CPS4EU

Cyber Physical Systems for Europe

D9.8 –WP9 SME Use Cases Requirements

Reviewers (name – company): Antoine RETAGGI (ARCURE), Ferenc ENDER (SPINSPLIT)

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D9.8 – WP 9 SME Use Case Requirements

Document Manager:	**Guillaume GIRAUD**		
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Prepared by:	Jean-Florent CROS (ACOEM), Wael CHAHROUR (AIRLANE), Ferenc ENDER (Spinsplit), Anis ZIADI (M3Systems), Antoine RETAGGI (ARCURE)
Approved by (WP Leader):	Guillaume GIRAUD
Reviewed by	Antoine RETAGGI (ARCURE) - Ferenc ENDER (SPINSPLIT)
Approved by (Coordinator):	Philippe GOUGEON et Antoine DUPRET

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Contributors

Name	Partner
Jean-Florent CROS	ACOEM
Wael CHAHROUR	AIRLANE
Antoine RETAGGI	ARCURE
Anis ZIADI	M3Systems
Guillaume GIRAUD	RTE
Ferenc ENDER	Spinsplit

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0 INTRODUCTION

0.1 PURPOSE

This document intends to provide a first, general description of WP9 SME Use Cases (12 to 16) to WP1-WP6 leaders/participants, so they can better understand the use cases main purposes and the environment where they will be implemented.

These use cases cover a very wide range of CPS in domains such as vehicles, chemical processing, smart cities or tools monitoring. This variety of applications provides a broad view of the needs to the WP1-4 component suppliers.

With these descriptions, more synergies between WP and partners may emerge, especially where common needs are identified.

0.2 SCOPE

The following document describes WP9 SME use cases of the WP9.

- UC 12 – ARCURE
- UC 13 - Spinsplit
- UC 14 - ACOEM
- UC 15 - M3Systems
- UC 16 – AIRLANE

0.3 LINK TO OTHER DOCUMENTS/TASKS

ID	Description
D3.1	D3.1- SW specification for AI methods for perception and detection
D3.2	D3.2- Specification and requirements of perception for localization
D4.1	D.4.1 - Specifications of collaborative mechanisms

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0.4 DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

Definition / acronym / abbreviation	Description
ADAS	advanced Driver Assistance Systems
BCM	ARM based board computer module
CAN	Controller Area Network
DC	Direct Current
GNSS	Global navigation satellite system
GSA	European GNSS Agency
I/Q	In-phase and quadrature components
IoT	Internet of Things
ITS	Intelligent Transport Systems
NoSQL	Not only Structured Query Language
PTZ	Pan Tilt Zoom
PVT	Position-Velocity-Time
RF	Radio Frequency
RMP	Reactor Main Panel
RTI DDS	Data Distribution Service implementation from RTI company
SCADA	Supervisory, Control And Data Acquisition
SERCOM	Serial communication service
SW	Software
TCRT	Thermal Characterisation Reference Test
TEH	Thermo-electric heat pump
USB	Universal Serial Bus
VMS	Video Management Software

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1 UC 12 - PEDESTRIAN DETECTION ON OFF-ROAD CONSTRUCTION TRUCKS BASED IN THE ARTIFICIAL INTELLIGENCE WITH THE VISION TECHNOLOGY [ARCURE]

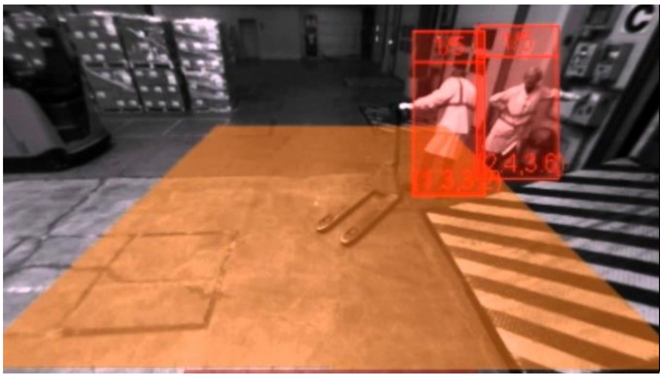
1.1 OVERALL DESCRIPTION

1.1.1 High level Use Case Description

The use case is about offering a solution for enhancing the autonomy of industrial machinery (Off-road construction trucks) by detecting the pedestrian around the vehicles.

For instance, Blaxtair is the only smart camera which is able to distinguish a person from another obstacle in real time and alert the operator with a visual and sound signal in case of danger. A control screen in the cabin allows the driver to judge the critical nature of the situation and then avoid an accident.

In CPS4EU, ARCURE aims to develop a Proof of Concept (PoC) of a vision based system in an embedded development platform hosting a **Deep Learning** algorithm for person detection in off-road vehicle application.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1.1.2 Main Features

The main features that will be developed and proposed to the customers of Blaxtair (a vision-based system that detect and classify pedestrian in off-road conditions) are:

- detect pedestrian with atypical position

Figure 1 - pedestrian with atypical position

- improve the range of pedestrian detection fitted to the need of the industrial market. The targeted range is from 0.3 meter to 15 meters.
- reach a high level of reliability necessary for autonomous machinery.

The user must be notified if the system is not working properly.

1.1.3 Limits

Training the algorithm needs a specific dataset of images in industrial context. This dataset has to be very large and diverse.

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1.2 REQUIREMENTS

This section contains Use Case requirements at a level of detail sufficient to enable CPS4EU designers to design components and pre-integrated architectures to satisfy those requirements, and testers to test that the system satisfies those requirements.

Throughout this section, every stated requirement will be externally perceivable by users, operators, or other external systems.

1.2.1 Functional Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Functional Requirement	UCE-FNC-01	Localization of the detected pedestrian	The detected pedestrian shall be localized in 2 dimensions (width and depth)	High	Client

Table 1 – UC1 Functional Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Functional Requirement	UCE-FNC-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW

Table 2 – UC1 Functional Requirements interrelations with Modules & Pre-integrated Architectures

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1.2.2 Interface Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Interface Requirement	UCE-INT-01	Power Supply 12/24 DC	The power supply has to be 12/24V DC	High	Client
Interface Requirement	UCE-INT-02	CAN interface	The system has to embed a CAN interface	Medium	Client
Interface Requirement	UCE-INT-03	USB 3.0 interface	The system has to embed a USB 3.0 interface	High	Internal
Interface Requirement	UCE-INT-04	3 discrete outputs	The system has to embed 3 discrete outputs	High	Internal

Table 3 – UC1 Interface Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Interface Requirement	UCE-INT-01	Power Supply 12/24 V DC	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Interface Requirement	UCE-INT-02	CAN interface	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Interface Requirement	UCE-INT-03	USB 3.0 interface	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Interface Requirement	UCE-INT-04	3 discrete outputs	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW

Table 4 – UC1 Interface Requirements interrelations with Modules & Pre-integrated Architectures

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1.2.3 Performance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Performance Requirement	UCE-PRF-01	Processing performance > 550 TOPS	The processing performance has to be at least 550 TOPS	High	Internal
Performance Requirement	UCE-PRF-02	Detection rate > 99,99%	The detection has to be at least 99,99%	High	Client
Performance Requirement	UCE-PRF-03	Detect pedestrians with atypical positions	It shall be possible to detect the pedestrian in whatever position they are (laid down, squatting, sideways, sitted…)	High	Client
Performance Requirement	UCE-PRF-04	Detect pedestrians from 0,3m to 15m	Pedestrian shall be detected from 0,3m to 15m in depth (from the camera)	High	Client
Performance Requirement	UCE-PRF-05	Start time < 20s	The system must start in less than 20s	High	Internal
Performance Requirement	UCE-PRF-06	Detection latency < 200ms	The system must detect and alert the user in less than 200ms	High	Standard

Table 5 – UC1 Performance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Performance Requirement	UCE-PRF-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Nvidia Jetson TX2
Performance Requirement	UCE-PRF-02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW
Performance Requirement	UCE-PRF-03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW
Performance Requirement	UCE-PRF-04	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW
Performance Requirement	UCE-PRF-05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW
Performance Requirement	UCE-PRF-06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW

Table 6 – UC1 Performance Requirements interrelations with Modules & Pre-integrated Architectures

1.2.4 Security Requirements

N/a

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1.2.5 Operational Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Operational Requirement	UCE-OPR-01	Hardware temperature range: -25°C +65°C	The system must be operationnal in the following temperature range: -25°C +65°C	High	Client
Operational Requirement	UCE-OPR-02	Hardware protection: minimum IP67	The minimum protection rate must be IP67	High	Client
Operational Requirement	UCE-OPR-03	Usage in various light conditions	The system has to work properly in various light conditions	High	Client
Operational Requirement	UCE-OPR-04	Power consumption < 15 W	The power consuption shall be less than 15W	High	Internal
Operational Requirement	UCE-OPR-05	Autotest	The system shall detect all internal failures and it has to warn the user if the detection is not working properly	Medium	Internal

Table 7 – UC1 Operational Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Operational Requirement	UCE-OPR-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Operational Requirement	UCE-OPR-02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Operational Requirement	UCE-OPR-03	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	COTS Camera + Arcure HW and housing
Operational Requirement	UCE-OPR-04	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW
Operational Requirement	UCE-OPR-05	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW and SW

Table 8 – UC1 Operational Requirements interrelations with Modules & Pre-integrated Architectures

1.2.6 Usability Requirements

N/a

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1.2.7 Policies & Compliance Requirements

N/a

1.2.8 Design Constraints

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Design Constraints	UCE-DSG-01	Modular SW architecture	The Software architecture has to be modular in order to implement easily new functionalities	Medium	Internal
Design Constraints	UCE-DSG-02	Weight of the Processing Unit < 2kg	The total weight of the Processing Unit shall be less than 2kg	Medium	Internal

Table 9 – UC1 Design Constraints Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Design Constraints	UCE-DSG-01	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure SW
Design Constraints	UCE-DSG-02	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Arcure HW

Table 10 – UC1 Design Constraints Requirements interrelations with Modules & Pre-integrated Architectures

1.2.9 Ethical Requirements

N/a

1.2.10 Other Requirements

N/a

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2 UC 13 - CPS BASED FLOW CHEMISTRY MODULES WITH PREDICTIVE MAINTENANCE TECHNOLOGIES FOR PHARMA 4.0 [SPINSPLIT]

2.1 OVERALL DESCRIPTION

2.1.1 High level Use Case Description

Flow chemistry is a method to carry out chemical reactions under well controlled conditions in small volume reactors. The reactors are fed with a constant stream of reagent supply and product(s) are drained from the reactor as a result of the reaction carried out inside. Comparing to more traditional batch reactors where the reaction kinetics scales typically strongly non-linearly with size, flow reactors are easier to scale as the product throughput depends primarily on the operation time and/or the number of operational reaction units.

Figure 2a shows the overview of the demonstrational flow chemistry system with three operational units and corresponding functions:

- **Pump module**, is responsible for taking in the reagents and dispensing them with defined flow rates and volumes
- **Thermostat module**, that incorporates the flow reactor and maintains its temperature. The temperature is defined by the chemical reaction recipe. The reaction results in a liquid solution that is transferred to the third module
- **Electrospinner module**, that is responsible for the formulation of the product, i.e. transforms the liquid solution into a dry, nanofiber layer, as a drug carrier media.

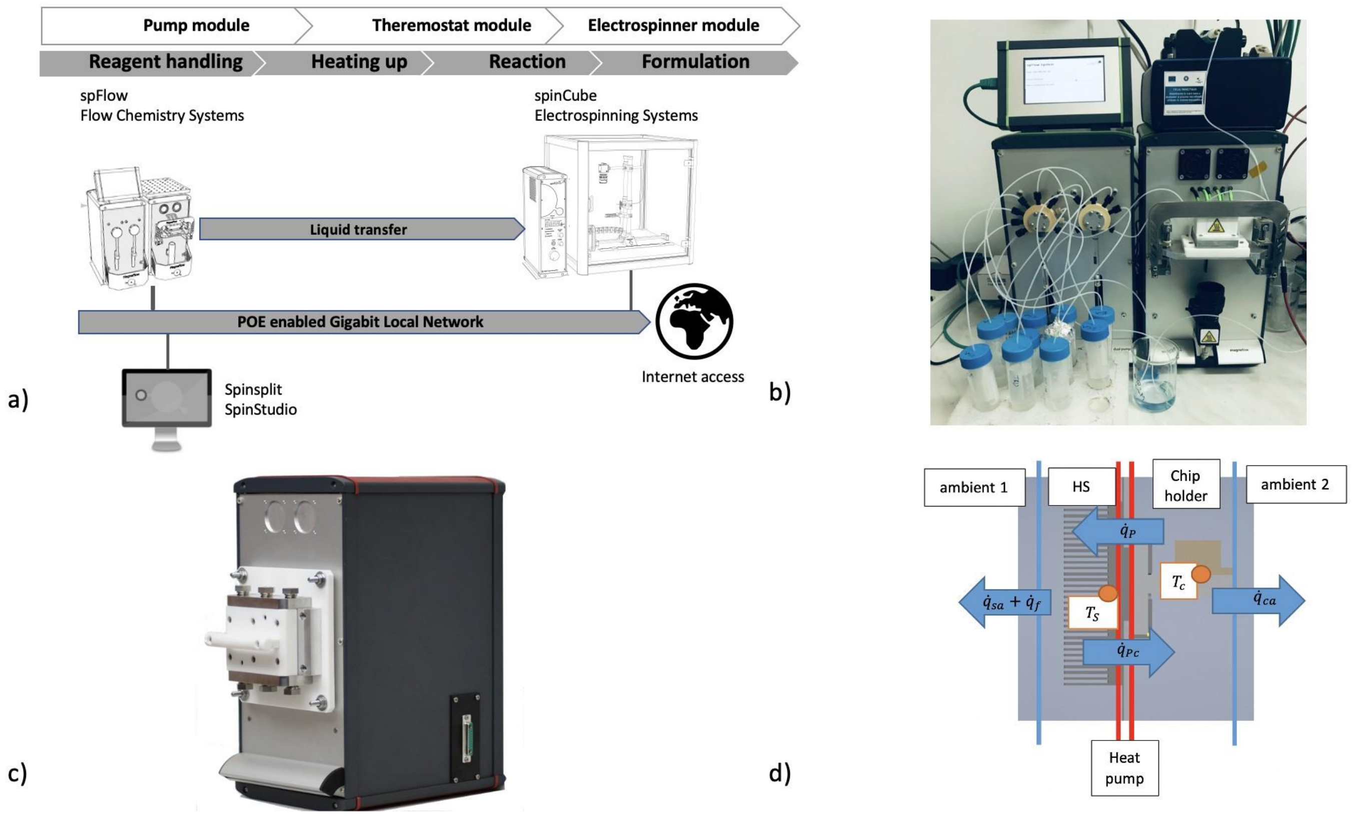

Figure 2 Overview of the Case Study a) Network configuration of the system modules b) Deployed flow chemistry module in operation c) Thermostat module d) Heat flow paths of the thermostat module

The operational units of the flow chemistry system are connected to the local network infrastructure, and operated by an orchestrator service called SpinStudio. The chemical process is conducted based on a recipe called *session*, which is a set of *tasks*. The tasks are executed sequentially by the prescribed iteration number.

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Figure 2b shows an example of an actual deployed Spinsplit flow chemistry system in operation. Figure 2c shows a single thermostat module with a reactor assembled on its front panel. The thermostat is a thermo-electric heat pump (TEH), with one side facing inside the chassis and is equipped with forced convection heat sink. The working side of the TEH is facing outwards, providing a thermal interface for the reactor assembly. Therefore, the operator can change the reactor according to the actual reaction type. Figure 2d shows the heat flow paths of the assembled TEH. During the *session* the reactor may be subjected to heavy thermal fluctuation. This thermal stress affects the performance of the thermal interface, as well as the q_{pc} heat flow between the TEH and the reactor.

Our ambition is to demonstrate a method to monitor the quality of this thermal interface and, therefore, to predict future maintenance.

2.1.2 Main Features

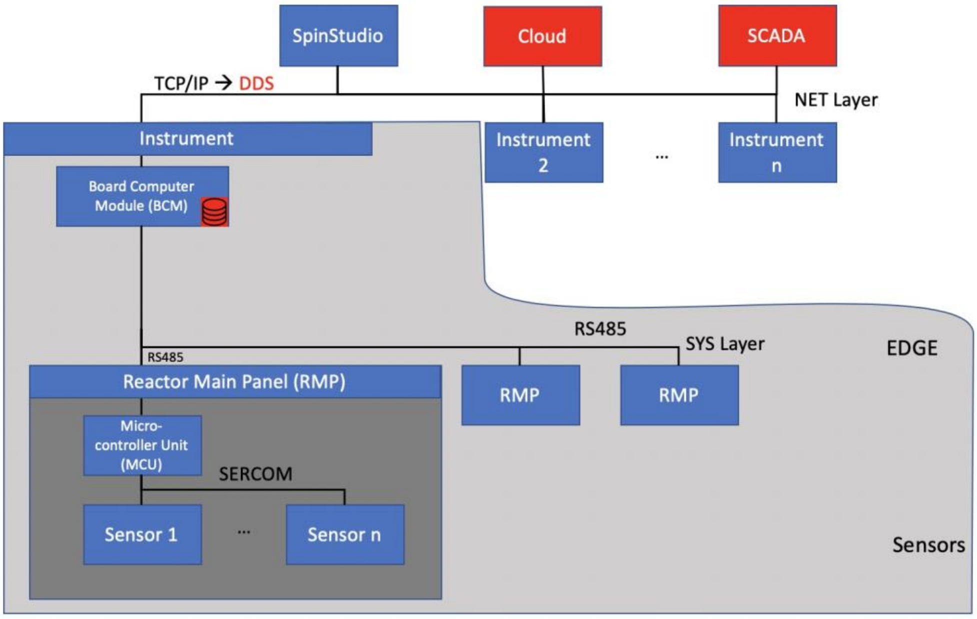

Figure 3 - The infrastructure of Spinsplit IoT

Figure 3 shows the basic infrastructure of Spinsplit IoT, serving as the basis of the implementation. Each *instrument* of the chemical flow process is connected to the local network. Each *instrument* features an ARM based board computer module (BCM) running Linux. Within the *instrument*, modules are communicating through a serial system bus. Each module is controlled by a Reactor Main Panel (RMP), which handles the real time operations and base level communication with sensors/actuators using a serial communication service (SERCOM). A high level orchestrator of the *instrument's* operation is Spinstudio, a software framework for commanding instruments. Spinstudio is featuring also connectivity to cloud services and to SCADA systems.

Figure 4 introduces the proposed operation of the demonstrator. *Reactor assembly* is done by the operator. Following this, a *Thermal Characterisation Reference Test (TCRT)* is performed to determine the thermal characteristics of the assembled reactor. The test method is defined by CPS4EU partner BME. This reference test results are stored in a thermal model database (*Model data*).

Followed by the reference test, the sequence of the chemical flow reaction is initiated (*Start session*). Except from the first iteration, a *Thermal Characterisation Control Test (CTCT)* is performed. Based on the previously assembled *Model data* and the actual measurement data, the quality of the TEH thermal interface is quantified (*Evaluate test model*). If no significant degradation is predicted until the end of the *session*, the system is engaged to perform the next iteration of the chemical reaction. In case of the significant degradation of the TEH thermal interface was detected, the user (operator) is prompted to decide whether the experiment is halted or continued.

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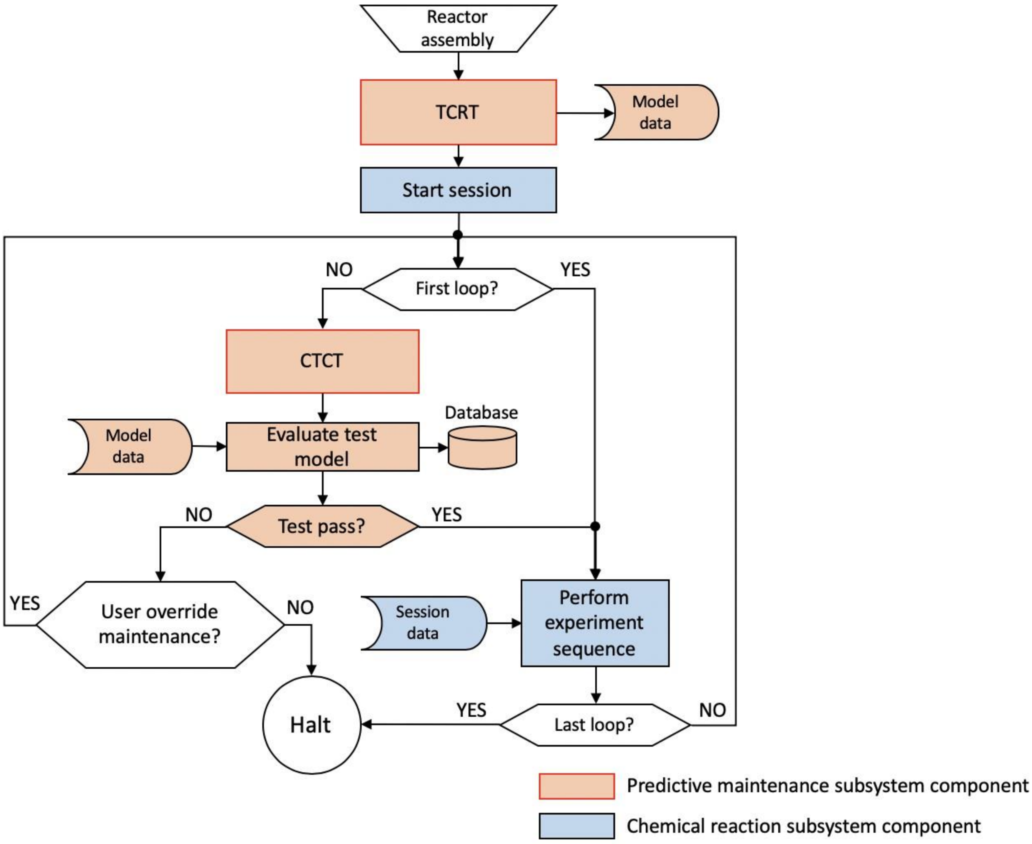

Figure 4 Simplified flowchart of the predictive maintenance process

2.1.3 Limits

Corporate or regulatory policies	Spinsplit products must comply CE regulations
Hardware limitations (timing requirements, memory requirements)	BCM module has 4GB internal memory.
Interfaces to other applications	In the case study Spinsplit's own measurement control software SpinStudio will be used
Specific technologies, tools, and databases to be used	To temporarily store the data in the BCM a nonSQL database will be used
Communications protocols	RTI DDS communication platform will be used for data streaming

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2.2 REQUIREMENTS

This section contains Use Case requirements at a level of detail sufficient to enable CPS4EU designers to design components and pre-integrated architectures to satisfy those requirements, and testers to test that the system satisfies those requirements.

Throughout this section, every stated requirement will be externally perceivable by users, operators, or other external systems.

2.2.1 Functional Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Functional Requirement	**UC13-FNC-01**	Interchangeable reactors	The operator can mount various interchangeable reactors onto the thermostat module	High	Use case
Functional Requirement	**UC13-FNC-02**	Modulated reactor temperature	The reactor temperature is modulated through the TEH according to the chemical reaction recipe	High	Use case
Functional Requirement	**UC13-FNC-03**	Minimal measure	At minimum internal temperature of the TEH and the reactor temperature should be measured	High	Use case
Functional Requirement	**UC13-FNC-04**	Temperature acquisition	The temperature values are acquired periodically with at least 1 sec sampling period	High	Use case
Functional Requirement	**UC13-FNC-05**	Temperature storage	Temperature values with time stamp are logged and stored in a local database by the BCM	Medium	Use case
Functional Requirement	**UC13-FNC-06**	Data transmission	Temperature log database/data stream can be transmitted through the local network	High	Use case
Functional Requirement	**UC13-FNC-07**	RTCT trigger	Reference Thermal Characterisation Test (RTCT) can be triggered from the controller software	High	Use case
Functional Requirement	**UC13-FNC-08**	RTCT SpinStudio task	RTCT can be defined as a task of a SpinStudio session	Medium	Use case
Functional Requirement	**UC13-FNC-09**	CTCT trigger	Control Thermal Characterisation Test (CTCT) can be triggered from the controller software	High	Use case
Functional Requirement	**UC13-FNC-10**	CTCT SpinStudio task	CTCT can be defined as a task of a SpinStudio session	High	Use case
Functional Requirement	**UC13-FNC-11**	RTCT storage	RTCT measurement data and model are stored at the controller desktop computer	High	Use case
Functional Requirement	**UC13-FNC-12**	Changes monitoring	Monitoring changes in the thermal performance of the interface between TEH and the reactor module	High	Use case

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Functional Requirement	**UC13-FNC-13**	Predictive maintenance	Predictive maintenance based on historical and actual health of the thermal interface layer	High	Use case
Functional Requirement	**UC13-FNC-14**	Session halt	User is prompted to halt the session for maintenance, followed by an emergency protocol or to continue the last experiment The user interface is implemented in SpinStudio software	High	Use case

Table 11 – UC13 Functional Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Functional Requirement	**UC13-FNC-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-02**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-03**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-04**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-05**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-06**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-07**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-08**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-09**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-10**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-11**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-12**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UC13-FNC-13**	n/a	n/a	n/a	n/a	n/a	n/a	BME Thermal Analysis algorithms	n/a	n/a	

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Functional Requirement	**UC13-FNC-14**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 12 – UC13 Functional Requirements interrelations with Modules & Pre-integrated Architectures

2.2.2 Interface Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Interface Requirement	**UC13-INT-01**	The thermal interface between the reactor and TEH is defined	The thermal interface is a 8x12 cm flat stainless steel surface with appropriate thermal interface material (TIM) deposited on the surface. The temperature of the interface ranges from 0 to 110°C and 0 to 100W heat pumping power.	High	Use case
Interface Requirement	**UC13-INT-02**	The applied thermostat controller can handle 3 external temperature sensor inputs plus the chassis internal temperature		High	Use case
Interface Requirement	**UC13-INT-03**	Data streaming from the edge devices is based on RTI-DDS platform	This is to preserve compatibility with other Spinsplit products	High	SpinSplit standards
Interface Requirement	**UC13-INT-04**	The BCM module is connected to the local network via 10/100 LAN	This is to preserve compatibility with other Spinsplit products	High	SpinSplit standards
Interface Requirement	**UC13-INT-05**	The thermostat controller uses RS232 interface @115200 bps	This is to preserve compatibility with other Spinsplit products	High	SpinSplit standards
Interface Requirement	**UC13-INT-06**	RTCT or CTCT database stored in BCM is transmitted through FTP		High	Use case
Interface Requirement	**UC13-INT-07**	RTCT or CTCT database stored in BCM is transmitted through database services		Medium	Use case

Table 13 – UC13 Interface Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Interface Requirement	**UC13-INT-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UC13-INT-02**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UC13-INT-03**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	RTI DDS
Interface Requirement	**UC13-INT-04**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UC13-INT-05**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UC13-INT-06**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UC13-INT-07**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 14 – UC13 Interface Requirements interrelations with Modules & Pre-integrated Architectures

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

2.2.3 Performance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Performance Requirement	**UCE-PRF-01**	CTCT measurement duration	CTCT measurement should not take longer than 60 minutes	Medium	Use case
Performance Requirement	**UCE-PRF-02**	Temperature measurement accuracy	Temperature measurement accuracy is at least +/-1°C with in the full operating range	Medium	Use case

Table 15 – UC13 Performance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Performance Requirement	**UCE-PRF-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Performance Requirement	**UCE-PRF-02**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 16 – UC1 Performance Requirements interrelations with Modules & Pre-integrated Architectures

2.2.4 Security Requirements

N/a

2.2.5 Operational Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Operational Requirement	**UCE-OPR-01**	RTCT must precede CTCT		High	Use case

Table 17 – UC1 Operational Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Operational Requirement	**UCE-OPR-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 18 – UC1 Operational Requirements interrelations with Modules & Pre-integrated Architectures

2.2.6 Usability Requirements

N/a

2.2.7 Policies & Compliance Requirements

N/a

2.2.8 Design Constraints

N/a

2.2.9 Ethical Requirements

N/a

2.2.10 Other Requirements

N/a

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

3 UC 14 - MONITORING NETWORK FOR ENVIRONMENT QUALITY (WELL-BEING) AND THREAT DETECTION IN ONE BIG EUROPEAN CITY [ACOEM]

3.1 OVERALL DESCRIPTION

3.1.1 High level Use Case Description

The objective is to deploy in several European cities different projects based on small and communicant sensors developed in WP3 with collaborative interaction developed in WP4.

The purpose of the sensors are really different depending of the use cases, from providing a well-being index to the population to the safety aspect on the city. The **three main applications** developed on this project are :

1. Cartographies of global Environment Quality Index
2. Geo-localized threats alerts : Gun Shot Detection System
3. Detection, identification, localisation of noisy vehicles: Noise Radar

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

3.1.2 Main Features

3.1.2.1 Environmental Quality Index map

Currently, environmental measurements in the city, as air quality, are performed by metrological stations. Due to the price of each station, only a few were installed in each cities. For example there are 6 PM10 (particle size smaller than 10µm) measurements stations in Paris city. With this spaced mesh it is impossible to provide local information for the citizen about the pollutant and to explain their origin. However the pollutant rate can be very different from one street to another due to local construction site, bus station, traffic jam…

The purpose of this project is to develop environmental pod to measure different pollutants (NO, NO_2, O_3, CO, CO_2, PM1, PM2.5, PM10, noise, EMC…). The main feature is to provide accurate local pollutant measurement and an Environmental Quality Index easy to understand for everyone.

The pod is designed for the SmartCity market, it should be easy to install in a city (low energy, long range communication, light), accurate and cost effective.

With specific data analysis on the measurement performed by the pod network in the same city, it should be possible to increase the accuracy of each pod and understand the origin of the pollution. It is the key point of this part of the project: provide accurate and local measurement with a cost effective network of pod.

To develop these specific data analysis ACOEM will install a pod network in a selected big European city.

Figure 6- Photo of the Environmental PODs used to collect data

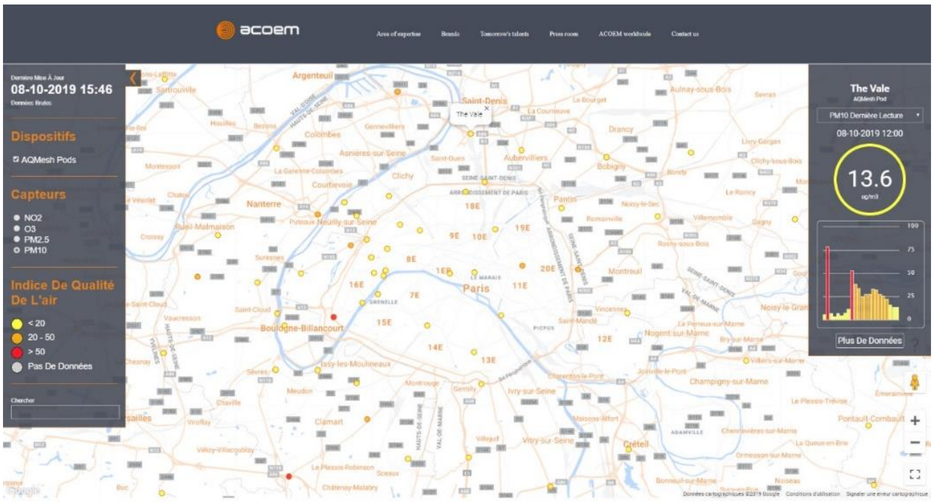

Figure 5 - Example of Environmental Quality Index map

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

3.1.2.2 Gunshot Detection System

The second part of the project is a Gunshot Detection System based on acoustic method. The purpose of this project is to develop POD able to detect, identify and localize threat in city, transportation network, industries, stadiums…

Figure 8- First version of the Gunshot Detection Pod composed of a 4 microphones antenna

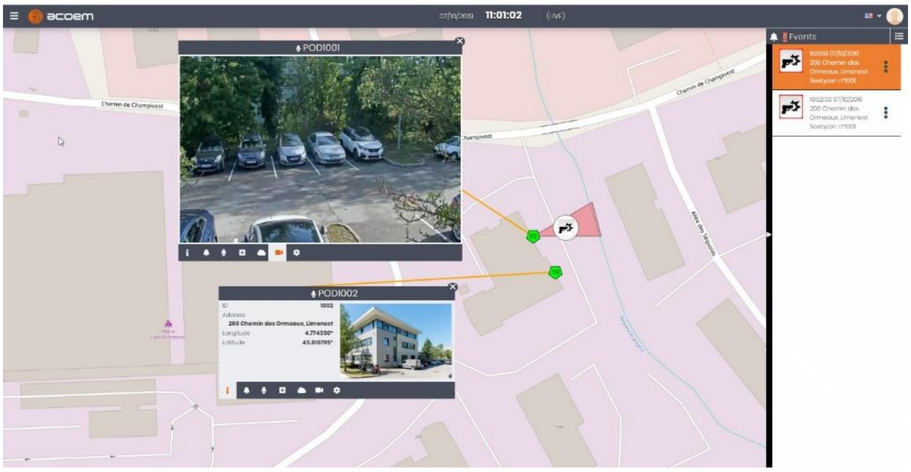

Figure 7 - Example of Gun Shot Detection System

Based on AI integrated on the POD, the system detects in real time an abnormal situation, identifies the gunshot and provides the azimuth/elevation of the sound origin.

The detection of an abnormal situation is based on an algorithm that analyses in real time the audio signal to detect high level and impulsive noise.

When an abnormal noise is detected, a large number of parameters is computed based on the audio signal. All these parameters are the inputs of a neuronal network specially trained to identify a gunshot. This neuronal network can make the difference between a firecracker, a nozzle gunshot noise and a supersonic bullet noise. To train this neuronal network an ACOEM gunshot database was used from our defence product experience. During the project ACOEM also performs specific shooting tests with real gunshot to collect data and test the system.

The last part of the process is the localisation of the shooter. The localisation process methodology is linked to the distance of the shooter, the type of the gun used, the direction of the bullet:

1. Short distance gunshot (less than 150m between pod and shooter) with no supersonic bullet noise recorded by the pod (because the bullet is not supersonic or because the gunshot is not on the pod direction) ➔ The pod analyses the nozzle noise recorded by the 4 microphones antenna. With a specific algorithm integrated on the pod, the pod computes the azimuth and elevation of the shooter
2. Short distance gunshot (less than 150m between pod and shooter) with supersonic bullet noise recorded by the pod (because the bullet is supersonic and the gunshot is on the pod direction) ➔ The pod analyses the nozzle noise and the supersonic bullet noise recorded by the 4 microphones antenna. With specific algorithms integrated in the pod and fusion process between the two types of information, the pod computes the azimuth, elevation and distance of the shooter
3. Long distance gunshot with only supersonic bullet noise recorded by the several pods (no nozzle noise) ➔In this case, no localisation information could be computed with only one pod. The computed information is sent to a server. A specific fusion algorithm merges data coming from several pods to localise the shooter position.

A key point for this application is the threat identification reliability. The number of false alarms needs to be very low in order to avoid any disconnection of the system by the end user. To reduce the number of errors, a training period is necessary. During the training period all the abnormal situations are recorded and after manual identification added to our database to improve the neuron-network.

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To avoid personal data recording, we limit the duration of a noise record to 1.5s. A minimum delay of three seconds is necessary between two noises. With this method it is impossible to record more than 33% of any conversation.

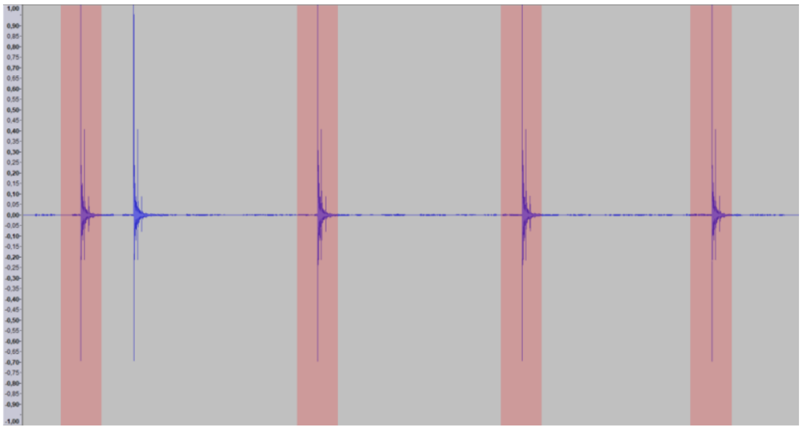

Figure 9- Example of a 5 gunshots noise signal, the red parts are the 4 records done by the system during the training period. The 2 firsts gunshots are spaced by 2s therefore the second gunshot is not recorded

Based on this pods capability 2 main use cases were imagined: integrated to a CCTV network or for temporary events.

*3.1.2.2.1 Gunshot detection system **integrated to a CCTV network***

In this use case, the customer manages a large CCTV network (from hundred to more than 10 thousand cameras) with few operators to control all the videos. The Gunshot Detection System helps the operator to focus on the threat in real time and provides appropriate actions to manage the threat. By moving automatically the PTZ camera on the threat the Gunshot Detection System increases the efficiency of the CCTV network with the record of interesting information for further investigation.

In this use case the pods are collocated with CCTV camera and they use the CCTV network for power supply (POE) and communication (private wired IP network)

The main purposes of the system are:

- Detection, identification and localisation of the threat in less than 3 seconds,
- Increase efficiency of a CCTV network to focus the CCTV camera and operators on the threat.

The typical customers are City council, Police department, Transportation operator, Sensitive industrials, Parking operator, Stadium operator…

The pod will be installed outside or inside (Concert hall entrance, subway station…) collocated with the CCTV camera. They will be mounted on a plan wall, an existing mast, a wall corner, the top of a building or on the ceiling.

Figure 10- Example of CCTV installation

The sensor will be installed in a public place, the safety aspect has to be taking into account (for example avoid sensor drop due to wind).

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The Gun Shot Detection system integrated to a CCTV network goes through the following main phases:

1. A threat happens in the city
2. The pods close to the event detect, identify and localize the threat (2 pods detect the event in this example)
3. An alarm is sent by the pods to the ACOEM server with Threat type, Azimuth and Elevation (→)
4. The ACOEM server logs the threat and acoustic signal of the threat. If several pod localize the threat then the server computes the coordinate of the threat (Data Fusion)
5. The ACOEM server sends to the VMS (→) the type of threat and:
    a. the Azimuth/Elevation for each camera collocated with the pod (if no data fusion)
    b. the GPS coordinates of the threat (if data fusion)
6. The VMS moves the PTZ camera to the right direction and show the video on the control room main screen with threat description (→)

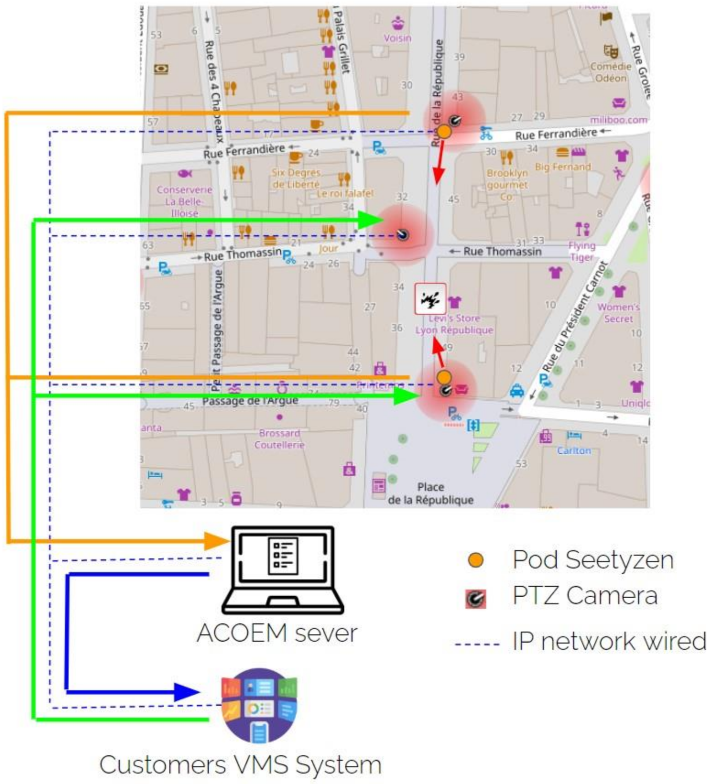

Figure 11 - Gun Shot Detection system integrated to a CCTV

*3.1.2.2.2 Gunshot detection **for temporary events***

In this use case, the customer needs to protect a specified area during a temporary event as a fan zone, meeting, sport event, festival… During this kind of event there are few or no CCTV camera, but a private security company is used to secure the location.

The customer uses the Gunshot Detection System to improve the efficiency of the dedicated security service.

In case of threat, the system identifies and localizes the danger, which helps the security company to provide the appropriate action to manage the threat.

The pods have to be easy to install, should communicate with M2M wireless network and be powered by external batteries or solar panels.

The main purposes of the system are:

- Detection, identification and localisation of the threat in less than 15 seconds,
- Increase efficiency of a security service.

The typical customers are private security company, city council, police department,…

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The sensor will be installed outside (Fan zone entrance, around the fan zone, close to the stage…) or inside (building entrance...). They will be mounted on a plan wall, an existing mast, a temporary mast, the top of a building, …

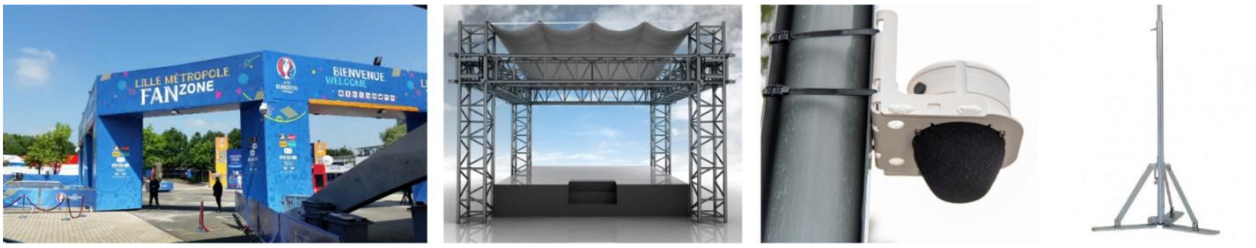

Figure 12 - Example of temporary events installation

The sensor will be installed in a public place, the safety aspect has to be taking into account (for example avoid sensor drop due to wind).

Figure 13 - Gun Shot Detection system for temporary events

The Gun Shot Detection system for temporary events goes through the following main phases:

1. A threat happens in the fan zone or around
2. The pods close to the event detect, identify and localize the threat (3 pods detect the event on this example)
3. An alarm is sent by the pods to the ACOEM cloud server with Threat type, Azimuth and Elevation
4. The ACOEM cloud server logs the threat and acoustic signal of the threat. Then the server with all the information coming from the different pods and the field computes the coordinate of the threat
5. The ACOEM cloud server linked to a mobile application sends an alarm on field
   a. To the security manager who manages the appropriate response,
   b. To the closest security agent on the field.

For this application, the pods and the global system need to have several improvements in comparison to the CCTV use case:

- Decreased power consumption,
- M2M communication,
- GPS for localisation and time synchronisation,
- Server in the cloud,
- Mobile application to have field notification.

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3.1.2.2.3 Noise Radar

In cities and suburbs, vehicles are the main source of disturbance at home (e.g.: CRDOC survey performed for BRUITPARIF in 2016), and mainly the two-wheeled vehicles.

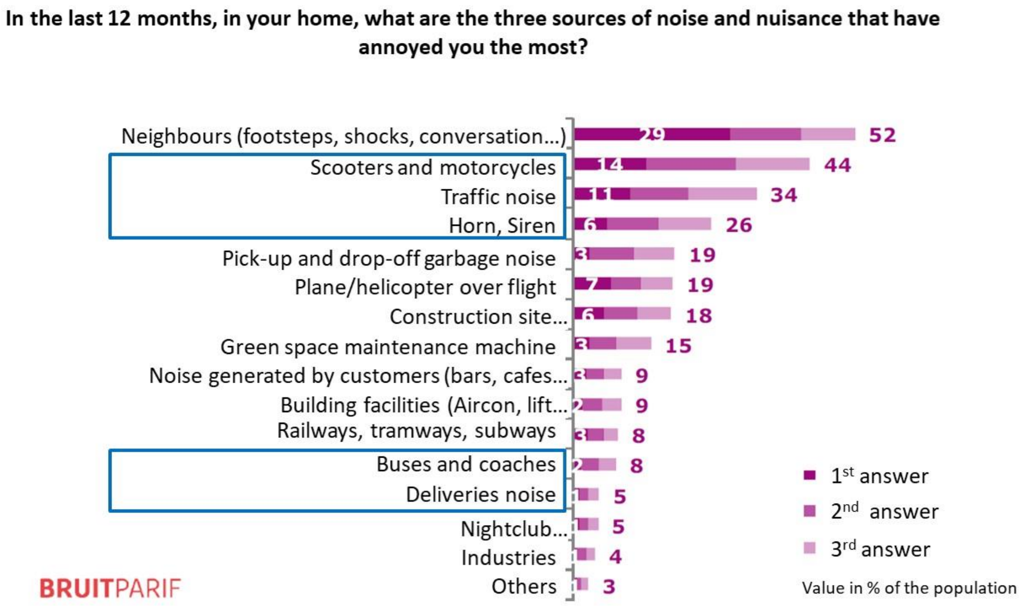

Figure 14- Survey conducted by CREDOC for BRUIPARIF in 2016

In Europe, the standard ISO 5130 describes the method to control the vehicle noise. To perform this control a Class 1 sound level meter is needed. The vehicle has to be controlled in stationary position with a microphone close to the exhaust pipe and with a regulation of the engine speed.

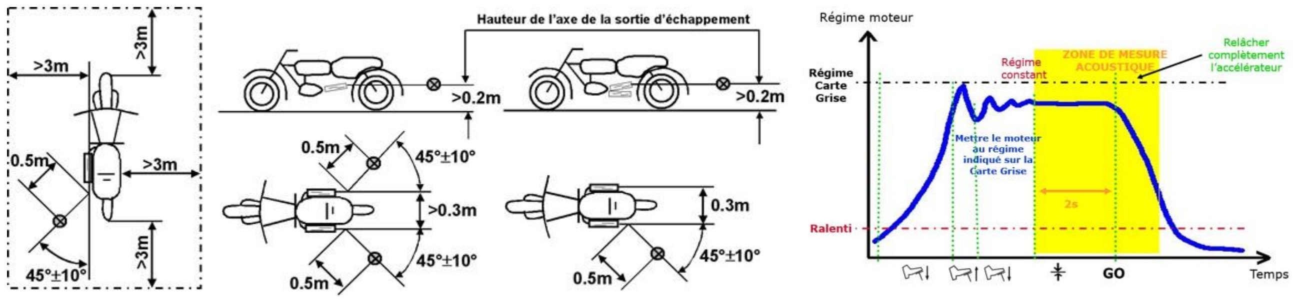

Figure 15 - ISO 5130 Measurements of sound pressure level emitted by stationary road vehicle - Extract

This methodology is complex and needs trained police officers. Based on this standard, it is not possible to perform a lot of controls, neither a 24/7 survey of an area.

To reduce the noise disturbance coming from the vehicle, government and cities are looking for new method to control the vehicle noise automatically in the traffic.

To address this need, ACOEM develops a global system composed of:

- Pod to identify and localize the main noise source,
- Class 1 sound level meter for metrological noise measurement,
- Camera with Licence Plate Recognition capability,
- Server to merge all the data,
- Communication system to send information to the authority.

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The pod has the same hardware than the Gunshot detection system (Figure 8- First version of the Gunshot Detection Pod composed of a 4 microphones antenna) with specific software and neuronal network to identify vehicle noise and localize the origin (Azimuth, Elevation) of the main noise source during the time.

When the sound pressure level is over a threshold, the sensor will identify the type of noise and if it is coming from the environment or from a vehicle. This identification is performed with specific neuronal network trained on vehicle noise data base.

Based on the 4 microphones signal, the pod is able to compute azimuth and elevation over the time to have a precise localisation of the vehicle.

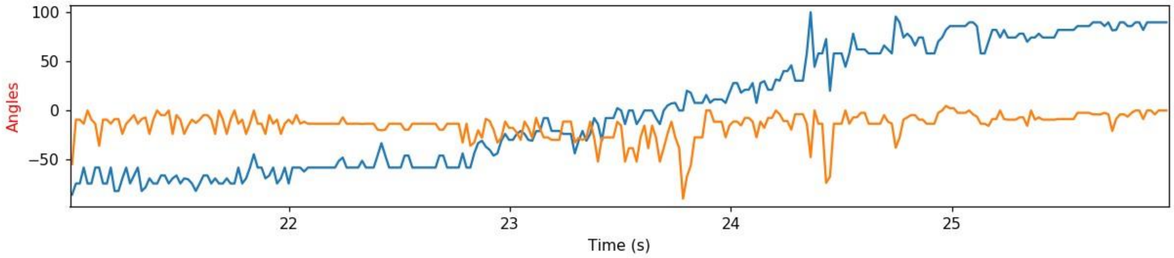

Figure 16 - Azimuth (blue curve) and Elevation (orange curve) over the time of a vehicle driving in front of the sensor

Because the noise measurement must be indisputable from a metrological point of view, the maximum noise pressure level is measured by a class 1 sound level meter manufactured by ACOEM and located close to the pod. This maximum noise level is adjusted with the correction factor due to the environmental parameters (temperature, atmospheric pressure, distance…).

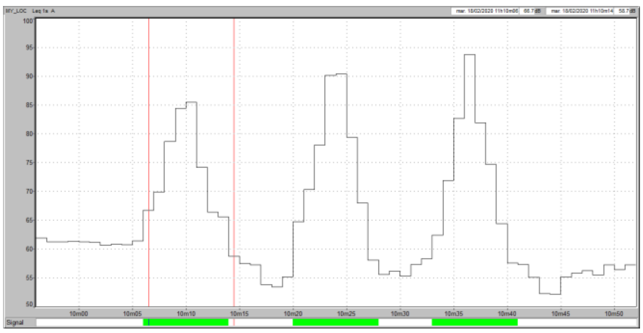

Figure 17 - Time history of the sound pressure level measured by the sound level meter, the 3 maximum levels were measured when motorcycle drove in front of the sensor

When the vehicle is driving in front of the system, the camera records a video and identifies the licence plate automatically.

All the data is merged in a local server to have on a same document the metrological maximum noise level of the vehicle, a picture of the vehicle with the location of the maximum noise level. All the data is securely transferred from the local server to the authority.

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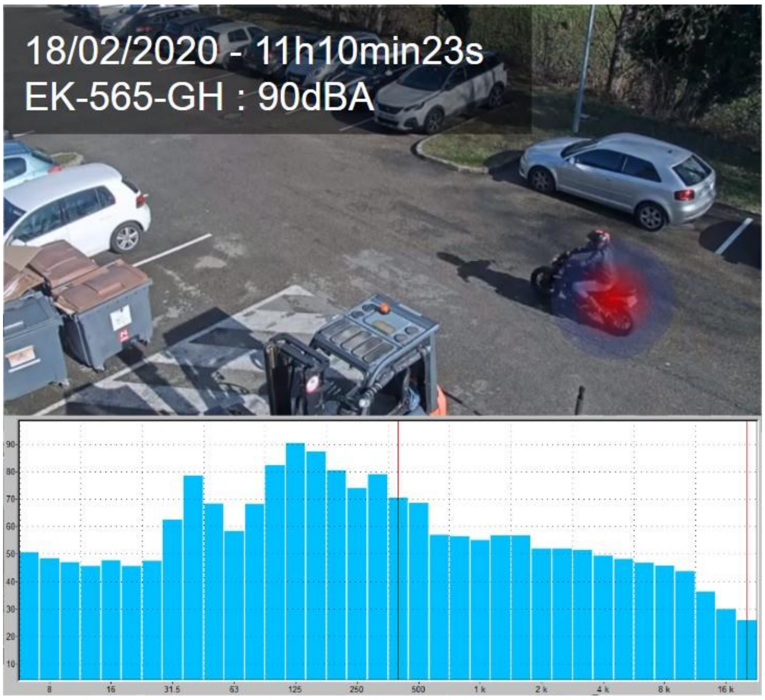

Figure 18 - Example of noise report

3.1.3 Limits

For the Environmental Quality index[1], the experiment on a big European city will help ACOEM to validate a business model for the data. The maintenance cost and the life time expectancy of the sensor should be taken into account to validate the economical part. The other limitation will be the accuracy of the sensitive part. ACOEM need to collect data to develop the measurement correction algorithm.

A key point for the Gunshot detection system is the number of false alarms and the reliability of the system. If the systems have too many false alarms, at the end the operator will switch down all the system. To reduce the number of false alarms, tagged noise data is a mandatory to train the AI. The experimentation will be a way to build up our database, but ACOEM have to collect them in accordance with the European GDPR .

About the Noise radar system, the main limitation will be an evolution of the legislation to change the standard way to control the vehicle noise. Because the system has to be automatic from the measurement to the penalty, all the measurement uncertainties has to be evaluated and the error coming from the environment has to be corrected (temperature variation, pressure variation, reflexion…).

[1] *European Air Quality Index ,see* https:/www.eea.europa.eu/themes/air/air-quality-index/index

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

3.2 REQUIREMENTS

This section contains Use Case requirements at a level of detail sufficient to enable CPS4EU designers to design components and pre-integrated architectures to satisfy those requirements, and testers to test that the system satisfies those requirements.

Throughout this section, every stated requirement will be externally perceivable by users, operators, or other external systems.

This section will be completed in a next version of the deliverable

3.2.1 Functional Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 19 – UC1 Functional Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 20 – UC1 Functional Requirements interrelations with Modules & Pre-integrated Architectures

3.2.2 Interface Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 21 – UC1 Interface Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 22 – UC1 Interface Requirements interrelations with Modules & Pre-integrated Architectures

3.2.3 Performance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 23 – UC1 Performance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 24 – UC1 Performance Requirements interrelations with Modules & Pre-integrated Architectures

3.2.4 Security Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 25 – UC1 Security Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 26 – UC1 Security Requirements interrelations with Modules & Pre-integrated Architectures

3.2.5 Operational Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 27 – UC1 Operational Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 28 – UC1 Operational Requirements interrelations with Modules & Pre-integrated Architectures

3.2.6 Usability Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 29 – UC1 Usability Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 30 – UC1 Usability Requirements interrelations with Modules & Pre-integrated Architectures

3.2.7 Policies & Compliance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 31 – UC1 Policies & Compliance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 32 – UC1 Policies & Compliance Requirements interrelations with Modules & Pre-integrated Architectures

3.2.8 Design Constraints

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

Table 33 – UC1 Design Constraints Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 34 – UC1 Design Constraints Requirements interrelations with Modules & Pre-integrated Architectures

3.2.9 Ethical Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 35 – UC1 Ethical Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 36 – UC1 Ethical Requirements interrelations with Modules & Pre-integrated Architectures

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

3.2.10 Other Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 37 – UC1 Other Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 38 – UC1 Other Requirements interrelations with Modules & Pre-integrated Architecture

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4 UC 15 - OPEN LOOP TESTBENCH ALLOWING THE VALIDATION OF THE DEVELOPED SENSOR FOR AUTOMATED DRIVING APPLICATIONS [M3S]

4.1 OVERALL DESCRIPTION

4.1.1 High level Use Case Description

The applications of geo-positioning are undergoing exponential development. Intelligent Transport Systems (ITS), mainly in the Road domain, is one of the two major fields of application as shown in the latest market analysis for the GNSS systems published by GSA (https://www.gsa.europa.eu/market/market-report).
Some Road ITS systems, such as:

- autonomous driving
- and advanced Driver Assistance Systems (ADAS),

are “safety critical”, since their failure may cause human death or injury.
Others, such as:

- GNSS-based Road User Charging systems,
- Regulated freight transport systems (hazardous substances, livestock, etc.),
- “Pay-as-you-drive” insurance,

are “liability critical”, because they include financial or regulatory aspects.
For those systems, there is a strong need to be able to prove they do meet their end-to-end performance

Consequently, in the proposed use case, we are considering the problem of the performance assessment of the GNSS Based Positioning Component of the ITS System.

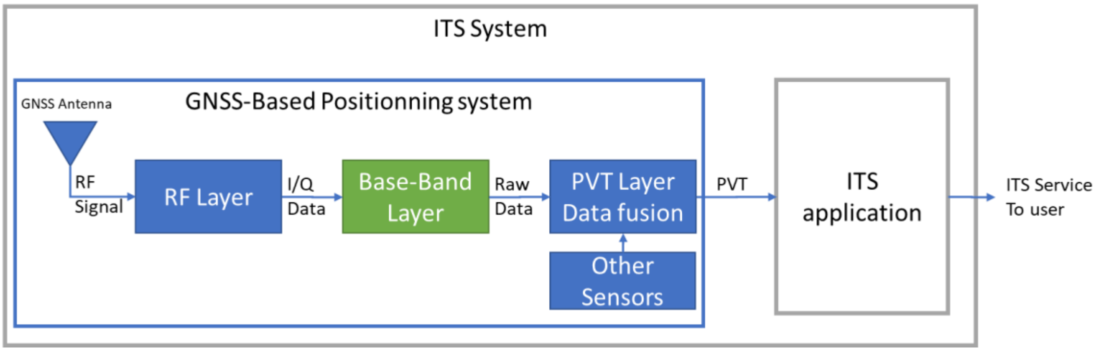

Figure 19 : GNSS Based positioning system

As shown in Figure 19 the GNSS Based Positioning system is providing the PVT (Position-Velocity-Time) information to the ITS application.

Inside the GNSS Based Positioning System, the GNSS baseband layer is in charge of processing the I/Q signals provided by the RF front end in order to product raw data measurements (Pseudo-range, Doppler, C/N0, …) that are, then, used for the PVT computation. This raw data is the fundamental observation of the GNSS sensor that is one of the key inputs to the sensors fusion layer.

As the environmental conditions often encountered in ADAS application, especially in urban and deep-urban areas, are very challenging, the methodology and tools for performance evaluation of the GNSS Based positioning system are not well defined.
Indeed, in such conditions major vulnerabilities are causing non deterministic behaviour of the GNSS receivers:

- Multipaths due to the interactions between the GNSS signal and the obstacles around,
- Interferences due to other sources of radio waves, unintentionally or intentionally produced.

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Only recently the EN16803 standard has defined a process in line with metrology approach to characterise GNSS receivers for ITS applications.
The standard recommends the use of "record-playback" method and tools to test GNSS receivers. This is based on field trials that consist in GNSS signal recording together with accurate mobile trajectory. Based on the obtained data files (I/Q and reference trajectory) it is then possible to replay the signal in laboratory conditions and to test GNSS based positioning solutions.

This approach has following major benefits:

- The generated signals are representative of the "real world" since they have been collected on the field, this is not necessarily the case for simulated signals in particular for complex environments;
- The tests are reproducible and can be used as references to support certification process in the future.

The use case is aiming to demonstrate a complete process and associated test bench that enables to assess GNSS positioning performances both using simulated scenario and replay of "on-the field" recorded data as recommended in EN 16 803 standards. This process enables to simulate and replay on-the field recorded data. It also enables to verify the content of digitized GNSS signal (I/Q data) by means of the baseband implementation developed in WP3 by M3 Systems.

4.1.2 Main Features

The simulation test bench is illustrated in Figure 20 here below

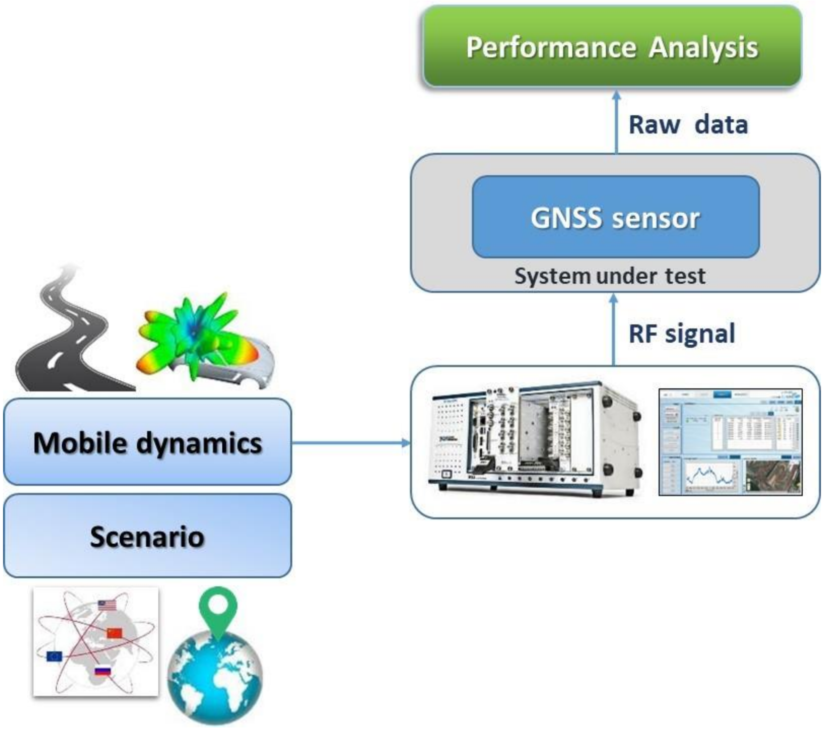

Figure 20 : Simulation test bench Simulation test bench using synthetic scenario

This test bench will be coupled with a multipath simulation tool (SE-NAV) that enables to generate reflected GNSS signals using a 3D model of the environment.

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No 826276

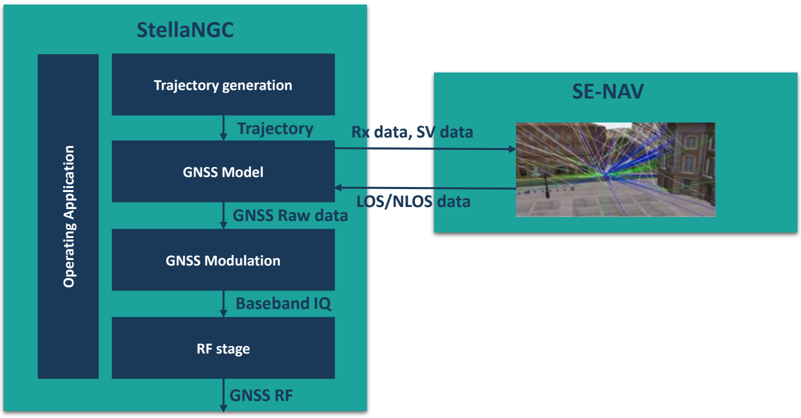

Figure 21 : – GNSS signal and Multipath and Jamming Simulators: Stella NGC + SE-NAV.

Concerning the “record-playback”, an equipment that enables the sensors data collection in a mobile environment will be used. The data files recorded during tests are then replayed in laboratory environment using the same platform as for simulation with the difference that simulated files are replaced by recorded files (I/Q data and trajectory).

Figure 22 : data logger

In addition to these simulation & record/playback features, the test bench enables to characterise the recorded I/Q data in order to verify the level of vulnerabilities that are represented in the data. This is an essential capability in order to make sure that “on-the filed “scenario is representative and contains significant vulnerabilities to challenge the GNSS based positioning solution. The process to verify the content of I/Q recorded data is illustrated in Figure 23.

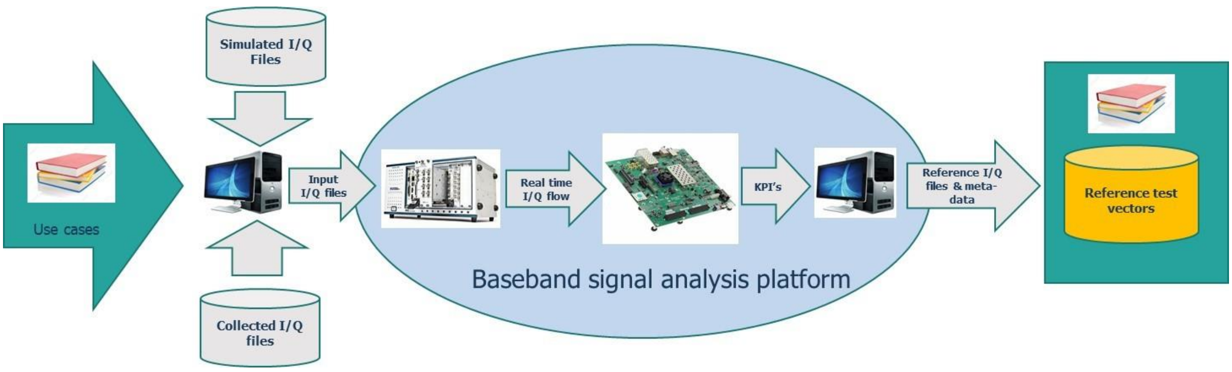

Figure 23 : Process to analyse recorded I/Q data

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4.1.3 Limits

- The proposed test bench is derived from existing solutions at M3 Systems that will be assembled to support the proposed process. Consequently, the user HMIs will be derived from the existing. (Stella NGC. Stella RP) for both recorder and Replay Functions.
- Concerning the recorded data, a limited set of scenarios will be provided based on recorded tests conducted by M3 Systems.
- The I/Q data analyser derived from WP3 development will provide an initial set of KPI's to characterise the I/Q data and the quality of recorded GNSS signal. These KPI's may have to evolve in the future based on standards that are currently under definition at CENELEC

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4.2 REQUIREMENTS

This section contains Use Case requirements at a level of detail sufficient to enable CPS4EU designers to design components and pre-integrated architectures to satisfy those requirements, and testers to test that the system satisfies those requirements.

Throughout this section, every stated requirement will be externally perceivable by users, operators, or other external systems.

4.2.1 Functional Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Functional Requirement	**UCE-FNC-01**	IQ data test set generation	The test bench shall allow to generate the data set needed by the Base-band processing receiver testing.	High	Client requirement
Functional Requirement	**UCE-FNC-02**	GNSS signal simulation set up	The test bench shall allow to configure Stella NGC Simulation in order to generate needed signals.	Medium	Client requirement
Functional Requirement	**UCE-FNC-03**	IQ Data characterization	The test bench shall be able to analyse and characterize the IQ data.	Low	Client requirement
Functional Requirement	**UCE-FNC-04**	Wired RF replay	A wired RF replay function shall be proposed, through Stella RP, for GNSS receivers testing	Medium	Client requirement

Table 39 – UC1 Functional Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Functional Requirement	**UCE-FNC-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UCE-FNC-02**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UCE-FNC-03**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Functional Requirement	**UCE-FNC-04**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

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Table 40 – UC1 Functional Requirements interrelations with Modules & Pre-integrated Architectures

4.2.2 Interface Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Interface Requirement	**UCE-INT-01**	Input Data (IQ) format	the test bench shall support storage data format of Stella NGC and Stella RP for its inputs.	Low	Client requirement
Interface Requirement	**UCE-INT-02**	out-put IQ Data format	Outputs (I/Q data) shall be compliant with data format supported by Stella RP Replay	High	Client requirement

Table 41 – UC1 Interface Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Interface Requirement	**UCE-INT-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Interface Requirement	**UCE-INT-02**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 42 – UC1 Interface Requirements interrelations with Modules & Pre-integrated Architectures

4.2.3 Performance Requirements

N/a

4.2.4 Security Requirements

N/a

4.2.5 Operational Requirements

N/a

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

4.2.6 Usability Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Usability Requirement	**UCE-USB-01**	Definition of data testing set	The user shall be able to define and configure the test signal and its components : GNSS signal, Multipath and Jammer, before the simulation, by specifying them through an appropriate GUI.	High	Client requirement

Table 43 – UC1 Usability Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Usability Requirement	**UCE-USB-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 44 – UC1 Usability Requirements interrelations with Modules & Pre-integrated Architectures

4.2.7 Policies & Compliance Requirements

N/a

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4.2.8 Design Constraints

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
Design Constraints	**UCE-DSG-01**	Functions splitability	the sub-functions of the test bench shall be distributed such that they can be used separately.	High	Client requirement

Table 45 – UC1 Design Constraints Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		
Design Constraints	**UCE-DSG-01**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Table 46 – UC1 Design Constraints Requirements interrelations with Modules & Pre-integrated Architectures

4.2.9 Ethical Requirements

N/a

4.2.10 Other Requirements

N/a

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5 UC 16 - INTELLIGENT MOTOR CONTROL APPLICATION AS SAAS TO OFFER MACHINE LEARNING CAPABILITIES FOR EXTERNAL PARTIES [AIRLANE]

5.1 OVERALL DESCRIPTION

5.1.1 High level Use Case Description

Airlane Technologies acts as an electronic module provider for handheld tools (crimper/cutter/grinder/saw).

Especially for professional tools, but not only, predictive maintenance and auto-diagnostic capability have become a requirement for most of the major tool providers. For example, prediction of abrasive aging of a grinder would be a real benefit for user and tool provider. Also, there are many tool application where specific cycles are applied like a crimper, a torque wrench or a torque controlled screwdriver, etc…

With handheld tools data connectivity, predictive maintenance is currently achievable through artificial intelligence models running in cloud instances. Airlane Technologies has already deployed a cloud based solution with a major actor of handheld tools market. This cloud based solution exploits data from connected tools in order to achieve predictive maintenance based on motor frequencies characteristics. Also, at production and service centers, the cloud based software enables tools manufacturer to automate calibration and tests.

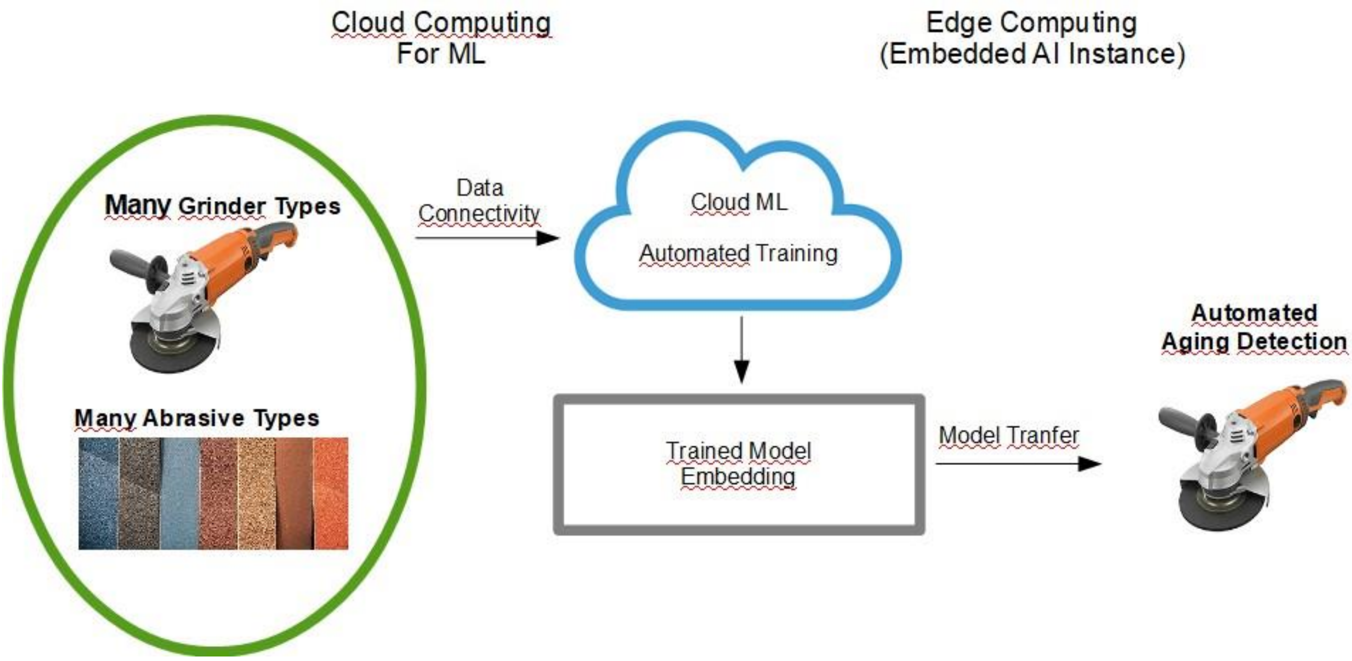
With CPS4EU, Airlane Technologies aims at using Edge Computing capability in order to embed artificial intelligence into electronic modules that will enable automated user assistance.

A major objective with this use case is to embed AI into motor control application module for handheld tools.

Two concrete use cases are defined as following:

- Automatic detection of abrasive disk aging on a grinder based on AI model
- Automatic detection of crimp/wrench cycle based on AI model

The abrasive aging detection can be illustrated as shown here after:



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5.1.2 Main Features

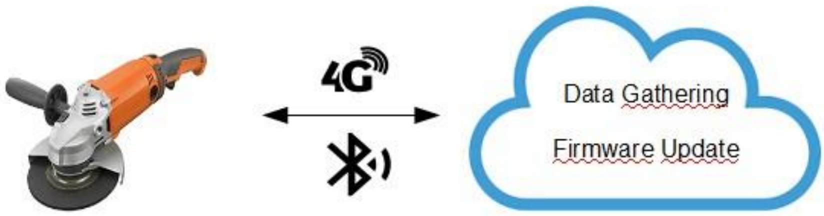
For this Use Case, there are several fields where CPS platform is expected to provide technical solution.

As briefly explained, it shall be possible at first to exploit data from the electronic modules (vibration, motor torque, motor frequencies…). The gathered data is intended to be injected into machine learning system in order to enable tool manufacturer to develop artificial intelligence models for the different kind of handheld tools.

Once model trained with gathered data, the CPS platform shall enable automation of model embedding into handheld tools. It is expected that the model can be executed by handheld tools embedded core, meaning that model embedding shall be achieved by over-the-air firmware update.

The first feature required is handheld tool connectivity. Currently, final customers and handheld tools manufacturers feel like having wireless connectivity either through cellular or Bluetooth connection. In this application, connectivity can be designed for low data rate. Actually, data volume is estimated to approximately 1Mo/day (20ko/cycle with 50 cycles per day).

Connectivity feature is exploited to generate data for machine learning in development phase and along product lifecycle. Connectivity of handheld tool shall also enable edge computing capability through firmware and model update.



Knowing the application, it is required that data connectivity can be achieved with low power consumption in order to minimize handheld battery energy.

The other major feature expected is AI model development and training. For handheld tools manufacturers, a cloud application shall allow online development of AI model. Preferred programming language should be Python or Javascript (like achievable currently with PyTorch or Tensorflow).

The AI model development application feature is in fact an IDE for model scripting and compilation. It shall allow conception of AI models but also model training.

The platform will enable tools manufacturers to choose how to interact with end-users (warning light, messages, …).

5.1.3 Limits

This section will be completed in a next version of the deliverable

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826276

5.2 REQUIREMENTS

This section contains Use Case requirements at a level of detail sufficient to enable CPS4EU designers to design components and pre-integrated architectures to satisfy those requirements, and testers to test that the system satisfies those requirements.

Throughout this section, every stated requirement will be externally perceivable by users, operators, or other external systems.

This section will be completed in a next version of the deliverable

5.2.1 Functional Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 47 – UC1 Functional Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 48 – UC1 Functional Requirements interrelations with Modules & Pre-integrated Architectures

5.2.2 Interface Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 49 – UC1 Interface Requirements Description

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Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 50 – UC1 Interface Requirements interrelations with Modules & Pre-integrated Architectures

5.2.3 Performance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 51 – UC1 Performance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 52 – UC1 Performance Requirements interrelations with Modules & Pre-integrated Architectures

5.2.4 Security Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 53 – UC1 Security Requirements Description

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Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 54 – UC1 Security Requirements interrelations with Modules & Pre-integrated Architectures

5.2.5 Operational Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 55 – UC1 Operational Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 56 – UC1 Operational Requirements interrelations with Modules & Pre-integrated Architectures

5.2.6 Usability Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 57 – UC1 Usability Requirements Description

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement

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Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 58 – UC1 Usability Requirements interrelations with Modules & Pre-integrated Architectures

5.2.7 Policies & Compliance Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 59 – UC1 Policies & Compliance Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 60 – UC1 Policies & Compliance Requirements interrelations with Modules & Pre-integrated Architectures

5.2.8 Design Constraints

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

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Table 61 – UC1 Design Constraints Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 62 – UC1 Design Constraints Requirements interrelations with Modules & Pre-integrated Architectures

5.2.9 Ethical Requirements

Requirement Type	Requirement ID *(calculated)*	Short Description	Description	Priority (H/M/L)	Source
		xxx	xxx	High	

Table 63 – UC1 Ethical Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 64 – UC1 Ethical Requirements interrelations with Modules & Pre-integrated Architectures

5.2.10 Other Requirements

		Short Description	Description		Source

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		xxx	xxx	High	

Table 65 – UC1 Other Requirements Description

Requirement Type	Requirement ID *(calculated)*	Computing			Connectivity		Sensing		Collaborative	CPS Tools	Non-CPS4EU module / tech
		HP Embedded Computing	AI Computing	Vision Computing	Connectivity (V2X, M2M)	Cyber Security	Ultra precise localisation system	Perception and interpretation of environment	Cooperative algorithms		

Table 66 – UC1 Other Requirements interrelations with Modules & Pre-integrated Architecture

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6 REQUIREMENTS GATHERING METHODOLOGY

This section reports the methodology adopted to define the requirements related to the CPS4EU Industry Automation use cases. In the following paragraphs the type of requirements, the adopted notation and the requirement code conventions are described.

Requirements play major roles as they:

- Form the basis of system architecture and design activities
- Form the basis of system integration and verification activities
- Act as reference for validation and stakeholder acceptance
- Provide a means of communication between the various technical staff that interact throughout the project.

6.1.1 Requirements Types

According to the IEEE Standard Glossary of Software Engineering Terminology[2], a requirement is:

- A condition or capability needed by a user to solve a problem or achieve an objective
- A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents
- A documented representation of a condition or capability as in (1) or (2).

CPS4EU SME (WP9) Use Case requirements are classified into the following types:

Functional Requirement	A requirement that specifies a function that a system, or system component, must be able to perform. A requirement specifying **what** the overall system, or a specific component, will be able to do. Statements of services that the system should provide, how the system should react to particular inputs and how the system should behave in particular situations. Among the functional requirements are also included security requirements relating to the security services offered by the system to users or other systems.
Non Functional Requirement	A requirement specifying **how** the system or component will implement its functionality. In this document the following non-functional types of requirements are considered: • Interface Requirements • Performance Requirements • Security Requirements • Safety Requirements • Operational Requirements • Usability Requirements • Policies & Compliance Requirements • Design Constraints • Ethical Requirements • Other Requirements.

The following table describe each requirement type:

[2] *https://ieeexplore.ieee.org/document/159342/definitions#definitions*

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Requirement Type	Req.ID	Requirement Description
Functional Requirement	**FNC**	Functional Requirements describe the behaviour and information that the solution will manage. In the case of a non-system solution, the behaviour typically refers to a workflow and the information refers to the inputs and outputs of the workflow. Additionally, the requirements describe how the data will be transformed and by whom. In the case of a system solution, the functional requirements describe the features and functionality of the system as well as the information that will be created, edited, updated, and deleted by the system.
Interface Requirement	**INT**	Interface requirements define how the system is required to interact or to exchange information with external systems (external interface), or how system elements within the system interact with each other (internal interface). Interface requirements include physical connections (physical interfaces) with external systems or internal system elements supporting interactions or exchanges. External interface requirements are important for embedded systems and outline how your product will interface with other components. There are several types of interfaces you may have requirements for, including: • Hardware: Describe the logical and physical characteristics of each interface between the software product and the hardware components of the system. • Software: Describe the connections between this product and other specific software components (name and version), including databases, operating systems, tools, libraries, and integrated commercial components. Identify data that will be shared across software components. • Communications: Describe the requirements associated with any communications functions required by this product, including e-mail, web browser, network server communications protocols, electronic forms, and so on. Identify any communication standards that will be used, such as FTP or HTTP. Specify any communication security or encryption issues, data transfer rates, and synchronization mechanisms.
Performance Requirement	**PRF**	If there are performance requirements for the Use Cases under various circumstances, state them here and explain their rationale, to help the developers understand the intent and make suitable design choices. Specify the timing relationships for real time systems. Performance requirements can refer to individual functional requirements or features (e.g. speed of response for a certain functionality).
Security Requirement	**SEC**	Security requirements are related to both the facility that houses the system(s) and the operational security requirements of the system itself. Specify the security and privacy requirements, including access limitations to the system, such as log-on procedures and passwords, and of data protection and recovery methods. This could include the factors that would protect the system from accidental or malicious access, use, modification, destruction, or disclosure. In safety-critical embedded systems this might incorporate a distributed log or history of data sets, the assignment of certain functions to different single systems, or the restriction of communications between some areas of the system. Examples:

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		• Access requirements • Integrity requirements • Privacy requirements.
Safety Requirement	**SAF**	Safety requirements are defined for the purpose of risk reduction. They are derived from laws, standards, best practices and experience. Examples: • Quality Assurance (Monitoring & Reviews) • Quality control (Testing & Inspections) are included as well as • Design and development rules • System architecture • Fault tolerance, detection and recovery, • Redundancy and functional independence
Operational Requirement	**OPR**	Examples: • Delivery mode • Access mode • Availability • Maintainability • Reliability • Capacity • Scalability • Portability • Installation.
Usability Requirement	**USB**	Examples: • Environment of use • Appearance and style • Ease of use • Internationalization • Accessibility.
Policies & Compliance Requirement	**P&C**	These requirements identify relevant and applicable organizational policies or regulatory requirements that could affect the operation or performance of the system(s). Examples: Laws and regulations, standards, business rules.
Design Constraint	**DSG**	Example: Environmental Requirements, which identify the environmental conditions to be encountered by the system in its different operational modes. This should address the natural environment (e.g. wind, rain, temperature, fauna, salt, dust, radiation, etc.), indUC13d and/or self-indUC13d environmental effects (e.g. motion, shock, noise, electromagnetism, thermal, etc.), and threats to societal environment (e.g. legal, political, economic, social, business, etc.).
Ethical Requirement	**P&E**	See §5.1 Ethics of CPS4EU proposal, with particular reference to the document "Ethical Aspects of Cyber-Physical Systems": http://www.europarl.europa.eu/RegData/etudes/STUD/2016/563501/EPRS_STU%282016%29563501_EN.pdf
Other Requirements	**OTR**	Any other requirement that cannot be classified with the above categories.

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6.1.2 Requirement Identification

The CPS4EU SME Use Case requirements will be uniquely identified by an alphanumeric code consisting of:

<Use Case number>-<classification>-<number>, where:

<Use Case ID>	**SME UC12**	Pedestrian detection on off-Road Construction trucks
	SME UC13	CPS based flow chemistry modules
	SME UC14	Monitoring network for Environment Quality (well-being) and Threat Detection
	SME UC15	Open Loop test bench allowing the validation of the developed sensor for Automated Driving applications
	SME UC16	Intelligent motor control application as SaaS
<classification>	**FNC**	Functional Requirements
	INT	Interface Requirements
	PRF	Performance Requirements
	SEC	Security Requirements
	OPR	Operational Requirements
	USB	Usability Requirements
	P&C	Policies & Compliance Requirements
	DSG	Design Constraints
	ETH	Ethical Requirements
	OTR	Other Requirements
<number>	A progressive number that uniquely identifies the requirement within a requirement type.	

Example:
UC1-USB-01 → Use Case: UC1, Requirement type: Usability Requirement, Requirement number: 01

6.1.3 Requirement Principles

The following principles apply:

Characteristics	Specific requirements should comply with the following characteristics: • unambiguous • complete • consistent • ranked for importance and/or stability • verifiable • modifiable • traceable.
Cross-references	Specific requirements should be cross-referenced to earlier documents that they relate to.
Readability	Careful attention should be given to organizing the requirements to maximize readability.
IDs	All requirements should be uniquely identifiable (via ID).

Each requirement should also be **testable**.

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6.1.4 Requirement Attributes

Each requirement will be classified according to the following ***Priority***:

Priority	***Feature***	***How to describe it***
High	A required, must have feature	The system **shall**…
Medium	A desired feature, but may be deferred till later	The system **should**…
Low	An optional, nice-to-have feature that may never make it to implementation	The system **may**…

The ***Source*** field identifies the origin of the requirement i.e. where/whom it comes from.

The ***Computing***, ***Connectivity***, ***Sensing***, ***Collaborative***, ***CPS Tools*** fields describe the relationship between the requirement and the WP1-WP6 module, i.e.

- If/how the requirement will have some impact on WP1-6 modules
- if the requirement foresees the usage of a WP1-6 module

If the requirement foresees a non-CPS4EU module or tech to be used, that is to be specified in the ***Non-CPS4EU module / tech*** field.

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7 CONCLUSION – NEXT STEPS

The use cases descriptions give not only an overall description but also precise requirements, that should be completed in a next version of D.9.8 for some use cases.

They are a first step to share a common understanding the needs of the market in CPS4EU. They have to be analysed by components WP 1-4. Based on comments from these partners, the requirements should evolve and integrate more details.

The next steps will be to:

- Organize the dissemination of these descriptions inside CPS4EU (dedicated webinar for example);
- Formalize the existing links between WP9 use cases and the work in WP 1-4 and WP6 (i.e. UC14 and WP4, UC12 and WP3, …);
- Develop the interactions between partners to find new possible collaboration and opportunities with these use cases;
- Identify the common needs between use cases with WP6 support to maximize the use of PIARCH.

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