Roadside Infrastructure and Enhanced Perception for Autonomous Vehicles

Paris Saclay Autonomous Lab study case

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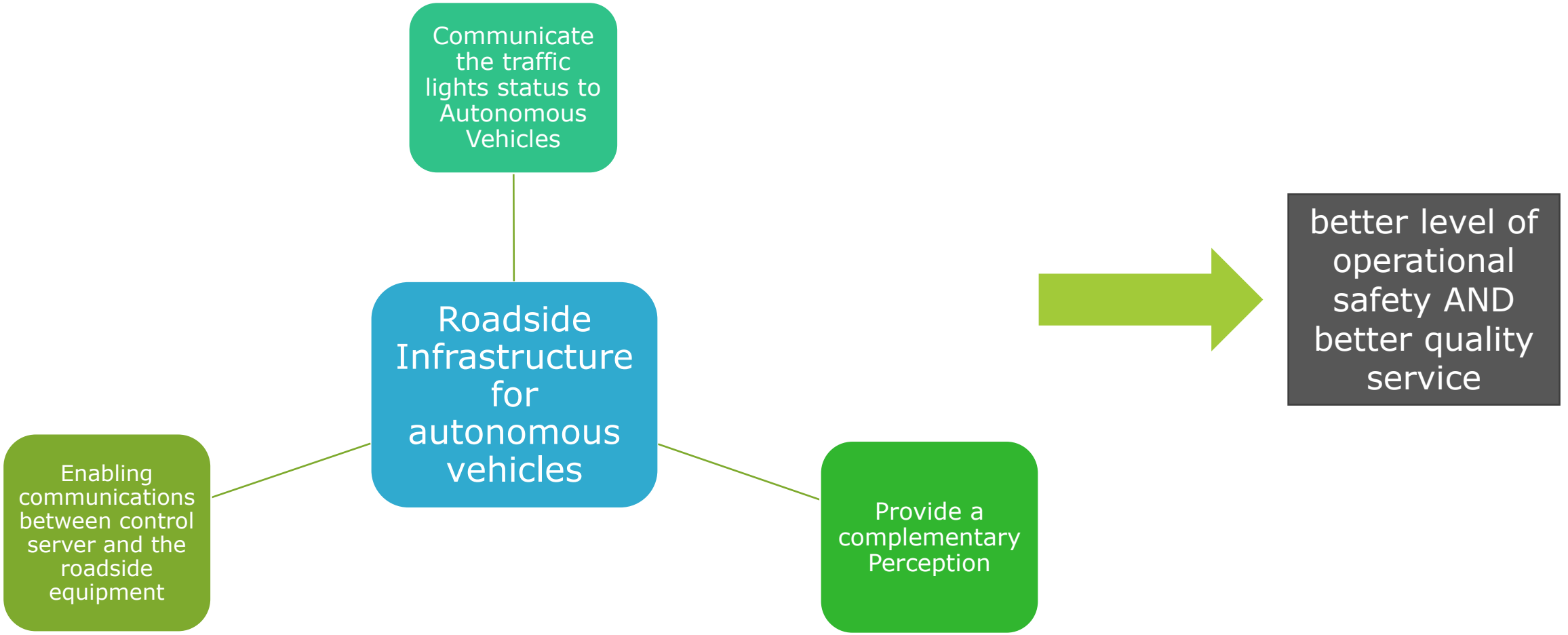
WHY ?

Purpose of Roadside Infrastructure

PURPOSE OF ROADSIDE INFRASTRUCTURE FOR AUTONOMOUS VEHICLES



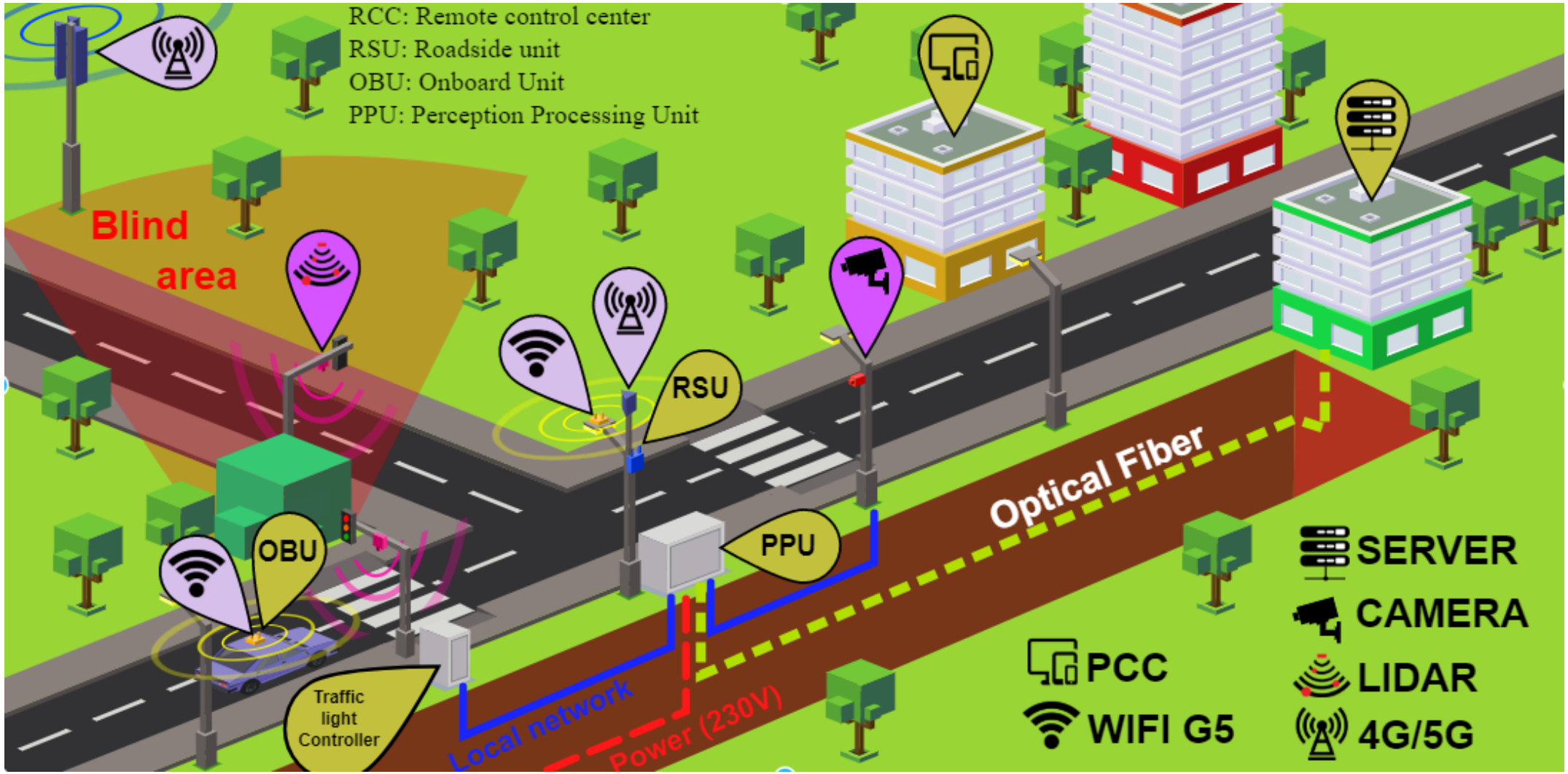
HOW ?

Enhanced Perception Implementation

Network Architecture Conception

Roadside Infrastructure Integration

EXPERIMENTATION SITE'S CONFIGURATION



ENHANCED PERCEPTION DESIGN

Conception of the perception system

ROAD INSPECTION

- **Without Vehicles**
  - Identification of the itinerary's « Critical areas »
  - Characterization of these areas to different categories (pedestrian crossing, bus stop, crossroad, dangerous vertical curve, etc)

- **With Vehicle**
  - Sort the previous list with respect to vehicular sensors

→Decrease the list of equipped areas if unnecessary compared to the equipment of autonomous vehicles

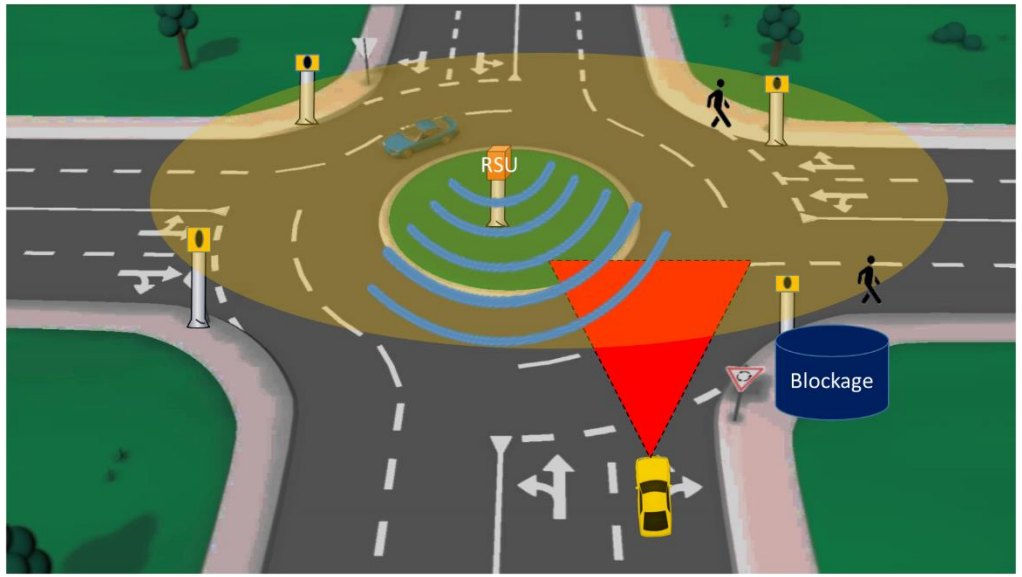
→ **Critical areas detection**
→ **Typology definition of these areas**
→ **Initial Perception system's conception (sensors)**

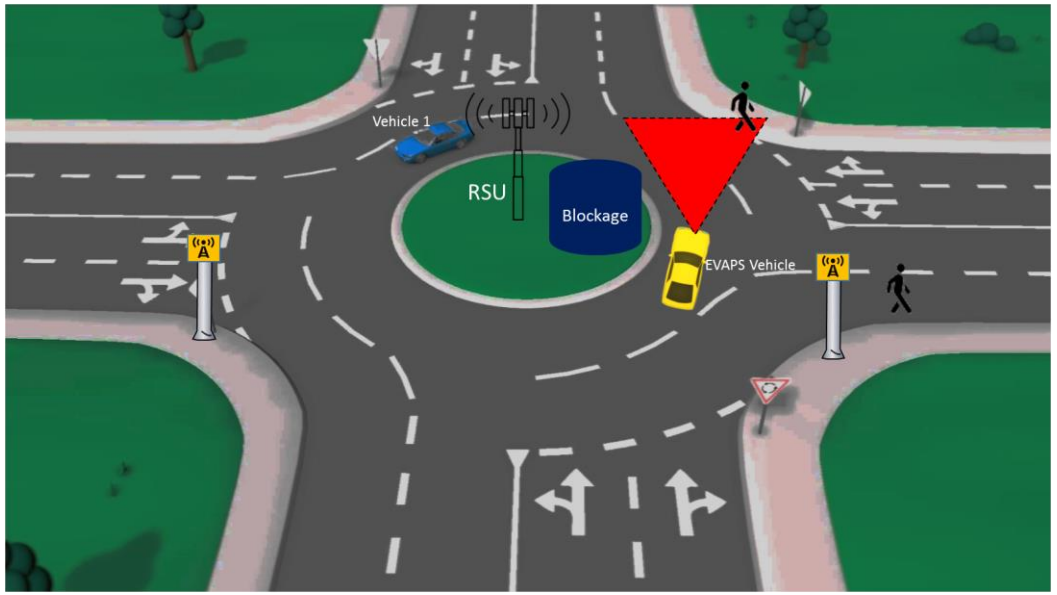
ROAD INSPECTION

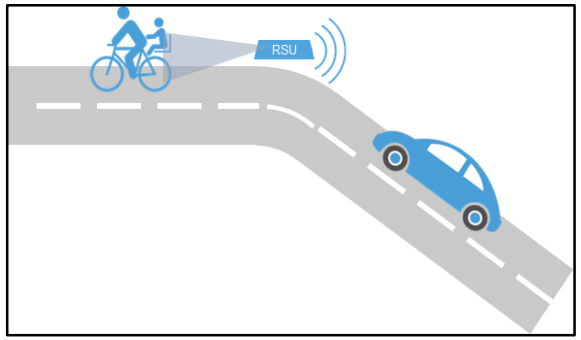
- **Typology definition Example :**

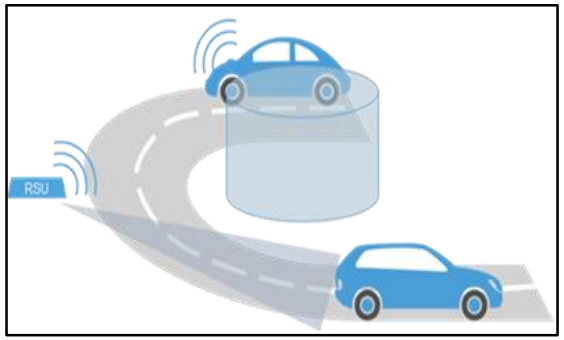
Code	Characteritics
PDX	Pedestrian and cycle crossing
STP	Bus station
LGT	Crossroad with signal lights
RND	Old style Roundabout
MRD	Modern Roundabout
CRV	Dangerous horizontal or vertical curve
MTN	Multi-transport node
NLX	Crossroad without signal lights

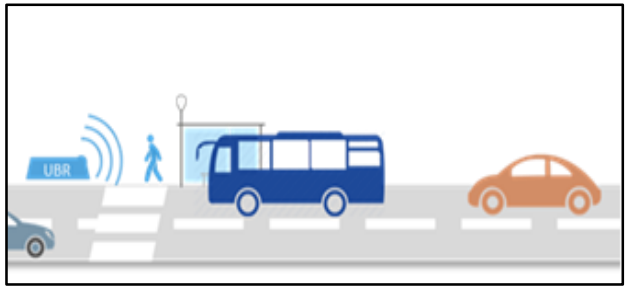
USE CASE 1 : BLIND ZONES





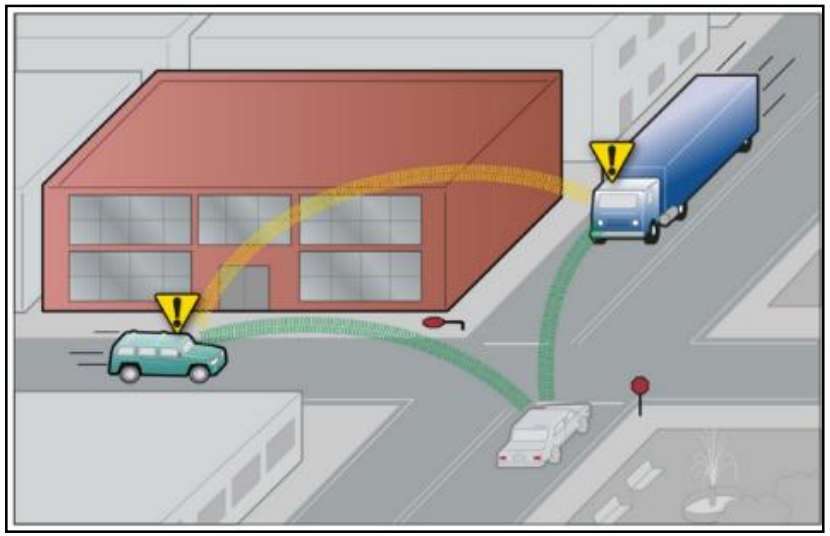






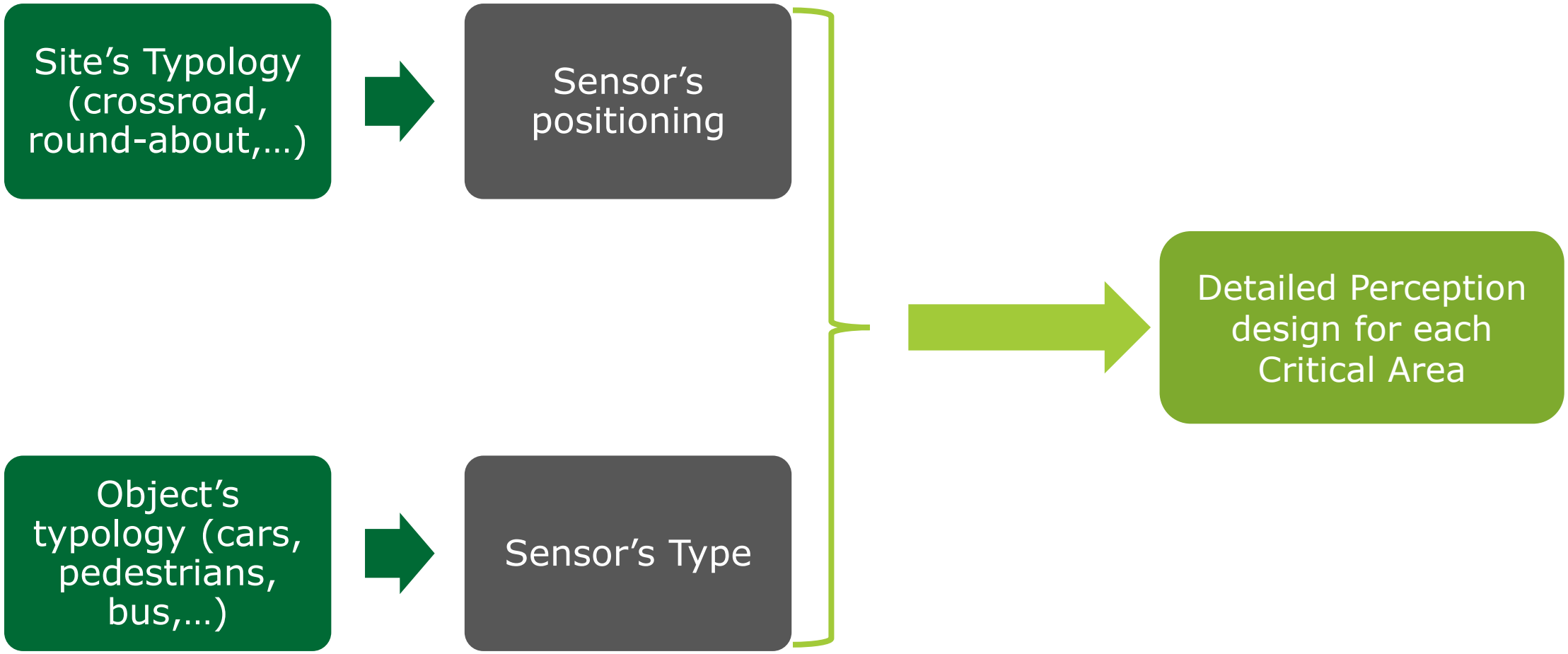
Vehicle sensor's perception → infrastructure sensors take over

USE CASE 2 : SPEED ANTICIPATION



Roadside sensors allow the perception of upcoming events → the vehicle can adapt its speed accordingly

DETAILED PERCEPTION SYSTEM'S DESIGN



DETAILED PERCEPTION SYSTEM DESIGN : IMPLEMENTATION DETAILS ON A CROSSROAD

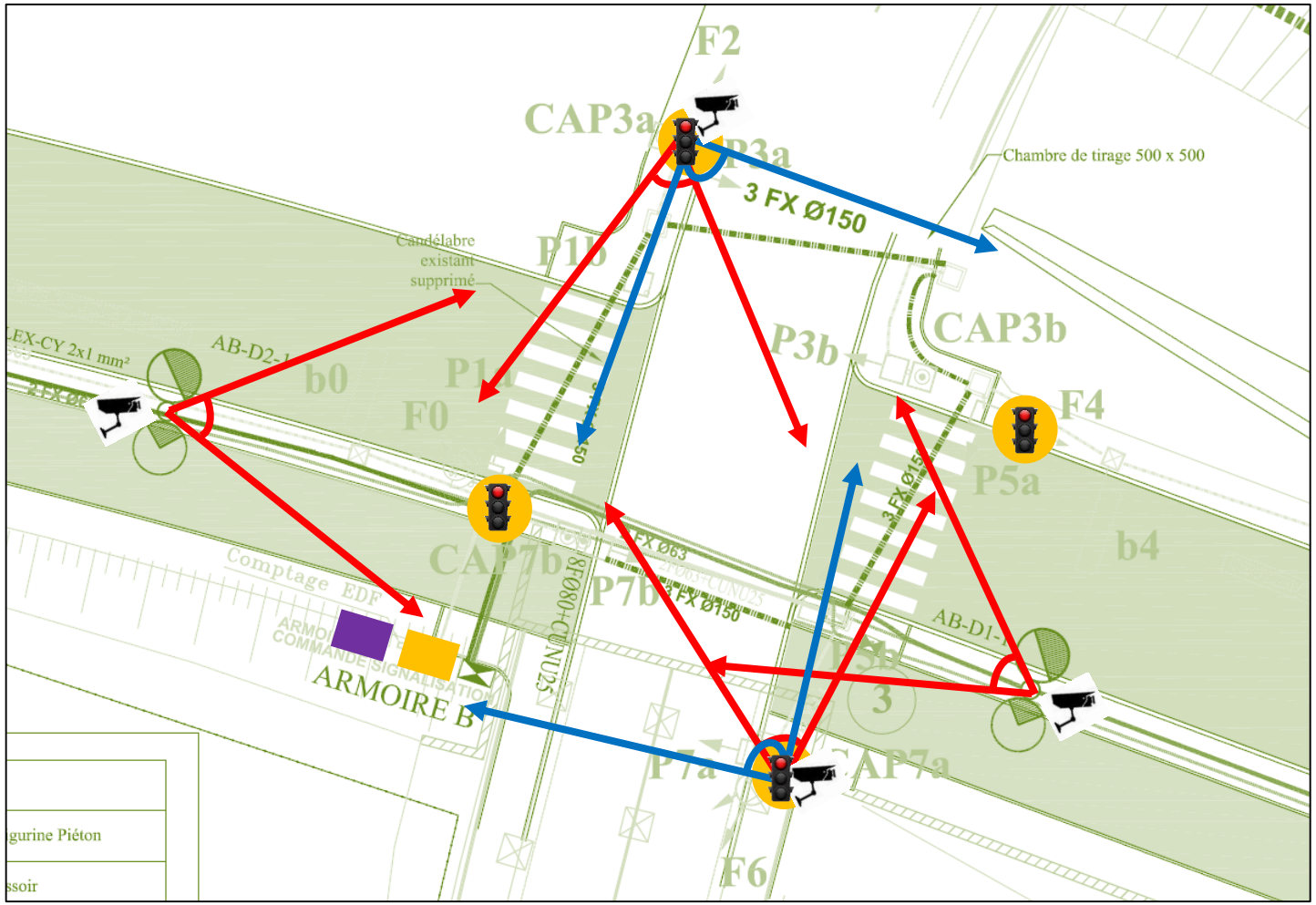
Roadside unit

Crossroad controller

Trafic light

Optical/thermic sensor

Lidar



EXAMPLE OF DEPLOYABLE SENSORS

Video Cameras
Axis & Foscam

Thermal cameras
Flir & ITS

Lidars
Quanergy M8

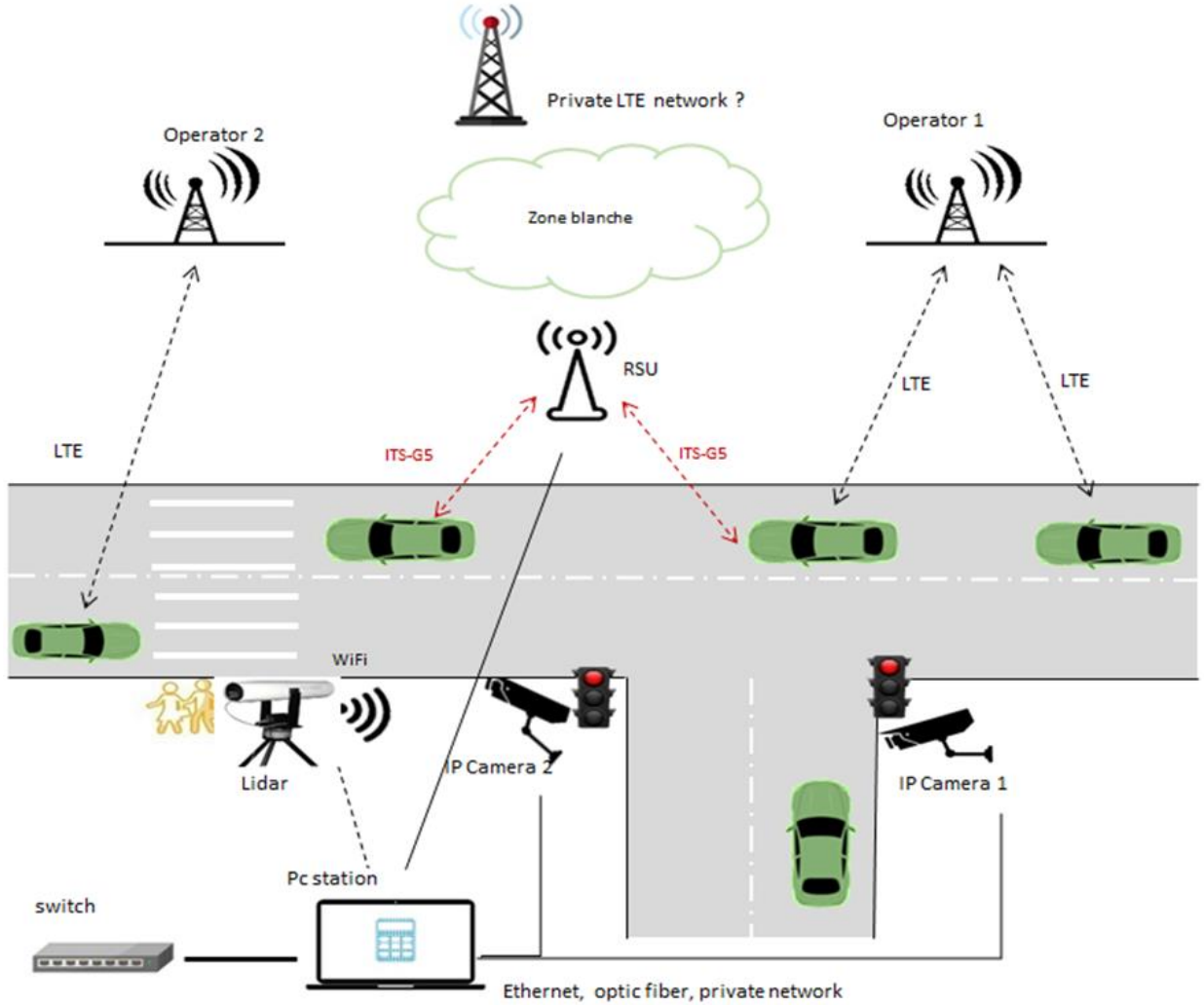
NETWORK ARCHITECTURE

LOCAL INFRASTRUCTURE BROADCASTING NETWORK

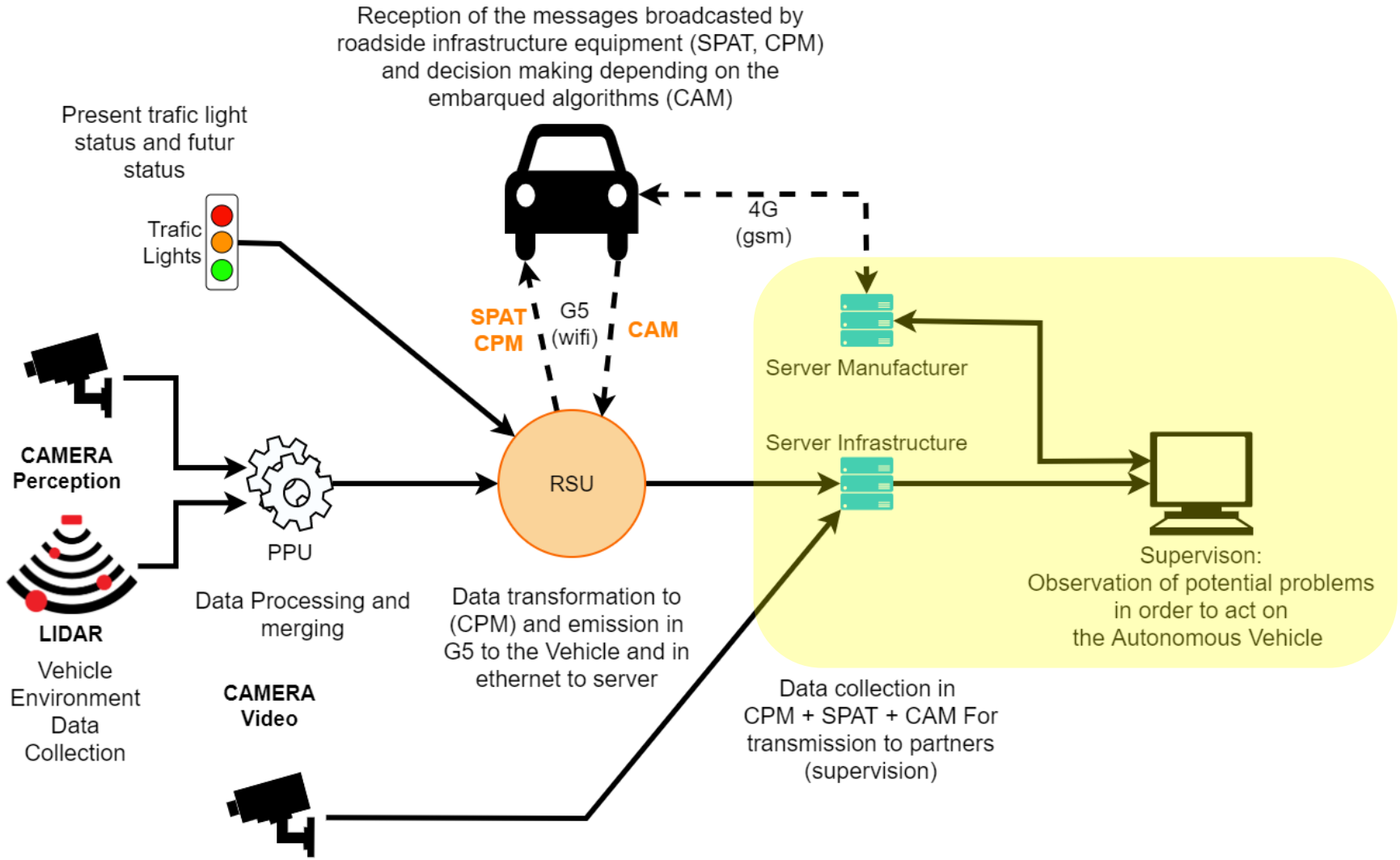
Communication between Autonomous Vehicles and Roadside Infrastructure's equipments :

- **I2V : Infrastructure to Vehicle**
- **V2X : vehicle to Vehicle AND vehicle to Infrastructure (vehicle to everything)**

→ Road side unit (RSU101) equipment



ENHANCED PERCEPTION EQUIPMENT'S INTERACTIONS IN THE NETWORK ARCHITECTURE



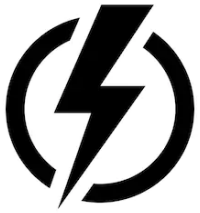
ROADSIDE INFRASTRUCTURE INTEGRATION

Integration in the existing environment and road structure

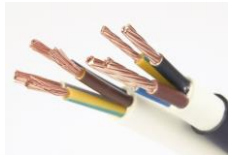
IMPLEMENTATIONS PROBLEMATICS

Power Network

Availability Nearby

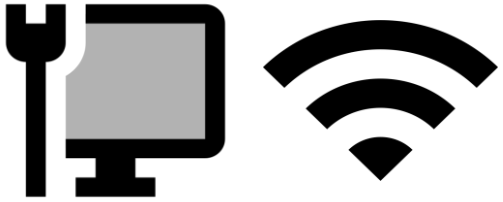


Power source Choice



Communication Network

Wired or Mobile ?



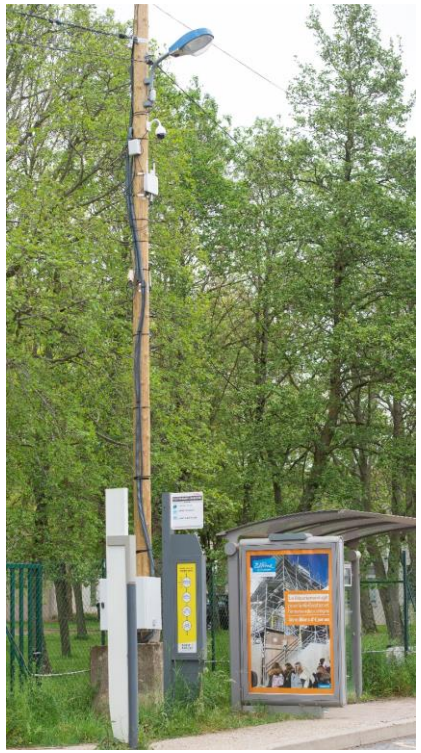
Existing or to Implement ?

IMPLEMENTATIONS PROBLEMATICS

Roads and utilities

Electric candelabrum

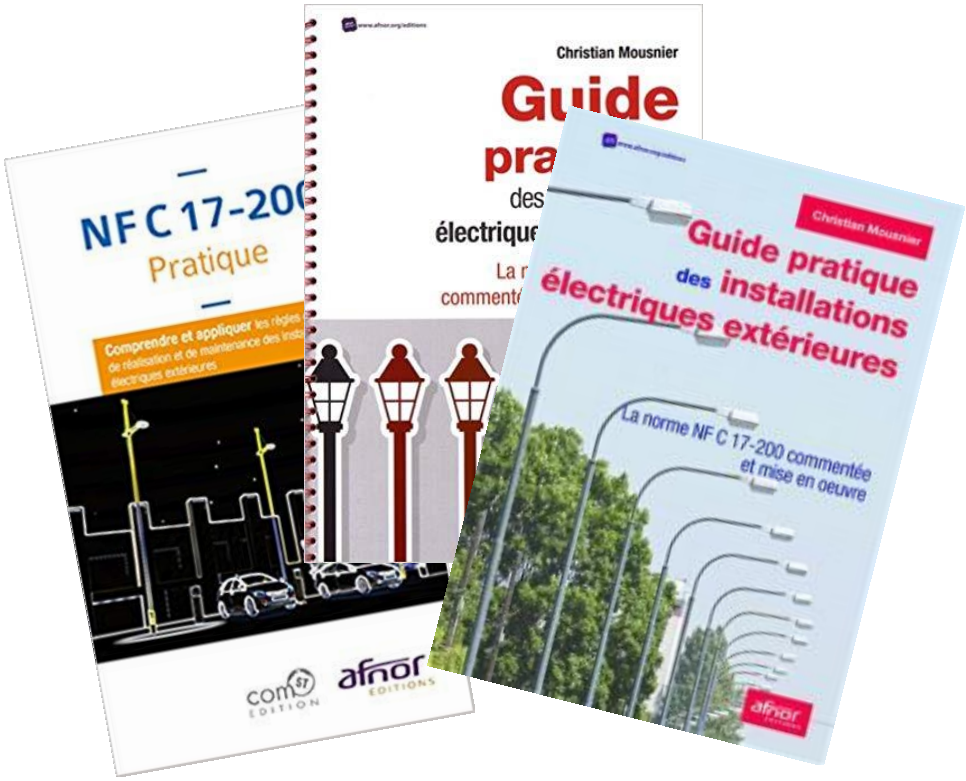
Temporary Mast



Underground Network

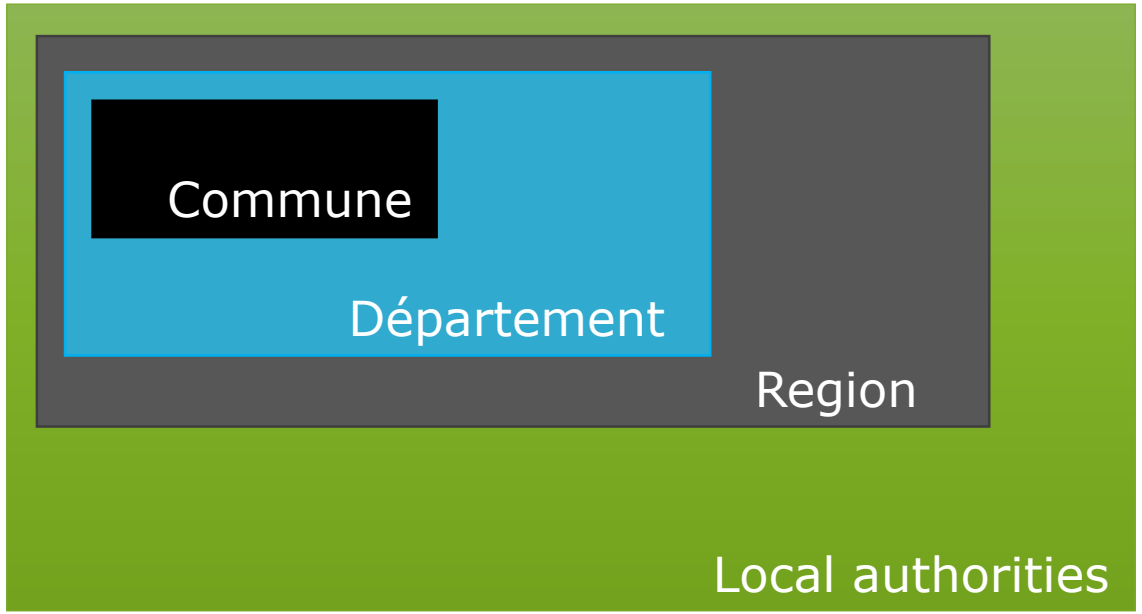
Arial Network

Security measures

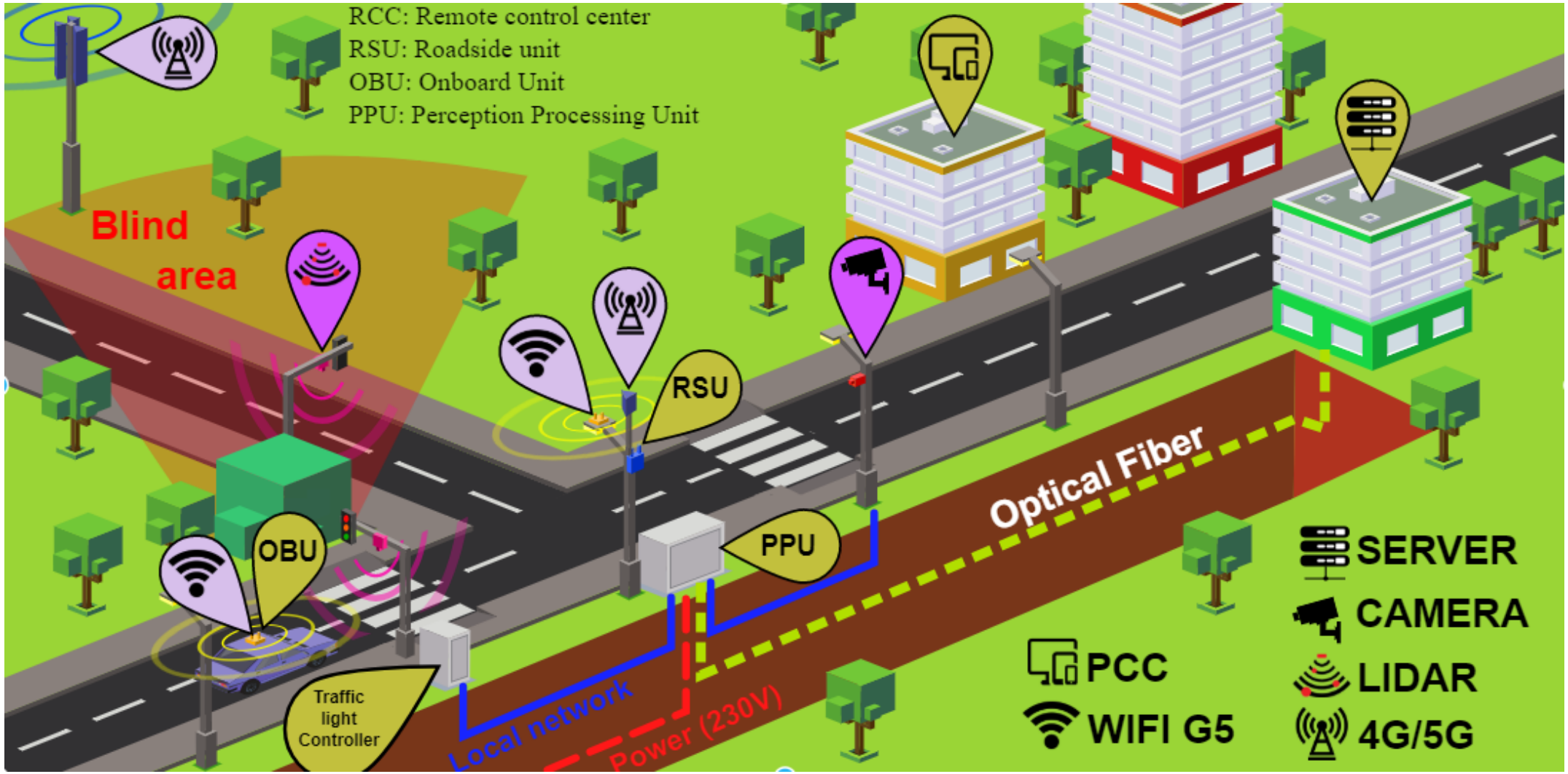


Communication with Authorities

- **Road decrees , road permissions**
- **Deadlines for each project → renewal for extantion of projects**
- **Dynamics of each territory : territory development**



SYNTHESIS : GENERAL ARCHITECTURE OF AN EQUIPPED SITE



PARIS SACLAY AUTONOMOUS LAB STUDY CASE

Focus on site 1: Multi-Transport Node Massy Palaiseau

STUDY CASE : PARIS SACLAY AUTONOMOUS LAB

- **Context :**
  - **Area of experimentation : Essonne Department (south of Paris)**
  - **Experimentation actors involved :**
    - Transdev
    - Renault Group
    - Paris Saclay Agglomeration
    - Vedecom
    - SystemX
    - Saclay University

- **Duration : March 2017 to February 2020**

STUDY CASE : PARIS SACLAY AUTONOMOUS LAB

Vedecom Team Project :

- Laurent Fevrier (communication network and project leader)
- Nassima Frissa (infrastructure engineering)
- Abhishek Jandial (enhanced perception)
- Edouard Dupin (server/network architecture)
- Maxime Le Guilloux (equipment prototype and maintenance)

INSTITUT VEDECOM
DU VÉHICULE DÉCARBONÉ ET COMMUNICANT ET DE SA MOBILITÉ

→ Design and implement the roadside infrastructure architecture and enhanced perception for the Paris Saclay Autonomous Lab Experimentation

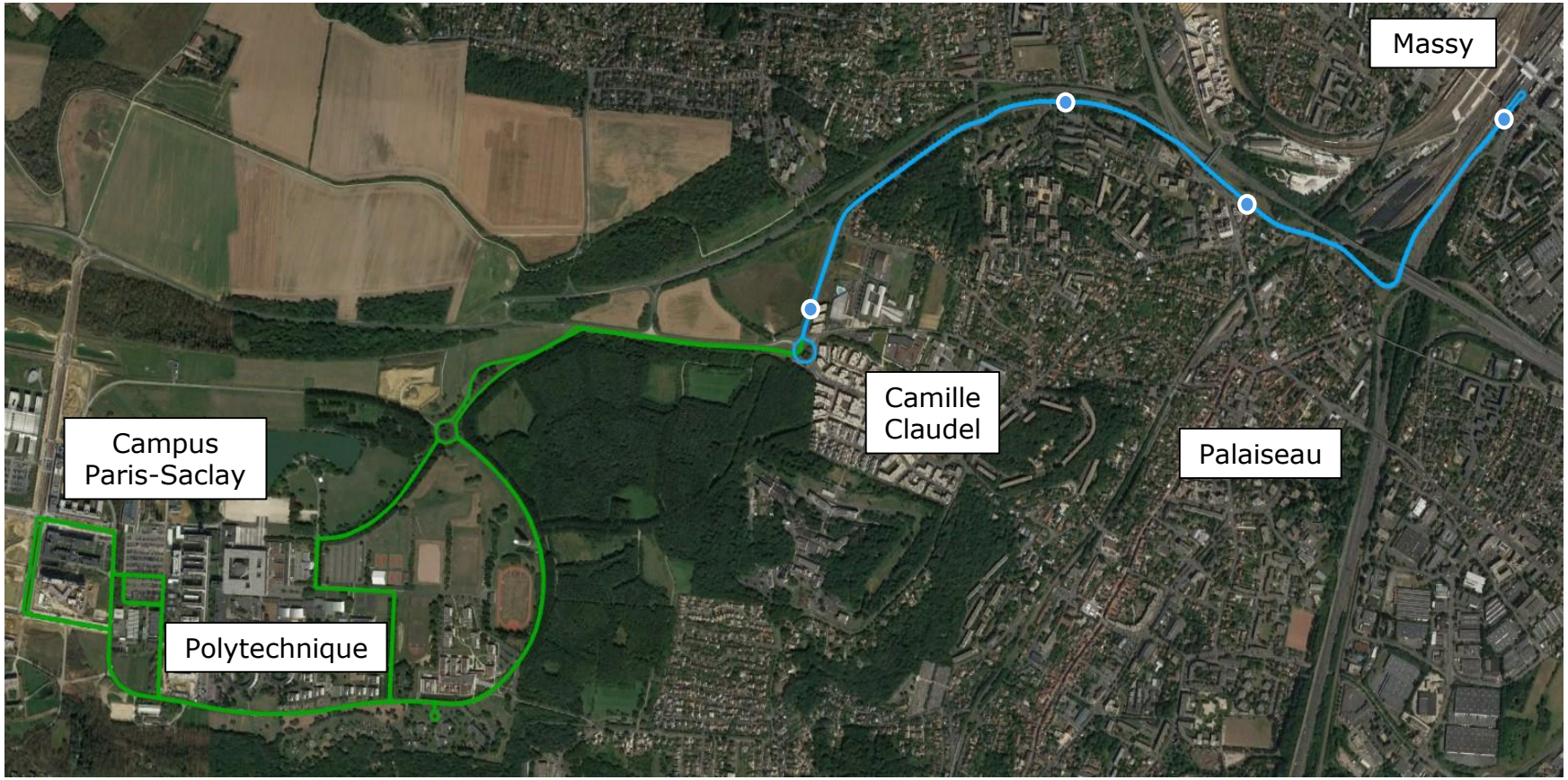
STUDY CASE : PARIS SACLAY AUTONOMOUS LAB

Blue zone

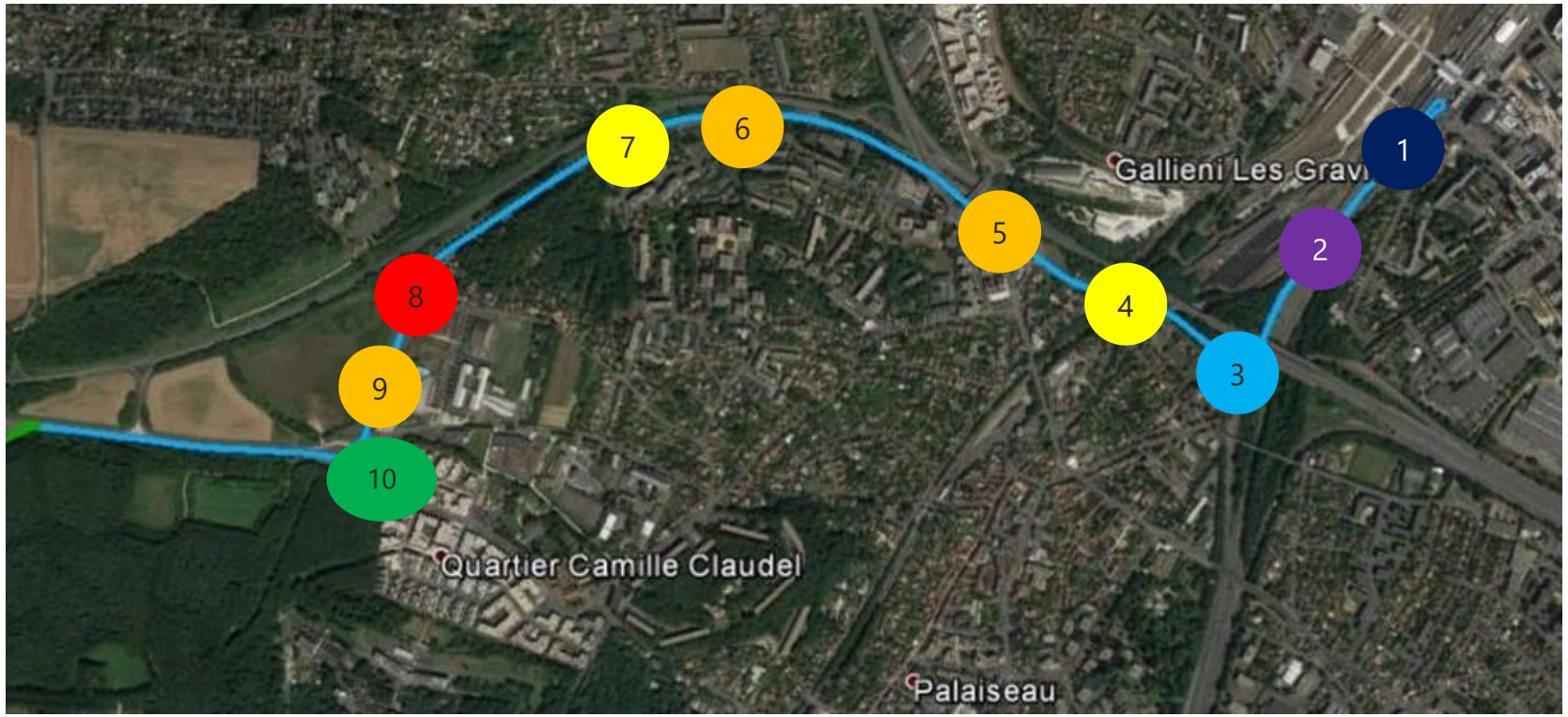
- Public Transport Specific Lane : from Massy Palaiseau Train station to "Camille Claudel" round-about
- Transdev Shuttle Experimentation

Green zone :

- Public roads in the vicinity of Ecole Polytechnique Campus
- Renault Robot-Taxi experimentation zone



PARIS SACLAY AUTONOMOUS LAB : EQUIPPED SITES AND TYPOLOGY

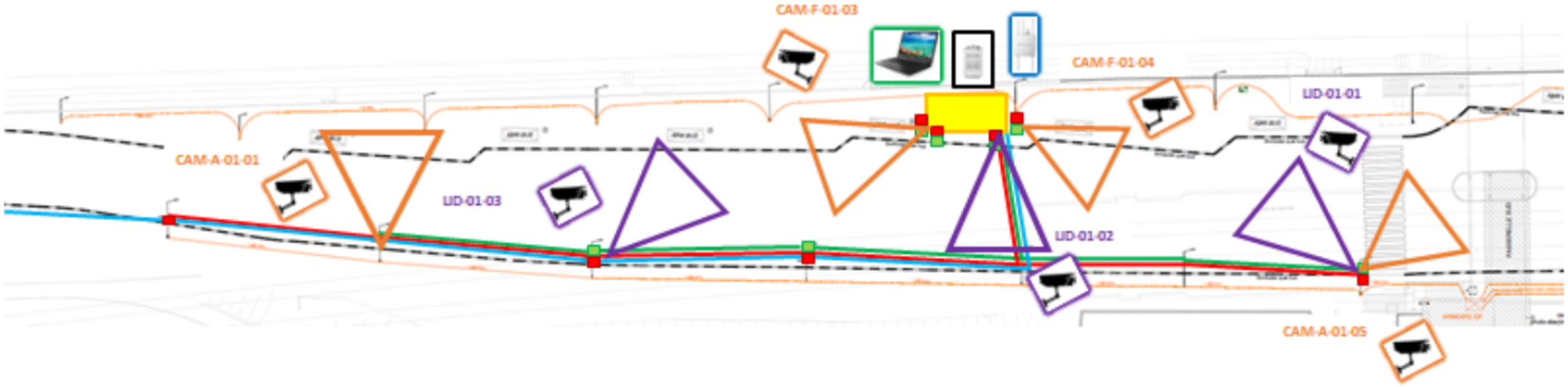


Legend	Characteristics
8	Pedestrian and cycle crossing
5 ; 6 ; 9	Bus station
4 ; 7	Crossroad with signal lights
10	Modern roundabout
3	Dangerous horizontal or vertical curve
1	Multi-transport node
2	Crossroad without signal lights

PARIS SACLAY AUTONOMOUS LAB : EQUIPPED SITES AND TYPOLOGY

Legend	Characteristics
18 ; 30	Bus station
42 ; 43 ; 45	Crossroad with signal lights
10 ; 14	Modern roundabout
12 ; 17 ; 22 ; 24 ; 34 ; 36	Crossroad without signal lights

FOCUS ON SITE 1 : MULTI-TRANSPORT NODE MASSY PALAISEAU



Small Cell 4G sur local Albatrans reliée au coffret en FO et RJ45
Small Cell 5G sur local Albatrans

PC connecté dans le local de relève Albatrans

RSU installé et raccordé sur local Albatrans

Quatre caméras installées sur les candélabres existants

Fibre optique aérienne sur candélabres vers les autres points du parcours

Liaison RJ45 catégorie 6A entre tous les composants du site

Trois lidars : 1 installé sur local Albatrans et 2 sur candélabres

Alimentation électrique aérienne sur candélabres

CONCLUSION

QUOTE

"Learning and innovation go hand in hand. The arrogance of success is to think that what you did yesterday will be sufficient for tomorrow."

William Pollard