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PAsCAL

Enhance driver behaviour & Public Acceptance of Connected & Autonomous vehicles

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D4.1 – Scenarios and experimental protocols

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Disclaimer

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Version History

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V0.2	**15/07/2021**	**M. Larique**	Draft
V1.0	**20/07/2021**	**M. Larique**	Pre-final version for quality review
V2.0	**31/07/2021**	**M. Larique**	Final version

List of acronyms	
Acronym	**Meaning**
CAV	Connected and Autonomous Vehicles
DAB	Data Advisory Board
EAB	Ethics Advisory Board
eHMI	External Human-Machine Interface
eVTOL	Electric Vertical Take-off and Landing
FP7	Seventh Framework Programme (EU)
FPS	Frame per second
GPS	Global Positionning System
HMI	Human-Machine Interface
HSS	Home Study Simulator
L3/L4/L5	Level 3/4/5 (for driving automation)
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
LIST	Luxembourg Institute of Technology (LU)
OB	Objective
PAV	Personal Aerial Vehicle
PBQ	Pedestrian Receptivity Questionnaire
PC	Personal Computer
PRQ	Pedestrian Behaviour Questionnaire
SAE	Society of Automotive Engineers

SOB	Specific Objectives
UBFC	Université Bourgogne - Franche-Comté (FR)
UMUX	Usability Metric for User Experience
UTBM	Université de Technologie de Belfort-Montbéliard (FR)
UV-C	Ultraviolet C (wavelengths from 100 to 280 nm)
UX	User Experience
VR	Virtual Reality
WP	Workpackage

Notice

This document complies with the European Blind Union's guidelines (http://www.euroblind.org/publications-and-resources/making-information-accessible-all) in order to be accessible to anyone, including blind and partially sighted people, and at the same time and at no additional cost.

Table of Contents

Table of Figures

List of tables

Executive summary

The aim of the PAsCAL project, funded under the "Horizon 2020" Research and Innovation program, is to improve the understanding of the implications of connected and automated vehicles (CAVs) on society. The project will create a "Guide2Autonomy" to capture this new knowledge. Outcomes from the project will contribute to the training of future drivers and passengers and will help decision-makers to move towards the new forms of individual and collective mobility made possible by the spread of driverless cars.

During the PAsCAL project, the perceptions and expectations of citizens regarding the new autonomous and connected driving technologies will be examined, trying to better understand their fears and concerns and to help to prepare solutions that will be able to bridge the anticipated emotional and cultural gaps. If these are not tackled, the barriers to adoption, inherent in the world of CAVs, may not be removed.

Likewise, the behaviour of drivers in semi-autonomous vehicles and that of all other road users will be studied, again to identify the main obstacles that will need to be removed in order to make man-machine interaction commonplace, whilst being as safe as possible.

To these purposes, specific surveys have been prepared in WP3 and accurate behavioural analyses are carried out in WP4 with extensive use of modern technologies, such as driving simulators and virtual reality platforms.

The results of the simulation experiments will provide a better understanding of the reasons for the distrust towards CAVs expressed by many European citizens. They will describe reactions and behaviours in situations that are still completely new and yet to be determined. They will allow useful conclusions to be drawn in terms of vehicle design, human-machine interface layout, and the more holistic organization of the transport system.

All of this new knowledge will be incorporated into the "Guide2Autonomy" which will be made available to all relevant stakeholders. Specific anticipated items for inclusion will be how best to train CAV users (the current "drivers"), the necessary certifications that must be obtained and any new traffic rules to be adopted. It is hoped that all of this will assist with a smooth transition to wide-scale CAV adoption.

A specific focus, as part of the PAsCAL project, will be reserved for people who are currently unable to drive traditional vehicles; Blind or partially

sighted citizens are a specific case considered by the project. For these road users, connected autonomous driving offers numerous advantages in terms of freedom of movement and increased personal autonomy.

In addition to the behavioural surveys and virtual journey experiences conducted using simulators, PAsCAL will finally create 5 road-transport pilot projects, conducted in different countries of the European Union. The pilot projects will focus respectively on: autonomous high-capacity buses; user training through driving schools and driving academies; different types of connected shared vehicles; autonomous bus lines and, last but not least, applications that allow people with disabilities to travel, thanks to new autonomous driving technologies within a transport network.

The current document presents the simulation scenarios and the corresponding experimental protocols that define the 5 experiments WP4 is made of. From their initial design to the details of their implementation.

The common background is presented in chapter 2, including the positioning of WP4 within the PAsCAL project, a recall of the WP4 objectives, the presentation of the simulators involved then how the research questions and the scenarios were imagined then chosen.

Much more details about the scenarios development and the experimental protocols (scientific definition, recruitment of the subjects, technical information about the simulation systems, measurement tools including questionnaires…) for each of the 5 experiments are exposed in chapter 3.

Additional information about deviations and references are provided in chapters 4 and 5.

1 Introduction

1.1 Purpose and organization of the document

The following deliverable D4.1 aims to provide a clear definition of all simulation scenarios and experimental protocols of the five experiments being run within WP4.

Chapter 2 explains how was managed the collective works for defining the research questions to be addressed by WP4 experiments, then to harmonise some elements like questionnaires and metrics, so we keep consistent along WP4 and the whole PAsCAL project.

In chapter 3, we present the scenario and the experimental protocol of the five experiments. For each one, we follow rather the same structure by delivering respectively the scientific definition of the experiment, some key elements about the subjects' sample and the simulation system, the full scenario of the simulation, the definition of the measurement package, and the questionnaire to be performed, then the detailed protocol.

The document finishes with explanations about the deviations due to the Covid-19 outbreak that hit almost from the beginning of WP4, chapter 4. References and literature are provided in chapter 5.

As this document was written by several authors, the style may vary according to the chapters and paragraphs despite the efforts made to ensure its homogeneity. Thank you for your indulgence.

1.2 The intended audience of this document

The main audience for this document is twofold. The consortium members of the PAsCAL project first, especially partners responsible for other simulation experiments dedicated to training (WP5) and pilots (WP6), but also partners in charge of transversal analysis and cross-fertilisation (WP7) so they can have a clear idea of the conditions the WP4 experiment were run.

A second but no less important audience is the wider research community for whom this document can serve as a basis for discussion of both the experimental protocols and the results that will emerge from the WP4 experiments.

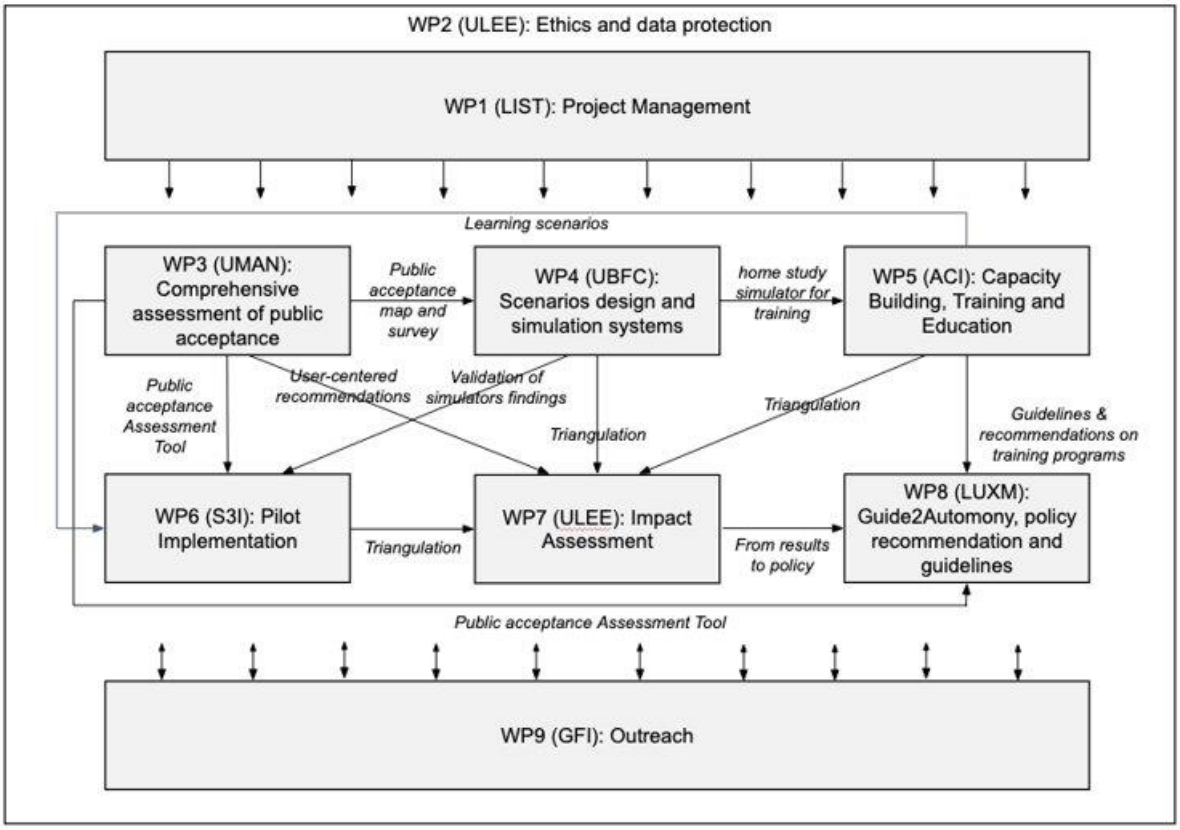
2 Common background

2.1 WP4 within the PAsCAL project

As explained in the project executive summary, workpackage 4 (WP4) is part of a chain of several experimental workpackages within the PAsCAL project. They shouldn't remain stand-alone.

On the contrary, the WP4 should reuse some WP3 outputs, such as surveys, and also feed the WP5 (simulation experiments dedicated to training and education), WP6 (life-size pilots), and WP7 (impact assessment), as shown in the figure below.

Figure 1 Linkage between the workpackages within PAsCAL project



2.2 Recall of WP4 objectives

Here are the objectives assigned to WP4 to be addressed through its different experiments, as they are written in the description of the action:

- 2 overall project objectives are specified for WP4:
    - OB 02: Optimize and validate connected and automated transport solutions for current non-drivers,
    - OB 03: Analyse driver's behaviour in different scenarios,

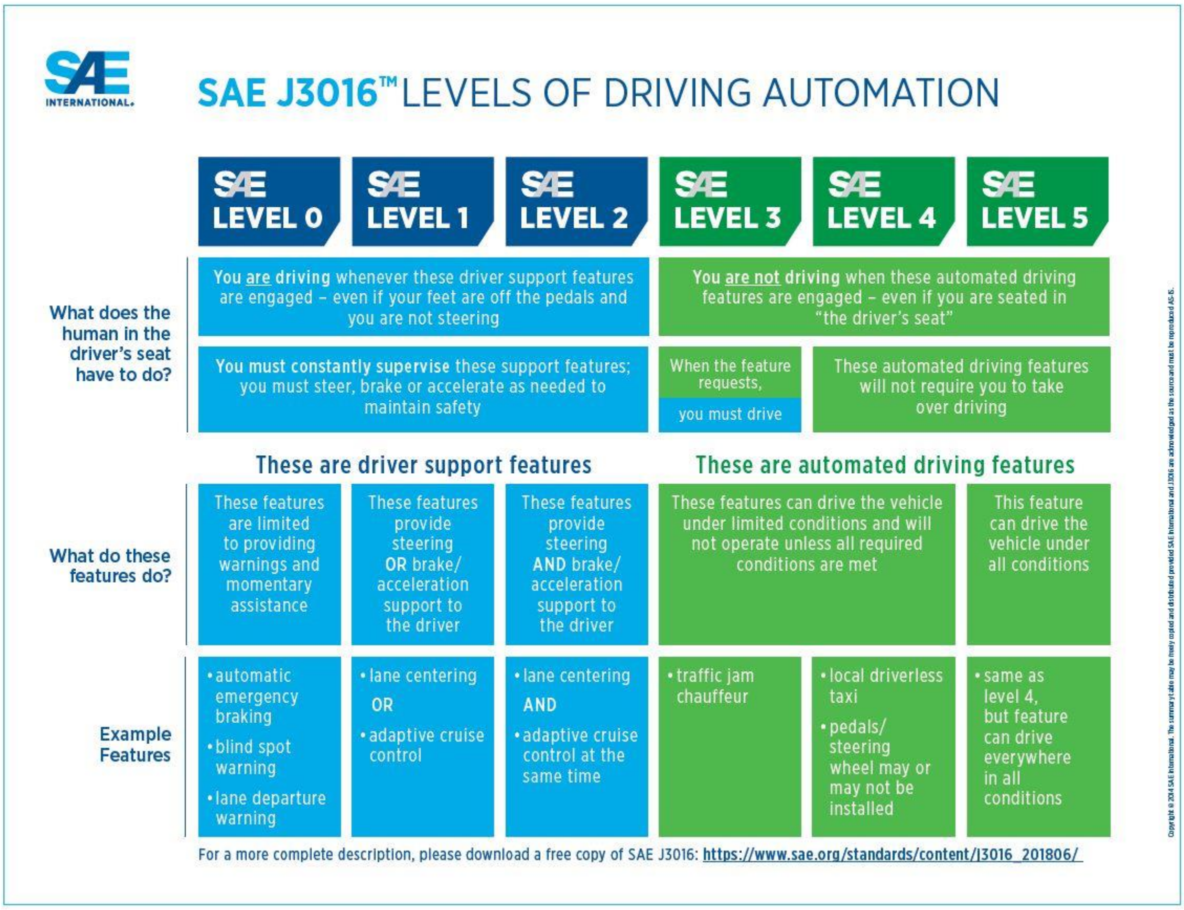
- 4 other specific objectives are also given to WP4:
    - SOB 01: To apply the survey developed in WP3 to participants exposed to CAVs,
    - SOB 02: To collect attitudes, acceptances of participants exposed to CAV contexts (pedestrians, passengers) and user behaviour during the simulated use of CAVs,
    - SOB 03: To optimize connected and automated transport solutions for current non-drivers,
    - SOB 04: To assess and elaborate common issues, approaches, and lessons learned across all modes.

We can observe that SOB 02 refers to OB 03 with a wider target as it also includes passengers and other road users in addition to drivers. SOB 03 is very similar to OB 03. SOB 01 and SOB 04 appear to be more transversal.

As for the whole PAsCAL project, connected and autonomous and connected vehicles are understood as vehicles equipped with level 3 to 5 driving automation systems, according to the SAE taxonomy in its 2018 version (Society of Automotive Engineers, 2018).

The following figure summaries the functionalities offered by such driving automation systems:

Figure 2 SAE taxonomy for driving automation



2.3 A wide pool of simulators

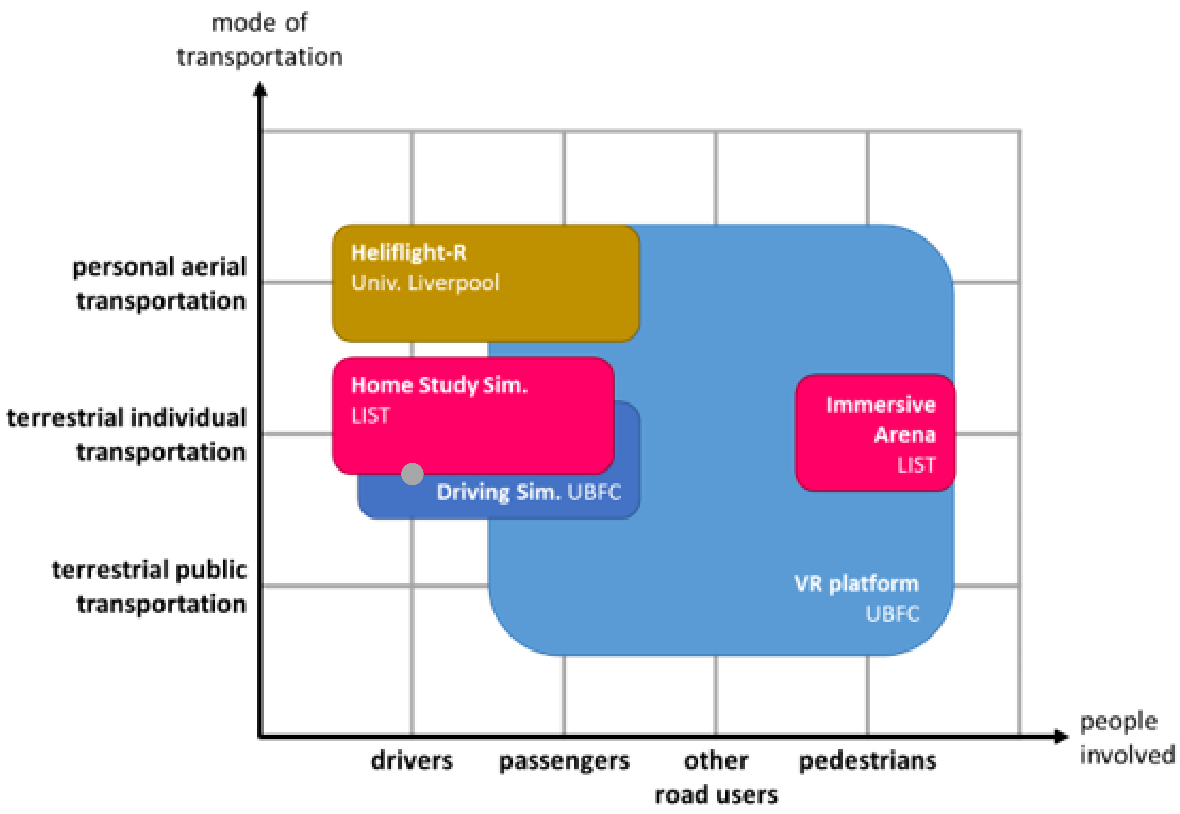
To achieve these objectives, the WP4 partners have at their disposal a large pool of complementary simulators covering many needs:

- A large driving simulator at UBFC for highly immersive driving simulations,
- Desktop car simulator at LIST for repeated trials,
- A flight simulator at the University of Liverpool for testing personal aerial vehicles,
- An Immersive Arena at LIST for investigating pedestrians facing CAVs,
- And a virtual reality platform at UBFC for various purposes immersive simulations that do not require driving activity, such as for fully autonomous vehicles.

A deeper description of each simulator is given in chapter 3.

The following figure shows how the available simulators cover many potential use cases in terms of both types of people involved and mode of transportation.

Figure 3 Potential use cases covered by the simulators involved in WP4



2.4 Definition of the research questions

For defining the research questions as a start point of task 4.1, WP4 partners had to collectively elaborate proposals and choose the ones to be addressed through the different experiments of WP4.

2.4.1 Collective ideation process for research questions

For collecting many various ideas, a 3-round call was organised along with the literature review which was performed quite simultaneously. A 2-day workshop was also organised for both agreeing on overall research themes connected to the WP4 objectives, and stimulating our creativity by running a brainstorming (World Café method from Méthodes de design UX) (Lallemand & Gronier, 2018).

The whole process allowed to collect 38 ideas of research questions and associated scenarios to address them, given that each of them addresses at least one of the WP4 objectives.

For each one, the author(s) provided not only a research question and a dedicated scenario but also a description of the participants needed, the simulator, and the equipment to be involved.

2.4.2Selection of the research questions to be implemented

Once the number of proposals for research questions and scenarios was enough, an evaluation phase started to choose the ones to be developed and implemented through the different WP4 experiments.

The evaluation considered both feasibility criteria (rated by the partner(s) potentially involved by running the corresponding experiment) and interest criteria, detailed by scientific interest (pure interest and originality), relevance to PAsCAL objectives, consistency with other workpackages, relevance regarding the partner’s interest and the current/future societal challenges.

All WP4 partners and some other interested partners have been parts of this evaluation process.

At the end of the day, a smaller group composed of the simulator operators and a few partners with great expertise made the final choice: 16 of the 38 proposals were selected to be addressed by the 5 experiments to be performed within WP4, they are listed below.

Experience 1 (XP1): Drivers experiencing a L3 car on a driving simulator

- RQ 1.1: How the HMI design affects efficiency and acceptance of taking over requests?
- RQ 1.2: How the HMI design regarding the feedback about the vehicle perception of its environment affects passengers' trust?
- RQ 1.3: Does driving experience affects the driver's likelihood to accept and use a L3 CAV?

Experience 2 (XP2): Disabled passengers experiencing L5 shuttles on a VR platform

- RQ 2.1: How is the acceptance of a L5 shuttle-based transportation service for disabled people?

- RQ 2.2: How is perceived a L5 shuttle and how accessible it is in a multimodal trip context?

Experience 3 (XP3): Acceptance and behaviour over time in an L4 vehicle

- RQ 3.1: Does driver acceptance vary after multiple exposures to an L4 vehicle?
- RQ 3.2: Does driver cognitive load vary after multiple exposures to an L4 vehicle?
- RQ 3.3: Does driver performance vary after multiple exposures to an L4 vehicle?

Experience 4 (XP4): Pedestrians encountering autonomous vehicles with external HMIs on the Immersive Arena

- RQ 4.1: How the eHMI design can influence the crossing behaviour?
- RQ 4.2: What is the most impacting aspect of eHMIs?
- RQ 4.3: What is the impact of the different aspects of eHMIs?
- RQ 4.4: How consistent are the eHMI understanding and trustworthiness through different contexts?

Experience 5 (XP5): Pilots experiencing L3 and L4 personal aerial vehicles on a flight simulator

- RQ 5.1: How much the level of comfort (subjective and objective), ease-of-use, and risk perception might vary between levels 3 and 4?
- RQ 5.2: What behaviour and level of acceptance will learners and experienced pilots have in a level 3 PAV flying in an urban environment?
- RQ 5.3: What behaviour and level of acceptance will learners and experienced pilots have in a level 4 PAV flying in an urban environment?
- RQ 5.4: Does the intervention of a human trainer make a difference to people's acceptance and use of higher levels of autonomy in PAVs?

The table below shows how the 5 experiments implementing the 16 chosen research questions address the WP4 objectives and cover the different levels of driving automation.

Table 1 Alignment of the experiments with WP4 objectives and coverage of the different driving automation levels

		WP4 objectives						CAV/PAV		
		OB 02	OB 03	SOB 01	SOB 02	SOB 03	SOB 04	L3	L4	L5
XP1	Drivers experiencing a L3 car on a driving simulator		x	x	x		x	x		
XP2	Disabled passengers experiencing L5 shuttles on a VR platform	x		x	x	x	x			x
XP3	Acceptance and behaviour over time in an L4 vehicle		x	x	x		x		x	
XP4	Pedestrians encountering autonomous vehicles with external HMIs on the Immersive Arena	x		x	x	x	x	x	x	x
XP5	Pilots experiencing L3 and L4 personal aerial vehicles on a flight simulator		x	x	x		x	x	x	

2.5 Harmonisation

2.5.1Questionnaires

Each experiment to be performed within WP4 involves (a) questionnaire(s) before and/or after the simulation, as an essential tool for assessing attitudes and behavioural intentions.

To address the global project’s research questions in addition to their dedicated ones, some WP4 experiments reuse some of the WP3/WP5/WP7 questionnaires. This will open for comparing the results of the different samples of the population and getting cross-fertilisation. However, to keep a reasonable duration in terms of acceptability and reliability, a careful selection of items was proceeded while making sure the main themes were correctly addressed. Special attention was also paid to address the different indicators specified by the deliverable D7.2 Impact indicators.

Besides, some scientifically validated questionnaires were also integrated such as NASA TLX for cognitive load, literature-based questionnaires/items for pedestrians’ behaviours, and UX.

2.5.2Metrics

Specific attention was paid to get consistent metrics from the similar experiments to be run, especially from XP1 on UBFC’s Driving Simulator and XP3 on LIST’s Home Study Simulator which both involves driving simulators. To achieve this goal, a large table listing and specifying the respective metrics was set up and shared. Furthermore, several technical meetings were dedicated to agreeing on a common set and common definitions, as close as possible to SAE definitions as specified in SAE standards (Society of Automotive Engineers, 2015).

2.6 Ethics and data issues

2.6.1 Ethics

Each partner responsible for an experience has to design the experience and to manage the procedures for both meetings the national requirements regarding ethics, depending on the experiment location(s), and obtaining the PAsCAL Ethics Advisory Board (EAB) validation by submitting the supporting documents, as described in deliverable D2.1 Project Ethics Handbook.

2.6.2 Data

Each partner responsible for an experiment has to design the data flow and to manage the procedures for both meetings the national requirements regarding data protection, depending on the experiment location(s), and obtaining the PAsCAL Data Advisory Board (DAB) validation by submitting the supporting documents, as described in deliverable D2.2 Data Management Setup and D2.3 Data Protection Handbook

3 Experimental protocols

3.1 Experience 1: Drivers experiencing a L3 car on a driving simulator

3.1.1 Scientific definition

3.1.1.1 Scientific context

On the road to the fully autonomous vehicle, the level 3 vehicle brings a lot of difficulties regarding the human factor. The automation of such a vehicle is advanced enough for the driver to be able to do other things when autonomous driving is engaged, but the driver is still responsible for taking over the controls. This taking over the process being particularly critical, it needs efficient HMIs so the automation and the driver act coherently and safely.

3.1.1.2 Research questions

In addition to the overall research question of the acceptance of autonomous vehicles (here, level 3 ones), the experience 1 specifically addresses these more specific research questions:

- RQ 1.1: How the HMI design affects efficiency and acceptance of taking over requests?
- RQ 1.2: How the HMI design regarding the feedback about the vehicle perception of its environment affects passengers' trust?
- RQ 1.3: Does driving experience affects the driver's likelihood to accept and use a L3 CAV?

3.1.1.3 Research hypothesis

- Regarding the taking over signals: a sound signal combined with a light signal will be perceived more effectively than a sound signal alone.
- Regarding the taking over signals: a light signal will be evaluated as more satisfying than a sound signal.
- Regarding the HMI impact on passengers' trust: an HMI displaying rich feedback on the vehicle's perception of its environment (for example class of road, speed limit, ahead of events like traffic jam, road works, vehicle parked on the lane…) will lead to greater trust towards the system than a poorer HMI/no feedback at all.

3.1.1.4 Variables

- Controlled variables:
    - Type of taking-over/handover signal:
        - Combination A: graphic signal (text and icon, animation + basic sound signal (ringtone) + luminous signal (dynamic light strip)
        - Combination B: same graphic signal (text and icon, animation + richer sound signal (ringtone then vocal message), no luminous signal
    - Presence or not of visual feedback about the vehicle's perception of its environment:
        - With feedback
        - Without feedback
- Observed variables:
    - Attitude and behavioural intention questionnaire
    - Reaction time when delegating control/taking back control of driving
    - Gaze direction/eyes behaviour
    - Heart rate
    - Galvanic skin response / electrodermal conductivity
    - Wrist movements

3.1.2 Subjects sample

3.1.2.1 Targeted population

Minimum 40 participants respecting the following criteria:

- Inclusion criteria:
    - Having a driving licence
    - Being a regular driver (at least 3 000 km during the past year)
    - Being in good general health
    - Having never suffered from epilepsy
    - Age: from 18 to 85

- Diversity criteria:
    - Age: as diverse as possible
    - Gender: at least 5 of each, as balanced as possible
    - Socio-professional category: as varied as possible

- Driving experience:
  - At least 12 with less than 40 000 km
  - At least 12 with more than 40 000 km
  - As balanced as possible

3.1.2.2 Recruitment process

UBFC combined recruiting people in the own researchers' social sphere and subcontracting recruitment to students from the ESTA business school which was joint to UTBM.

We kept an eye on the diversity criteria throughout the whole recruitment process.

3.1.3 Simulation system

3.1.3.1 Driving simulator

UBFC's static driving simulator is made of a genuine Peugeot 308 Mk1 whose powertrain has been removed. It has been equipped with sensors, effort feedback, and electronics for interfacing with the simulation PC.

Figure 4 UBFC's driving simulator

The simulation software, SIM2, is provided by Université Gustave Eiffel, one of the main French entities committed to transportation research. It runs on a PC that is part of a cluster.

Four other PCs are dedicated to computing the virtual views and displaying them through:

- 3 beamers composing a 180° front view on a large cylindrical screen facing the car,
- 3 monitors facing the mirrors for rear-viewing.

3.1.3.2Embedded HMI

3.1.3.2.1 HMI design

The main goals of the designed HMI for the UBFC's driving simulator are:

- to inform the user about the autonomous driving activity,
- to provide a button to take over/hand over driving control,
- to inform the user about the perception of the environment by the vehicle.

Figure 5 HMI embedded within the driving simulator

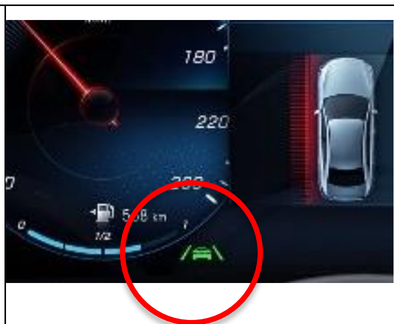
In order to simulate a feedback about the perception of the environement by the vehicle, the designed HMI displays the following information:

- Current road type (urban, rural, or highway),
- Current speed limit,
- Enventual events ahead like traffic jam, obstacle, roadwork,
- CAV’s awareness about its environment (excellent, medium, or poor),
- Related autonomous driving availability.

Considering the capabilities of the simulator, the designed HMI remains rather simplistic. It focuses only on relevant and important information. It avoids overwhelming or distracting users with non-essential content. Specific events related to the availability of autonomous driving are strengthened to improve the user's reaction efficiency. In addition, other human-machine interfaces (HMI) systems are provided to inform the user of important events related to autonomous driving, such as LED strips placed on the dashboard, audio and voice messages played by the tablet, and text messages displayed on the touchscreen.

Existing automotive interfaces were analysed by realizing a benchmarking of the HMIs relating to driving automation. These findings allowed the creation of an HMI offering consistency with the current automotive industry pratices and the traffic code.

Table 2 Pictures extracted from the benchmark for HMIs and the analysis of the interfaces in the industry

1	Lane Assist Icon on a Mercedes	
2	Lane Assist Icon on an Audi	

3	Blue LEDs on a dashboard	
4	Blue LEDs on a steering wheel on a BMW	

3.1.3.2.2 HMI development

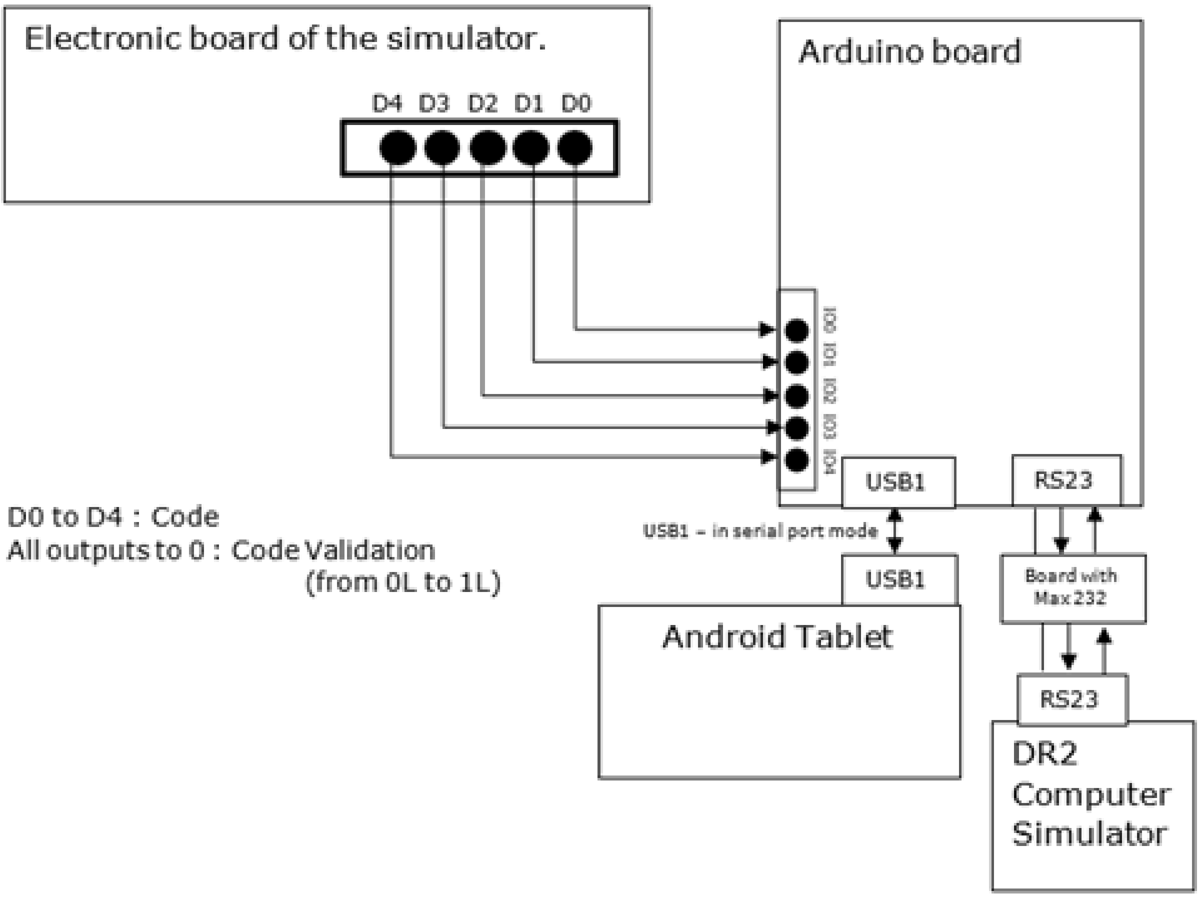
The simulation environment contains three elements (presented in a schema in Figure 6)

1. PC: which is used to control the simulator
2. Simulator
3. Tablet: which is used to display the HMI to the user

The development of the HMI is done using an Android tablet and application. The main advantages of this choice are ease of use, high connectivity with external components, and a low cost for both development and components.

An Arduino Mega 2560 (rev. 3) device is used as a connector between the simulator, the PC, and Android. It acts as a proxy forwarding event from the simulator's electronic pins to the tablet and from the tablet to the PC. It is also controlling the dashboard LED based on instructions received from the tablet.

Figure 6 Schema of the connectivity of the components



To make the app flexible regarding the experiment's needs, it uses settings. It is possible to use a button or a switch for the autonomous activation/deactivation, define the take-over timer duration, enable/disable lights and/or sound and enforce the detailed view or select only some specific elements (road conditions, road type, speed limit, and car awareness).

When first connecting the Arduino to the car simulator, some issues were noticed, especially when delivering data from and to the Arduino. Those issues were mainly some latencies between the communication from the Arduino to the simulator and the simulator to the Arduino. Because of those latencies, the event triggers were sometimes misinterpreted on devices, delayed in delivery, or completely lost, resulting in an inconsistent and inappropriate application state.

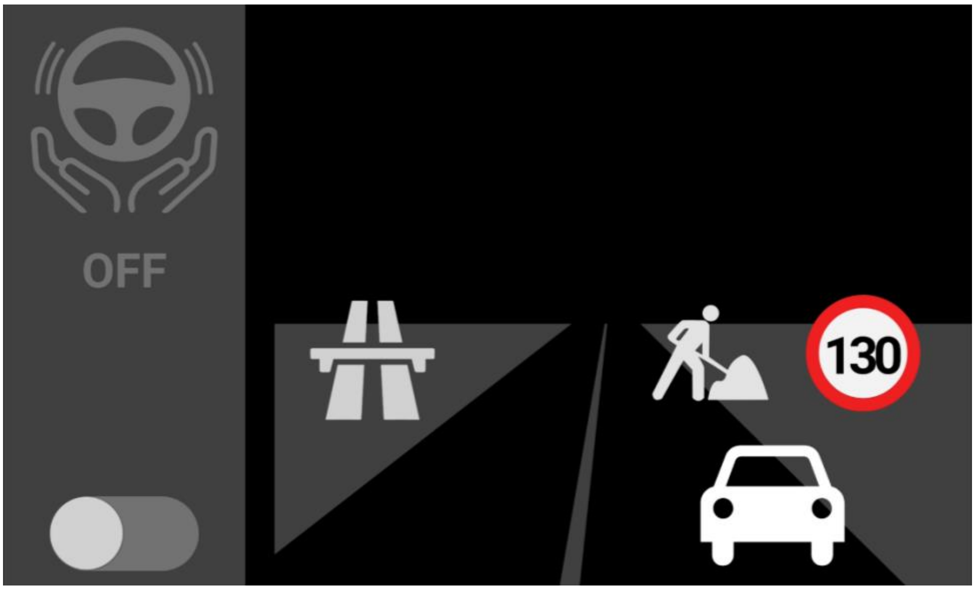
After an investigation by replicating the issue in a controlled environment, findings revealed that this issue was being caused by a blocking process introduced by a library used to control the external LEDs. To make the communication of events reliable, an ack protocol has been put in place, ensuring consistent delivery of messages from one device to another.

The application can run as expected and provides the necessary information and controls of the autonomous driving to the user, allowing the experiment to run (see section 3.1 for more information about the experiment).

Figure 7 The settings panel of the app

Figure 8 Autonomous driving enabled, on the highway, with speed limit to 130km/h and the car awareness being medium

Figure 9 Autonomous driving disabled view of the app, on the highway with the speed limit at 130km/h and some roadworks ahead



3.1.3.2.3 HMI integration

The touchscreen is made of a 10 inches Android tablet. It is supported by custom support designed and manufactured by UBFC for providing a robust and sleek integration within the cockpit, in a similar way to some contemporary cars.

The light strip is deployed along with a black aluminium profile, covered by a black semi-transparent diffusor, and glued to the bottom of the windscreen, in order to be easily ignored when switched off.

The cables run behind the trims to make them as invisible as possible.

3.1.3.2.4 Advanced HMIs

To be able to provide the most relevant information to the user, considering the user accessibility and the user’s environment, some advanced HMIs have been researched, thought, and designed through brainstorming sessions (see Table 3).

However, the simulator previously used for the first set of HMIs was heavily constrained as it cannot be altered easily. One of them was that there were no possibilities to export real-time data concerning the environment, nor the vehicle real-time data, preventing all kinds of extensions requiring this technology. We also had to limit the data to the number of output pins available: 5 pins were present on the simulator, which brings the number of events to a maximum of 32. This meant quite limited possibilities of HMIs and interactions through them. In conclusion, the team had to go beyond the scope of the simulator to put in place such advanced interfaces.

Those interfaces are planned to be implemented within the pilots in which they can help conduct research and/or improve the user experience within the pilot (pilot 3: autonomous shuttle and pilot 4: autonomous bus line). They will display information data (itinerary, next stops, a timetable for other transportations, unplanned stops, sudden breaks, deviation of the itinerary, …) to correlate them with feedback from users regarding their trip on board of the autonomous shuttle.

Another opportunity for those interfaces that will be investigated is to run an experiment based on customizable interfaces and their impact on user acceptance and cognitive load.

Below is a list of these advanced HMIs and potential implementation in regards to the pilots mentioned here above.

Table 3 List of advanced HMIs being implemented in regards to the concerned pilots and with the indication of the target users for those improvements

Name & Description	Target users	Pilot(s) for application
Text to Speech	Blind, Colour deficient	4
Providing textual information (panel, lights, signalization, vehicle state, abrupt stops, …) through the form of voice information.		
Explain deviant driving behaviour	All	4
Providing information to the user about the unusual state of the vehicle (unplanned stop, sudden acceleration, itinerary deviation, …).		
Incorporate messages in an entertaining view	All	4
Interrupting "entertaining" information (bus itinerary, connection timetable, videos, …) to show important messages (ex.: deviant behaviour).		
Navigation information	All	4
Displaying information such as next stop on the vehicle itinerary, the remaining distance, and duration, …		
Entertaining views	All	3, 4
Displaying information non-related to the vehicle such as videos, connection timetables, map, …		

3.1.4 Scenario development

Here is a full step-by-step description of the simulation scenario.

Table 4 Detailed description of XP1 scenario

1	0:00		As a start, the subjects are in a stationary car parked on the side of a country road. The road is clear, with no traffic. 
2	0:00		The subjects start the engine and enter the road in manual driving mode.
3	0:05		The subjects are driving on a country road with a speed limit of 70km/h.
4	0:50		The subject turn left to pass through a suburban area. 
5	0:55		The HMI notifies that autonomous driving is available. The subjects activate the autonomous driving mode via the touchscreen located in the middle of the dashboard.
6	1:30		The subjects leave the suburban area and end up in a rural area again. Traffic becomes denser, in both directions. Autonomous driving is still activated.
7	2:00		The subjects encounter roadworks. The car automatically adjusts speed (30 km/h) and trajectory accordingly.

			
8	3:00		The car leaves the roadworks area and resumes the legal speed.
9	3:10		The HMI warns of the need to take back control of the vehicle. The subjects take back control by steering or by pressing a pedal.
10	4:25		The HMI notifies that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
11	4:50		The car approaches a truck parked on the side of the road. The vehicle automatically adjusts its trajectory and overtakes the truck. 
12	4:58		The car automatically resumes its journey.
13	6:20		The HMI warns of the need to take back control of the vehicle. The subjects take back control by steering or by pressing a pedal.

14	6:30		The subjects take a highway entrance then speed up to 110km/h. 
15	7:25		The HMI notifies that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
16	7:45		The subjects arrive in a traffic jam area on the highway. The vehicle automatically slows down and adjusts its speed. 
17	8:25		Traffic resumes its course, and the car automatically speeds up to 110km/h.
18	9:10		The HMI warns of the need to take back control. The subjects take back control by steering or by pressing a pedal.
19	10:05		As the legal speed is 110km/h, the subjects are expected to overtake 1 or 2 cars in manual driving.
20	10:20		The HMI notifies that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
21	11:00		The car automatically leaves the highway.

22	11:35		The car automatically continues on a country road limited to 70km/h.
23	11:45		The HMI warns the subject of the need to take back control. The subjects take back control by steering or by pressing a pedal.
24	12:00		The subjects arrive in a roadworks area. They are expected to give way to a priority car coming in the opposite direction, then to adjust trajectory and speed to pass by the roadworks area. 
25	12:30		The subjects leave the roadworks area and resume their cruising speed.
26	12:35		The HMI notifies that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
27	13:10		On a priority road, the car turns right. Autonomous driving is still activated.
28	13:30		The HMI warns the subject of the need to take back control. The subjects take back control by steering or by pressing a pedal.
29	13:50		The subjects encounter a traffic jam area. They slow down, stop, restart, and adjust their speed.

			
30	14:10		The vehicles causing the traffic jam turn right, and the subjects can resume their trip on the country road.
31	15:15		The HMI notifies the subjects that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
32	16:55		The HMI warns the subjects of the need to take back control. The subjects take back control by the steering wheel or by pressing a pedal.
33	17:50		The subjects encounter a truck parked on the side of the road. They are expected to slow down and give way to a priority car coming from the opposite direction, then to adjust trajectory and speed to overtake the truck. 
34	17:55		The subjects resume their trip.

35	18:30		The HMI notifies the subjects that autonomous driving is available. The subjects activate autonomous driving via the touchscreen.
36	19:50		End of the simulation: the car automatically slows down and parks on the side of the road.
37	19:55		The subject turns off the engine.

3.1.5 Measurement package

3.1.5.1 Measurement tools

Subjective measures:

- Survey
- interview

Objective measures:

- Driving parameters
- Eye-tracking
- Heart rate
- Electro-dermal response
- Wrist motility

3.1.5.2 Data collection

- All questionnaires are administrated through Qualtrics online services.
- Interviews are audio recorded while the experimenter takes some notes.
- Driving parameters are set to be saved in one single file by the simulation software.
- Eye-tracking data are recorded on a SDCard by the dedicated datalogger.
- Heart rate is also recorded by a dedicated datalogger.
- The electro-dermal response was recorded via TEA Captiv software.
- Wrist mobility data are recorded by the watch, then transferred to a PC.

At the end of each experiment, all data are back up both on a UTBM-held server and redundant hard disk drives (RAID 1).

3.1.6Questionnaires

Here is the main questionnaire to be passed just after the simulation.

Table 5 XP1 main questionnaire

Indicators	Sources	Items
Demographics information		Which age group do you belong to? 18-29 ; 30-39 ; 40-49 ; 50-59 ; 60 +
Demographics information		What is your gender? Female, male, not specified
Demographics information		What is your socio-professional category?
Demographics information		Driving experience
Past experience with autonomous mobility	wp3	I think I am very well informed about the latest trends in autonomous mobility. I do not agree at all; I agree
Past experience with autonomous mobility	wp3	I read a lot and regularly about autonomous vehicles.
Past experience with autonomous mobility	wp3	When it comes to autonomous vehicles, I do not know anything at all.
Past experience with autonomous mobility	wp3	I have already had experience with autonomous mobility.
Past experience with autonomous mobility	wp3	I have used autonomous technologies before, namely…a function in my/a car. Please indicate which function(s): a completely autonomous car. Please indicate which car (make, type): a completely autonomous shuttle or a minibus. Please describe where/which: I have never used autonomous technology.

Indicators	Sources	Items
General attitude towards CAVs	wp3	The thought of autonomous cars is generally… disconcerting; promising
General attitude towards CAVs	wp3	In principle, I would find autonomous cars … very bad; very good
General attitude towards CAVs	wp3	My spontaneous attitude towards autonomous cars is… very negative; very positive
General attitude towards CAVs	wp3	As a means of transportation, I would prefer… the conventional variant; autonomous vehicle
Willingness to pay	wp3	Imagine buying a new conventional car soon. What makes / model? How much would you pay for this (new) car: in euros. For this type of car, I would like to be equipped with completely autonomous technology: 1) pay less (in euros); 2) more (in euros); 3) as much; 4) I would pay extra to get this car without fully autonomous technology (in euros)
Willingness to adopt	WP6	After this experience, would you use an autonomous car for your daily commute? Certainly Probably; Depends on how the technology evolves; Probably not; Not at all
Willingness to let others use	WP6	Would you let other members of your family or close circle use autonomous cars? Certainly; Probably; Depends on how technology evolves; Probably not; Not at all
Willingness to let others use	WP6	Would you encourage your family or friends to use self-driving cars? Certainly; Probably; Depends on how technology evolves; Probably not; Not at all
Changed mobility behaviour	WP6	After this experience, would you use a shared autonomous car for your daily trips? Yes; No; Depends on how technology evolves; I don't know
Changed mobility behaviour	wp3	If autonomous shuttle were available, I would use them. does not apply at all to applies completely
Changed mobility behaviour	wp3	I think I could do well with autonomous cars. does not apply at all to applies completely

Indicators	Sources	Items
Perceived Risk	wp3	If large sections of the population use autonomous cars, travel for all citizens would be... more dangerous/less dangerous.
Perceived Risk	wp3	If large sections of the population use autonomous cars, the number of traffic accidents would be... higher/lower.
Perceived Risk	wp6	How do you describe the self-driving car reactions? Very good; Safe; Neutral; Unpredictable; Dangerous
Perceived Ease of Use	D7.2	How easy would you find it to use the vehicle?
Perceived quality of travel	wp3	If I used an autonomous car, my travelling experience would be... less pleasant/more pleasant.
Perceived quality of travel	wp6	How well do you think that the self-driving car performed regarding steering, acceleration, and braking? Better than a human driver; Same as a human driver; Worse than a human driver; Just different
Perceived usefulness	D7.2 (Kaur & Rampersad , 2018)	Using driverless Vehicles can improve my living and working efficiency
Attitudes	wp6	How did you feel while travelling in a CAV? Trustful; Careful; Insecure; Safe; Nervous; Curious; Critical; Unaffected
Attitudes	wp6	Was using a CAV the experience you had anticipated? Positively surprised; Negatively surprised; It was as I expected; Other
Attitudes	wp3	The idea that large sections of the population use %SOLUTION% feel good. does not apply at all; applies fully and completely
Attitudes	wp3	Large sections of the population use %SOLUTION% I imagine as stressful.
Attitudes	wp3	I think I could do well with autonomous cars. does not apply at all; applies fully and completely

Indicators	Sources	Items
Attitudes	wp3	If autonomous cars were available, I would use them. does not apply at all; applies fully and completely
Attitudes	wp3	I can imagine that I would have problems using autonomous cars.
Attitudes	wp3	I would try to avoid autonomous cars as much as possible
Human Factor	The System Usability Scale (Gronier & Baudet, 2021)	1. I think that I would like to use this system frequently. Strongly disagree (1) to strongly agree (5)
Human Factor	UMUX (Finstad, 2010a)	This system's capabilities meet my requirements Strongly disagree (1) to strongly agree (5)
Human Factor	UMUX	Using this system is a frustrating experience
Human Factor	UMUX	This system is easy to use
Human Factor	UMUX	I have to spend too much time correcting things with this system

3.1.7Experimental protocol

3.1.7.1Sanitary measures for Covid-19 prevention

Before coming, the subjects are asked to register their coming at UTBM's facilities by filling an online survey and to apply the following rules:

- Wear a facemask,
- Wash their hands often,
- Keep 1-meter physical distancing,

while experimenters apply the same rules and wear a high filtration FFP2 facemask.

After each experiment:

- The driving simulator cabin is fully disinfected,
- All instruments are placed in a dedicated labelled "dirty" box then disinfected and stored in a clean box for the next experience,

- All contact surfaces (seats, tables, door handles…) are also disinfected
- UTBM's facilities are extensively ventilated.

3.1.7.2Conduct of the experiment

The following paragraphs explain the sequence of an experiment on a step-by-step basis:

1. A preliminary questionnaire on the acceptance of using autonomous driving at any level: (20 minutes)

The subjects are asked to complete the first questionnaire two weeks before the experiment.

2. Welcome and explanation of sanitary rules (20 minutes)

The subjects are welcomed in our laboratory by a designated researcher who remains the main contact person throughout the experiment. Then, the participants are informed about the hygiene rules and the procedure of the experiment is detailed.

3. Upstream questionnaire (20 minutes)

Before starting the experiment, the subjects are asked to complete a questionnaire (similar to the primary questionnaire) relating to personal and socio-demographic information, their driving experience, and their attitude towards autonomous vehicles.

4. Sensor placement (10 minutes)

The subjects wear, under the supervision and assistance of the researcher, all the measuring devices planned: eye-tracking glasses, heart rate sensor, electrodermal conductivity sensor, and wrist movement measurement sensor.

5. Installation and familiarization with the driving simulator (15 minutes)

The subjects sit in the driving simulator. After adjusting the cockpit to suit their preferences (adjustment of the seat and mirrors), they begin a familiarisation phase consisting of driving normally in the simulator.

6. Rest phase (5 minutes)

To have reference physiological data, the subjects were asked to rest, in a relaxed situation, for 5 minutes. This allows recording heart rate at rest.

7. Experiment (30 minutes)

The experiment can then begin: the subjects will be driving a level 3 autonomous vehicle. They must travel through various environments. Throughout the journey, the autonomous vehicle will ask the subject to hand over or take over driving. In total, 12 manoeuvres will be requested via different signals (graphic, sound, luminous).

The experiment scenario is detailed in paragraph 3.1.4.

8. Removal of test equipment (10 minutes)

The subjects remove the measuring sensors, under the supervision and assistance of the researcher.

9. Final questionnaire and interview (45 minutes)

The subjects are asked to answer a second questionnaire. The items are similar to those are used in the WP3 and WP6: Demographics information, Past Experience with Autonomous Mobility, General Attitude towards CAVs, Willingness to Pay, Willingness to Adopt, Willingness to Let Others Use, Changed Mobility Behaviour, Perceived Risk, Perceived Ease of Use, Perceived Quality of Travel, Perceived Usefulness, Attitudes. Participants will also complete the UMUX questionnaire (Usability Metric for User Experience; Finstad (2010) and the SUS questionnaire (System Usability Scale; Gronier & Baudet, 2021).

Finally, the researcher interviewed the subjects. A semi-structured interview was performed regarding the general positive and negative points of the experience, the confidence felt towards the autonomous vehicle, the quality and efficiency of the information released by the tablet, and the efficiency and satisfaction of the different signals. They are invited to describe their feelings and experiences regarding the different conditions of the experiment.

10. Acknowledgements (10 minutes)

Once the researcher has answered their various questions/comments and ensured that they can drive in real conditions, the subjects are warmly thanked before leaving the facilities.

3.2 Experience 2: Disabled passengers experiencing L5 shuttles on a VR platform

3.2.1 Scientific definition

3.2.1.1 Research questions

In addition to the overall research question of the acceptance of autonomous vehicles (here, level 5 ones), experience 2 specifically addresses these more specific research questions:

- RQ 2.1: How is the acceptance of a L5 shuttle-based transportation service for disabled people?
- RQ 2.2: How is perceived a L5 shuttle and how accessible it is in a multimodal trip context?

3.2.1.2 Research hypothesis

1. The acceptability of using the autonomous shuttle will increase if the system offers advanced services to users,
2. Subjects will report a higher willingness to pay for the services offered by the premium autonomous system compared to those available on the basic autonomous shuttle,
3. The journey on the premium autonomous shuttle will be rated more enjoyable and satisfying than the journey in a conventional city bus.

3.2.1.3 Dependent and independent variables

- Controlled variables:
    - Type of vehicle:
        - Shuttle L5
        - Conventional bus
        - Premium autonomous shuttle

- Observed variables:
    - Attitude and behavioural intention questionnaire
    - Heart rate
    - Galvanic skin response / electrodermal conductivity
    - Wrist movements

3.2.2 Subjects sample

3.2.2.1 Targeted population

Minimum 12 participants respecting the following criteria:

- Inclusion criteria:
  - Motor disability
  - Being in good general health
  - Good communication skills (oral and written comprehension) in French
  - Age: from 18 to 54

- Exclusion criteria:
  - Balance disorder
  - Severe visual disturbances and/or colour blindness
  - Prone to epilepsy
  - No consent from the medical doctor in charge of the check-up for inclusion

- Diversity criteria:
  - Age: as diverse as possible
  - Gender: at least 3 of each, as equal as possible
  - Socio-professional category: as diverse as possible

3.2.2.2 Recruitment process

Subjects are recruited either directly by phone and meeting in related associations[1] or through contacts in the community. Recruitment took place over several months to achieve the desired 15 participants. The recruitment process was challenged because of the sanitary conditions at this time.

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[1] Association des Paralysés de France and Club Handisport

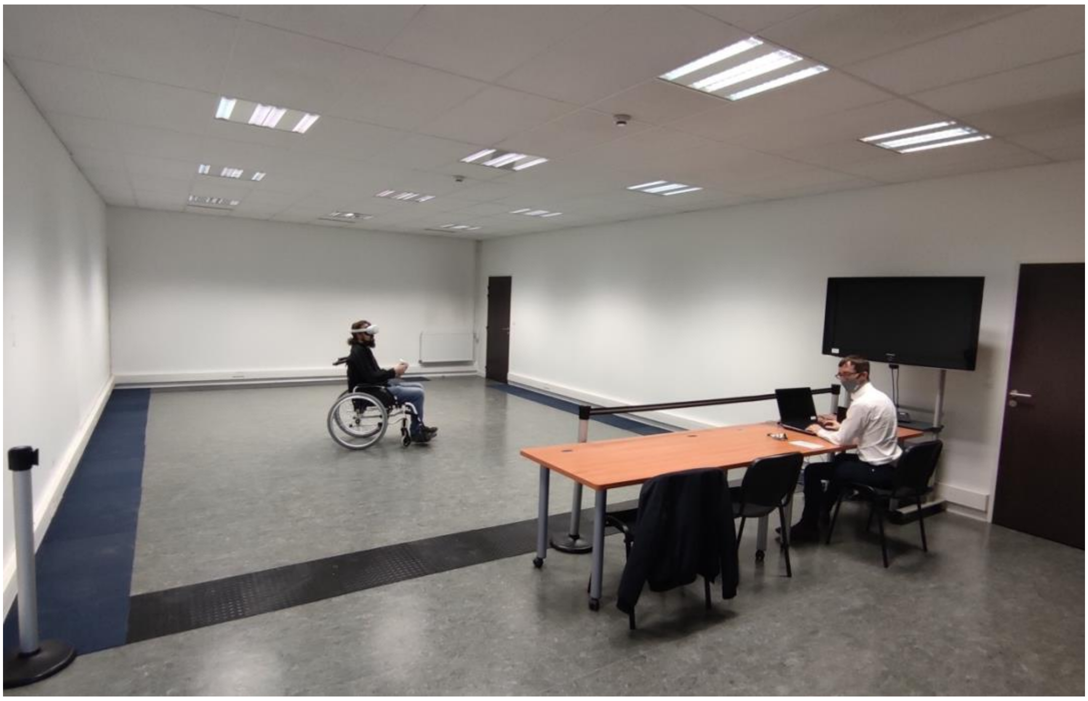
3.2.3 Simulation system

3.2.3.1 Virtual Reality system

To conduct our experiment, we use Oculus Quest II VR headsets. These are wireless headsets that offer high-quality graphics performance to allow maximum usability and a high level of immersion.

Instead of using the built-in computing capacity, we run the simulation on a powerful PC that is connected to the headset via 5Gbit WiFi, using the software Virtual Desktop.

Figure 10 Virtual reality simulation room



3.2.4 Scenario development

3.2.4.1 Detailed scenario

The subject is at a bus stop in the countryside. He waits for the L5 shuttle for 1 minute. The shuttle arrives and stops, the subject is invited to get on, enjoy a 5-minute ride and get off when the shuttle arrives in town. The subject must walk a few meters to an ATM to withdraw money. After that, he has to take a conventional bus from the bus stop. The subject gets on the conventional bus, which travels around the city for 3 to 4 minutes. The subject gets off at the bus stop and he is required to walk to a mailbox to mail a letter. Finally, the subject calls the premium autonomous shuttle by a system of call on command. The shuttle arrives, the subject gets on it and returns to his starting point in the countryside. The premium shuttle offers him a video presenting the dedicated services during the trip. Finally, the subject gets out of the shuttle to finish the scenario.

At the end of the experiment, the subject completed an approximately 20-minute ride in the different vehicles, including 3 summonses, 6 ingresses and egresses, and 2 vehicle changes.

Table 6 Detailed description of XP2 scenario

1	0:00	The simulation begins in an outdoor space located on the edge of the city, served by a regular line of autonomous shuttles. The subjects are on the sidewalk, near the station marked by a bus stop and equipped with a digital information panel. The panel announces an approaching shuttle, which will indeed arrive about ten seconds later.
2	0:10	The subjects move a few meters to position themselves near the vehicle.
3	0:15	The shuttle’s doors open, and the lifting platform deploys automatically, allowing the subject to board and take a seat in the location provided for wheelchairs (signage and/or indication by a coloured arrow and/or a highlighting of the place, consistent with the indicators seen during the tutorial).
4	0:40	An embedded HMI allows the subject to trigger the doors closing and the shuttle departure.

5	0:44	The shuttle leaves the city quickly and takes the winding country road. 
6	5:46	After a 5-minute trip, the shuttle enters a new city (another side of the map) and then stops in front of ATMs.
7	5:49	The shuttle doors open, the subject gets off using the lifting platform, then moves a few meters to reach the ATM. 
8	6:03	As the subjects reach the control zone located in front of the ATM, the machine delivers a bundle of cash.
9	6:13	The subjects having left the platform, the shuttle doors close, the vehicle sets out again and leaves the subject's potential field of view by turning into an adjacent street.
10	6:13	A new zone to reach appears in front of a bus stop. A few seconds after the subject has reached this area, a traditional bus arrives and stops.

11	6:13	The doors open and a lifting platform deploys. The subject gets on the bus and takes a seat reserved for wheelchairs.
12	6:30	The bus starts a few seconds after the doors close and heads for the next station. 
13	7:01	At the next station, the bus stops, and the doors open.
14	7:01	The new zone to reach is in front of shop B (a letterbox). The subject must therefore go to the letterbox. 
15	7:20	The subject must press a button (highlighted by a blink) that triggers an animated action (a letter slides into the letterbox).

16	7:22	The bus restarts and leaves the area.
17	7:29	Once this is done, the subject must go to the station equipped with a terminal allowing a shuttle to be called on-demand and informing its destination.
18	7:42	The subject calls a shuttle via a simple manipulation on the terminal's touch screen.
19	7:50	Shortly afterwards, a second autonomous shuttle arrives, the doors open, and the lifting platform deploys, inviting the subject to take a seat in the vehicle.
20	8:11	An embedded HMI allows the subject to control the closing of the doors and the departure of the shuttle.
21	8:19	The autonomous shuttle follows the route of the first shuttle in the opposite direction. Meanwhile, the embedded HMI offers infotainment services to the subject (weather forecast, news reports, listening to music, watching a video).
22	13:07	The autonomous shuttle returns to the starting point on the edge of the city and stops there.
23	13:10	The doors open and the platform deploys to allow the subject to exit the shuttle.
24	13:20	When the subject has arrived at their destination, they are transported to the tutorial room of the virtual reality application. A message announces the end of the

		experience, thanks the subject and invites them to remove their VR headset

3.2.5Measurement package

3.2.5.1Measurement tools

Subjective measures:

- Survey
- interview

Objective measures:

- Heart rate
- Electro-dermal response
- Wrist motility

Note : No eye traking available in XP2 because of technical incompatibility with the VR headset.

3.2.5.2Data collection

All questionnaires are administrated through Qualtrics online services.

Interviews are audio recorded while the experimenter takes some notes.

We performed a video recording of both the simulation (screen capture software) and the simulation room (with a video camera on a pod).

Heart rate was recorded by a dedicated datalogger.

The electro-dermal response was recorded via TEA CAPTIV software.

Wrist mobility data are recorded by the watch, then transferred to a PC.

At the end of each experiment, all data are back up both on a UTBM-held server and redundant hard disk drives (RAID 1).

3.2.6Questionnaires

Here is the main questionnaire to be passed just after the simulation.

Table 7 XP2 main questionnaire

Indicators	Sources	Items
Demographics information		Which age group do you belong to?
Demographics information		What is your gender? Female, male, not specified
Demographics information		What is your socio-professional class?
Demographics information		Type of handicap
Past experience with autonomous mobility	wp3	I think I am very well informed about the latest trends in autonomous mobility. I do not agree at all; I agree
Past experience with autonomous mobility	wp3	I read a lot and regularly about autonomous vehicles.
Past experience with autonomous mobility	wp3	When it comes to autonomous vehicles, I do not know anything at all.
Past experience with autonomous mobility	wp3	I have already had experience with autonomous mobility.
Past experience with autonomous mobility	wp3	I have used autonomous technologies before, namely…a function in my/a car. Please indicate which function(s): a completely autonomous car. Please indicate which car (make, type): a completely autonomous shuttle or a minibus. Please describe where/which: I have never used autonomous technology.
General attitude towards CAVs	wp3	The thought of autonomous cars is generally… disconcerting; promising
General attitude towards CAVs	wp3	In principle, I would find autonomous cars … very bad; very good
General attitude towards CAVs	wp3	My spontaneous attitude towards autonomous cars is… very negative; very positive

Indicators	Sources	Items
General attitude towards CAVs	wp3	As a means of transportation, I would prefer… the conventional variant; autonomous vehicle
Willingness to pay	wp3	A single ticket for local public transport costs around 2.50? euros in the city, and is valid for 90 minutes. I would like, for local public transport tickets with autonomous technology (that is to say without driver), ... 1) pay less (in euros); 2) more (in euros); 3) as much; 4) I would pay extra to be able to use the local public transport service without fully autonomous technology (in euros)
Willingness to pay	wp3 (8) + D7. 2 (Nordhoff et al., 2018)	Some local public transport providers offer a kilometre rate. Suppose that such a ticket costs 1.50 euros plus 20 cents/km. I would like, per kilometre with local public transport with autonomous technology (that is to say without driver), ... 1) pay less (in euros); 2) more (in euros); 3) as much; 4) I would pay extra to be able to use the local public transport service without fully autonomous technology (in euros)
Willingness to pay	wp6	Would you like to pay a higher price for a shared vehicle with autonomous features? 1) Yes; 2) No 3) Depends on how technology evolves; 4) I don't know
Willingness to adopt	WP6	Could you imagine yourself using shuttles like these in the future? Certainly; Probably; Depends on how the technology evolves; Probably not; Not at all
Willingness to adopt	wp6	How often would you use an autonomous shuttle? Everyday; Regularly; Not often; Never
Willingness to let others use	WP6	Would you let other members of your family or close circle use the autonomous shuttle? Certainly; Probably; Depends on how technology evolves; Probably not; Not at all
Willingness to let others use	WP6	Would you encourage your family or friends to use self-driving cars? Certainly; Probably; Depends on how technology evolves; Probably not; Not at all
Changed mobility behaviour	wp6	After this experience, would you use a shared connected vehicle for your daily trips? Yes; No; Depends on how technology evolves; I don't know
Changed mobility behaviour	wp3	If autonomous shuttle were available, I would use them. does not apply at all to applies completely

Indicators	Sources	Items
Changed mobility behaviour	wp3	I think I could do well with the autonomous shuttle. does not apply at all to applies completely
Changed mobility behaviour	wp3	I would let my children use autonomous shuttle does not apply at all to applies completely
Perceived Risk	wp6	How did you feel while travelling with the autonomous shuttle? Trustful Careful Insecure Safe Nervous Curious Critical Unaffected
Perceived Risk	wp6	Which issues would concern you relating to the use of autonomous shuttle? System failure; Risk of an accident; Legal liability in case of an accident; Enter/exit the vehicle at the right stop or moment; Information about itinerary/stops; None
Perceived Risk	wp6	How do you describe the self-driving shuttle reactions? Very good; Safe; Neutral; Unpredictable; Dangerous
perceived Ease of Use	D7.2	How easy would you find it to use the vehicle?
Perceived quality of travel	wp3	If I used an autonomous shuttle, my travelling experience would be... less pleasant/more pleasant.
Perceived quality of travel	wp6	Was the trip comfortable compared with a conventional bus? More comfortable; Less comfortable; No different; I don't know
Perceived usefulness	wp6	Which potential benefits do you see in using a self-driving shuttle? Safety; Convenience; Punctuality; Better service; Lower price; Less congestion; Lower pollution; Other; None
Perceived usefulness	wp6	Which potential shortcomings do you see about using this kind of shuttle? Higher accident risk; Worse service; Less information onboard; Loss of jobs; Less security; Higher price
Perceived usefulness	D7.2 (Distler, Lalleman d, & Bellet, 2018)	On-demand, transport can help individualize travellers' needs

Indicators	Sources	Items
Perceived usefulness	D7.2 (Distler et al., 2018)	Autonomous shuttles can be a solution in case somebody is unable to drive if you need to bring kids to school, for disabled persons, for the elderly…
Perceived usefulness	D7.2 (Distler et al., 2018)	It is good that one can take the shuttle anywhere and anytime
Perceived usefulness	D7.2 (Distler et al., 2018)	The shuttle could help to go to areas which are currently not accessible by public transport, it would be a good complement to traditional public transport
Attitudes	wp6	How did you feel while travelling in a CAV? Trustful; Careful; Insecure; Safe; Nervous; Curious; Critical; Unaffected
Attitudes	wp6	Was using a CAV the experience you had anticipated? Positively surprised; Negatively surprised; It was as I expected; Other
Attitudes	wp3	If I used an autonomous shuttle, I would be... more dependent/more independent of other people.
Attitudes	wp3	To be independent of other people is... unimportant/important to me
Attitudes	wp3	The idea that large sections of the population use CAV feels good. does not apply at all; applies fully and completely
Attitudes	wp3	Large sections of the population use CAV I imagine as stressful.
Attitudes	wp3	I think I could do well with the autonomous shuttle. does not apply at all; applies fully and completely
Attitudes	wp3	If autonomous cars were available, I would use them. does not apply at all; applies fully and completely
Attitudes	wp3	I can imagine that I would have problems using autonomous cars.
Attitudes	wp3	I would try to avoid autonomous cars as much as possible
Human Factor	UMUX (Finstad, 2010)	This system's capabilities meet my requirements Strongly disagree (1) to strongly agree (5)

Indicators	Sources	Items
Human Factor	UMUX	Using this system is a frustrating experience
Human Factor	UMUX	This system is easy to use
Human Factor	UMUX	I have to spend too much time correcting things with this system

3.2.7Experimental protocol

3.2.7.1Sanitary measures for Covid-19 prevention

Before coming, the subjects are asked to register by filling an online survey and to apply the following rules:

- Wear a facemask,
- Wash their hands often,
- Keep 1-meter physical distancing,

while experimenters apply the same rules and wear a high filtration FFP2 facemask.

After each time somebody new wear the VR headset, we apply a protocol based on the recommendation published by the French VR community, consisting in:

- Extensive chemical disinfection of the VR headset and all its accessories
- Putting the VR headset and its eventual accessories in a Cleanbox and applying two 1-minute cycles of UV-C based disinfection

After each experiment:

- All instruments are placed in a dedicated labelled “dirty” box then disinfected and stored in a clean box for the next experience,
- All contact surfaces (seats, tables, door handles…) are also disinfected
- UTBM’s facilities are extensively ventilated.

3.2.7.2Conduct of the experiment

The following paragraphs explain the sequence of an experiment on a step-by-step basis:

0. Questionnaire (20 minutes)

The subject must complete a preliminary questionnaire one to two weeks before the experiment.

1. Reception of subjects and explanation of sanitary rules (20 minutes)

The subjects are welcomed in our laboratory by a designated researcher who remains the main contact person throughout the experiment. Then, the participants are informed about the hygiene rules and the procedure of the experiment is detailed.

2. Medical interview (20 minutes)

The subject must carry out a medical interview with a medical doctor. The subject communicates directly through a webcam on a computer. The medical doctor checks that the subject has no medical contraindications to the experiment.

3. Sensor placement (10 minutes)

The subjects wear, under the supervision and assistance of the researcher, all the measuring devices planned: heart rate sensor, electrodermal conductivity sensor and wrist movement measurement sensor.

4. Rest phase (5 minutes)

To have reference physiological data, the subjects were asked to rest, in a relaxed situation, for 5 minutes. This allows recording heart rate at rest.

5. Tutorial and familiarization (2 minutes)

The subject is wearing a virtual reality headset in a room dedicated to the simulation experience.

He firstly must follow a tutorial explaining how to move and interact in the virtual environment.

6. Experiment (15 minutes)

Once each step of the tutorial has been validated, the experience can begin. It should last 15 minutes maximum (excluding the duration of the tutorial) to minimize the risk of discomfort associated with the use of virtual reality.

At this point, the subject is still seated, allowing a smoother return to reality than standing. Then, he comes to the removal of the instrument phase and answering the questionnaires/interview.

7. Removal of measuring instruments (10 minutes)

The subject removes the measuring instruments, monitored and assisted by the researcher.

8. Questionnaire and interview after the test (45 minutes)

The subject is then invited to answer a new questionnaire. The proposed items are common to those in WP3 and WP6: demographic information, experience with autonomous mobility, the general attitude toward CAVs, willingness to pay, willingness to adopt, willingness to let others use, change in mobility behaviour, perceived risk, perceived ease of use, perceived quality of travel, perceived usefulness, attitudes. Participants will also complete the UMUX (Usability Metric for User Experience; Finstad, 2010) questionnaire.

Finally, an interview with the subject will be conducted. This will be a semi-structured interview during which general positive and negative points of the experience, the confidence felt towards the autonomous vehicle, the quality and efficiency of the different means of transportation used will be discussed. He/she could discuss his/her experience and feelings about the different experimental conditions.

9. Acknowledgements (10 minutes)

Once the researcher has answered their various questions/comments and ensured that they can drive in real conditions, the subjects are warmly thanked and released from the laboratory.

3.3 Experience 3: Acceptance and behaviour over time in an L4 Vehicle

The objective of this study is to expose subjects over a period of time to assess driver behaviour, cognitive load and acceptance. Subjects are exposed to a wide variety of situations including pedestrians crossing the road, crossroads, and automation mode change. The study consists of three main stages an initial assessment, repeated exposures, and a final assessment step.

Figure 11 A view of one area within the simulator environment.

3.3.1 Scientific definitions

3.3.1.1 Research Questions

- RQ 3.1: Does driver acceptance vary after multiple exposures to an L4 vehicle?
- RQ 3.2: Does driver cognitive load vary after multiple exposures to an L4 vehicle?
- RQ 3.3: Does driver performance vary after multiple exposures to an L4 vehicle?

3.3.2 Subjects sample

The target is approximately 30 subjects which will be drawn from LIST employees, interns and students and certain other externals who may be invited. These will be balanced as far as possible between male and female drivers.

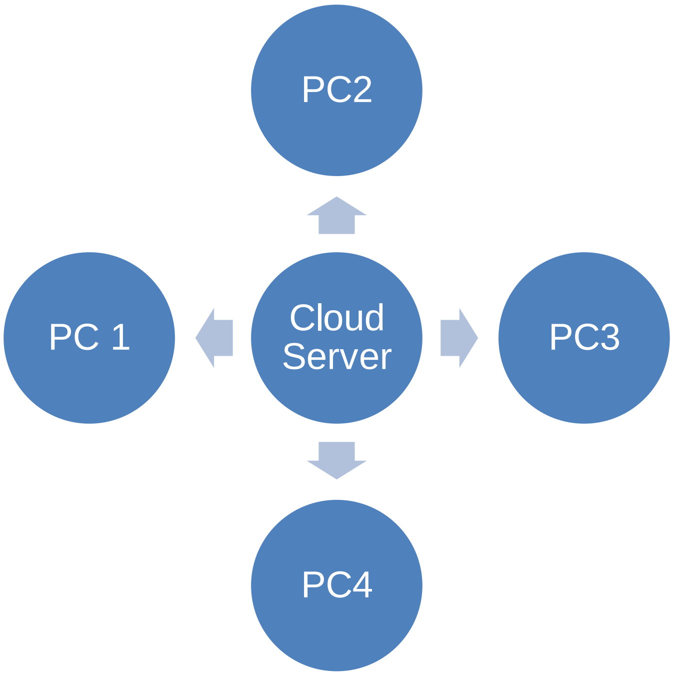
3.3.3 Simulation system

The simulator system design was inspired by a similar one developed for the FNR MADSAV project [WEB12]. In that project, users took part in a three months trial using a similar design of phases to this project. The earlier system was intended to be used by PAsCAL, however, although it was usable for two levels of automation the driving time required by the instructors (WP5) along with the number and complexity of events ordered meant that the older simulator was no-longer suitable. Changes made included adding a wider range of incidents such as roundabouts, pedestrian crossings and a variety of junctions. The driving time was also creased from less than 10 minutes to approximately 30 minutes. The vehicle dynamics and mode changes were also modified in response to comments.

Figure 12 The set-up showing the login screen. A Logitech steering wheel along with pedals are shown.

The HSS platform is designed to be lightweight and easy to install and run. It is primarily intended to allow large scale collection of data, over a long period of time with less need for researchers to supervise every stage. It consists of a client application installed on a PC, a Logitech G29 steering wheel, and a cloud architecture to store the data collected. At the time of writing more than 270 logins had been set-up for the PAsCAL project.

Figure 13 The Cloud Server can support multiple personal computers set up for the PAsCAL project and across many countries. Four is an example, far more can be used. Each PC is equipped with a Logitech G29 steering wheel.



3.3.3.1Simulation Design

An urban environment was built, along with a suburban area. Within this, three main routes are provided. The overall urban area is approximately 64km2. Each route lasts approximately thirty minutes and can be in a variety of traffic and driving (eco vs sport) modes. Within each route, there are approximately 40 different tasks (e.g., crossroads, junctions etc.) and at certain points, the driver is asked to take back or give back control of the vehicle.

Figure 14 Map of Urban Simulation Environment

Before this phase of the scene, the subject has a short 5-minute manual driving phase. There is a small familiarisation route. In total the current simulator as used in WP4 and excluding the additional work for WP5, provides around 90 minutes of different driving routes and a total of approximately 5-6 hours driving time for participants. Table 8 outlines the size and features of the urban environment. Participants will experience three routes, over four sessions. For the first and last session, they will experience the same route, whereas for rounds 2 and 3 they will experience the same route but with different traffic density conditions. The remaining route will be used for the 15-minute training session during the first meeting.

Table 8 The tasks in the Urban Simulation Environment

Tasks	Total Number	Tasks per route
Roundabout	26	11
Crossroads	63	22
Pedestrian Crossing	44	11
Overtaking area	10	1

Within the simulator, a variety of vehicles with different traffic densities are provided with these range from cars to busses. Traffic exists on both sides of the road and not all of the other vehicles comply with signalling requirements at junctions. Mode shifts are signified with an audible tone and general engine noise in the car is provided.

3.3.4Scenario development

Subjects will take part of a maximum six-week period, where they experience an urban environment in level 4 automation. The scenario will involve the drivers experiencing manual driving, followed by autonomous mode where they need to take back control of the vehicle at various points when the automated system is unable to handle a particular situation for example when there is a pedestrian crossing from behind a bus or when there is a poor connection to other vehicles. The vehicle then resumes automated mode when it is safe to do so. The urban environment consists of three different routes, and each driver experiences these in two driving modes eco and sport. Within each route, they experience three primary phases, an initial manual driving step, an automated area (with mode shift changes) and a destination point where they must park. In common with the example suggestions from the SAE taxonomy (Society of Automotive Engineers, 2018), the vehicle can operate in level 4 only within a designed area and when all safety conditions are met. A GPS navigator is provided which shows the designated route.

The basic components of the scenario include common traffic situations which were specified by trainers in WP5. Table 8 provides the number of incidents. A sample of these situations are illustrated in the following figures. The FPS indicator on the left gives the frames per second being displayed in the monitor by the simulation software. This is only used during testing and is to assess if the machine available has a powerful enough graphics card. This will not be visible to those taking part in the trial. As an absolute minimum the computer being used should be able to display at 25 frames per second, however, in general a target of 50 or more is desirable.

Figure 15 Manual Stage in a suburb

Figure 16 Single Lane Urban Road with vehicle pulling out from right

Figure 17 Single Lane Roundabout

Figure 18 Dual Lane roundabout

Figure 19 Pedestrians crossing from behind a bus

Figure 20 Dual Lane Urban Road

The GPS navigation system can be seen in the previous figures. A red line indicates the desired route, along with a dot which indicates the position of the car with respect to the route and surrounding streets. The interface also indicates the current vehicle mode (green symbol on top right) and if automated mode is possible at that location. The current speed limit is also displayed, along with if the vehicle is in eco or sport mode.

3.3.4.1 Manual Intervention

Manual intervention is required in certain designated circumstances, these include when visibility is obscured and a pedestrian may cross (see Figure 19), when on dual lane roundabouts, when crossing onto a dual lane road and when there is deemed to be insufficient other connected vehicles.

3.3.5Measurement package

The measurements used are similar to those in experiment 1 (UBFC's driving simulator) and are collected and stored on the cloud platform. These include:

1. Time
2. Country (e.g. indicating side of the road)
3. Road name
4. Current Speed Limit
5. Current Vehicle Speed
6. Angle
7. Input steering angle
8. Break Input
9. Acceleration
10. Distance to Centre of Lane
11. Wrong Lane indicator
12. Direction
13. Position
14. Steering Input
15. Forward Input (acceleration pedal value)
16. Reverse Input (break pedal value)
17. Driving Style (e.g. eco or sport)
18. Driving mode (manual or automated)
19. Current Tasks
20. Current Route ID
21. Collisions (vehicles, buildings, total)
22. Warning Response Time
23. Warning Displayed (status)
24. Distance to lead vehicle

25. Distance to following vehicle
26. Positions of other visible vehicles in the scene

3.3.6 Questionnaires

A standard background questionnaire will be used to collect demographic data such as age, gender, driving experience and experience of automated vehicles. For the initial and final assessment phases the short acceptance questionnaire based on the one used in WP5 has been develop (see appendix). Many changes were made to this questionnaire in order to focus on more specific issues. In order to assess cognitive load, the NASA TLX questionnaires (Hart & Staveland, 1988) will be used after each trial.

3.3.7 Semi-Structured Interviews

During the first and final assessment step. Participants will take part in a semi-structured interview. The interview will specifically explore how the participants felt towards the vehicle behaviours at key points in the trial. For example, the handover to/from the driver, different elements (e.g. roundabouts or junctions). To minimise interviewer bias, a methodology known as repartory grids will be used (Kelly, 1992). This approach will present a set of elements as mentioned earlier, the participants are then asked to select a set of constructs to describe these elements. They are then asked to rate each element with respect to the constructs provided. This allows the participants to define how they would describe the experience, rather than being asked to rate the experience on the basis of keywords or terms prescribed by the interviewer.

3.3.8 Experimental protocol

Although initially intended to be a study undertaken at home, this is problematic due to Covid restrictions. As often visits are still required by the researchers in order to correctly install and check hardware, fix hardware problems and to assist if required. In addition, even in the initial plan a number of steps were scheduled to take place at LIST, these included the simulator familiarisation, initial assessment and final assessment. As a result, all studies will now take place at designed located at LIST, where a set-up (Figure 12) can be used. It should be noted that the home simulator concept has already been developed and tested (although with different tracks) in the FNR MADSAV project (Mirnig et al., 2019). Therefore, the main added value in this project is again the repeated exposure over a period of time in the study with routes that have been devised with the trainers involved in WP5 in PAsCAL.

Table 9 Weekly Phases of the Simulator Study

Week 1	**Familiarisation and Initial Assessment** Simulator familiarisation phase. This is to allow the subject to understand and gain experience in the basic controls (15' approx.) Initial Assessment Phase (Duration 30' approx.) Semi-structured interview Completion of Acceptance Questionnaire NASA TLX Questionnaire
Weeks 2-4	**Randomised trials.** Two visits to the simulator (variation in traffic conditions) Completion of Acceptance and NASA TLX questionnaires
Week 5-6	**Final Assessment** Final Assessment Phase (Duration 30' approx.) Semi-structured interview acceptance questionnaire. NASA TLX Questionnaire

The initial and final assessment steps will use the same route. An explanation of the protocol for each phase is presented in the following section.

3.3.8.1Familiarisation and Initial Assessment

This step is undertaken alongside one of the research team, this is to ensure that the subjects can be provided with the assistance they require in order to familiarise themselves with the simulator. Also, as the initial assessment provides a controlled data point, it is important that the same conditions apply to all those taking part. The steps involved are outlined below:

1. Subject arrives at a designated location where the equipment is located.
2. The researcher explains the purpose of the study, along with the associated risks, privacy and ethical issues.
3. The subject is given a briefing sheet, instructions, along with a consent form to sign.
4. The initial profile questionnaire is undertaken.
5. The subject undertakes the familiarisation phase in the simulator, during this time subject may ask for assistance and the researcher can provide assistance. Duration 15 minutes. The researcher observes and takes notes relating to the performance of the driver.
6. They take a short break to discuss the simulator and to ask any questions.
7. If both the researcher and subject are ready to proceed, then the assessment phase is undertaken. The researcher observes and takes notes in relation to any clear problems observed.
8. The repertory grids analysis is undertaken.
9. After completion of the assessment phase the subject is asked to complete the first questionnaires.

3.3.8.2Randomised Trials

During this phase the subject arrives at the agreed time to take part in a 30-minute trial. This will take place approximately once per week, although this may change subject to holidays and availability.

1. Subject arrives at a designated location
2. Subject takes part in randomised trial conditions lasting approximately 30 minutes. This will entail either experiencing a high or low traffic condition.
3. Subject completes questionnaire

3.3.8.3Final Assessment

The purpose of this step is to collect the final trial data, therefore it requires a researcher to be present to ensure consistency and laboratory conditions. The steps involved are outlined below:

1. Subject arrives at a designated location where the equipment is located.
2. The researcher explains the purpose of the final assessment.
3. The subject undertakes the final trial in the demonstrator, during which time the evaluator observes and takes notes.
4. The researcher conducts a short semi-structured interview with the subject
5. The subject completes the NASA TLX questionnaire.
6. After completion of the assessment phase the subject is asked to complete the final questionnaire.
7. The researcher debriefs the subject on the purpose of the trial and asks if the subject if they have any questions. The researcher may also ask the subject to provide some explanations with respect to their behaviour in the final trial.

3.4 Experience 4: Acceptance and behaviour of pedestrians facing CAVs in the Immersive Arena

The main question of the Experience 4 is "*How to improve acceptance of Connected and Autonomous Vehicles (CAV) by pedestrians?".* Our hypothesis is that the improvement of pedestrians' trust and understanding in CAVs intentions can be observed through their behaviour in crossing situations. Furthermore, some scientific papers highlighted the importance of eHMI (external Human-Machine Interface) on CAV: the status information explains the absence of a driver steering the vehicle and additionally informing about the vehicle's intent adds a further sense of safety (Faas, Mathis, & Baumann, 2020).

3.4.1 Scientific definition

3.4.1.1 Research context

The interactions between pedestrians and autonomous vehicles raise new research issues. Deb et al. (2017) note that a large percentage of pedestrians (around 60%) do not trust that vehicles (drivers) will respond appropriately towards them. When faced with autonomous vehicles, the numbers are more ambiguous, as on the one hand autonomous vehicles are perceived as machines capable of avoiding human error, but on the other hand CAVs require, as machines, to be accepted by pedestrians. This acceptance refers directly to technological acceptance models, such as TAM (Davis, 1989), TAM2 (Vankatesh & Davis, 2000) or UTAUT (Vankatesh et al., 2003). Thus, the factors of CAV-pedestians acceptance are multiple. They include, for instance, the general attitude towards CAVs, social norms, trust, perceived effectiveness, perceived infrastructure compatibility, perceived system effectiveness, perceived anxiety and stress (Deb et al., 2017; Hewitt et al., 2019).

One way to create a new form of interaction between CAVs and pedestrians is to integrate an external interface (eHMI) on the vehicle that will be visible to road users (Ackermann et al., 2019). Another way is to adapt the infrastructure in order to offer a safe environment to the users. It is called eHMI all the solutions (Interfaces on CAV or some elements of road infrastructure) which could help road users to feel secure.

In PAsCAL project, this task therefore focuses on external interfaces, infrastructure and pedestrian behaviour in the specific context of road crossing.

3.4.1.2 Research questions

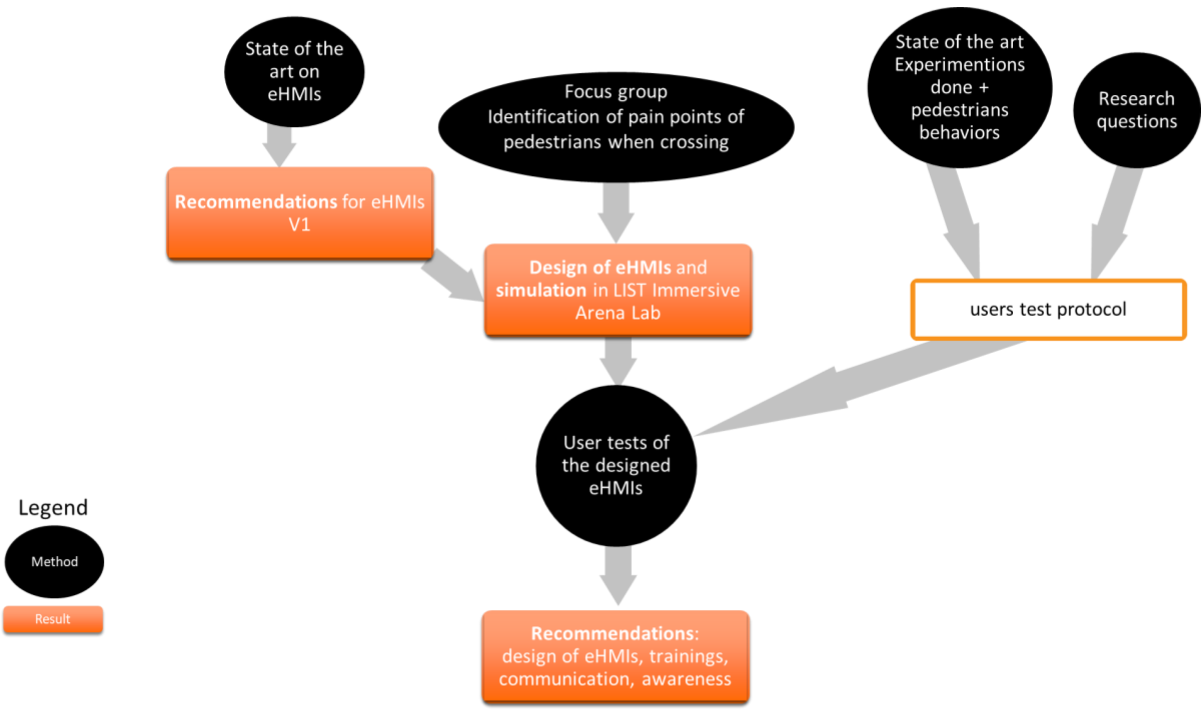
The general hypothesis of this task is: eHMI design has an impact on CAV's understanding & trust and so influence the pedestrian's crossing behaviour.

The focus was made on the four following research questions:

1. RQ 4.1: How the the eHMI design can influence the crossing behaviour?
2. RQ 4.2: What is the most impacting aspect of eHMIs?
3. RQ 4.3: What is the impact of the different aspects of eHMIs?
4. RQ 4.4: How consistent are the eHMI understanding and trustworthiness through different contexts?

The results of this task are to write some recommendations to be done for the design of understandable and trustful eHMIs (Figure 21).

Figure 21 Walkthrough to the recommendations.



3.4.2Subjects sample

Since the participants will be subjected to different road crossing situations, facing autonomous driverless vehicles, a counterbalanced distribution of the experimental scenarios is considered, in order to avoid learning biases. Thus, 60 subjects are forsee, men and women, selected according to their attitudes towards autonomous vehicles (collected with a questionnaire), their transport practices, their driving experience, and their attitude as a pedestrian (collected with a questionnaire).

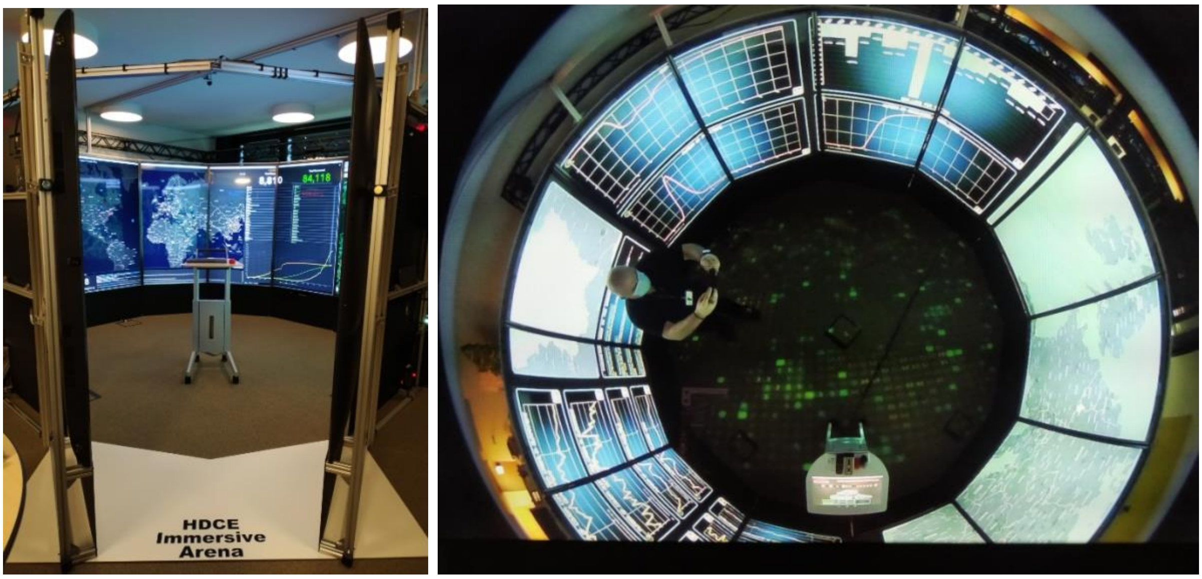
Participants will be subject to a strict protocol for compliance with health standards.

3.4.3Simulation system

The LIST 360deg Immersive Arena will be used to carry out the experiments.

The LIST 360deg Immersive Arena features 12 75” vertical screens building a full 360° display-wall with 2m height, 3.6m diameter and a resolution of 13400x1920 pixels. Multiple subjects can stand and move inside the Arena. Cameras are installed to record experiments and to adapt the simulation depending on the subjects’ behaviour/movements.

Figure 22 LIST 360deg Immersive Arena



On the software side an adapted version of CARLA - Open-source simulator for autonomous driving research is used to generate an immersive urban simulation with moving cars [Web2]. Within the

Simulation the location of the experiment, control cars, add other pedestrians and change the light and weather conditions can be adapted.

Figure 23 Picture extracted from CARLA simulator.

3.4.4 Scenario development

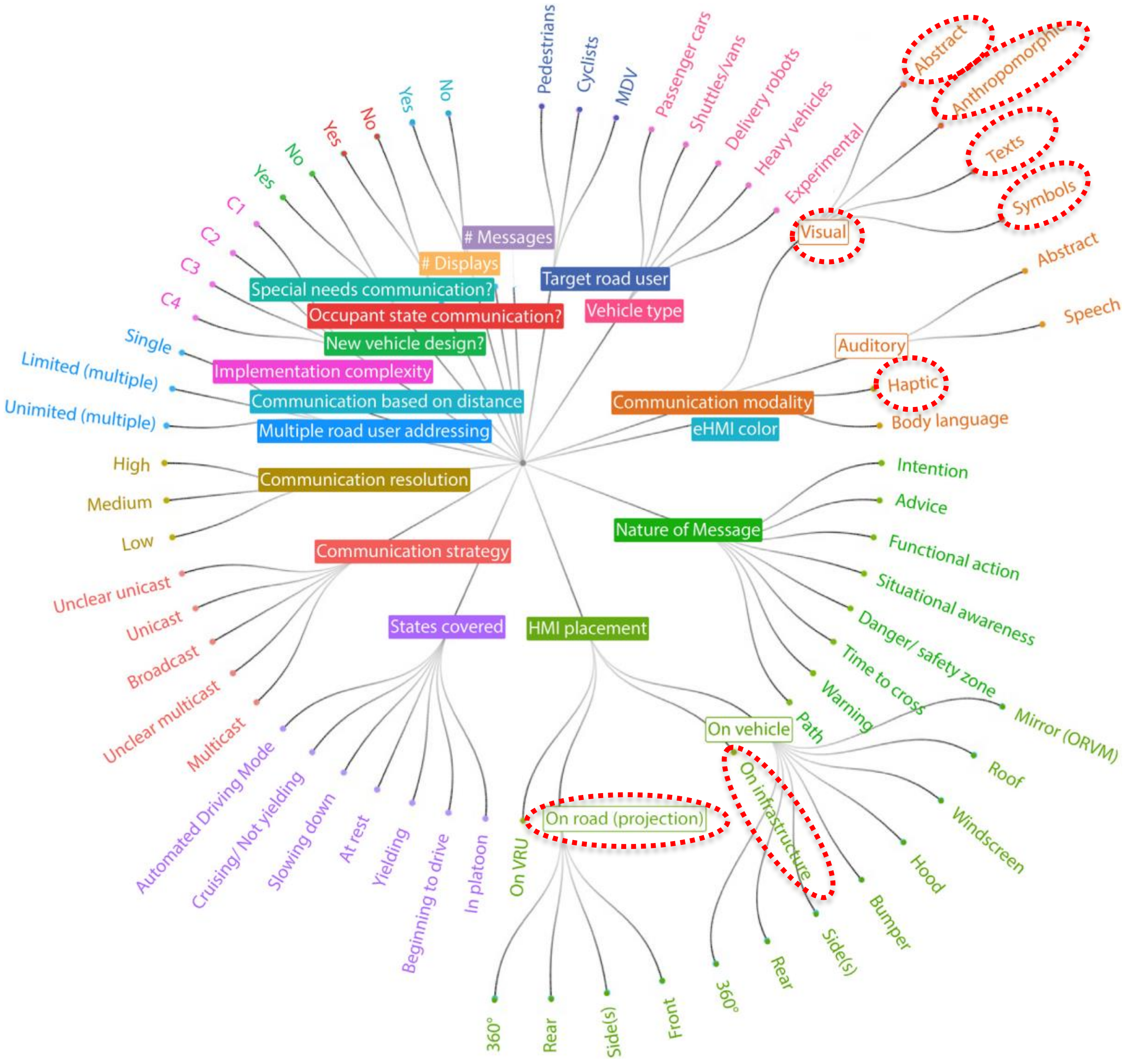
To define the scenario used during the experiment, several methods have been used. First, different eHMIs proposed by constructors or from the scientific literature have been listed with a focus on visual eHMIs. Then, to collect pedestrians' habits, two focus groups replicated two times with a total of 14 participants have been organised. They have been completed by an online survey. Through both methods, the projection of participants about the co-habitation of CAV and pedestrians and the advice of participants about the listed eHMIs have been collected. This study helped to select several eHMIs and to design some others that will be tested in the LIST 360deg Immersive Arena, but also, to refine the user profiles needed and some context for the simulation.

3.4.4.1 Scenario definition

3.4.4.1.1 Literature review of visual eHMIs

Dey et al. propose a categorization of eHMIs, see Figure 24 (Dey et al., 2020). For the PAsCAL project, the choice was done to concentrate on visual eHMIs. Two to five eHMIs have been selected (the exact number is indicated in brackets) for each following category: textual interfaces (4), abstract using lighting (5), using symbols (2), on road projection (2), anthropomorphic (4), others (3: including haptic, physical use of street furniture and other).

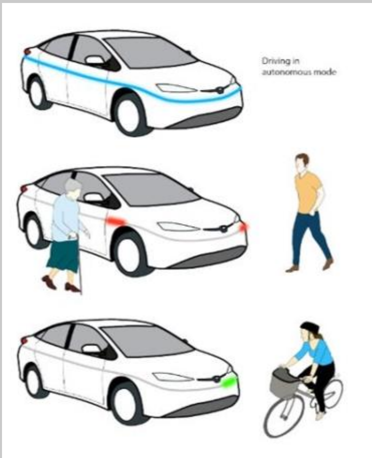
Figure 24 Circular dendrogram visualizes the taxonomy used to code the existing eHMI concepts (Dey et al., 2020), those used in this experiement are circled in red.

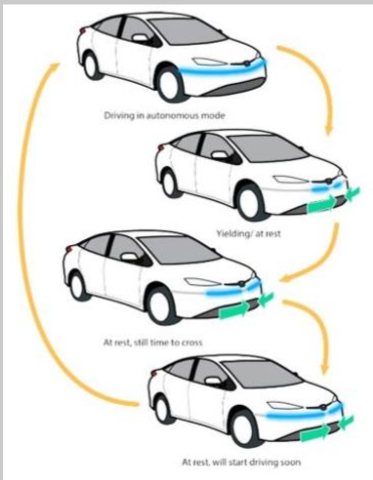


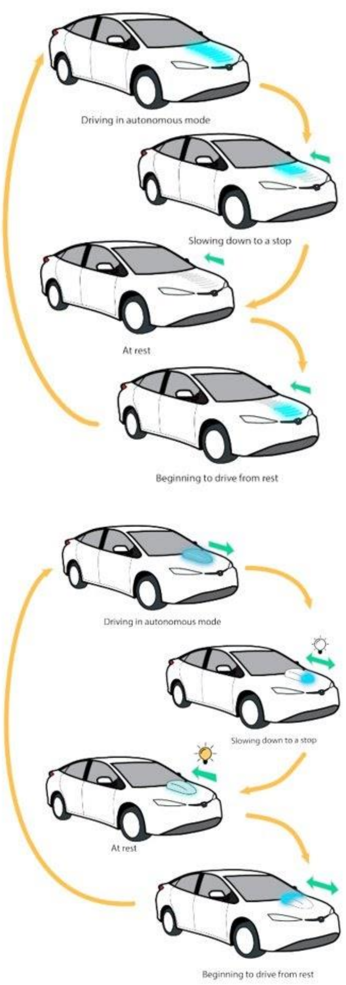
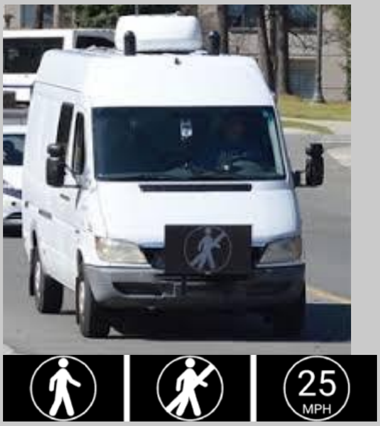
The selected eHMIs used in focus groups and online survey are listed in the table below.

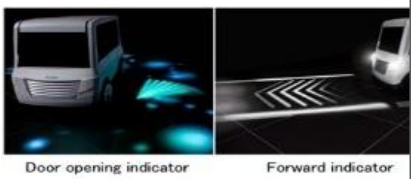
Table 10 Selected eHMIs.

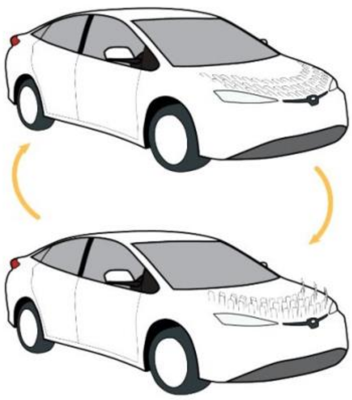
Category	Source	Image(s) shown	Explanations
Textual	**[[Web3]**		The CAV is displaying the message “after you” to indicate that it will let you cross. Blue LEDs indicate that it is a CAV
	[Web4]		The CAV is displaying “STOP” on the back
Textual + symbol	**[Web5]**		The car is displaying “Waiting for you to cross” and an icon of a pedestrian crossing to indicate that it will let you cross
Textual	**[Web6]**	 	The CAV displays several messages in front : - “go ahead” completed by arrows that scroll to the right to indicate to cross - “on my way” to indicate is driving - “bye” to the passager quiting the car - “11th street” the destination of the CAV

			“Hey David” + photo : is waiting that David in coming in the CAV
Abstract (lightening)	(Dey, Martens, Wang, Ros, & Terken, 2018)		The blue LEDs stripe is indicated that the CAV is driving in automatic mode. The red LEDs indicate that pedestrians are detected but the CAV will continue it route and show where they are detected. The green LEDs indicate that pedestrian (or here bike) is detected and the CAV will stop and show where they are detected.

	(Li, Dikmen, Hussein, Wang, & Burns, 2018)		The LEDs big band indicate the distance detected between the CAV and pedestrian(s). Green: the pedestrian has the time to cross Yellow: the pedestrian has maybe the time to cross, but it is dangerous. Red: the pedestrian has not the time to cross.
	(Dey et al., 2018)		The blue long LEDs stripe indicates that the CAV is driving in atomatic mode. When the stripe is going small the CAV is yielding or at rest. The stripe is going bigger to show that the time to cross is decreasing and that the CAV will restart.

	(Dey et al., 2018)		These two eHMIs work the same. When the LEDs part is full it indicates that the CAV is driving in autonome mode. The LEDs part coming smaller shows that the CAV is slowing down. No LED: the CAV is at rest. The LEDs par coming bigger shows that the CAV is restarting.
Symbols	(Clamann, 2015)		The CAV diplays different icons to indicate that the pedestrian can cross, can not cross, and the speed of the CAV.
	[Web7]		The CAV displays a “smile” to indicate that it is waiting that the pedestrian cross.

Road projection	[Web8]		The CAV projects a zebra on the road to indicate that it will let the pedestrian cross the road. Other projection shows that the CAV is turning.
	[Web9]		The CAV projects different info on the road: the blue one is indicating that the door is opening, white indicates that the CAV is drivinf forward, red indicates that the CAV is driving reverse.
Anthropomorphic	(Alvarez, Moreno, Sipele, Smirnov, & Olaverri-Monreal, 2020)		The eyes displayed on the roof of the CAV open when a pedestrian is detected.
	[Web10]		Eyes on the CAV follow the pedestrian.
	(Chang, Toda, Sakamoto, &		When eyes are opened on the CAV a pedestrian is detected.

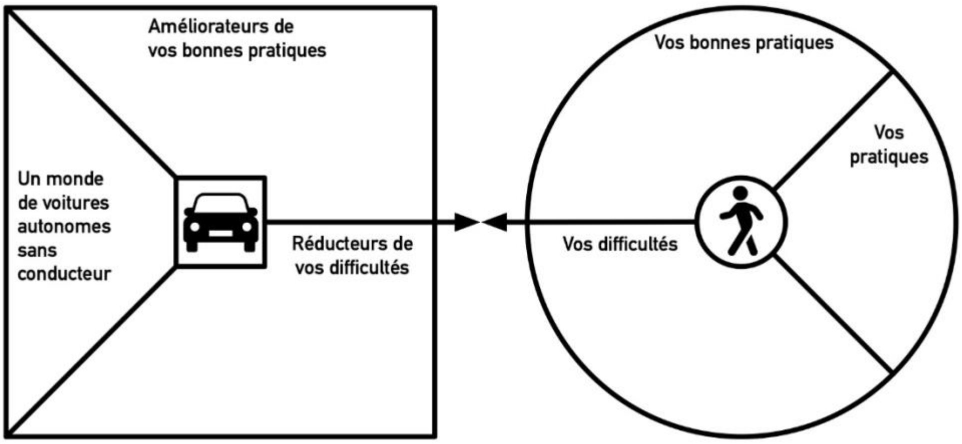
	Igarashi, 2017)		
	[Web6]		The lamps are abstract eyes which follow the crossing pedestrian.
Other	**[Web11]**		The zebra rises to protect crossing pedestrians.
	(Dey et al., 2018)		Some peaks rise when the CAV starts.
Haptic	**(Wang et al., 2020)**		The pedestrian receive on a wristband or a smartphone a vibration feedback to ask to don't cross.

Focus groups

Two focus groups were organised during April, by Visio conference due to the sanitary context, with two groups of seven persons each.

For the first focus group, the Proposition Value Canvas method has been used to identify jobs, pains and gains and some improvements ideas of pedestrians when they are crossing a road nowadays (Osterwalder, Pigneur, Bernarda, & Smith, 2015).

Figure 25 The proposition value canvas, adapted to the PAsCAL workshop.



The second focus group was focused on interactions between CAVs and pedestrians during a road crossing. Participants were asked to react to the hypothesis scenario of CAV arriving next year in their town. Then, participants were asked as pedestrians to comment on the main benefits and risks of CAVs in their opinion. But also, to indicate what could help them to see CAVs as reliable vehicles. Afterwards, listed eHMIs organised by category were presented to participants and they have been asked to explain how they understand each eHMI and what are their feelings about it. Finally, they sorted all eHMIs to indicate their preferred in terms of understandability and safety.

Thanks to these focus groups, some categories of eHMIs have been eliminated like the anthropomorphic, selected the preferred eHMIs and combined several needs to propose new composed eHMIs.

Online survey

An online survey was developed to collect pedestrians' habits and their perception of some eHMIs. The complete questionnaire is available in Annexes 6.2.1 Online survey questionnaire page 118 -Tables 17 XP4 online survey.

The survey was based on several questionnaires used in literature to identify pedestrian's profile, acceptance of CAVs and user experience of interface (here the CAVs eHMIs):

- **PRQF** – issued from the Demographic questionnaire (Deb, Strawderman, Carruth, et al., 2017; Deb, Strawderman, DuBien, et al., 2017) to register demographic data (age, gender, location, etc.)
- **PBQ** – issued from Pedestrian behaviour questionnaire (short version) (Deb, Strawderman, Carruth, et al., 2017; Deb, Strawderman, DuBien, et al., 2017) to identify the pedestrian's profile: aggressive behaver, positive behaviour, making errors or not, doing law violations or lapses or not.
- **PRQ** – issued from Pedestrian receptivity questionnaire (Deb, Strawderman, Carruth, et al., 2017; Deb, Strawderman, DuBien, et al., 2017) about the acceptance of CAVs.
- **MCAH** – issued from Mobility characteristics and characteristics of autonomy and health (Lord, Cloutier, Garnier, & Christoforou, 2018) about autonomy and health of participants like are they able to walk alone.
- **meCUE** – issued from Questionnaire for measuring user experience (Minge, Thüring, & Wagner, 2016) to identify user experience of each eHMI presented.

The participants were randomly redirected to one sub questionnaire containing all the listed eHMIs above (see Table 10) for only one category.

3.4.5Measurement package

3.4.5.1 Controlled variables

The controlled variables in this experiment are:

- Sex
- Age
- General attitude towards autonomous vehicles
- The type of external interface tested on the vehicle

- The presence or absence of a ground indication (pedestrian crossing or not - zebra)

3.4.5.2 Observed variables

The observed variables in this experiment are:

3.4.5.2.1 Observable pedestrians' crossing behaviour, through the variables described in the Table 11.

Table 11 Independent variables regarding the observable pedestrians' crossing behaviour.

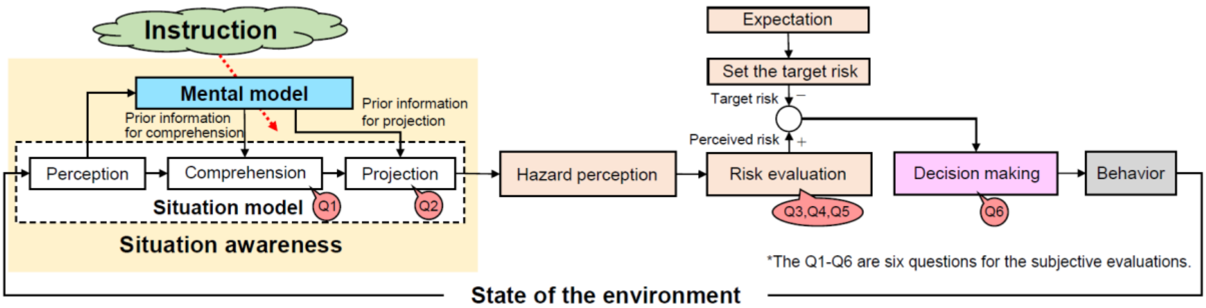
Indicators of the crossing behaviour	Methods to measure indicators
Cross or not	• Observation
Hesitations	• Think aloud using Speech to text • Question Q6 (Did you hesitate when you crossed the road?) (Liu, Hirayama, & Watanabe, 2021) • Observation
Crossing speed	• Motion capture (accelerometer)
Attention before crossing (look or not and look what)	• Eye-tracking to collect where the pedestrian looks, time of looking • Think aloud using Speech to text
Gap between pedestrian and car when crossing	• In meters
Trajectory	• Motion capture • Observation

In this study, the factors considered as they can influence the results will be:

1. Risk perceived / feeling of security / Emotion / Stress, as in Liu's model (see Table 12)

2. Confidence in the decision of crossing, as in Liu’s model (see Table 13)
3. Profile of the pedestrian
4. Evaluation of the eHMIs and their UX

Figure 26 The cognitive-decision-behaviour model of a pedestrian based on the model of (Liu et al., 2021). This model of the cognitive-decision-behaviour includes three parts: situational awareness, risk evaluation based on hazard perception, and decision making ba



3.4.5.2.2 Evaluation of the perceived risk

The evaluation of the perceived risk will be done through the variables described in the Table 12.

Table 12 Independent variables regarding the evaluation of the perceived risk.

Indicators	Methods
Risk evaluation	Questionnaire items from (Liu et al., 2021) to ask after each crossing decision • Q3: Did you feel the behaviour of the car was dangerous? • Q4: Did you trust the car when you crossed the road? • Q5: Did you feel a sense of relief when you crossed the road? Think aloud using Speech to text

Indicators	Methods
Perception of risk	Observation of the behaviour : Crossing or not
Emotion	Think aloud using Speech to text
Stress	Heartbeat rate using stress wristband

3.4.5.2.3 Evaluation of the confidence in the crossing decision

The evaluation of the confidence in the crossing decision will be done through the variables described in the Table 13.

Table 13 Independent variables regarding the evaluation of the confidence in the crossing decision.

Indicators	Methods
Hesitation during crossing	• Question Q6: Did you hesitate when you crossed the road? from (Liu et al., 2021) to ask after each crossing decision • Observation • Think aloud using Speech to text
Reflection	Open question: After thinking, was it a good idea to cross? to ask after each crossing decision
Projection	Open question: In real life, do think that you will cross or not? to ask after each crossing decision

3.4.5.2.4 Evaluation of the eHMIs and their UX

The evaluation of the eHMIs and their User eXperience (UX) will be done through the variables described in the Table 14.

Table 14 Independent variables regarding the evaluation of the eHMIs and their UX.

Indicators	Methods
Has been seen?	Open questions: • Did you have the feeling that the car intended to stop? • Does the car give you an indication of its intention? Think aloud using Speech to text Eye tracking, with a focus on the look at the eHMI parts
How pedestrian understand the eHMI?	Questionnaire items from (Liu et al., 2021) to ask after each crossing decision : • Q1: Was it easy to understand the driving intention of the car? • Q2: Was it easy to predict the behaviour of the car? Think aloud using Speech to text
What remembers the pedestrian?	Open question: Could you describe how the car gave you indication of its intention?
User experience of the eHMI	Using one of these questionnaires adapted to the context: • UMUX (Usability Metric for User Experience) (Finstad, 2010b) • meCUE (Minge et al., 2016)

3.4.5.2.5 Modification of the pedestrians' crossing behaviour

With different designs of eHMI, does different crossing behaviours can be observed (see Table 11)?

3.4.6Questionnaires

Several questionnaires will be used regarding several evaluations.

3.4.6.1Questionnaires about pedestrians' attitudes

The "*pedestrian receptivity questionnaire for FAVs*" (PRQ) (Deb et al, 2017) will be used to collect the pedestrian receptivity toward fully autonomous vehicles (FAVs is called CAV level 5 in PAsCAL project). It is a sixteen survey items based on attitude, social norms, trust, compatibility, and system effectiveness. This scale is the same as used in the survey about the perception of the eHMIs (please see Table 14). This objective was to compare the results extracted from the survey, with the experiments conducted in the Immersive Arena Lab.

The "Pedestrian Behaviour Questionnaire" (PBQ) (Deb et al., 2017) will be used to measure frequency of risky behaviours among pedestrians. This survey includes five dimensions (please see Tables 17):

1. the violation (deliberate deviation from social rules without intention to cause injury or damage);

2. the error (deficiency in knowledge of traffic rules and/or in the inferential processes involved in making a decision);

3. the lapse (unintentional deviation from practices related to a lack of concentration on the task; forgetfulness);

4. the aggressive behaviour (a tendency to misinterpret other road users' behaviour resulting in the intention to annoy or endanger);

5. the positive behaviour (behaviour that seeks to avoid violation or error and/or seeks to ensure traffic rule compliance).

In the framework of our experiment, this questionnaire will allow us to determine pedestrian profiles and to treat them as an independent variable, which can influence the behaviour towards autonomous vehicles.

3.4.6.2Questionnaires about the user experience (UX)

To collect the perceived user experience, the following questions will be used:

- The Usability Metric for User Experience (UMUX) (Finstad, 2010), which is a four-item Likert scale used for the subjective assessment of an IHM's perceived usability. The items are updated to better match with the eHMIs.
- Some items extracted from the meCUE questionnaire (Component model of User Experience) (Minge et al., 2016). The questionnaire consists of 34 items and covers four components: 1. product perceptions (usefulness, usability, visual aesthetics, status, commitment), 2. user emotions (positive, negative), 3. consequences of usage (intention to use, product loyalty), and 4. overall judgment. The focus will be especially done on the emotional aspects of the eHMIs, using usefulness, usability and aesthetics items.

3.4.7 Experimental protocol

The experimental protocol will follow a procedure that will ensure compliance with health regulations for the safety of the participant.

Actions of the sanitary protocol to follow prescriptions in regard of the health regulations in context of Covid-19 crisis are highlighted in grey in the following.

3.4.7.1 Before the experience day

- Confirmation of the date + asking to come with its own pen and smartphone

3.4.7.2 The experience day

- Assurance of wearing mask + inscription in the present list
- Disinfection of sensors + Arena touching parts
- Welcoming + hand disinfection + consent form signing
- Questionnaire about pedestrian profile (if no pen, loan of a disinfected pen)
- Explanation of the Immersive Arena
- Equipment of the person with sensors
- Familiarisation phase: 1 or 2 situations to train (with a truck or a bicycle)
- Show randomly different situations (with eHMI and without, three different eHMI, with zebra and without) and observe the pedestrian behaviour.

- After each situation complete some questions about the crossing or not decision and the eHMI
- Review and debriefing of each eHMI
  - UMUX and/or meCUE questionnaire
  - PBQ questionnaire
- Final questionnaire about preferred situations and why + training and communication needs
- Question about how to provide Amazon Voucher
- Thanks
- Cleaning

3.4.7.3After the experience day

Send of the Voucher (50€)

3.5 Experience 5: Pilots experiencing L3 and L4 personal aerial vehicles on a flight simulator

3.5.1 Scientific definition

Although the project primarily targets road-based transport modes, the methodology to be used as well as many of the corresponding results will be transferable to rail, air, and sea.

The University of Liverpool will investigate autonomous personal aerial vehicles (PAVs), exploring the operation and acceptance of these types of vehicle within the connected autonomous vehicle paradigm. This transport mode, commonly referred to as eVTOL (electric vertical take-off and landing) is set to revolutionise the transport system of tomorrow and change urban mobility forever. This vision of an aerial cityscape has stimulated a substantial body of research aimed at designing and testing PAVs as well as how to safely and effectively integrate them into ground-based infrastructure.

The simulation will utilise a baseline commuter scenario use case and automated vehicle model first created in the FP7 myCopter project [WEB13]. Participants are provided with an overview of proposed flying CAV operation and asked for their views on a range of topics e.g. noise, privacy, safety, etc. They then 'fly' in the simulated vehicle and its environment as per the envisaged scenarios. A debrief session will also be conducted with participants to see if and how their views have changed having experienced CAVs in (simulated) operation.

The research questions addressed are:

- RQ 5.1: How much the level of comfort (subjective and objective), ease-of-use and risk perception might vary between levels 3 and 4?
- RQ 5.2: What behaviour and level of acceptance will learners and experienced pilots have in a level 3 PAV flying in an urban environment?
- RQ 5.3: What behaviour and level of acceptance will learners and experienced pilots have in a level 4 PAV flying in an urban environment?

- RQ 5.4: Does the intervention of a human trainer make a difference to people's acceptance and use of higher levels of autonomy in PAVs?

3.5.2 Subjects sample

The target is approximately 30 subjects which will be drawn from University of Liverpool students and employees. These will be balanced as far as possible between male and female operators, both with and without piloting experience.

The simulator is located on top of a motion platform and requires the subject to climb/descend a 6 ft ladder to gain access to/exit the cockpit. The subjects need to be able to complete this without assistance.

It is possible some subjects may experience a disconnect between visual and vestibular motion cues, resulting in motion sickness. Vulnerability to this should be checked prior to participation in the experiments.

3.5.3 Simulation system

The Heliflight-R full motion flight simulator was commissioned in the School of Engineering at UoL in 2008 (Figure 27).

Figure 27 Heliflight-R

The outside world scene is rendered using one of several image generators, projected onto a 12 ft diameter dome by three HD projectors. X-plane has been selected for this study due to the availability of Liverpool city and airport databases, purchased from OrbX. The output from each display channel is warped and blended to create a seamless image on the surface of the dome covering a field of view of approximately 210° by 70° (Figure 2). The instrument panel uses LCD displays, featuring two touch screens. They are also user- programmable. The motion platform features 6 Degrees of Freedom, using 24-inch electric actuators. The simulator's motion performance envelope is documented in Table 1. The base accommodates an 1800 Kg payload.

Figure 28 Heliflight-R field of view

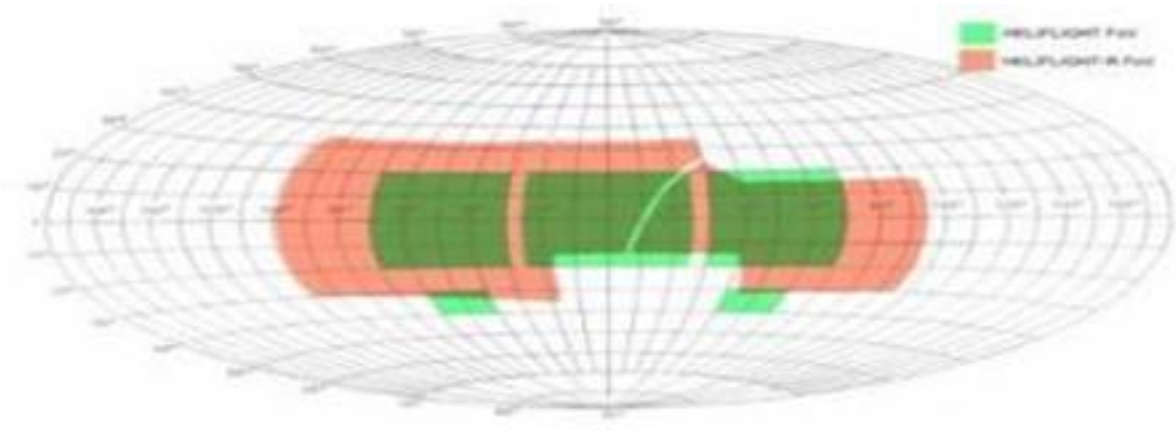


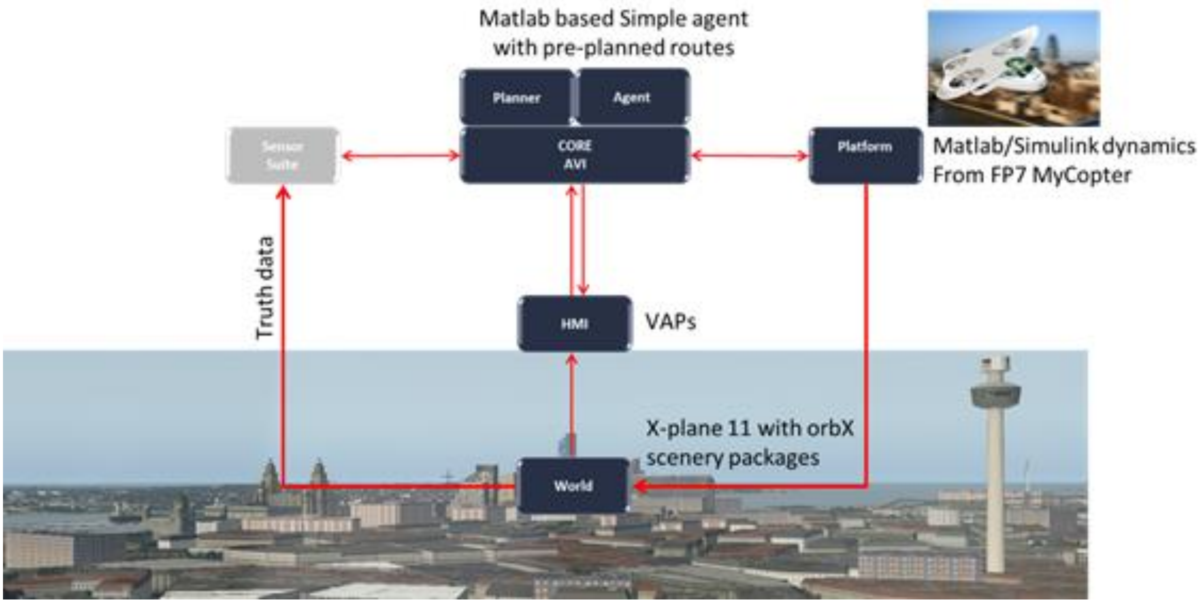
Table 15 Heliflight-R performance envelope

	Displacement	Velocity	Acceleration
Pitch	-23.3°/25.6°	±34 °/s	300 °/sec^2
Roll	-23.2°	±35 °/s	300 °/sec^2
Yaw	±24.3°	±36 °/s	500 °/sec^2
Heave	±0.39 m	±0. 7 m/s	+/- 1.02 g
Surge	-0.46 /+0.57 m	±0. 7 m/s	+/- 0.71 g
Sway	±0.47 m	±0. 5 m/s	+/- 0.71 g

HeliFlight-R is reconfigurable for flight dynamics engineering and training applications. Aircraft-specific cabs can be implemented to allow for authentic fixed wing or rotorcraft simulation environment. This included the use of two pilots, with extra capacity for in-flight analysis. Authentic controls allow for re-configurable force-feedback and re-configurable instruments. All physical switches and levers are user programmable as required.

For this study, the Matlab-based flight dynamics model from the EU FP7-funded project myCopter is used with autopilot and pre-planned routes from Liverpool Airport to three vertiports around Liverpool City Centre. The system architecture is illustrated in Figure 3.

Figure 29 System architecture



3.5.4Scenario development

Participants will need to be able to control the vehicle in the event of the system relinquishing control. For road-based autonomous systems, passengers are much more likely to be experienced in driving and can intervene by taking control from the autonomous system when required or desired. For the airborne system equivalent to a road vehicle, passengers require an equivalent of a pilot license. For this work, this means training the occupants to fly the vehicle should they have to intervene. Even experienced pilots will need to train to a level of competence with the myCopter configuration. Furthermore, with the planned number of test subjects – this would be a time consuming for the instructor.

A solution to this is that the system contains a high level of automatic functionality. i.e. the user need only select an option such as (change of) destination airfield if prompted or desired. This level of functionality exists on current manned and unmanned aircraft with automatic waypoint navigation, flightpath, landing systems etc. Therefore, the user need only select the destination and need not intervene in the flying task.

3.5.4.1Conduct of the scenario

The scenario is that on arrival at Liverpool John Lennon airport, a passenger (subject) will take an Unmanned Air Taxi from the airport to Liverpool city centre. The route from the airport towards the city centre is depicted in Figure 4. Departure from the airport is illustrated in Figure 5. Three vertiports serve the city centre region (Figure 6). The first is the Pier Head, close to the waterfront and central tourist attractions and further transport links. The second is to the east of the city centre in the knowledge quarter close to the cathedrals and University. The third, Seacombe Terminal, is on The Wirral, across the River Mersey from Liverpool city centre. The passenger selects the Pier Head vertiport as the destination.

Figure 30 Unmanned air taxi route from Liverpool airport to the city centre

Figure 31 Liverpool airport

Figure 32 Liverpool city region vertiports

The first run of the simulation will feature CAV level 4 examined, where the flight takes place as planned. The second run however will feature city centre airspace, which includes the Pier Head Vertiport, closed as illustrated in Figure 7, as the vehicle approaches the city centre airspace. The autonomous system onboard reroutes to the knowledge quarter and continues on the journey with no need for the subject to intervene.

The third run will feature a similar closure of airspace. However, this time the system will choose to divert to the Seacombe Terminal (Figure 8). This choice is less practical for the subject, as an additional journey is required to cross the river to reach the city centre. Although the CAV level 4 system can continue on the journey, the occupant intervenes to change the destination to the knowledge quarter vertiport.

The final scenario is based on CAV level 3. Again, airspace is closed as the vehicle approaches the city centre region. This time however, the autonomous system does not have the capability to select a new route. Therefore, the default option for the vehicle is to return to the departure point, unless the subject selects a new destination.

Figure 33 City centre airspace which includes the Pier Head Vertiport closed – Divert to the Knowledge quarter

Figure 34 City centre airspace which includes the Pier Head Vertiport closed – Divert to Seacombe Terminal

Finally, a cohort of subjects will be receive additional training, where an instructor will take part in the trials with the participant and provide information on the system and the decision making process, to determine if this additional knowledge provides additional confidence in the autonomous vehicle operation in managed airspace.

3.5.5Measurement package

The variables in this experiment are:

- Gender
- Age
- Piloting skill level
- General attitude towards autonomous vehicles
- The type of external interface tested on the vehicle
- The presence or absence of other aircraft
- Time histories of vehicle parameters (trajectory, control inputs (autonomous or human operator)
- Cockpit video/audio recording

3.5.6Questionnaires

A standard background questionnaire will be used to collect demographic data such as age, gender, driving and flying experience (if any) and experience/perception of eVTOL / PAV.

Prior to the simulation evaluation, the subject will be briefed on how to use the questionnaires and after each simulation run the subject will be asked to provide feedback on their perceived comfort level with the run and decision options using the questionnaires.

After the simulation runs, elements of the NASA TLX rating scale will be completed by the occupant detailing:

- **Mental Demand -** How much mental and perceptual activity was required? Was the task easy or demanding, simple or complex?
- **Physical Demand -** How much physical activity was required? Was the task easy or demanding, slack or strenuous?
- **Temporal Demand -** How much time pressure did you feel due to the pace at which the tasks or task elements occurred? Was the pace slow or rapid?
- **Overall Performance -** How successful were you in performing the task? How satisfied were you with your performance?
- **Effort -** How hard did you have to work (mentally and physically) to accomplish your level of performance?
- **Frustration Level -** How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task?

3.5.7 Experimental protocol

The session will last approximately 2 hours and consist of a briefing session (approximately 30 mins), the simulation experiments (approximately 1 hour) and a debriefing session (approximately 30 mins).

- Briefing session: The subject will be briefed on the project and goals of the simulations. The subject will be asked about their level of experience and comfort with flight and of autonomous systems. The experiments will be described and the options available in each test case and required subject inputs and outputs. The safety procedures and enhanced covid protocols will be described (including participants wearing gloves in the simulator and enhanced cleaning processes between participants). The subject will be told that some subjects are prone to experiencing some motion sickness and must let the simulation controller know if this occurs.
- Simulation Experiments: The simulation experiments will be run in the same order for all subjects. The order of participants age/sex/piloting skill is not important to the experiment. Each task is briefed again as the task is about to be undertaken. After the first task, the experiment will be started during the cruise phase to save time. Subjects perception and comfort will be ascertained after each run.

Debrief session: the subject will be asked to complete the NASA TLX scale and provide any additional feedback.

4 Deviations

4.1 Covid-19 impact

The Covid-19 outbreak had a major impact on both organisation and people's mindset/attitudes towards some transportation modes.

Regarding the organisation of the experiments, it impacted almost each step of it. Many of the partners had to organise themselves for working exclusively remotely, while they were still elaborating the research questions and designing the associated scenarios and experimental protocols. Ordering the necessary materials, developing the simulations, and setting up the simulators have been considerably retarded as soon as we weren't able to regularly access our facilities. Finally, most of the experiments need the subject to come at the partners' respective facilities, what has been forbidden/made much more complicated for many months, depending on the sanitary rules of each country. It also implied heavy additions to the experimental protocols in order to ensure both subjects' and experimenters' safety while running the experiments.

Regarding the people's mindset/attitudes among transportation, the Covid-19 was also a major changer. Most of the European citizens haven't been allowed to travel anymore for months and, when they were allowed again, we observed massive changes in the behaviours: some transport modes being avoided because associated to a higher risk of contamination, and some other ones becoming increasingly popular as they were seen as safe alternatives. For this reason, the partners were forced to adapt some questionnaires for taking into account some recent changes in peoples' behaviour, measuring it and, more generally, not ignoring such an event that made a big change.

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6 Annexes

6.1 Annexes relating to experiment 3

6.1.1 Profile Questionnaire

Table 16 XP3 profile questionnaire

Are you	**Quel est votre genre ?**
Male Female Other Prefer not to say	Masculin Féminin Autre Je ne souhaite pas répondre à cette question
Please tell us your age	**Quel est votre âge ?**
18-25 26-36 37-47 47-57 More than 57	18-25 ans 26-36 ans 37-47 ans 47-57 ans Plus de 57 ans
What country do you currently live in?	**Dans quel pays habitez-vous ?**
Germany Belgium **France** Luxembourg **Other**	Allemagne Belgique France Luxembourg Autre

Which of the following services, features or technologies have you used before?	**Parmi les services, fonctionnalités ou technologies suivants, lesquels avez-vous déjà utilisés ?**
Navigation & routing services (GoogleMaps, Waze,...) Bike-, Scooter-, Car-sharing services (ShareNow, Free2Move, Lime,...) Ride-sharing (Uber, Cabify, taxi apps,...) Carpooling (BlaBlaCar, Leadmee,...) Connected features (next stop indicator in buses,...) Driver assistance (speed limit indicator, blind spot detection, lane assist,...) Adaptative cruise control (the vehicle controls the speed according to traffic) Automatic steering (autonomous parking or vehicle keeping itself in lane) I don't know I have never tried these CAV functions or services	Services de navigation et de guidage (GoogleMaps, Waze,...) Services de partage de vélos, de scooters et de voitures (ShareNow, Free2Move, Lime,...) Voiture avec chauffeur (Uber, Cabify, applications de taxi,...) Covoiturage (BlaBlaCar, Leadmee,...) Fonctions connectées (indicateur de prochain arrêt dans les bus,...) Aide à la conduite (indicateur de limite de vitesse, détection des angles morts, assistance au maintien de la trajectoire,...) Régulateur de vitesse adaptatif (le véhicule contrôle la vitesse en fonction du trafic) Direction automatique (stationnement autonome ou maintien du véhicule dans sa voie) Je ne sais pas Je n'ai jamais essayé ces fonctions ou services de VCA auparavant
Were you a passenger or/and a driver in the Connected and Automated Vehicle (CAV)?	**Avez-vous déjà été passager·ère ou/et conduct·eur·rice d'un véhicule connecté et automatisé (VCA) ?**

A passenger A driver both I have never been in one N/A	Passager Conduct·eur·rice Les deux Aucun N/A

6.1.2 Acceptance Questionnaire

How did you feel while traveling in a CAV?	**Comment vous êtes-vous senti·e en voyageant dans un VCA ?**
Trusting Careful Insecure Unsafe Nervous Curious Critical Unaffected Neutral	Confiante Prudente Pas en sécurité En sécurité Nerveuse Curieuse Critique Naturelle Neutre
How did you find the experience of using a CAV?	**Comment avez-vous vécu l'expérience de l'utilisation d'un VCA ?**
Positively surprised Negatively surprised It was as I expected I don't know	Positivement surprise Négativement surprise C'était comme je m'y attendais Je n'en sais rien

How do you describe the reactions of the CAV?	**Comment qualifieriez-vous les réactions du VCA ?**
Very predictable Predictable No opinion Unpredictable Very unpredictable	Très prévisibles Prévisibles Sans opinion Imprévisibles Très imprévisibles
I found understanding the operating limits of the autonomous more of the CAV?	**A quel point l'utilisation d'un VCA a-t-elle été difficile ?**
Very Easy Easy Neither easy nor difficult Difficult Very Difficult	Très facile Facile Ni facile ni difficile Difficile Très difficile
Did you hear the warning signals?	**Avez-vous entendu les signaux d'alarme ?**
Every Time Some of the time None of the time	Chaque fois De temps en temps Jamais
Was it easy to change the driving mode (autonomous/non autonomous)?	**Etait il facile de changer le mode de conduite (autonome/non autonome)?**

Very easy Easy Neither easy nor difficult Difficult Very difficult	Très facile Facile Ni facile ni difficile Difficile Très difficile
How did you find the amount of information provided by the on-board system?	**Comment avez vous trouvé la quantité d'information fourni par le système embarqué ?**
1. Too much Information 2. 3. About the Right Amount of Information 4. 5. Not Enough Information	1. Il y avait trop d'information 2. 3. La bonne quantité d'informations 4. 5. Il n'y avait pas assez d'information
Did you feel confident with the on-board system?	**Vous êtes-vous senti·e en confiance avec le système embarqué ?**
1. Very Confident 2. 3. Neither Confident nor lacking in Confidence 4. 5. Not Confident at all	1. Très confiant 2. 3. Ni confiant ni en manque de confiance 4. 5. Très en manque de confiance
How safe did you feel when the vehicle was in autonomous mode?	**Dans quelle mesure vous êtes-vous senti·e en sécurité lorsque le véhicule était en mode autonome ?**

1. Being very safe 2 3 Neither safe nor unsafe 4 5. Being very unsafe	1. Très en sécurité 2. 3. Ni en sécurité, ni en insécurité 4. 5. Très en insécurité
During the change over to autonomous mode how safe did you feel?	**Pendant le passage en mode automatique, vous êtes-vous senti·e en sécurité ?**
1. Being very safe 2. 3 Neither safe nor unsafe 4. 5. Being very unsafe	1. Très en sécurité 2. 3. Ni en sécurité, ni en insécurité 4. 5. Très en insécurité
During the change over to manual mode how safe did you feel?	**Pendant le passage en mode manuel, vous êtes-vous senti·e en sécurité ?**
1. Being very safe 2. 3 Neither safe nor unsafe 4. 5. Being very unsafe	1. Très en sécurité 2. 3. Ni en sécurité, ni en insécurité 4. 5. Très en insécurité
How safe did you feel when you were driving in manual mode?	**Dans quelle mesure vous êtes-vous senti·e en sécurité lorsque le véhicule était en mode manuel ?**

1. Being very safe 2. 3 Neither safe nor unsafe 4. 5. Being very unsafe	1. Très en sécurité 2. 3. Ni en sécurité, ni en insécurité 4. 5. Très en insécurité

6.1.3NASA TLX

Hart and Staveland (Hart, 1988) NASA Task Load Index (NASA TLX). For each of the questions the participant is asked to provide rating on a 21 point scale from Very Low to Very high.

Task: When the CAV changed from automated to manual mode, how did you find the task?

Mental Demand: How mentally demanding was the task?
Physical Demand: How physically demanding was the task?
Temporal Demand: How demanding or rushed was the pace of the task?
Performance: how successful were you in accomplishing what you were asked to do?
Effort: How hard did you have to work to accomplish your level of performance?
Frustration: How insecure, discouraged, irritated, stressed, and annoyed were you?

6.2 Annexes relating to experience 4

6.2.1Online survey questionnaire

Tables 17 XP4 online survey.

Source	Original item	Translated item (FR)
PRQF	What is your gender?	Quel est votre genre ?
	What is your age?	Quel est votre âge ? (en année)
/[2]	/	Quelle est votre nationalité (ou quelles sont vos nationalités) ?[3]
PRQF	In which US state do you live?	Dans quel pays habitez-vous ?
/	/	Avez-vous un ou plusieurs enfant(s) de moins de 10 ans à votre charge ?[4]
PRQF	How would you describe the area where you live?	Comment décririez-vous l'environnement dans lequel vous vivez ?
/	/	De manière générale, avez-vous plutôt l'habitude de vous déplacer... (à pied, à vélo, à trottinette, en voiture, en bus ou par moyen de transport en commun, autre)[5]
PRQF	How often do you walk in a day?	En moyenne, combien de fois marchez-vous par jour ?

[2] /: not issued of a published questionnaire, defined for this specific survey.
[3] What is (are) your nationality(ies)?
[4] Do you have one or more children under the age of 10 in your care?
[5] In general, do you tend to travel... (by foot, bicycle, scooter, car, bus or public transport, other)

	What range best describes your daily walking time?	En moyenne, combien de temps marchez-vous par jour ?
MCAH	Difficulty in walking?	Avez-vous des difficultés à marcher ?
	Accident victim in past?	Avez-vous déjà été victime d'un accident de la route ?
	Driving license?	Avez-vous un permis de conduire, et si oui depuis combien de temps ?

Source	Original item	Translated item (FR)
PBQ	**As a pedestrian, how often do you have the following behaviours?**	**En tant que piéton, à quelle fréquence avez-vous les comportements suivants ?**
PBQ	I cross the street even though the pedestrian light is red.	Je traverse la rue même si le feu pour piétons est rouge.
	I cross outside the pedestrian crossing even if there is one (crosswalk) less than 50 meters away.	Je traverse en dehors du passage pour piétons même s'il y en a un (passage pour piétons) à moins de 50 mètres.
	I cross between vehicles stopped on the roadway in traffic jams.	Je traverse entre les véhicules arrêtés sur la chaussée dans les embouteillages.
	I cross even if vehicles are coming because I think they will stop for me.	Je traverse même si des véhicules arrivent car je pense qu'ils vont s'arrêter pour moi.
	I realize that I have crossed several streets and intersections without paying attention to traffic	Je me rends compte que j'ai traversé plusieurs rues et intersections sans faire attention à la circulation.

	I forget to look before crossing because I am thinking about something else.	J'oublie de regarder avant de traverser parce que je pense à autre chose.
	I get angry with another road user (pedestrian, driver, cyclist, etc.), and I yell at him.	Je me mets en colère contre un autre usager de la route (piéton, conducteur, cycliste, etc.) et je lui crie dessus.
	I have gotten angry with a driver and hit their vehicle.	Il m'est arrivé de me mettre en colère contre un conducteur et de heurter son véhicule.
	I thank a driver who stops to let me cross.	Je remercie un conducteur qui s'arrête pour me laisser traverser.
	I let a car go by, even if I have the right-of-way, if there is no other vehicle behind it.	Je laisse passer une voiture, même si j'ai la priorité, s'il n'y a pas d'autre véhicule derrière elle.

Source	Original item	Translated item (FR)
PRQ	A fully autonomous vehicle (FAV) is driven by technology instead of by a human. A FAV is equipped with radars, cameras, and sensors which can detect the presence, position, and speed of other vehicles or road-users. With this information, the FAV can then respond as needed by stopping, decelerating and/or changing direction. A driverless vehicle has the potential to reduce pedestrian-motor vehicle crashes and to decrease the	Une voiture entièrement autonome sans conducteur (VAC) est conduite par la technologie et non pas par un humain. Une VAC est équipée de radars, de caméras et de capteurs capables de détecter la présence, la position et la vitesse d'autres véhicules ou usagers sur la route. Grâce à ces informations, la VAC peut alors réagir en s'arrêtant, en décélérant et/ou en changeant de direction. En considérant cela, quel est votre degré

	possibility of severe injuries by controlling the driving task effectively. You have recently learned that there will be fully autonomous vehicles on the road in your area. As you consider this, how much would you agree or disagree with the following statements.	d'accord avec chacune des affirmations suivantes ? Il n'y a pas de bonnes ou de mauvaises réponses. Soyez spontané·e, seul votre avis compte.
PRQ	FAVs will enhance the overall transportation system.	Les VAC vont améliorer le transport dans son ensemble
	FAVs will make the roads safer.	Les VAC vont rendre les routes plus sûres.
	I would feel safe to cross roads in front of FAVs.	Je me sentirais en sécurité si je traversais la route devant des VAC.
	It would take less effort from me to observe the surroundings and cross roads if there are FAVs involved.	Si je veux traverser en présence de VAC, ça me demandera moins d'efforts pour vérifier la route.
	I would find it pleasant to cross the road in front of FAVS.	Je trouverais cela plaisant de traverser la route devant des VAC.
	People who influence my behaviour would think that I should cross roads in front of FAVs.	Les gens que j'ai l'habitude d'écouter pensent que je peux traverser la route devant des VAC.
	People who are important to me would not think that I should cross roads in front of FAVs.	Les gens qui comptent pour moi vont plutôt penser qu'il ne faut pas traverser la route devant des VAC.
	People who are important to me and/or influence my	Les gens qui comptent pour moi et/ou que j'ai l'habitude

	behaviour trusts FAVs (or has a positive attitude towards FAVs).	d'écouter ont confiance dans les VAC ou en ont une bonne opinion.
	Interacting with the system would not require a lot of mental effort.	Interagir avec le système ne me demanderait pas de beaucoup réfléchir.
	FAV can correctly detect pedestrians on streets.	Les VAC vont pouvoir détecter correctement les piétons dans les rues.
	I would feel comfortable if my child, spouse, parents – or other loved ones – cross roads in the presence of FAVs.	Je me sentirais serein·e si mon enfant, partenaire, parent, ou autre proche, traversait la route en présence de VAC.
	I would recommend my family and friends to be comfortable while crossing roads in front of FAVs.	Je dirais à ma famille et à mes amis qu'ils peuvent avoir confiance quand ils traversent la route en présence de VAC.
	I would feel more comfortable doing other things (e.g., checking emails on my smartphone, talking to my companions) while crossing the road in front of FAVs.	Je me sentirais plus serein·e de faire autre chose quand je traverse la route devant des VAC (par exemple regarder mes emails sur mon téléphone, ou discuter avec des amis).
	The traffic infrastructure supports the launch of FAVs.	L'infrastructure routière est prête pour le lancement des VAC.
	FAV is compatible with all aspects of transportation system in my area.	Les VAC vont pouvoir fonctionner avec tous les types de transport et leur infrastructure de ma région.
	FAVs will be able to effectively interact with other vehicles and pedestrians.	Les VAC seront capables d'interagir de manière efficace avec les autres véhicules et les piétons.

Original item	Translation for this document
Dans la section suivante, nous allons vous présenter plusieurs interfaces de communication entre les voitures autonomes sans conducteur et les piétons (ou tout autre usager de la route). Ces interfaces ont pour objectif d'informer le piéton (ou tout autre usager de la route) sur le comportement de la voiture autonome. Merci de donner votre avis pour chacune de ces interfaces, à l'aide des questions qui vous seront posées juste en dessous.	In the following section, we will present several communication interfaces between driverless autonomous cars and pedestrians (or any other road user). These interfaces aim to inform the pedestrian (or any other road user) about the behaviour of the autonomous car. Please give your opinion on each of these interfaces, using the questions below.
A votre avis, comment fonctionne cette interface ? C'est-à-dire, quel message est affiché, à quel moment, et pour communiquer quelle(s) information(s) ? (réponse optionnelle)	How do you think this interface works? That is, what message is displayed, at what time, and to communicate what information? (optional answer)

Source	Original item	Translated item (FR)
PRQ adapted to the interface		Face à ce type d'interface pour une voiture autonome sans conducteur (VAC), merci d'indiquer votre degré d'accord avec chacune des affirmations suivantes.[6]
	I would feel safe to cross roads in front of FAVs	Je me sentirais en sécurité si je traversais la route devant des VAC disposant de cette interface.

[6] When faced with this type of interface for an autonomous driverless car (CAV), please indicate your level of agreement with each of the following statements.

	It would take less effort from me to observe the surroundings and cross roads if there are FAVs involved	Si je veux traverser en présence de VAC disposant de cette interface, ça me demandera moins d'effort pour vérifier la route.
	I would find it pleasant to cross the road in front of FAVS.	Je trouverais cela plaisant de traverser la route devant des VAC disposant de cette interface.
	Interacting with the system would not require a lot of mental effort.	Interagir avec cette interface ne me demanderait pas de beaucoup réfléchir.
	FAV can correctly detect pedestrians on streets.	Les VAC disposant de cette interface vont pouvoir détecter correctement les piétons dans les rues.
	I would feel more comfortable doing other things (e.g., checking emails on my smartphone, talking to my companions) while crossing the road in front of FAVs.	Je me sentirais serein·e si mon enfant, partenaire, parent, ou autre proche, traversait la route en présence de VAC disposant de cette interface.

Source	Original item	Translated item (FR)
meCUE adapted	It is quickly apparent how to use the product.	L'interface est facile à comprendre
	The operating procedures of the product are simple to understand.	On perçoit rapidement comment fonctionne l'interface
	The product is creatively designed.	L'interface est conçue de manière créative
	The product is stylish	L'interface est élégante
	I consider the product extremely useful.	Je considère cette interface comme extrêmement utile

	The functions of the product are exactly right for my goals.	A l'aide de cette interface, je peux traverser la route
/	/	Selon vous, comment pourrait-on améliorer cette interface ? (réponse optionnelle)[7]

Original item	Translation for this document
En général...	**In general...**
Parmi toutes les interfaces présentées, laquelle vous semble la plus compréhensible ?	Of all the interfaces presented, which one do you find the most understandable?
Pourquoi ? (réponse optionnelle)	Why or why not? (optional answer)
Parmi toutes les interfaces présentées, laquelle vous semble la plus sûre ?	Of all the interfaces presented, which one do you think is the most secure?
Pourquoi ? (réponse optionnelle)	Why or why not? (optional answer)
Quelle serait pour vous l'interface idéale (compréhensible et sûre) permettant à une voiture autonome sans conducteur de communiquer avec les piétons et tout autre usager de la route (vélos, trottinette…). Pourriez-vous nous la décrire : fonctionnement, type de messages, etc. (réponse optionnelle)	What would be for you the ideal interface (understandable and safe) allowing an autonomous driverless car to communicate with pedestrians and any other road user (bicycles, scooter...). Could you describe it to us: functioning, type of messages, etc.? (optional answer)

[7] How do you think this interface could be improved? (optional answer)

Original item	Translation for this document
En général...	In general...
Selon vous, chacune des propositions suivantes permettrait-elle aux piétons (ou tout autre usager de la route) de mieux comprendre le comportement des voitures autonomes sans conducteur ?	In your opinion, would each of the following proposals help pedestrians (or any other road users) to better understand the behaviour of autonomous driverless cars?
Une campagne de communication dans les médias (télévision, radio, journaux) de manière générale	A communication campaign in the media (TV, radio, newspapers) in general
Une campagne de communication officielle dans les médias (comme pour la prévention routière, par exemple)	An official communication campaign in the media (as for road safety, for example)
Une campagne de communication officielle par voie postale ou électronique (boîte mails)	An official communication campaign by post or electronically (mailbox)
Une formation à l'école pour les enfants de moins de 18 ans	Training at school for children under 18
Une formation pour le passage du permis	Training for the driving licence
Une formation libre et gratuite pour les adultes (par exemple stage dans une école de conduite)	Free training for adults (e.g. training in a driving school)
La possibilité de tester la "conduite" d'une VAC	The possibility to test drive a CAV
Autre ? (réponse optionnelle)	Other? (optional answer)

Original item	Translation for this document
Si le sujet des voitures autonomes sans conducteur vous intéresse, vous pouvez nous transmettre vos coordonnées afin de participer à de futurs ateliers ou expérimentations sur	If you are interested in the subject of autonomous driverless cars, you can send us your contact details to participate in future

les voitures autonomes sans conducteur.	workshops or experiments on autonomous driverless cars.
Acceptez-vous que nous vous recontactions pour participer à de futurs ateliers ou expérimentations sur les voitures autonomes sans conducteur ?	Do you agree to be contacted for future workshops or experiments on autonomous driverless cars?
Merci d'indiquer votre Nom de famille	Please enter your Last Name
Merci d'indiquer votre Prénom	Please enter your first name
Merci de nous indiquer votre adresse email pour que nous puissions vous contacter :	Please enter your email address so we can contact you:

PAsCAL

Enhance driver behaviour & Public Acceptance of Connected & Autonomous vehicles