LOCALISATION SYSTEMS FOR INTELLIGENT VEHICLES: **NEEDS AND CHALLENGES**

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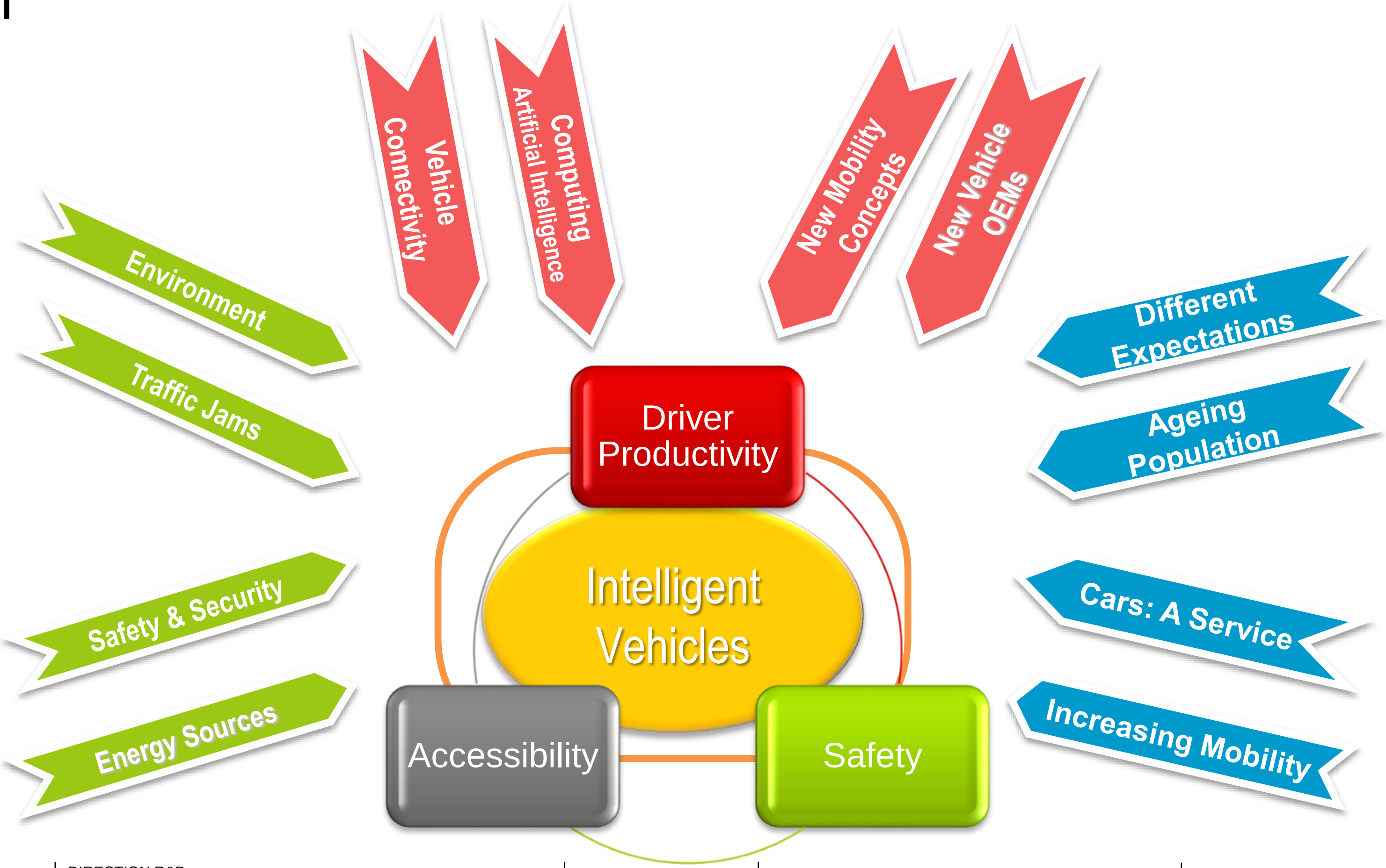
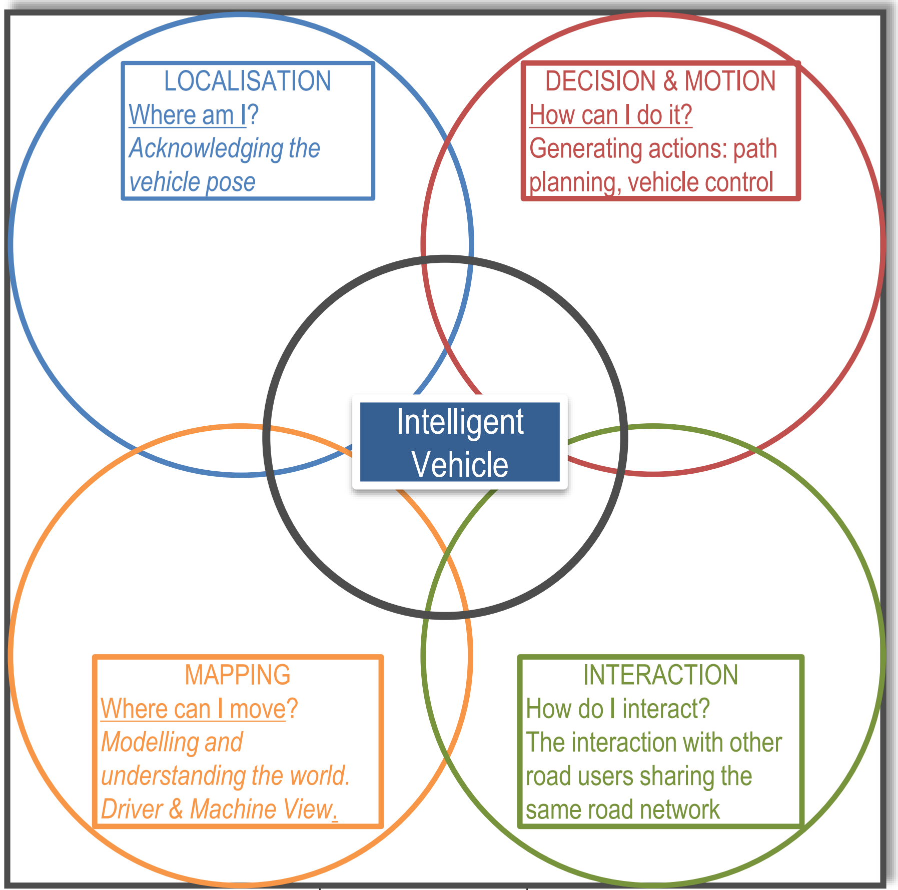
OUTLINE

- **Context**
  - The motivation
  - Intelligent Vehicles → Vehicle Navigation
- **Needs & Challenges**
  - Driving Assistance Systems
    - E.g. Road Intersection Warning
  - Cooperative Vehicles
    - E.g. Arrival of an emergency vehicle towards an intersection
  - Autonomous Vehicles
    - E.g. Autonomous valet parking service
- **Challenges & Localisation Systems**
  - Sample Issues
  - Some solutions
- **Conclusions**

CONTEXT


Vehicle Connectivity
Computing Artificial Intelligence
New Mobility Concepts
New Vehicle OEMs
Environment
Traffic Jams
Safety & Security
Energy Sources
Different Expectations
Ageing Population
Cars: A Service
Increasing Mobility
Driver Productivity
Intelligent Vehicles
Accessibility
Safety

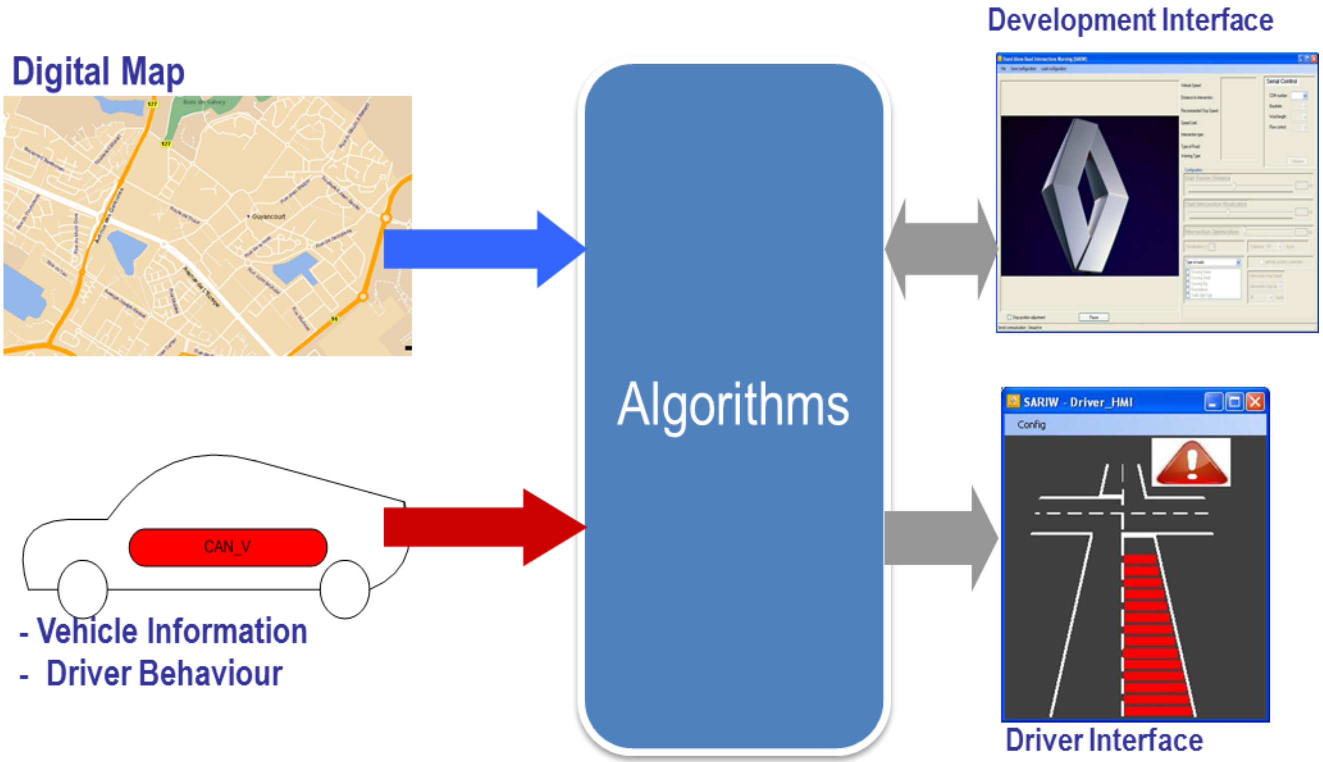
INTELLIGENT VEHICLES → VEHICLE NAVIGATION



NEEDS

- **Driving Assistance Systems**
  - Machine Perception →Judgement / Evaluation → Inform / Warn →Operator or machine acts
  - Challenges:
    - Perception is a hard problem: Laser Rangers, Radars, Machine Vision
    - Making a numerical model with incomplete information is difficult
    - Understanding a situation to decide under uncertainty a challenge
  - Maps:
    - Provide context, a priory information
    - e.g. road geometry for ACC, speed limits, the proximity of an intersection, etc.
  - Localisation
    - We need to know the vehicle location and projected to the map
    - Any projection error will imply that any map information is false.

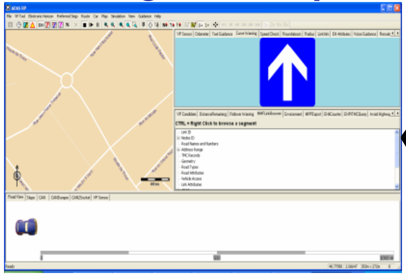
NEEDS: DRIVING ASSISTANCE SYSTEMS: EXAMPLE ROAD INTERSECTION WARNING



NEEDS: DRIVING ASSISTANCE SYSTEMS: EXAMPLE ROAD INTERSECTION WARNING

If the projection of the vehicle in the map is wrong, the whole strategy is **INVALID**

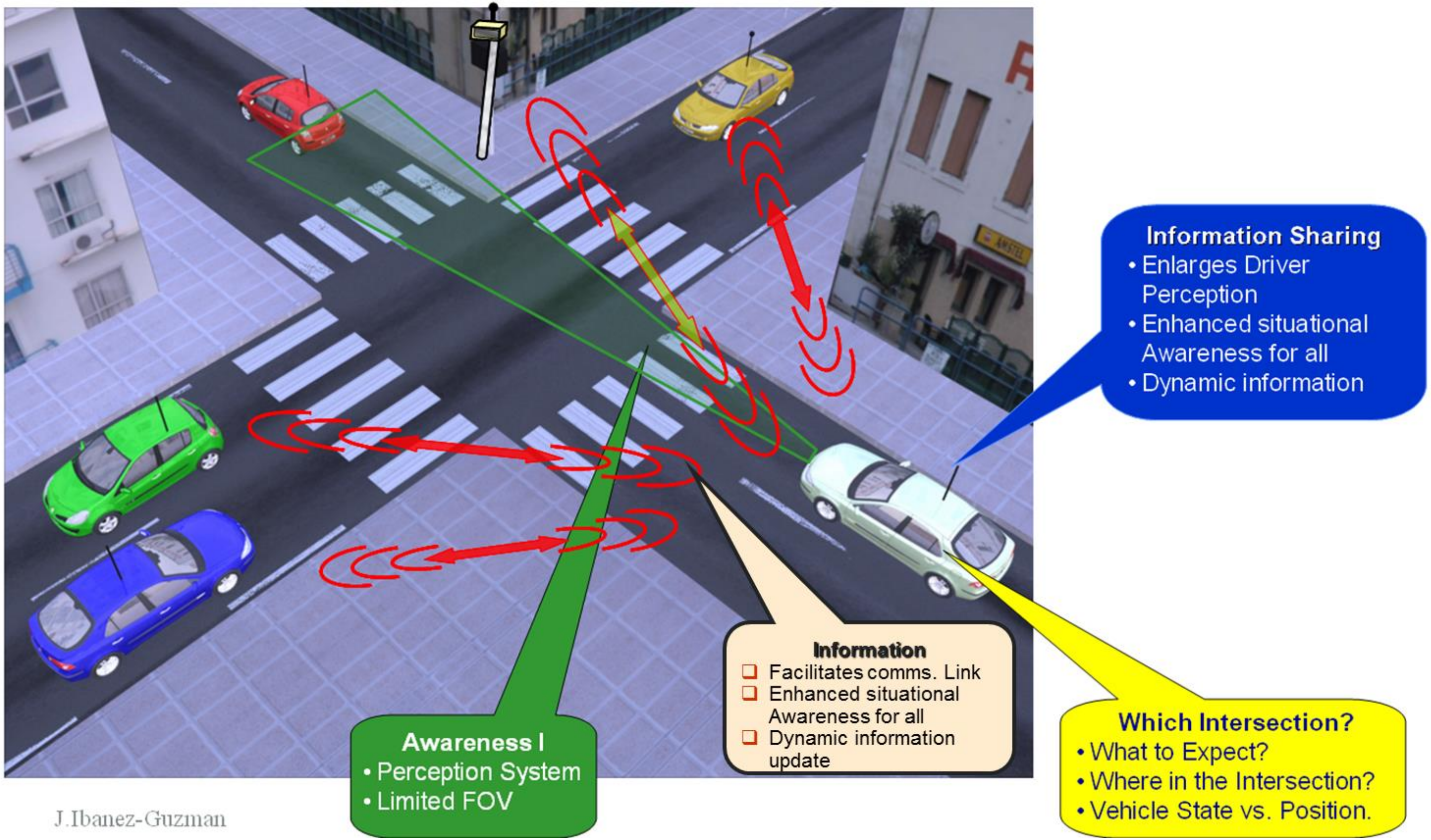
Information from Navigation Map



- ntersection Type
- Distance with r t to the n t intersection
- Ve s
- Ty d
- er of La
- section Geome
- Roundabout

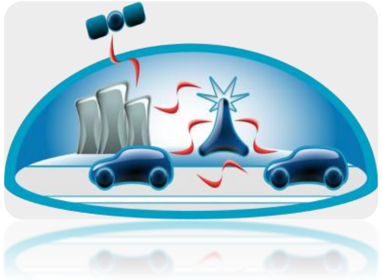
NEEDS

- Cooperating Vehicles V2X: Example Road Intersection Warning



NEEDS

- **Cooperating Vehicles V2X: The enabling technologies**



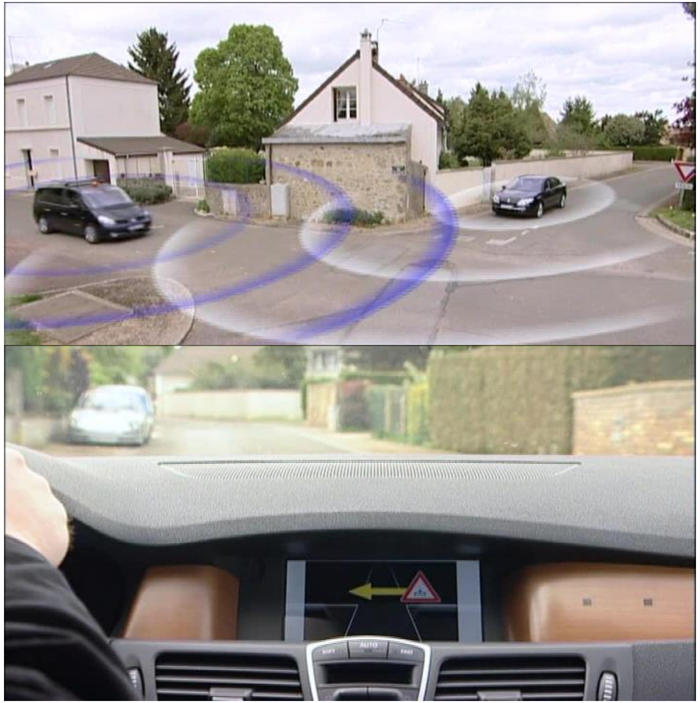
Localisation
LOC

Wireless Connectivity
V2X

Local Dynamic Map
LDM

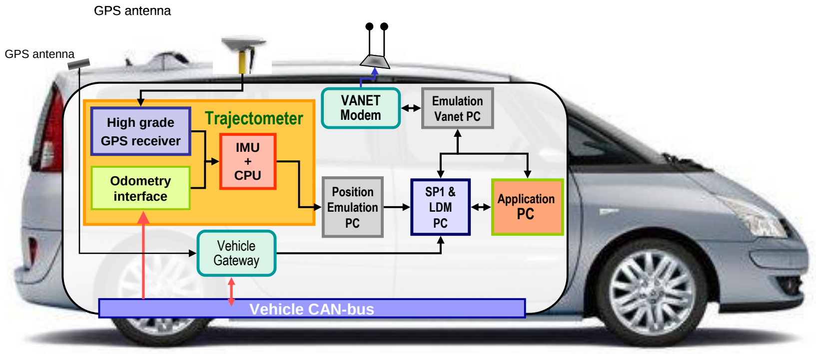
NEEDS

- **Cooperating Vehicles V2X:** e.g. Arrival of an emergency vehicle at an intersection
  - An emergency vehicle approaches an intersection.
  - It communicates its presence and direction of motion to neighboring vehicles.
  - Accordingly drivers are warned of its presence.

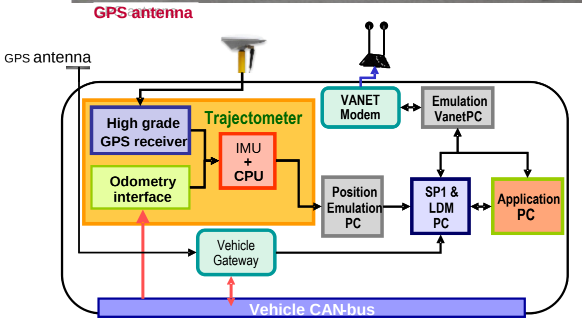


NEEDS

- **Cooperating Vehicles V2X:** e.g. Arrival of an emergency vehicle at an intersection

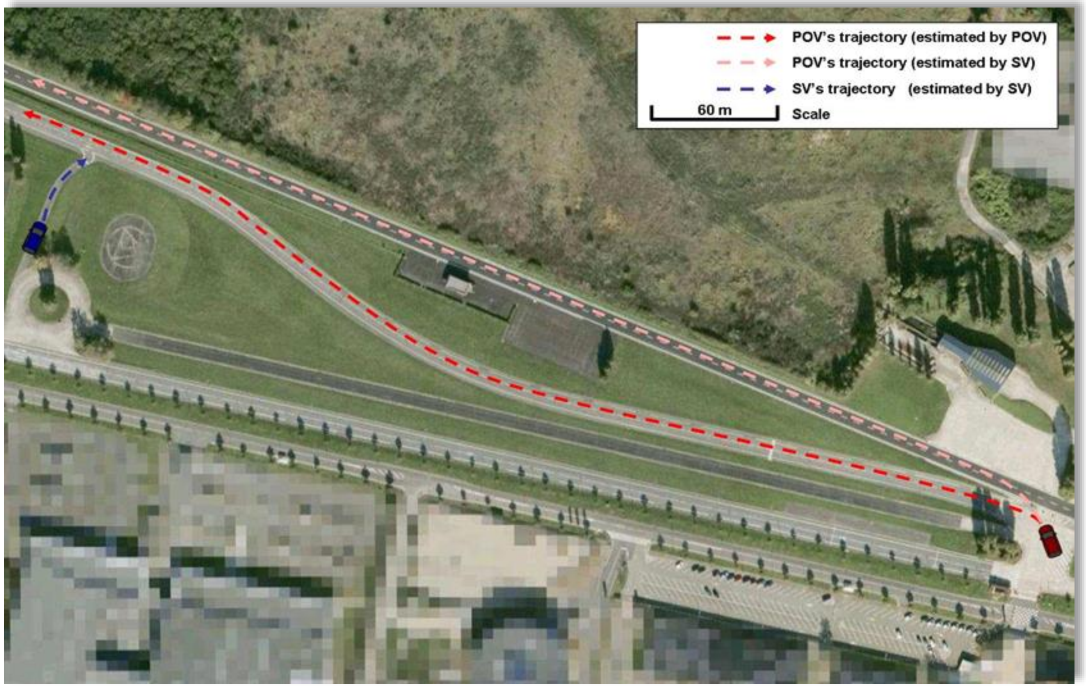


- Gateway: Interface to vehicle CAN-bus
- Localisation System
- Purpose Built Map LDM
- Fusion Process
- Application Computer
- RF Modems 5.9GHz



CHALLENGES

- **Cooperating Vehicles V2X:** e.g. Arrival of an emergency vehicle at an intersection



NEEDS: AUTONOMOUS VEHICLES

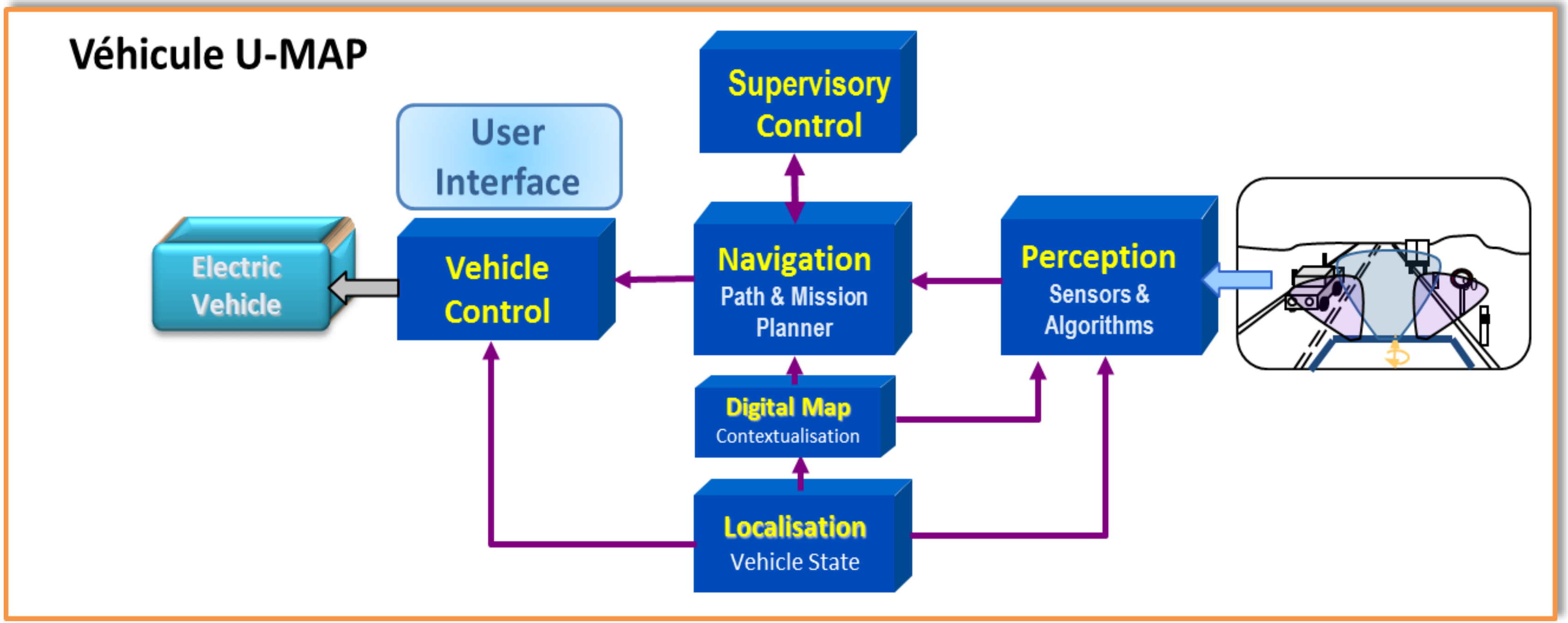
- **Context. Intelligent Mobility**
  - Technological convergence: Connectivity, Computer Power, Artificial Intelligence
- **The trends:**

- Driverless Vehicles
  - New Mobility Services
- Autonomous Vehicles
  - Traditional Clients

Converge robotique
automobile classique

NEEDS: AUTONOMOUS VEHICLES

- **A typical Functional Architecture**



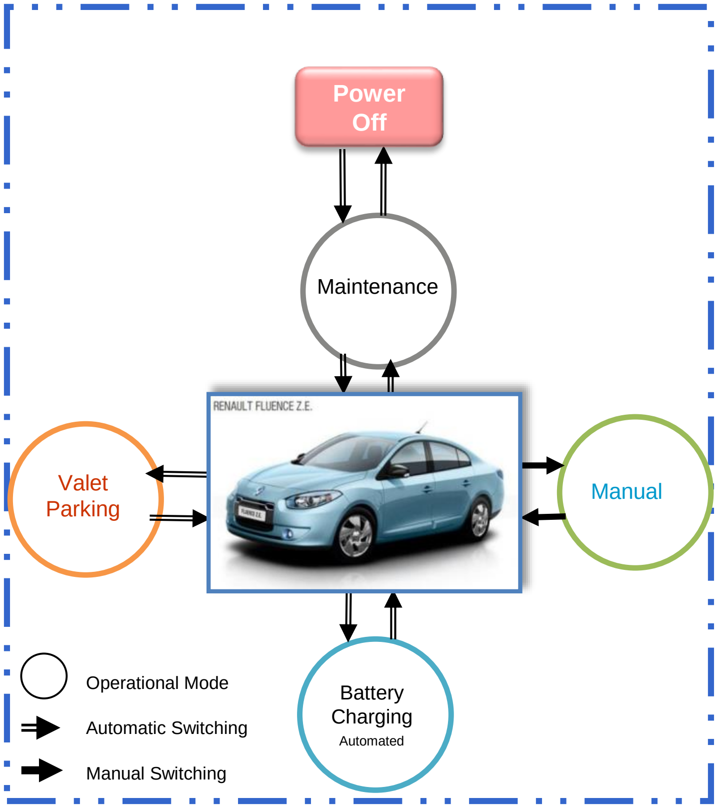
NEEDS: AUTONOMOUS VEHICLES

E.g. unmanned valet Parking

- **Purpose**:

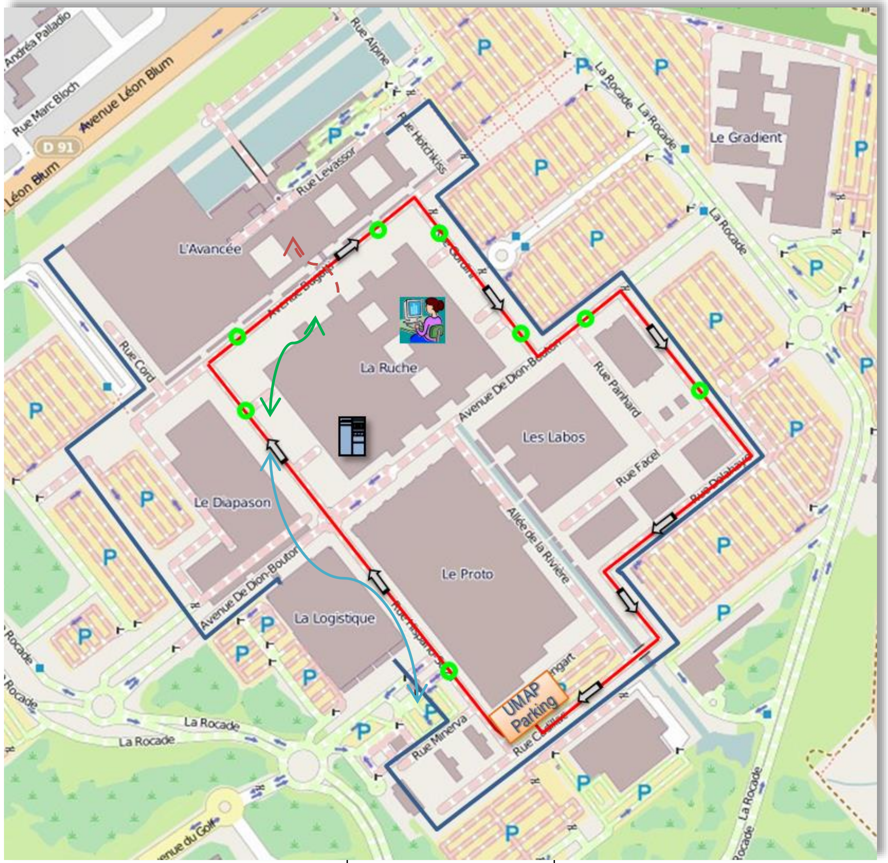
  To offer an *integrated valet service* for the use of EVs within the Technocentre Renault a demonstrator platform of autonomous driving technologies.

- **Objectives**
  - To provide a System Solution for the use of computer controlled EVs evolving in constrained spaces.
  - To develop safe and reliable systems for autonomous vehicles, using automotive type components
  - To build the technological know-how on: localisation, perception, navigation, control, integrity monitoring



NEEDS: AUTONOMOUS VEHICLES

- E.g. unmanned valet Parking

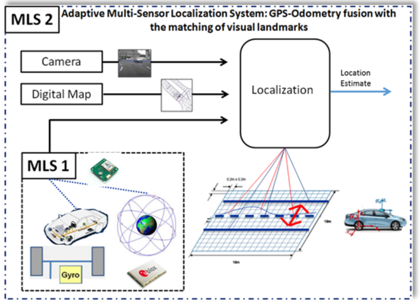


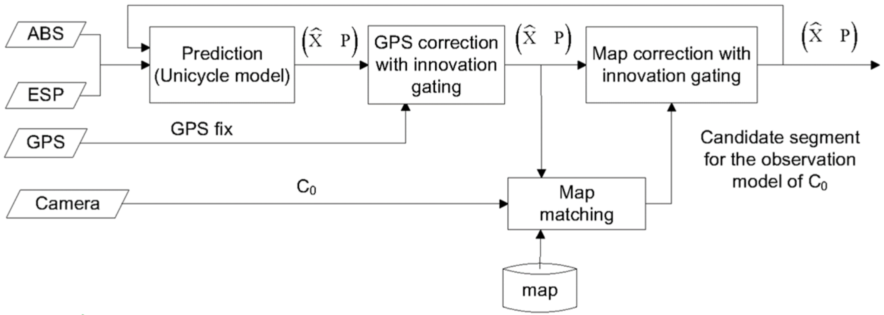
Vehicle parking area

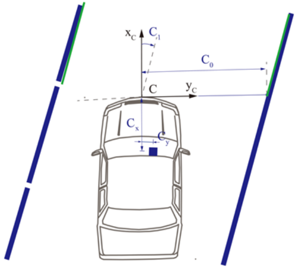
Pick-up points

NEEDS: AUTONOMOUS VEHICLES

- **E.g. unmanned valet Parking: Localisation system**







Components

- CAN bus Proprioceptive Data
- GNSS Rx + MEMS IMU
- Mobileye Camera
- Map of Drivable Area

Output (10Hz)

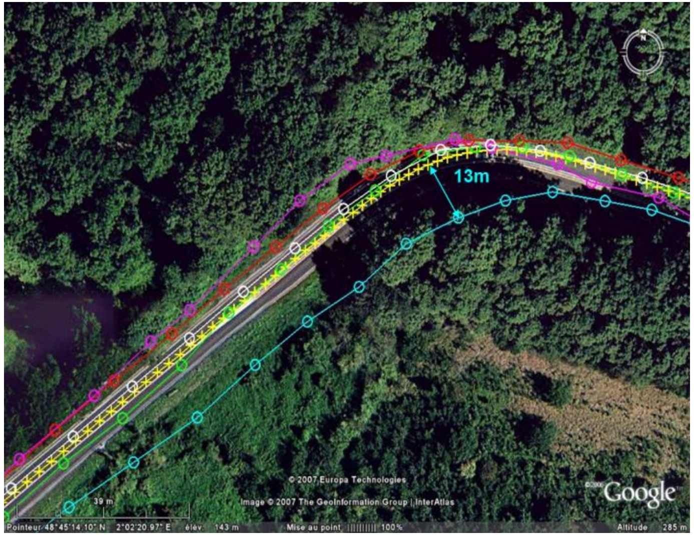
- Position and Heading
- Velocity
- Confidence Indicators

Automotive Components, Low Computational Needs, Renault's IP

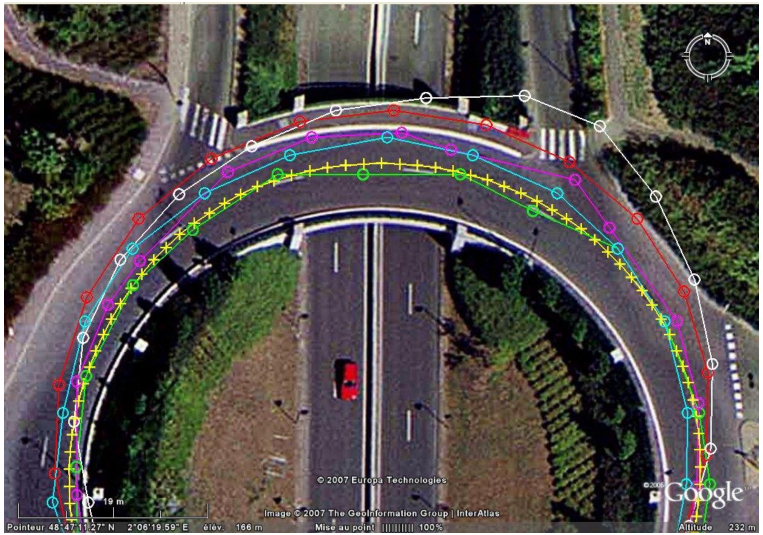
CHALLENGES: AUTONOMOUS VEHICLES

- **The navigation environment can be very complex**
  - Urban Canyons, tree canopies,
- **Information sources can suffer strong disturbances**

CHALLENGES: AUTONOMOUS VEHICLES

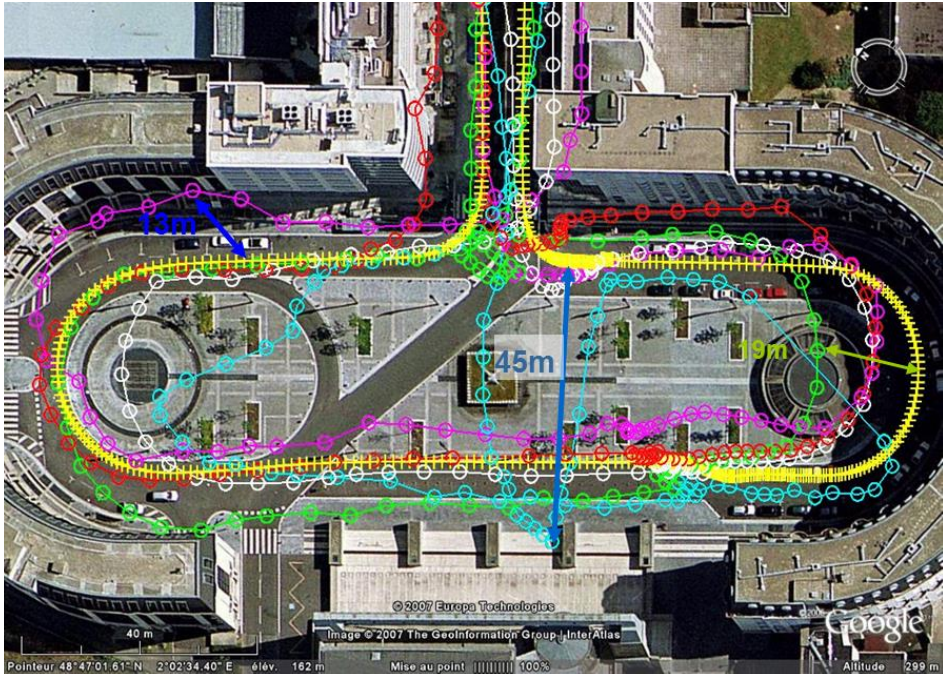


Effects on GNSS responses from tree canopies

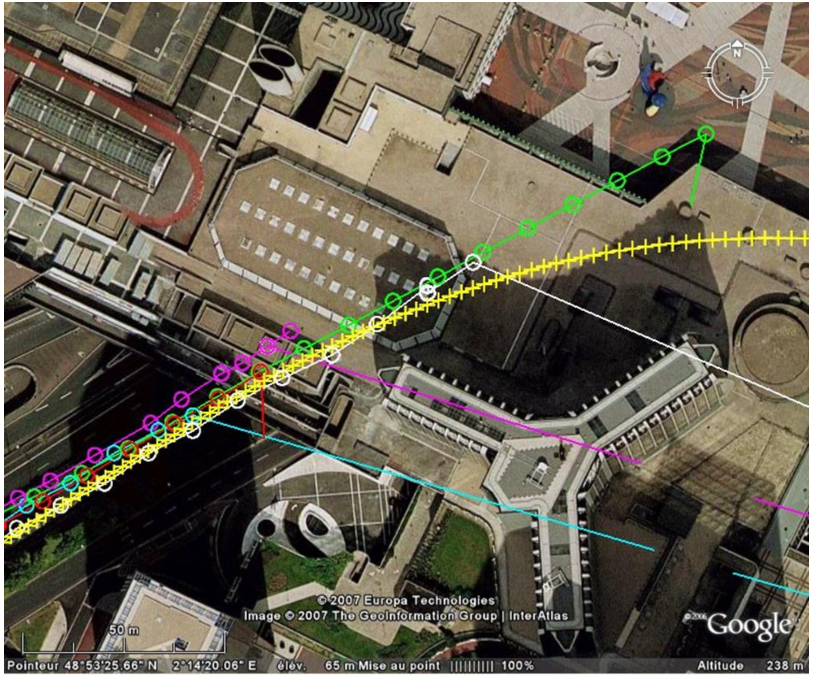


Errors on GNSS responses even at simple roundabouts.

CHALLENGES: AUTONOMOUS VEHICLES

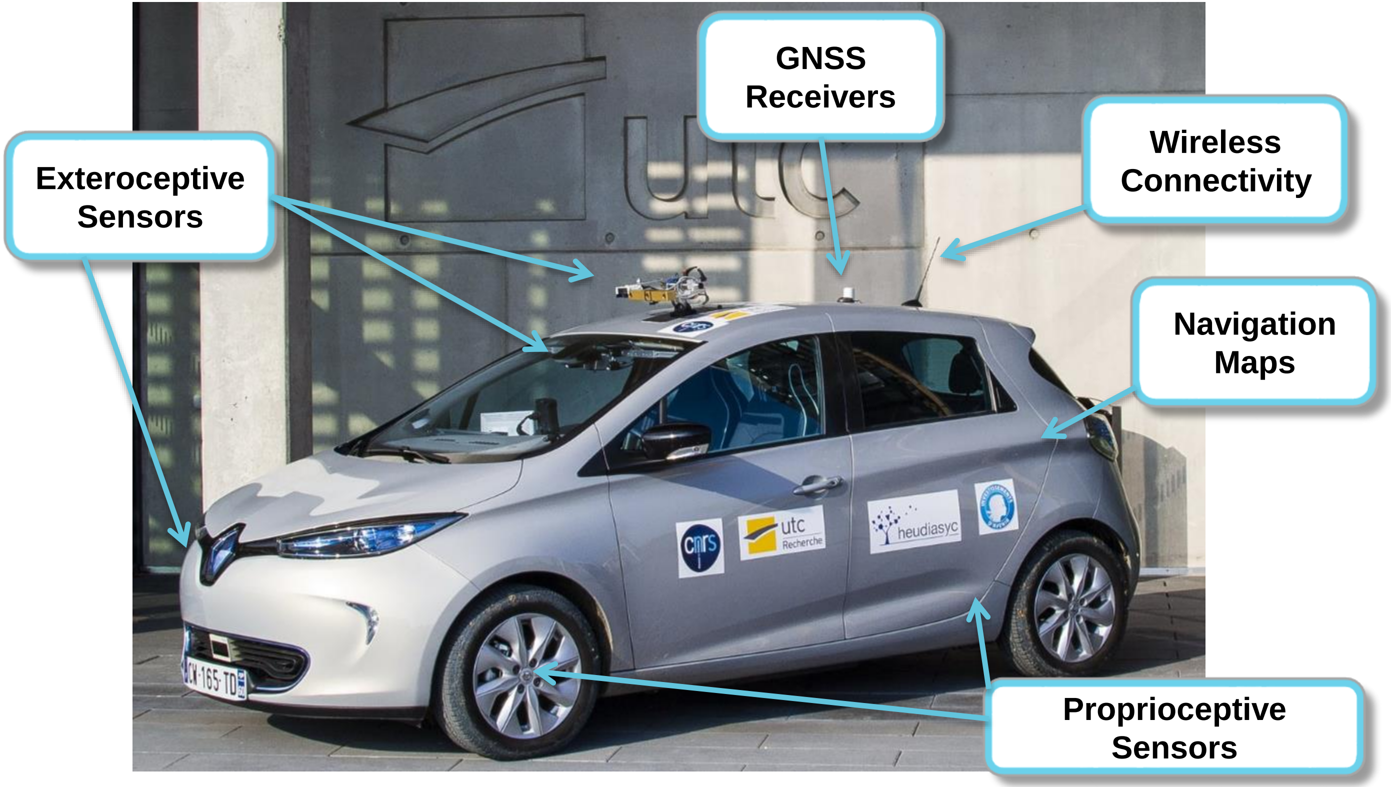


Effects on GNSS responses due to multipath.

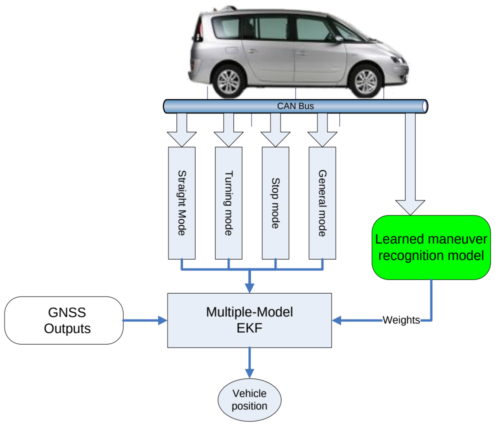


Effects on GNSS responses due to full occlusion as vehicle enters a tunnel.

AUTONOMOUS NAVIGATION: SOURCES OF INFORMATION

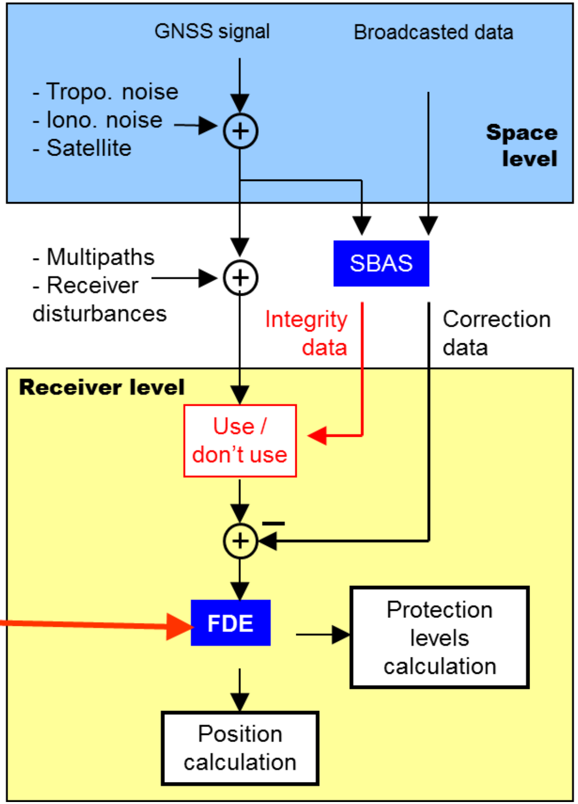


AUTONOMOUS NAVIGATION: DIFFERENT SOLUTIONS EXPLORED



Exploiting Vehicle information and GNSS data using machine learning methods

Fault Detection and Exclusion through Integrity Monitoring



CONCLUSIONS

- Localisation estimates (position & attitude) are needed for all modern intelligent vehicle applications.
- The limitations of GNSS systems are well understood, new features as those brought by the Galileo constellation should provide better performance.
- Autonomous Vehicles are a major trend: Localisation shall become a safety critical function → work towards high integrity localisation
- Combine different solutions:
  - Augment GNSS estimates via other sensors
  - Combine absolute localisation solutions with those from relative localisation solutions like optical odometry or SLAM
- Major interest by vehicle OEMs, hence our participation in ESCAPE one of the first Galileo centred solutions for Avs.