**Exploratory notice to verify the uniqueness of the supplier for the assignment ex art. 76, par. 2, letter b), point 2) of Legislative Decree 36/2023 of the supply of an integrated travel simulation system for the Department of Civil, Environmental, Land Building Engineering and Chemistry of the Polytechnic University of Bari.** National Center for Sustainable Mobility (MOST) Funded within the Mission 4 Component 2 Investment 1.4 - Call “*Proposte di intervento per il potenziamento di strutture di ricerca e creazione di ‘campioni nazionali’ di ricerca e sviluppo su alcune key Enabling Technologies*” code CN000023 (CUP: D93C22000410001).

|  |  |
| --- | --- |
| POLITECNICO DI BARI  Dipartimento di Ingegneria Civile, Ambientale, del Territorio, Edile e di Chimica - DICATECh  Sede: Via Orabona, 4  70125 BARI - ITALY  Cfr: 80006480281 - P.IVA: IT00742430283 | PNRR - Missione 4: Istruzione e ricerca  Componente 2: Dalla ricerca all’impresa  Investimento 1.4 Potenziamento strutture di ricerca e creazione di campioni nazionali di R&S" su alcune Key Enabling Technologies, finanziato dall’Unione Europea-NextGenerationEU  Progetto Centro Nazionale per la Mobilità Sostenibile, MOST – **Flagship Project ECOBIKE Ecosystem of connected laboratories, centres and parks for bike and e-bike modeling, prototyping, testing and experiencing** CUP: D93C22000410001 |

**ALL. 1: RELAZIONE TECNICA**

**ANNEX 1: TECHNICAL REPORT**

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# Introduction

The Italian government within the National Recovery and Resilience Plan (PNRR), under Mission 4 Component 2 Investment 1. 4 notice 'Proposals for the strengthening of research structures and the creation of 'national champions' of research and development on certain Key Enabling Technologies', has financed the National Centre for Sustainable Mobility (MOST) with the aim of promoting innovative solutions within the sector of 'sustainable mobility'.

The centre is organised in a Hub&Spoke system, with a Hub in Milan and fourteen Spokes located throughout the country. Spoke 8, based at the Politecnico di Bari, aims to identify and integrate the technological, economic and social drivers to promote the ecological transition of mobility towards a Mobility as a Service (MaaS) model and other innovative and sustainable mobility services.

Among the activities of the MOST some flagship projects have been funded. Specifically, the flagship project ECOBIKe (Ecosystem of connected laboratories, centres and parks for bike and e-bike modeling, prototyping, testing and experiencing) has the objective of set up a system of laboratories focused of different topic related to the development of cycling as a safe, healthy and sustainable mode of transportation as well as to define an experimental set to check new infrastructures layout and solutions.

The project focus is to set up a cutting-edge laboratory network for modeling, prototyping, testing, experiencing and enjoying e-bikes: four, cloud-connected, Italian sites to test and develop new solutions for ebikes, with a special attention to decarbonization, digitalization, business and service to the community. Poliba's new lab will experience modeling and driving styles, creating virtual experiences and studying more safe driving styles as well as the effects of design solution of road infrastructures on riders behaviour and safety and road users in general.

Polytechnic University of Bari is realizing laboratories to be located in Bari, Matera and Mola di Bari according to the integrated synergic approach to R&D of the MOST national center . One of these labs is the Lab@PoliBA devoted to the study of drivers’ behavior by using driving simulator and a simulation system for shared micromobility, infrastructure network solutions and aims to become a benchmark for research on digital twins of two wheeled vehicles. In addition, Lab@Poliba will share its new tools for test and validation of the smart battery pack within a new real e-bike in closed and synergic collaboration with the Research Center of Vaimoo company and the other partners of the flagship project.

The Department of Civil, Environmental, Land Building Engineering and Chemistry of the Polytechnic University of Bari (hereinafter referred as “DICATECh”), to reach the objective of the Ecobike project needs to purchase of an integrated cycling and pedestrian simulation system in a virtual environment (hereinafter referred to as the system). The system will consist of a bicycle simulator capable of operating to observe the behaviour of drivers in suitably realised virtual environments and a pedestrian simulator. The system is an essential tool for observing the behaviour of users of the transport system with particular reference to the need to analyse the response to different driving scenario defined by different parameters (such as infrastructural, traffic, weather, light etc.) and model their propensity towards sustainable mobility alternatives and identifying and check the impact of those scenarios also considering biological responses.

The use of the simulation systems for these purposes constitutes an important advancement in mobility and transport research allowing the study of human behaviour as stand alone user (rider or pedestrian) or as interacting users.

The prototype of the system that has been identified is the one proposed by the company **Würzburger Institut für Verkehrswissenschaften GmbH /Germany).**

Compact Bicycle Driving Simulator and a pedestrian simulation system based a bicycle mockup with a set of sensors/actuators, a viewing system, a computers’ network, a biosignal systems of sensors, a specific software to realize vehicle dynamic and scenario design and management and a pedestrian simulation based on a VR hardware system. The whole systems is able to be developed by integrating further driving simulators (for ex. Car driving Simulators).

The supply has as its object the acquisition of scientific equipment and materials necessary and functional exclusively for the performance of the activities envisaged by the CN MOST and the achievement of its objectives.

# Context and needs

The purchase of the system would represent a crucial investment as it meets the need for a technological development that is essential to meet the research challenges as envisaged by the CN MOST.

The need for this equipment is in the context of the **National Recovery and Resilience Plan** (Mission 4, Component 2, Investment 1.4), in which our university actively participates to the MOST National Centre.

The system is an integral part of the integrated multidisciplinary laboratories envisaged by the activities of the Ecobike Flagship project, where the data collected by the various monitoring platforms will converge and where specific processing and testing of algorithms and calibration of choice models will be possible.

# Description

## System architecture

The System is made up of the following main elements:

* Vision Systems
* Vehicle Mockup
* Computing Computer Network
* Simulation Software Packages
* Biosignal sensors system
* Pedestrian Simulator

# Technical characteristics of the Bicycle Simulator

The vision system is a foldable 360° vision for an immersive experience. The bicycle mockup consisting of a sensor/actuator setup and a real bicycle adapted for the simulation. The sensor and actuator is controlled by the software driving simulator according to the simulated scenario and the vehicle dynamics. The Vision and vehicle simulation system is managed by a network of at least 6 workstations according to the number of vehicle and vision system. To monitor the biological response of the drivers a system of sensors made up of Eye tracking and biosignal sensors is properly setup with a DPU for control and data recording is available in the software.

The software solution allows the interchange of scenarios and the passive participation (at least at this stage of development) of the pedestrian and other vehicles in the simulated driving environment.

The architecture is designed to allow for possible future integration with other simulators (e.g., bicycle, electric scooter, motorbike, car, truck).

In the following paragraphs, a detailed description of the systems’ components is given, explaining the characteristics of the hardware and software.

## WP1 Hardware Setup

### WP1.1: Vision system (360° view)

In order to enable realistic visualization, the vision system is made up of a LED display based solution. In the basic configuration, this includes a vision system with approx. 180° visibility, 6 single LED panels (with resolution: Full-HD or higher).

To a full immersive experience, a view extension of a total of 12 LED individual panels is offered, resulting in a completely closed viewing system (360° view). A corresponding setup is shown as an example in Figure 2-1. The components required for this are described in the following section[s](#_bookmark14).

The scope of the basic configuration of the vision system includes:

* + - * 6 LED panels (resolution: Full-HD or higher, size: approx. 50")
      * 3 monitor stands
      * 3 operator monitors



Figure 2-1: 360° viewing system of the, left: unfolded, right: viewing system in test mode and operator workplace with monitors.

## WP1.2: Bicycle Prototype

The bicycle mockup consists of a sensor/actuator setup and a real bicycle adapted for the simulation.

### Bicycle mockup

The following configuration is the basis for the mockup (the variant will be agreed):

* + - * + Bicycle frame shape: (commercial) trapezoidal frame, medium frame size. If necessary, a low-entry frame is also possible at the customer's request. [Figure 2-2](#_bookmark6) illustrates possible assembly variants based on different bicycle frame shapes. [Figure 2-3](#_bookmark7) shows a current setup for a customer project (trekking trapeze).

Immagine che contiene ruota, pneumatico, bici, trasporto

Descrizione generata automaticamenteImmagine che contiene ruota, pneumatico, bici, Telaio della bicicletta

Descrizione generata automaticamente

Figure 2-2: Assembly variants: Trekking trapeze (left) or city bike low entry (right).

* Gears: derailleur gears, mechanical gear indicators, if necessary, number of gears and transmission ranges can be adjusted according to the customer's wishes.
* Brakes: (commercially available) hydraulic bicycle brake system, front and rear brake levers.
* Seatpost/rear: Dropper seatpost, can be operated by the test person using a handlebar lever.
* Handlebar/Front: Tool-free height-adjustable handlebar.

Immagine che contiene ruota, pneumatico, bici, bicicletta

Descrizione generata automaticamenteFigure 2-3: Example trekking trapeze setup.

### Sensor/actuator design

#### Riding resistance and steering

Immagine che contiene interno, attrezzo per l'allenamento, pavimento

Descrizione generata automaticamenteImmagine che contiene trasporto, pneumatico, raggio, bicicletta

Descrizione generata automaticamente

Figure 2-4: Cycletrainer (left) and steering plate (right).

With regard to the sensor and actuator design, it is planned to use a direct-drive electromagnetic cycletrainer as an actuator to adjust and measure the rider's load [(Figure 2-4](#_bookmark9), left). The cycletrainer is controlled by means of the SILAB driving simulation software and the vehicle dynamics described in section 2.3. The front wheel rests on a steering plate, through which the steering angle is recorded by means of a built-in sensor ([Figure 2-4](#_bookmark9), right). Cycletrainer and steering plate are mounted on a movable rocker plate. A rear wheel is not included.

#### Braking system

The braking system is implemented exclusively as a sensor system ([Figure 2-5](#_bookmark10)). It will be used commercially available hydraulic bicycle brakes. The aim is to ensure familiar lever operation as well as realistic hand forces. The driver's lever movement is measured by (pressure) sensors, which transmit the measured values to the vehicle dynamics. The corresponding deceleration is then calculated by the vehicle dynamics and transmitted to the simulated bicycle.

Immagine che contiene oggetti in metallo, bici, leva, carbone

Descrizione generata automaticamenteImmagine che contiene testo, Impianto elettrico, connettore, ingegneria

Descrizione generata automaticamente

Figure 2-5: Brake lever (left), brake caliper and brake sensors (right).

#### Display and handlebar control unit

It is requested to install a small touchscreen monitor as a display. The size is based on the size of current smartphone displays. The input device is to be a standard handlebar control unit with three to five buttons, which can be freely assigned via the software SILAB ([Figure 2-6](#_bookmark11)).

Immagine che contiene Videocamere/fotocamere e obiettivi, Strumento ottico, carbone, Ricambio auto

Descrizione generata automaticamenteImmagine che contiene testo, cavo, computer, interno

Descrizione generata automaticamente

Figure 2-6: Control unit (here: BOSCH Intuiva; left) and display (right).

### Tool-free adjustment of saddle height and riding position

For quick and tool-free adjustment of the saddle height and riding position, it is requested to install a so-called dropper post and a height-adjustable stem. With a dropper post, the seat height can be infinitely adjusted by the test person himself via a handlebar lever. In the case of the height-adjust- able stem, the height of the front can be adjusted by the experimenter to the test person at the beginning of a test session by means of a quick release.

Immagine che contiene bici, Sellino di bicicletta, Biciclette - Attrezzatura e forniture, bicicletta

Descrizione generata automaticamente Immagine che contiene bici, carbone, bicicletta, aria aperta

Descrizione generata automaticamente

Figure 2-7: Height adjustment rear (dropper post, left) and front (tool-free height-adjustable stem, right)

### Headwind simulation

Concerning the simulation of headwind, the use of two fans adapted to bicycle-specific aspects is planned. The fans are controlled by the SILAB simulation software and the vehicle dynamics described in section 5. According to the manufacturer, the maximum wind speed that can be produced is approx. 50 km/h or 6 Bft ("strong wind").

Immagine che contiene elettronica, cavo, pavimento, interno

Descrizione generata automaticamenteFigure 2-8: Headwind fan

## WP1.3: Computer network

The computer network of the simulator for the basic configuration of the vision system consists of 6 PCs of the following type:

In terms of performance, the specification fulfils at least the following key data:

* + - * 19" rack with the exception of the operator PC as well as the PC for the operator views. These PCs are supplied in a tower case.
      * Processor: Intel® Core™ i5-13600KF or better
      * 32 GB RAM
      * NVidia GeForce graphics card 4060 or higher (for the render PCs)
      * 500 GB SSD
      * Windows 11

This enables a smooth graphical output of the simulation that can be realized on all views with a resolution of 1920x1080 (Full-HD) at least.

Setting up the PCs with Windows 11 Pro as well as integration of the computers into a network is part of the scope.

Due to the real-time requirement for the PCs, no virus scanner will be set up on the simulator PCs. Therefore, for security reasons, it is recommended to place the PCs on a separate network so that the risk of malware infection is minimized.

All computers are installed in a network cabinet and wired to the vision system and the bicycle mockup (maximum cable length 15 m).

### WP1.4: Hardware: Upgrade to 360° view

As described in section 4.1.1, an optional view extension to a total of 12 LED panels is requested, resulting in a completely closed viewing system (360° view). The scope of delivery and services includes:

* + - * 3 more viewing system / render PCs
      * 3 additional monitor stands
      * 6 additional LED panels (size and resolution of the basic view system)
      * an upgrade of the computer cabinet
      * as well as the personnel costs for the extended construction and installation work.

For traffic safety research reasons, the system will be extended to 360° vision.

### WP1.5: Hardware: Eye tracking and biosignal sensors

#### Eye tracking

For measuring eye movements, we recommend the Pupil Labs Core Eye Tracking System. The system consists of an open-source software suite and a portable eye-tracking headset. A correspond- ing DPU for control and data recording is available in SILAB and is included in the delivery.

#### Biosignal sensors

For measuring various biosignals, the system will be the 8-Channel biosignalsplux kit (SKU: 820201017) from Plux Biosignals.

The customized research kit includes an 8-channel hub as well as the following sensors:

* + - * Electromyography (EMG) Sensor (SKU: 820201201)
      * Electrodermal Activity (EDA) Sensor (SKU: 820201202)
      * Electrooculography (EOG) Sensor (SKU: 820201232)
      * Blood Oxygen Saturation (SpO2) Sensors (SKU: 820201239)
      * Electroencephalography (EEG) Sensor (SKU: 820201204)
      * Electrocardiography (ECG) Sensor (SKU: 820201219)
      * Piezo-Electric Respiration (PZT) Sensor (SKU: 880971201)

Furthermore, we the following accessories will be provided:

* + - * Gelled Self-Adhesive Disposable Ag/AgCl Electrodes (SKU: 870992015)
      * Nuprep Skin Preparation Gel (SKU: 870992020)
      * Ten20 Conductive Paste (SKU: 870992021)

A corresponding DPU for data recording is available in SILAB and is included in the delivery

## WP 2: Software

### WP 2.1: SILAB Edition and SILAB Software Add-on Package BICYCLE

SILAB is developed by WIVW and delivered in the current version 7.2.

Scenario design is currently based on German guidelines for road networks. An Italian version will be developed.

The software also includes the BICYCLE software add-on package. The package contains modules for cycling-specific vehicle dynamics (e.g. resistance, brakes, steering, sound) as well as a short training programme to speed up familiarization with the simulator.

The cycling-specific vehicle dynamics are deliberately kept simple for the user and can be easily adapted / parameterized by the user (either globally or on a project-specific basis). The goal is to create a realistic cycling impression, a high level of immersion and meaningful, analyzable simulator riding data. There is also the possibility to integrate other vehicle dynamics.

### Resistance module

The resistance module controls the driver's load and simulated driving speed as a function of climb/descent, speed-dependent wind load, rolling resistance, as well as additional environmental parameters/constants. The resistance model brakes *and* accelerates the simulated bicycle depend- ing on the corresponding environmental parameters provided by SILAB (e.g. higher riding resistance on climbs, additional acceleration due to gravitational force on descents, etc.).

The resistance module can be parameterized using the following parameters, among others:

* + - * + System weight (rider + bike + payload)
        + Rolling resistance coefficient
        + Drag coefficient
        + Driver's frontal area
        + Air density

### Headwind module

The headwind module controls the travelling wind speed. The module controls both of the fans described in section 4.2.6 and the modulation of the simulated wind load in the resistance module. The simulated wind noise while riding is also automatically adjusted.

### Brake module

The brake module simulates a realistic bicycle brake system with independently acting front and rear brakes. The wheel load shift during braking is also taken into account, i.e. the simulated rear wheel can "lock" if braking is too hard (which is accompanied by a reduction in deceleration).

On the software side, the maximum braking force and the modulation can be set separately for the front and rear brakes. The wheel load shift can be switched on active or inactive. On the hardware side, the brake lever can be used to adjust the reach and pressure point.

The brake module can be parameterized using the following parameters:

* + - * + Maximum possible braking force for front and rear brakes separately
        + Wheel load shifting

Geometry data of the simulated bike

On/Off

* + - * + Friction coefficients for tires/surfaces

### Steering module

The steering ratio can be freely parameterized by the software, i.e. the actual handlebar angle and the simulated handlebar angle can differ from each other if desired. In addition, it is possible to design the steering ratio depending on the speed, e.g. to allow for different steering angles at higher/lower speeds. A freely configurable and speed-dependent rolling (i.e. a "tilting" of the horizon while steering) is also implemented, which can be switched on or off.

The steering module can be parameterized using the following parameters:

* + - * + Sensitivity of the steering as a function of the riding speed
        + Rolling/tilting of the horizon as a function of riding speed

### Sound module

In addition, the vehicle dynamics has a bike-specific sound module that provides both ambient sounds and the bike's own sounds. Included are: background noise (city/country), wind noise, a tyre rolling noise and brake noises (grinding noises, locking rear wheel). All sounds of the sound module can be switched on or off separately and their volume can be adjusted. The 3D sound simulation of the surrounding traffic remains unaffected by the sound module described.

The sound module includes the following additional sounds:

* + - * + Background/ambient noise (city noise, birds chirping, etc.)
        + Airstream noise (speed-dependent)
        + Rolling noise (depending on speed)
        + Brake noises (e.g. locking rear wheel, "brake grinding")

The sound module includes noise-cancelling headphones to shield the driver from unwanted background noise and an intercom system for communication between the study participant and the experimenter.

### Data recording

The following vehicle dynamics parameters can be recorded on the SILAB side:

* + - * + Simulated travel speed, (longitudinal) acceleration
        + Braking forces (separate for front and rear wheels)
        + Riding resistance forces (downhill force, wind load, rolling resistance, etc.)
        + Riding power (cadence, watts)

as well as lots of other parameters like traffic/traffic participants data, lane/road information, sur- rounding objects etc.

### Simulator familiarization

The importance of getting used to a simulator is often underestimated and neglected for reasons of time or cost. An adaptation of the test person to the psychophysical conditions contributes decisively to valid results and is therefore strongly recommended.

For this purpose, practice rides are provided to help you get used to the simulation (documentation included). The objectives are to reduce or avoid simulator sickness, objectively safe simulator control, creating a subjectively safe riding experience and getting the rider used to the examination situation.

On the acclimatization scenario ([Figure 2-9](#_bookmark24)) there are several sections for performing appropriate exercises (getting on/off, starting, braking and shifting; lane keeping and cornering).



Figure 2-9: Acclimatization scenario.

Several sections of the route are available for practising turning manoeuvres. Several intersections are available with different right-of-way regulations and other road users. The cyclist must get into the right or left lane accordingly, or go straight ahead, stop if necessary and start again. It is based on the navigation display/announcement. Due to the circular arrangement, the routes can be driven for any length of time until the turning is sufficiently practiced.

## WP2.2: Upgrade to SILAB Enterprise Edition

An upgrade to SILAB Edition Enterprise is requested. Details of the different simulator software editions can be found in the product description attached.

## WP3: On-site delivery and installation/commissioning

Work package 3 includes the delivery of the components and the assembly or commissioning of the bicycle simulator on site at the Politecnico di Bari premises.

Two sockets with separate fuse protection (16A with 30 mA RCD) are required for the electrical connection (one for the monitor circuit and one for the computer cabinet). The metal frame of the visual system and the computer cabinet must be included in the local potential equalisation (by the client). The low-impedance continuity of the connections must be checked (by the client). An earth- ing terminal for connecting the simulator must be provided by the client.

The simulator requires 25 - 30 m2 of space at least.

## WP4: Instruction and software training

The subject is a two-day training course for the client's personnel. This training course deals with the operation of the simulator, the functionalities of the individual software components and the use of the scenario packages included in the scope of system. The training will takes place on site at the DICATECh premises.

## WP5: Support, Care and Maintenance

Starting from the date of acceptance of the system by the client, a period of two years o support care and maintenance is included. The WIVW provides services during normal business hours (Monday to Friday, 9 a.m. to 4 p.m. to ensure the operability of the system. Support Requests can be received by e-mail (silab@wivw.de) or by phone (+49 931 78009-400).

Also included in work package is the maintenance of the respective SILAB Edition software (Professional or Enterprise) for two years after startup of the system. Support, care and maintenance costs are due at the beginning of the term. Support and care services beyond the second year (e.g. software updates yearly) is included in this offer.

## List of the elements to be provided for the Bucycle simulator

|  |  |  |
| --- | --- | --- |
|  | ***Item Description*** | ***Quantity*** |
| **Hardware** | | |
| HW | Digital Monitor for high immersion of simulation | 12 |
| HW | Monitor stands | 6 |
| HW | Windows PC for Image Generation (SILAB) | 6 |
| HW | Windows PC for Simulation Control (Operator, Traffic, Rider Observation, Data Logging) | 2 |
| HW | Linux PC for Mockup Control (Vehicle Dynamics, HMI, Sound) | 1 |
| HW | Network cabinet | 1 |
| HW | Operator screens | 3 |
| HW | Audio System (inc. headphones and intercom) | 1 |
| HW | Mockup bicycle (independently acting front and rear brakes) | 1 |
| HW | Rocker Plate / Passive Motion Platform | 1 |
| HW | HMI Screen (Mockup) | 1 |
| HW | Brake sensors | 2 |
| HW | Steering angle sensor | 1 |
| HW | Speed/rotation sensors | 2 |
| HW | Handlebar Control Unit | 1 |
| HW | Sensorbox | 1 |
| HW | Fans for headwind simulation | 2 |
| HW | Bicycle trainer (Tacx Neo 2t) | 1 |
| HW | Eyetracker (Pupil Labs) | 1 |
| HW | Physiological sensors (Biosignalsplux Kit with variety of sensors) | 1 |
| HW | Various Material | 1 |
| **Software** | | |
| SW | SILAB Professional Edition (Editor for Scenarios, Detailed control over traffic etc.) | 1 |
| SW | SILAB Bicycle package | 1 |
| SW | SILAB Update to Enterprise Edition (including programming interface - Java, Python, C++) | 1 |
| SW | Simulation of Pedelec as well as S-Pedelec | 1 |
| SW | Extensive Parametrization of Pedelec module | 1 |
| SW | Steering ratio can be freely parametrized | 1 |
| **Services** | | |
| SRV | Bicycle Simulator System Integration | 1 |
| SRV | Bicycle Simulator Project Management | 1 |
| SRV | Simulation Software Care and Maintenance | 1 |
| SRV | Physiological Sensor Integration | 1 |
| SRV | Eyetracker Integration | 1 |
| SRV | Shipment of all Equipment | 1 |
| SRV | Documentation (in English) | 1 |
| SRV | Site Acceptance Test | 1 |
| SRV | Driving Simulator Training | 1 |
| SRV | Travel Expenses | 1 |

## Distinctive and unique features

The unique and distinctive components of the system proposed by WIVW are listed below.

1. Driver's lever movement is measured by (pressure) sensors
2. The steering ratio can be freely parameterized by the software
3. independently acting front and rear brakes
4. The brake module can be parameterized using the following parameters:

* Maximum possible braking force for front and rear brakes separately
* Wheel load shifting (Geometry data of the simulated bike; On/Off)
* Friction coefficients for tires/surfaces

[5] Simulation of Pedelec as well as S-Pedelec

[6] extensive parametrization of Pedelec module

[7] Integration and interaction of the simulators in the VR scenario

# Pedestrian Simulator

The pedestrian simulator is divided into the following work packages:

* WP2.1: Hardware setup (Visual system and computer network)
* WP2.2: Simulation Software-packages (SILAB and SILAB HEAD MOUNTED DISPLAY)
* WP2.3: Delivery, installation, and commissioning of the simulator on site
* WP2.4: Instruction and software training
* WP2.5: Support, Care and Maintenance

In order to connect the pedestrian simulator with the bicycle simulator, they must be in close proximity so that they can be networked and the test subjects can be instructed together.

## WP2.1: Hardware-Setup

In order to maximise immersion, the simulator supplied is equipped with a VR vision system. The various components of the simulator are described below.

### WP2.1.1. Visual system and movement space

Current VR goggles are used as the viewing system for the test subject. These have at least the following key technical data:

* Display resolution of 2448 x 2448 pixels per eye
* Refresh rate of 90Hz

The VR goggles are connected to the corresponding computer either wirelessly or by cable. The goggles enable eye tracking data to be recorded, which can be synchronised with other driving simulation data.

The simulator allows a maximum size of 7 x 7 metres for the walkable area. The total space requirement is 9 x 9 metres. The test subject is provided with two hand controllers to interact with the environment. The positions of the controllers are recorded by the simulation software, and button presses can be recorded by the simulation software and presented to other participants, for example.

### WP2.1.2 Computer network

The computer network consists of at least three computer cases, which are set up near the operator desk (operator desk is not included).

All computers required for the realisation of the described functions (software package head mounted display) are included in the scope of delivery. The client must ensure that the room is sufficiently cooled so that the PCs can be operated within their operating temperature range. This is between 10°C and 30°C.

Immagine che contiene testo, schermata, diagramma, linea

Descrizione generata automaticamente

Figure 2-1: Schematic representation of the computer network.

The simulation PCs fulfil at least the following requirements:

* Processor: Intel® Core™ i5-13600K
* 32 GB RAM
* GeForce RTX 4060 or higher (for the render PCs)
* SSD with 500 GB size
* Operating system: Windows 11 Pro
* The simulation PCs fulfil the following functions:
  + Operator
  + Skeleton tracking
  + VR visualisation

A control monitor, a mouse and a keyboard are included in the offer for the operating PC. An additional monitor shows the subject's view. The client shall provide a table measuring at least 1.60 m x 0.80 m for setting up the operator PC and for the co-foam monitor. An earthing point must be provided by the client in the vicinity of the set-up.

The cables between the computer network and the operator desk must not exceed a maximum length of 15 metres. The client must provide an appropriate space for this. The client must provide a 230V line with 16A fuse protection (separately) for the power supply.

Due to the real-time requirement for the PCs, no virus scanner will be set up on the simulator PCs. Therefore, for security reasons, it is recommended to place the PCs on a separate network so that the risk of malware infection is minimized.

## WP2.2.: Software

### SILAB Edition and SILAB Software Add-on Packages HEAD MOUNTED DISPLAY

SILAB is developed by WIVW and delivered in the current version 7.2 (see the detailed product descriptions for different editions in the attachment). We recommend SILAB Edition Professional. Scenario design is currently based on German guidelines for road networks. An Italian version will be developed.

The pedestrian simulation is to be realised using a head-mounted display. The software modules required for this are included in the HEAD MOUNTED DISPLAY add-on package. In order to visualise the pedestrian to the cyclist on the bicycle simulator, the movements of the test person are recorded by software and fed into the simulation software. In this way, body movements (e.g. raising an arm) are transferred to the simulation. Due to technical limitations, the recorded movement model is only approximate and does not fully correspond to the real movements. In addition, short-term losses in the recording are possible, which may result in unrealistic movements being displayed to the cyclist of the bicycle simulator.

The body movement is recorded via skeleton recognition and tracking. Multiple cameras are used to interpolate skeleton data points resulting in depth data (X, Y and Z coordinates) which can be used to visualize the body movements in the simulation. Further, the use of multiple cameras also allows the skeleton to be recognized regardless of the pedestrian's rotation. In general, four cameras will be used for skeleton recognition and tracking.

Immagine che contiene calzature, vestiti, persona, tennis

Descrizione generata automaticamente

Figure 2-2: Exemplary illustration of skeleton recognition

Immagine che contiene diagramma, origami, design

Descrizione generata automaticamente

Figure 2-3: Illustration of interpolation of skeleton data

## WP2.3.: On-site delivery and installation/commissioning

Work package 2.3. includes the delivery of the components and the assembly and commissioning as well as the networking of the bicycle and pedestrian simulator and setting up the Head mounted display package. It can subsequently be used in the following configurations:

* Pedestrian simulator alone
* Simulation together with bicycle simulator

## WP2.4: Instruction and software training

The subject of work package 2.4 is a two-day training course for the client's personnel. This training course deals with the operation of the simulators, the functionalities of the individual software components and the use of the scenario packages included in the scope of delivery. The training takes place on site.

## WP2.5: Support, Care and Maintenance

For a period of one year, starting from the date of acceptance of the system by the client – the WIVW provides services during normal business hours (Monday to Friday, 9 a.m. to 4 p.m. to ensure the operability of the system. Support Requests can be received by e-mail (silab@wivw.de) or by phone (+49 931 78009-400).

Support, care and maintenance costs are due at the beginning of the term. Support and care services beyond the first year (e.g. software updates yearly) are not subject of this offer. The current annual costs for support, maintenance and care are €7000 for SILAB Edition Professional and €9000 for SILAB Edition Enterprise. In this offer the 2nd year for support, maintenance and care is included.

## List of the items to be provided for the pedestrian simulator

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  | ***Item Description*** | ***Quantity*** |
| **Hardware** | | |
| HW | VR Headset with a framerate of 90Hz | 1 |
| HW | VR Headset eyetracker | 1 |
| HW | VR controller for interaction | 2 |
| HW | Windows PC for image generation | 1 |
| HW | Windows PC for operator | 1 |
| HW | Windows PC for skeleton capture | 1 |
| HW | Camera for skeleton recognition | 4 |
| HW | Tripod with camera mounts | 4 |
| HW | Network cabinet | 1 |
| HW | WiFi Router for data transmission | 1 |
| HW | Audio System | 1 |
| **Software** | | |
| SW | SILAB Professional Edition (Editor for Scenarios, Detailed control over traffic etc.) | 1 |
| SW | SILAB Package Head Mounted Display (90 fps) | 1 |
| SW | Co-Simulation with other types of SILAB simulators enables research on interaction subjects | 1 |
| SW | Unique skeleton recognition algorithm transfers participant’s movements into the simulation | 1 |
| **Services** | | |
| SRV | Pedestrian Simulator System Integration | 1 |
| SRV | Pedestrian Simulator Project Management | 1 |
| SRV | Shipment of all Equipment | 1 |
| SRV | Simulation Software Care and Maintenance | 1 |
| SRV | Documentation (in English) | 1 |
| SRV | Site Acceptance Test | 1 |
| SRV | Pedestrian Simulator Training | 1 |
| SRV | Travel Expenses | 1 |

# Time and cost plan

### Schedule

Work can begin immediately after the order is placed. Due to the currently difficult to predict delivery times for hardware components, we expect the project to take at least six months. The exact timing is done in consultation with the client.

### Cost plan

|  |  |  |  |
| --- | --- | --- | --- |
| **Bicycle Simulator** | **Cost type** | **€** | **€/WP** |
| WP1.1.1: Vision system (180° view) |  |  | 9210 |
| WP1.1.2: Mockup |  |  | 29160 |
| WP1.1.3: Computer network |  |  | 24890 |
| WP1.1.4: Hardware: Upgrade to 360° view – optional |  |  | 16880 |
| WP1.1.5: additional Hardware: Eye tracking and Biosignal Sensors |  |  | 10660 |
| WP1.2.1: Software |  |  | 39000 |
| WP1.2.2: Upgrade to SILAB Enterprise Edition - optional |  |  | 15000 |
| WP1.3: On-site delivery and installation/commissioning |  |  | 17372 |
| WP1.4: Instruction and software training |  |  | 11392 |
| WP1.5: Support, Care and Maintenance (first and second year) |  |  | 9000 |
| Discount Bicycle Simulator |  |  | -2564 |
| **WP1 Total Bicycle Simulator** |  |  | **180000** |
|  |  |  |  |
| **WP2 Pedestrian Simulator** | | | |
| WP2.: Visual System and Computer Network |  |  | 43786 |
| WP2.2: Software: |  |  | 39500 |
| SILAB Professional Edition |  | 35000 |  |
| SILAB Package HEAD MOUNTED DISPLAY |  | 4500 |  |
| WP2.3: On-site delivery and installation/commissioning |  |  | 13992 |
| WP2.4: Instruction and software training |  |  | 8872 |
| WP2.5: Support and Care (first and second year) |  |  | 9000 |
| **WP Total Pedestrian Simulator** |  |  | **115150** |
| **Grand Total €** |  |  | **295150** |

The provider will charge the amount stated in this document for the product offered without tax. It is a tax-free delivery within the EU. The tax is paid by the customer in Italy directly to the tax office.

The software is delivered / made available by download immediately after receipt of the order and is due for payment immediately after provisioning.

30% of the hardware costs are due when the order is placed. A further 30% of the hardware costs are due upon delivery to the customer. All other costs are due after acceptance of the product.