PRISSMA Project
Research and Investment Platform for Security
and Safety of Autonomous Mobility
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[L0.1] WP4 – TESTS IN REAL CONDITIONS STATE OF THE ART : PRIMARILY REPORT

Rapport initial : Etat des lieux WP4

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Abstract.

This document presents different approaches for the validation of AI-based automated mobility systems, and more particularly the elements specific to real-life testing. It includes contextual elements of a global methodology, the integration in validation cycles as well as an inventory of existing test sites and associated equipment.

Résumé.

Ce document présente différentes approches pour la validation des systèmes de mobilités automatisé à base d'IA, et plus particulièrement les éléments spécifiques aux tests en conditions réelles. Il reprend des éléments de contexte d'une méthodologie globale, l'intégration dans des cycles de validation ainsi qu'un état des lieux des sites de tests existants et les équipements associés.

Table of contents

1 INTRODUCTION

This document aims to provide a basis for future methodological work on real-life testing automated vehicles integrating AI. It integrates elements of state of the art on existing works or projects, working hypotheses applied to the PRISSMA project or reflections on the direction of the work of this group.

The first part aims at briefly presenting the current thinkings and approaches about the validation of the safety of automated driving systems and how to integrate these elements in the test approach of the PRISSMA WP4 on real-world tests.

The second part aims to recall the validation approach in system engineering applied to artificial intelligence and the points of convergence with the PRISSMA project.

A normative and regulatory state of the art is then proposed, with a focus on the situation of experiments in France.

Finally, the last part of this document describes the state of the art on the various test sites identified in Europe and the United States with the technical and functional characteristics of these sites.

2 INTEGRATION OF OPEN ROAD TESTS

The PRISSMA project is based on three main test phases, simulation validation, controlled environment testing and finally real-world testing. Each test phase has its own conditions and expectations. In the case of the tests in real conditions, objects of study of the WP4, we propose in this first part to define working hypotheses relating to the contents and the scope of these tests.

2.1 Three phases approach

2.1.1. Components, systems and systems of systems

The object of study in this chain of validation is also an essential parameter to define. When we are interested in a mobility system, it is possible to distinguish:

- The vehicle
- The physical and digital infrastructure
- The operating environment
- The supervision

Within these different systems, it is also possible to identify several components participating in the mobility function. Among these components, we can find bricks integrating AI. The validation process can then choose to integrate these components, the complete systems or the systems of systems. These choices depend on the objectives of the project but also on the expectations of each test phase and therefore of the WP concerned.

In the framework of WP4, the emphasis is put on the study of the mobility system as a whole, sometimes on some specific systems when they require a complete operating environment to be testable. This is the case of supervision for example. In all cases, the study of the components of a system is not in the scope of this work-package, so the validation process should be agnostic with respect to the vehicle, which will then be perceived as a black box.

2.1.2. Tests for global performance, services and UC

The second aspect to be taken into consideration in the scope of the study is the type of tests considered. Indeed, it is possible to consider unit tests on simple system functions (obstacle detection, intersection crossing, ...), use cases or complete services. Depending on the type of test considered, the indicators will be very different. On the other hand, it is also possible to define tests that are independent of the proposed services.

Generally speaking, for open road tests, it is preferable to test on use cases and complete services. Unit tests are more likely to be planned in the previous phases, on a track or simulation. However, in the same way as for the object of study, series of unit tests on specific functions may be considered when these functions require a complete environment that cannot be reproduced in a controlled environment. This is particularly the case for functions related to operating conditions and interactions with other users.

2.1.3. No critical safety in tests in real conditions.

Generally speaking, tests carried out in real conditions and therefore on roads open to traffic must not induce external risks. The environment of these tests being by nature uncontrolled, the vehicle must be able to master the external events and the safety of the mobility system. This is why tests specifically targeting safety functions and the management of critical situations must be carried out upstream in the other phases of the project.

This vision of safety currently seems to be shared by many actors in the autonomous mobility ecosystem: the various components of the mobility system (supervision, connectivity, perception, etc.) increase the quality of service, <u>but the vehicle remains in control of its safety in all critical situations.</u>

2.1.4. Standardized, specific and random tests

If we consider a series of tests for the validation of AI-based mobility systems, we can assume that some of these tests will become standardized while others will remain applied to very specific systems or functions. Whatever the mobility system considered, some of the basic functions will be common and the associated tests can then be used on a wide range of systems. On the other hand, some of the tests will have to respond to particular functions and therefore be specially designed for this purpose.

Whether these are common functions or specifically designed to address individual problems, each mobility system will have a large number of functions. When these functions are combined with the operating environment variables: infrastructure, equipment, weather conditions, other road users, one is faced with an even greater number of scenarios in which these functions apply.

So many combinations would then require an equivalent number of tests to be exhaustive, which in many cases does not seem possible. We must then turn to two factors:

- First, isolate the primary functions that actually require a test in order to reduce this share
- Introduce random tests to cover the widest possible range of situations.

2.1.5. Operational Design Domain

One of the major challenges of real-life testing is to test the robustness of the mobility system as a whole, particularly under real operating conditions. Thus, tests on specific use cases will ensure the adequacy of the system with its ODD.

2.2 Scenario approach

The interest of this scenario approach is to be able to demonstrate the safety of mobility systems in all situations they are facing. This scenario approach is the subject of work in several working groups such as at the UN (WP 29/GRVA/VMAD) and at the French level with groups from FVA and STRA.

Without repeating the basics, the aim of this section is to specify the methods for describing these scenarios and integrating them into the tests under real conditions.

The first important notion is the level of abstraction of the description of the scenarios. We usually distinguish three levels: functional, logical and concrete scenarios.

- Functional:
- Logical:
- Concrete

An important aspect to notice about the scenario concept described in [xx] is that the scenario description does not define any ego vehicle. Rather, it describes situations, sequences and events involving multiple actors and vehicles. When applied to a particular driving system, the autonomous vehicle can potentially play the role of any of the vehicles defined in the scenario.

Recently, the working group dedicated to this work at the Ministry of Transport proposed the following description axis:

- 1 - Static traffic environment

Includes all the elements of the static description of the environment such as the road configuration, the infrastructure and the equipment in place... All these elements constitute the static part of the ODD.

- 2 - Nominal driving maneuver

Allows to describe the action of the ego vehicle in nominal conditions (Rolling, overtaking, intersection crossing ...). A standardized list of nominal maneuvers can be used to address most scenarios.

- 3 - Hazards

Includes the events that can occur in traffic, mainly interactions with third parties (other road users, pedestrians, objects ...) but also system malfunctions. These malfunctions can concern the ego vehicle, its passengers or another part of the system (such as a failure on the supervision side for example).

- 4 - System response

Specifically deals with the response maneuvers of the system in the face of the hazards previously mentioned. This maneuver must take into account the three axes (static environment, nominal driving maneuver and hazards) to propose a response adapted to the situation. These maneuvers also greatly depends on the considered ego system kind, which is why a list of standardized maneuvers seems very complicated. However, a selection of certain attributes on emergency and MRM maneuvers for example can be considered.

- 5 - Hazards affecting the system response

These elements deal with the dynamic variables that can modify the system response. The dynamic elements that make up the ODD fall into this category, such as weather conditions or the degree of road adherence. One can also note the other malfunctions of the system that do not affect the nominal maneuver but have an impact on the system response to a hazard.

Focus PRISSMA: In order to integrate this approach in the PRISSMA framework, it is therefore essential to start the description of these different axes, applied in a first step to the different pilot cases identified in the project. This first description applied at a functional or even logical level will allow to better define the relevant tests and associated protocols in the framework of WP4.

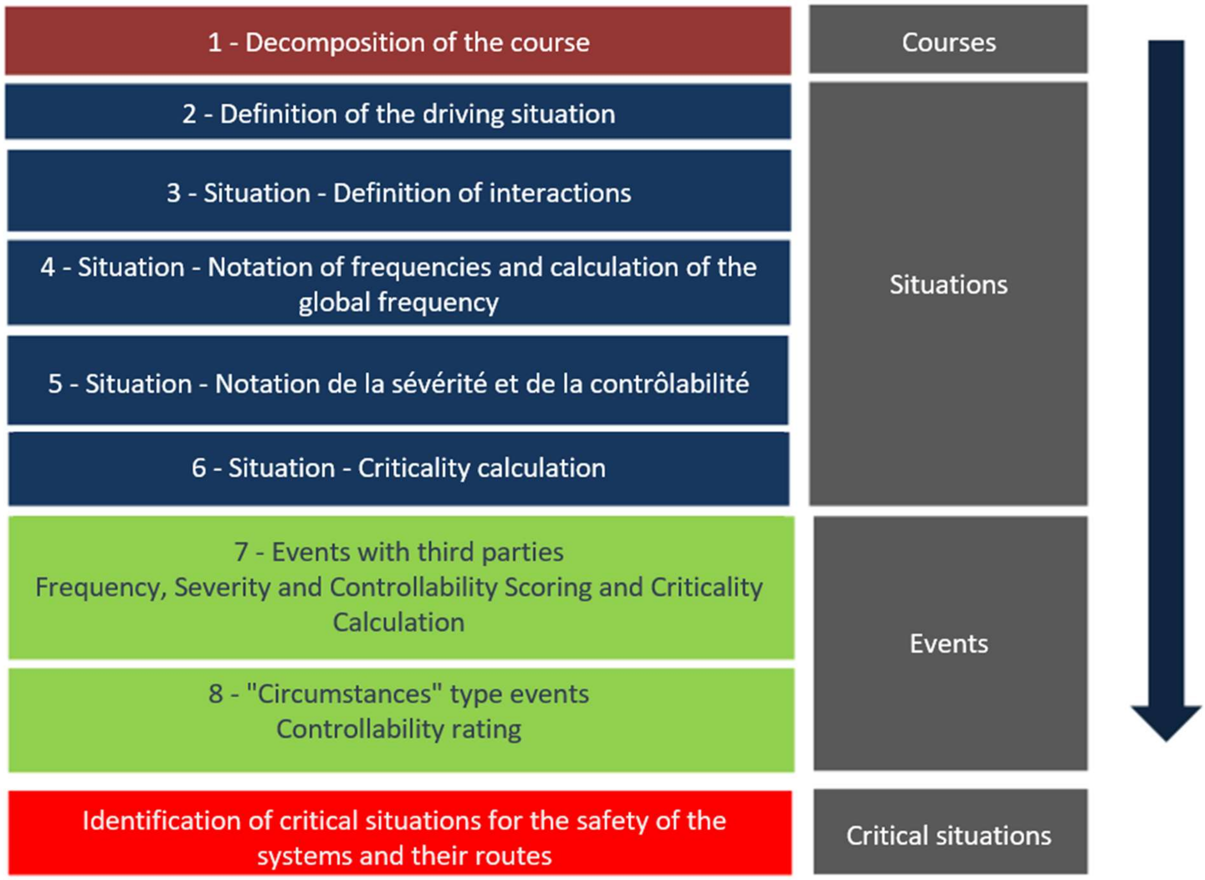
The contribution of all the partners will be necessary to deal with the different axes of description and we will particularly note:

- the expected contribution of the partners in charge of the pilot cases (RATP, Valeo) on the description of axes 2, 4 and 5 which focus on nominal driving maneuvers and system responses to hazards.
- the coordination to be set up with WP8 on the subjects related to the description of the ODD in order to best respond to the description of axes 1 and 5 on the operating environment.

2.3 Pathway security analysis

In parallel to this scenario-based method, other pathway-centric approaches were explored by different working groups. The route safety analysis allows the identification of route specificities and potential critical areas without taking into account the vehicle characteristics. This method can then be an interesting complement to the scenario approach.

Several working groups involving government departments, academic partners and industry have proposed innovative approaches in recent years to the description and validation of safety around automated vehicles. Among these, we can mention the joint IFSTTAR / STRMTG approach on the safety analysis of predefined routes.



Extracted and translated from IFSTTAR methodology

This method consists in breaking down the whole route into multiple homogeneous sections, associating the possible manoeuvres and assigning weights concerning their criticality in terms of safety. This allows for a systematic approach.

3 VALIDATION PROCESS OF AI FUNCTIONS

This paragraph is a work-in-progress initiative to depict the principles et key aspects of the validation of a system of systems, and the possible impact of the introduction of AI functions.

TBD : Certification, Homologation, Qualification

3.1 System's engineering key aspects for validation

As described by the IEEE 15288 standard (REF) and recalled for the PRISSMA project in the deliverable 8.13 (REF), the processes for engineering a system and manage its configuration can be visually organized in V layout to depict the main objectives of the system engineering:

- The left branch of the V groups the activities to define the system fulfilling the needs of the stakeholders involved in the mission to which the system contributes.
- The bottom of the V, often called the implementation process, is dedicated to the procurement of the system's parts to be assembled in a consistent part fulfilling the objectives of the system.
- The right branch of the V, often called IVV[1] activities, groups the activities to justify that the produced system fulfills its definition and the needs of the stakeholders.
- The verification of the consistency of the activities relies on the extensive usage of traceability and coverage analysis link any identified information at each process activity.

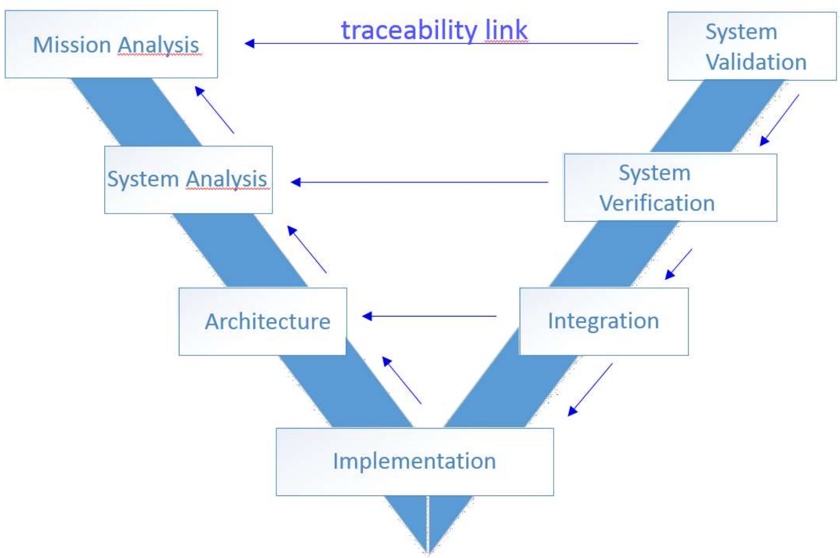


Figure 1 : Typical V cycle of system engineering activities

FOCUS PRISSMA: Beyond the different verification techniques used during the IVV activities, a key aspect to produce confidence in the realized system is the traceability and coverage analysis between justification elements and definition elements. Each definition element like

[1] Integration, Verification & Validation

requirement, use case, or scenario must be uniquely identified, so as justification elements like review, tests and test results.
The completion of validation activities necessarily leads to an analysis of the completion of justification elements regarding definition elements thanks to traceability analysis between definition elements and justification elements.

3.2 Summary of IVV activities and major concerns of transition to operation

Integration process [IEEE 15288]:

The purpose of the Integration process is to synthesize a set of system elements into a realized system (product or service) that satisfies system requirements, architecture, and design.

This process assembles the implemented system elements. Interfaces are identified and activated to enable interoperation of the system elements as intended. This process integrates the enabling systems with the system-of-interest to facilitate interoperation.

Verification process [IEEE 15288]:

The purpose of the Verification process is to provide objective evidence that a system or system element fulfils its specified requirements and characteristics.

The Verification process identifies the anomalies (errors, defects, or faults) in any information item (e.g., system requirements or architecture description), implemented system elements, or life cycle processes using appropriate methods, techniques, standards or rules. This process provides the necessary information to determine resolution of identified anomalies.

NOTE: The Verification process determines that the "product is built right". The Validation process determines that the "right product is built". [1]

FOCUS PRISSMA: The PRISSMA project focus on some particular verification activities: the tests that can be taken on an AD system (simulation test, closed road or open road tests). Since the verification scope is to verify a system against its requirements, and not the stakeholder's needs it fulfills, the quality of the requirements will have a particularly strong impact on the seamless transition of the verification success to the validation success: if the system has good requirements, then a successful verification will enable a successful validation. But if the system requirements definition process has flaw, then the delivered system fulfilling its requirements will probably won't fill the stakeholders' needs.

Validation process [IEEE 15288]:

The purpose of the Validation process is to provide objective evidence that the system, when in use, fulfills its business or mission objectives and stakeholder requirements, achieving its intended use in its intended operational environment.

The objective of validating a system or system element is to acquire confidence in its ability to achieve its intended mission, or use, under specific operational conditions. Validation is ratified by stakeholders. This process provides the necessary information so that identified anomalies can be resolved by the appropriate technical process where the anomaly was created.

NOTE 1: The validation process determines that the "right product is built". The verification process determines that the "product is built right".

NOTE 2: Validation is also applicable to the engineering artifacts (viewed as system elements) produced in the definition and realization of the system. [1]

FOCUS PRISSMA: This process is key for the PRISSMA project. The good definition of stakeholder needs and requirements is a key factor of success in traditional engineering projects, and will also be the case with AI AD system: what environment is enough for validation, what are all the stakeholders involved for a particular AD system are typical questions relative to validation that should be addressed.

Indeed, the question of the environment for the evaluation of an AI system is essential.

For example, validating an AI system according to a protocol proposed by the manufacturer in the ODD defined for the system could be a first step.

In a second step, we would push the system to its limits with RODs (Restricted Operational Domain) in "edge cases" to test the limits of the AI system. The use of the OEDR (Object and Event Detection and Response) will also foster specific activities for the validation of the ADS.

Transition process [IEEE 15288]:

The purpose of the Transition process is to establish a capability for a system to provide services specified by stakeholder requirements in the operational environment.

This process moves the system in an orderly, planned manner into the operational status, such that the system is functional, operable and compatible with other operational systems. It installs a verified system, together with relevant enabling systems, e.g., planning system, support system, operator training system, user training system, as defined in agreements. This process is used at each level in the system structure and in each stage to complete the criteria established for exiting the stage. It includes preparing applicable storage, handling, and shipping enabling systems.

NOTE: In the case of system upgrades, the transition activities need to be accomplished with minimal disruption to ongoing operations. [1]

FOCUS PRISSMA: As stated in §6.8 [8.13], the transition of some systems during their lifecycle can arise some particular troubles. For an AD system, its transition from validation (maybe in closed road) to operation (possibly in open road) should be planned, along with the transition for the enabling systems that will guarantee its security.

These questions are typically core questions of the PRISSMA project.

Operation process [IEEE 15288]:

Although the operation process is part of the IEC 15288 standard, it is addressed in deeper viewpoint by the Integrated Logistic Support detailed [8.13]

The purpose of the Operation process is to use the system to deliver its services. This process establishes requirements for and assigns personnel to operate the system, and monitors the services and operator-system performance. In order to sustain services it identifies and analyzes operational anomalies in relation to agreements, stakeholder requirements and organizational constraints.

NOTE ISO/IEC 20000-1:2011 (IEEE Std 20000-1:2013), provides requirements for establishing a service management system, which supports the Operation process to achieve its purpose.[1]

3.3 Interrelation of ADS validation and Ground transportation SoS

A key aspect of this process regarding the integration of AD system has been highlighted in the deliverable [8.13]:

FOCUS PRISSMA: The integration of a given set of elements of a system needs some particular tests to be taken to assess the capabilities of this set regarding system's requirements. Depending on the system of interest, the scope of the tests to be taken should be analyzed properly:
* AD vehicle: the SOI is one vehicle. The integration of some components, including AI components, is a state-of-the art activity in system engineering: the context of these components is simulated. As mentioned in §**Erreur ! Source du renvoi introuvable.**, the configuration management of the set of these system's element AND its test system should be done carefully.
* AD system of system: one AD system is a part of the AD system of systems. Even if this AD system comprising the AD vehicle fleet and possible remote supervision has been validated, the operation of the first vehicles in the Road is an integration for the AD system of system. The transition from validation to operation of a given AD system should be ruled and audited by authoritative organizations.

From [8.13] is enlightening the need to consider the concept of system of systems to analyze problems of the validation of an AD system:

When the system's elements can be used in different systems at the same time, the SOI can be analyzed as a system of systems (SoS):
More precisely, the characteristics of a SoS are (Maier, 1998):

- *Operational independence of constituent systems*
- *Managerial independence of constituent systems*
- *Geographical distribution*
- *Emergent behavior*
- *Evolutionary development processes*

Considering the system-of-systems of ground mobility, a given AD system is a subsystem of the ground mobility SoS considered as a whole:

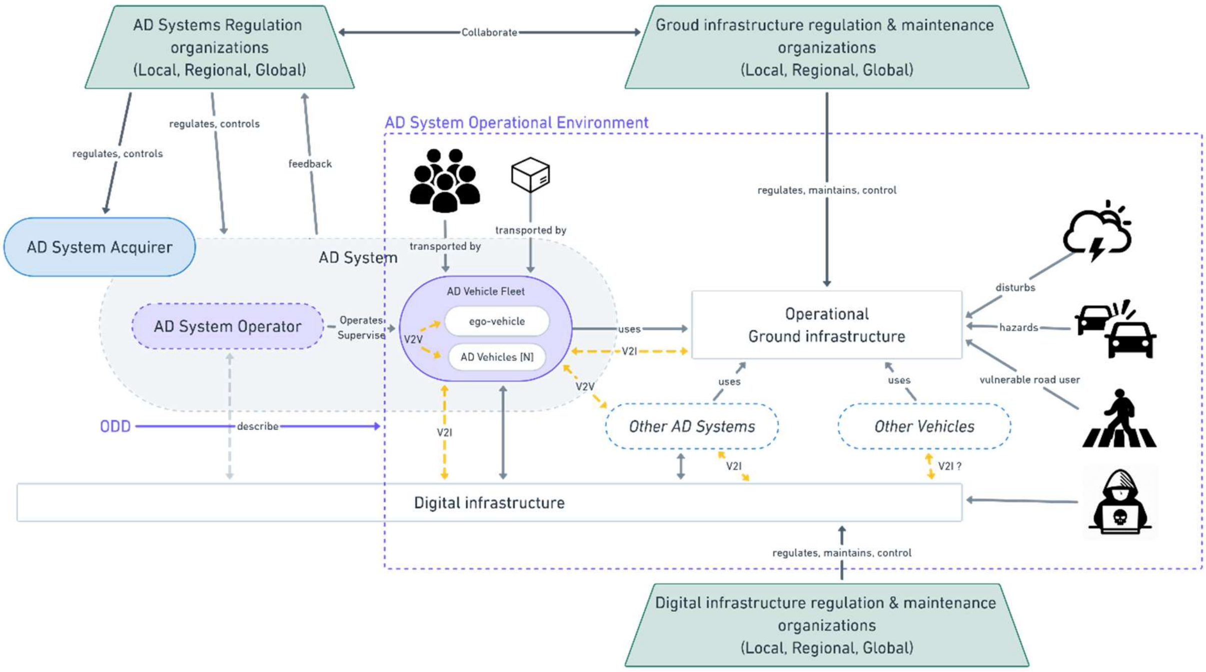


Figure 2 : Generic ground system of systems analysis

When engineering a standalone system (not system-of-systems engineering), the complexity of the whole system is split into smaller parts which can be separately studied. When running such processes, the requirements of a given system's element is an input for the V cycle of this system element. This element can then be recursively divided into sub-elements, and the process is iterated until the level of parts to be analyzed fits the organizations constraints.

The system analysis of the parent system can contribute to realize the mission analysis of the system elements and, ideally, the requirements of the system elements are all defined during the definition of the parent system. In this case, the validation of the system's element can be assessed separately before the element is assembled into the parent system to be integrated.

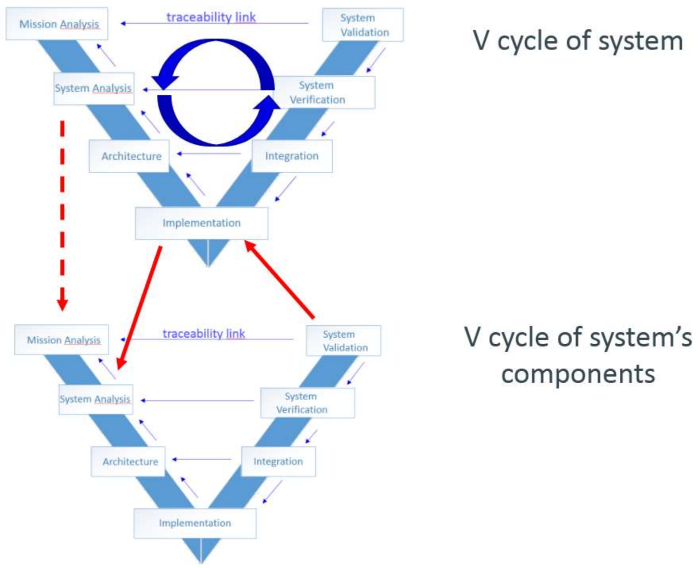


Figure 3 : V cycle integration between system and system's parts

When engineering a system of systems, some capabilities of the system of system can only arise because of the presence of such systems, and cannot be easily split into smaller independent functions allocated to each subsystem.
In that case, it's highly probable that an AD system contributing to the ground transportation system of systems can only be fully validated after being integrated into the SoS. Since the SoS of ground transportation cannot be halted for integrating the ADS, it implies that the ADS can be completely secured after only a sufficient time of operation. The impact of the transitions process between the different V cycle is then to be highly considered.

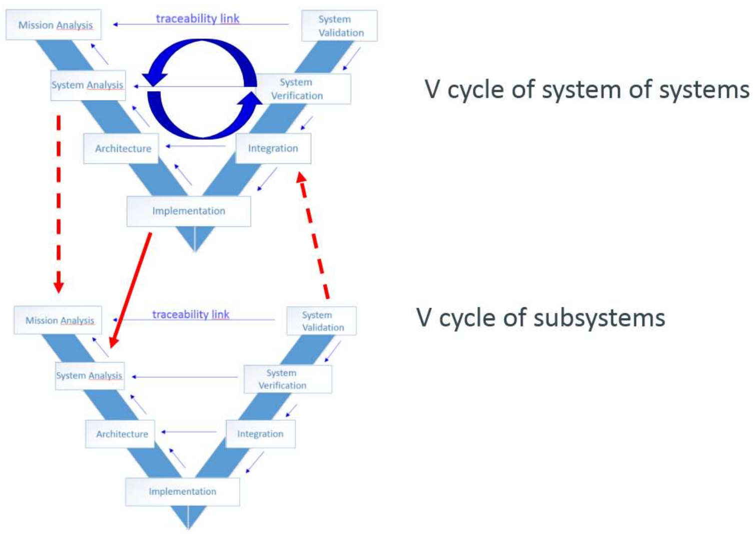


Figure 4 : V cycle integration between system of systems and subsystems

The previous statements lead to the following hypothesis on the process for validating an autonomous driving system:

- In the recurring V cycle of the SoS of ground transportation, a clear list of capabilities and requirements applicable to any ADS is made available to all the stakeholders involved in the design operation and maintenance of ADS.
- In the V cycle of the ADS, the system validation strategy should define the ADS functions that can only be validated by integrating the ADS system into the ground transportation SoS. Those validation strategies should include some KPI to monitor the progress of the validation other a period of time, and different phases of maturity where a human operator might have to be permanently in capability of taking over the vehicles to prevent accidents.
- The continuing recording and analysis of the data of the integrated ADS is mandatory to assess the correct behavior and safety of the ADS as a part of the ground transportation SoS. In other words, the completion of the validation of the ADS can only be assessed after monitoring the decrease some operational KPI (like amount of nearly accidents, or amount of security distance limit broken).
- The components of the ADS are all fully qualified before the ADS system is integrated into the ground transportation SoS:
    - Vehicles are homologated in closed roads
    - Supervision and infrastructure are verified
- The ADS system has been verified and certified in closed road before being integrated into the ground transportation system of systems.
- Since the IA components involve training based on their operational environment data (which is the case for a shuttle on a predefined road), it's realistic to say that the ADS system and the vehicle should be trained first for operating on the closed road, then be replaced by their version trained for the operational road. To give confidence on this process, it's recommended that:
    - The functions impacted by these training should be isolated in order to give certification on closed road a level of confidence on the other components.
    - The extensive use of simulation of the operational environment with digital twin injection on the closed road should give further confidence on the ability to deploy the ADS or the vehicle on the operational environment.
    - Strict configuration management rules shall be enforced to enable certification authorities to reproduce the tests ran in closed road with any version of the AI component (either trained for the closed road, either for the operational environment).

3.4 Impact of the insertion of a new component in a system

The verification or the validation of a system relies on different techniques like peer review, tests or analysis. The verification and validation tests are driven by black box technique: the system is considered a black box, which can be influenced only by its inputs, and monitored by its output. The functional chains are chains of internal functions which can be observed by the interfaces of the system.

In the simple example below, two functional chains are enough for defining the expected behavior of the system, and thus define the scope of the functional verification and validation of the system.

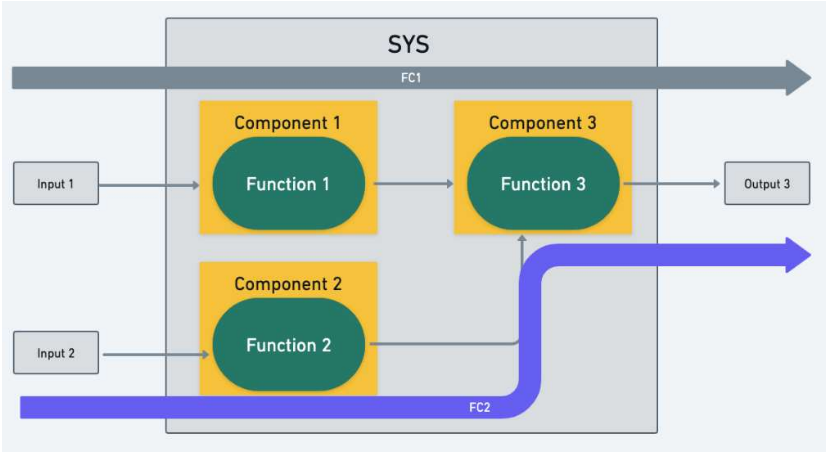


Figure 5 : Example system with functional chains

Even if the system is tested as a black box, the knowledge of its inner composition enables to infer some properties of its components. For example, an error detected on the functional chain FC2 implies that either Component 2 or Component 3 has defect. The testability analysis of such system would lead to test the functional chain FC1 to locate the defect: if the FC1 has no error, the defect is on the component 2 or in the connections of Component 2 with its neighbors.

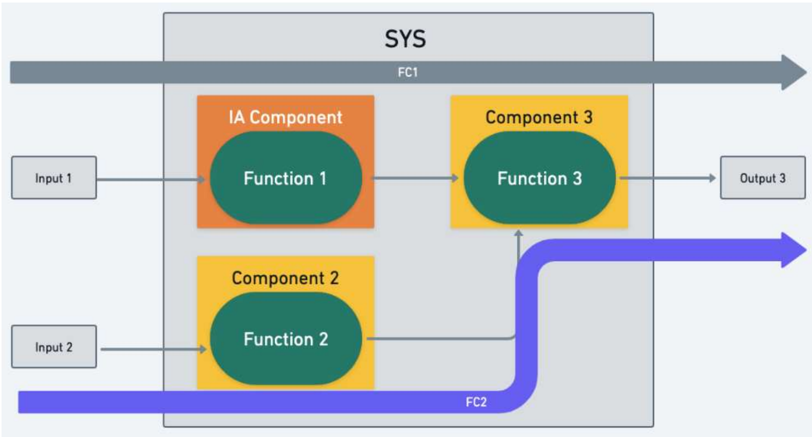


Figure 6 : Example of the introduction of AI component into A functional chains

The insertion of an IA based component implies to revalidate all the functional chains containing the IA based components. In the previous example, if the component 1 only is replaced by an IA, then revalidating FC1 is enough. If the component 3 is replaced, then the validation should encompass FC1 and FC2.

3.5 State of the art in AI evaluation and validation

Based on PRISSMA [1.1] the current key aspects of AI evaluation are listed below:

- *Specification of DNNs and understanding their dynamics with regard to changes in the input signal*
- *Design of datasets and creation of a training set that covers in the input ODD and functions specification in robust manner. Metrics that evaluate datasets for autonomous systems are a key metric/KPI.*
- *Measuring of uncertainty of AI systems are important to stochastically characterize the ODD of a DNN.*

The aspects to be evaluated during V&V of IA based system are listed below:

- *Repeatability, or the demonstration of the capability of the ADS to have the same response for the same events and classes of events (the same human crossing, or another human crossing)*
- *Robustness, with a focus on the tests at the limits of ADS Operational Domain*
- *Coverage and correlation analysis of the scenario used for testing in simulation*
- *Performance and precision of IA functions*
- *Anticipation & prediction rightness of the IA function*
- *Testability, which is a design characteristic which allow the status (operable, inoperable, degraded) of a system element to be determined and the isolation of faults within the system to be performed in a timely manner.*
- *Explicability and interpretability is the ability to explain the outcome of a component based on the knowing of is inner components and it’s input.*
- *Cyber security, with classical threat and risks assessments and mitigation tasks*
- *Resilience to defect including cyber security*
- *Traceability, like mentioned before*

4 NORMATIVE AND REGULATORY ENVIRONMENT

Automated driving testing in France

4.1.1. Regulation for experiments

The legislative and regulatory framework for organizing experiments on open roads with driver delegation vehicles was put in place by Article 37 of the 2015 Energy Transition Law. This law allows the French government to take the necessary measures for experiments with driverless vehicles by ordinance. These measures will be taken in the ordinance of August 3, 2016 and mainly incorporate the following elements:

- The experiments are subject to authorization.
- This authorization is issued by the minister in charge of transport after the opinion of several authorities (minister of the interior, road manager, traffic police and transport organizing authority).

This ordinance will subsequently be supplemented by two other texts. First, the decree of March 28, 2018 specifies the conditions for issuing the authorization. In these conditions we can note the following major points:

- The experiments must fall within one of the following cases: technical trials, performance evaluation or public demonstration.
- The experimentation may concern a passenger or freight transport service
- The authorization specifies the road sections on which the experimentation is authorized.
- In delegated driving mode, a natural person (driver) is responsible for driving the vehicle. This person may be outside the vehicle but must be able to take control of the vehicle at any time.

Secondly, the order of April 17, 2018, and then the order of May 26, 2021, which amends it, comes to describe the content of the application file for authorization. This file must contain:

- A questionnaire completed by the applicant.
- A list of the road sections making up the route.
- The list of manoeuvres envisaged within the framework of the experiment.

4.1.2. Other European countries

In most other European countries, tests and experiments on open roads require similar authorizations, as is the case in the United Kingdom, Finland, Germany and Spain. These authorizations are also issued on a case-by-case basis and the supporting elements may vary. The definition of the road sections used may be less exhaustive, for example.

4.1.3. CEN/ISO standards work in progress

Among the working groups and sub-groups concerned by the automated vehicle theme, we can mention the groups below which integrate real-life tests in their reflections or normalization process.

- ISO TC204 WG14 and WG18
- ETSI, Standard + Technical specifications

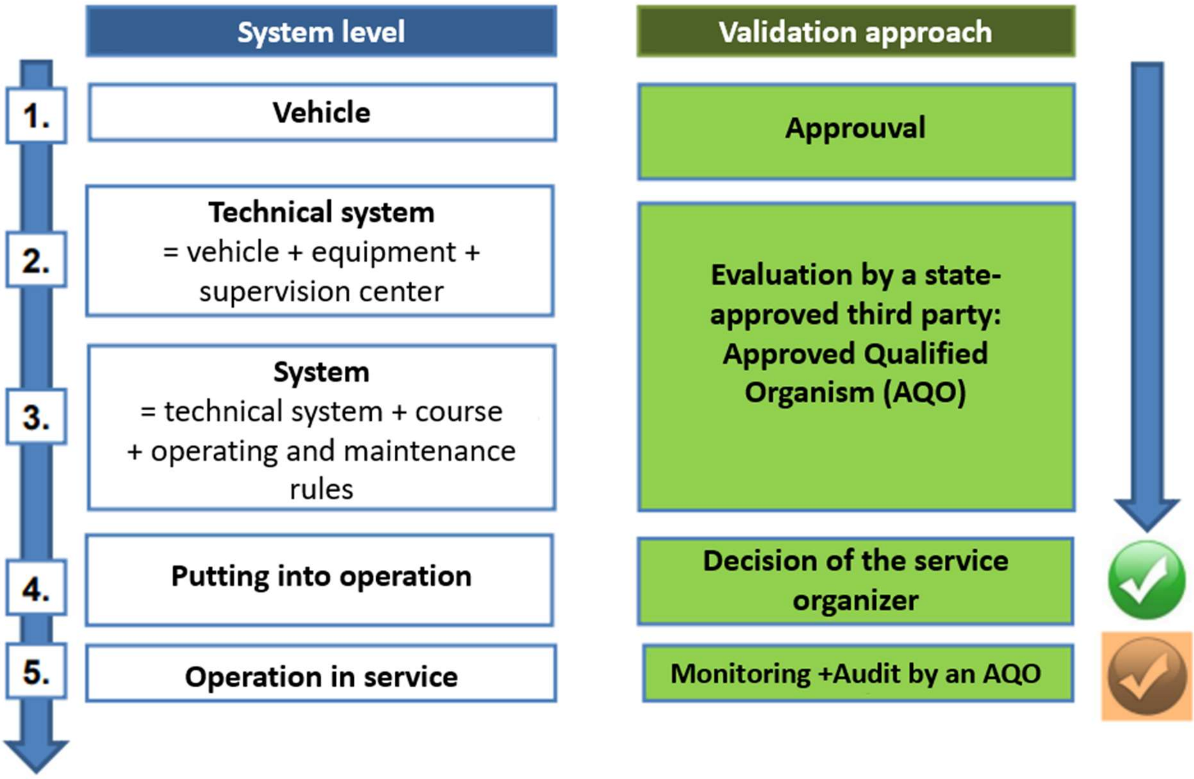
A new working group is also being created to deal specifically with AI in this automated mobility and which should take up the same test concept:

- WG20 on Big Data and Artificial Intelligence supporting ITS

4.1.4. Towards a definitive framework

In order to provide for the implementation of a permanent legislative framework, the law on the orientation of mobility opened the possibility of adapting the legislation to automated vehicles in 2019. This first step was then completed by the ordinance of April 14, 2021. The main purpose of this text is to specify the principles of responsibilities of each party. It was then completed by the decree of June 29, 2021 which sets the conditions for the deployment of automated road transport systems.
The following concepts are mainly addressed in these texts:

- Definitions of several notions such as automation levels, transport system, minimal risk and emergency maneuvers.
- The distinction of use cases with on-board or remote driver
- The general principle of safety demonstration presented below



Extracted and translated from French ministry of transport presentation on automated road transport regulation.

We note that the notion of routes, equipment and operating rules is well included in this safety demonstration process. These provisions will come into force on September 1st 2022. According to the Ministry of Transport, this regulatory framework has been designed to be complementary to the European approval by vehicle type, whose provisions are also being adapted.

5 TEST SITES IN REAL CONDITIONS

5.1 Different test sites

5.1.1. Examples USA

5.1.1.1. GoMentum Statio, Concord / Walnut Creek, California

1/ Aims and objectives

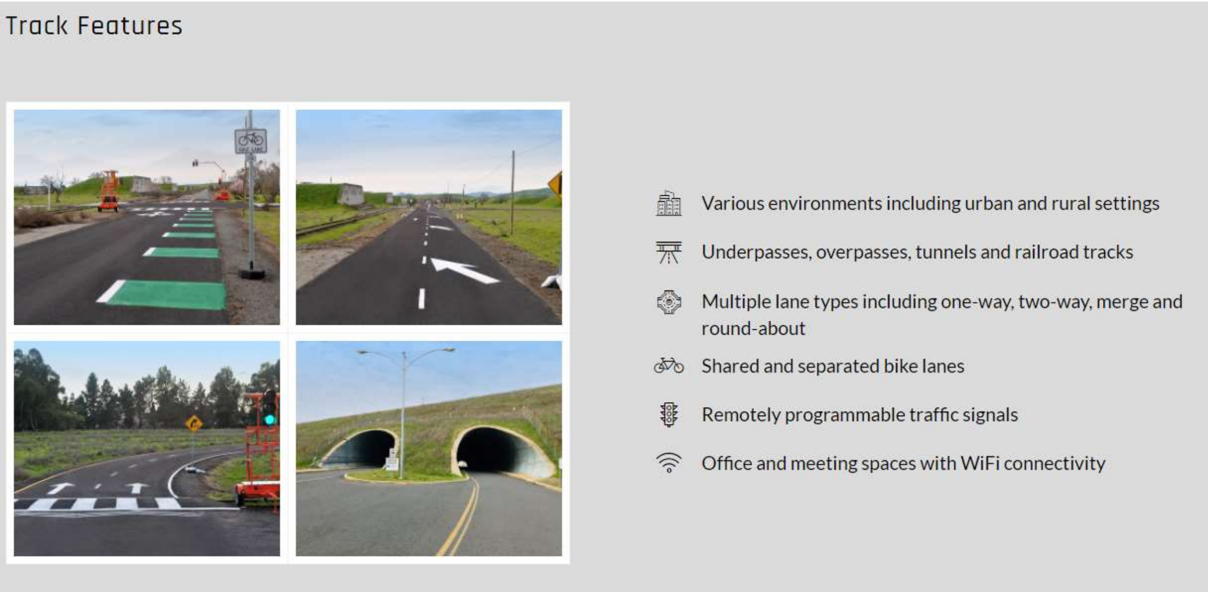
GoMentum Station, the largest secure testing facility dedicated to connected and automated vehicle technologies in the country, is owned and operated by AAA Northern California, Nevada & Utah, whose goal is to help members and the public adapt to the rapidly changing mobility landscape, while continuing to focus on road safety.

The 2,100-hectare GoMentum Station is the center for cutting-edge transportation research. The innovative technology explored and tested at GoMentum Station is working on the next generation of transportation, providing unprecedented mobility options for people, and will help advance road safety toward zero fatalities.

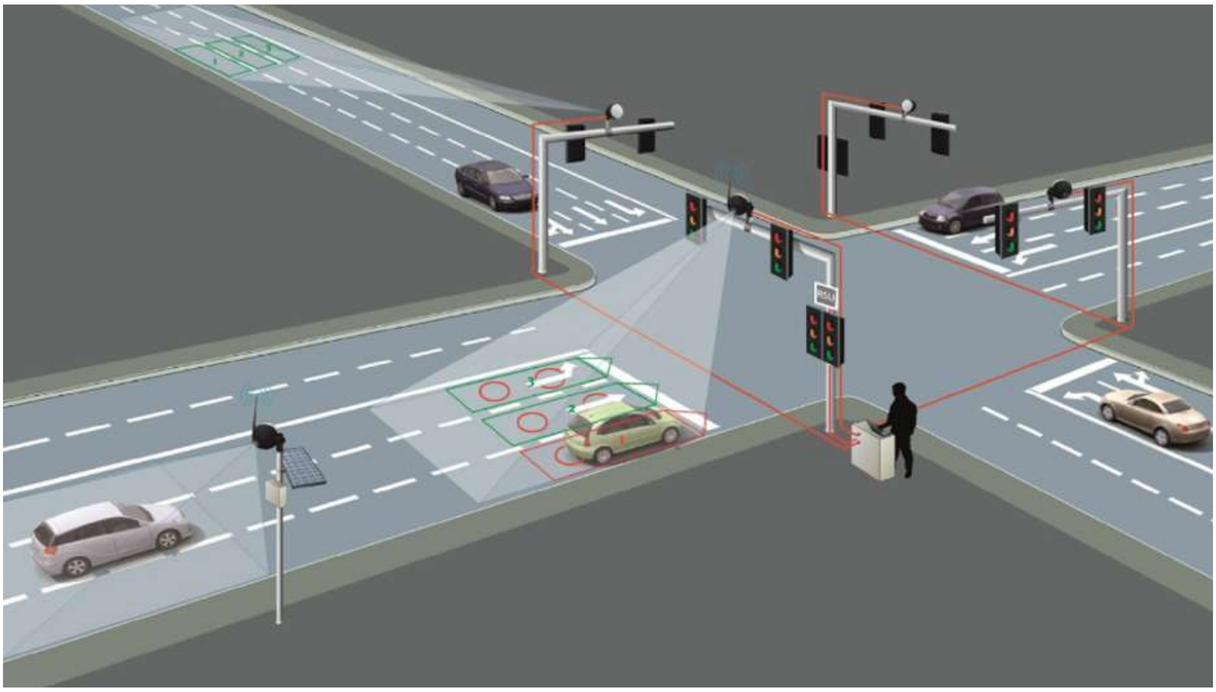
GoMentum Station is a partnership with the City of Concord and Contra Costa Transportation Authority.

2/ Description of the environment

It is a secure test bed allowing any type of company or vehicle to test their technologies under different conditions.



The track is more than 30 km long, with 48 intersections and 9 different zones (office simulation, road, city, etc.).
It also allows to simulate different conditions such as the passage of a 1km tunnel, crossroads, areas without right or left turn, areas in co-activity with bicycle lanes etc.



The V2X lab has controllers, video detection units, DSRC/C-V2X equipment and data switches that make up a modern city intersection. Currently, the lab has equipment from the following vendors:

- Traffic light controllers: Trafficware, Siemens, Intelight
- On-board units (OBU) / roadside units (RSU): Commsignia, Savari, TraffficCast, Siemens.
- Detection: Iteris, Blue City Technology
- Switch: Cisco with edge computing capabilities

The Lab offers training in the installation of this equipment as well as tutorials on various technologies.

- The communications are done in DSRC/CV2X/5G.
- SPAT/MAP/CAM type messages are communicated, as well as Emergency Vehicle Preemption (EVP) and Transit Signal Priority (TSP) signals.

3/ Use cases

Digital twin: GoMentum has developed a digital twin of its entire environment in 3D to enable the development and testing of driver assistance system functions, to create its own scenarios...

GPS data correction: RTK (real-time kinematic) corrected GPS accuracy is used for applications that require higher accuracy, such as centimeter positioning down to 2 cm.

At GoMentum, three OxTS GPS base stations are available. One is located at the fire station and covers the entire downtown area up to the tunnels. A second base station is located in Bunker C on 12th Street. A third mobile GPS base station (RT-Base S) can be deployed anywhere in the facility.

The corrections are offered in different formats: RTCA, RTCA2, RTCM, RTCMv3, CMR, CMR+. Update rates vary according to the format. The corrections are transmitted by Freewave FCR2 900 Mhz radios. Novatel receivers can be configured to receive corrections using NavConnect.

Test Scenarios:
Structured scenarios are an established method for testing the behavioral performance of automated vehicles. Structured scenarios are orchestrated maneuvers of various roadway actors-such as pedestrians or encroaching vehicles-that allow for a reproducible evaluation of a vehicle under test (VUT). These maneuvers are typically based on pre-existing standards tests, natural driving logs, or public databases. The performance of the STV in these scenario tests forms the basis for its behavioral competencies.

Several structured scenarios for Level 2 and Level 3/4 ADAS that assess the following competencies, either via prescribed test protocols or via custom derived protocols using GoMentum's unique features are offered:

- NHTSA Forward Collision Warning (FCW)
- NHTSA Lane Departure Warning (LDW)
- NHTSA's Imminent Crash Braking (ICB)
- IIHS Autonomous Emergency Braking (AEB)

- IIHS Autonomous Pedestrian Emergency Braking (PAEB)
- NHTSA Traffic Jam Assist (TJA)
- Euro NCAP Car-to-Car Automatic Emergency Braking (AEB C2C)
- Euro NCAP Automatic Emergency Braking for vulnerable road users (AEB VRU)
- Euro NCAP Lane Keeping System (LSS)
- Euro NCAP Speed Assist Systems (SAS)
- Traffic light priority
- Detection of a vulnerable user

[L0.1] Annual Project Status Report

Identity card of the site							
Infrastructure	Test bed installed between Concord and Walnut Creek, including 30km of road. This test bed allows for the testing of different situations for various autonomous mobilities.						
Since When	In October 2014, the Contra Costa Transportation Authority announced that the GoMentum Station proving grounds would be used to test self-driving cars; according to them, "The public will not have access to the test site, and the self-driving cars will be restricted to the test bed site. With 2,100 acres (850 ha) of testing area and 19.6 miles (31.5 km) of paved roadway, the CNWS is currently the largest secure test bed site in the United States". Mercedes-Benz is reported to have licenses to test new driving technology, including smart infrastructure such as traffic signals that communicate with cars.[citation needed] Among the site's other notable features: "a 7-mile (11 km)-long roadway is great for testing high-speed driving, and a pair of 1,400-foot (430 m)-long tunnels" for sensor testing. Among the roughly 30 partners listed on the company's site are automakers Toyota and Honda, ridesharing companies Uber and Lyft and China-based autonomous driving company Baidu. In summer 2015, reports suggested the Apple electric car project was interested in using the site, as members of Apple's Special Project group were reported to have met GoMentum representatives but there were no subsequent reports of Apple personnel and vehicles actually using the site.The property was acquired and repurposed by the Contra Costa Transportation Authority, acquired in August 2018 by AAA Northern California, Nevada & Utah. In August 2019, GoMentum announced the October launch of its V2X (vehicles-to-everything) testing facility.						
Purposes	GoMentum Station, the nation's largest dedicated secure testing facility for connected and automated vehicle technology, is owned and operated by AAA Northern California, Nevada & Utah, whose goal is to assist members and the public in adapting to the fast-changing mobility landscape, while continuing to focus on traffic safety. The 2,100 acre GoMentum Station is the center of cutting-edge transportation research. The innovative technology being explored and tested at GoMentum Station will redefine the next generation of transportation, bring unprecedented mobility options to people, and help advance traffic safety towards zero fatalities. GoMentum Station is a partnership with the City of Concord and Contra Costa Transportation Authority.						
Stakeholders	Concord (city) Contra Costa Transportation Authority AAA Northern California, Nevada & Utah (American Automobile Association) : site management Traffic Signal Controllers: Trafficware, Siemens, Intelight On-Board Unit (OBU) /Roadside Unit (RSU): Commsignia, Savari, TraffficCast, Siemens Detection: Iteris, Blue City Technology Switches: Cisco with edge computing capabilities						
Road type	The track is more than 30km long, with 48 intersections and 9 different zones (office, road, city simulation etc.). It also allows for the simulation of different conditions such as a 1km tunnel, crossroads, areas without right- or left-turns, areas in co-activity with cycle tracks etc.						
Type of equipment installed	Network coverage	RSU	Traffic signal Computer	Traffic signal controler	DSRC radio antenna	video cameras	Switch IP
	5.9 GHz Dedicated Short Range Communications (DSRC) / C-V2X - 5G	X	X	X	X	X	X
Functionalities related to the deployed equipment	RSU = V2X communication (link to in-vehicle equipment) PC = contains the applications, runs the algorithm Bluetooth scanner = allows tracking of vehicles on travel time and traffic density issues						
Type of vehicles being tested	Particular connected vehicle	Priority vehicle (eg : emergency)	Autonomous Public transportation				
On going use case (or going to be)	NHTSA Forward Collision Warning (FCW) NHTSA Lane Departure Warning (LDW) NHTSA Crash Imminent Braking (CIB) IIHS Autonomous Emergency Braking (AEB) IIHS Pedestrian Autonomous Emergency Braking (PAEB) NHTSA Traffic Jam Assist (TJA) Euro NCAP Automatic Emergency Braking Car-to-Car (AEB C2C) Euro NCAP Automatic Emergency Braking Vulnerable Road User (AEB VRU) Euro NCAP Lane Support Systems (LSS) Euro NCAP Speed Assist Systems (SAS)						
Application	C-ITS						
C-ITS shared (or going to be)	MAP	SPAT	CAM	EVP	TSP		
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock						
Links	http://gomentumstation.net/v2x-lab/						

5.1.1.2. El Camino (California - SR82)

1/ Aims and objectives

In 2005, Caltrans partnered with the Metropolitan Transportation Commission (MTC) and UC Berkeley's California PATH program to create the nation's first public connected vehicle testbed on El Camino Real (State Route 82), a signalized arterial roadway that serves more than 50,000 vehicles traveling between San Francisco and San Jose each day.

In 2018, Caltrans and PATH collaborated with the USDOT (US Department of Transportation) to update the testbed equipment so that it is now compliant with the latest standards and implementation architecture for the Mapconnected vehicle Testbed. These upgrades were recently used to successfully demonstrate the Multi-Modal Intelligent Traffic Signal System (MMITSS), including Connected Vehicle-based traffic control and signal priority for transit, freight, and pedestrians, and eco-driving, two important applications of connected vehicles that were developed with USDOT funding.

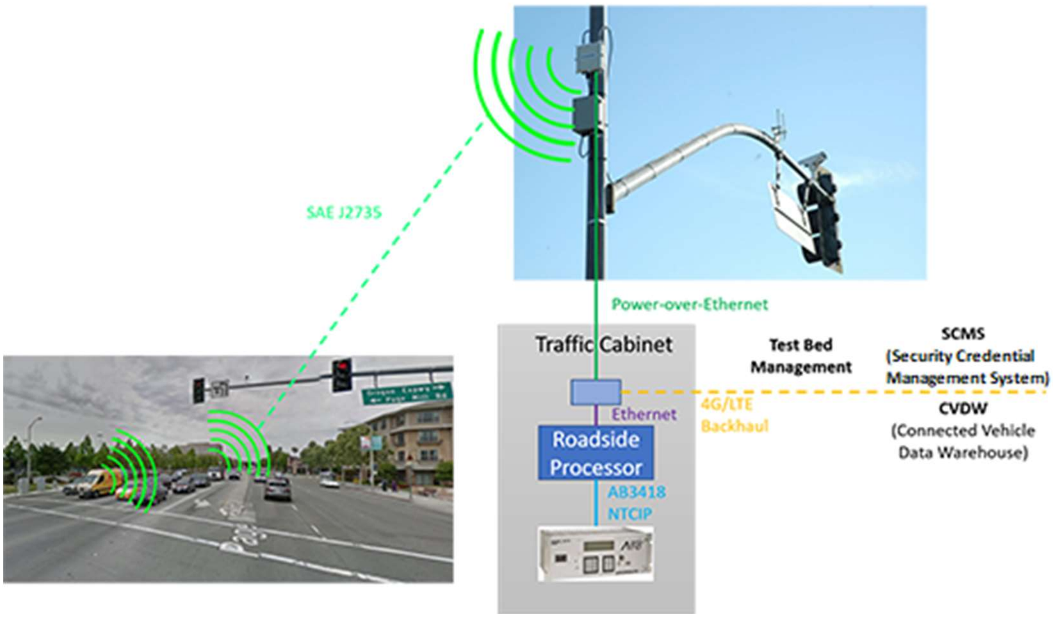
Starting in January 2019, Caltrans is working with PATH to expand the testbed size from the initial 11 intersections to 31 intersections between Medical Foundation Dr in Palo Alto and Grant Rd in Mountain View. In November 2019, the testbed has 16 operational intersections between Medical Foundation Dr and Dinah's Ct in Palo Alto. It is anticipated that this connected vehicle corridor will serve as a model deployment that can be replicated on similar corridors in other urban areas of California.

2/ Description of the environment

V2I Message Rate (messages per second)

Cross-Street Name	Outbound Rate			Inbound Rate				Last Update
	MAP	SPaT	RTCM	BSM	MAP	SPaT	RTCM	2022-03-02 14:37:15
Medical Foundation Dr	1	9	6	0	1	10	6	8
Embarcadero Rd	1	10	6	0	1	21	9	7
Churchill Ave	1	10	6	0	1	10	5	9
Serra/Park	1	10	6	0	4	43	22	5
Stanford Ave	1	10	6	0	4	40	21	7
Cambridge Ave	1	10	6	0	4	39	20	2
S California Ave	1	10	6	0	6	59	25	7
Page Mill Rd	1	10	6	0	3	28	14	4
Portage/Hansen	1	10	6	0	4	39	19	5
Matadero Ave	1	9	6	0	5	57	26	5
Curtner Ave	1	10	5	0	3	30	16	7
Ventura Ave	1	10	6	0	3	33	18	3
Los Robles Ave	1	9	6	0	4	45	22	7
Maybell Ave	1	10	6	0	2	28	14	1005926
W Charleston Rd	1	9	6	0	2	20	11	8
Dinahs Ct	1	10	6	0	1	10	6	3

Caltrans is working with PATH and ProspectSV to ensure that the testbed is available to all developers to test the performance of connected vehicle technologies in real-world conditions.



Message	Abbreviation	From	Frequency	To	Channel	PSID	DSRC Message ID
MAP/GID	MAP	RSU	1 Hz	OBU	180	0p80-02 (0x82)	18
Signal Phase and Timing	SPaT		10 Hz				19
Signal Status Message	SSM		1 Hz			0pE0-00-00-15 (0x20-40-95)	30
Basic Safety Message	BSM	OBU	10 Hz	RSU	180	0p20 (0x20)	20
Signal Request Message	SRM		Asynchronous			0pE0-00-00-16 (0x20-40-96)	29
RTCM Corrections Message	RTCM	RSU	Type 1004 1 Hz	OBU	180	0p80-00 (0x80)	28
			Type 1012 1 Hz				
			Type 1006 1/15 Hz				
			Type 1007 1/15 Hz				

3/ Use cases

- Speed limits
- Detection and warning of wrong way
- Traffic light priority
- Status of the lights

[L0.1] Annual Project Status Report

Identity card of the site						
Infrastructure	Test bed installed on El Camino Real Corridor (SR 82, in California), in a very dense urban area, in a straight line but crossing 31 intersections, and crossed by 50 000 vehicles/day.					
Since When	Test bed installed in 2005 as part of a PATH research project, and perpetuated since.					
Purposes	The challenge is to create a full-scale demonstrator that will serve as the basis for connected infrastructure and connected (and autonomous) mobility for all California projects. The project uses the latest communication standard of the American automotive industry (SAE Dedicated Short Range Communications (DSRC) Message Set Dictionary J2735_201603) The UBRs used are version 4.1 The communication between the UBR and the light controller is done using the AB3418 protocol.					
Stakeholders	PATH project (University of Berkeley - Algorithm) DIGI (Sensors / IOT) MobileMark (Antennas, communication equipment) Caltrans (California Department of Transportation) / ProspectSV (Silicon Valley) (cluster managed by CalTrans) US Department of Transportation (regulation, standardisation)					
Road type	Main road in a dense urban centre with 31 junctions included in the test bed					
Type of equipment installed	Network coverage	RSU	Traffic signal Computer	Traffic signal	DSRC radio antenna	Backhaul
	DSRC (5,9 Ghz)	X (31)	31 (linux)	31 (Caltrans 2070 traffic controller)	31	X
Functionalities related to the deployed equipment	RSU = V2X communication (link to in-vehicle equipment) PC = contains the applications, runs the algorithm					
Type of vehicles being tested	Particular connected vehicle	Priority vehicle (eg : emergency)				
On going use case (or going to be)	Speed limits Detection and warning of wrong way Traffic light priority Traffic light status					
Application	C-ITS					
C-ITS shared (or going to be)	MAP/GID	SPAT	SSM - Signal Status Message	Basic Safety Message - BSM	SRM - Signal request message	RTCM corrections message
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	Lien : https://www.caconnectedvehicletestbed.org/index.php/about.php#rsu-version					

5.1.1.3. Tallahassee (Florida US90)

1/ Aims and objectives

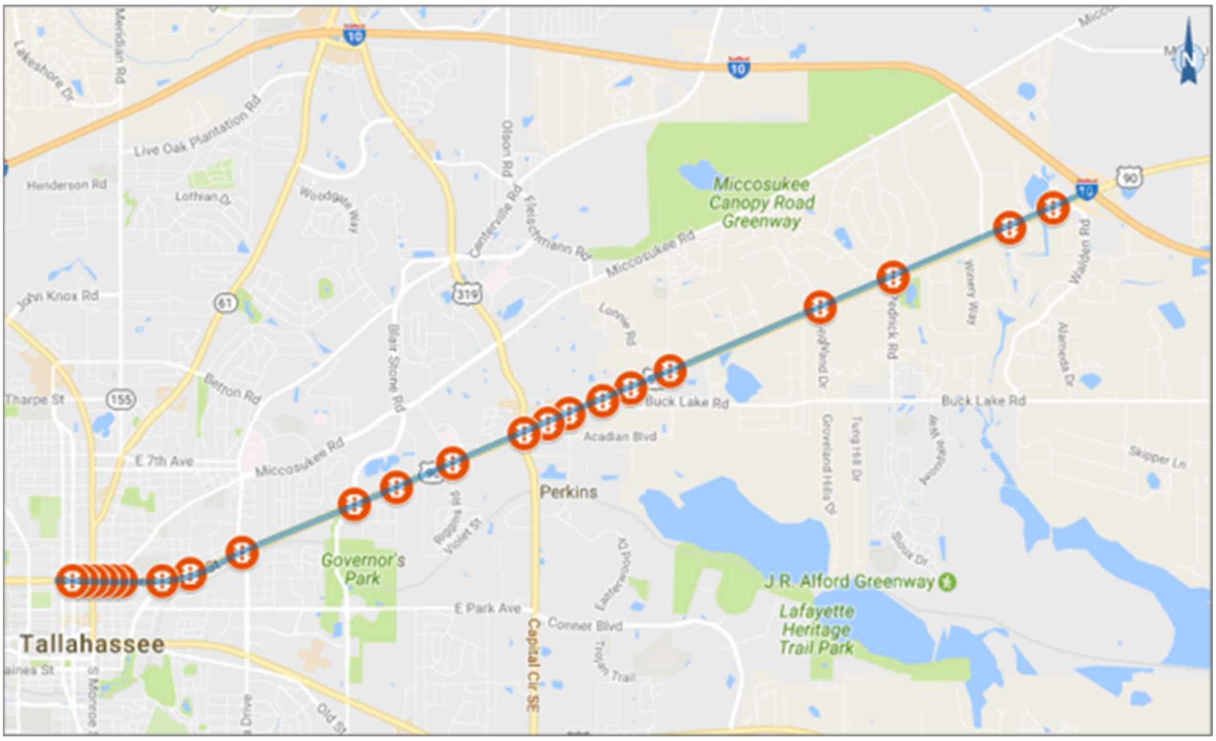
As part of the Florida Department of Transportation's Transportation Systems Management and Operations (TSM&O) program, traffic management solutions have once again become a priority, particularly due to the technological advances offered by connected vehicles (CVs). A concrete example is the major SPAT challenge project using CV technology underway in the city of Tallahassee.

The testing and implementation of SPaT at select Florida intersections advances the capabilities of connected vehicles, particularly in intersection safety applications. They will also provide FDOT and local agency staff with experience in operating and maintaining CV infrastructure and applications.

The main issue in the short term was to verify if the system worked well, especially on this hilly and forested road along US90.
The long-term challenge was to verify the effectiveness and safety of the device for users.

2/ Description of the environment

- The American Association of State Highway and Transportation Officials (AASHTO) has challenged all states to deploy dedicated short-range communications (DSRC) at a minimum of 20 intersections by 2020.
- US 90 Mahan Drive will have 22 signalized intersections equipped with DSRC.
- FDOT and the City of Tallahassee have partnered to install RSU to broadcast SPaT information 24/7 for in-vehicle units (OBUs) to receive.



3/ Use cases

- Speed limits
- Detection and warning of wrong way
- Traffic light priority
- Status of the lights
- Travel time measurement

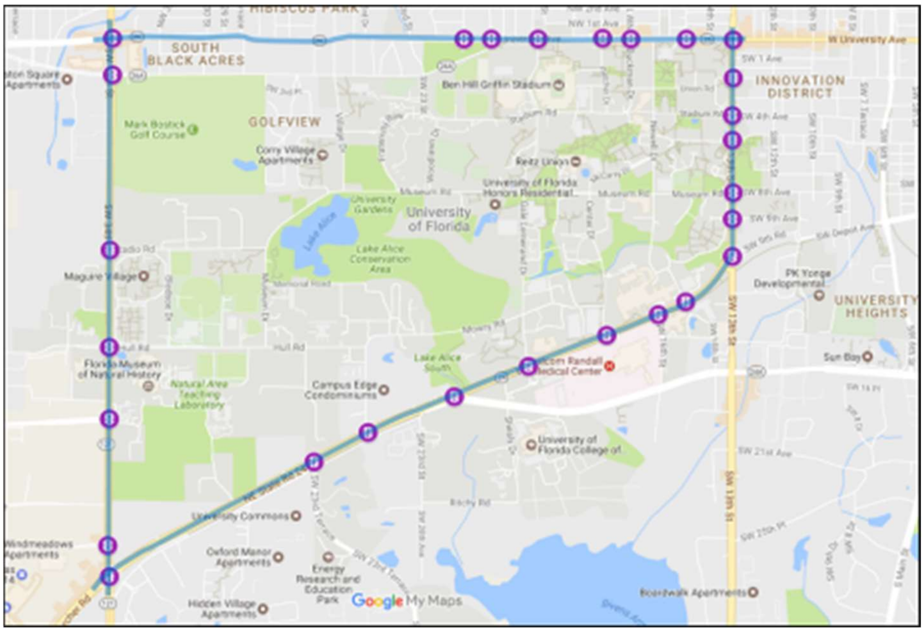
Identity card of the site						
Infrastructure	US90 Tallahassee Road (Florida), where 22 intersections / traffic light junctions were equipped with short-range communication devices (DSRC), RSU to broadcast 24/7 SPAT messages to the OBUs of connected vehicles					
Since When	Test bench installed in 2017 which is intended to be perpetuated.					
Purposes	The challenge is to be able to create a full-scale demonstrator here in connection with the SPAT Challenge led by AASHTO in conjunction with the local authorities, in order to have tests on connected roads and SPAT messages throughout the USA. This is one of three demonstrators in Florida, along with Pinellas County and Gainesville Trapezium.					
Stakeholders	FDOT (Florida Department of Transportation - equipment configuration and SPAT messages) City of Tallahassee (installs equipment, on poles, and light controllers) AASHTO (American Association of State Highway and Transportation Officials) US Department of Transportation (regulations, standards) OEM (for UBRs - trains city crews to maintain equipment) FDOT, city and OEMs handle RSU / OBU / traffic signal controller communication testing.					
Road type	Main road in a dense urban centre with 22 junctions included in the test bed					
Type of equipment installed	Network coverage	RSU	Traffic signal Computer	Traffic signal	DSRC radio antenna	MCTT
	5.9 GHz Dedicated Short Range Communications (DSRC)	X (35)	22 (linux)	22	22	Multichannel test tool
Functionalities related to the deployed equipment	RSU = V2X communication (link to in-vehicle equipment) PC = contains the applications, runs the algorithm Bluetooth scanner = for travel time and traffic density					
Type of vehicles being tested	Particular connected vehicle	Priority vehicle (eg : emergency)				
On going use case (or going to be)	Speed limits Detection and warning of wrong way Traffic light priority Traffic light status Travel time measurement					
Application	C-ITS					
C-ITS shared (or going to be)	MAP	SPAT				
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	https://books.google.fr/books?id=7o0TEAAAQBAJ&pg=PA164&lpg=PA164&dq=Pinellas%20County%20SPaT&s https://www.fdot.gov/traffic/its/projects-deploy/cv/maplocations/us90-spat.shtm					

5.1.1.4. Gainesville SPaT Trapezium

1/ Aims and objectives

This project is being deployed with connected vehicle (CV) technologies and applications along four roads forming a trapezoid surrounding the University of Florida's main campus. These are SR 121 (SW 34th St), SR 26 (W University Ave), US 441 (SW 13th St) and SR 24 (SW Archer Rd). The goal of the project is to improve travel time reliability, safety, throughput and traveler information. This project will also deploy and test pedestrian and bicycle safety via connected vehicles and smartphone applications.

2/ Description of the environment



The project covers 27 traffic signals equipped with 27 roadside units. The project became operational in September 2019.

The project involved a number of different vehicles (71) each equipped with OBU (on-board communication):

- 4 city vehicles
- 2 FDOT vehicles
- 38 campus-related vehicles
- 10 buses
- 17 fire trucks

The project has been completed and is currently operated and maintained by the City of Gainesville. The University of Florida is validating the performance and results of the implemented technologies. FDOT and the City of Gainesville have become familiar with how V2X applications can be used to address safety and mobility issues and understand the variables of such a technology deployment. FDOT and the vendors will continue to provide training and workforce development to support similar initiatives in the future. The City of Gainesville will be able to improve the monitoring of these critical intersections and roadways. Improvements have been made to bicycle and pedestrian safety through the use of innovative smartphone-based applications. This project creates a test bed for emerging ITS technologies.

3/ Use cases

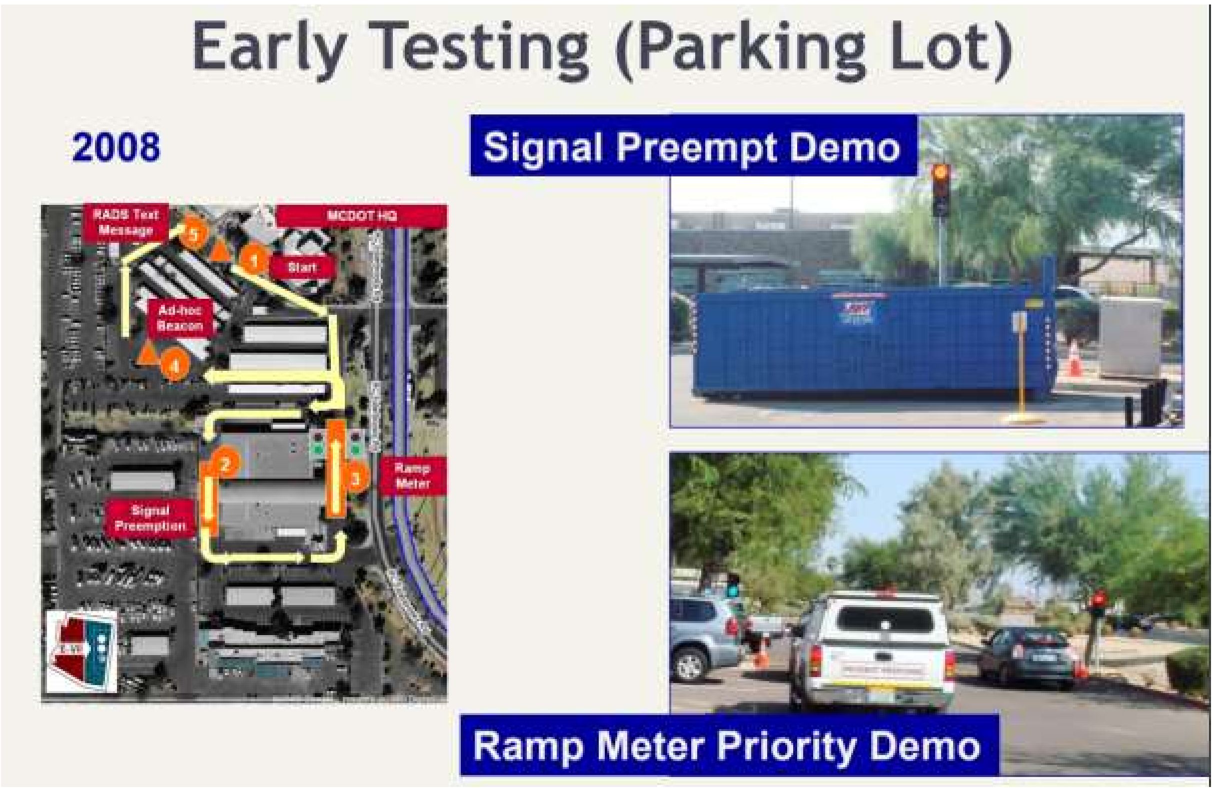
- Speed limits
- Detection and warning of wrong way
- Priority to fire
- Status of the lights
- Traffic jam detection
- Travel time (bluetooth)

Identity card of the site						
Infrastructure	Florida, City of Gainesville. A connected "trapezoid" was installed comprising 4 main roads around the University of Florida campus (present on site). 27 intersections were equipped with OBUs, short-range antennas, and connected to traffic light controllers. 71 OBUs were also deployed on a variety of vehicles.					
Since When	The test bench installed in 2017, which is intended to be made permanent, has been operational since 2019.					
Purposes	The challenge is to be able to create a full-scale demonstrator here in connection with the SPAT Challenge led by AASHTO in conjunction with the local authorities, in order to have tests on connected roads and SPAT messages throughout the USA. This is one of three demonstrators in Florida, along with Pinellas County and Gainesville Trapezium.					
Stakeholders	FDOT (Florida Department of Transportation - equipment configuration and SPAT messages) City of Gainesville (installs equipment, on poles, and light controllers) AASHTO (American Association of State Highway and Transportation Officials) US Department of Transportation (regulations, standards) OEM (for RSU - trains city crews to maintain equipment) FDOT, city and OEMs handle RSU / OBU / traffic signal controller communication testing					
Road type	Main road in a dense urban centre with 31 junctions included in the test bed					
Type of equipment installed	Network coverage	RSU	Traffic signal Computer	Traffic signal	DSRC radio antenna	MCTT
	5.9 GHz Dedicated Short Range Communications (DSRC)	X (27)	27 (linux)	27	27	Multichannel test tool
Functionalities related to the deployed equipment	RSU = V2X communication (link to in-vehicle equipment) PC = contains the applications, runs the algorithm Bluetooth scanner = for travel time and traffic density					
Type of vehicles being tested	Particular connected vehicle	Priority vehicle (eg : emergency)	Autonomous Public transportation			
On going use case (or going to be)	Speed limits Detection and warning of wrong way Traffic light priority Traffic light status Traffic jam detection Travel time (bluetooth)					
Application	C-ITS					
C-ITS shared (or going to be)	MAP	SPAT				
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	https://www.fdot.gov/traffic/its/projects-deploy/cv/maplocations/gains-trapezium.shtm					

5.1.1.5. Anthem Arizona

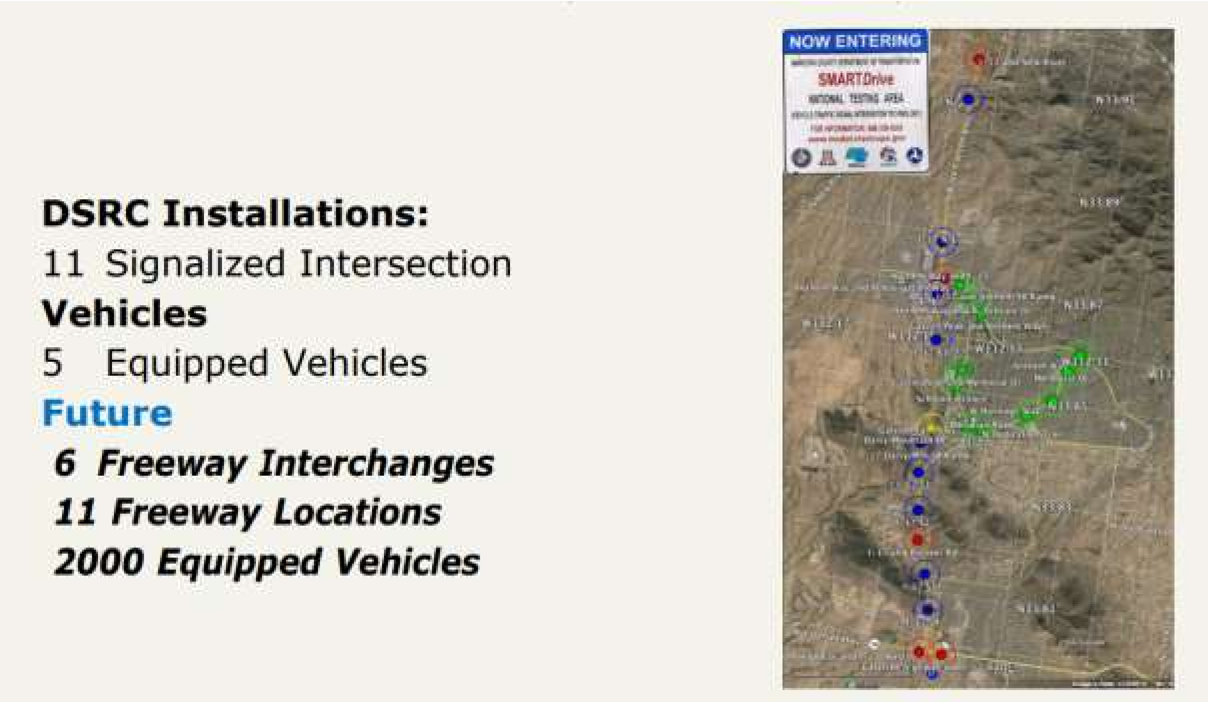
1/ Aims and objectives

The Connected Infrastructure project began in 2007 with thoughts on traffic control along major roads in the city of Anthem, Arizona.
The first experiments took place in 2008 in an industrial zone with large parking lots.



2/ Description of the environment

5 initial intersections were equipped with RSUs, antennas connected to traffic signal controllers in 2010 and since 2011, this has included 11 intersections along a 5.5 mile stretch of West Daisy Mountain Drive, Anthem, AZ, with planned expansions along I-17, I-10 and MC-85.



The challenge is to advance multi-vehicle signal priority technologies in a real-world traffic environment, demonstrate signal priority and traveler/pedestrian information applications, and integrate the I-17 interchange.

FIGURE 3

DSRC Radio Unit Installed on an Intersection Luminaire

Identity card of the site						
Infrastructure	11 intersections along an 8km stretch of West Daisy Mountain Drive, Anthem, AZ, with planned extensions along I-17, I-10 and MC-85 (Anthem Arizona)					
Since When	Test bench installed in 2010, operational since 2011 and extended to 11 traffic light junctions.					
Purposes	The challenge is about being able to carry out a full-scale demonstrator here in connection with the SPAT Challenge led by AASHTO in conjunction with the local authorities, in order to have tests on connected roads and SPAT messages throughout the USA.					
Stakeholders	ADOT (Arizona department of transportation - setting of SPAT messages) MCDOT (Maricopa County Department of Transportation - algorithm and applications, manages all the city's traffic lights) Arizona university US DoT (regulation) Equipment providers (RSU, city tech training, maintenance) ADOT, the city and the providers manage communication tests RSU/OBU/traffic signal controlers					
Road type	Main road in a dense urban centre with 11 junctions included in the test bed					
Type of equipment installed	Network coverage	RSU	MMITSS	Traffic signal	DSRC radio antenna	Blackhaul
	5.9 GHz Dedicated Short Range Communications (DSRC)	X (11)	X (MULTI-MODAL INTELLIGENT TRAFFIC SIGNAL SYSTEM)	11	11	x
Functionalities related to the deployed equipment	UBR = V2X communication (link to in-vehicle equipment) PC = contains the applications, runs the algorithm					
Type of vehicles being tested	Particular connected vehicle	Priority vehicle (eg : emergency)	Autonomous Public transportation			
On going use case (or going to be)	Speed limits Detection and warning of wrong way Traffic light priority Safety of vulnerable road users					
Application	C-ITS					
C-ITS shared (or going to be)	MAP	SPAT	CAM			
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	https://www.azcommerce.com/media/1546949/anthem_az_final_mcdot.pdf					
	https://www.youtube.com/watch?v=2wYWQo81RQ4					

5.1.2. Examples Europe

5.1.2.1. Paris Saclay Autonomous Lab

1/ Aims and objectives

The project aims to develop new autonomous mobility services, i.e. without a driver, on dedicated lanes, public roads and campuses, in addition to the existing transport solutions on the Saclay plateau.

It integrates cutting-edge technologies in terms of on-board vehicle intelligence, supervision systems, connected infrastructures, and secure telecommunications networks. It was co-sponsored by the Renault group, the Transdev group, the Vedecom Institute, the IRT SystemX, and the University of Paris-Saclay with the contribution of ENSTA.

Launched in 2017, the Paris-Saclay Autonomous Lab project is one of the experiments selected on April 24, 2019 by the government after the call for projects "Autonomous Road Vehicle Experimentation" (EVRA) launched in June 2018 as part of the Programme d'Investissements d'Avenir (PIA). It aims to test a complete autonomous transport system, consisting of autonomous vehicles (3 Renault ZoéCab prototypes and 1 Transdev-Lohr i-Cristal shuttle), fleet supervision, connected infrastructure and customer applications. The aim is to define the conditions for deploying an autonomous mobility service on a larger scale.

2/ Description of the site environment

The experimentation will be opened gradually from May 21, 2019 to a panel of users. For this large-scale experiment, 9 km of fiber optics were laid throughout the experimentation area, as well as 4 km of electrical cable and 6 km of Ethernet cable. Nearly 200 public lighting poles were used, supplemented by 70 temporary poles. On the 8 km of road, 25 sites (multi-modal interchange, intersections with traffic lights, traffic circles, bus stops...) were equipped with communication and perception infrastructures. 85 sensors were deployed (10 M8 lidars, 20 thermal cameras for vehicle detection, 20 thermal cameras for pedestrian detection, 35 video cameras) as well as 25 roadside units, associated with 25 roadside cabinets containing the processing units and network equipment. This RSU + box set, designed by Vedecom and named Vedecom Box, allows the processing and the communication of upstream and downstream information from the vehicle.

The Renault ZOECab prototypes and the Transdev-Lohr i-Cristal shuttle are 100% electric and equipped with autonomous technologies. Equipped with Lidar-type sensors, cameras, an inertial unit and autonomous driving software, they integrate all the usual traffic constraints: identification of the presence of other vehicles or pedestrians, management of crossroads, traffic circles or speed bumps, traffic light recognition, etc. They are level 4 (SAE standard - fully autonomous in specific areas). Inside, the vehicles are equipped with cameras and information screens to accompany passengers during their journey.

The communicating and intelligent infrastructure was designed, implemented and developed by Vedecom, which also managed the entire human factors study of the project (pedestrian and passenger relations with the autonomous vehicle).

Paris-Saclay Autonomous Lab' is a complete autonomous transport system, including electric and autonomous vehicles, a centralized control station for supervising services, a connected infrastructure and client applications.

-Intelligent autonomous vehicles

The 100% electric Renault ZOE Cab prototypes and the Transdev-Lohr i-Cristal shuttle incorporate all the usual traffic constraints, such as identifying the presence of other vehicles and pedestrians, managing intersections, roundabouts, speed bumps and recognizing traffic lights. These vehicles are equipped with sensors such as GPS, Lidar, cameras, an inertial unit and autonomous driving software, with complete autonomy in specific areas.

Inside, the vehicles are equipped with cameras and screens to accompany passengers during their journey.

The experimentation takes place with a "safety operator" on board the vehicle.

Intuitive and user-friendly client applications

-The Mobibot by Transdev smartphone application allows users to follow the route taken by the Transdev-Lohr i-Cristal shuttle in real time. The user can thus know the time of arrival of the shuttle at its stop, as well as have a simulation of its journey - geographical and temporal - to its destination with integration of its possible journey on foot.

-A Marcel smartphone application, specific to the ZOE Cab experiment, allows users to reserve an autonomous car on demand, for an immediate or delayed trip. Depending on the user's location, the application directs him to the nearest meeting point and indicates the vehicle's arrival time. On board the vehicle, the user can follow his journey on the application and his arrival time at the drop-off point.

-A connected urban infrastructure

The Paris-Saclay Autonomous Lab services must fit into the traffic flow and reach speeds compatible with the traffic while guaranteeing a very high level of safety, both on open two-way roads and on the dedicated bus lane. To achieve these levels of service, the project partners have decided to deploy and test a connected infrastructure that will be composed of connected traffic lights, sensors and connectivity equipment at the roadside. These are mainly thermal cameras and lidars placed at 25 strategic locations. This infrastructure provides vehicles and supervision with enhanced vision to anticipate any unforeseen events. The communicating traffic lights allow vehicles to adapt their approach speed according to the state of the light. Finally, in order to improve the safety of pedestrians and cyclists, the contribution of connected objects such as smartphones or watches will be studied in the experimentation to be taken into account by the autonomous vehicle or to alert the equipped user.

-Supervision from a Centralized Control Station

The supervision system allows the Centralized Control Station located in Massy station to monitor and control the proper functioning of the services in real time. The supervisor can visualize all the vehicles in circulation, monitor their status, the status of the system components and, thanks to the connected infrastructure, anticipate possible obstacles on the route and intervene if necessary. The supervisor has the possibility to be in direct contact with the passengers and can interact with them.

3/ Use cases

The project will evaluate two main aspects: the technological aspect, with the implementation of an autonomous and connected transport system; and the acceptability aspect, with the reception of panelists to study the appropriation of the services by the final customers.

- A night-time public transport service on a dedicated lane with an autonomous Transdev-Lohr i-Cristal shuttle, which will serve the Plateau de Saclay neighborhoods from Massy station, outside the operating hours of the existing regular services, and using the dedicated TCSP (Transport Collectif en Site Propre) lane used by the buses
  From 12:30 a.m. to 3 a.m., an autonomous Transdev-Lohr i-Cristal shuttle will serve - in both directions - 4 stops (Massy Palaiseau, Palaiseau Ville, La Vallée, Camille Claudel) over a total distance of nearly 6 kilometers. This service will provide users with a night-time link between Massy station and the Saclay plateau, in addition to their travel by train, RER, bus, etc.
  This service is designed to be perfectly consistent with the existing public transportation offer, with a view to ensuring continuity of service and extending the schedule. It optimizes the existing road infrastructure and commercial speed, thanks to the use of dedicated lanes for public transit. It also relies on existing stops, which provide optimal service to the main districts, from Massy station to Camille Claudel, located in Palaiseau.

- A daytime on-demand car service provided by autonomous Renault ZOE Cab prototypes on the Paris-Saclay urban campus. This service will allow people who travel to the campus by public transport to move freely around the site.
  Service operation:
    - The user calls in real time, or reserves, a vehicle from a dedicated Marcel smartphone application.
    - A prototype Renault ZOE Cab autonomous and electric picks up the user at the nearest meeting point.
    - The user gets into the vehicle and is driven to the nearest drop-off point.
    - If necessary, the car stops on the way to pick up another passenger to make all or part of the same journey.

  This service aims to provide a fine service to the territory with meeting and drop-off points that do not hinder the traffic of other road users, chosen in the immediate vicinity of the most frequented places, and never much further than 300 meters away.

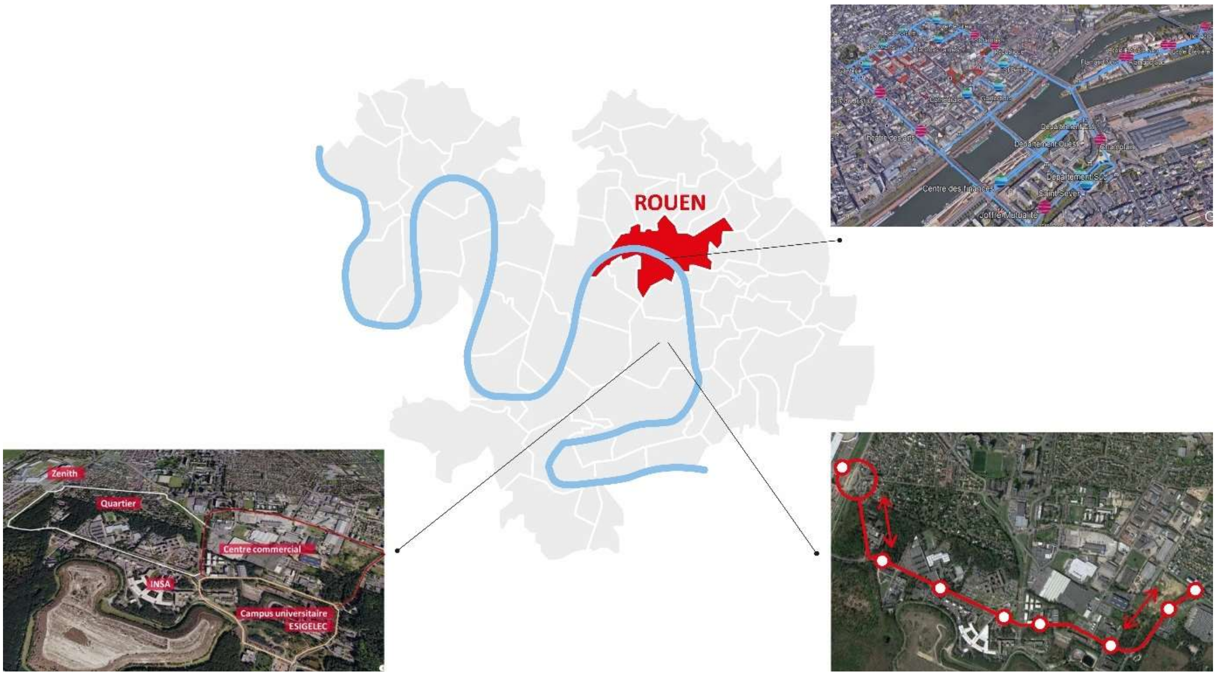
[L0.1] Annual Project Status Report

Identity card of the site									
Infrastructure	In Paris Saclay, 8km of roads have been equipped with various sensors (at 25 sites) in order to run ZoeCab and Transdev-Lohr i-cristal. Two services will gradually be opened up to a panel of users: a night-time public transport service on a dedicated lane with an autonomous electric Transdev-Lohr i-Cristal shuttle that will serve the districts of the Saclay plateau from the Massy station; and a daytime on-demand car service provided by electric and autonomous Renault ZOE Cab prototypes, aimed at providing a fine service to the campus in addition to the public transport network.								
Since When	Launched in 2017, the Paris-Saclay Autonomous Lab project is one of the experiments selected on 24 April 2019 by the government following the call for projects "Experimentation of the Autonomous Road Vehicle" (EVRA) launched in June 2018 as part of the Future Investment Programme (PIA).								
Purposes	The project aims to develop new autonomous mobility services, i.e. without a driver, on dedicated lanes, public roads and campuses, in addition to the existing transport solutions on the Saclay plateau. It integrates cutting-edge technologies in terms of on-board intelligence in vehicles, supervision systems, connected infrastructures and secure telecommunication networks. It was co-directed by the Renault group, the Transdev group, the Vede-com Institute, the IRT SystemX, and the University of Paris-Saclay with the contribution of ENSTA. The aim is to test a complete autonomous transport system, consisting of autonomous vehicles (3 Renault ZoéCab prototypes and 1 Transdev-Lohr i-Cristal shuttle), a fleet monitoring system, a connected infrastructure and customer applications. The aim is to define the conditions for the deployment of an autonomous mobility service on a larger scale.								
Stakeholders	Renault (commuter) Transdev (commuter) IRT SystemX (modelling) VEDECOM (R&D connectivity, intelligent infrastructure, V2X communication) Université Paris Saclay (algorithms) EPAPS (Établissement Public d'Aménagement Paris-Saclay), the Paris-Saclay urban community, the Essonne department and Ilede-France mobilités								
Road type	Streets in low-density areas within a new neighbourhood containing crossings, junctions, dedicated roads for public transport.								
Type of equipment installed	Network coverage	RSU	Video cameras	LIDAR M8	Vehicle thermal imaging cameras	Pedestrian thermal imaging cameras			
	DSRC-ITS G5 ou C-V2X	X (25)	X (35)	X (10)	X (20)	X (20)			
Functionalities related to the deployed equipment	Cameras and LIDAR = HD Mapping Thermal cameras = car or pedestrian detection (avoidance)								
Type of vehicles being tested	Autonomous public transportation	Particular connected vehicle							
On going use case (or going to be)	State of the lights Positioning of the vehicle Traffic light priority HD Mapping Remote vehicle call								
Application	C-ITS	Supervision Autonomous public transportation Transdev							
C-ITS shared (or going to be)	SPAT / MAP								
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock								
Links	https://www.ensta-paris.fr/sites/default/files/fichiers/actus/communique_de_presse_paris_saclay_autonomous_lab_fr_15mai2019.p https://vipress.net/inauguration-du-paris-saclay-autonomous-lab-experimentation-de-services-de-mobilite-autonome-connectes-au								

5.1.2.2. Rouen Normandy Autonomous Lab

1/ Aims and objectives

Rouen Normandy Automonous Lab is the first mobility service with autonomous electric vehicles on public roads in Europe. This innovative and sustainable transport solution is the result of close collaboration between the know-how and innovation capacities of key players in the mobility of tomorrow. These experiments have been selected as winners of the national TIGA and SAM EVRA calls for projects and of the European SHOW program.



Between 2018 and 2020, a transport on demand service serving the 1st - last km, with 4 Renault Zoé, on 10kms of open roads in the Madrillet Technopole with 17 stops.

Starting in 2021, a regular bus line reinforcement service with autonomous i-Cristal shuttles at the Madrillet Technopole - Under development, opening to testers in 2021.

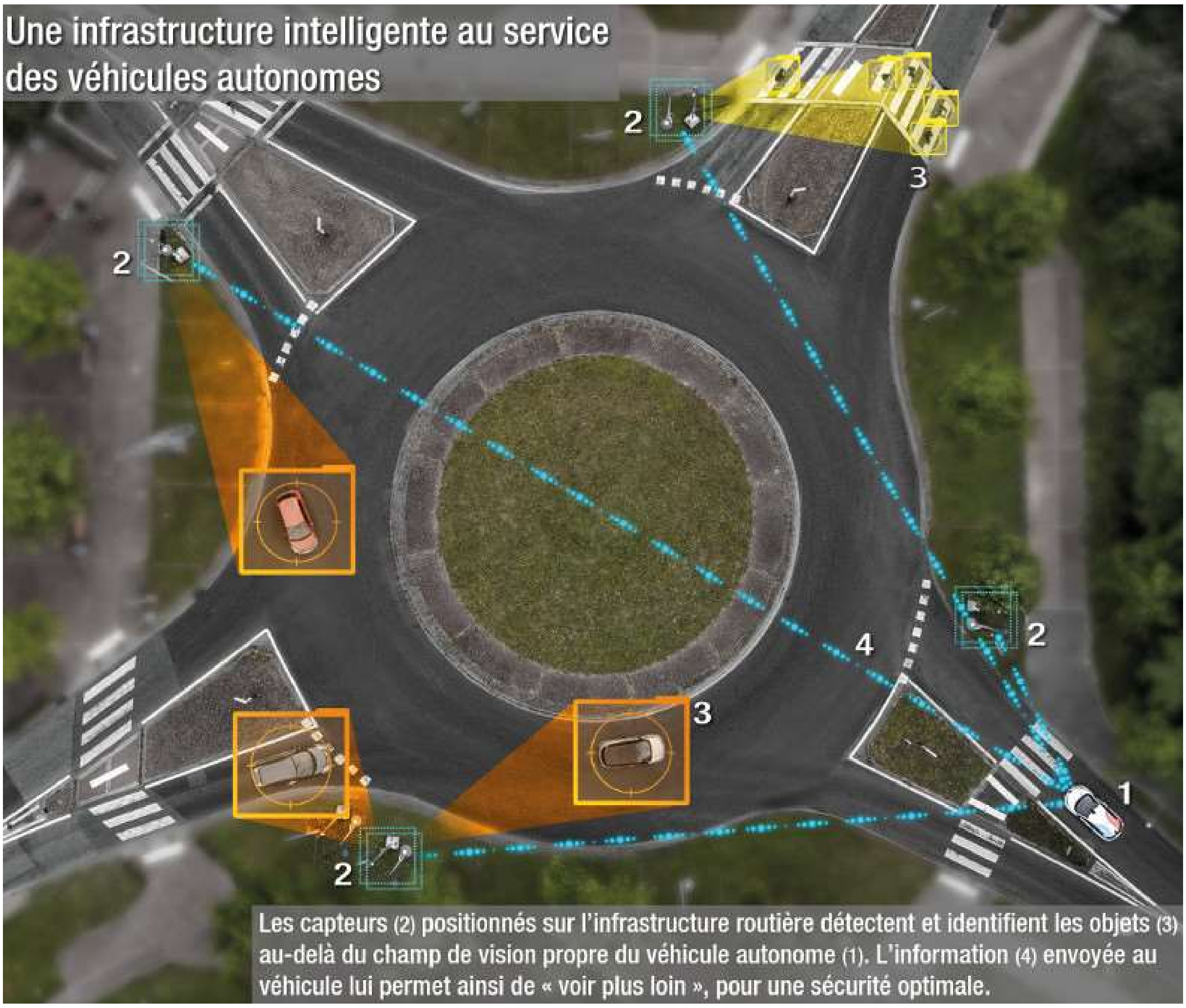
In addition, an on-demand transportation service in downtown Rouen in a Renault Zoe - Under development, opening to testers in 2021.

2/ Description of the site environment

This project aims to build a "complete system" of autonomous transportation. In order to offer a service on open roads with a commercial speed equivalent to that of conventional vehicles, while guaranteeing the safety of passengers, the project is experimenting with innovative technologies that form a global transport system.

The scope of the system includes the customer application for booking a trip, the fleet control station, the connected infrastructure, the secure telecommunications networks, the autonomous vehicles and their equipment. The operator, located in the control room, monitors the fleet and can intervene if necessary by requesting that the vehicles limit their speed or stop. Audio and video communications between passengers and the control station will also be possible at any time.

This system is the result of the Groupe Renault - Transdev partnership, where each partner contributes its expertise: Groupe Renault for the vehicle, autonomous and connected technologies, Transdev for supervision, connected infrastructure and secure telecommunications. To guarantee efficient, secure and transparent services, it is essential to rely on robust and efficient wireless data communications. This private LTE network from Ericsson, operational in March 2019, interconnects the different parts of the Autonomous Transport System - ATS by Transdev: the autonomous vehicles, the connected infrastructure (sensors, LIDAR) and the supervision by the centralized control station (PCC).



The private LTE (4G+) network infrastructure implemented by Ericsson operates in three different 3GPP frequency bands (in the 2600 MHz range) and offers data rates of 80 Mbps downlink and 29 Mbps uplink.

The environment is also equipped to provide other information to the car: intersections, traffic circles, crosswalks are equipped with radars, cameras, and communicate to the autonomous vehicle these data allowing it to anticipate the movements of other cars or even pedestrians.

This system also includes all the reflections on insurance and liability issues, and on future regulatory developments. Within the framework of the project, they are carried out by the Matmut Group.
The shuttle is planned for a speed of 18km/h at first and will be tested at 30km/h. The level of automation corresponds to level 4 SAE.

Rouen Normandy Autonomous Lab is fully integrated into the traditional transport offer piloted by the Metropolis of Rouen, the Organizing Authority for Mobility. The strong presence of the latter in the project, supported by the Normandy Region, demonstrates the willingness of public actors to integrate these new services and to accelerate the transformation of cities towards an efficient Smart City, for the benefit of the inhabitants.

The societal acceptability of the autonomous, shared and on-demand mobility service, as well as the involvement of the general public, are indeed major pillars of the project.

3/ Use cases

Groupe Renault and Transdev have equipped the vehicles with cameras, laser scanners (Li-DAR), a differential GPS system and HD mapping to ensure a 360° view and precise location. The vehicles establish a real-time 3D representation of their environment, which allows them to detect, locate and identify moving and stationary objects around them and thus make the best decisions. 17 stopping points were recorded through sensors strategically positioned on the infrastructure along the route. These additional sensors transmit data to the vehicles, allowing them to see even further than their own sensors, anticipate their surroundings and be alerted to the presence of vehicles or pedestrians outside their range.

Passenger safety is essential. At the control station, operators keep an eye on the vehicles at all times. A button allows passengers to communicate with them at any time.

In the event of an anomaly, the operators can intervene on the car, activate an emergency brake, reduce its speed or stop it immediately. The control station has real-time access to the vehicles' position, camera and lidar data, as well as to the images taken by the vehicle, which are received through a secure connection.

[L0.1] Annual Project Status Report

Identity card of the site									
Infrastructure	Urban route, 10 km long with 17 stops and crossing several junctions								
Since When	Between 2018 and 2020, a transport on demand service serving the 1st - last km, with 4 Renault Zoé, on 10kms of open roads at the Madrillet Technopole with 17 stops. From 2021, a regular bus line reinforcement service with autonomous i-Cristal shuttles at the Madrillet Technopole - Under development, opening to testers in 2021. In addition, a transport-on-demand service in Rouen city centre in Renault Zoé - Under development, opening to testers in 2021.								
Purposes	Rouen Normandy Automonous Lab is the first mobility service with electric self-driving vehicles on public roads in Europe. This innovative and sustainable transport solution is the result of close collaboration between the know-how and innovation capacities of key players in the mobility of tomorrow. These experiments were selected as winners of the national TIGA and SAM EVRA calls for projects and the European SHOW programme. The scope of the system includes the customer application for booking a journey, the fleet control station, the connected infrastructure, the secure telecommunications networks, the autonomous vehicles and their equipment. The operator, located in the control room, monitors the fleet and can intervene if necessary by requesting that the vehicles limit their speed or stop. Audio and video communication between passengers and the control centre will also be possible at any time.								
Stakeholders	Rouen Renault Transdev Ericsson								
Road type	Roads and streets in dense urban areas, crossing several junctions								
Type of equipment installed	Network coverage	RSU	Video cameras	LIDAR					
	4G+ LTE / 5G (private) 3GPP 2600 MHz	X	X	X					
Functionalities related to the deployed equipment	Cameras = HD Mapping								
Type of vehicles being tested	Autonomous public transportation	Priority vehicles							
On going use case (or going to be)	State of traffic lights Positioning of the vehicle Traffic light priority HD Mapping Remote vehicle call (scheduled stops)								
Application	C-ITS	Supervision Autonomous public transportation Transdev							
C-ITS shared (or going to be)	SPAT / MAP								
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock								
Links	https://www.renaultgroup.com/news-onair/actualites/comment-developper-un-systeme-global-integrant-des-vehicules-autonomes https://www.transdev.com/fr/communique-de-presse/rouen-normandy-autonomous-lab-premiers-tours-de-roue-avant-louverture-								
	https://www.rouennormandyautonomouslab.com/								

5.1.2.3. Rennes Metropole

1/ Aims and objectives

This experimentation is a complement to an experimentation that has been taking place in the same area since January 2019. It is a new public transportation line that serves the campus, stopping at 2 high-traffic structural bus stops. It will run on some portions with motorized urban traffic, and in other places on a zone reserved for shuttles, active and soft modes.

The route will initially be covered by 2 Navya shuttles, before 2 shuttles from another provider are added in order to test the interoperability of different shuttles. Distance: 2.6 km, then 6.2 km in a second phase (in phase with the arrival of the metro line B on campus), the line will be extended to the east of the campus, with the objective of complete integration into the network.

2/ Description of the environment

These shuttles combine several technologies. They work thanks to a stereovision camera and 2D and 3D lidar sensors that allow it to analyze the environment and detect obstacles. Its GPS antenna determines the vehicle's position precisely in real time and an odometry system estimates its speed very accurately. For this experimental phase, a receptionist is nevertheless present on board to answer all passengers' questions.

3/ Use cases

Interoperability between shuttles from different manufacturers

Identity card of the site									
Infrastructure	since January 2019. It is a new public transport line that serves the campus, stopping at two high-traffic bus stops. It will run on certain sections with motorised urban traffic, and in other places on a zone reserved for shuttles, active and soft modes.								
Since When	Since January 2019, with new sites planned for experimentation in 2022 around the University Hospital to create a soft mobility hub. This experiment is part of the "Intelligent Mobility" project led by Rennes Métropole and is supported by EVRA (Autonomous Road Vehicle Experimentation) funding as part of the ADEME call for projects. It also echoes the work of the "Mobility in a sustainable city" research and training chair at the university. This project has been selected by the EIT Digital (IRISA, INRIA, IMT Atlantique, University of Rennes 1) to apply for the European call for projects "Horizon Europe - Urban mobility".								
Purposes	Experiment with autonomous vehicle systems to complement the existing public transport network. Fight against congestion by taking advantage of a shared system between users generating better traffic conditions. Develop an efficient public transport service using autonomous vehicles within a campus, a hospital, or extend the catchment area in connection with strong public transport lines by a zonal feeder service.								
Stakeholders	Rennes Metropolis French administration Transport operator (Keolis) ID4CAR competitiveness cluster Universities Public and private companies (Navya)								
Road type	not specified								
Type of equipment installed	Couverture réseau	RSU	LIDAR						
	4G+ LTE / 5G (private)	X	X						
Functionalities related to the deployed equipment									
Type of vehicles being tested	Transport public autonome								
On going use case (or going to be)	State of traffic lights Positioning of the vehicle Traffic light priority								
Application	C-ITS								
C-ITS shared (or going to be)	SPAT/MAP								
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock								
Links	https://metropole.rennes.fr/sites/default/files/file-PolPub/PDU%202019-2030.pdf								
	http://www.presse.metropole.rennes.fr/upload/espace/1/pj/9747_7409_CP_mise_en_service_2_nouvelles_navettes_18112019.pdf								

5.1.2.4. Digital Motorway Test Bed (Germany Motorway A9)

1/ Aims and objectives

Improving traffic safety and efficiency as well as reducing emissions are important goals of the German federal government. To support these goals, the Federal Ministry of Transport and Digital Infrastructure (BMVI), together with the VDA, bitcom and the Lander of Bavaria, launched the "Digital Motorway Test Bed" (Ger.. Digitales Testfeld Autobahn (DTA)) in 2015. It is located on an approximately 140 km long stretch of the A9 between Nuremberg and Munich. In addition to other digital test fields in urban and rural areas, the DTA represents an optimal environment for innovative developments in the field of connected and automated driving as well as smart infrastructure.

The DTA is intended to offer providers of innovative technologies, such as automated driving or smart infrastructure, the opportunity to develop and test these technologies in a real functional environment. With the combination of a modern road infrastructure and the availability of state-of-the-art communication technologies, such as full LTE mobile network coverage, a high-precision digital map (per section) or special signage for automated vehicle positioning, it offers a unique test environment for the automotive industry, suppliers, telecommunication companies and research institutes.

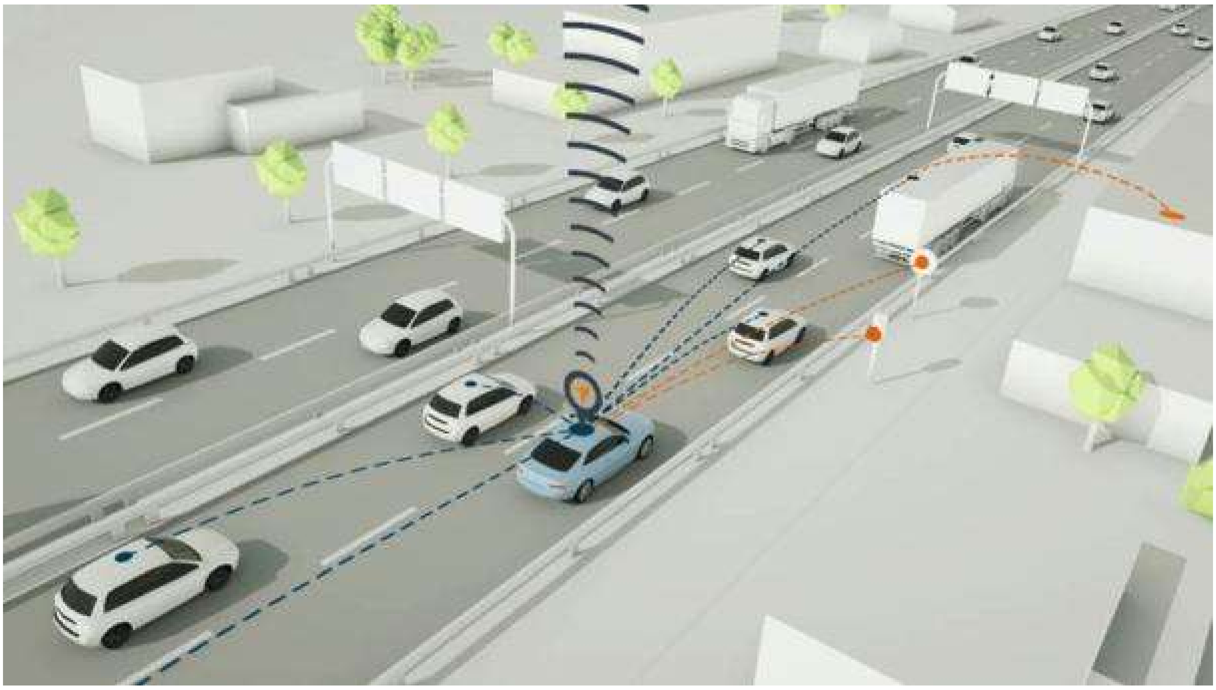
In addition to objectives such as supporting research and promoting innovation, the DTA is also intended to serve as a test environment for new infrastructure measures. Furthermore, the direct contact with everyday traffic is supposed to promote the societal acceptance of new technologies. Thus, as an open technology test area, the DTA is available to many stakeholders.

2/ Description of the site environment

This test area is part of the DTA defined and implemented by the German Federal Ministry of Transport and Digital Infrastructure. The test site consists of 6 smallcells, each with two sectors.

They are deployed along about 30 km of the German highway A9 from Nuremberg-Feucht to Greding. In addition, the rural road (Bundeststrasse) from Allersberg to Wendelstein is covered, which allows testing to be carried out off the freeway. All roads are public and the current regulations apply. The freeway includes segments without speed limits.

A spectrum license for the trial of a mobile radio network has been granted by the German regulator BNetzA to enable the deployment of a trial network. The mobile radio network covering the test field consists of seven base station sites deployed at 700 MHz with the latest LTE version.



It consists of two Evolved Packet Core (EPC) user plans consisting of service gateways (S-/P-GW) and packet data network (PDN) allowing access to the public Internet and the MEC network. It is possible to split this single network into two networks by connecting the cell site to an EPG belonging to virtually a different MNO. In this way, it is possible to emulate a national border.

Figure 2-14: Trial Site Germany A9 Motorway

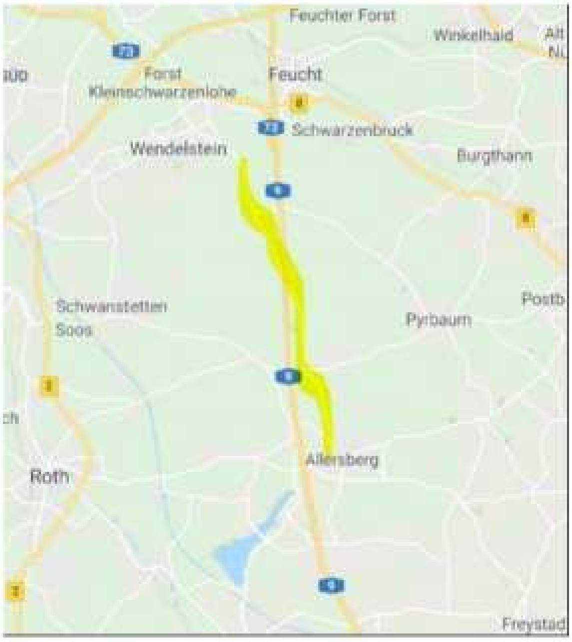


Figure 2-13: Trial Site Germany A9 Rural Road

3/ Use cases

The use cases developed on this testbed are :

- **Travel time and vehicle density measurement: iRoute 2**

In order to assess the traffic situation and to detect disruptions (traffic jams, etc.), different options were examined on the A9 freeway.
First of all, there are local detectors (airborne detection and side radar). In addition, the traffic situation can be determined by mobile detectors. A third data acquisition technology is route-related measurement (e.g. travel time) by Bluetooth scanners.
In addition to the detection technologies mentioned above, data can also be extracted from automatic license plate recognition (ANPR) cameras to additionally record specific vehicle characteristics.

The challenge here was to compare vehicle identification technologies in order to provide the most accurate information on travel times and traffic conditions.

In this use case, 3 areas along the highway were identified:
- Areas close to built-up areas with traffic data collection equipment
- Areas close to settlements without facilities
- Areas outside of urban areas

To realize this use case, were installed :
- 18 stations for collecting traffic data such as radar
- 38 bluetooth scanner
- ANPR recognition cameras on 14 intersections

- **Hazardous area detection: Intelligent slipperiness forecast**

In this use case, weather data and road condition data are used via cameras installed along the highway or via sensors installed on maintenance vehicles.

The information is then sent to the security headquarters / road network manager who will be able to send the appropriate equipment to avoid any accidents in these dangerous areas.

For the use case in question, a 20m zone was chosen to perform the road condition recognition tests.

- **Detection of wrong way**

Wrong-way driving incidents represent an increased risk to road safety. Early and reliable detection and reporting of these incidents can reduce this risk.

The objective of this measure was to use modern detection systems to automatically and reliably detect wrong-way drivers in the vicinity of junctions and to warn them directly. In a later step, it was planned to transmit corresponding warnings to other road users on the main road in the area of the intersection.

At three intersections on the A9 (km 514 (AS Eching), km 518.8 (AS Garching-North), km 520.4 (AS Garching-South)), infrastructure-based telematic wrong-way driver warning systems have been tested since mid-2015. Three different technical concepts were used:

- Radio field
- Combination of a radar and an induction loop
- Surveillance radar

The investigation was divided into short-term and long-term observations. Within the framework of the short-term observations, a controlled contraflow was carried out at two different times in coordination with the Bavarian street construction administration and the departure from the corresponding intersection was blocked.

Identity card of the site						
Infrastructure	German motorway A9. Part of the "Digital Motorway Test Bed 30 km equipped (between Nuremberg-Feucht and Greding)					
Since When	2015, testing in 2020					
Purposes	Equipment implemented by the German BMVI, used in the 5G Croco project, to be continued					
Stakeholders	Ministry of Transport and Digital Infrastructure (BMVI) VDA (automobile association) Bavarian State (Munich) Bitcom (operator) BNetzA (German frequency regulator) LiangDao GmbH (LIDAR)					
Road type	Straight motorway all the way, 2 x 3 lanes, speed limit only in some areas					
Type of equipment installed	Network coverage	Base station	Bluetooth scanner	RSU	Video Cameras	Radar
	5G/LTE / Mobile radio network ITS G5 (short range)	7 (700 MHz / LTE)	X (38)	X (18)	X (ANPR)	X (At the 3 intersections)
Functionalities related to the deployed equipment	ANPR cameras = number plate reading Bluetooth scanner = with number plate reading, allows to measure travel times (distance measured by identifying a vehicle at different points) Video and lidar sensors = Analysis of objects and associated parameters					
Type of vehicles being tested	Particular connected vehicle	Autonomous Vehicle	Autonomous public transportation	Autonomous freight transport		
On going use case (or going to be)	Anticipation of collision detection HD Mapping Speed limits Travel time measurement Detection and warning of wrong way Dangerous zone detection (e.g. slippery road) Border crossing simulation for operator transfer and Quality of Service continuity Number plate recognition					
Application	C-ITS	VA				
C-ITS shared (or going to be)	DENM (vehicle positioning, traffic conditions)	CAM (vehicle speed)				
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	https://www.bast.de/EN/Traffic_Engineering/Subjects/V5-digital-test-bed.html					
	https://www.bmvi.de/EN/Topics/Digital-Matters/Digital-Test-Beds/digital-test-beds.html					

5.1.2.5. Spain-Portugal cross-border corridor

1/ Aims and objectives

The ES-PT cross-border corridor is located at the northern border of Portugal with Spain. This border is established by the Minho/Miño river, which has several bridges providing road infrastructure for trucks, cars and pedestrians.

International trade as well as large passenger flows are of great importance and provide ideal conditions for conducting diversified trials to highlight the benefits offered by 5G connectivity for passenger transport offered by 5G connectivity to CCAM use cases.

Spain:

- Urban roads 4 km in the city of Vigo
- A55 : 10km
- AP9 : 5km

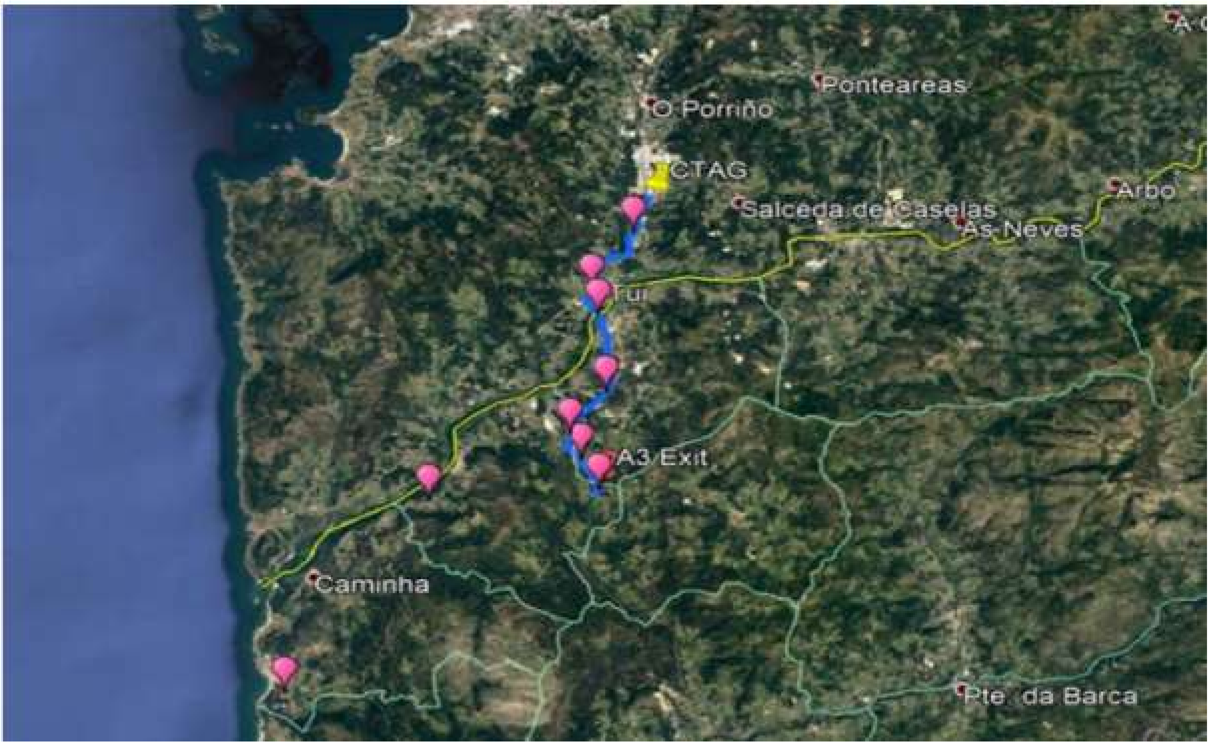
Portugal:

- A3 : 4km
- N13 : 1km
- A28 : 10km

Pilot infrastructure:

- 3G/4G Cellular Communication.
- 1 MEC Node (based on CONCORDA Project)
- ITS-G5
- In-Vehicle Communication Units, developed by CTAG
- Road Side Units, developed by CTAG
- C-ITS Platform to manage the corridor events.

2/ Description of the environment



The 5G infrastructure that has been planned for the development of the 5G-MOBIX project is as follows:

On the Spanish side:

- MEC node with additional capabilities for interconnection with another operator's MEC nodes.
- Multiple smallcells, initially based on 4G LTE but capable of evolving to 5G NR, to reinforce coverage. The exact number of nodes will depend on the area of the corridor to be reinforced.
- A network slicing framework for appropriate isolation between V2X and eMBB services, based on SDN/NFV technologies or more traditional means (such as local slicing and QoS differentiation).
- Multiple SIM cards properly registered in Telefonica's provisioning systems for access to V2X services

On the Portuguese side:

- MEC.
- 5G base stations (BTS).
- 5G Core.
- Fiber optic interconnections.
- Fixed IP/MPLS network.
- Power supply.

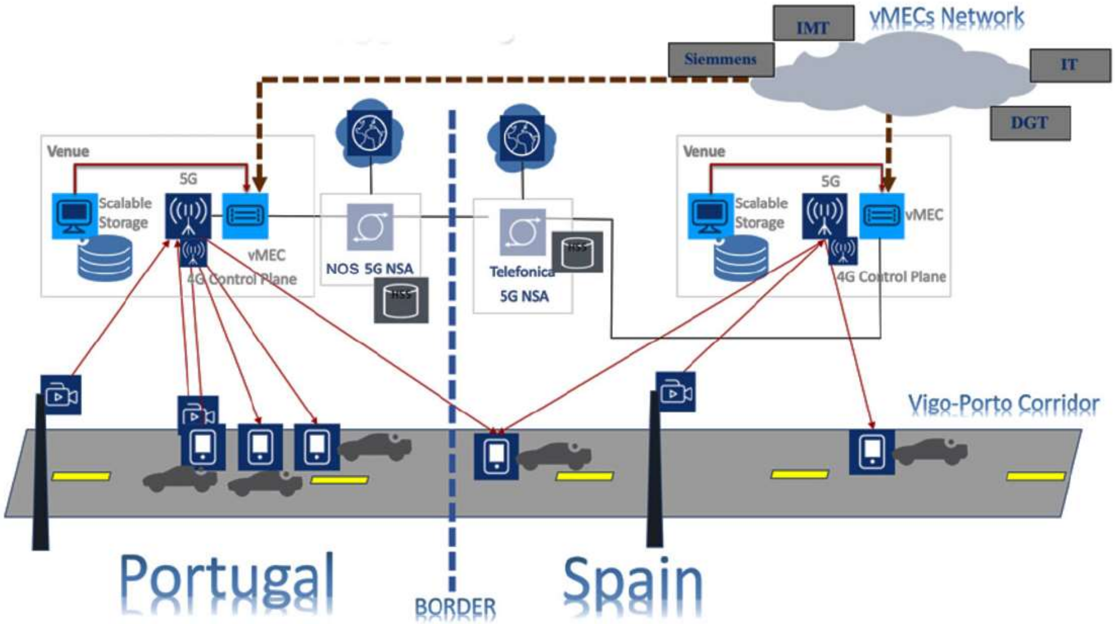
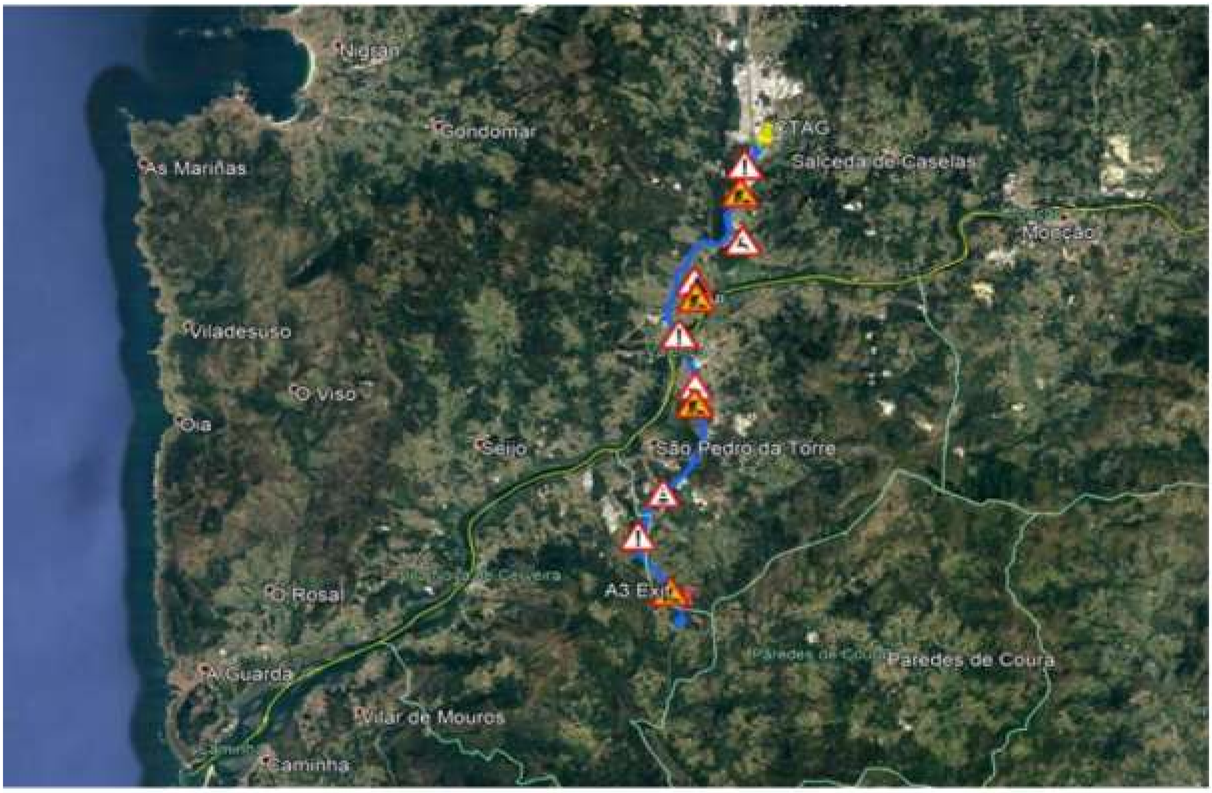


Figure 7 5G-Mobix Scenario

3/ Use cases



- **High quality of service connected public transport**

In this use case, the connected bus is linked to a 5G network.
It is equipped with a 4K camera at the front of the vehicle and is able, thanks to various sensors to recognize its environment.
Thus, this high level of service can be measured from different points of view:

- Users who can access multimedia services without delay with high quality content reproduction;
- The bus control center can monitor the bus environment in real time using the 4K camera images (live-streaming);
- Thanks to its sensors, the bus records everything that happens around it and sends the information to the ITS control center in order to perform HDMapping and eventually update the maps of the surrounding connected vehicles.

- **Detection of vulnerable persons in an autonomous mobility framework**

Automated last mile shuttles will play an important role in the near future of European cities. The cooperation of these vehicles with VRUs (Vulnerable Road Users) in order to increase the comfort and safety of these users, as well as having an alternative solution when the path of these vehicles is obstructed, implies a valuable advance in connected cities. 5G technology will allow these developments even in cross-border areas or near national borders.

This use case was developed thanks to an autonomous shuttle connected in 5G and a VRU equipped with a smartphone that sends positioning, speed and location information to the shuttle, which will identify this "obstacle" and avoid it and/or slow down and brake.

Identity card of the site						
Infrastructure	Portuguese A3 motorway at the border between Portugal and Spain (5km section)					
Since When	installation in 2016/2017, tests carried out in 2018					
Purposes	Equipment implemented by the Portuguese partners of the SCOOP project. These equipments are intended to last, via the PI which is the operator of the Portuguese infrastructures.					
Stakeholders	TIS (evaluation), IT (R&D sensor routes, 5G security and C-ITS message extension), A-to-B (use case development) IP (Infrastructure Portugal) Siemens CCG (corridor coordination on the Portuguese side) IMT (National Road Traffic Authority) AENL (Road Management Concessionaire) Nokia (5G) ISEL (5G performance) NS (5G integration)					
Road type	Straight motorway all the way					
Type of equipment installed	Network coverage	RSU	Traffic radar	Video		
	ITS G5 / Cellular / Hybride 5G	X (10)	X	x		
Functionalities related to the deployed equipment	Video and lidar sensors = Analysis of objects and associated parameters					
Type of vehicles being tested	Particular connected vehicle	Connected and autonomous public transportation				
On going use case (or going to be)	Speed limits Travel time measurement One-way detection and warning Obstacles on the road Detection of dangerous areas (e.g. slippery road, weather conditions) Border crossing simulation for operator transfer and Quality of Service continuity HDMapping High Quality of Service connected public transport Detection of vulnerable users					
Application	C-ITS	VA				
C-ITS shared (or going to be)	DENM (Obstacle on the road, weather conditions, work on the road, animal on the road, difficult traffic, accident, stationary vehicle, person on the road)	CAM (vehicle speed, traffic control)	IVIM			
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	http://www.scoop.developpement-durable.gouv.fr/en/IMG/pdf/scoop_scoop_crosstests_evaluation_-_secor http://www.scoop.developpement-durable.gouv.fr/scoop-cross-tests-une-etape-determinante-pour-l-a53.h					
	https://www.5g-mobix.com/assets/files/5G-MOBIX-D2.1-Use-case-specifications-v1.0.pdf					

5.1.2.6. Barcelona - Ciutat de Granada

1/ Aims and objectives

The test and trial site is located in the city of Barcelona, is part of the 5GCroco project, in the 22@ district, and is integrated into the 5GBarcelona end-to-end infrastructure. It currently consists of one cabinet and three smallcells deployed along the public street "Ciutat de Granada". In this test and trial site, it is planned to emulate a cross-border scenario, with two different virtual MNOs deployed at this location, having their own virtual core networks and small cells.

2/ Description of the environment

The 5G neutral hosting platform provides 3 street lights connected to the street cabinet. The street lights are equipped with 3.5 GHz LTE small cells used to provide connectivity to the CTTC emulated vehicle and PSA/CTTC vehicles. The street cabinet is equipped with a cloud platform to deploy local vEPCs that provide access to application servers hosted by MEC and controlled by the same cloud platform. They will host the CME-deployed portion of the ACCA backend software for each vMNO. The street cabinet is connected to the cross-border IXP platform with a transport network based on Ethernet and optical technologies. The 5G neutral hosting platform can deploy dedicated network slices for the different vMNOs required in a cross-border scenario. The NFV management and orchestration (MANO) platform for service orchestration is based on the software stack provided by the 5GCity project. A network slice is defined as a single network service instance or a concatenation of network service instances according to the 3GPP and ETSI NFV Standards Development Organizations (SDO).

The cross-border IXP platform provides the physical infrastructure through which multiple vMNOs can exchange data traffic. It is also equipped with servers used to emulate the public Internet cloud, offering both virtual machines and containers. The ACCA use case will also deploy software there, representing the centrally hosted part of the backend. This part includes services that do not need to be hosted at the edge and allows communication between edge servers in cases where they cannot communicate directly, as can be assumed initially for CMEs operated by different MNOs. Interconnection between different vMNOs, and emulation of public Internet cloud servers is done through an SDN switch. The cross-border IXP platform also provides network slices for different cross-border scenarios. The MANO NFV platform is based on the SONATA open source software stack.

The backend software deployed for the ACCA use case consists of a CME-hosted edge geoservice, a traffic management system (TMS), and a central geoservice hosted on the emulated public Internet cloud. The geoservice is used to warn vehicles of a potential hazard. It will provide authentication, subscription, notification, data fusion and alert calculation services. On the other hand, urban and road infrastructures provide access to multiple sources of information that can be considered, in a broad sense, as sensors. The TMS serves as an asset management tool for the different geoservices located in the MEC and processes the road safety information generated by external sensors and roadside units into the V2X information base. The TMS has a global view of the cross-border scenario and is able to distribute the hazards received from one geoservice to the other regions involved. This role is therefore crucial for the demonstration of a cross-border scenario where different geoservices hosted by MNO will have to synchronize the events occurring in their respective areas of interest through the Internet-hosted TMS service.

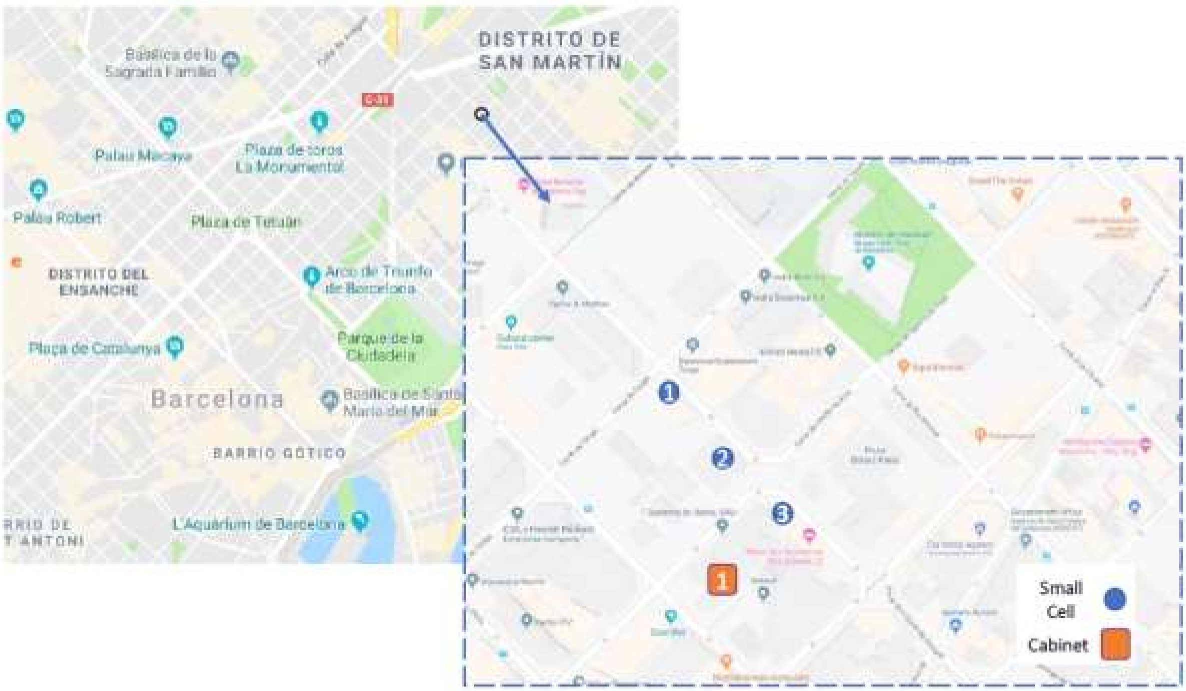


Figure 2-15: Test and trial site Barcelona

[L0.1] Annual Project Status Report

Identity card of the site						
Infrastructure	Smartpoles deployed along the "Ciutat de Granada" in central Barcelona					
Since When	Tests carried out in 2020					
Purposes	The equipment is designed to last					
Stakeholders	CTTC: Centre for Technology and Communication of Catalonia I2CAT: internet research center, NextWorks (Infra telecom) WorldSensing (sensors) PSA (vehicle) EURECOM (algorithm)					
Road type	Street in the town centre but reserved for certain vehicles so not very busy.					
Type of equipment installed	Network coverage	RSU	Smallcells			
	5G/LTE	X (3)	X (3 LTE smallcells 3,5 GHz))			
Functionalities related to the deployed equipment	RSU & smallcells = communication V2X					
Type of vehicles being tested	Particular connected vehicle					
On going use case (or going to be)	Speed limits Detection and warning of wrong way Incident detection (stationary vehicle) Traffic jam detection					
Application	C-ITS					
C-ITS shared (or going to be)	CAM	DENM				
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock					
Links	Lien : https://5gcroco.eu/images/templates/rsvario/images/5GCroCo_D4_4.pdf					

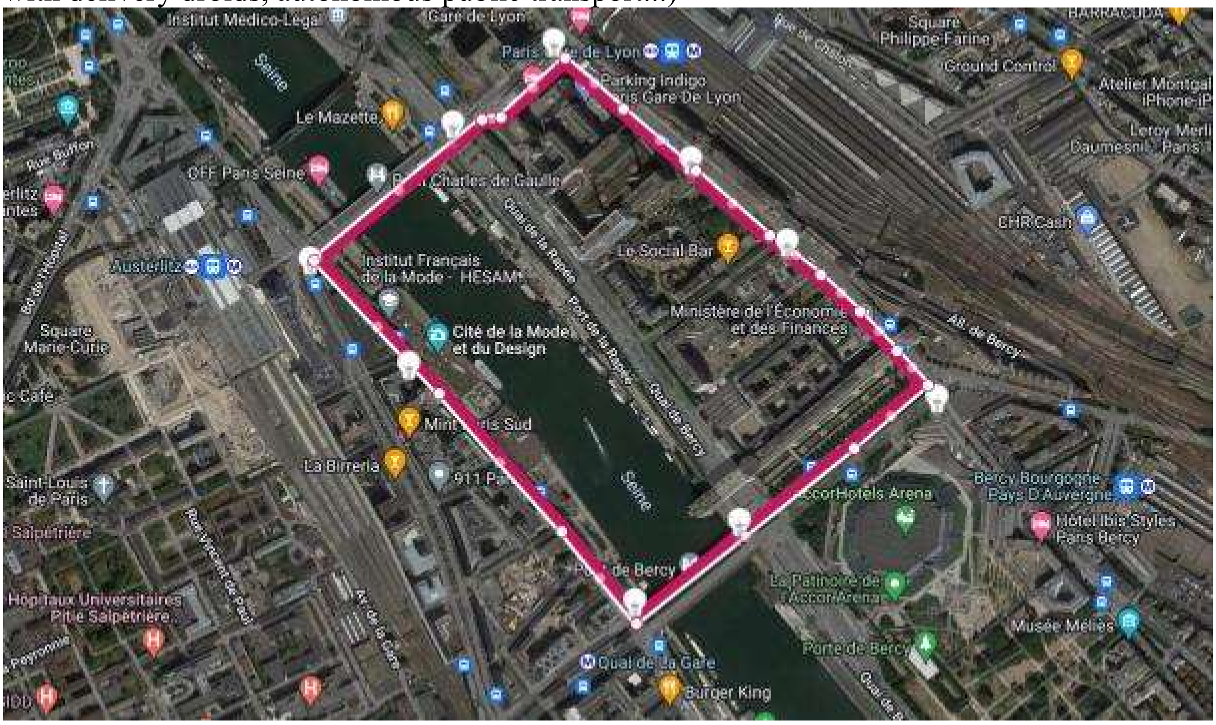
5.2 Paris2Connect

5.2.1. Aims and objectives

Paris2Connect, an innovative project, initiated in late 2018, aims to demonstrate how a shared urban digital infrastructure can meet the growing needs of Smart City, connectivity and autonomous mobility, in an inclusive and environmentally friendly way. This project was set up by a public-private consortium. The private actors took care of the upgrade of the "smartpole" type infrastructure while the city took care of the upgrade of the traffic lights part.

This approach has enabled the Paris2Connect project to be integrated into the INDID project, which is the logical continuation of the European SCOOP@F and C-ROADS France projects.

Solutions have already been tested to make public spaces more accessible to the visually impaired and to observe mobility. In 2021, a call for experimentation has been launched in order to make this connected infrastructure as open as possible to experimentation to develop new services. Available data such as LIDAR streams, thermal camera streams, JSON metadata or raw tracking lists will be made available to develop new services on topics such as the rationalization and optimization of public space (road occupation, parking), the pacification and security of public space (pedestrian experience, management of priorities at traffic lights), the contribution to a more sober and sustainable public space (intelligent lighting, management of cleanliness) or finally the contribution to a more service-oriented public space (urban logistics with delivery droids, autonomous public transport...)



5.2.2. Description of the environment

Fire Management Environment

The SLT is upgraded by the city of Paris to be able to interact with any connected vehicle. The link has been made with the traffic light controllers of 10 traffic light junctions as well as RSUs installed on the SLTs of these junctions.
In this context, the format of the transmitted data will be standardized to the SPAT MAP GLOSA, SSEM SREM format.
The messages are upgraded as standards evolve.

Coordonnées GPS (X)	Coordonnées GPS (Y)	Carrefour	Domaine	Numéro du support	Type support
2,37385821900822	48,8377070124592	478	SLT	S04318	BP42 avec potence
2,37107064739737	48,8396044216246	1293	SLT	PC23653	Potelet carré
2,36795562786468	48,8417703902277	1630	SLT	S22276	Potelet carré
2,37069634455272	48,8432933417832	814	SLT	S21419	BP31
2,37225363602214	48,8442585304213	1177	SLT	S23557	BP31
2,37272530249517	48,8441280570218	1177	SLT	S23575	Potelet carré
2,37446259352554	48,8431671651311	1654	SLT	S23399	Potelet carré
2,37631050057168	48,8421882930189	654	SLT	PC21792	Potelet carré
2,37898794852825	48,8404988689303	664	SLT	S05772	BP31
2,37597737747482	48,8386962029536	243	SLT	S11647	BP31

Augmented perception environment deployed on intelligent lighting poles also called smartpoles

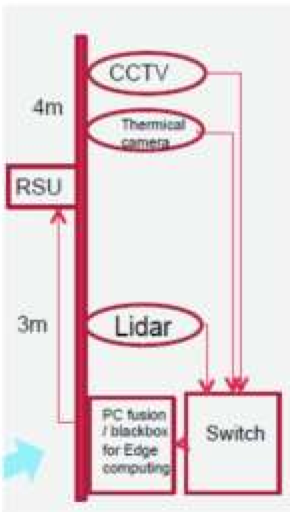
Below is a summary table of the masts selected for the augmented perception:

	N°	Location	Arrdt	Longitude	Latitude
Smart Pole 1		Quai d'Austerlitz /Pont Charles de Gaule	75013	2.3678487	48.8417663
Smart Pole 2	190	Rue Van Gogh / Rue de Bercy	75012	2.3722477	48.844352
Smart Pole 4		Boulevard de Bercy / Rue de Bercy	75012	2.379152	48.8401312
Smart Pole 5		Pont de Bercy / Boulevard de Bercy		2.3756078	48.8386671
Smart Pole 6		Pont de Bercy / Quai d'Austerlitz (Quai de la Gare)	75013	2.3737169	48.8377131
Smart Pole 7		Charles de Gaulle Bridge / Quai de la Râpée / Rue Van Gogh		2.3704375	48.8433801
Smart Pole 8	134	Rue de Bercy (southern section)	75012	2.3764636	48.8419886
Smart Pole 10		Quai d'Austerlitz	75013	2.3696361	48.8405341
Smart Pole 11	173	Rue de Bercy (northern section)	75012	2.3747177	48.842952

<u>List of augmented perception equipment by mast</u>

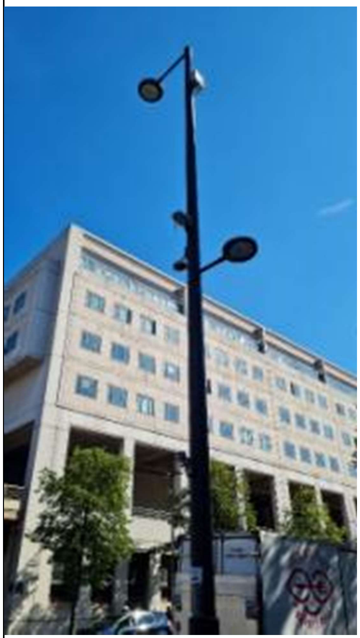
Numéro de Smartpole	Equipement 1	Equipement 2	Equipement 3	Equipement 4	Equipement 5	Equipement 6
Smartpole 2	caméra Axis P3717-PLE	UBR	Switch Axis	PC industriel 1		
Smartpole 11	caméra Axis P3717-PLE	caméra ThermiCam 2 345	Switch Axis	PC industriel 1		
Smartpole 8	caméra Axis P3717-PLE	Lidar	Switch Axis	PC industriel 1	UBR	PC industriel 2
Smartpole 4	caméra Axis P3717-PLE	Lidar	Switch Axis	PC industriel 1	UBR	PC industriel 2
Smartpole 5	caméra Axis Q6010/Q6075	Lidar	Switch Axis	PC industriel 1	UBR	PC industriel 2
Smartpole 6	caméra Axis P3717-PLE	caméra ThermiCam 2 345	Switch Axis	PC industriel 1	UBR	
Smartpole 10	caméra Axis P3717-PLE	caméra ThermiCam 2 345	Switch Axis	PC industriel 1	UBR	
Smartpole 1	caméra Axis P3717-PLE	Lidar	Switch Axis	PC industriel 1	UBR	PC industriel 2
Smartpole 7	caméra Axis P3717-PLE	Lidar	Switch Axis	PC industriel 1	UBR	PC industriel 2

Location and heights of the different equipment:



Smart pole n° 6 Face au 1 Quai de la Gare (décembre 2020)

Some photos in real situation:

Environment connectivity

Connectivity and data

A private 4G network that can be upgraded to 5G

- The infrastructure includes private network quality coverage in LTE and scalable 5G in 2022.
- The LTE or 5G network is based on TDD technology on the 2600MHz frequency in B41 with 2x2 Downlink MIMO on a bandwidth of 20MHz for 4G and 40MHz for 5G.

Data that may be made available :

Personal data, subject to subcontracting agreement in the sense of RGPD of the city of Paris:

- videos from the cameras

Non-personal data, i.e. data from :

- lidar flow,
- flow of thermal cameras,
- JSON metadata stream,
- "raw "tracking list" (list of geolocated objects in real time) or "metadata

5.2.3. Use cases

Roadmap of use cases considered for testing on the infrastructure

On the Paris2Connect perimeter, the objective is twofold:

1. Provide a validated C-ITS service offering as broad as possible within the timeframe of the Day 1 C-ITS Services, with priority given to Group G or SI "Signalized Intersections / Traffic Signal Intersections

Concerning the C-ITS, SSEM/SREM messages as well as SPAT/MAP messages are deployed. One of our challenges is to arrive in the short term to also exchange CPM.

Various vehicles are concerned by these messages: connected / autonomous private vehicles, autonomous public transport RATP, delivery droids or priority vehicles.

Solutions have already been tested to facilitate the accessibility of public space for the visually impaired, to observe mobility, the effect of waves or noise pollution.
In 2021, a call for experimentation has been launched in order to make this connected infrastructure as open as possible to experimentation to develop new services.

Available data such as LIDAR flows, thermal camera flows, JSON metadata and raw tracking lists are made available to develop these new services in areas such as the rationalization and optimization of public space (road occupation, parking), the pacification and security of public space (pedestrian experience, management of priorities at traffic lights), the contribution to a more sober and sustainable public space (intelligent lighting, management of cleanliness) or finally the contribution to a more service-oriented public space (urban logistics with delivery droids, autonomous public transport...)

Tests took place at the end of 2021 to verify the good communication between the systems in real life, within the framework of the INDID project:

- on the concepts of informing users when approaching intersections with driving instructions (G1 - GLOSA)
- on priority requests by a vehicle with the principle of a "virtual" call loop. Call and acknowledgement transmitted to the controllers in DIASER format and specific phase (G2) taken into account. Technically upgraded, traffic light intersections can now receive messages from priority vehicles and thus integrate the information into the traffic light plan management. These tests should enable better management of traffic flows by prioritizing emergency vehicles.

The elements are visible via the following video: https://youtu.be/Y3tA__rkIbc

New use cases are envisaged around the risks of collisions on the road as well as the anticipation / identification of the presence of vulnerable users.

Finally, connectivity will also be tested for an autonomous urban logistics use case:

The experimentation of the Twinswheel droid of the company Soben aims at demonstrating the safety of the autonomous mode, with an operator being able to intervene remotely, thanks to the 4G network and later 5G. The autonomous driving mode is made possible thanks to the prebuilt maps and the pre-established virtual routes. The experiment also includes simulations of hazards on the trajectory of the droid requiring the intervention of the operator. The goal is to clearly establish the safety of the movement and the controllability of the droid if necessary.

2. Develop an autonomous "last mile" public transportation service from Gare d'Austerlitz -> Gare de Lyon -> Bercy Arena -> Quai de la Gare -> Gare d'Austerlitz.

The autonomous mobility project is also part of the French consortium SAM EVRA. The autonomous service is provided by Local Motors shuttles operated by RATP, the historical Parisian operator.

Concerning **Supervision (private) Autonomous public transport RATP**
The supervision of the system will be deployed by RATP. It will be based mainly on the monitoring set up by the telecommunications operator, but will also loop through the other monitoring resources set up, including the performance observed by the various autonomous vehicles. This will allow for real-time verification of the performance of the communications means and for adaptation of the vehicles' operating modes according to the level achieved.

- Monitoring of the vehicle possible or not
- Monitoring of passenger behavior possible or not
- Assistance available or not

Depending on the performance achieved, the QoS of the system will be adapted in order to guarantee the safety of users and the environment in all cases. This will be done by adopting fallback modes (speed adjustment or even stopping).

The functions of perception call upon various and complementary technologies which are :

- Image processing from the visible spectrum (Camera)
- Image processing from the infrared spectrum (IR camera)
- Distance measurement by optical system (LIDAR)

The characteristics of the equipment implementing these technologies are specified in the appendix. These first uses of the data collected for the supervision of the autonomous mobility service will allow, for example, the detection of events on the route (crowds, obstacles, traffic jams, special vehicles).

[L0.1] Annual Project Status Report

Identity card of the site									
Infrastructure	Dedicated route (loop) of 3.5km between the 12th and 13th arrondissements of Paris, (between Austerlitz, Bercy and Lyon stations) on which work to upgrade the infrastructure to a shared infrastructure has been carried out via the installation of smartpoles, ancillary equipment and traffic light junctions.								
Since When	The equipment was installed in 2019/2020 and is intended to last for the 2024 Games								
Purposes	Paris2Connect, an innovative project, initiated at the end of 2018, aims to demonstrate how a shared urban digital infrastructure can meet the growing needs of the Smart City, connectivity and autonomous mobility, in an inclusive and environmentally friendly way. This approach has enabled the Paris2Connect project to be integrated into the INDID project, which is a logical continuation of the European projects SCOOP@F, C-ROADS France. Solutions have already been tested to facilitate the accessibility of public space for the visually impaired, to observe mobility. In 2021, a call for experimentation has been launched in order to make this connected infrastructure as open as possible to experimentation to develop new services. Available data such as LIDAR flows, thermal camera flows, JSON metadata and raw tracking lists will be made available to develop new services on topics such as the rationalisation and optimisation of public space (road occupation, parking), the pacification and securing of public space (pedestrian experience, management of priorities at traffic lights), the contribution to a more sober and sustainable public space (intelligent lighting, management of cleanliness) or finally the contribution to a more service-oriented public space (urban logistics with delivery droids, autonomous public transport. ..)								
Stakeholders	City of Paris (technical services, PC lutèce for traffic light management) Delegate (management of smartpoles) ATC France (shared infrastructure management) Aximum (UBR) Nokia (4G telecommunication network evolving to 5G) RATP (data, network and autonomous mobility, RGPD management) Signify (smartpoles) Exem, Securaxis, PArking Map (wave observatories, noise pollution and mobility) Ministry of Ecological and Solidarity Transition + RATP (VA and VA supervision, INDID project)								
Road type	A 3.5km loop in a very dense urban centre (12th and 13th arrondissements of Paris), with local service to the Austerlitz, Lyon and Bercy stations. There are also speed limits with 30 and 50km/h zones. This route crosses 9 traffic light junctions.								
Type of equipment installed	Network coverage	RSU (smartpoles)	Video cameras	Thermal cameras	Sound sensors	LIDAR	PC fusions / switch	RSU SLT	Traffic signal controler
	4G -> 5G 3,6GHz Short range ITS G5	8	9	3	2	5	9	10	10
Functionalities related to the deployed equipment	RSU = infrastructure/vehicle communication in hybrid ITS G5 / 4G Video and lidar sensors = raw data production (function of different equipment)								
Type of vehicles being tested	Connected / autonomous passenger car	Autonomous public transport	Delivery droide	Priority vehicles					
On going use case (or going to be)	Status of traffic lights Speed limit Anticipation of traffic jams Vehicle positioning Traffic light priority Risk of collision Vulnerable users								
Application	C-ITS	Supervision Autonomous public transport RATP							
C-ITS shared (or going to be)	SSEM/SREM	SPAT / MAP	CPM (to be implemented)						
Applicable regulations	RGPD / Zone regulations (speed limits on certain sections, etc.) / Regulations on rolling stock								
Links	https://paris2connect.agorize.com/fr/challenges/appel-a-experimentations								
	https://www.ratp.fr/groupe-ratp/newsroom/innovation/paris2connect-devoile-six-cas-dusage-ambitieux-pour-la-ville-de								

5.2.4. Use case experimented with RATP: R&I and AI programs of the RATP group

The generic scenario:

- To make an autonomous mobility service run safely and define the different strategies to adopt when there are obstacles on the route. The challenge is to guarantee safety and quality of service (characterization with indicators)
  - We are in a system engineering that integrates :
    - Infrastructure
    - Vehicles
    - Supervision

- The generic scenario will be deployed on a pre-defined route of 3.5 km between the stations of Austerlitz, Lyon and Bercy

The objective is to analyze the contribution of the connected infrastructure on the performance and quality of the autonomous mobility service.

Use Case Description:
Identification of obstacles on the path of the autonomous vehicle and decision making for the operation of the service

Development of an algorithm to detect obstacles and presences on the route of the autonomous vehicle and its impact on the service according to contextual elements (configuration, size / characterization, proximity of the vehicle ...).

These are:

- To specify the needs in terms of analysis of events that may occur on the route, with reference to the expected quality of service and safety objectives (definition of classification elements and expected performance...)
- Identify, classify, analyze and qualify in real time the presence of objects or people on a pre-defined route, to produce useful information for the operation of the service,
- To send back to the supervision service the data produced by the algorithm and differentiated and hierarchical alerts according to their level of relevance (proximity of the vehicle's route, behavior within a group, etc.),
- Anticipate security and service performance issues.

A/ Input data

Data generated by the P2C infrastructure: (infrastructure subsystem)

- Lidars
- Tracking list
- Video

Vehicle data

- Location
- Speed
- ...

B/ Data produced by the algorithm

- Real-time event identification
- Classification and qualification of events
- Identification of the level of risk by integrating a set of factors including the proximity / occurrence risk of collision with the vehicle
- Formalization of alerts: presence, localization, qualification, classification... of an obstacle on the path of the vehicle

C/ Process of data transfer to the supervision

- Sending alerts to the supervision subsystem
- Validation of the reliability of the information transmitted

Deliverables:

- Algorithm,
- Training procedure of the algorithm,
- Measuring the impact of the certification methodology and standards,
- Technical architecture for data analysis, transfer and latency control,
- Measuring the impact in terms of quality of service

5.2.5. Description of the scenario and use case for the L4 Valeo DAR vehicle, in connection with Paris2Connect

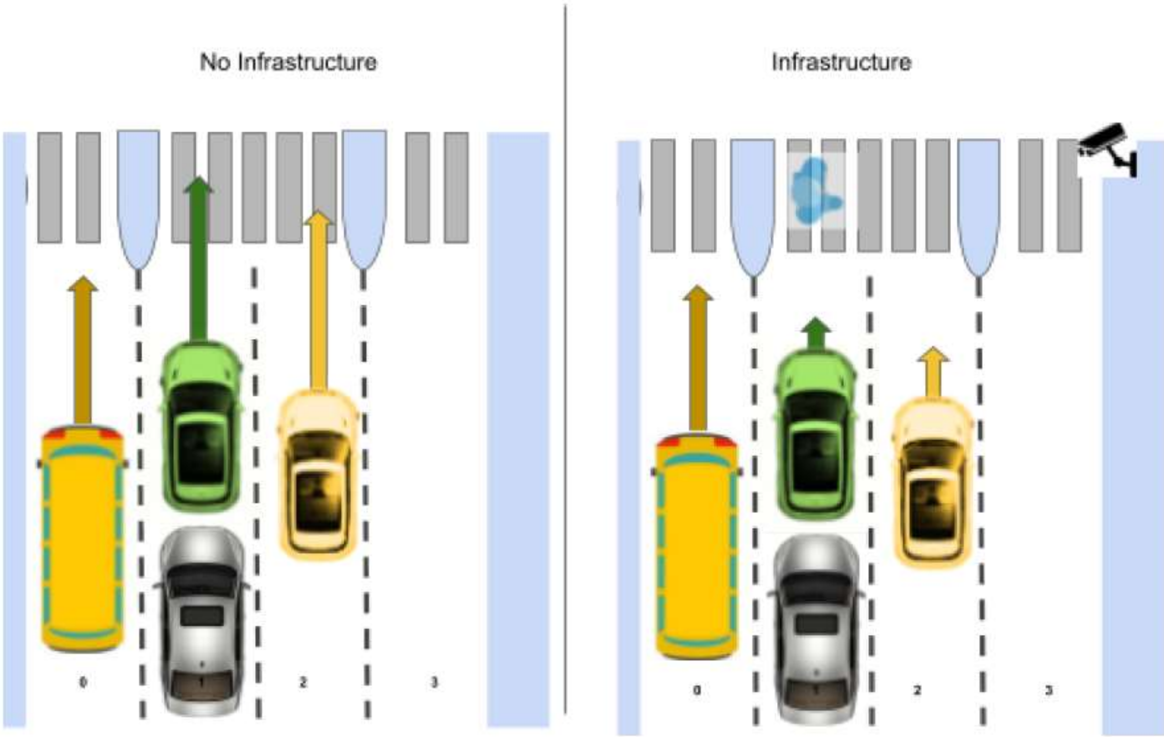
1. Context and description of the selected POC, use cases

Valeo's L4 autonomous prototype vehicle is equipped with a system that allows it to operate in urban environments (with the presence of an authorized driver responsible for its safety). Able to communicate with the infrastructure via C-V2X, the vehicle is able to use the data received from the infrastructure to complement its own perception, prediction and decision-making capabilities.

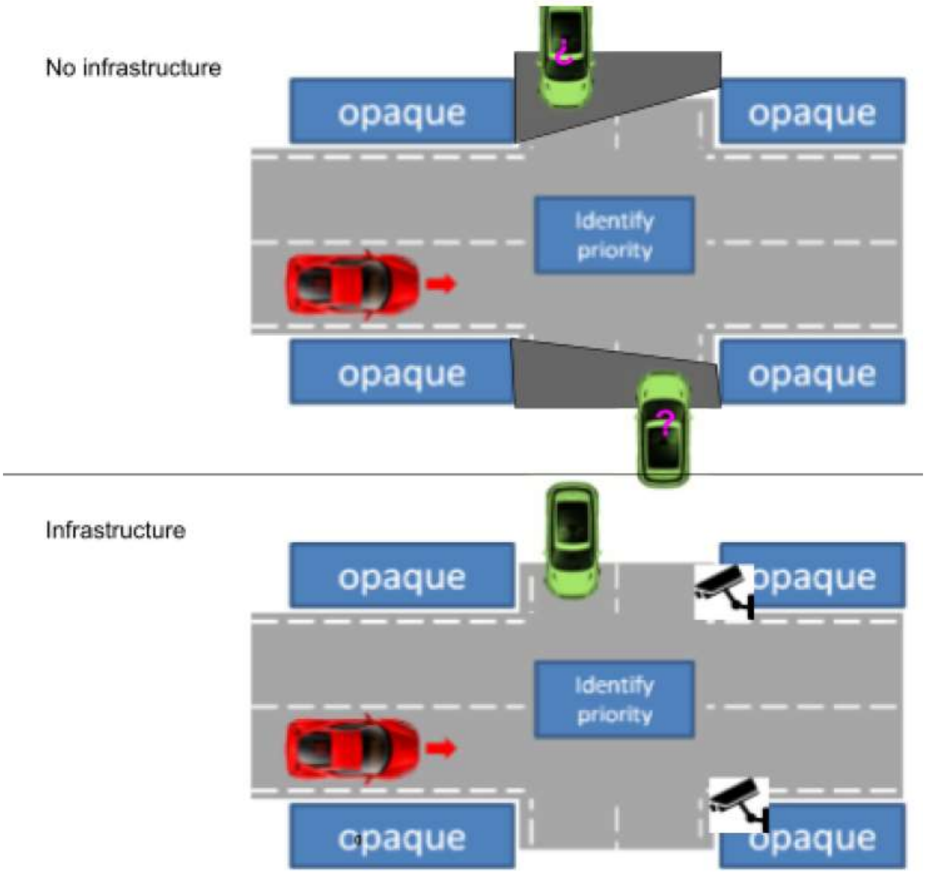
The generic scenario is to drive a level 4 autonomous vehicle in an urban environment (see description in the Appendix), on a predefined route, in the area covered by the Paris2Connect connectivity facilities.

Upstream of the PoC, we will analyze the contributions of the connected infrastructure on the performance and comfort of the autonomous vehicle. These contributions can be analyzed at different levels, depending on the use cases.

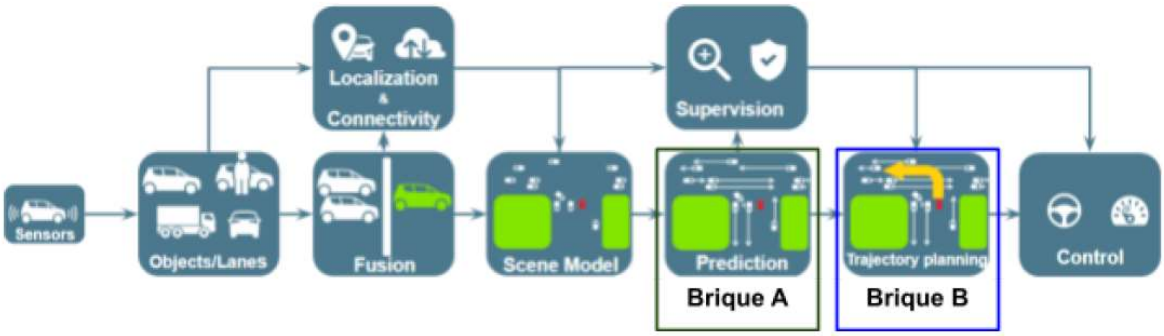
- Contribution to the prediction of user trajectories - The infrastructure will provide a more complete view of the scene, which can be exploited to allow a better prediction of the nearby environment.



- Provide visibility when approaching tight areas or intersections - The infrastructure will provide a view of the scene that can change the behavior of the vehicle.



2. AI bricks under study



One of the AI bricks available in the vehicle could be studied, the choice will be made according to the concepts available for the evaluation of an AI brick in the framework of Prissma :

- Brick A: The scene prediction brick. It exploits the vehicle's perception, as well as V2X data, to provide an augmented perception with an interactive prediction;
- Brick B: The perception and decision brick of the recommended speed with respect to the visibility of the scene. It exploits the perception of the vehicle, as well as the available V2X data, in order to provide a speed recommendation adapted to the visibility in the vicinity of the road model and the situations encountered;

3. Interests with respect to Paris2Connect, in the context of the methodology and expectations of the Prissma project

- The evolutionary environment of Paris2Connect increases the perception capabilities of an autonomous vehicle.
- The use cases highlight the interest of combining remote perception with on-board perception for a level 4 or lower autonomous vehicle;
- The implementation of an evaluation and certification methodology for these AI bricks allows to bring a relevant evaluation of a level 4 autonomous system in urban environment on usual behavioral points in town.
- The following points develop primary methodologies that can be deployed on the perception and speed recommendation decision brick, allowing its first evaluation.
    - As a first step, it may be relevant to evaluate its ability to recommend orders of magnitude of speed according to well-defined test cases, for example when the situation may require a significant reduction in speed;
    - Secondly, it may be relevant to evaluate the variability of the speed recommendations made by the brick: indeed, too much variability may be detrimental both inside the cabin and for other road users.
- The behavior of the AI bricks proposed for the study can be compared according to the presence or absence of connectivity. The exploitation of the methodology developed in the framework of Prissma will allow to see the consequent contribution (or not) of the infrastructure on the performances.
- In general, the AI bricks proposed in the study can be evaluated both from a performance point of view with respect to safety standards, but also according to behavioral criteria (traffic fluidity, cooperation with the environment) approached in the framework of Paris2Connect.

Depending on the bricks under study, preliminary tests in simulation and replay will be performed. However, no specific simulation model porting work is planned for this POC.

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- Décret n° 2018-211 du 28 mars 2018 relatif à l'expérimentation de véhicules à délégation de conduite sur les voies publiques
- Ordonnance n° 2021-443 du 14 avril 2021 relative au régime de responsabilité pénale applicable en cas de circulation d'un véhicule à délégation de conduite et à ses conditions d'utilisation
- DGITM. Démonstration de sécurité des systèmes de transport routier automatisés : Apports attendus des scénarios de conduite. Février 2022
- PFA. Automated driving safety validation: proposals from the French Eco-system. Janvier 2020.
- IFSTTAR. STPA : Analyse de sécurité des parcours prédéfinis.
-

Appendix 1 - The Paris2Connect equipment

RSU

CPU

NXP i.MX6 – ARM A9 4 x 1Ghz

RAM

2 GB

STOCKAGE

8 GB + carte SD

SYSTEME D'EXPLOITATION

Linux Debian 9

CONNECTIVITÉ

Ethernet PoE 100Mbps full duplex
2x ITS G5
GPS
Modem cellulaire (2G/3G/4G)

LOGICIELS INTÉGRÉS

Support ITS stack
- ETSI Geonet
- CAM, DENM, SPAT, MAP, IVI et standards POI
- TS 103-097 norme de sécurité assistée par un module de sécurité matériel intégré
- ETSI uppertester

LDM interne avec facilité d'u lisa on API JSON
Logiciel à la demande incluant la connecti vité MQTT et AMQP

ACCES A DISTANCE

SSH v2 (mot de passe root fourni)
API spécifi que, JSON pour la LDM
SNMP
OpenVPN, L2TP, PPTP
SMS API

ALIMENTATION

48v PoE
Consomma on < 15w
Ba erie de secours intégrée

ENVIRONNEMENT

Résistance au vent 200km/h
IP67, IK10
Température -40 à +70°C

POIDS ET TAILLE

< 2.5kg
Longueur : 31cm
Largeur : 21cm
Hauteur : 7.5cm
+ Antenne: 21.5cm

AXIMUM

LIDAR MQ8

MQ-8™ Series LiDAR Sensor

HIGH ACCURACY | FINE RESOLUTION | LONG RANGE | HIGH PERFORMANCE

MQ-8-Plus

MQ-8-PoE-Plus
MQ-8-PoE-Ultra

The MQ-8™ Series LiDAR sensor is the next generation of Quanergy's 3D LiDAR sensors and smart perception software solutions. Part of Quanergy's Flow Management™ Platform, the MQ-8 Series meets the unique challenges of flow management applications that require accurate, high-volume people and vehicle tracking in the security, smart city, social distancing, and smart spaces industries.

The MQ-8 Series LiDAR sensor features a smart beam structure of narrowly spaced, asymmetric beams that delivers up to 70m continuous tracking range (140m diameter), enabling up to 15,000 m^2 coverage with a single sensor. The MQ-8 sensor is paired with the powerful QORTEX DTC™ perception software to provide a higher classification accuracy compared to traditional LiDAR systems. In addition, the beam pattern provides 360° scanning with flat mounting to maximize coverage and reduce installation time and costs.

The MQ-8 sensor is paired with the powerful QORTEX DTC™ perception software for sophisticated flow management applications that require accurate tracking of large numbers of people and vehicles in complex environments.

Key Features

Industry-Leading Classification Range

With an industry-leading classification range, the MQ-8 can detect, track, and classify over 250 people and vehicles with 10% reflectivity up to a range of 70m (140m diameter) with 95% accuracy. Besides, the sensor features a 360° horizontal field of view for rapid and reliable scanning of large areas.

10-20x Lower Cost Than Traditional Camera Systems

A single MQ-8 sensor can cover up to 15,000m^2 area, up to 100x wider than the equivalent camera-based system. With fewer devices to purchase, install, and maintain, the system provides 10-20X lower cost than traditional camera systems.

Day and Night Vision

The MQ-8 LiDAR sensor is immune to ambient lighting conditions, maintaining high performance even in extremely bright and low light applications.

Angular Resolution

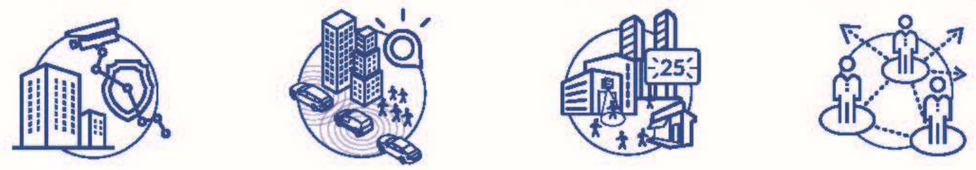
The MQ-8 features an angular resolution of 0.03-0.13° depending on the frame rate to reliably detect objects with pinpoint accuracy.

Automated ID Handover™

The unique QORTEX Automated ID Handover allows continuous tracking of a person or a vehicle throughout the entire systems' field of view, virtually on an unlimited basis. This capability allows for very powerful systems-wide data solutions such as curb to gate application at airport, flow management/footfall analytics in retail, social distancing application in public venue like stadium.

Applications

Security | Smart City | Smart Spaces | Social Distancing



QUANERGY

MQ-8 Plus SENSOR

MQ-8-PoE SENSOR Plus Ultra

Parameter	MQ-8-Plus	MQ-8-PoE-Plus	MQ-8-PoE-Ultra
Laser Class	Class I Laser Product (Eye Safe, IEC 60825-1)		
Wavelength	905nm		
Measurement Technique	Time of Flight (TOF)		
Minimum Sensor Range	2m		
Maximum Sensor Range	150m (80% reflectivity) 50m (10% reflectivity)		200m (80% reflectivity) 70m (10% reflectivity)
Range Accuracy (1σ at 50m)	<3cm		
Frame Rate	5-20Hz		
Angular Resolution	0.03°-0.13° dependent on frame rate		
Detection Layers	8		
Field of View (FOV)	Horizontal: 360°, Vertical: 12.4° (-1.6°/-14°)		
Output Connection	M12 Connector: 100/1000Mbps Ethernet, NMEA/PPS, Power	RJ45 802.3at (PoE+)	
Data Outputs	Angle, Distance, Intensity, Time Stamps (synchronized to GPS when available)		
Returns	Up to 3		
Output Rate	430,000 points per second (1 return), 1.3M points per second (3 returns)		
Nominal Power	16W	18W	
Operating Voltage	9-30VDC	42.5-57VDC	
Operating Temperature	-20°C to +60°C (-4°F to +140°F)		
Storage Temperature	-40°C to +105°C (-40°F to +220°F)		
Nominal Weight	900g	1375g	
Dimensions	103mm (D) x 87mm (H)	115mm (D) x 134mm (H)	
Shock & Vibration	ETSI EN 300 019-2-5, IEC Class 5M3		
Environmental Protection	IP69K	IP67	
Certifications and Compliance	FDA, FCC, CE, RoHS, WEEE		
Warranty	2 Years		

*Specifications are subject to change without notice

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QPN 96-00073 Rev A

Thermical sensor

Thermicam

SPÉCIFICATIONS TECHNIQUES

Présentation du système	
Fonctionnalités de détection	Détection de présence des véhicules et des cyclistes au niveau de la ligne d'arrêt et à l'approche Détection de la présence des piétons Surveillance du flux de trafic (nombre, densité, classification, vitesse, distance inter-véhiculaire, temps inter-véhiculaire, niveau de service) Détection des véhicules à contresens (licence en option) Recueil de données routières au niveau de la ligne d'arrêt : nombre, densité, classification (licence en option) Surveillance du temps de parcours Wi-Fi ITS-IQ (licence en option) Communication sur le cloud ITS-IQ (licence en option) Priorité des feux tricolores V2X (licence en option)
Nombre de zones de détection	24 zones de détection de véhicules \ 8 zones de détection de cyclistes \ 8 zones de détection de piétons \ 16 zones de recueil de données sur le trafic \ 6 zones de détection de véhicules à contresens
Configuration	Configuration de page Web via une connexion Wi-Fi, Ethernet ou CPL sécurisée
Caméra	
Type	Matrice à plan focal (FPA), microbolomètre VOx non refroidi Infrarouge longues ondes (7,5 à 14 µm)
Résolution	VGA (640 x 480)
Fréquence d'affichage des images	30 images/s
Compression	H.264, MPEG-4, MJPEG
Vidéo en continu	RTSP

Types de produit	Numéro de référence	Résolution	Distance focale	Champ de vision	Distance de détection pour l'approche de véhicules
ThermiCam2 V2X 690	10-7450	VGA	13 mm	Horizontal : 48° Vertical : 39°	2 à 33 m / 6 à 108 pi
ThermiCam2 V2X 645	10-7454	VGA	7,5 mm	Horizontal : 45° Vertical : 35°	10 à 75 m / 32 à 245 pi
ThermiCam2 V2X 632	10-7458	VGA	9 mm	Horizontal : 32° Vertical : 26°	15 à 75 m / 100 à 300 pi

Boîtier	
Matériau	Boîtier en aluminium avec pare-soleil en polycarbonate intégré
Dimensions (y compris le support de montage)	Montage vertical : 45 cm x 16 cm x 12 cm (18,0 po x 6,3 po x 4,7 po) Montage horizontal : 46 cm x 18 cm x 12 cm (18,2 po x 7,1 po x 4,7 po)
Alimentation, sorties, communication	
Alimentation	24 à 42 V AC/DC
Consommation électrique	< 11 W
Contacts de sortie	Contacts secs N/O et N/C directs 16 contacts secs N/O via l'interface TI CPL2 ED&IO 16 canaux de sortie via TI CPL2 EDGE et le module RM (SDLC)
Ethernet	10/100 Mbit/s pour configuration, flux vidéo, surveillance, API publique JSON
PoE	PoE mode A
CPL	Débit de 50 Mbit/s par courant porteur en ligne via l'interface TI CPL2 EDGE
Wifi	IEEE 802.11 pour configuration et surveillance de la durée des trajets par connexion Wifi
V2X	
Couche V2X Access	DSRC IEEE 802.11p
Couche transport et réseau	WSMP IEEE 1609.3 WAVE
Couches installations	SAE J2735 BSM, SPaT, MAP
Spécifications environnementales	
Résistance aux chocs et aux vibrations	Spécifications NEMA TS2
Matériaux	Résistant aux intempéries et aux UV
Indice IP	IP67
Plage de température	-34 °C à +74 °C (-29 °F à +165 °F)
Conformité aux réglementations	
FCC / Directives UE	FCC partie 15, classe A, CEM 2014/30/UE, RoHS 2011/65/UE, LVD 2014/35/UE, RED 2014/53/UE

Les spécifications peuvent être modifiées sans préavis. Pour obtenir les spécifications les plus récentes, rendez-vous sur www.flir.com

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10-0565-ITS_EMEA

The World's Sixth Sense®

AXIS P3717

AXIS P3717-PLE

Caméra multidirectionnelle 8 MP avec IR pour une couverture à 360°

Le modèle AXIS P3717-PLE Network Camera est une caméra compacte de 8 mégapixels équipée de quatre objectifs vari focaux permettant une vidéosurveillance d'ensemble et détaillée. Avec une adresse IP et un câble réseau, cette unité quatre caméras en une procure une solution flexible et économique pour la surveillance multidirectionnelle. Grâce à son éclairage IR à 360°, la technologie Forensic WDR et Lightfinder, elle offre une excellente qualité vidéo dans toutes les conditions d'éclairage. Chaque tête de caméra peut être positionnée individuellement (panoramique, inclinaison, roulement et torsion) le long d'une piste circulaire. Le zoom et la mise au point à distance simplifient l'installation et le couvercle transparent, sans bords vifs, garantit des vues non déformées dans toutes les directions. La caméra est livrée avec une protection étanche.

> 8 MP, caméra multidirectionnelle à 360°, 1 adresse IP

> Éclairage IR à 360°, zoom et mise au point à distance

> Axis Lightfinder et Forensic WDR

> Positionnement souple des quatre têtes de caméra vari focales

> Axis Zipstream pour réduire les besoins en bande passante et stockage

AXIS P3717-PLE

Caméra	
Capteur	4 capteurs CMOS RVB à balayage progressif 1/2,8"
Objectif	Vari focal, 3–6 mm, F1.8–2.6 **Mode de capture 4 x 1080p :** Champ de vision horizontal : 96°–49° Champ de vision vertical : 53°–27° Champ de vision diagonal : 113°–55° Mise au point motorisée, zoom motorisé
Jour et nuit	Filtre infrarouge à retrait automatique
Éclairage minimum	**Couleur :** 0,17 lux à 50 IRE F1.8 **Noir et blanc :** 0,04 lux à 50 IRE F1.8, 0 lux avec éclairage IR activé
Durée d'obturation	1/32 500 s à 2 s avec 50 Hz 1/32 500 s à 2 s avec 60 Hz
Réglage de l'angle de la caméra	Panoramique ±90°, inclinaison de 17 à 102°, rotation de 5 à 95°, torsion ±20°
Vidéo	
Compression vidéo	Ligne de base H.264 (MPEG-4 Partie 10/AVC), profils principal et avancé Motion JPEG
Résolutions	4 x 1920 x 1080 (4 x HDTV 1080p) à 160 x 90
Fréquence d'image	Jusqu'à 25/30 ips (50/60 Hz)
Flux vidéo	Flux multiples, configurables individuellement en H.264 et Motion JPEG Technologie Axis Zipstream en H.264 Fréquence d'image et bande passante contrôlables VBR/MBR H.264
Réglages de l'image	Saturation, contraste, luminosité, netteté, Forensic WDR, balance des blancs, contrôle d'exposition, zone d'exposition, ajustement en cas de faible éclairage, rotation : 0°, 90°, 180°, 270° y compris Corridor Format, superposition dynamique de texte et d'image, masque de confidentialité polygone, compression
Réseau	
Adresse IP	Une adresse IP pour tous les canaux
Sécurité	Protection par mot de passe, filtrage d'adresse IP, HTTPS[a], cryptage, contrôle d'accès réseau IEEE 802.1X[a], authentification Digest, journal d'accès utilisateurs, gestion centralisée des certificats
Protocoles pris en charge	IPv4/v6, HTTP, HTTPS[a], SSL/TLS[a], QoS Layer 3 DiffServ, FTP, CIFS/SMB, SMTP, Bonjour, UPnP™, SNMP v1/v2c/v3(MIB-II), DNS, DynDNS, NTP, RTSP, RTP, SFTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH
Intégration système	
Interface de programmation	API ouverte pour l'intégration logicielle, avec VAPIX® et AXIS Camera Application Platform ; caractéristiques disponibles sur *www.axis.com* AXIS Video Hosting System (AVHS) avec connexion en un clic ONVIF® Profile S et ONVIF® Profile G, caractéristiques disponibles sur *onvif.org*
Vidéo intelligente	**Fournis** AXIS Video Motion Detection, alarme de sabotage **Compatibles** AXIS Perimeter Defender[b], AXIS Guard Suite comprenant AXIS Motion Guard, AXIS Fence Guard et AXIS Loitering Guard Prise en charge de AXIS Camera Application Platform permettant l'installation d'applications tierces, voir *www.axis.com/acap*
Déclencheurs d'événements	Détecteurs, matériel, signal d'entrée, stockage, système, heure, analyse, événements de stockage local
Actions sur événement	Mode de vision diurne/nocturne, incrustation de texte, enregistrement vidéo, envoi d'images, envoi de notifications, envoi de messages trap SNMP, envoi de clips vidéo, LED de statut Chargement de fichiers : FTP, HTTP, HTTPS, réseau partagé, SFTP et e-mail Notification : courrier électronique, HTTP, HTTPS, TCP et message trap SNMP
Flux de données	Données d'événement
Ressources intégrées d'aide à l'installation	Compteur de pixels, assistant de mise au point, mise au point à distance, zoom à distance
Général	
Boîtier	Boîtier en plastique et aluminium certifié IP66, IP67 et NEMA 4X, résistant aux chocs conforme à la norme IK09 avec dôme enduit en polycarbonate, pare-soleil (PC/ASA) Couleur : blanc NCS S 1002-B Pour des instructions concernant la peinture du boîtier et ses incidences sur la garantie, contactez votre partenaire Axis.
Montage	Support de fixation avec trous pour boîte de jonction (boîte double, boîte simple, boîte de jonction octogonale 4" et boîte de jonction carrée 4") Entrée latérale de conduit ½" (M20) Adaptateur de conduit ¾" (M25) inclus
Développement Durable	Sans PVC
Mémoire	RAM de 1 024 Mo, mémoire flash de 512 Mo
Alimentation	Power over Ethernet (PoE) IEEE 802.3at Type 2 Classe 4 Éclairage IR allumé : classe 4, 11,1 W en standard, 17 W max. Éclairage IR éteint : classe 3, 8,6 W en standard, 11 W max.
Connecteurs	RJ45 10BASE-T/100BASE-TX PoE
Éclairage infrarouge	Quatre éclairages IR contrôlables individuellement avec LED IR 850 nm longue durée de vie, basse consommation Portée de 15 m (49,2 pi) ou plus, en fonction de la scène
Stockage	Compatibilité avec carte microSD/microSDHC/microSDXC Cartes Dual SD Prise en charge du cryptage de carte SD Prise en charge de l'enregistrement sur un espace de stockage réseau (NAS) Pour des recommandations sur les cartes SD et le stockage NAS, voir *www.axis.com*
Conditions d'utilisation	-30°C à +50°C (-22°F à +112°F) Humidité relative de 10 à 100 % (avec condensation)
Conditions de stockage	-40°C à +65°C (-40°F à +149°F)
Homologations	**CEM** EN 55032 Classe A, EN 50121-4, IEC 62236-4, EN 61000-3-2, EN 61000-3-3, EN 55024, EN 61000-6-1, EN 61000-6-2, FCC Partie 15 Sous-partie B Classe A, ICES-003 Classe A, VCCI Classe A, RCM AS/NZS CISPR 32 Classe A, KC KN32 Classe A, KC KN35 **Sécurité** IEC/EN/UL 62368-1, IEC/EN/UL 60950-22 **Environnement** IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-78, IEC/EN 60529 IP66/67, IEC/EN 62262 IK09, NEMA 250 Type 4X **Autre** IEC 62471
Dimensions	Hauteur : 91,5 mm (3,6 po) ø 255 mm (10,04 po)
Poids	2,0 kg (4,4 lb)
Accessoires fournis	Outil de montage RJ45, tournevis T20, guide d'installation, licence pour 1 utilisateur décodeur Windows®
Accessoires en option	AXIS T94N01D Pendant Kit, supports et armoires Axis Pour plus d'accessoires, voir *www.axis.com*
Logiciel de gestion vidéo	AXIS Companion, AXIS Camera Station, logiciel de gestion vidéo des partenaires de développement d'applications d'Axis disponibles sur le site *www.axis.com/vms*
Langues	Anglais, Chinois simplifié, Chinois traditionnel, Français, Allemand, Italien, Japonais, Coréen, Polonais, Portugais, Russe, Espagnol
Garantie	Garantie Axis de 3 ans, voir *www.axis.com/warranty*

a. *Ce produit inclut un logiciel développé par l'OpenSSL Project pour une utilisation dans l'OpenSSL Toolkit. (openssl.org), ainsi qu'un logiciel de cryptographie développé par Eric Young (eay@cryptsoft.com).*
b. *Un seul capteur*

AXIS Q6010 / Q6075

Fiche technique

AXIS COMMUNICATIONS

AXIS Q6010-E Network Camera

Pour une surveillance en temps réel à 360° et des détails très précis

Avec quatre capteurs 5 MP, AXIS Q6010-E procure une vue d'ensemble complète à 360° avec une excellente utilisabilité des images jour et nuit. Conçue pour fonctionner avec n'importe quelle caméra AXIS Q60-E PTZ Network Camera, elle autorise la commande PTZ en un clic et le pilotage automatique pour le suivi PTZ automatique dans les zones de visualisation. Et chaque capteur dispose d'objectifs interchangeables avec mise au point automatique et calibrage de positionnement pour une flexibilité maximale et une configuration précise. AXIS Q6010-E utilise le même support, la même alimentation électrique et le même câble réseau que la caméra AXIS Q60-E PTZ Network Camera connectée pour une installation économique. De plus, Zipstream avec prise en charge de H.264/H.265 réduit significativement les besoins en bande passante et en stockage sans compromettre la qualité d'image.

> Caméra à 360° avec commande PTZ en un clic

> 4 capteurs 5 MP, résolution totale de 20 MP

> Objectifs interchangeables et inclinables

> Nécessite une caméra AXIS Q60-E PTZ Network Camera

> Pilotage automatique inclus

ONVIF | G S T

HDTV NETWORK VIDEO

AXIS Q6010-E Network Camera

Modèles	AXIS Q6010-E 50 Hz AXIS Q6010-E 60 Hz
Caméra	
Produits pris en charge	AXIS Q60-E PTZ Network Cameras
Capteur	Balayage progressif RVB CMOS 1/2,5" 4 x 5 MP
Objectif	Objectifs à mise au point automatique, iris fixe, F2.0, distance focale : 2,8 mm Champ de vision horizontal : 360° Champ de vision vertical : 84°
Jour et nuit	Filtre IR à retrait automatique
Éclairage minimum	Couleur : 0,4 lux à 50 IRE, F2.0 Noir et blanc : 0,03 lux à 50 IRE, F2.0
Durée d'obturation	1/32500 à 1/20 s
Réglage de l'angle de la caméra	Panoramique, inclinaison et rotation
Panoramique/inclinaison/zoom	Commande PTZ en un seul clic
Vidéo	
Compression vidéo	Profils principal et avancé H.264 (MPEG-4 Partie 10/AVC) H.265 (MPEG-H Partie 2/HEVC), Profil principal
Résolutions	4 x 2592 x 1944 à 320 x 240 Par défaut : 2592 x 1944
Fréquence d'image	Jusqu'à 20 ips (50/60 Hz) dans toutes les résolutions
Flux vidéo	Plusieurs flux configurables individuellement en H.264 et H.265 Technologie Axis Zipstream en H.264 et H.265 Fréquence d'images et bande passante contrôlables VBR H.264/H.265
Réglages de l'image	Résolution, compression, saturation, luminosité, netteté, contraste, balance des blancs, niveau d'exposition, mode d'exposition, réglage fin de l'obturation et du gain du comportement en luminosité normale et faible luminosité, masques de confidentialité polygonaux (8 par canal maximum), WDR, texte dynamique, incrustation d'image
Réseau	
Sécurité	Protection par mot de passe, filtrage d'adresses IP, cryptage HTTPS[a], contrôle des accès réseau IEEE 802.1x (EAP-TLS)[a], authentification Digest, journal des accès utilisateur, gestion centralisée des certificats, protection contre les attaques par force brute, firmware signé
Protocoles pris en charge	IPv4, IPv6 USGv6, HTTP, HTTPS[a], SSL/TLS[a], QoS Layer 3 DiffServ, FTP, SFTP, CIFS/SMB, SMTP, Bonjour, UPnP®, SNMP v1/v2c/v3 (MIB-II), DNS, DynDNS, NTP, RTSP, RTP, SRTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP, SOCKS, SSH, LLDP
Intégration système	
Interface de programmation	API ouverte pour l'intégration logicielle, avec VAPIX® et plate-forme d'applications pour AXIS Camera ; caractéristiques disponibles sur *axis.com* AXIS Video Hosting System (AVHS) avec connexion en un seul clic Profil ONVIF® G, Profil ONVIF® S et Profil ONVIF® T, caractéristiques disponibles sur *onvif.org*
Vidéo intelligente	Inclus Pilotage automatique, AXIS Video Motion Detection, AXIS Guard Suite avec AXIS Motion Guard, AXIS Fence Guard et AXIS Loitering Guard, alarme de sabotage, événements de stockage local Compatibilité Prise en charge de la plateforme d'applications AXIS Camera (ACAP) permettant l'installation d'applications tierces, voir *axis.com/acap*
	Outils d'analyse, événements de stockage local, entrées virtuelles via API État du périphérique : seuil de température de fonctionnement supérieur, seuil de température de fonctionnement supérieur ou inférieur, seuil de température de fonctionnement inférieur, dysfonctionnement du ventilateur, suppression de l'adresse IP, perte de réseau, nouvelle adresse IP, échec de stockage, système prêt à fonctionner, plage de température de fonctionnement respectée Stockage local : enregistrement en cours, interruption du stockage E/S : déclenchement manuel, entrée virtuelle PTZ : PTZ prêt Programmés et récurrents : événement programmé Vidéo : mode jour-nuit, flux de données vidéo en direct ouvert, sabotage
Actions sur événement	Enregistrement vidéo : carte SD et partage de réseau Chargement d'images ou de clips vidéo : FTP, SFTP, HTTP, HTTPS, partage de réseau et e-mail Mise en tampon de vidéo ou d'image avant et après alarme pour enregistrement ou téléchargement Notification : courrier électronique, HTTP, HTTPS, TCP et SNMP PTZ : Préréglage PTZ Incrustation de texte, mode jour/nuit, LED de statut, mode WDR, incrustation de texte
Flux de données	Données d'événements
Ressources intégrées d'aide à l'installation	Mise au point à l'installation, sélection de l'objectif, calibrage de positionnement, connexion à distance PTZ
Général	
Boîtier	Certification IP66, NEMA 4X et IK10 Dôme en polycarbonate Boîtier aluminium
Développement Durable	sans PVC
Mémoire	RAM de 2048 Mo, mémoire Flash de 512 Mo
Alimentation	Consommation électrique sans PTZ : PoE 9 W standard, 22 W max 24 V CC 9 W standard, 75 W max 24 V CA 16 VA standard, 97 VA max
Connecteurs	RJ45 pour 10BASE-T/100BASE-TX/1000BASE-T PoE Port RJ45 10BASE-T/100BASE-TX/1000BASE-T Q60-E
Stockage	Prise en charge des cartes SD/SDHC/SDXC et du cryptage Enregistrement sur une unité de stockage réseau (NAS) Pour des recommandations sur les cartes SD et le stockage NAS, voir *axis.com*
Conditions d'utilisation	-40 °C à 50 °C (-40 °F à 122 °F) avec AXIS Camera Heater Kit -20 °C à 50 °C (-22 °F à 122 °F) Température maximale conformément à la norme NEMA TS 2 (2.2.7) : 74 °C (165 °F) Température de démarrage : -30 °C -40 °C à 50 °C (-40 °F à 122 °F) avec AXIS Camera Heater Kit Humidité relative de 10 à 100 % (avec condensation)
Conditions de stockage	-40 °C à 65 °C (-40 °F à 149 °F) Humidité relative de 5 à 95 % (sans condensation)
Homologations	CEM EAC, EN 55032 Classe A, EN 55035, EN 50121-4, IEC 62236-4, EN 61000-3-2, EN 61000-3-3, EN 61000-6-1, EN 61000-6-2, FCC Partie 15 Sous-partie B Classe A, ICES-3(A)/NMB-3(A), VCCI Classe A, RCM AS/NZS CISPR 32 Classe A, KC KN32 Classe A, KN35 Sécurité IEC/EN/UL 62368-1, CAN/CSA C22.2 No. 62368-1, IEC/EN/UL 60950-22, CAN/CSA-C22.2 No. 60950-22 Environnement IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, IEC 60068-2-78, IEC/EN 60529 IP66, IEC/EN 62262 IK10, NEMA 250 Type 4X, NEMA TS 2 (2.2.7-2.2.9)
Dimensions	ø 395 mm (15,6 po) Hauteur : 201 mm (7,9 po)
Poids	4,5 kg (9,1 lb) sans AXIS Q60-E PTZ Network Camera

Accessoires fournis	Adaptateur Q60-E, vis à baïonnette, guide d'installation, licence 1 utilisateur décodeur Windows®
Accessoires en option	AXIS Lens M12 6 mm 5P, AXIS Lens M12 12 mm 5P, AXIS Lens M12 16 mm 5P, AXIS T91 Mounting accessories, Axis Midspan 60 W 1-port, AXIS Camera Heater Kit Pour en savoir plus sur les accessoires disponibles, voir *axis.com*
Logiciel de gestion vidéo	AXIS Companion, AXIS Camera Station, logiciel de gestion vidéo des partenaires de développement d'applications d'Axis disponibles sur *axis.com/vms*
Langues	Anglais, Allemand, Français, Espagnol, Italien, Russe, Chinois simplifié, Japonais, Coréen, Portugais, Polonais, Chinois traditionnel
Garantie	Garantie Axis de 3 ans et option de garantie prolongée d'AXIS, voir *axis.com/warranty*

a. *Ce produit inclut un logiciel développé par le projet OpenSSL pour une utilisation dans la boîte à outils OpenSSL (openssl.org), ainsi qu'un logiciel de cryptographie développé par Eric Young (eay@cryptsoft.com).*

Responsabilité environnementale :

axis.com/environmental-responsibility

Appendix 2 - Presentation of the Valeo Drive4U L4 Urban vehicle

This prototype vehicle is equipped with a system allowing it to evolve in urban environment (with the presence of an authorized driver in charge of its safety). This evolution is done in a mode of very high autonomy by exploiting various bricks:

- Perception bricks, powered by redundant sensor coverage (shown below), increased terrain model knowledge, and scene interpretation and prediction bricks;
- Decision bricks at different levels (route management, optimal maneuver decision, trajectory planning);
- Robust control bricks (longitudinal and lateral control of the vehicle allowing automatic lane changes and intelligent target control)
- Bricks for monitoring the state of the system and the surrounding environment. Indeed, this vehicle is able to detect environments beyond its operating environment. It is also capable of detecting situations requiring emergency maneuvers. This supervision is accompanied by prevention and vehicle safety bricks.