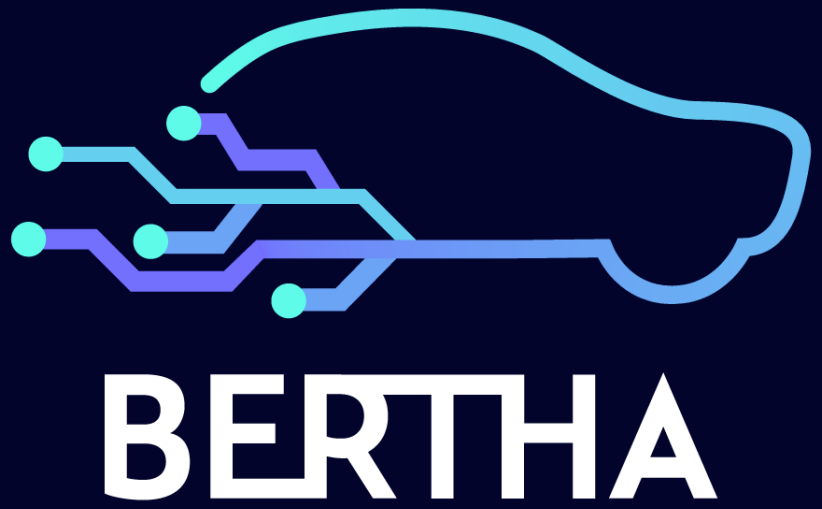


BEhavioural ReplicaTion of Human drivers for CCAM

General overview of the project

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

BERTHA

1 Introduction to the project

What is BERTHA?

BERTHA is a Horizon Europe project meant to develop a **Driver Behavioural Model (DBM)** to make **autonomous vehicles** safer and more human-like.

36
months
(from Nov. 2023 to Oct. 2026)

14
partners
(from 6 countries)

€7.9M
budget
(fully EU-funded under Horizon Europe)

HORIZON Research and Innovation Actions | Grant Agreement No. 101076360
Call and topic 'HORIZON-CL5-2022-D6-01-03'

A Driver Behavioral Model (DBM)

BERTHA will develop a scalable probabilistic Driver Behavioural Model (DBM) to determine what, how and why drivers react in real life, covering:

The full spectrum of **drivers**

Physical, cognitive, and emotional **domains**

Complex, real-life **situations**

Personal, cultural, and contextual **factors**

This will lead to **more human-like** Connected Autonomous Vehicles (CAV) and allow them to really understand other **road users** and anticipate **unexpected risks**

The BERTHA HUB

The model will be embedded in a **simulation platform (HUB)** for OEM[1] and TIERs[2] that:

- ✓ Is **open**, **transparent**, and **scalable**
- ✓ Incorporates new use cases according to **driver diversity**
- ✓ Takes into account **situational and environmental** aspects

The HUB will speed up developments, reduce costs, and increase user acceptance, thus enhancing **societal acceptance of CAVs**

[1] *Original Equipment Manufacturer.*
[2] *Different levels of suppliers for the automotive industry.*

The BERTHA demonstrators

The project includes a **set of interrelated demonstrators** to show this DBM approach as a reference to design human-like, easily predictable and acceptable behaviour of automated driving functions in mixed traffic scenarios.

Demonstrators which are components of the BERTHA approach

HUB prototype
Collaboration platform to test technologies for CCAM.

Simulator powered by CARLA
The DBM integrated in CARLA for the simulation of mixed traffic scenarios.

Demonstrators for Tier approaches

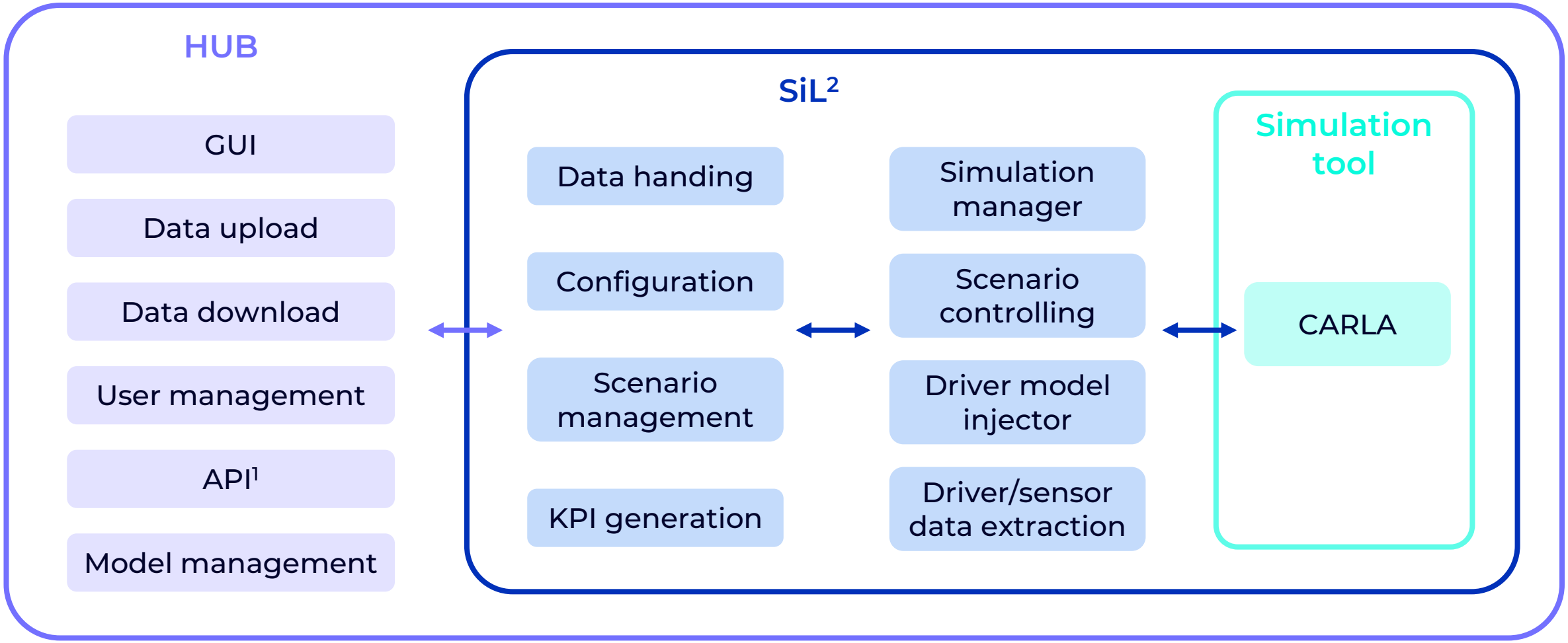
Application to driving functions
Human-like Connected Autonomous Vehicle (CAV) implemented as ego vehicle in CARLA.

Automated driving function in an urban setting
Validation of DBM combining a FOT [1] in real urban conditions with measures on a test track simulating real situations.

Demonstration in ADAS[2] features
Features related to scene interpretation, collision avoidance and trajectory following.

[1] Field Operational Test. | [2] Advanced Driver-Assistance Systems.

The HUB prototype



[1] *Application Programming Interface.* | [2] *Software in the Loop.*

The BERTHA solution at a glance

Bayesian Belief Networks mathematical approach

Methodology for the data gathering from driving simulations, questionnaires and FOT

Decision-making / risk module

Affective module

Motor module

Perceptual module

Integrated Driver Behavioural Model (DBM)

Scalable module structure: data can be added to increase driver personalities, scenarios and other driving factors

BERTHA HUB to host

the **mathematical model**

the **data** coming from simulations, FOT, tests with drivers and sociological profiles

[DEMO] ADAS with modules from BERTHA implemented

[DEMO] DBM implemented in **CARLA** IA cars driven by different driver personalities

BERTHA's methodology

Module structure (skeleton) from partners' previous experience and existing databases

Short-term use cases application

Testing, driving simulators, FOTs and questionnaires

Feed the skeleton to build the model

Validation in use-cases scenarios

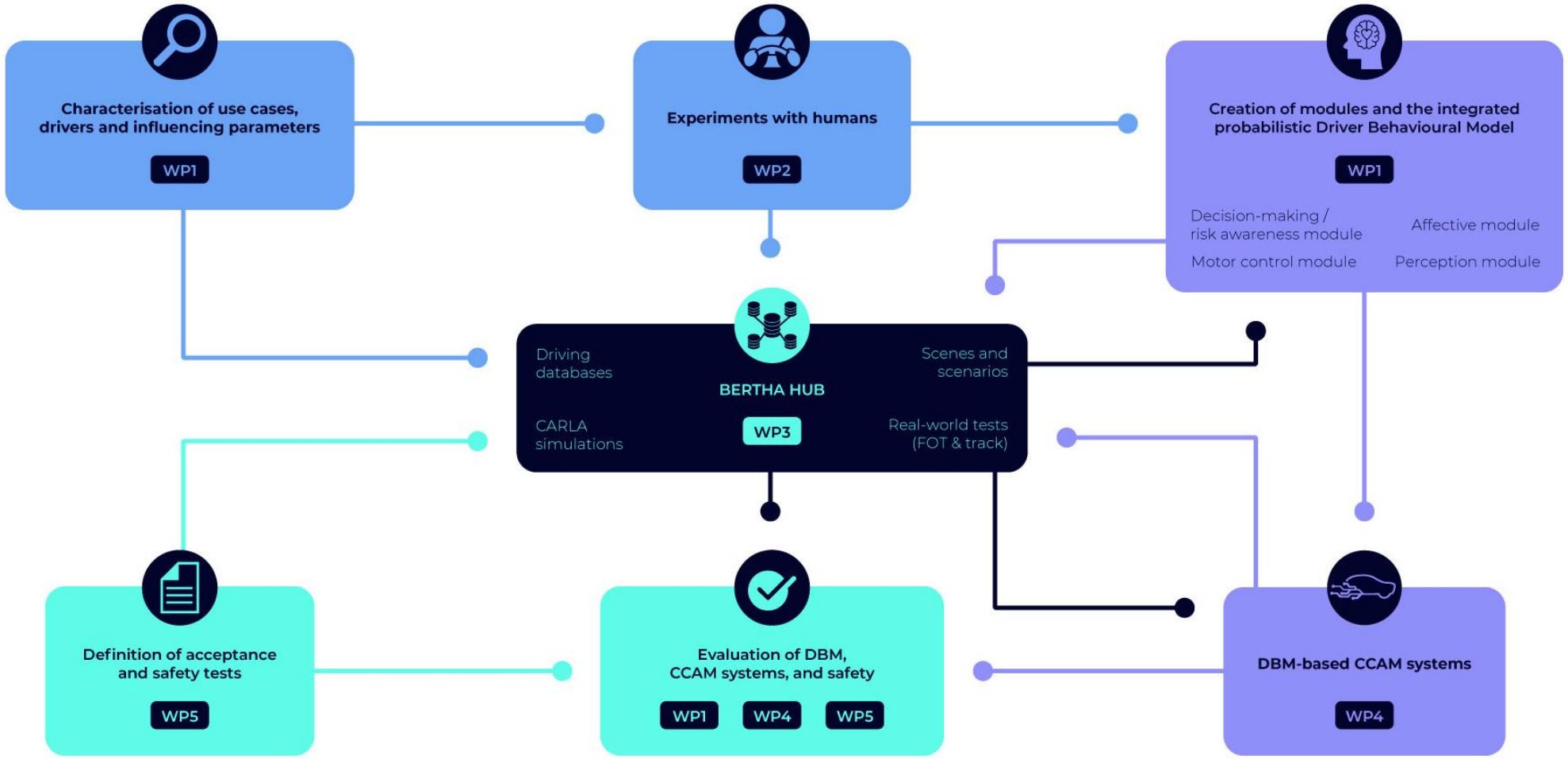
Methodology to feed and make the model scalable

Methodology for **long-term** sustainability

[DEMO] **Simulator powered by CARLA**

[DEMO] **HUB prototype**

BERTHA's methodology



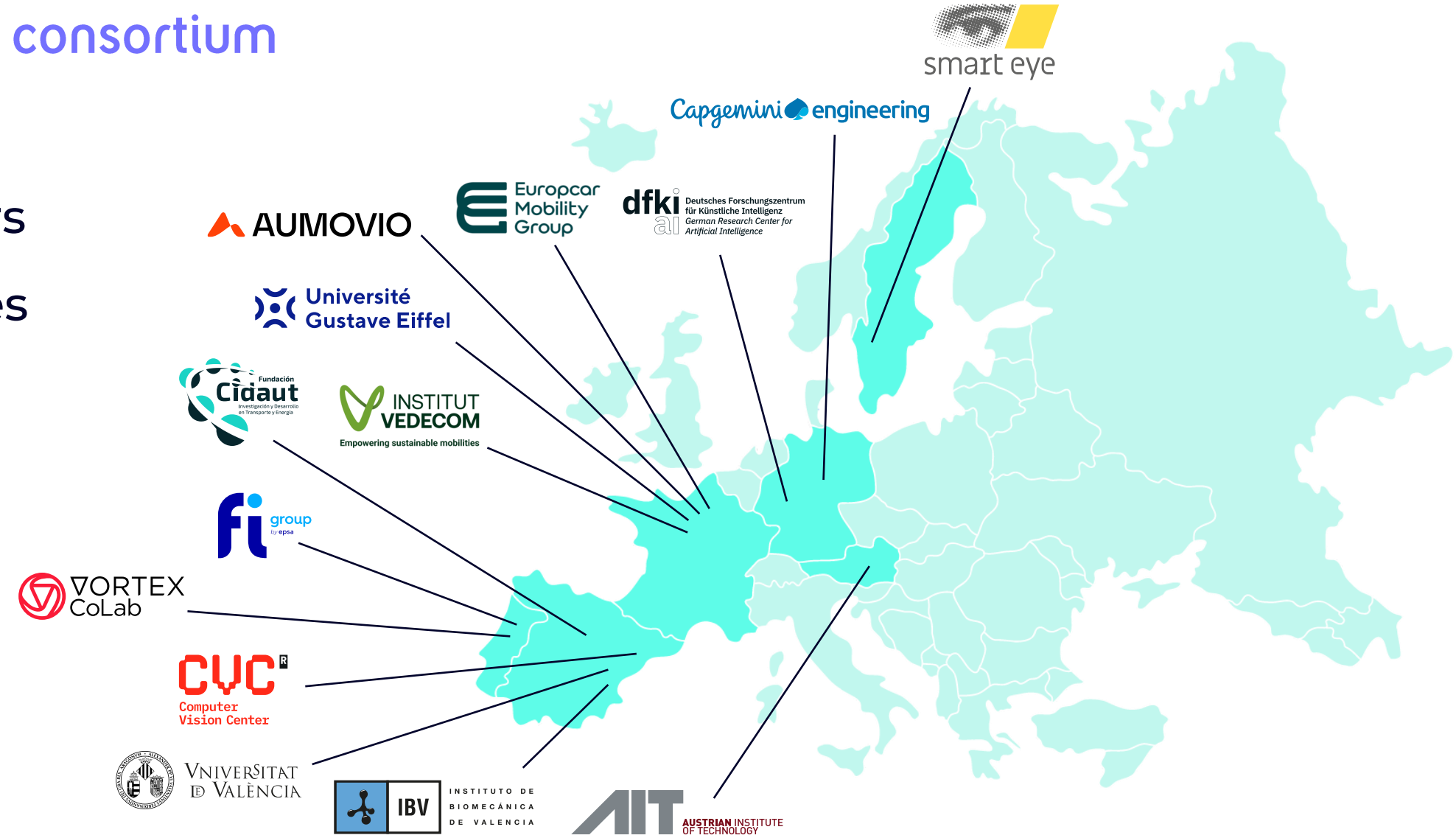
BERTHA's strategic objectives

1. Development of an **affective module** for drivers.
2. **Motor control** for wheel drive and pedal activation influenced by the affective state of the driver.
3. Development of two computational modules aiming to simulate **risk assessment** and **decision making**, as performed by real human drivers.
4. Development of a **perceptual module**.
5. Methodology for **DBM scalable development**.
6. A **scalable integrated probabilistic model** of the human driver.
7. AI-driven **traffic scenario generator**.
8. Evaluate the interaction of the human-driver **behavioural aspects** on the performance of **CCAM systems**.
9. Identification of a **Typology of Driver Reaction Patterns**.
10. Speed up **CAV implementation** due to a Human Centred approach, Lean cycles of develop-test, and an Open Multi-collaborative space.
11. **Community-focused approach** (tooling and SiL-infrastructure) for collaborative HUB-assisted cross-stakeholder sharing, testing, and evaluation of traffic-participant model, ADAS test cases, AI models, and formatted data.
12. To train and test autonomous driving solutions under **more realistic behaviour simulations**.

The BERTHA consortium

14 partners

6 countries



The BERTHA work plan

WP6 Exploitation and dissemination

WP7 Management

WP2
Human driving performance data collection

INSTITUT VEDECOM
Empowering sustainable mobilities

Methodology

Use cases

Releases

Methodology

WP1
Driver Behavioural Model

Pilot release of DBM

First release of DBM

WP3
Open human behaviour HUB development

Capgemini engineering

Validated DBM

Releases

WP4
Evaluate the application of human DBM in CCAM technologies

CVC Computer Vision Center

Fair assessment of safety and acceptance

WP5 Acceptance and safety standard CCAM tests

Collaborating with the CCAM Partnership

BERTHA takes part in the CCAM Partnership, co-programmed with the EC in the Horizon Europe framework, which aims at advancing **Connected, Cooperative, and Automated Mobility** (CCAM). It focuses on improving road safety, reducing environmental impact, and promoting inclusive mobility solutions by bringing together various R&D projects.

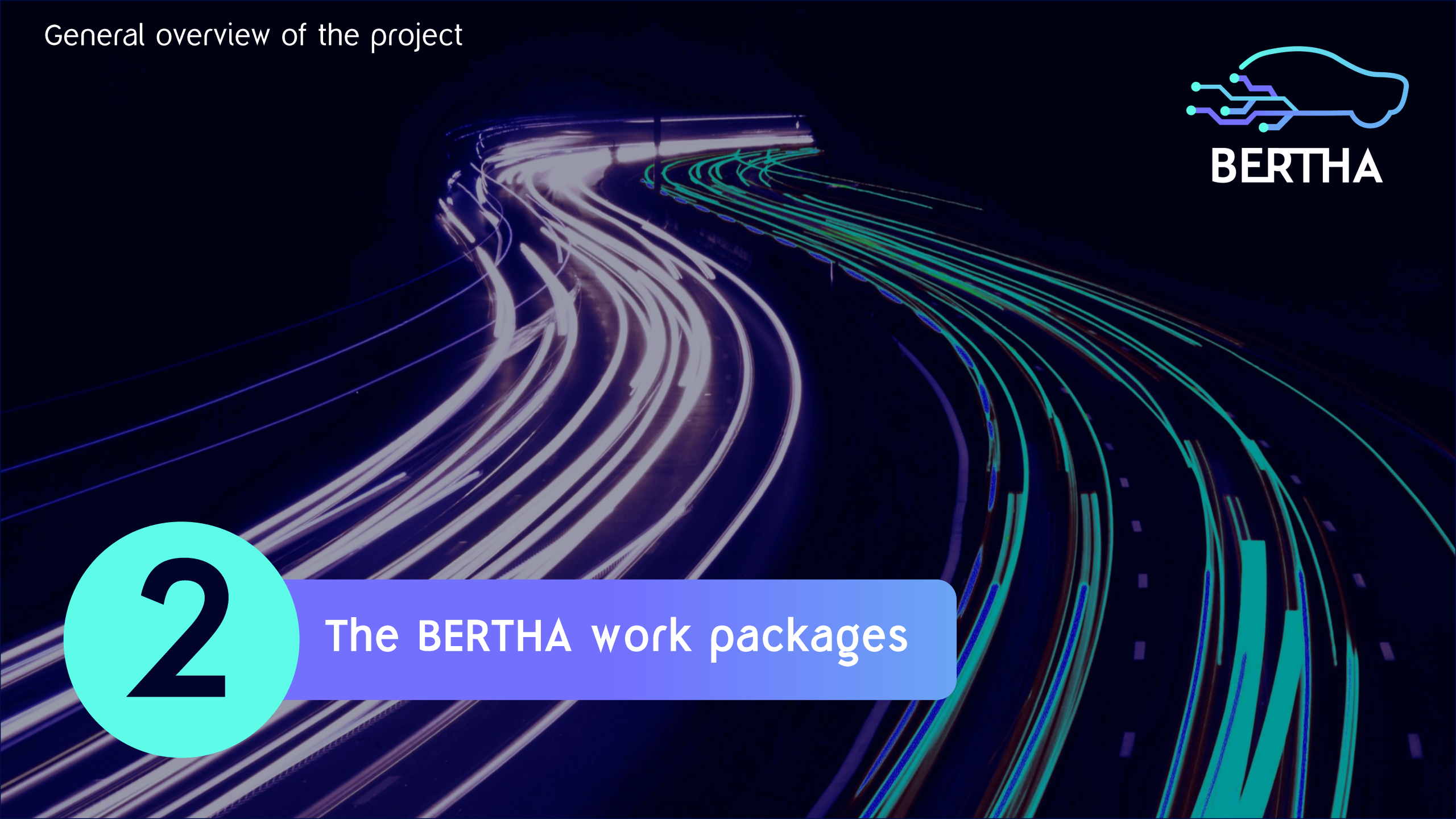
CCAM
CONNECTED, COOPERATIVE & AUTOMATED MOBILITY

+200
members
(from the industry and academia)

30
projects
(collaborative research)

7
clusters
(to organize the Partnership activities)

BERTHA leverages the Partnership's extensive network, facilitating knowledge sharing and best practices. In return, the Partnership benefits from BERTHA's cutting-edge research.



2 The BERTHA work packages

The BERTHA work plan

WP6 Exploitation and dissemination

WP7 Management

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WP5 Acceptance and safety standard CCAM tests

WP1. Driver Behavioural Model

The primary objective of WP1 is to develop a robust and scalable probabilistic Driver Behavioural Model (DBM) that comprehensively encompasses key facets of **human driving performance**, spanning a wide spectrum of **drivers and influencing factors**.

This sophisticated model will initially adopt a **Bayesian learning methodology** coupled with **complementary approaches**, fostering the gradual evolution of a concise yet comprehensive model.

Emphasizing the diversity in driver styles and varied driving scenarios, WP1 aims to build a model structured around **distinct modules**: Perception, Risk Awareness rooted in relevant cognitive states, Decision-Making, Affective, and Motor modules.

Starts: M1 (Nov. 2023) Ends: M36 (Oct. 2026) Led by: IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

WP2. Human driving performance data collection

WP2 aims at defining, from the envisaged behaviour modelling, the **indicators that are necessary for its realisation and validation**, providing a consensus definition for each of these indicators and all their parameters.

We will also define a **robust methodology to extract, store and share consistent data** from the data HUB coming from different data sources.

This data set will encompass **massive behavioural data** gathered through sociological approaches, with reduced sets of experimental data. The aim is to deepen the internal processes of drivers through the analysis of their behaviour and emotional state, using different devices in both lab conditions and naturalistic driving via FOT.

Starts: M1 (Nov. 2023) Ends: M36 (Oct. 2026) Led by: INSTITUT VEDECOM Empowering sustainable mobilities

WP3. Open human behaviour HUB development

WP3's objective is to develop a working prototype for a **decentralised, cloud-scalable platform** that offers collaborative workflows as a building block to improve models of traffic participants (drivers, pedestrians, and others).

This platform will include a simulation and collaborative benchmarking environment that allows standardised upload, use, or download of **stored traffic participant models/modules**, as well as standardised community-driven testing and benchmarking of **ADAS, autopilots and traffic participants**.

To achieve these functionalities, we will develop during this work package a **prototype of workflow** that allows collaborative, continuous improvement of AD-pilots and traffic participant models at the Automotive ecosystem level beyond the classic OEM-driven industry.

Starts: M1 (Nov. 2023) Ends: M36 (Oct. 2026) Led by: Capgemini engineering

WP4. Evaluate the application of human Driver Behavioural Model in CCAM technologies

The goal of WP4 is to **demonstrate the usefulness of BERTHA's DBMs**. This involves the implementation and execution of autonomous driving related tasks, where the DBM plays a core role.

Some of these tasks assume **simulation via BERTHA's HUB and CARLA simulator**, where specific scenes and scenarios, including corner cases, are semi-automatically created. In this case, both industrial pipelines and sensorimotor models for autonomous driving are considered.

BERTHA's DBMs are expected to bring **more fidelity to the simulated behaviours**. Other tasks will focus on real-world vehicles offering a certain level of autonomous driving. In this case, BERTHA's DBMs are expected to bring **more naturalistic adjustments**.

Starts: M6 (Apr. 2024) Ends: M36 (Oct. 2026) Led by: CVC Computer Vision Center

WP5. Acceptance and safety standard CCAM tests

WP5 aims to evaluate the **acceptance and safety performance** of the Cooperative, Connected and Automated Mobility (CCAM) solutions developed in the framework of the EU project.

Along the work package, **different scenarios** will be defined, prepared, and conducted to verify not only the efficiency of the measures established, but also to understand the perception of different users' profiles and different driving environments and situations, attending to human-driver **behavioural aspects**.

Tests will be performed in several traffic conditions and will be highly instrumented to record quantitative and qualitative parameters that will help to **assess the solutions and models generated**.

Starts: M3 (Jan. 2024) Ends: M36 (Oct. 2026) Led by: Fundación Cidaut Investigación y Desarrollo en Transporte y Energía

WP6. Exploitation and dissemination

WP6 aims to improve the **project's impacts** by concentrating on dissemination, exploitation, and communication initiatives. This involves the **communication and dissemination** of project progress and results to the appropriate audiences and the development of **exploitation strategies** for any relevant technologies and concepts produced throughout the Horizon Europe project. WP6 is also responsible for coordinating **data management** in the consortium and ensuring compliance with **GDPR and intellectual property rights (IPR)**.

Moreover, the BERTHA project will contribute, upon invitation by the CINEA, to common information and dissemination activities to increase the visibility and **synergies between HE/H2020 supported actions**. The beneficiaries of BERTHA will commit to reporting their results to the **European Partnership on Connected, Cooperative and Automated Mobility (CCAM)**, including providing necessary data to enable the monitoring of CCAM KPIs.

Starts: M1 (Nov. 2023) Ends: M36 (Oct. 2026) Led by: fi group by epsa

WP7. Management

WP7 is designed to streamline the comprehensive management of the ongoing EU project. It provides **essential resources for each work package**, ensuring the timely completion of milestones with satisfactory outcomes.

Backed by two key processes, the technical project management is fortified: one focuses on harmonising **legal, contractual, financial, and administrative facets**, while the other concentrates on rigorous **risk assessment**.

This involves identifying, evaluating, and prioritising risks, followed by the implementation of tailored **contingency measures**. Through these integrated processes, the consortium is assured of realising both **project and innovation objectives** seamlessly.

Starts: M1 (Nov. 2023) Ends: M36 (Oct. 2026) Led by: IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

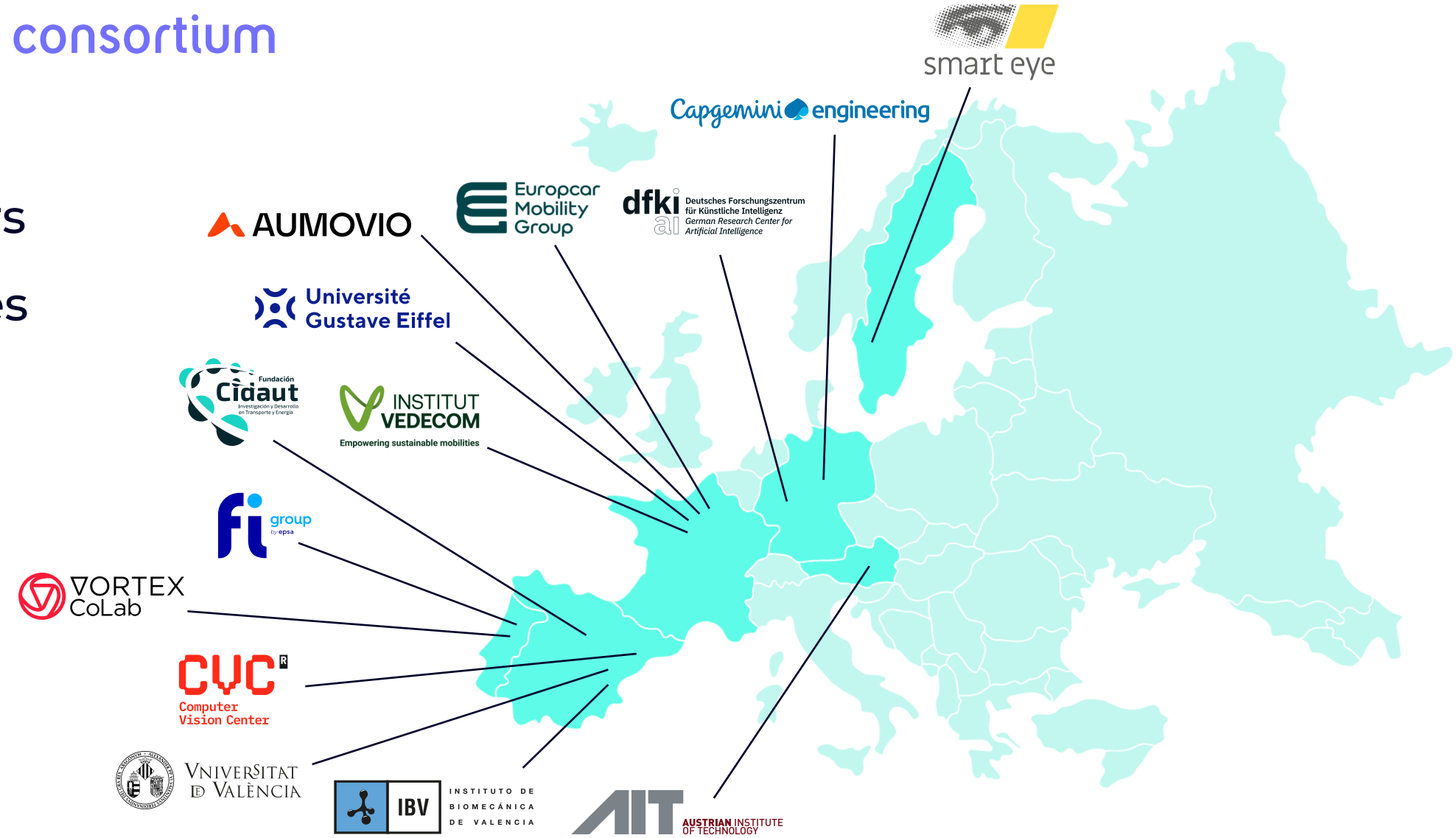
BERTHA

3 The BERTHA consortium

The BERTHA consortium

14 partners

6 countries



Instituto de Biomecánica de Valencia (IBV)

IBV INSTITUTO DE BIOMECÁNICA DE VALENCIA

The Instituto de Biomecánica (IBV) is an **R&D&I centre** of 165 professionals, where they study the **behaviour of the human body** and its relationship with the **products, environments and services** that people use. At IBV they develop and transfer scientific knowledge and technologies to improve people's health, well-being and quality of life, adding value to companies and the social and economic environment, leaning on human-centred approach.

Always **people-centred**, they organise their scientific knowledge through **5 areas**: 3D Anthropometry, Human Factors, Biomedical Engineering, Digital Health, and User Experience.

Applying the knowledge in multiple sectors generates R&D&I in response to the challenges of each area. HAV, the dynamic **Human Autonomous Vehicle simulator**, will be used to provide immersive experiences to get in-depth on the internal mechanisms that determine driving actions and the personal and cultural factors that impact driving decisions.

Institut VEDECOM

INSTITUT VEDECOM
Empowering sustainable mobilities

Created in February 2014, VEDECOM is an **Institute for Energy Transition (ITE)**, dedicated to **individual, carbon-free and sustainable mobility**, established as part of the French governmental plan 'Investment for the future'. It contributes to the '**Autonomous vehicle plan**', which was recently incorporated into the Solution for Future Industry Programme Alongside Eco-mobility; both of which are part of 'Nouvelle France Industrielle', the government's plan to invigorate the country's industry.

As a **public-private partnership-based foundation**, VEDECOM is based on an unprecedented collaboration between industries of the automotive and aerospace sectors, infrastructure and services operators in the mobility eco-system, academic research institutions and local authorities.

VEDECOM aims at becoming a European innovation leader in the fields of **electrified vehicles**, **autonomous and connected cars** and new infrastructure and services for **shared mobility and energy**. VEDECOM's research is focused on three areas: Vehicle electrification, connected and automated driving, and shared mobility and energy. Also, VEDECOM acts as an **approved training institution** by offering expert training and raising public awareness surrounding innovative mobility solutions. PSA Group, Groupe Renault, Valeo, Université Gustave Eiffel (ex: Ifsttar), Transdev, the Paris-Saclay development authority and the engineering school ESTACA are some of **VEDECOM's members**.

University Gustave Eiffel

Université Gustave Eiffel

University Gustave Eiffel is a French public university working on innovations for **smart cities**, **future transportation systems** and **road safety**.

The **LESCOT Laboratory**, involved in the BERTHA project, specialises in Ergonomics and Cognitive Sciences and works on different topics related to mobility and road safety, including:

- **Human Driver Modelling** (cf. COSMODRIVE model)
- The **Virtual Human-Centred Design (V-HCD)** of future driving aids and autonomous vehicles

German Research Centre for Artificial Intelligence (DFKI)

dfki ai Deutsches Forschungszentrum für Künstliche Intelligenz
German Research Center for Artificial Intelligence

The German Research Centre for Artificial Intelligence (DFKI) was founded in 1988 as a **non-profit public-private partnership**. In the field of innovative commercial software technology using Artificial Intelligence, DFKI is the leading research centre in Germany.

Based on **application-oriented basic research**, DFKI develops product functions, prototypes and patentable solutions in the field of **information and communication technology**. Research and development projects are conducted in 28 research departments, nine competence centres and eight living labs.

DFKI conducts research on **human-centric AI** in the major groundbreaking areas of AI research and applications with a focus on socially relevant topics and scientific excellence. The DFKI **Augmented Vision department** located in Kaiserslautern specializes in computer vision AI for applications in robotic perception, autonomous driving and human understanding.

Computer Vision Center (CVC)

CVC is a **non-profit institution** founded in 1995 by the Generalitat de Catalunya and the Universitat Autònoma de Barcelona (UAB). CVC is also a CERCA centre.

Its mission is to conduct research of renowned quality and international impact in the field of **computer vision**, transfer knowledge to companies and society, and train high-level scientists.

CVC is actively involved in both **high-quality research and development**, contributing to increased knowledge, innovation, and industrial competitiveness.

The centre **collaborates with companies** and undertakes technological projects in various areas, such as autonomous driving, personalised medicine, industry 4.0, human-computer interaction, and intelligent document analysis.

Capgemini Engineering

Capgemini engineering

As world leaders in **Engineering and R&D services**, Capgemini Engineering help its clients accelerate their journey towards the **intelligent industry**.

It brings them **global expertise and capabilities**, cutting-edge technologies in digital and software, agile engineering platforms, and an industrialised delivery model.

With more than 60,000 engineers and scientists across the globe, Capgemini Engineering unleashes the potential of **R&D and innovation** to help companies engineer smart products, optimised operations, new customer experiences, and new sources of value.

VORTEX-CoLab

VORTEX CoLab

VORTEX-CoLab is a **collaborative laboratory** in cyberphysical systems and cybersecurity whose vision is to create outstanding innovations that have a meaningful impact in industry and society. VORTEX-CoLab's innovation model thrives on combining academic insights and business mindsets to build acceleration programs with focus on raising the level of technological maturity of new research coming from our scientific partners and demonstrating their applicability in the **automotive, aerospace, telecommunications, medical devices and energy sectors**.

Using collaboration and diversity of knowledge as cornerstones, VORTEX-CoLab fosters a creative and open-minded culture to produce original combinations of **innovative solutions** and **cutting-edge proof-of-concepts** to create products that go far beyond just meeting customers' expectation.

It prototypes and scales products and services all the way **from concept to market**. It partners with organisations using co-creation to accelerate technology transfer. It collaborates with academic experts to conduct applied research that drives the field forward.

AUMOVIO

AUMOVIO

AUMOVIO is the **spin-off of Continental automotive** with around 87,000 employees worldwide.

AUMOVIO is the adaptive **Powerhouse for Future Mobility**, making it safe, exciting, connected, and autonomous.

To achieve this goal, AUMOVIO develop, produce and supply technologically leading and market-oriented products, hardware, software and modern mobility solutions.

In addition, we offer various services. Our diverse portfolio features a multitude of extremely well-established products and underpins our strong market position.

The department involved in the BERTHA project specialises in **cutting-edge AI, machine learning, and computer vision solutions** that address complex technological challenges.

In addition, it develops customised solutions for demanding tasks and adapts proven large-scale automotive technologies for industrial applications.

Fundación CIDAUT

Fundación CIDAUT is a **research and development centre** whose objective is research, development, and innovation of new technologies in the industrial sector, especially in the field of **transport and energy and the environment**.

The activities carried out from the centre are intended to cover the needs of companies and enhance their **competitiveness and industrial development**.

The centre carries out R&D projects that can be framed within the **following areas**: sustainable, intelligent and integrated transport; advanced materials and new processes- circular economy; mobility and security; energy and environment; technology of the information and communication; and industry 4.0.

The Fundación CIDAUT work methodology, consisting of addressing all the stages associated with the development of a new product, from the conception of the idea to pre-industrialization, going through the characterization of materials, the simulation of their behaviour and processing, the conception and design of prototypes and, finally, the validation.

Austrian Institute of Technology (AIT)

The AIT (Austrian Institute of Technology) is Austria's largest **research and technology organisation** and represents Austria’s commitment to more research and to secure Austria’s position as a hotbed of innovation. Despite being deeply rooted in Austria, the AIT is also a major player internationally.

According to its mission, AIT is strategically positioned as a key player in the European innovation system by performing applied research for and enabling the **market exploitation of innovative infrastructure-related solutions**.

The Digital Resilient Cities team within **AIT's Centre for Energy** develops urban management and planning solutions for the sustainable, smart, liveable, and resilient living spaces of tomorrow.

The team consists of experienced experts with a wide range of technical and professional backgrounds, including urban planners, architects, transport experts, energy experts, spatial planners, statisticians, geoscientists, and information scientists, who develop **innovative solutions in an interdisciplinary approach**.

Europcar Mobility Group

Europcar Mobility Group is a global **mobility services provider**, with a leading position in Europe. In the coming years, the Group's ambition is to become a leader in sustainable mobility services, driven by data, technology, and people.

Europcar Mobility Group offers to individuals and businesses a wide range of **car and van rental services**, be it for a few hours, a few days, a week, a month or more, on-demand or on subscription, relying on a fleet of more than 250,000 vehicles, equipped with the latest engines including more and more electric vehicles.

Its brands address differentiated needs, use cases and expectations: **Europcar®** - a global leader of car rental and light commercial vehicle rental, **Goldcar®** - a frontrunner at providing low-cost car rental services in Europe, **Fox-Rent-A-Car®**, one of the main players in the car rental market in the US, with a "value for money" positioning, and **Europcar On Demand®** – one of the European leaders of car-sharing (BtoB, BtoC).

Customers' satisfaction is at the heart of the Group's ambition and that of its more than 8,000 employees, everywhere Europcar Mobility Group delivers its **mobility solutions**, thanks to a strong network in 140 countries (including 16 wholly owned subsidiaries completed by franchisees and alliance partners).

FI Group

FI Group advises companies on the management of their R&D&I financing, through the design and implementation of actions aimed at boosting their **technological and economic development**.

These actions focus on the integral treatment of **R&D&I tax incentives** and the management of **calls for public grants and subsidie**s at the national and European levels, resulting in an improvement of the companies' profit and loss accounts.

Its commitment to achieving excellence in all its services has led FI Group to assume the leadership of the sector, both at the national and European levels, thus promoting an ambitious internationalisation plan with a clear objective: to help its clients in the **generation of value**.

Smart Eye

Smart Eye AB is a global leader in **Human Insight AI**, a technology that understands, supports, and predicts human behaviour in complex environments.

With its headquarters in Gothenburg, Sweden, and a presence worldwide, Smart Eye manufactures software and hardware for **eye, head, and body tracking**.

With multi-modal software and hardware solutions, Smart Eye provides unprecedented human insight in **automotive and behavioural research**, aiming to bridge the gap between humans and machines for a safe and sustainable future.

BERTHA

Keep informed through our communication channels!

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BERTHA project

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