment and operation of the action

Figure 71. Mobility monitoring via imagen processing timeline

Initial financial considerations

- Provisioning cost for cameras

Risk and mitigation measures

Table 24. Risks detected for Mobility monitoring via imagen processing

Risks	Mitigation Measures
Whole pilot can be blocked by late provisioning of the platform	Buffering timeline with expenses <10.000 EUR
Whole pilot can be blocked by lack of the camera system	Using FHG might be easier to provision but will result in more development efforts
Legal obstacles regarding the use of cameras	Continue with clarification/evaluate other approaches

Interactions with other pilots and actions

- Acts as a basis for Action 9 and 10.2
- Optional connection to Action 2.2 as additional data source

5.3.13. ACTION 12 (PILOT 6): 5G PRIVATE COMMUNICATION NETWORK IN OSTRA DISTRICT

Short description of the action and goal

This action aims to develop and implement 5G communication interfaces and data transmission solutions throughout the Ostra district, ensuring seamless connectivity and compatibility with the overarching platform. The objectives include establishing robust 5G communication interfaces, facilitating smooth data transmission and integration with the higher-level platform, improving connectivity for all smart city applications in the area, and enhancing the user experience through reliable and high-speed connectivity.

Technical specifications of the action to implement and operational aspects

The network consists of three basic elements: a Radio Access Network (RAN), which provides radio coverage in the Ostra district, a core network which manages the 5G network and provides connectivity to cloud services in the data network, and a 5G User Equipment (UE) which acts as a mobile modem for vehicles, robots and other devices enabling 5G connectivity.

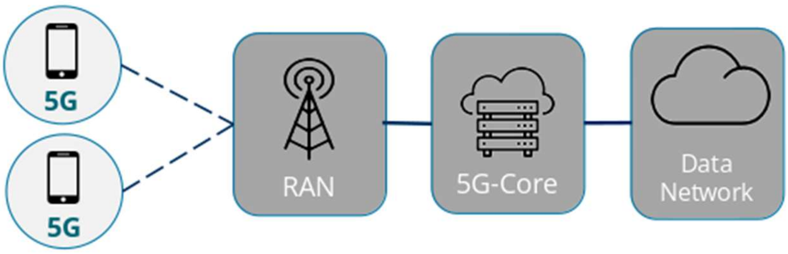

Figure 72. Basic private communication network elements

5G acts as a crucial technology for smart city solutions within the project, providing a private network that connects various pilot projects. This integrated architecture supports communication between mobile charging robots, autonomous vehicles, and static devices like traffic lights and cameras. The pilots are categorized into energy, logistics, and mobility optimization, each managed by dedicated control centers linked to a data platform that offers AI-based insights. The mobility data space ensures secure data exchange among stakeholders. With this architecture established, the next step is to assess the sustainability and impact of these 5G-enabled solutions.

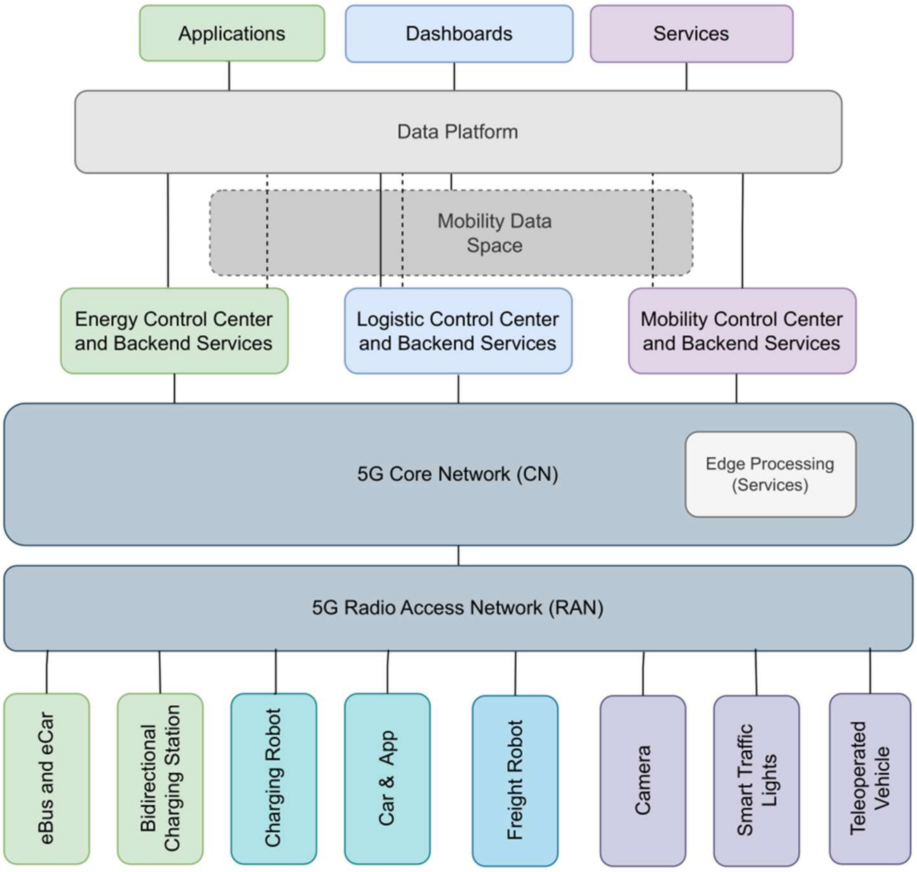

Figure 73. Private communication network architecture

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action and citizens were involved in an activity held in Autumn 2024.

Action deployment requirements

Technical and operational requirements

- Installation of 5G base stations and small cells throughout Ostra
- Development of software interfaces for data transmission and integration
- Compatibility testing with existing and planned smart city systems

Legal and administrative requirements

- Obtain necessary permits for 5G infrastructure deployment
- Ensure compliance with electromagnetic radiation regulations
- Establish data sharing agreements with relevant stakeholders

Data needs

- Network performance and coverage data
- User connectivity metrics
- Integration data flows with higher-level platform

Necessary partnerships

- TUD to lead the development and implementation of 5G interfaces
- Collaboration with local telecom providers for infrastructure deployment
- Dresden city administration
- Coordination with other pilot projects for integration needs

Initial financial considerations

The cost of the pilot is mainly determined by the requirements and complexity of the RAN. The Ostra district has large open areas that can be cover by the schedule financial resources. However, the existing housing development limits the possibility of complete coverage with a single base station. This is of particular importance for the Charging Robot (Section 5.2.1) and the Freight Robot (Section 5.2.5). Both the charging point of the charging robot and the entire operating area of the freight robot will most likely have to be covered by additional base stations. Depending on the location, this may require additional radio cells in the indoor and outdoor areas, which could exhaust the planned financial resources.

Timeline for the deployment and operation of the action

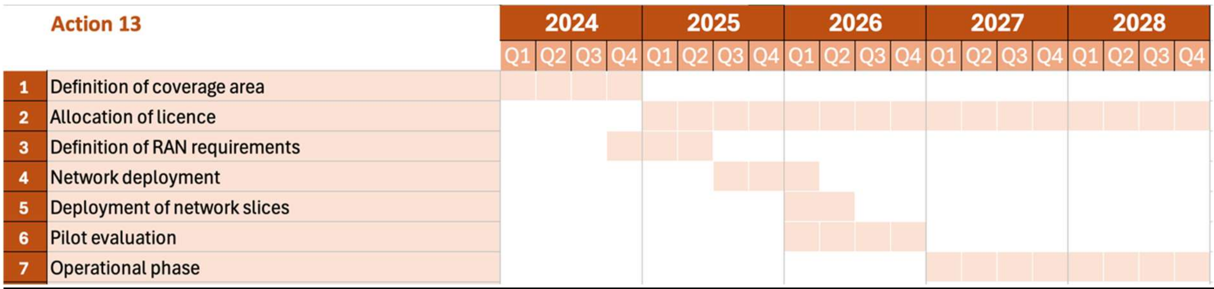

Figure 74. 5G private communication network timeline[3]

Risk and mitigation measures

Table 25. Risks detected for 5G private communication network (Dresden)

Risks	Mitigation Measures
Ultra-low latency communication requirements for autonomous vehicles	Integration of computing resources on the network edge to reduce latency of the communication network.
Network congestion	Implement robust traffic management and prioritization.
Cybersecurity threats	Ensure end-to-end encryption and regular security audits.
Integration challenges	Conduct thorough compatibility testing and stakeholder coordination.

5.3.14. ACTION 13 (PILOT 6): SLICING FOR USE CASE E.G. EVENTS

Short description of the action and goal

This pilot aims to implement 5G network slicing to prioritize critical data streams related to power grid management, machine control, and traffic safety, ensuring reliable connectivity for essential applications. By allocating dedicated bandwidth to key services, such as matching renewable energy generation with charging points and managing energy storage systems for charging robots, the project enhances operational efficiency and safety. Objectives include ensuring uninterrupted connectivity, improving user experience for system operators and end-users, and enhancing overall service reliability.

[3] Actions 12 and 13 will be implemented in a joint way. Action 12 serves as the basis for Action 13, which is why a joint schedule for implementation and operation was drawn up in the timeline of action 13. In this diagram, points 1 to 4 apply to Action 12. Point 5 refers to the extension described by Action 13. Points 6 and 7 are relevant for both actions.

Technical specifications of the action to implement and operational aspects

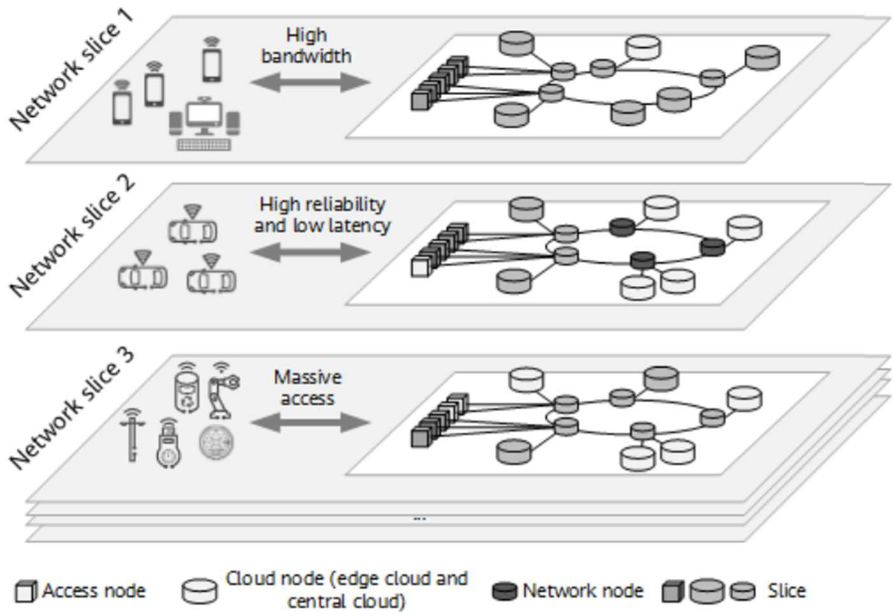

Figure 75. Network slicing scheme

Action deployment requirements

Technical and operational requirements

- Development and implementation of network slicing algorithms
- Integration with power grid management systems
- Setup of dedicated virtual networks for critical applications

Legal and administrative requirements

- Ensure compliance with data protection regulations for critical infrastructure
- Establish service level agreements for prioritized network slices
- Obtain necessary approvals for modifying existing network infrastructure

Data needs

- Real-time data on network usage and slice performance
- Critical data streams from power grid, machine control and traffic safety systems
- Usage patterns of key applications for optimization

Necessary partnerships

- TUD and DRE to collaborate on implementing network slicing
- Coordination with power grid operators, local energy utility, telecom provider and traffic management authorities
- Integration with charging infrastructure operators

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. Next activities to do in the next months will be:

- Engage telecom experts, city planners, and end-users in system design workshops.

- Conduct simulations of various network configurations and slicing scenarios.
- Activate the UT lab for small-scale testing of interfaces and network slicing algorithms.

Timeline for the deployment and operation of the action

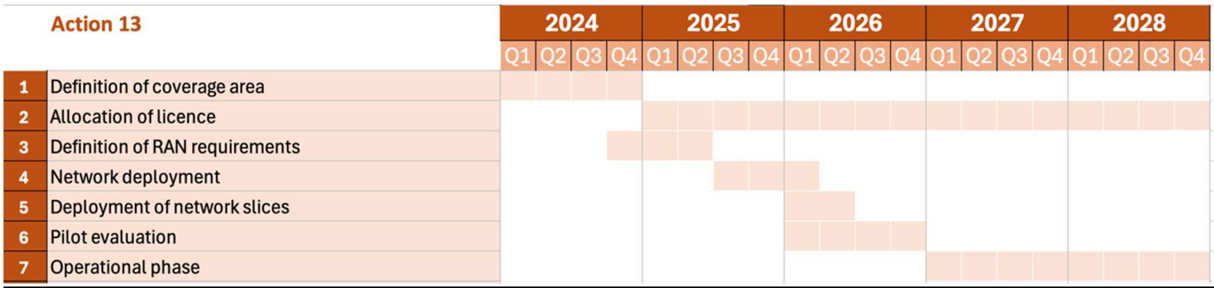

Figure 76. Slicing for use case timeline[4]

Risk and mitigation measures

Table 26. Risks detected for slicing for use case (Dresden)

Risks	Mitigation Measures
Network congestion	Implement robust traffic management and prioritization
Cybersecurity threats	Ensure end-to-end encryption and regular security audits
Integration challenges	Conduct thorough compatibility testing and stakeholder coordination

Interactions with other actions and pilots

- Integrate with power grid management systems for real-time data exchange
- Support other mobility solutions in the Ostra district with reliable 5G connectivity
- Align with Dresden's overall smart city initiatives for comprehensive digital infrastructure

5.3.15. ACTION 14 (PILOT 6): POWER GRID-BASED OPTIMIZATION AND CONTROL

Short description of the action and goal

Implement and test a small-scale bidirectional charging system in Dresden's Ostra district that consists of 2-3 electric vehicles and 1-2 bidirectional charging stations where extensive simulation studies will be done to assess the potential of this technology on grid stability, energy efficiency and CO_2 reduction. The expect goal of this action is the optimization of the power grid through demand-oriented transport and e-charging solutions to obtain insights for future scaling of bidirectional charging technologies in urban environments.

Simulations based in data from the physical deployment will help to understand potential benefits like peak load reduction, increased reneable energy integration and improved grid resilence.

Technical specifications of the action to implement and operational aspects

- Real-time data from the physical EVs and charging stations.
- Historical grid data for accurate simulation modeling.
- Simulated data for various scenarios of large-scale deployment.

[4] Actions 12 and 13 will be implemented in a joint way.

- Secure data storage and processing capabilities for both real and simulated data.

User experience testing: A small group of users will interact with the physical EVs and charging stations, providing valuable real-world data and feedback. The simulation results will inform potential user experiences in a larger-scale deployment.

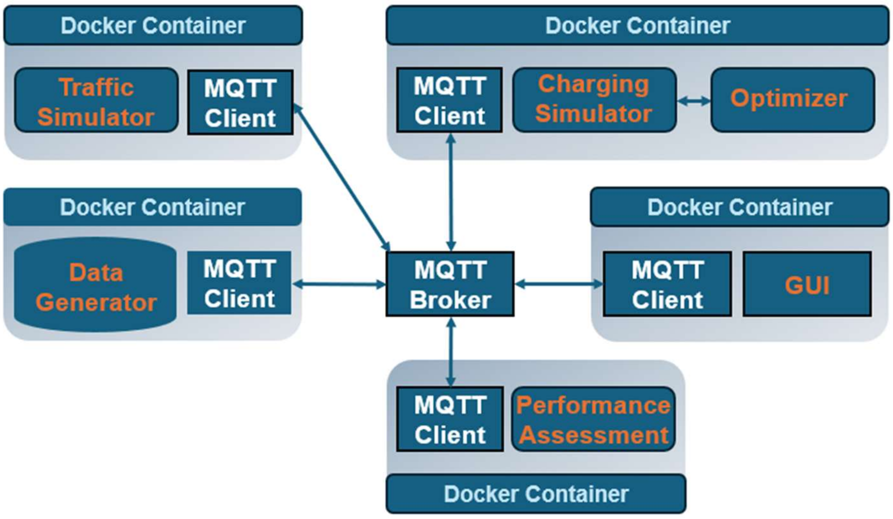

Figure 77. Power grid-based optimization and control action architecture

Action deployment requirements

Technical and operational requirements

- 2-3 EVs equipped with bidirectional charging capabilities.
- 1-2 bidirectional charging stations installed in the Ostra district.
- Development of comprehensive simulation models that can scale up the impact assessment.
- Data collection and analysis systems for both physical and simulated environments.

Legal and administrative requirements

- Obtain necessary permits for the installation and operation of bidirectional charging stations.
- Ensure compliance with data protection regulations for both real-world data collection and simulated data handling.
- Address any regulatory requirements for grid interaction, even in a simulated environment.

Necessary partnerships

- TUD to lead the implementation of the physical system and development of simulation models.
- Local energy providers and grid operators for data and validation of simulation models.
- EV manufacturers and charging station providers for the physical implementation.
- Software developers and data scientists for simulation model development.
- Potential engagement with fleet companies for future scaling possibilities (though not required within the current project scope).

Co-design process

A joint collaboration among partners from Dresden ecosystem has been produced for the identification of needs and requirements of this action. It is planned to continue this co-design process in the future and perform the activities describe below.

- Engage stakeholders in defining simulation scenarios and key performance indicators.
- Use UT lab facilities for visualization of simulation results and stakeholder workshops.
- Iterate on simulation models based on stakeholder feedback and emerging urban mobility trends.

The idea is to create simulation scenarios that explore various deployment scales of bidirectional charging systems, focusing on their impact on grid stability, energy efficiency, and CO_2 reduction.

Key performance indicators will include:

- Grid stability metrics (e.g., frequency response, voltage levels).
- Energy efficiency ratios (e.g., energy consumed vs. energy delivered).
- CO_2 emissions reductions based on different charging strategies.

Timeline for the deployment and operation of the action

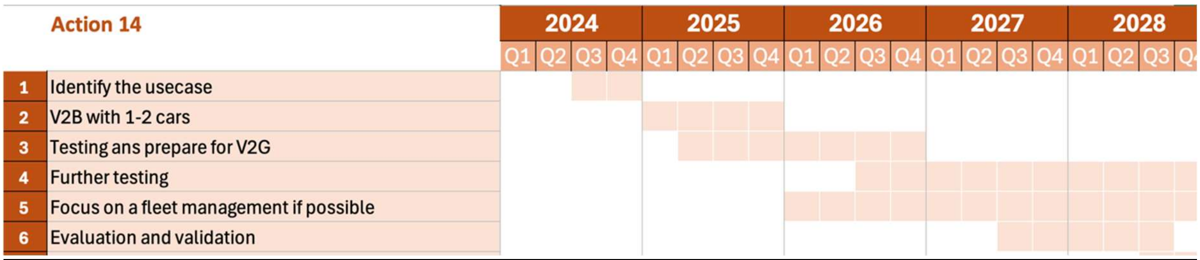

Figure 78. Power grid-based optimization and control action timeline

Initial financial considerations

- Cost of 2-3 EVs and 1-2 bidirectional charging stations
- Software development costs for simulation models
- Data collection and analysis infrastructure

Risk and mitigation measures

Table 27. Risks detected for Power grid-based optimization and control action (Dresden)

Risks	Mitigation Measures
Limited real-world data	Mitigate by ensuring robust data collection from the small-scale deployment and supplementing with historical data from other sources.
Simulation accuracy	Validate models against real-world data and continuously refine based on new insights.
Scalability challenges	Design simulation models with flexibility to account for various scaling scenarios.

Interactions with other actions and pilots

- Integrate findings with other mobility and energy management pilots in the Ostra district.
- Use simulation results to inform potential future expansions of bidirectional charging infrastructure.
- Collaborate with city planners to incorporate simulation insights into long-term urban energy strategies.

6. Lessons learned during the first stages of the project

One of the main outcomes of projects are the lessons learnt during the project execution since this allows others can apply the knowledge acquiered from past mistakes and successes and make better decisions in the future. These lessons will also serve for the replication in the other 5 european cities, part of the project.

This section includes the experiences reported by the two demo leaders, i.e. the ones in charge of the supervision of the actions to be deployed in the cities of Madrid and Dresden. This activity of management involves the technical design, the financial plan and the implementation in the demo areas. Specifically, the partner Madrid deals with the supervision of the 10 actions detailed in section 4 and the partner Dresden manages the deployment of the 15 actions described in section 5.

6.1. Madrid

Afer one year of project implementation, these are some of the aspects that Madrid finds as lessons learnt along this phase:

Good partnership balance and a proper project coordination: One of the main lessons learnt by Madrid is that in a project of this magnitude, with so many partners and cities involved, one of the keys is to know how to manage the project professionally and to have a good technical office. In our case, it has been shown that effective coordination not only added value in responding to the call but also in keeping the project running smoothly and aligned. Having complementary partners from the private sector, who are also service providers for the city, makes the consortium balanced, powerful and with many successful possibilities.

Importance of a correct demo area selection: Even during these 12 first months of the project, it has been confirmed that it was a good idea to choose a location like MercaMadrid, which is a complete environment to implement all the actions, but where it is also possible to have regulatory and municipal adjusment flexibility to authorize innovative solutions. Furthermore, Mercamadrid is also a partner involved in the project, what facilitates the process.

Appropiate and relevant milestones: The D2.1 has been a relevant milestone of the project since the commitment to have a detailed description of the demostrative actions by month 12 of the project has allowed to encourage partners to work intensively. As a result, the technical description of the actions and the required timeline have been determined after a strong collaboration among private and public entities that act as partners in the project.

Consider incentives for mobility services users: Another lesson learnt is the importance to incorporate incentives for the use of the mobility actions in order to maximize their impact. At first, having an application with wallet capabilities will make users feel rewarded with cheaper or even free municipal services but it is not discarded that these measures will have to be maintained in the medium term to ensure a higher use of the service.

Think futher from the very beginning: Last but not least, it has to be highlighted the importance of anticipating the actuations scalability and ensuring that the solutions or actions implemented truly have an impact and can be deployed massively.

6.2. Dresden

Based on the experience so far with the MOBILITIES FOR EU project in Dresden, several valuable lessons have been gained:

Early Citizen Engagement: The early implementation of the Urban Mobility Lab has proven invaluable for citizen information and participation. This foundation allows to conduct needs analyses through surveys and interviews at the project's outset, enabling effective monitoring of acceptance and satisfaction with new technologies throughout the project lifecycle. This approach will contribute to long-term sustainable utilization of the solutions beyond the project duration.

Collaborative Design Process: Collaboration with project partners has significantly enhanced the action design and planning. Through regular discussions and knowledge sharing, the synergies between pilots have been identified and the approach has been refined. Also in the future, insights from the feasibility study (action 5) can provide useful information to other actions to understand the traffic situation in the area and act consequently. This collaborative approach yields more robust designs than working in isolation, as it leverages diverse expertise and perspectives.

Adaptive Planning: During the design phase, challenges were encountered for the implementation of some actions. For instance, it was realized that the original scope of the automated catering logistics (action 4) needed adjustment due to unforeseen technical limitations. By maintaining open communication channels with stakeholders and partners, it was possible to identify these issues early and propose alternative solutions that still align with the project goals.

Scalability Considerations: The design phase has helped to identify actions with potential for upscaling after the project concludes. These are prioritized solutions that demonstrate clear benefits in terms of emissions reduction, improved traffic flow, and enhanced user experience. For example, the integration of sports facilities and traffic management (A3-2) shows promise for expansion to other event-heavy areas of Dresden. Moving forward, it is planed to establish a working group to continuously evaluate the scalability of Dresden actions and identify replication opportunities across the city.

Effective Discussion Formats: It is found that a combination of structured workshops and informal brainstorming sessions yields the best results for action design. Cross-functional teams involving technical experts, city planners, and community representatives have been particularly effective. Furthermore, it has learned to avoid overly technical discussions in broader stakeholder meetings, as these can hinder engagement from non-specialist participants.

Importance of Flexibility: The project has underscored the importance of maintaining flexibility in the approach, being a clear roadmap crucial to progress accordingly. However, this has to be open to adjustments based on emerging data and stakeholder feedback. This flexibility has allowed to optimize the resources and focus on the most impactful actions.

These lessons learned will continue to guide the approach of the ecosystem of Dresden as move forward with the implementation phase of the MOBILITIES FOR EU project in the city.

7. Conclusions and recommendations

Before starting the project MOBILITIES FOR EU, a set of actions was proposed to be implemented in the lead cities of Madrid and Dresden. Once the project began, and with the aim to optimise the performance of the actions and adapt these to the needs from the city and citizens, a process of co-design has been deployed to involve key stakeholders and potential users in the design of the actions to implement, and to higher the success levels of the implementation of these technologies maximizing their impact.

The present document has provided a comprehensive overview of the actions to be demonstrated in Madrid and Dresden as part of the project MOBILITIES FOR EU and specifically covers descriptions of these aspects: solutions to implement and objectives to reach, technical specifications of the solutions, different technical, operational, legal and administrative requirements, partnerships needed, initial financial considerations, implementation plans and potential risk and mitigation actions. The document is the result of the application of a methodology of co-design developed in the project to reach a consensus on the technical specifications and the implementation plans of the actions after the compilation of needs from entities involved in the implementation of the actions as well as other agents and citizens through diverse workshops, questionnaires and interviews.

The UT labs created in Madrid and Dresden have been key for the joint collaboration established, which will continue during whole project duration and in the next months will continue facilitating the configuration of specific details of actions that at this moment have not been closed. The social validation of the action's designs will be also reached by exploring the social acceptance and involvement of citizens in new activities addressed to continue compiling their needs and opinions in further activities. This feedback will be gathered throught activities and local events oragnised in the workframe of the Urban Mobility Labs, established in both cities.

Some lessons learnt have been already obtained during the first 12 months of the project from the lead cities of Madrid and Dresden. Madrid highlights the importance of professional management, a balanced consortium and choosing flexible implementation sites like MercaMadrid to ensure the success of actions execution. Additionally, the strong collaboration among public and private partners and the application of a co-design methodology have been crucial to fine tuning the technical actions to implement and design a detailed action plan. On other side, Dresden notices the suitability of the processes followed to co-design solutions by involving the different partners in structured workshops which has allowed to define technical aspects of the actions to implement and to identify scalable actions for the city beyond the project. Furthermore, the establishment of the Urban Mobility lab in the first stages of the project has ensured the early citizen engagement and compilation of their needs for sustainable long-term use of the solutions to test. Its remarkable how, in both cities, the importance of looking forward from the beginning, thinking in future upscaling of the actions has been detected as a must.

Madrid and Dresden ecosystems will continue working in the definition of the investment plans and business models to implement for the deployment of the actions described in this deliverable, which will be reported in the document D2.2 (Urban Mobility financial plans & BM for Madrid and Dresden) to be submitted at Month 18. By month 39, the required tenders, licenses and permits and the vehicles, infrastructures, systems and services deployed will be also reported, in the deliverable D2.3 (Licenses, tenders, construction and commissioning in Madrid&Dresden).

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📖 European Climate Law (Green Deal)

https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en

📖 "Data Space Support Centre" project, 10/2022-03/2026 (funded by the European Union as part of the Digital Europe Program)

https://dssc.eu

📖 Dresden Transport Services company (Dresdner Verkehrsbetriebe AG.

www.dvb.de/de-de/die-dvb/technik/fahrzeuge/bus

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