



EMT MADRID



**EMT Madrid, proyectos de automatización**

*Madrid, abril de 2026*

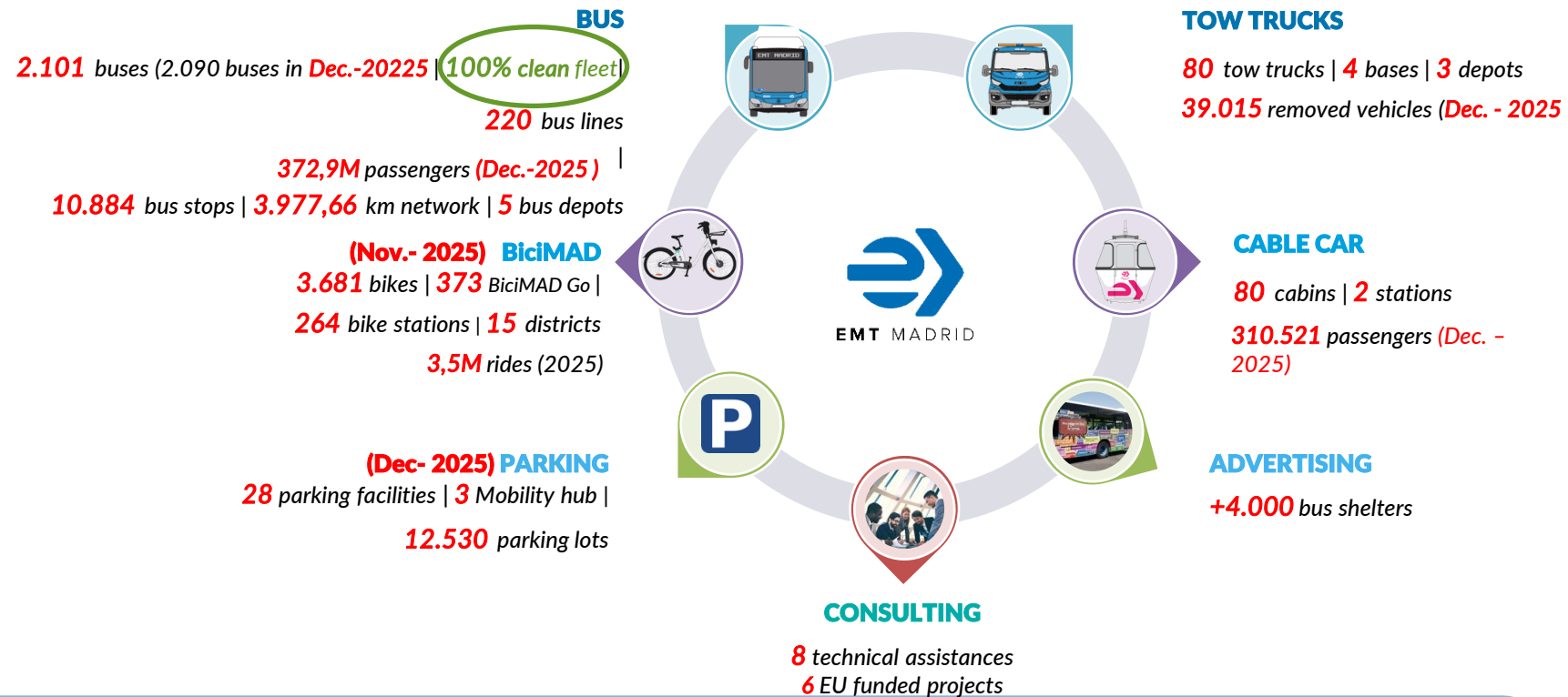
*Julián del Olmo Perandones – Jefe de División de Material Móvil en EMT Madrid*

# EMT MADRID



EMT is the **reference of surface mobility** in the city of Madrid. It counts with 9.923 workers, 7 business lines and 5 Bus Depots that enable the company to provide integrated and client-oriented services that foster a **sustainable and efficient mobility**.

## Assets EMT 2025



# Autobus project

- Mini bus GULLIVER

2007

## OPERATING TEMPERATURE RANGE

240-330°C

## COMERCIAL SPEED

6 km/h

## DIMENSIONS

5,3 x 2,0 x 2,9 m

## AVERAGE CONSUMPTION

0.9 kWh/km



# Autobus project

Gulliver

2007



## BATTERIES

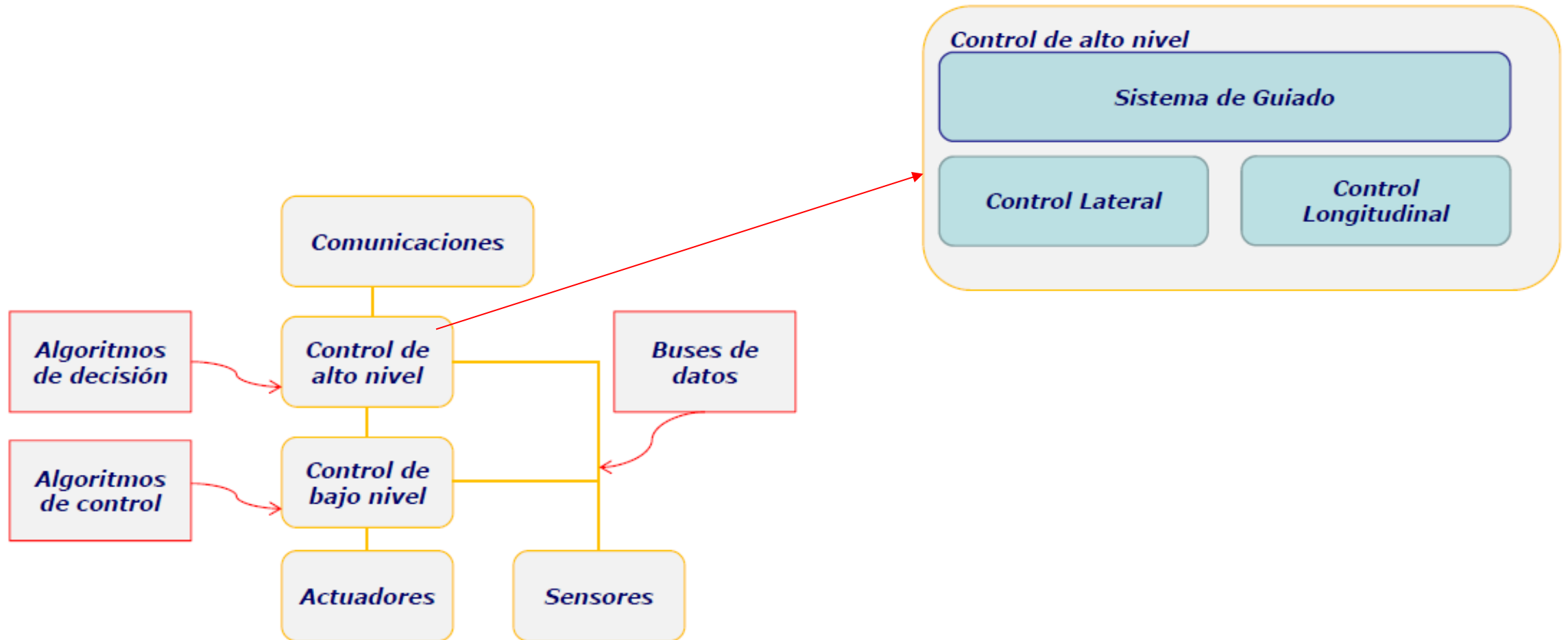
Na-NiCl<sub>2</sub> 85 Vcc  
27,2 Kw 72 kWh

## CHARGER

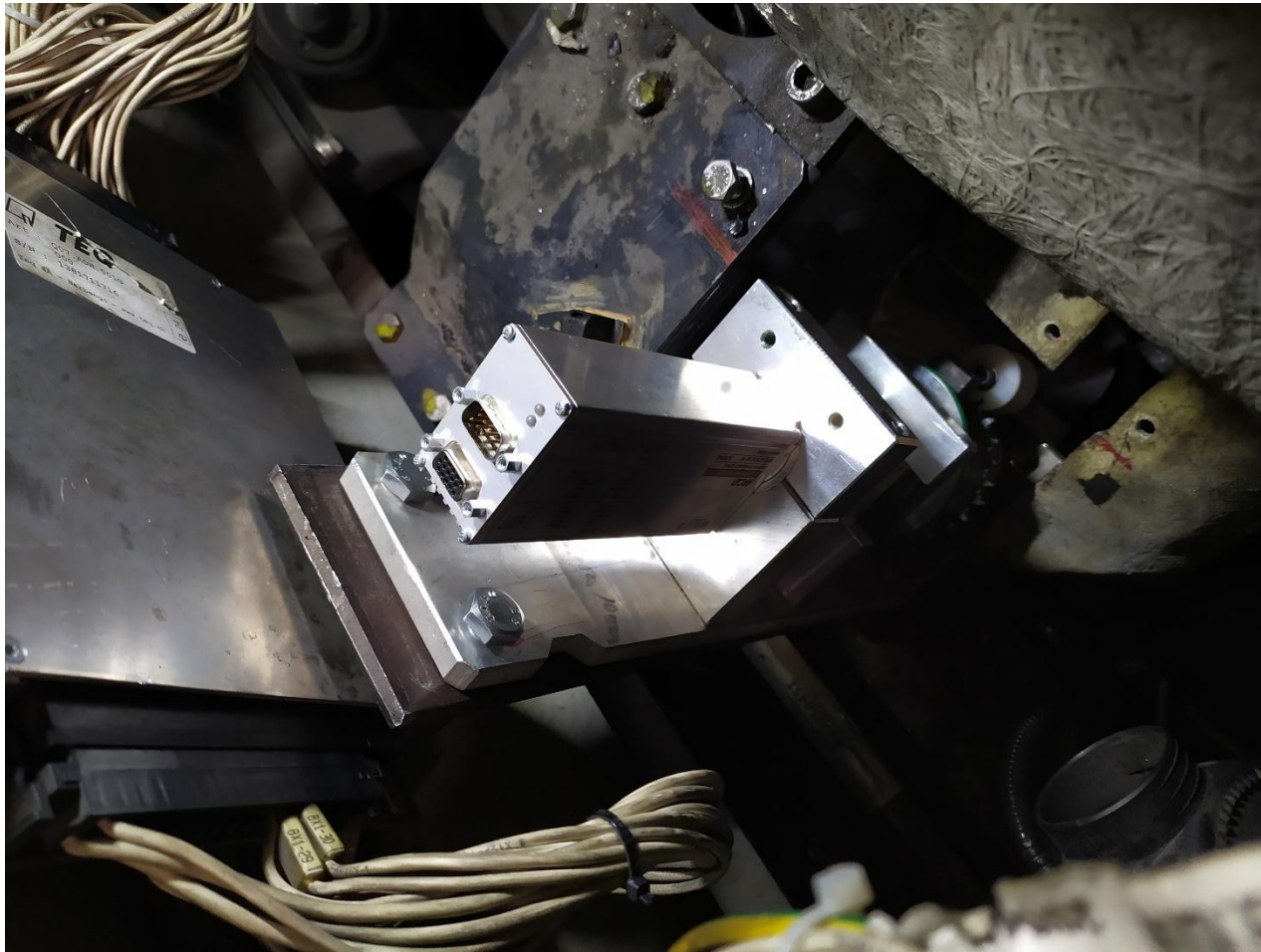
23kW charger:

- two 380V charge connector
- one 220V preheating connector

# Arquitectura de control



# Bajo nivel: Dirección



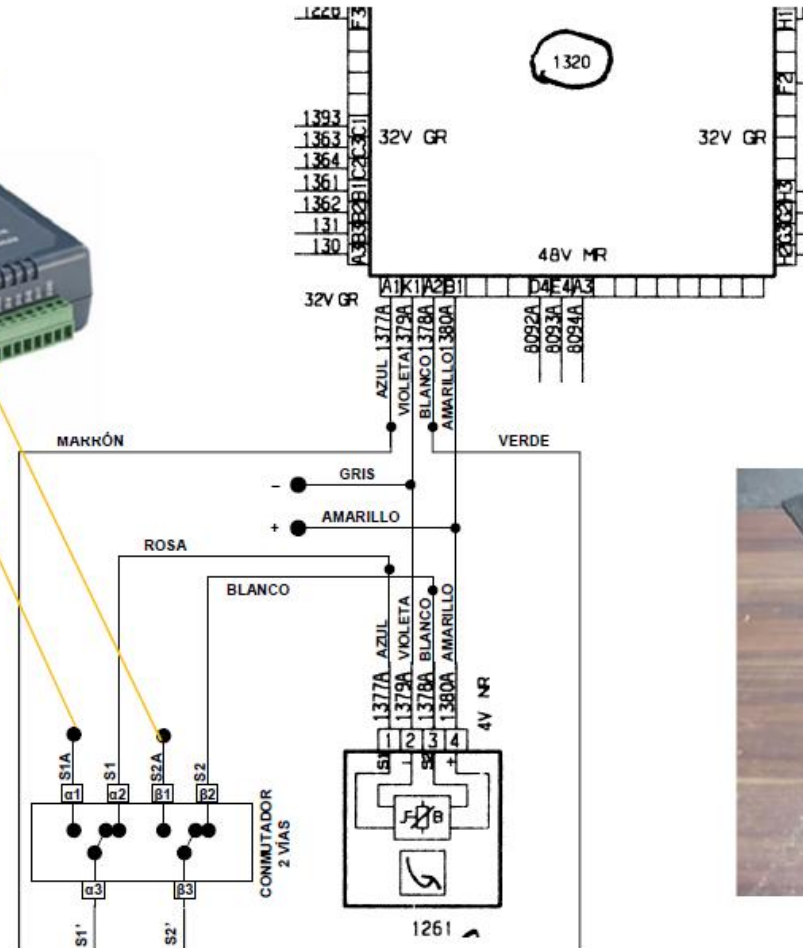
Sensor de giro

# Bajo nivel: Freno



# Bajo nivel: Acelerador

❖ Acelerador



# Percepción: GPS

- Nos da posición, velocidad, aceleración y orientación.
- Válido para el control longitudinal.
- Cartografía.
- GPS+IMU
- SET-UP



# Percepción: Cámaras y Lidar





# PCs para operación Proyecto SHOW

- 3 PCs
- Procesador Intel Core i7-8700T (Coffee Lake) 2.4 GHz - 35W
- 64 GB de RAM separado en 2 de 32 GB SO-DIMM DDR4 2666 - ECC Wide Temp
- -Almacenamiento primario de 1 TB M.2 SSD - Wide Temp
- -Almacenamiento secundario de 1 TB M.2 NVMe SSD - Wide Temp para guardar datos
- -Tarjeta de video dedicada Nvidia GeForce RTX 2700.

**SOPORTABA CÁMARA Y LIDAR.**

**1 PC para decisión y control**

**1 PC para visión artificial y fusión sensorial**

**1PC para controlar bajo nivel y coordinar el resto**



# PCs para operación

- 2 PCs
- Procesador Intel Core i7-8700T (Coffee Lake) 2.4 GHz - 35W
- 64 GB de RAM separado en 2 de 32 GB SO-DIMM DDR4 2666 - ECC Wide Temp
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- -Almacenamiento secundario de 1 TB M.2 NVMe SSD - Wide Temp para guardar datos
- -Tarjeta de video dedicada Nvidia GeForce RTX 2700.

1PC para Lidar y GPS

1 PC para controlar el bajo nivel y decisión y control.





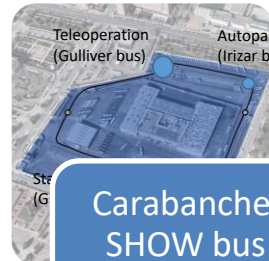
**SHOW&AU  
TO-BUS  
started**  
Jan'2020



**Madrid City  
Council  
negotiations**  
Feb'2021



**AUGMENTED  
CCAM started**  
Sept'2022



**Carabanchel  
SHOW bus  
depot pilot**  
Nov'22 –  
Nov'23



**BACSI event  
(400 pax)**  
Oct'2023



**EMW  
(280 pax)**  
Sept'2024



**Mobilities  
for EU  
starts**  
Jan'2024



**Final review  
SHOW (5,963  
pax)**  
Nov'2024



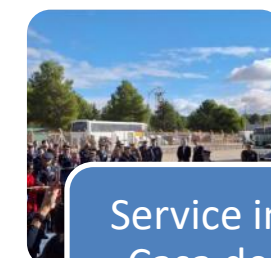
**Approval of  
Madrid  
Mobility  
Sandbox**  
Oct'2024



**New  
Regional  
Mobility Law  
announced**  
Jan'2025



**Piloting  
ACCAM use  
cases**  
March-May  
2025



**Service in  
Casa de  
Campo**  
Sept'2025



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The AUGMENTED CCAM Project has received funding from the European Union's Horizon Europe programme under Grant Agreement No. 101060717. The contents of this presentation reflect only the authors' view. The European Climate, Infrastructure and Environment Executive Agency (CINEA) and the European Commission are not responsible for any use that may be made of the information it contains.



**MOBILITIES  
FOR EU**



**Co-funded by  
the European Union**

# Proyecto AUTO-BUS

- Proyecto iniciado en Enero de 2020 y financiado por el CDTI
- Coordinado por EMT en colaboración con INSIA y CAR CSIC
- Estudio del impacto en la operativa de un centro de operaciones de autobuses autónomos
- Acciones:
  - Autoparking
  - Teleoperación
  - Bajo demanda a los distintos lugares de mantenimiento



POLITÉCNICA



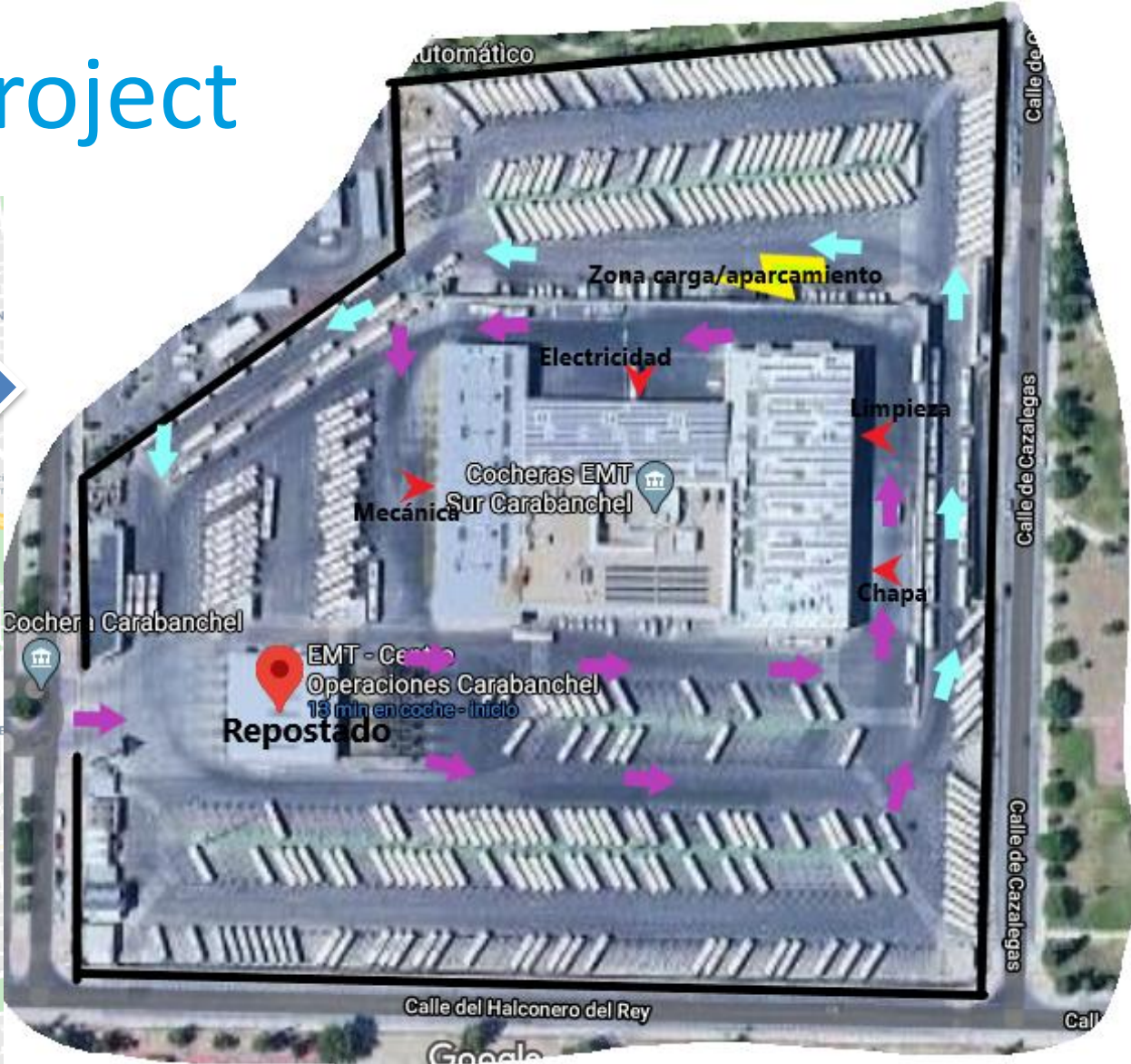
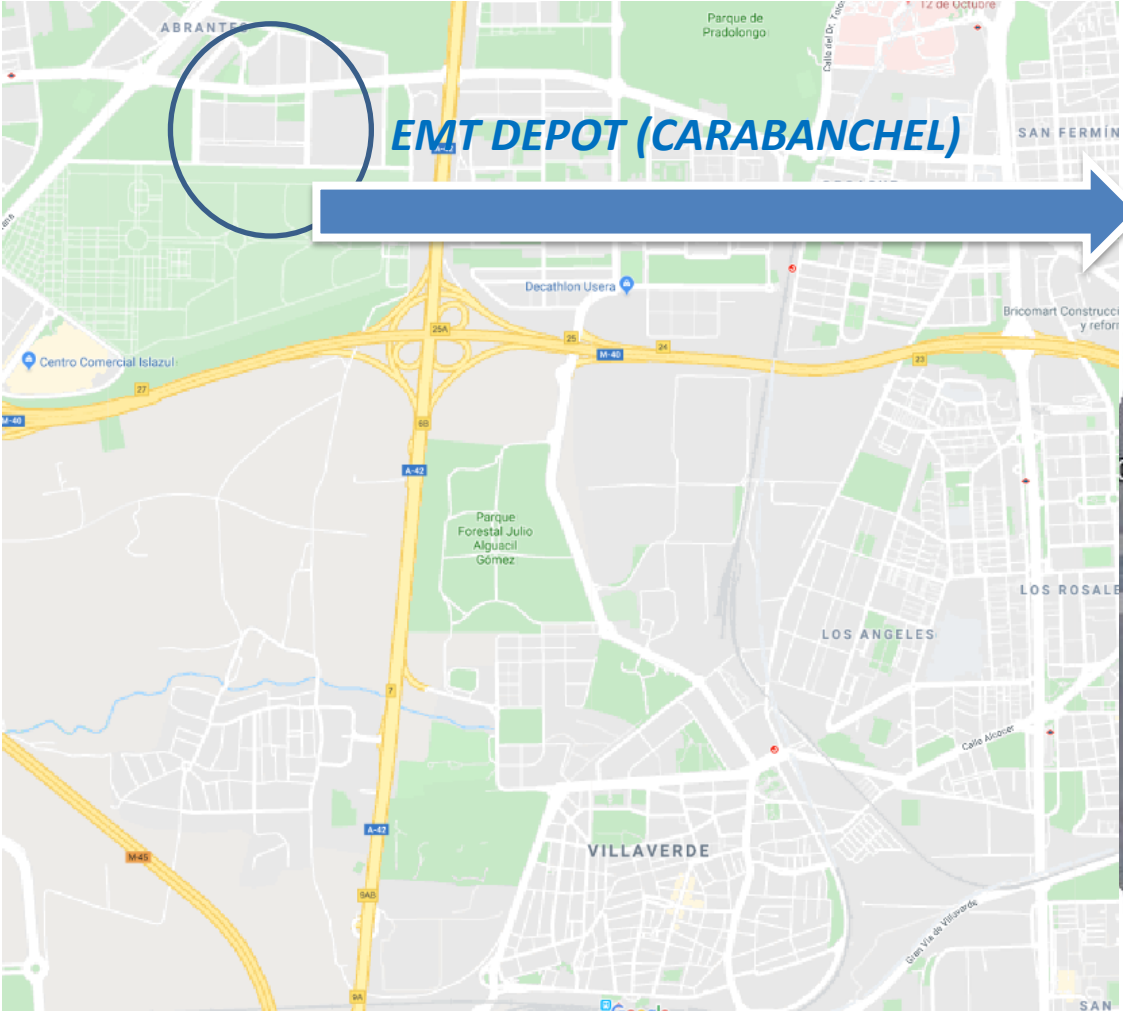
INSIA



CENTRO DE AUTOMÁTICA Y ROBÓTICA



# Autobus project



# HITOS Y DESVIACIONES

Tareas	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
<ul style="list-style-type: none"> <li>Actividad 1: Especificación de requisitos y descripción del Caso de Uso.</li> </ul>	■									
<ul style="list-style-type: none"> <li>Actividad 2: Análisis de los vehículos y el entorno operacional.                             <ul style="list-style-type: none"> <li>Estudio de vehículo</li> <li>Desarrollo del mapa electrónico del entorno</li> </ul> </li> </ul>	■									
<ul style="list-style-type: none"> <li>Actividad 3: Automatización e instrumentación de los vehículos.                             <ul style="list-style-type: none"> <li>Automatización</li> <li>Instrumentación de percepción</li> </ul> </li> </ul>		■	■	■	■	■				
<ul style="list-style-type: none"> <li>Actividad 4: Desarrollo de software de percepción y control                             <ul style="list-style-type: none"> <li>SW de percepción (marcas, obstáculos, líneas).</li> <li>SW de localización (exteriores e interiores).</li> <li>SW de guiado y navegación (incluyendo la evitación de obstáculos).</li> </ul> </li> </ul>			■	■	■	■	■	■	■	
<ul style="list-style-type: none"> <li>Actividad 5: Desarrollo de sistema de monitorización y control externo al vehículo.                             <ul style="list-style-type: none"> <li>Monitorización y Sistema de comunicaciones</li> <li>Teleoperación</li> <li>SW de gestión de vehículos</li> </ul> </li> </ul>					■	■	■	■	■	
<ul style="list-style-type: none"> <li>Actividad 6: Pruebas del sistema                             <ul style="list-style-type: none"> <li>Entorno controlado</li> <li>Depósito real de Carabanchel</li> </ul> </li> </ul>					■	■	■	■	■	■

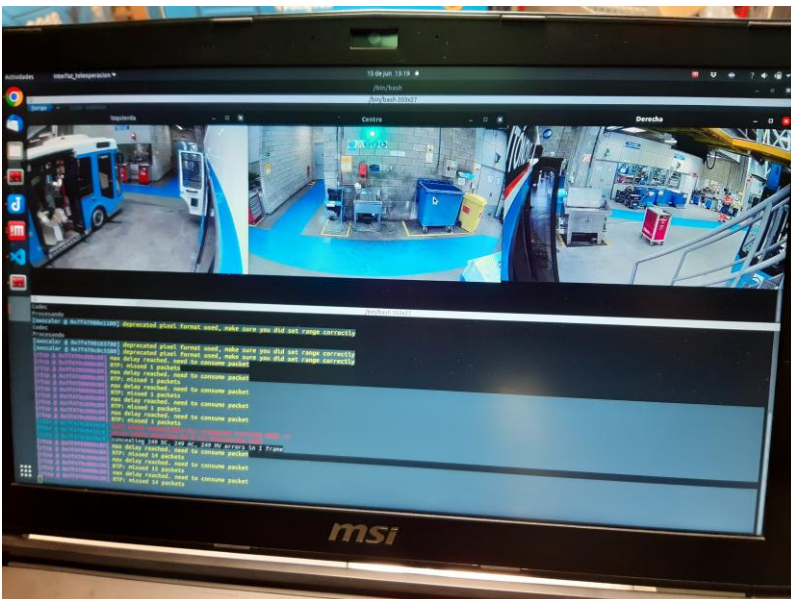
Desviación hito-1
  Desviación hito-2

# PRESUPUESTO

Hito-1		Hito-2			TOTAL PROYECTO			
	SOLICITUD	REALIZADO		SOLICITUD	REALIZADO		SOLICITUD	REALIZADO
Personal	310.408,00	238.510,22	Personal	130.309	208.028,90	Personal	440.717	446.539,12
Materiales	188.000,00	0	Materiales	0	114.593,67	Materiales	188.000	114.593,67
Colaboraciones externas	330.912,00	120.332,66	Colaboraciones externas	30.082	240.667,32	Colaboraciones externas	360.994	360.999,98
Gastos Generales	59.165,00	45.460	Gastos Generales	24.837	39.651	Gastos Generales	84.002	85.111,00
Otros Gastos	0	0	Otros Gastos	0	1550	Otros Gastos	0	1.550,00
	888.485	404.302,88		185.228	604.490,89		1.073.713	1.008.793,77
Nº HORAS								
No titulados Universitarios	1.809,00	963,00		0,00	589,00	No titulados Universitarios	1.809,00	1.552,00
Doctores/as	135,00	190,00		0,00	0,00	Doctores/as	135,00	190,00
Titulados superiores	1.960,00	2.200,00		1.448,00	2.188,00	Titulados superiores	3.408,00	4.388,00
Titulados medios	3.916,00	1.631,00		1.370,00	1.324,00	Titulados medios	5.286,00	2.955,00
	7.820,00	4.984,00		2.818,00	4.101,00		10.638,00	9.085,00

# Teleoperación

- Movimiento en remoto de vehículos.
- Zona acotada y cobertura WIFI



# SHOW in a nutshell

Deployment of shared, connected and electrified automated vehicles to advance sustainable urban mobility

- Coordinated by UITP
- 70 partners from 13 EU-countries
- January 2020 – December 2023
- 30 Mio. EUR funding from European Commission (GA No. 876630)

SHARED automation Operating models for Worldwide adoption



# Real-life services on open roads

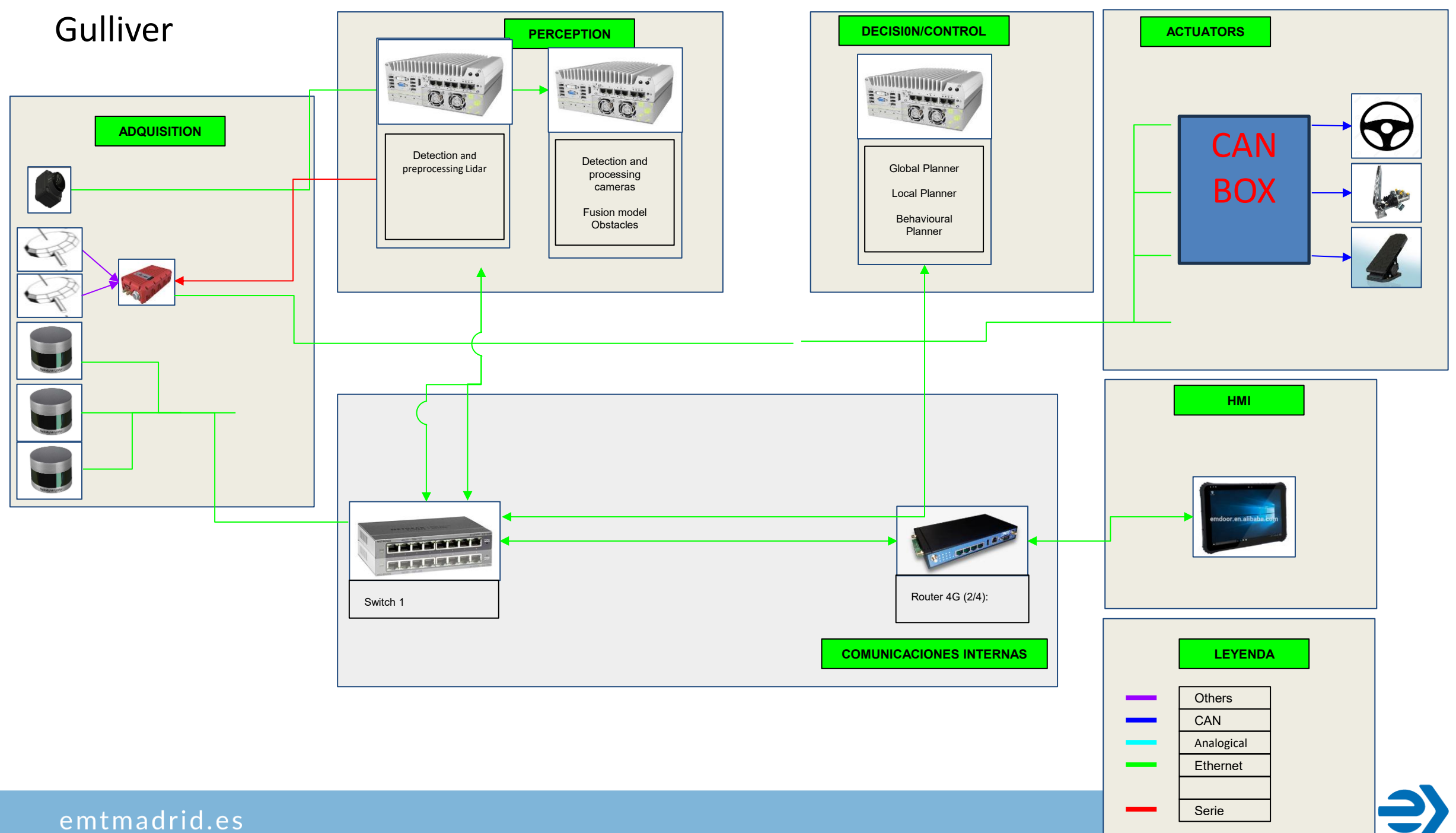


## Madrid Mega Site Scenario

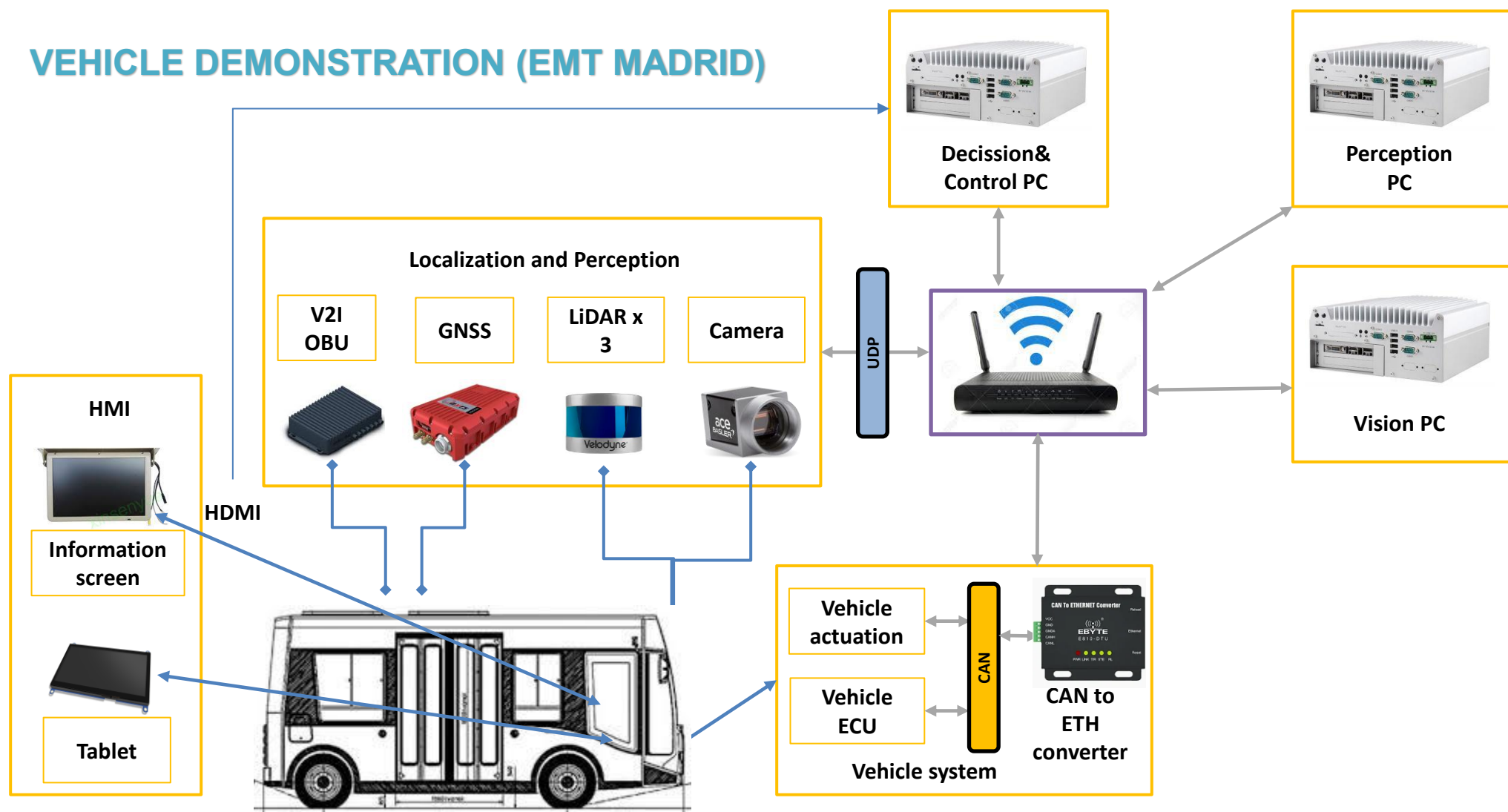
- Open traffic (La Nave->Villaverde Bajo Station)
- Semi-Controlled area (Carabanchel EMT Depot)
  - Autonomous route
  - Teleoperation



# Gulliver



# VEHICLE DEMONSTRATION (EMT MADRID)





# Proyecto europeo SHOW



# **SHOW- SHared automation Operating models for Worldwide adoption**

- **Proyecto europeo de más de 70 socios donde se pretende poner en servicio vehículos autónomo a gran escala.**
- **EMT participa como socio en uno de los 5 Megasites en los que se distribuye.**
- **Partners:**
  - **TECNALIA** Pilot leader and CAM technology provider
  - **IRIZAR** Electric bus OEM
  - **EMT** Madrid Public transport
  - **INDRA** IT provider

# Vis

## Overall vision

- **Automated Bus Depot** as a mean to optimize management and increase efficiency
- **CCAM contributing** to foster research and innovation, in urban open traffic

## In the project

- Enable and provide safe, sustainable and integrated people mobility, by
  - deploying a **mixed** CAVs fleet
  - following **complex** trajectories
  - in **various** traffic conditions
- Driving in **two scenarios**
  - Bus depot - semicontrolled

• Urban - open traffic  
emtmadrid.es

# MADRID Ecosystem

## Partners:

1. **EMT Madrid:** PTO and minibus demo operator
2. **INDRA:** Communication provider
3. **IRIZAR:** OEM and 12m eBus demo operator
4. **TECNALIA:** Mega Site leader and SAEL4 technology provider



## Stakeholders:

- **Madrid City Council:** Public administration in charge of the city. Facilitator & enabler of the Madrid Mega site
- **DGT:** National Traffic Authority
- **AEVAC:** Spanish Association for Autonomous mobility.



# Objetivos

Habilitar y proporcionar movilidad segura, sostenible e integrada de personas, mediante el despliegue de una flota mixta de 5 AV (vehículos de pasajeros) siguiendo trayectorias complejas con maniobras difíciles (intersecciones y rotondas), en varias condiciones de tráfico.

Tendrá un alto TRL (8), y se espera integrarlo en la plataforma MaaS-Madrid o API de la EMT para su gestión.

# Casos de uso

- Centro de operaciones de Carabanchel
- Lanzadera autónoma en recorrido con tráfico real entre La Nave y el metro Villaverde Bajo-Cruce

# SHOW: Madrid Mega pilot – mapa de casos de uso

The image features a central map of Madrid with several key locations highlighted by blue circles and text labels. The locations are: **EMT DEPOT (CARABANCHEL)**, **METRO STATION (VILLAVERDE BAJO)**, and **INNOVATION HUB (LA NAVE)**. The word **VILLAVERDE** is also written in large blue letters to the right of the map. The map shows major roads like the A-42 and M-40, and parks like Parque de Pradolongo and Parque Forestal Julio Abascal. Surrounding areas like ORCASITAS, LOS ROSALES, and LOS ANGELES are also labeled.



emtmadrid.es

# SHOW: Madrid Mega pilot – Carabanchel Centro de Operaciones

- Alto nivel autónomo (SAE 4).
- Área semi-controlada
- Interacción con otros autobuses y vehículos no autónomos.
- Depósito moderno con diferentes tecnologías de bus (GNC, híbrido, eléctrico)
- Interacción con las operaciones diarias en el depósito (maniobras, movimiento de mercancías, personas, etc.)
- Los autobuses deben ingresar al depósito y encontrar su estacionamiento.
- Los autobuses deben ser llamados a diferentes áreas de trabajo.
- Teleoperación desde la oficina del personal.
- 2 autobuses de diferentes fabricantes:
  - 1 x Irizar i2e
  - 1 x Tecnobus Gulliver (microbus)



# SHOW: Madrid Mega pilot – La Nave Boetticher-Villarver Bajo


- Itinerario: La Nave (Centro de innovación) – Villaverde bajo-Cruce Metro
  - 800 m por trayecto (línea de 1,6 km)
  - Trafico abierto
  - Rotondas
- C-ITS (concepto CCAM)
  - Comunicación híbrida (RSU-ETSI ITS G5 - 5G \*)
  - V2V
  - V2I
- 2 autobuses de diferentes fabricantes:
  - 1 x Irizar i2e
  - 1 x Tecnobus Gulliver (microbus)
- Coche de 2 pasajeros
  - 2 x twizy (Tecnalia)
- Servicio MaaS Madrid



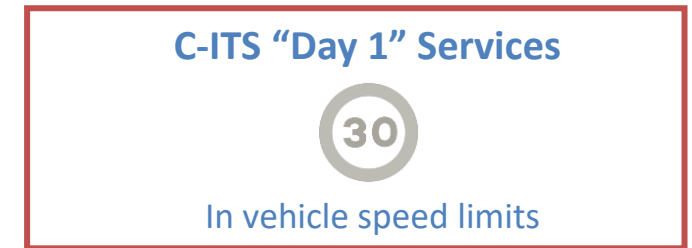
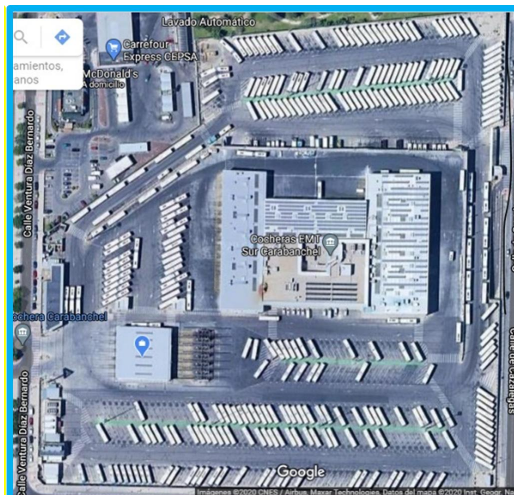
# Lessons learned: Infrastructure deployment

## Carabanchel

Provide information through V2X communications in real time is **highly relevant** for the development of autonomous driving

- CCAM platform (Platform HORUS owned by Indra)
- Development of C-ITS services
  - Speed limits information 
- Implementation of DENM messages
- RSU installation (ETSI ITS G5)

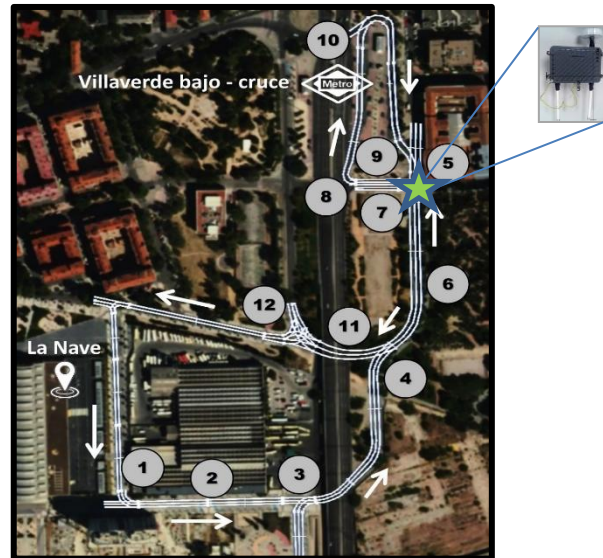
### Key elements



# Lessons learned: Infrastructure deployment

## Villaverde

### V2X equipment location



### Connected intersection environment



### V2X services/messages implemented

#### MAPEM (Map extended Message):

- Position and location information
- Allowed manoeuvres / movements
- Type of road and lane
- Road and traffic lights ID

#### SPATEM (Map extended Message):

- Traffic light cycle
- Traffic light real time status
- Traffic light cycle reliability
- Traffic light ID

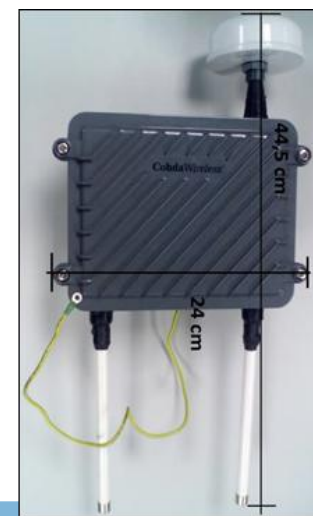
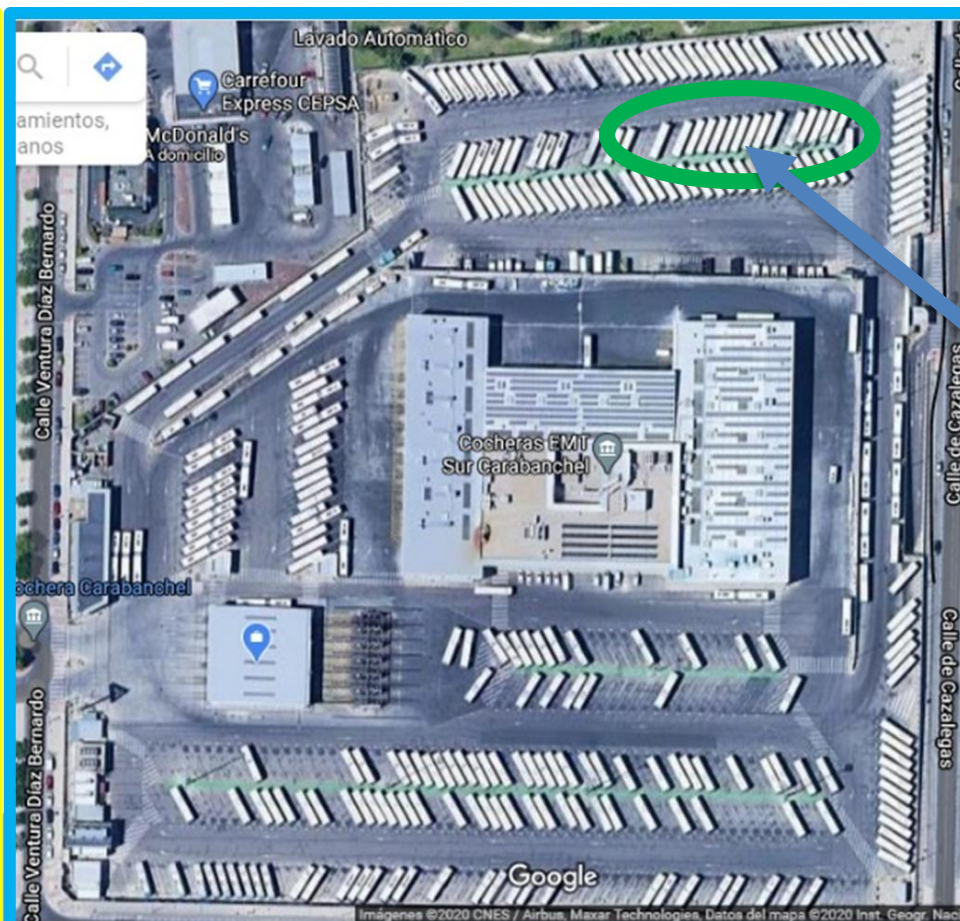
# Infraestructura

## C-ITS

- RSU-ETSI ITS-G5 & cellular communication
- C-ITS instance implemented and services will be based in CAM/DENM/MAP/SPAT messages

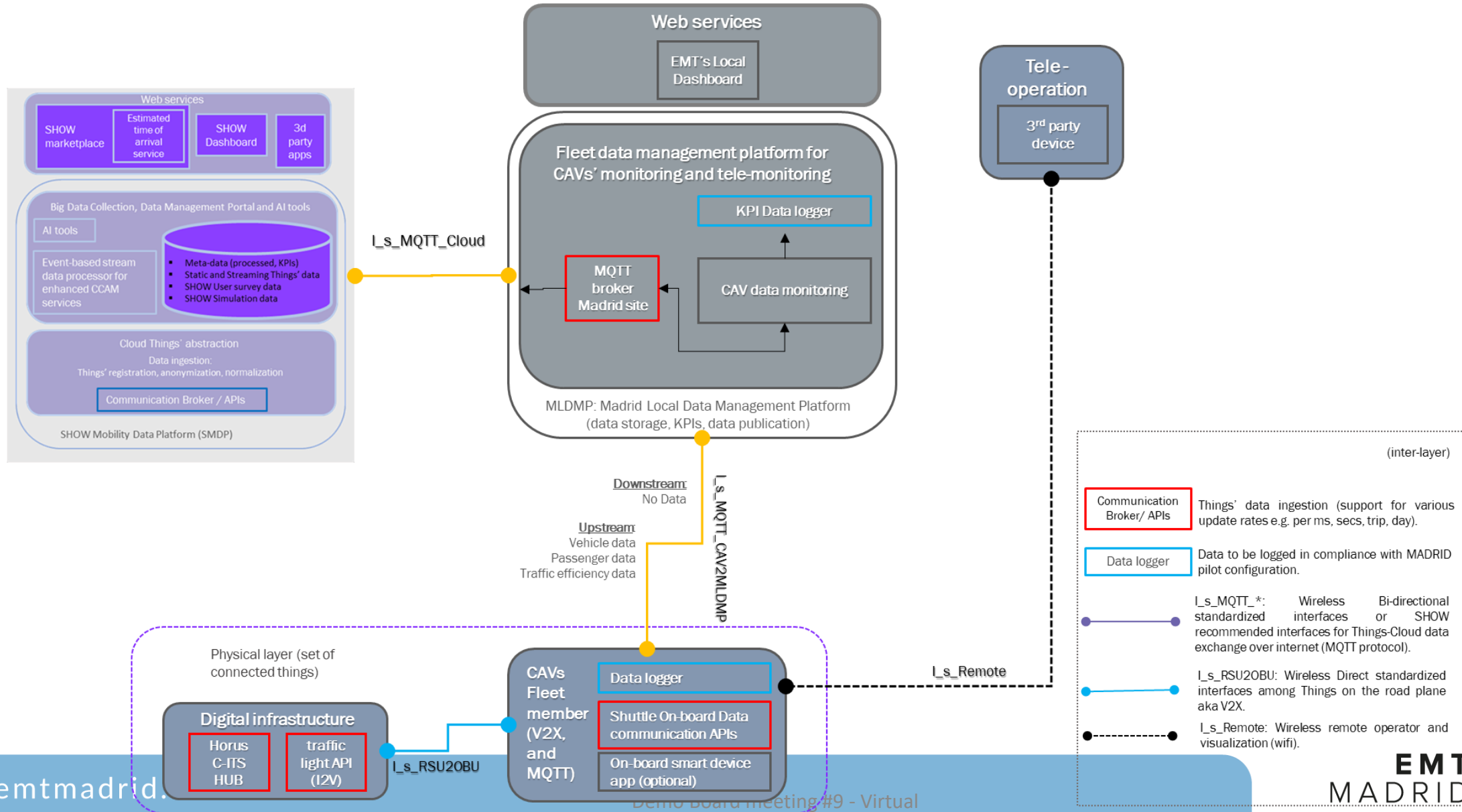
## Traffic lights (Villaverde)

- Possible integration with C-ITS module
- Sharing traffic light cycle with AV (V2I)



5G

# Madrid – ARCHITECTURE



# Scenario #1: Carabanchel, EMT bus depot



**Use Cases:** UC1.1 (normal conditions), UC1.2 (complex conditions), UC1.3 (interfacing other road users), UC1.6 (mixed flows), UC1.7 (teleoperation), UC1.8 (platooning), UC1.10 (MaaS), UC3.1 (demand response), UC3.3 (autoparking), UC3.5 (automated depot management)

## Service

- 5 stops service
- Teleoperation
- Platoon
- Autoparking
- DRT

## Fleet

- 2 Renault Twizy, L4
- 2 Microbus Gulliver, L4
- 1 Irizar 12m i2ebus, L4

## Comms. channel

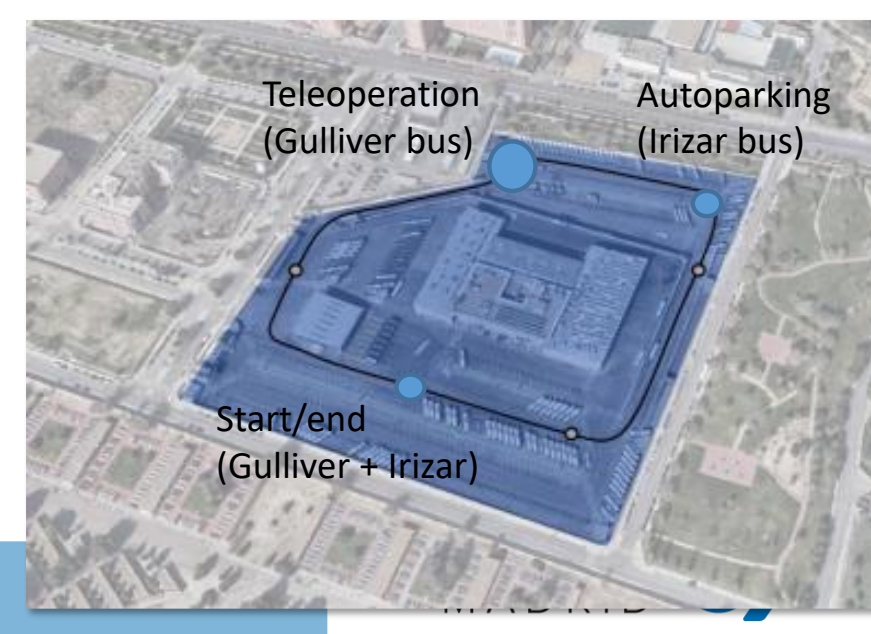
- Madrid LDMP
- Network-based IDS (Intrusion Detection System)

## Target passengers:

- EMT employees and visitors

## Key PDI

- CCAM infrastructure
- V2X (ETSI ITS G5) connectivity

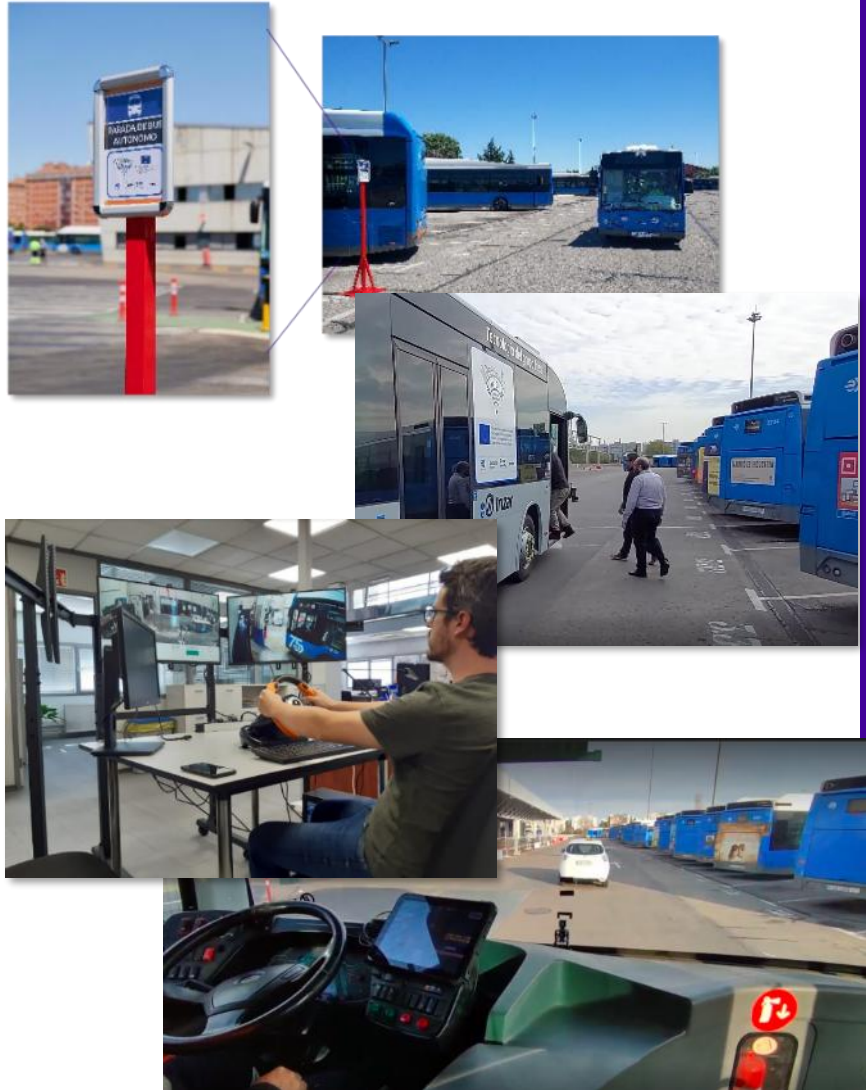


# Scenario #1: Carabanchel, EMT bus depot

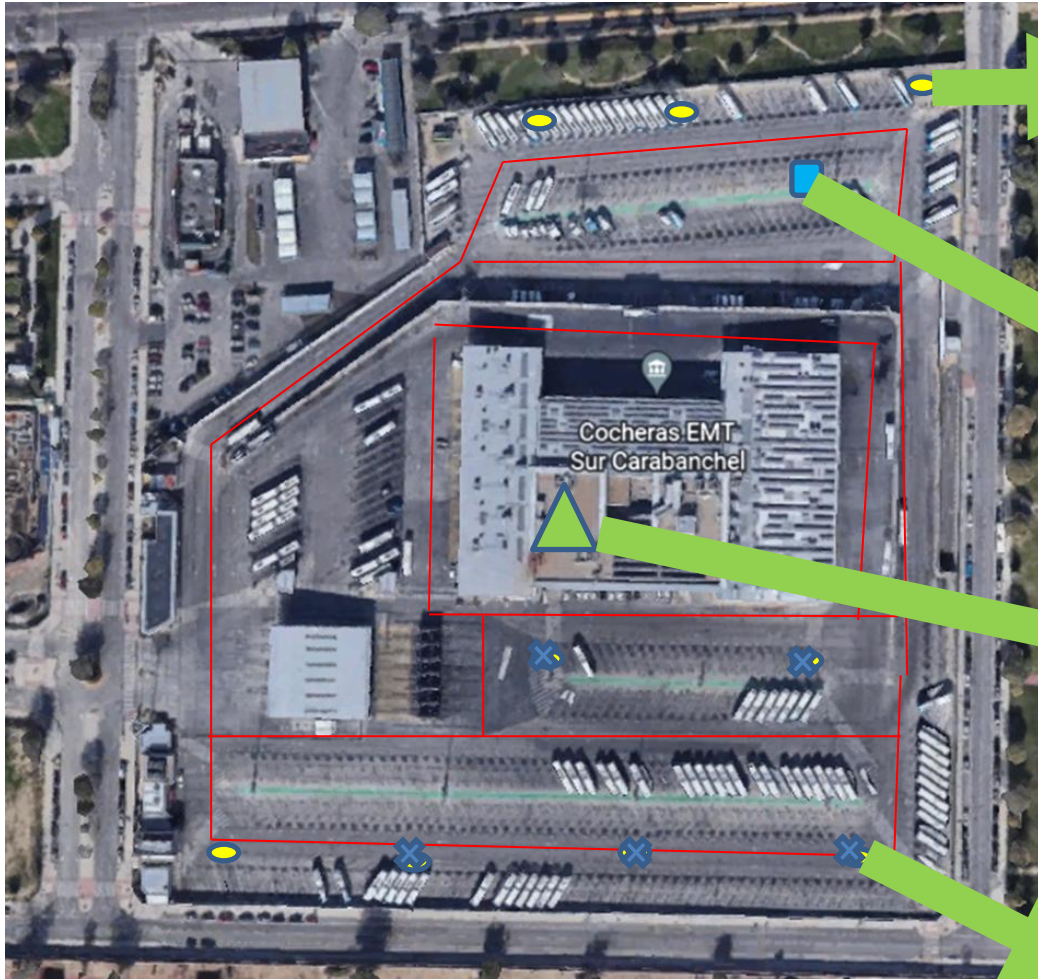


Provided support of CCAM infrastructure, 3 electric buses demonstrate:

- **5 stops service**
  - Gulliver-1 and i2ebus, on an 800m route
  - connect main Carabanchel POIs bus depot (65.000 m<sup>2</sup>)
  - traffic conditions: bus dominant, VRUs and mixed traffic
  - providing transport for employees and visitors
  - regulated sticker to comply with GDPR
  - 1Q satisfaction
- **Teleoperation**
  - Gulliver-2 remote control
- **Platooning**
  - i2ebus (follower) and Zoe
- **Autoparking**
  - i2ebus at located parking slots



# Teleoperation: Putting into service



WiFi.P.



R.S.U.



TELEOPERATION CONTROL CENTER



WiFi.P. AUX.



# Madrid Megasite U.C. 1.7 TELEOPERATION

# Scenario #2: Villaverde, urban open traffic



**Use Cases:** UC1.1 (normal conditions), UC1.2 (complex conditions), UC1.3 (interfacing other road users), UC1.6 (mixed flows), UC1.10 (MaaS)

## Service

- 5 stops service

## Fleet

- 1 Microbus Gulliver, L4
- 1 Irizar 12m i2ebus, L4

## Target passengers:

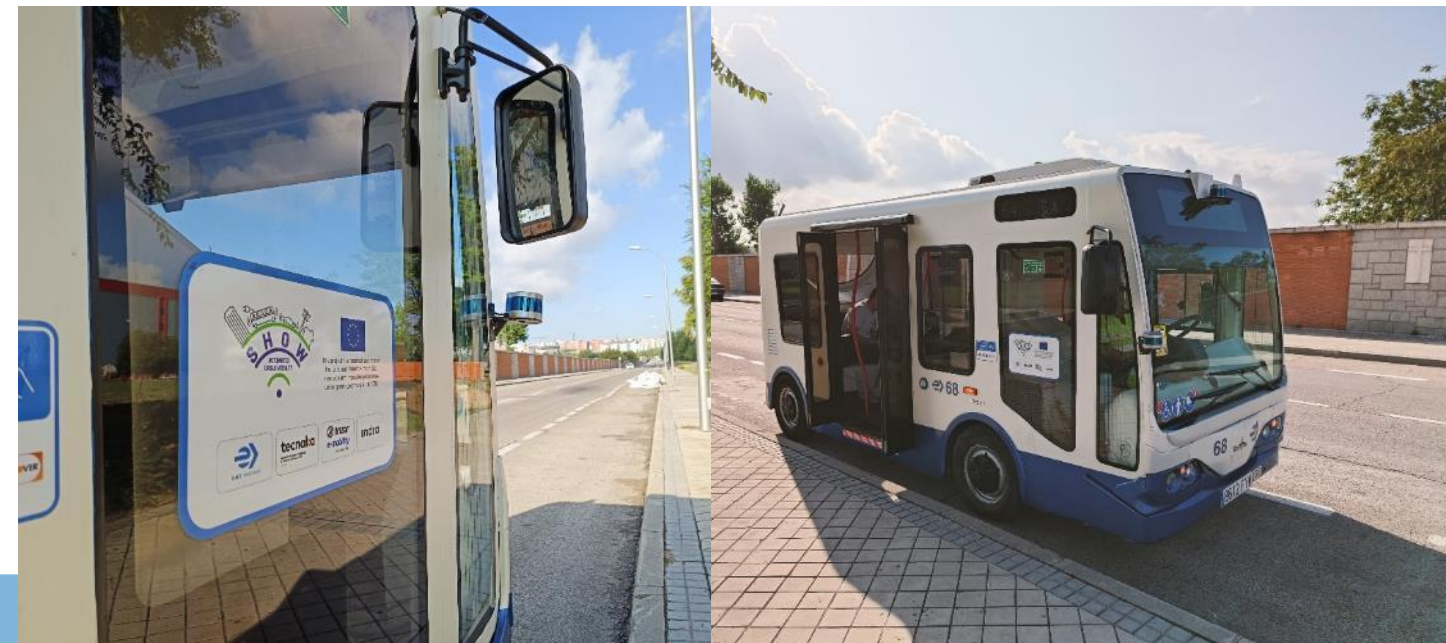
- Commuters, passers-by and EMT employees

## Key PDI

- CCAM infrastructure
- V2X (ETSI ITS G5) connectivity

## Comms. channel

- Madrid LDMP
- Network-based IDS (Intrusion Detection System)

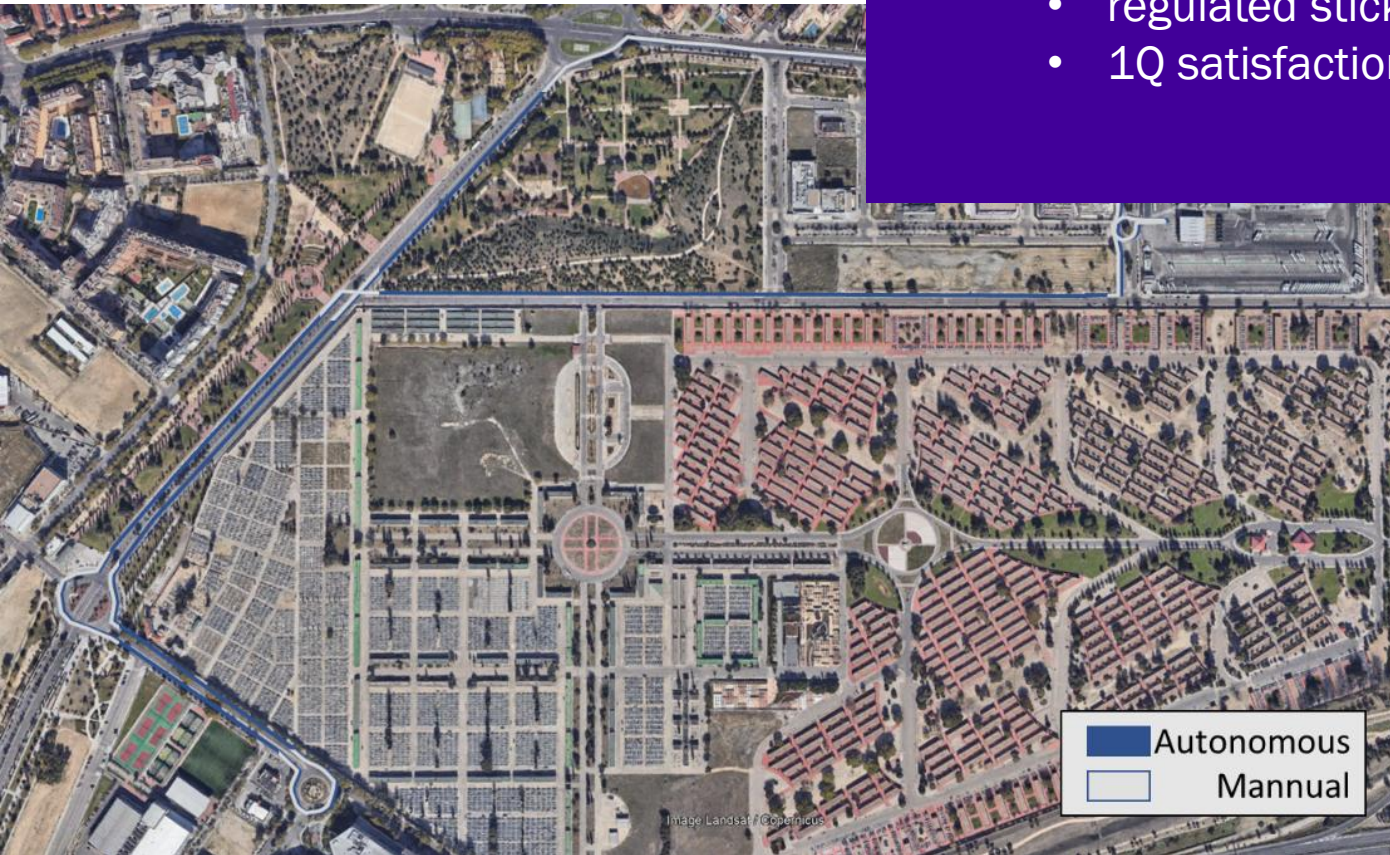


## Scenario #2: Uurban open traffic



Provided support of CCAM infrastructure, 2 electric CAVs

- 5 stops service
  - traffic conditions: mixed traffic flow, urban open traffic
  - Gulliver minibus and 12m i2ebus, on a 4 km route
  - providing PT for EMT employees, commuters and passers-by to a mall
  - regulated sticker to comply with GDPR
  - 1Q satisfaction QR survey



New itinerary (connecting a Mall), mixing autonomous and manual mode driving  
Currently in technical verification (perception)  
Municipality permit: waiting final concession

Both i2eBus and Gulliver:

- Have MOT permit already
- Short predemo phase during Nov-Dec '23. testing LDMP data flow (dashboard)

# KEY FEEDBACK–SCENARIO #1: CARABANCHEL

## From stakeholders

- From PTO: Scaling up potential. Therefore, ongoing conversation with OEMs to test further solutions
- From OEM: Potential for new business lines. Effort to be focused on industrialization and deployment



## From employees

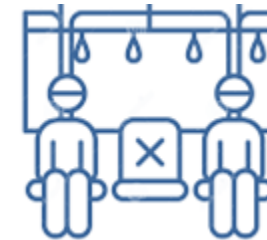
- High interest in jumping on board and experiencing the ride.
- Safety drivers: general acceptance
- Training sessions is crucial
- Rather good, despite the fact of being a PTO with more than 7,000 bus drivers

**Start date**

November 2022



**6 safety drivers**  
(Sept. '23)



**5,960 passengers**  
(Sept. '23)

Oct 2023 end of Demo: **11 months of operation**

# Business Models in Madrid



## Relevant BM: **BM2 – Automated bus depot management**

- **Employees acceptance** (specially amongst bus drivers) is wider than expected (probably due to the perception that a wider and more general automation is still a way ahead)
- Potential **savings in non-productive** hours (estimated in 3,337 hours/month/bus depot, around 108,000€/month/bus depot)
- **Low cost/benefit ratio for adapting existing non automated buses** (around 26% of the initial cost of an e-bus plus the cost of the e-bus itself)

# Expected Impacts, in Madrid

Main focus in Madrid is to **optimize bus depot operations** while at the same time making autonomous vehicles more attractive to general public by deploying PT services.

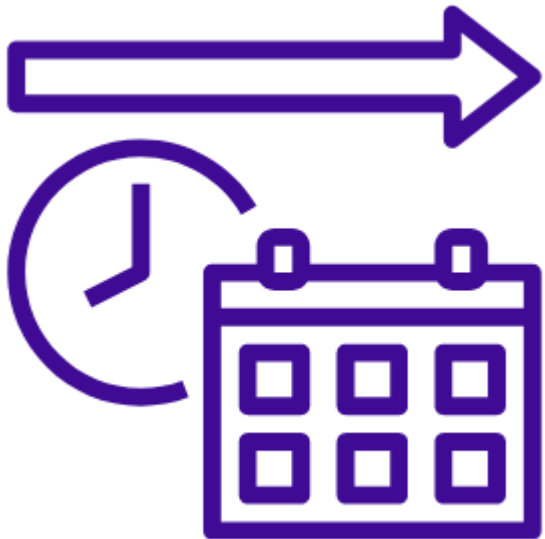
The main impact is the learning and research on how automation can help **improving efficiency** in bus depot management.

Further impacts for Madrid:

- On mobility:
  - Strengthening public transport** with flexible on-demand services
  - Development of a Mobility Sandbox in the city of Madrid
- On depot management:
  - New possibilities** including automated charging processes
- On market boost
  - EMT ongoing conversations with OEMs in order to **test new automated bus models**. Market needs to provide automated solutions
- On public-private cooperation
  - Further research** and innovation projects with local stakeholders



# Beyond the project



Exploring potential **addition of automated charging processes** by using inverted pantographs

Further development of services in **additional projects**



PTO already convinced that autonomous mobility solutions are mature enough to be deployed in **semi controlled environments** (bus depots).

However, there are still uncertainties about open traffic situations

**Aligned** with Madrid City Council strategies and overall vision (Strategic plan 21-25)

The OEM is committed to further develop the technology in order to improve reliability, reduce the cost of integrating the solutions into the vehicle and service PTOs to help them streamline their operations.



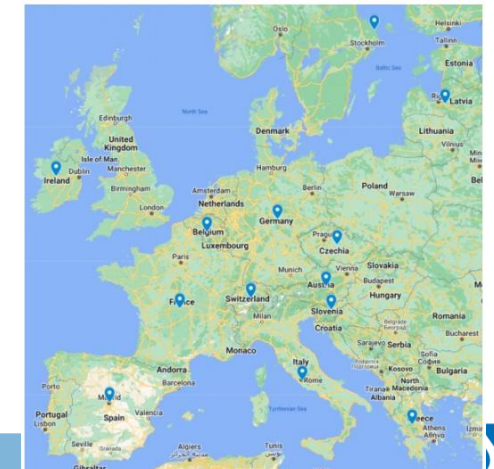
# AUGMENTED CCAM

Augmenting and Evaluating the Physical and  
Digital Infrastructure for CCAM deployment

# AUGMENTED CCAM IN A NUTSHELL

Augmenting and evaluating the Physical and Digital infrastructure for CCAM deployment

- **Objective:** Enabling Connected, Cooperative and Automated Mobility in real traffic conditions by understanding, harmonising and evaluating in an augmented manner adapted and novel support solutions of Physical, Digital and Communication (PDI) infrastructure, to advance its readiness for large scale deployment of CCAM solutions for all
- **Coordination:** FEHRL
- **Starting date:** 01/09/2022
- **Duration:** 44 months
- **Budget:** 11 M€ (9M€ financed)
- **Consortium:** 26 partners from 13 EU countries.
- **Spanish cluster:** ETRA, EMT, TECNALIA



# INTRODUCTION TO AUGMENTED CCAM

- **Autonomous and connected mobility** aims to improve the safety of all road users.
- To achieve this, it is essential to **extend the areas of operation of autonomous vehicles (ODD)**. One of the factors preventing their extension is the **lack of preparedness of the Physical, Digital and Communications Infrastructure (PDI)** of the transport network.
- The **lack of information and guidance to network operators** to determine the priority actions to be taken paralyse the upgrading of the network.
- **AUGMENTED CCAM** aims to address the shortcomings and challenges of modernising the infrastructure. The project aims to **understand, harmonise and evaluate** the proposed solutions for the support of the Physical, Digital and Communications Infrastructure. In a way that enables **large-scale development of CCAM solutions**.

# PDI SOLUTIONS

UC1: Emergency Vehicle approaching [EDI]

**UC2: Equipped VRU protection [ETRA]**

UC3: Non-equipped VRU protection [EDI]

**UC4: Traffic Management Optimizations based on Vehicle Probe Data from CCAM [ETRA]**

UC5: Localisation of assets and CCAM vehicles [LMT]

UC6: Minimum Risk Manoeuvre [VALEO & COFIROUTE]

UC7: Optimised Logistics Operation of AVs Leveraging on Advanced Digital Technologies and Digital Twin solutions [Wings]

UC8: Insertion [VALEO & COFIROUTE]

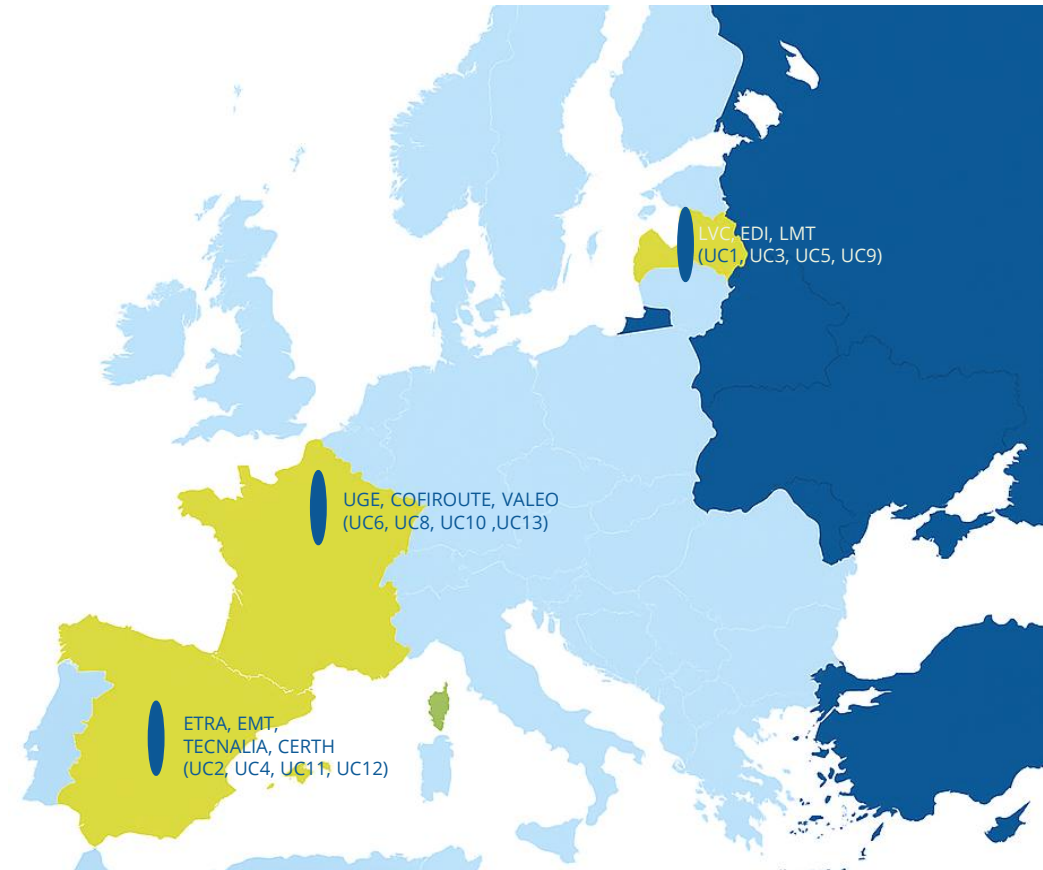
UC9: Temporary Road Works [EDI]

UC10: Insertion [UGE]

**UC11: Emergency Vehicle approaching [ETRA]**

**UC12: UAV-based non-equipped VRU Protection [CERTH]**

UC13: Road Workers in the Field [UGE]



# PDI enabled solutions of Madrid site

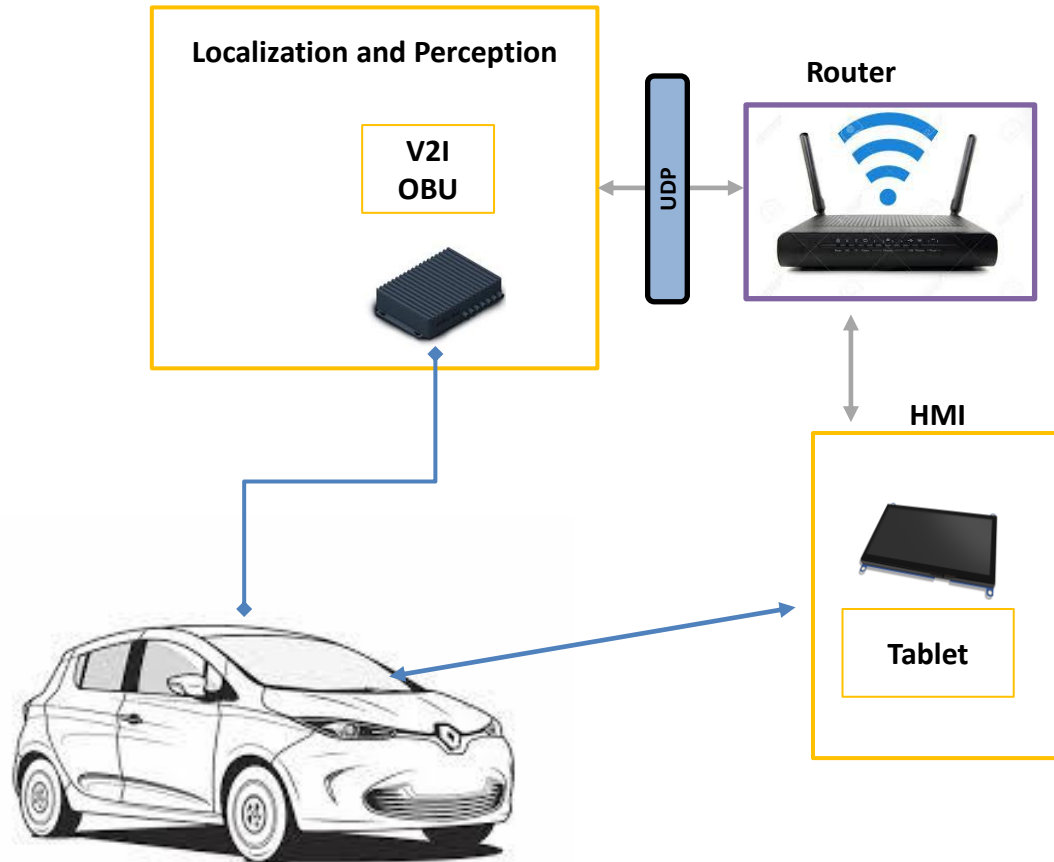
**Equipped VRUs protection [ETRA]:** The infrastructure will be monitoring the VRUs nearby Carabanchel's depot gate through AI Cameras and the Digital Twin will evaluate the potential risks. The CAVs will be alerted of the presence of VRUs and VRUs will be alerted of the presence of the CAV via a VRU app developed for the service and a wearable device..

**Traffic Management Optimization [ETRA]:** This PDI Solution aims to benefit from the information that CVs can provide to the Traffic Management System (TMS) to enhance traffic network efficiency. CVs will share their location and speed in real-time, along with their Origin and Destination. Thus, the TMS will be able to adapt to the reported traffic conditions in real time, apart from offering the CVs real time information on their route.

**Emergency Vehicle approaching [ETRA]:** This solution will help emergency vehicles to get to their destination in the shortest possible time thanks to the optimal route recommendations, the signal priority at crossings and the sending of alerts to other connected vehicles.

**UAV-based non-equipped VRU protection [CERTH]:** This PDI solution enhances the safety of VRUs in closed areas of interest. A camera-equipped UAV monitors the area on demand and detects and tracks VRUs. Thus, CAVs become aware of occluded VRUs. In parallel, the AI based risk assessment will dynamically estimate and classify collision risks providing feedback to the mission planner of the CAVs.

# VEHICLE DEMONSTRATION CONNECTED ARCHITECTURE (EMT MADRID)

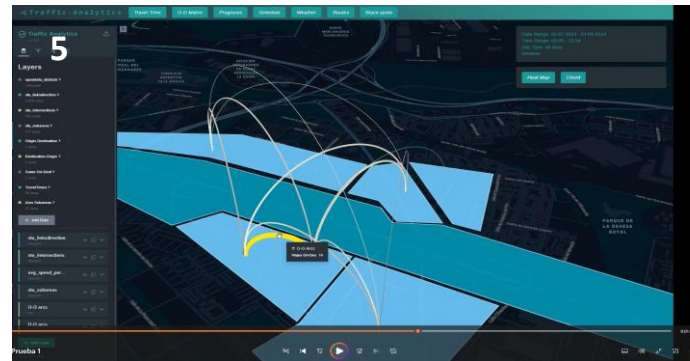


# Pilot site overview

**Key features:** urban environment, with a speed limit of 30-50 km/h and a moderate traffic intensity. EMT bus depot is a semi-controlled private environment.

**Existing PDI within the pilot:** Traffic lights, Traffic controllers.

**Additional/adapted PDI for ACCAM:** Cameras, RSU, router, Collision Risk Estimator module, VRU app, drone, Digital Twin of Use Cases 2, 4 & 11.



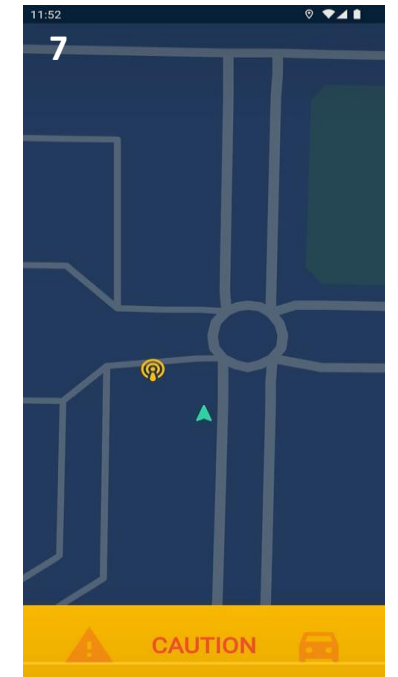
**Image 5:** Screenshot from Digital Twin showing generation of O-D matrices.



**Image 4:** Screenshot from camera showing VRU detection and trajectory estimation during technical validation of UC2 at EMT depot.



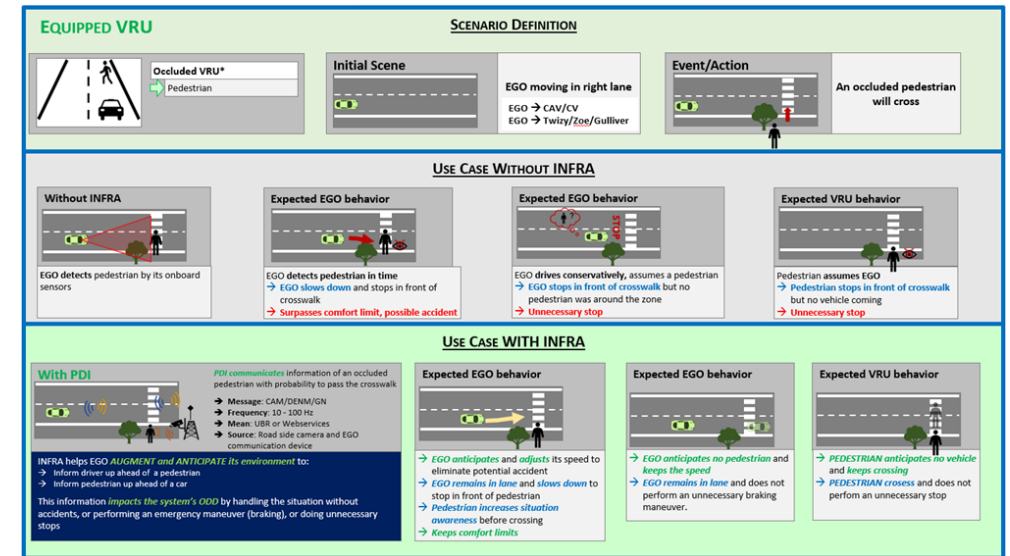
**Image 6:** Drone flying during validation of Use Case 12.



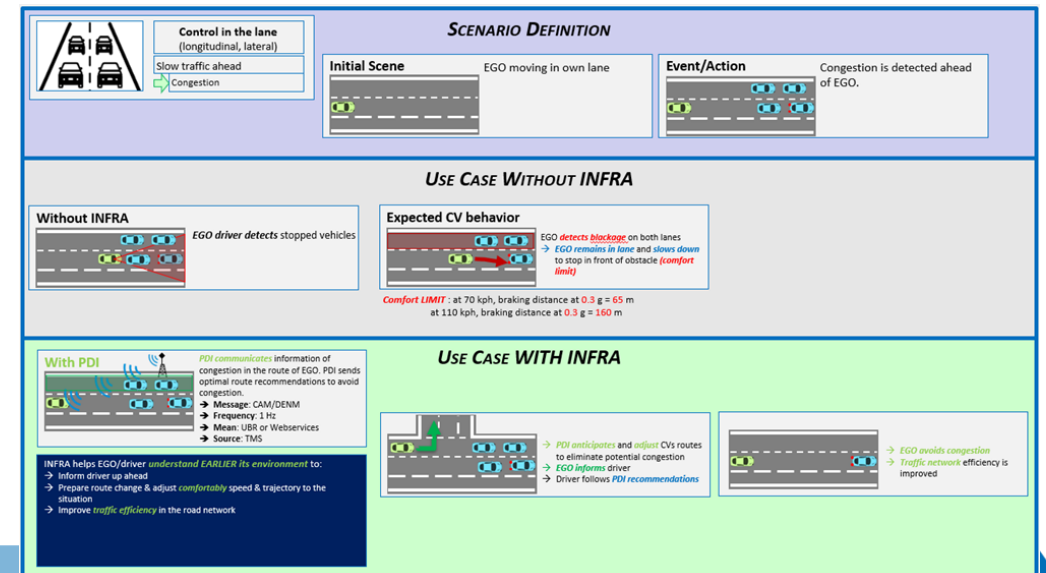
**Image 7:** Screenshot from VRU app showing VRU and CAV position and risk warning for Use Case 2.

# What

**UC2: Equipped VRUs protection [ETRA]:** The infrastructure monitors the VRUs nearby Carabanchel EMT depot's gate through Cameras and the Collision Risk Estimator module evaluates the potential risks. CAVs are alerted of the presence of VRUs and VRUs are alerted of the presence of the CAV via the VRU app developed for the service, installed on the VRUs smartphone.



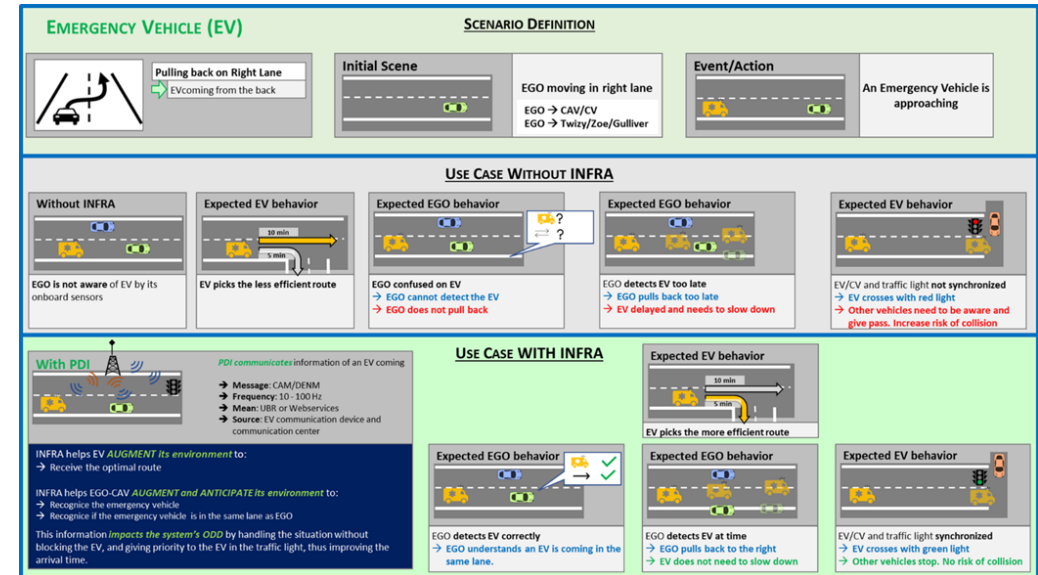
**UC4: Traffic Management Optimization [ETRA]:** This PDI Solution aims to benefit from the information that CVs can provide to the Traffic Management System (TMS) to enhance traffic network efficiency. CVs will share their location and speed in real-time, along with their Origin and Destination and will be provided with dynamic optimal route recommendation.



# What

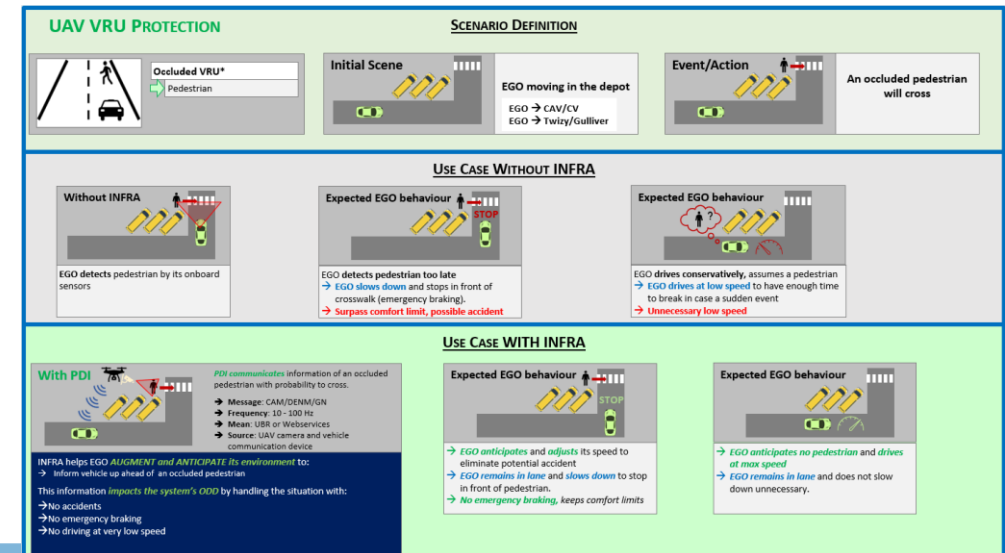
## UC11: Emergency Vehicle approaching [ETRA]:

This solution aims to help emergency vehicles to get to their destination in the shortest possible time thanks to optimal route recommendations, signal priority at crossings and the sending of alerts to other connected vehicles in its route.



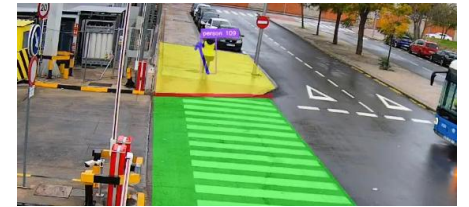
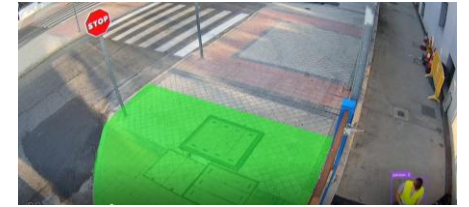
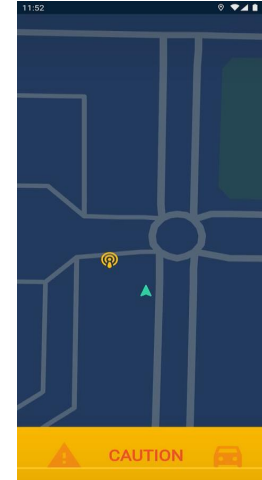
## UC12: UAV-based non-quepped VRU protection [CERTH]:

This PDI solution enhances the safety of VRUs in closed areas of interest. A camera-equipped UAV monitors the area on demand and detects and tracks VRUs. Thus, CAVs become aware of occluded VRUs. In parallel, the AI based risk assessment will dynamically estimate and classify collision risks providing feedback to the mission planner of the CAVs.

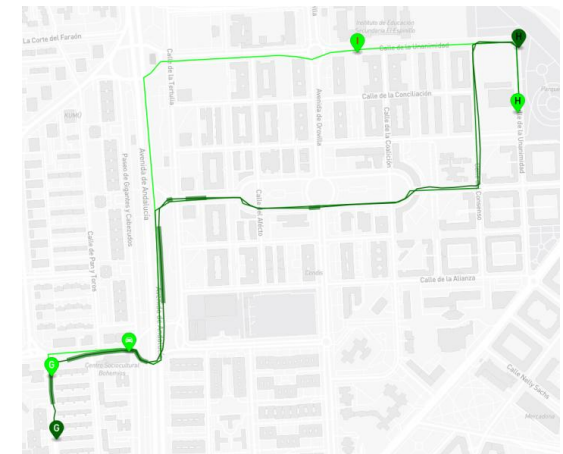
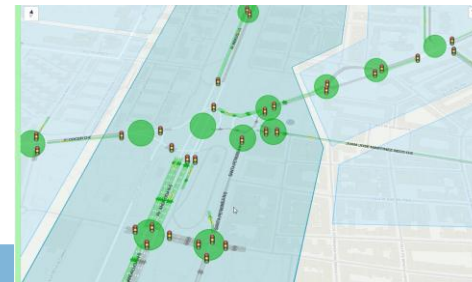
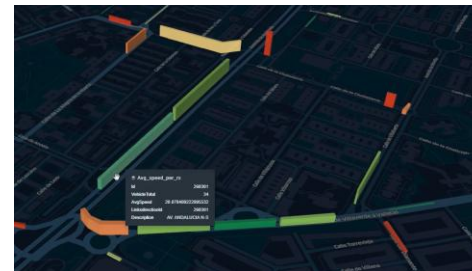
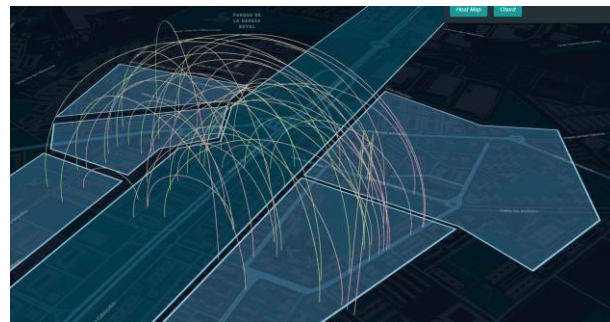
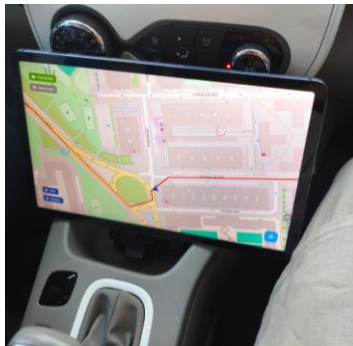


# PDI for CCAM (1/2)

## UC2: Equipped VRUs protection [ETRA]

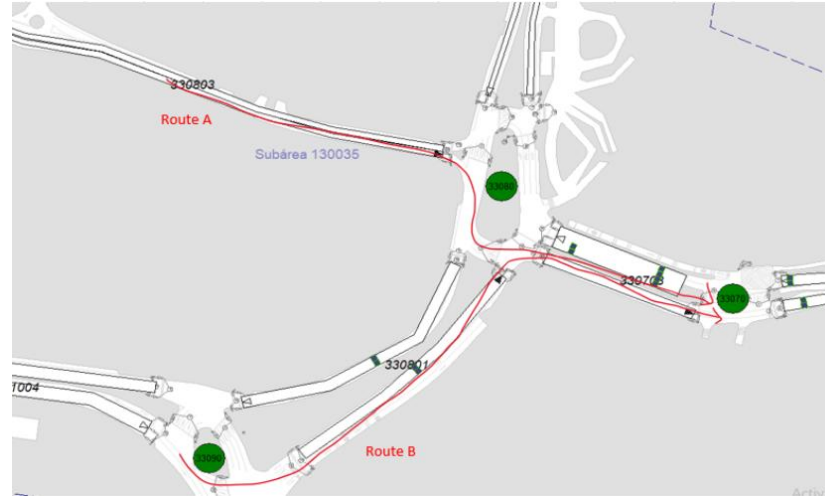
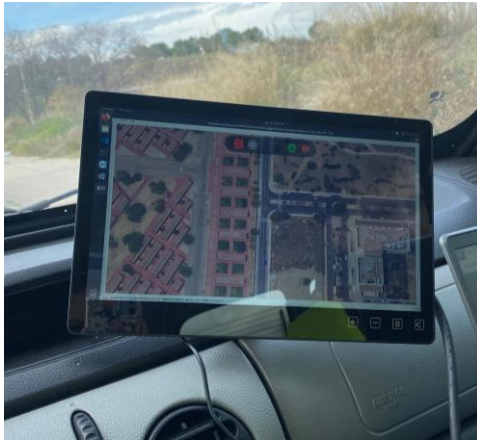


## UC4: Traffic Management Optimization [ETRA]:



# PDI for CCAM (2/2)

## UC11: Emergency Vehicle approaching [ETRA]:



## UC12: UAV-based non-qiipped VRU protection [CERTH]



# Demonstrators



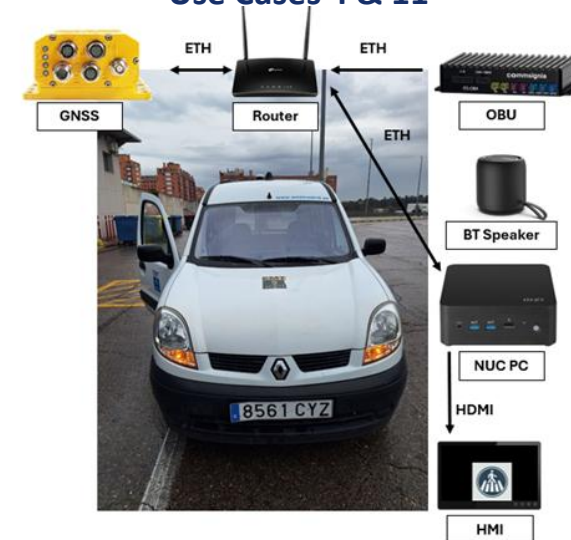
CAV (SAE L2) – Renault Twizy (Tecnalia)  
Use Cases 2 & 12



CV (SAE L0) – Ford Raptor (EMT)  
Use Cases 4 & 11



Emergency Vehicle (SAE L0) – Tow truck (EMT)  
Use Cases 11



CV (SAE L0) – Renault Kangoo(EMT)  
Use Cases 2, 4, 11 & 12

# Pilots – Equipped VRU protection

1 <sup>st</sup> PILOT ROUND	2 <sup>nd</sup> PILOT ROUND
28 – 30 January 2025	24 – 27 February 2025
4 VRUs*	15 VRUs (10 for CAV scenarios; 5 for CV scenarios)
2 Safety Drivers*	2 Safety Drivers*
2 CV Drivers*	5 CV Drivers

\* Users internal to the project.



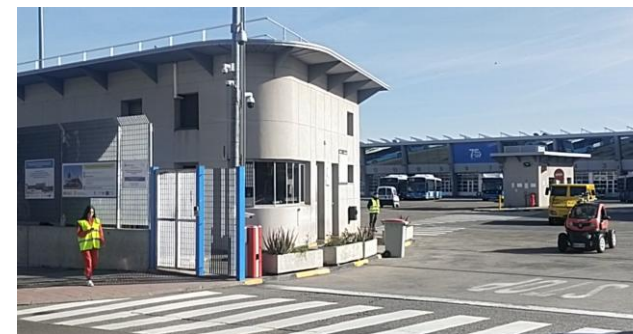
**AUGMENTED  
CCAM**

**UC2 -  
EQUIPPED VRUs  
PROTECTION**

**etra | +D** Spanish Site  
Augmenting and Evaluating the  
Physical and Digital Infrastructure for  
CCAM deployment

 **Funded by European Union.**  
The AUGMENTED CCAM Project has received funding from the  
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Agreement No. **101069717**

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Scenario 1: VRU about to cross and vehicle approaching.



Scenario 2: VRU crossing and vehicle approaching.



Scenario 3: VRU crossing or about to cross and no vehicle approaching.

# Pilots – TM optimisation

1 <sup>ST</sup> PILOT ROUND	2 <sup>ND</sup> PILOT ROUND
10 - 12 February 2025	24 – 26 March 2025
1 CV Drivers *	3 CV Drivers
1 TM Operator *	1 TM Operator

\* Users internal to the project.



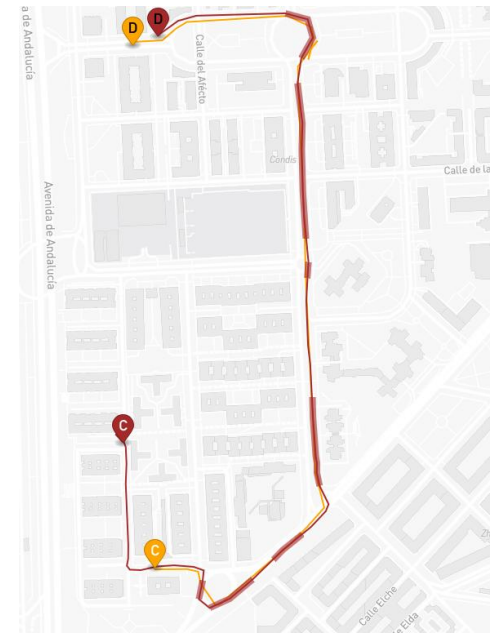
**AUGMENTED CCAM**

**UC4 - TRAFFIC MANAGEMENT OPTIMIZATION**

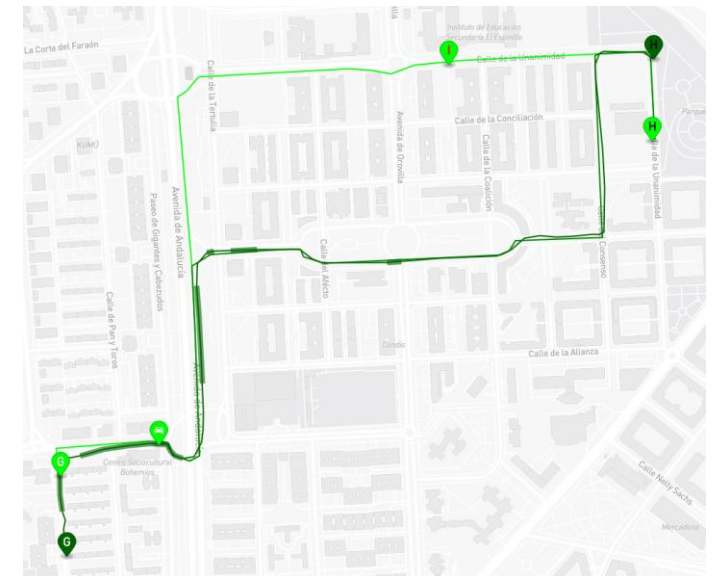
**etra|+D** Spanish site  
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Scenario 1: Optimal route recommendation



Scenario 2: New incident in planned route of CV. **EMT MADRID**

# Pilots – Emergency vehicle approaching

1 <sup>ST</sup> PILOT ROUND	2 <sup>ND</sup> PILOT ROUND
10 - 12 February 2025	24 – 26 March 2025 & 23 July 2025
2 CV Drivers *	2 CV Drivers
2 EV Drivers *	2 EV Drivers
-	1 TM Operator

\* Users internal to the project.

**AUGMENTED CCAM**

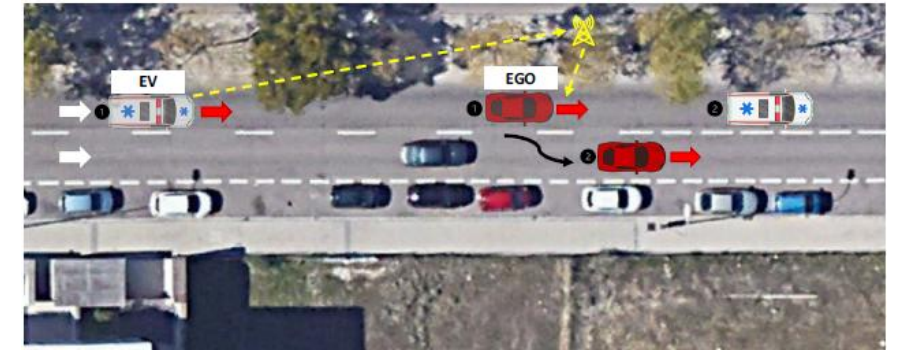
**UC11 - EMERGENCY VEHICLE APPROACHING**

**etra | +D Spanish site**

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Scenario 1: EV approaching in a 1-way road



Scenario 2: EV approaching in a 2-way road

# Pilots – UAV based non-equipped VRU protection

1 <sup>ST</sup> PILOT ROUND	2 <sup>ND</sup> PILOT ROUND
10 - 12 February 2025	01/04/2025 – 04/04/2025 & 05/05/2025 - 08/05/2025
1 CV Drivers *	6 CV Drivers
2 Safety Drivers *	2 Safety Drivers*
2 VRUs *	17 VRUs (11 for CAVs and 6 for CVs)

\* Users internal to the project.



**AUGMENTED CCAM**

UC12: UAV-Based non equipped VRU Protection

Spanish site

**tecnalía**

Augmenting and Evaluating the Physical and Digital Infrastructure for CCAM deployment

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# Additional pilots in virtual platforms

Driving simulator		
UC	Nº scenarios	Nº participants
2&12	4(2x2)	22
11	4	20

AV simulator		
UC	Nº scenarios	Nº speeds
2	2	3 (10-20 km/h)
11	4	4 (35-50 km/h)
12	2	3 (10-20 km/h)



Scenario 1: EV approaching behind (bus lane)



Scenario 2: EV approaching behind (parking spots)



Scenario 3: EV turning in intersection

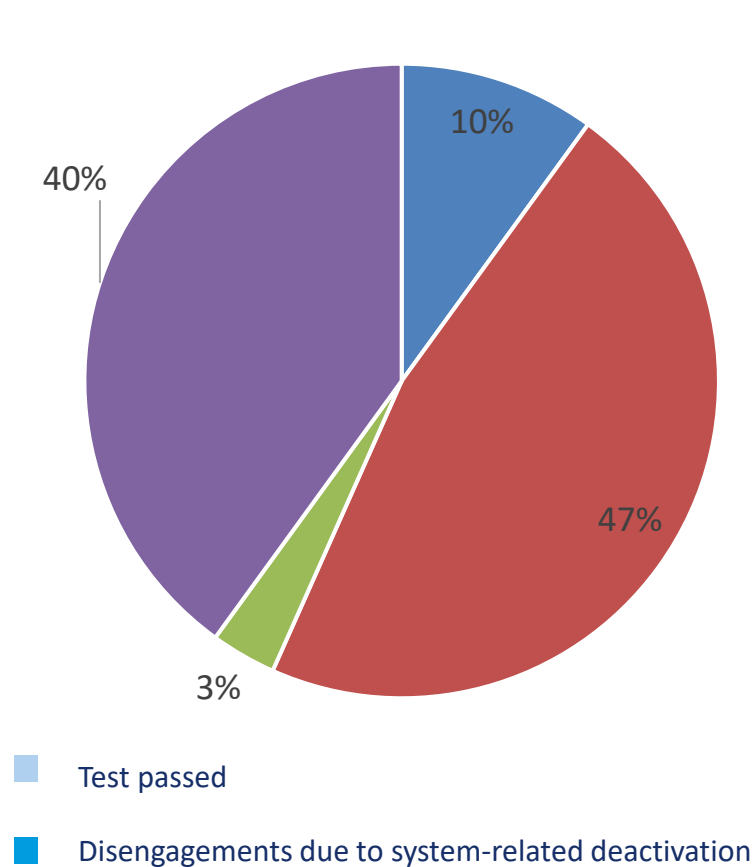


Scenario 4: EV crossing intersection

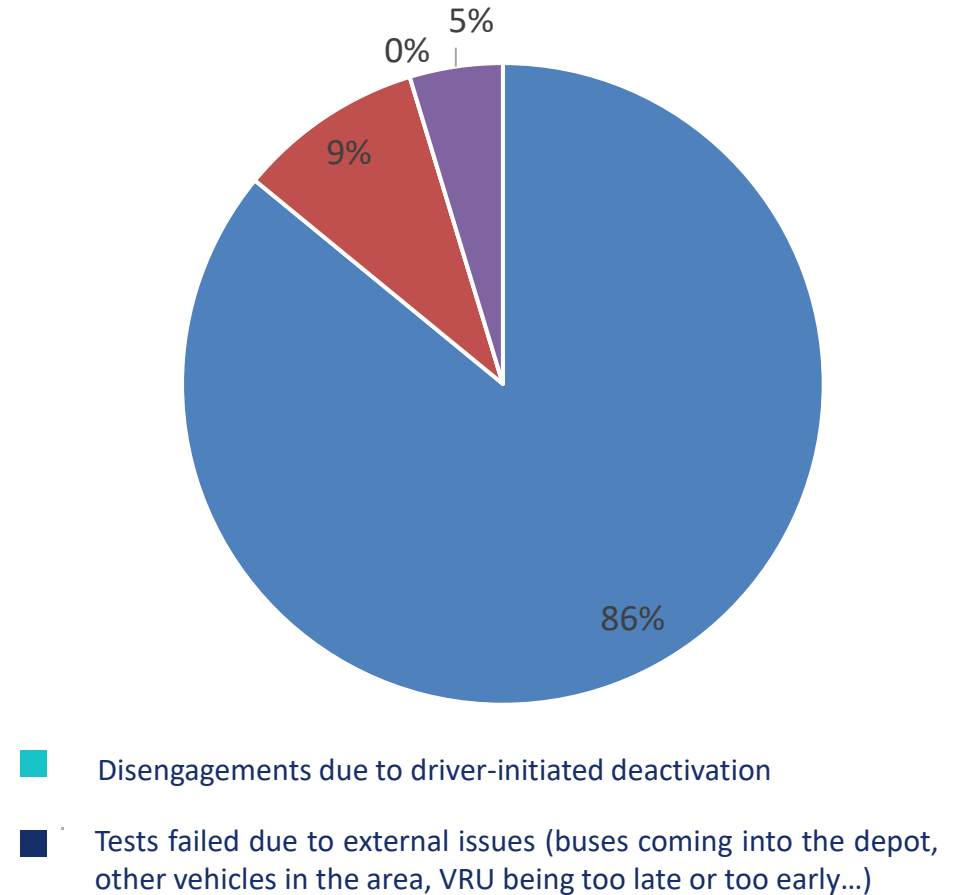
# Key findings

After the realization of the pilots of **Equipped VRUs protection** , we have got to the following findings:

1. Decreasing of disengagements in scenarios with PDI support vs. the ones without support.



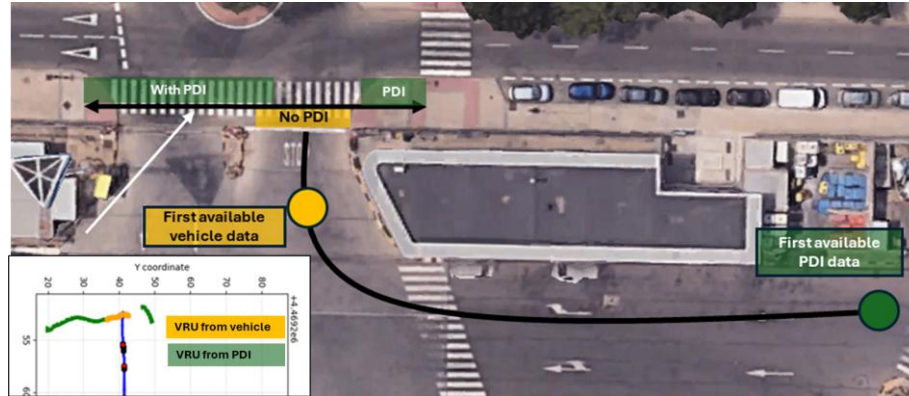
Baseline Scenarios – No PDI support



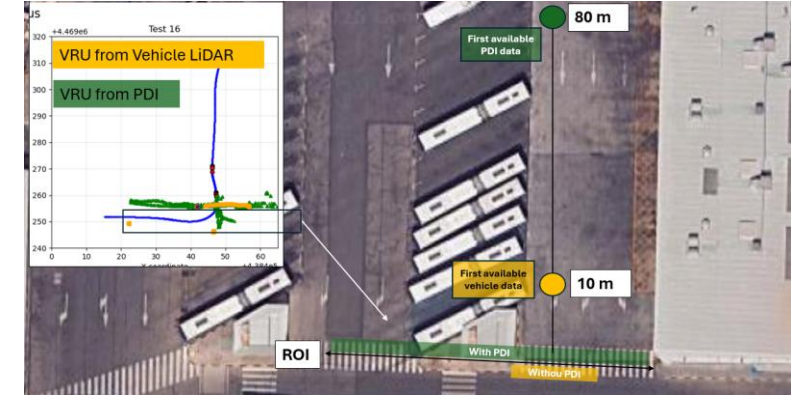
Experimental Scenarios – PDI support

# Key findings

2. PDI support successfully enhanced the CAVs' perception of the Region of Interest by 37% and 62.5% for the VRUs UCs, and improved the anticipation detection time for VRUs.

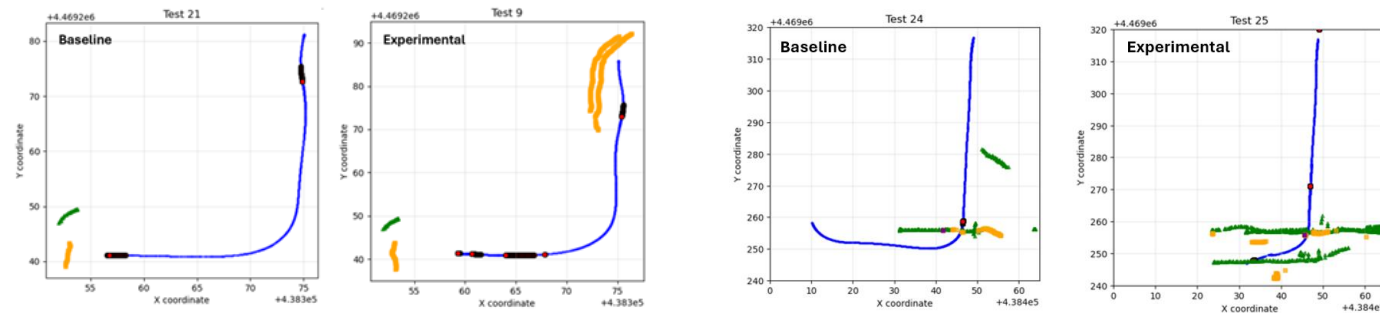


UC2 – PDI additional coverage



UC12 – PDI additional coverage

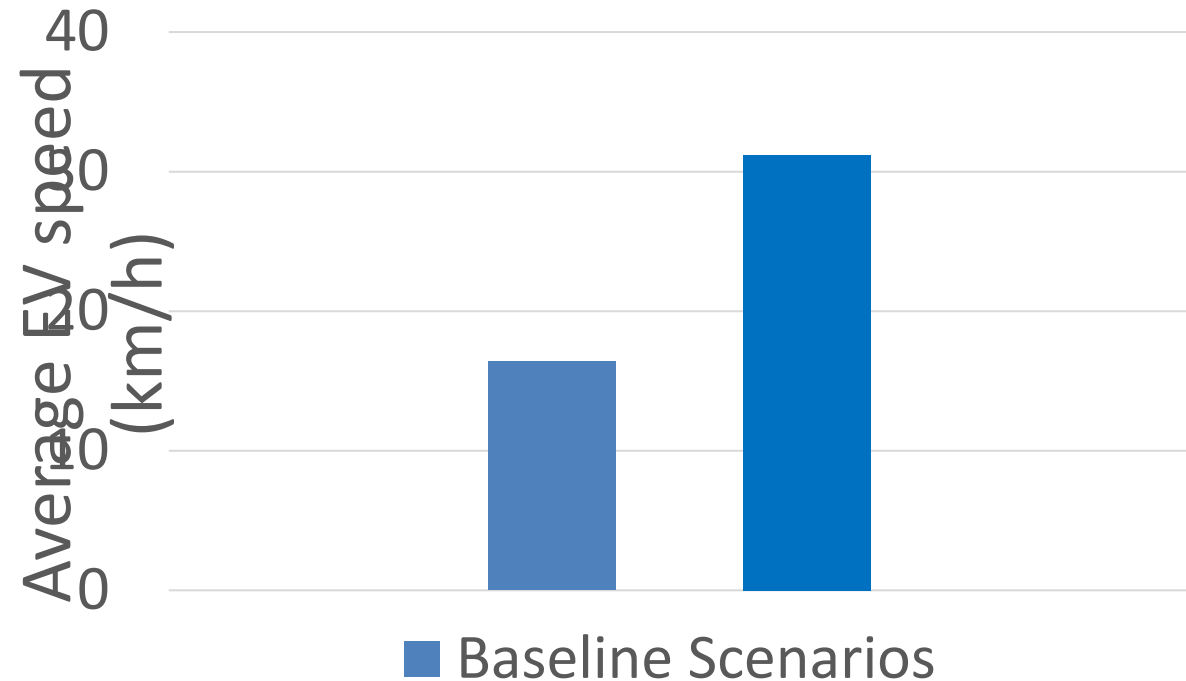
3. PDI improve safety margin between vehicle and VRU. An additional safe distance of around **3.5 m (Equipped VRUs protection)** and **7 m (UAV based non-equipped VRU protection)**.



# Key findings

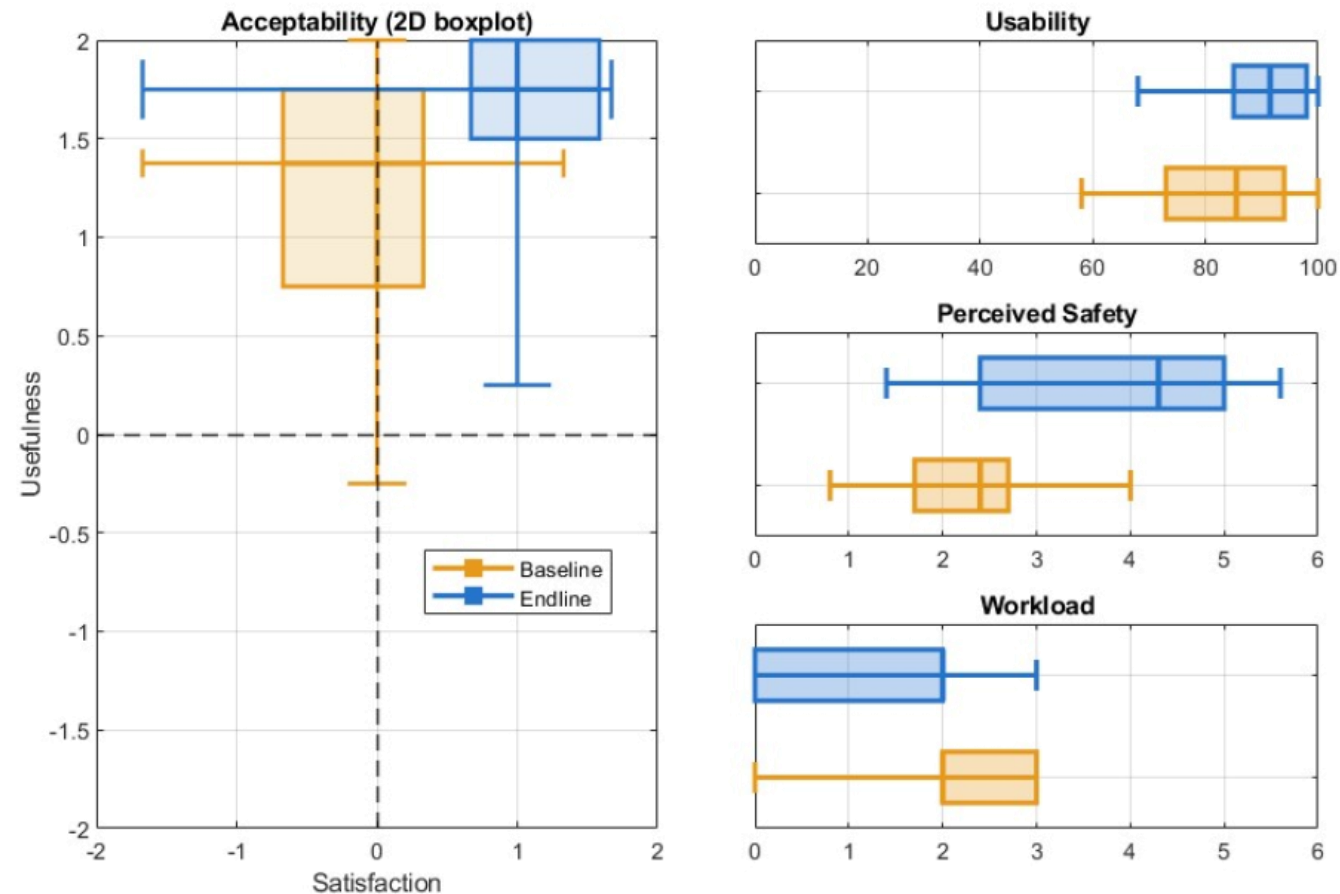
- The signal priority functionality enabled the Emergency Vehicle to increase its speed when approaching the intersection, reducing its travel time.

Scenario type	Avg. EV Speed (km/h)
Baseline	16,4
Experimental	31,2



# Key findings

- Involved VRUs, CV drivers and CAV safety drivers reported an increase in their perceived safety and system acceptability when comparing the experimental scenarios with the baselines, for all the use cases.



# Challenges & Lessons Learned

Related UC	Challenge / Observation	Lesson Learned
<b>UC2 – Equipped VRUs protection</b>	The installed cameras did not cover 100% of the region of interest, though it was not critical, since the uncovered area was effectively monitored by the CAV sensors.	For real deployment, a specific study for each intersection might be needed, considering different cameras' installation possibilities that ensure the coverage of the complete region of interest.
<b>UC4 – Traffic Management Optimization</b>	With the current number of CVs, it is very difficult to draw meaningful conclusions from the service operation beyond confirming its correct technical implementation.	For a large-scale validation and deployment of this solution, a higher penetration of CVs is mandatory.
<b>UC11 – Emergency Vehicle approaching</b>	For the real-world implementation in this service, it would be useful to define “emergency corridors” that connect relevant locations (e.g. hospitals, police stations) through big avenues across the city.	Analyse the city in which the solution is to be implemented and identify these relevant points and important avenues in which the implementation should start.
<b>UC12 – UAV-based non-equipped VRU protection</b>	False positives when the vehicle was travelling parallel to the VRU.  Speed planner can improve comfort even more	Improve collision risk estimator with more dynamic parameters of the vehicle and future trajectory planned.  Integrate intelligent speed calculator to take advantage of the VRU anticipation to increase comfort and efficiency.

# Proyecto BACSI

- Colaboración con el ejército del aire - INSIA



# Semana de la movilidad

- Ruta Paseo de la Castellana. Ayuntamiento-CTAG



# CONTEXT OF THE MOBILITIES FOR EU PROJECT

## Current situation

### GLOBAL:

Lack of public transport solutions with autonomous vehicles at the international level.

In Madrid, Alsa operates the only vehicle in Spain operating in open traffic on a regular CRTM line (Cantoblanco Autonomous University campus).

The autonomous vehicles deployed so far are of low capacity (approx. 12 passengers).

### MERCAMADRID:

There is no public transport solution within the complex, only 2 passing city bus lines.

Predominance of private transport.

Complex traffic environment.



# PROPOSED SOLUTION

## ZEV, Autonomous and Connected Vehicle (CCAM)

Regular commissioning of an electric midibus (ZEV) and autonomous (SAE Level 4+) with more than 20 seats, located in a collaborative and interconnected environment (CCAM) within the Mercamadrid area.

This autonomous electric midibus will operate in a real open traffic space during 8-12 hours a day on a recurring basis.

Proposed interior route to connect the main mobility attraction nodes of the complex, although it is foreseen to be updated throughout the project to adapt it to the needs of people.

Additionally, we are designing a Zero Emissions Mobility Plan specifically for Mercamadrid, with a strong customer centric focus, so that the circulation of the CCAM bus can achieve a real transformative effect on mobility in coordination with other environmentally friendly modes.



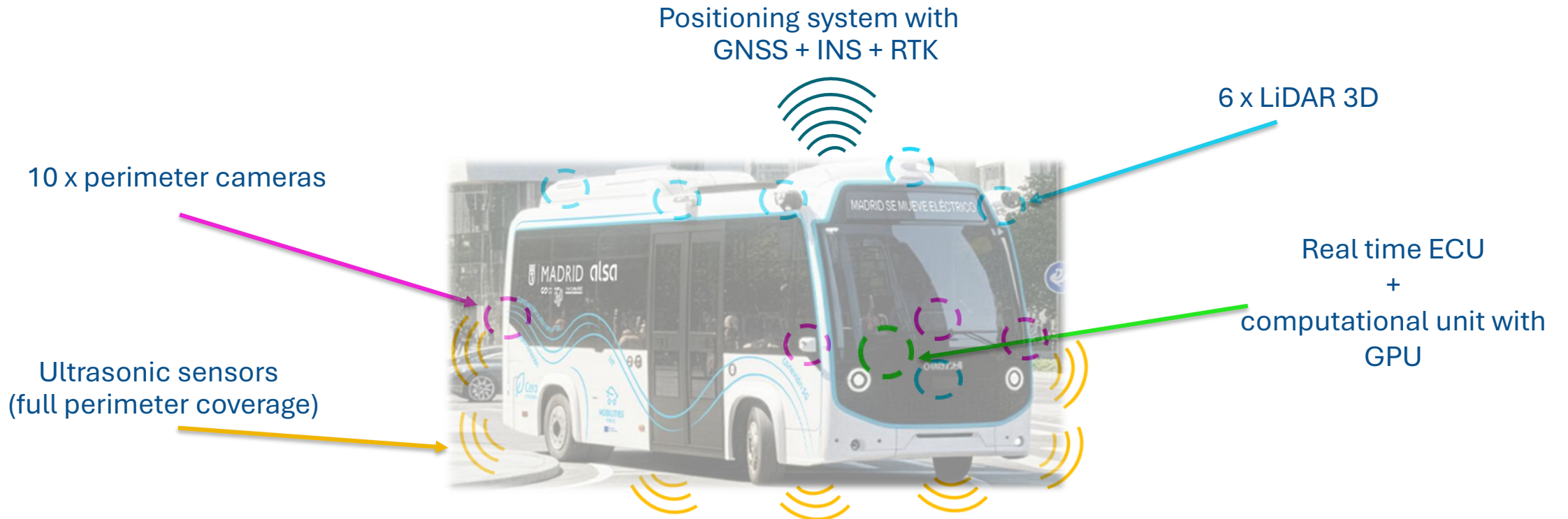
## PROGRESS MADE

- ✓ International benchmarking of solutions implemented in other cities and prospecting of autonomous vehicle manufacturers.
- ✓ Definition of technical criteria for bidirectional charging points to be compatible with the EMT Madrid fleet.
- ✓ Identification of key technical signals and KPIs to feed/receive from the shared data space for all partners.
- ✓ Preliminary design of the internal route based on attraction nodes and detected potential black spots.
- ✓ Definition of baselines to measure the improvement achieved with the project.
- ✓ Purchase and reception of the autonomous vehicle.
- ✓ Technical homologation of the vehicle and special permits with regulator.
- ✓ Training and qualification of the new role of on-board assistants.
- ❑ Design of studies, surveys, and work for specialized research on mobility and people's needs regarding the new service – *First surveys ongoing.*
- ❑ Identification and installation of additional onboard equipment (information screens, people counters, cameras, etc.) – *Final stage.*



# AUTONOMOUS DRIVING SENSORS

Autonomous vehicle SAE Level 4+



# AUTONOMOUS DRIVING SENSORS

Autonomous vehicle SAE Level 4+



Full longitudinal and lateral control



Total perception of the surroundings of the vehicle and the course of the route



# AUTONOMOUS DRIVING CAPABILITIES

Advanced software based on AI with the newest advancements on autonomous driving



Reaction to yield signs and pedestrian crossings



Driving in and exit roundabouts and other intersections



Approaching to and leaving from passenger stops



Overtaking / side shift

# AUTONOMOUS DRIVING CAPABILITIES

Advanced software based on AI with the newest advancements on autonomous driving



Interaction with temporary construction site objects



Overtaking Vulnerable Road Users (VRUs) on lane



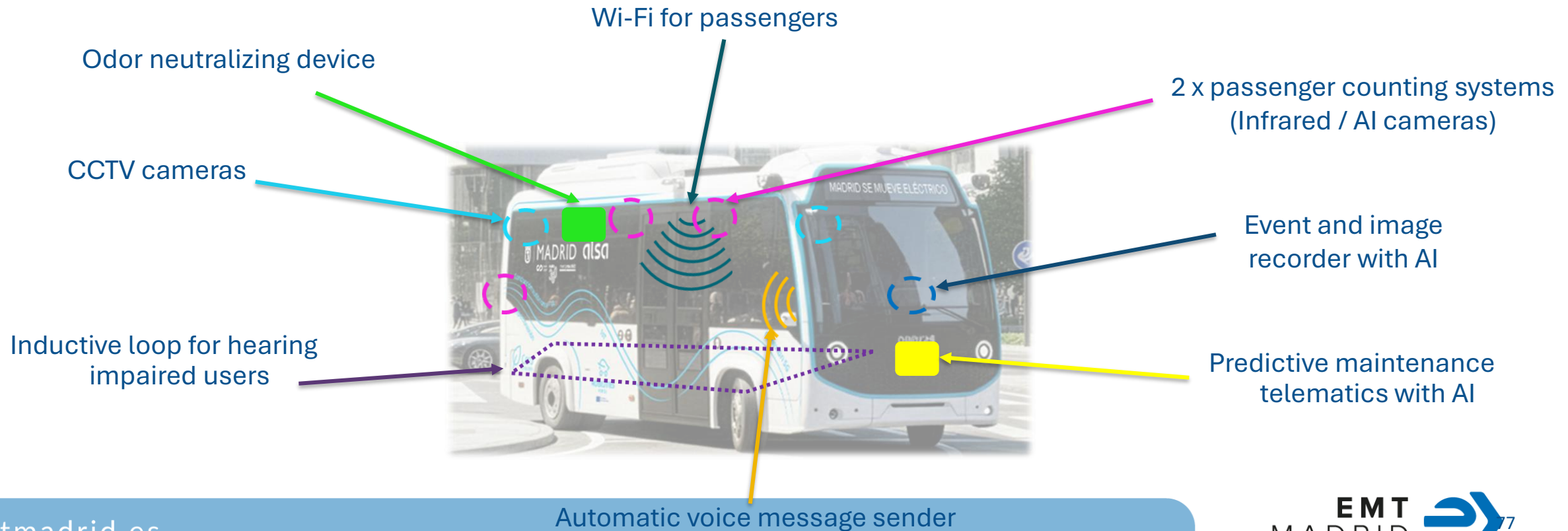
Collision avoidance with VRUs crossing the lane



Collision avoidance caused by “cut-in” maneuvers of other vehicles

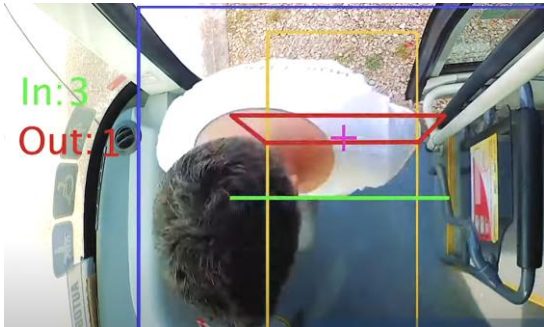
# ADDITIONAL ONBOARD EQUIPMENT

Several safety and comfort improvements onboard



# ADDITIONAL ONBOARD EQUIPMENT

Focus on the AI based additional systems fitted



## Passenger counting system

Based on IA and deep learning, these cameras can detect the entry/exit of each passenger and other attributes such as: pushchairs, wheelchairs, shopping trolleys...



## Event and image recorder

Based on Machine Vision and IA, the system includes dashboard interior and exterior cameras and accelerometers to identify safety risks such as: collisions, ABC events, etc. It also records a short video clip of every event as evidence for further action.



## Predictive maintenance telematics

Integrated into the vehicle's CAN bus, the system captures a broad range of technical signals and processes them using AI algorithms to perform remote diagnostics and make predictive maintenance recommendations before components malfunction.

## B) Disposiciones y Actos

### Alcaldía

**3311** *Decreto de 9 de septiembre de 2025 del Alcalde por el que se crea el Comité de Evaluación del Entorno Controlado de Pruebas de Proyectos Innovadores de la Ciudad de Madrid y se regula su composición y funcionamiento.*

Por Acuerdo de 28 de enero de 2025 del Pleno del Ayuntamiento de Madrid se aprobó la Ordenanza 1/2025, de 28 de enero, por la que se regula el entorno controlado de pruebas de proyectos innovadores de la ciudad de Madrid (en adelante, ordenanza sandbox), publicada en el Boletín Oficial de la Comunidad de Madrid el 12 de febrero de 2025.

La ordenanza sandbox proporciona un marco jurídico adecuado para testar funcionalidades, productos, soluciones y proyectos, garantizando que la innovación se desarrolle de forma segura, regulando un entorno controlado de pruebas (o regulatory sandbox), que consiste en un espacio seguro en el que pueden probarse y ponerse en práctica, con carácter limitado, distintos productos, servicios y proyectos innovadores.

El artículo 10 y la disposición adicional segunda de la ordenanza sandbox establecen la obligación de crear un comité de evaluación en el plazo máximo de seis meses desde la entrada en vigor de dicha norma, al que corresponderá el estudio, evaluación y seguimiento de las solicitudes de acceso al entorno controlado de pruebas.

En cumplimiento de estos preceptos, se procede a la creación del comité de evaluación, fijando su composición y regulando su funcionamiento, de acuerdo con lo establecido en la ordenanza sandbox y demás disposiciones aplicables, configurándose como un órgano colegiado de seguimiento, asesoramiento, coordinación y control del Ayuntamiento de Madrid en materia de regulatory sandbox, con competencia para evaluar y supervisar los proyectos presentados en el marco de dicha ordenanza.

En su virtud, de conformidad con lo dispuesto en el artículo 76.2 del Reglamento Orgánico del Gobierno y de la Administración del Ayuntamiento de Madrid, de 31 de mayo de 2004, y a propuesta de la titular del Área de Gobierno de Economía, Innovación y Hacienda,

### DISPONGO

#### Artículo 1. Objeto.

El objeto del presente decreto es la creación y la regulación de la composición y el funcionamiento del Comité de Evaluación del Entorno Controlado de Pruebas de Proyectos Innovadores de la Ciudad de Madrid (en adelante, el Comité), como órgano colegiado de seguimiento, asesoramiento, coordinación y control de las solicitudes de acceso al entorno controlado de pruebas.

#### Artículo 2. Adscripción y naturaleza jurídica.

El Comité se adscribe al área de gobierno competente en materia de innovación como órgano colegiado sin personalidad jurídica propia, estando integrado por representantes del Ayuntamiento de Madrid.

#### Artículo 3. Régimen jurídico.

1. El Comité se rige por lo dispuesto en el presente decreto sin perjuicio de las normas específicas que regulen su funcionamiento interno que, en su caso, serán aprobadas en el seno del propio órgano.

2. En lo no previsto en el presente decreto, será de aplicación lo dispuesto en las normas sobre órganos colegiados contenidas en el Reglamento Orgánico del Gobierno y de la Administración del Ayuntamiento de Madrid, de 31 de mayo de 2004, y en la normativa básica en materia de régimen jurídico del sector público.

#### Artículo 4. Finalidad y funciones.

1. El Comité tiene como finalidad el estudio y evaluación de las solicitudes de acceso al espacio controlado de pruebas, así como la propuesta de autorización de acceso al órgano autorizante y el seguimiento de las autorizaciones otorgadas.



El proyecto, en colaboración con el Centro Tecnológico de Automoción en Galicia, se realiza con motivo de la Semana Europea de la Movilidad

← Volver

# Carabante presenta el proyecto piloto de bus autónomo de EMT Madrid en la Casa de Campo



Nota de prensa 15/09/2025

- Desde hoy y hasta el próximo 24 de octubre prestará servicio de lunes a viernes, en horario de 12:00 a 17:00 horas
- El recorrido circular es de 1,8 kilómetros y contará con un total de seis paradas a lo largo del itinerario
- El trayecto, de carácter gratuito para los usuarios que deseen probarlo, se realizará de forma completamente autónoma
- Se trata de un vehículo 100 % autónomo, conectado, eléctrico y fabricado en España

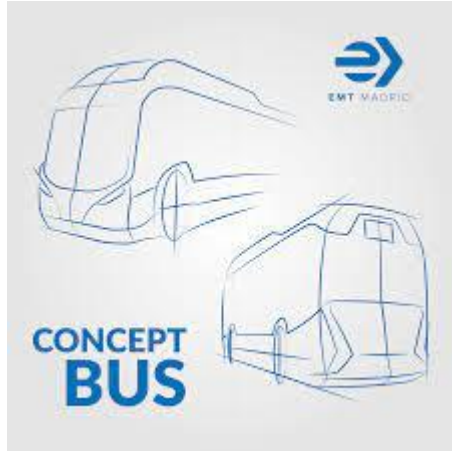
## Galería de imágenes



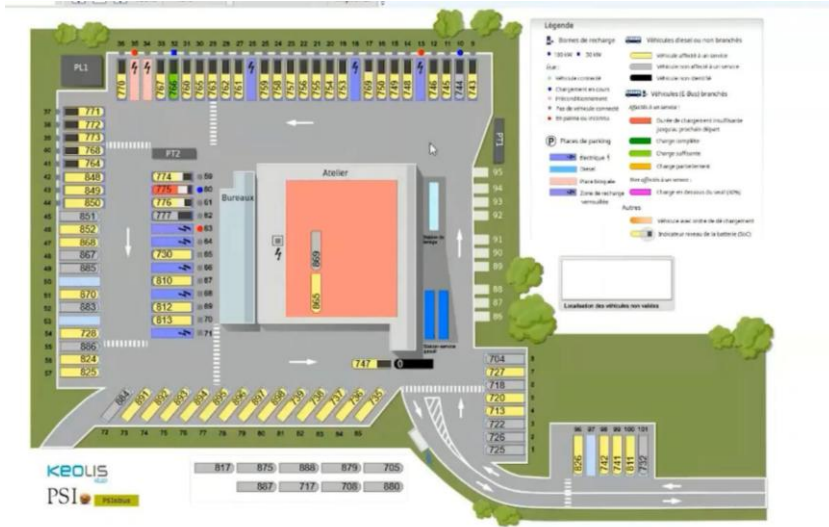
El delegado de Urbanismo, Medio Ambiente y Movilidad, Borja Carabante, ha inaugurado el primer bus autónomo que, gracias al proyecto piloto de la Empresa Municipal de Transportes (EMT Madrid) y el Centro Tecnológico de Automoción en Galicia (CTAG), recorrerá parte de la Casa de Campo de Madrid hasta el próximo 24 de octubre. Esta propuesta está encuadrada dentro de la programación de la Semana Europea de la Movilidad (SEM) 2025 que, bajo el lema 'Movilidad para todos', se celebrará en Madrid hasta el próximo 22 de septiembre.

Este pequeño vehículo eléctrico, 100 % autónomo, prestará servicio de lunes a viernes, en horario de 12:00 a 17:00 horas, en un recorrido circular de 1,8 kilómetros por la Casa de Campo. El trayecto, de carácter gratuito para todo aquel viajero que desee conocerlo, contará con un total de seis paradas. Este vehículo, 100 % fabricado en España, tiene capacidad para 12 ocupantes como máximo y va equipado con pantallas interiores

# EMT MADRID CONCEPT BUS



# Siguientes pasos



## Automated Bus Depot



# EMT MADRID VISION AND ROADMAP



## Vision

### PTO:

- Potential **savings in non-productive** hours at bus depots
- **Scaling up potential.** Ongoing conversation with OEMs to test further solutions
- **Low cost/benefit ratio for adapting** existing non automated buses
- Importance of **training**
- Autonomous mobility solutions are mature enough to be deployed in **semi controlled environments** (bus depots). However, there are still uncertainties about open traffic situations
- **Research** as an ally

### OEM:

- Potential for **new business lines.** Effort to be focused on industrialization and deployment, reducing the cost of integrating the solutions into the vehicle and service PTOs to help them streamline their operations

### However, Public Administrations (at least in Spain):

- **Not prepared** to cope with the sector's demands in terms of autonomous mobility.
- Expectations cannot be met with the **rigidity of the current regulatory** framework
- **Need to enable testing** without the current complex and costly procedures.

## Roadmap

### On mobility:

- **Strengthening public transport** with flexible on-demand services (i.e. new potential service in Casa de Campo)

### On depot management:

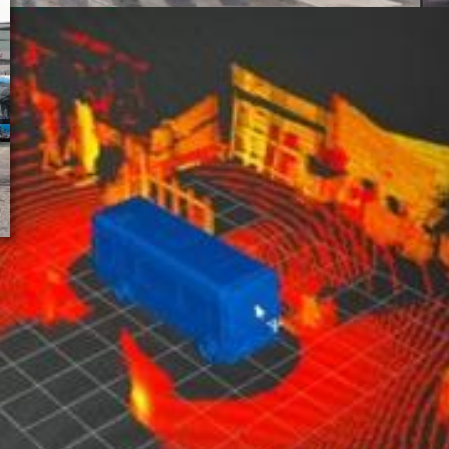
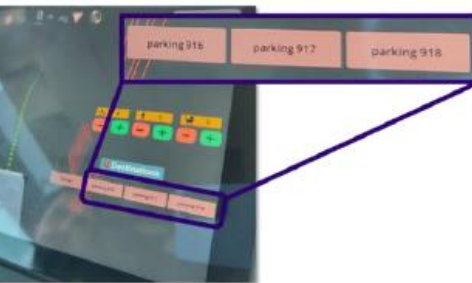
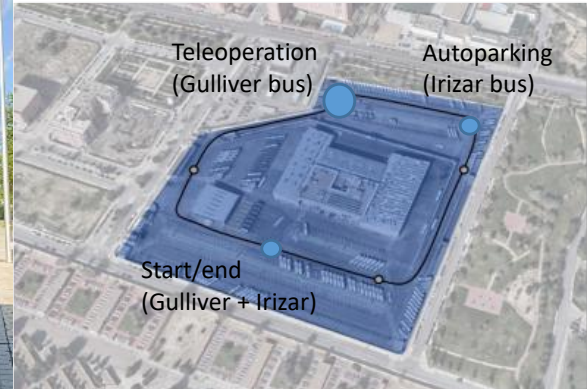
- **New possibilities** including automated charging processes by using inverted pantographs

### On market boost

- Ongoing conversations with OEMs in order to **test new automated bus models.** Market needs to provide automated solutions

### On public-private cooperation

- **Further cooperation** amongst institutions (i.e. CTAG)
- **Further research** and innovation projects (i.e. AUGMENTED CCAM and MOBILITIES for EU projects)



One single bus stop  
Autonomous route

Two lanes - two ways  
Two lanes - one way  
Intersections  
Starting points\*

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Thank you