Real world driving scenario identification for AV functional safety

Autonomous Vehicle Test & Develoment Symosium

06/06/2018

Speaker: Gildas Thiolon
Project Manager: Annie Bracquemond

version

INSTITUT VEDECOM
DU VÉHICULE DÉCARBONÉ ET COMMUNICANT ET DE SA MOBILITÉ

French Institute for Energy Transition

Ecosystem of 50 members

30 M€ budget

175 employees

>100 researchers

To develop :

Disruptive technologies and a **cross-disciplinary vision of new usages**, for **sustainable, safe, efficient and affordable mobility**

To contribute to air quality in urban areas and CO2 massive reduction

By **moving** Electric Vehicle from niche to **mass market**

Vehicle electrification

To offer sustainable, safe and efficient mobility

By **accelerating the introduction of automated cars**, w or w/o driver

Driving delegation and connectivity

To optimize mobility systems on territories

By **analysis and experimentation of new services** linked with clean, autonous and connected vehicles

Shared mobility and energy

CONTEXT :

- French car manufacturers need a database of the parameters defining multiple real life driving situations about :

  How does the ego vehicle evolve in real world traffic? How does it react to the other road users and pedestrians? How to control the ego vehicle dynamics knowing how human drivers do it?...

- At the end of 2015 VEDECOM launched the MOOVE project aimed at the acquisition of big data about real world driving

- The final goal of the MOOVE project is to provide a full representation of the ego vehicle environment in order to identify safety critical scenarios

OBJECTIVES

1. **Build a DATA BASE, with AV’s sensors outputs, containing every driving situations.**
2. **Quantifying the dimensioning parameters relating to ego vehicle’s environment, enabling the identification and extraction of Scenarios**
3. **Identifying and analyzing real world driving situations leading to safety critical scenarios (SCS) for an autonomous vehicle**

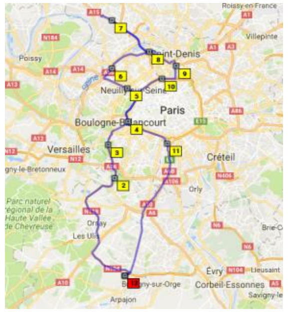
Goals :

- **Statistical Analyze of Parameters for each SCS**
- **Specify control laws for autopilot functions design**
- **Determine Safety Critical Scenarios to validate control laws with driving simulators (SVA project from SYSTEMX)**

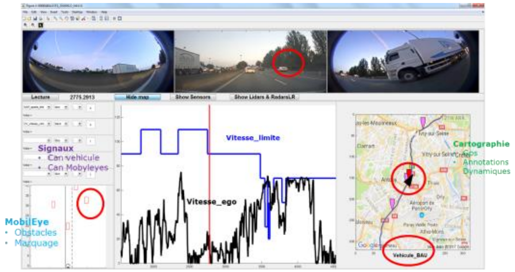
SCENARIOS IDENTIFICATION

- **Real world driving safety critical scenarios (SCS)**
- **SCS occurrence statistics**
- **New SCS**

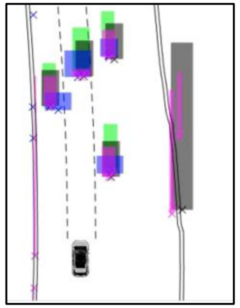
1. Big data :
Specific Data Collect



2.Preprocessing :
Data Transformation
at common format

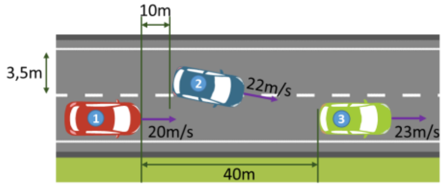


3. Perception algorithms for identification of mobile and static objects and infrastructure



4. Computation of High Level Parameters (HLP)
AV's environnement Modeling

5. Scenario exploration: safety event, variability (HLP) and Statistics



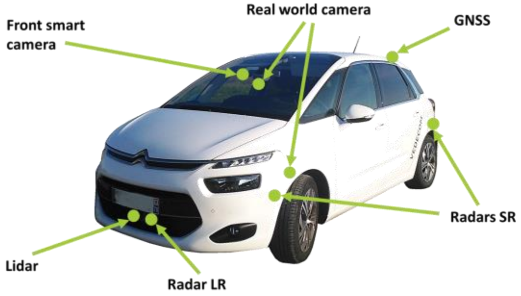
6 EQUIPED VEHICLES

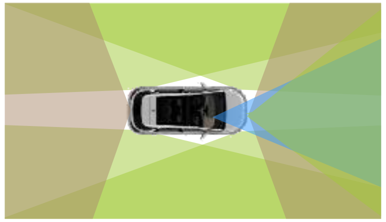
1.
Big data : Specific Data Collect

360° Vehicles perception sensors

- 2 Lidars Front rear
- 1 Long range radar front
- 4 Short range radar corners
- 1 Smart Camera Front

- 1 GNSS receiver
- IMU
- CAN vehicle information





360° Real Word videos

- Front wide dynamic
- Rear wide dynamic
- Left and right wide angle
- Front wide angle

Professional Drivers

- Driver’s head
- Driver’s hand
- Driver’s feet

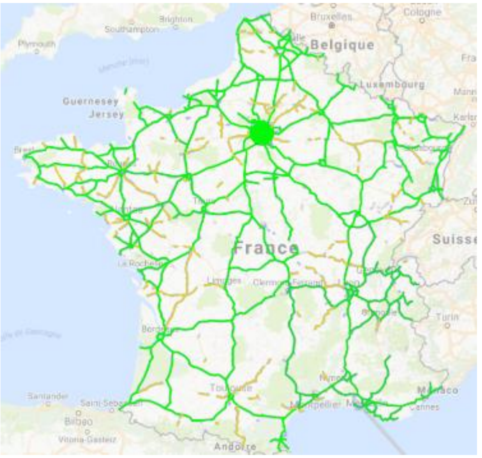
- Critical dynamic annotation screen by the driver

RECORDED ROAD

- Traffic JAM on Open divided Roadway around Paris, and some others major European cities.

- Highway in France, UK, Belgium, Germany, Italy, etc…

- Recording done by night, in the rain, snow…

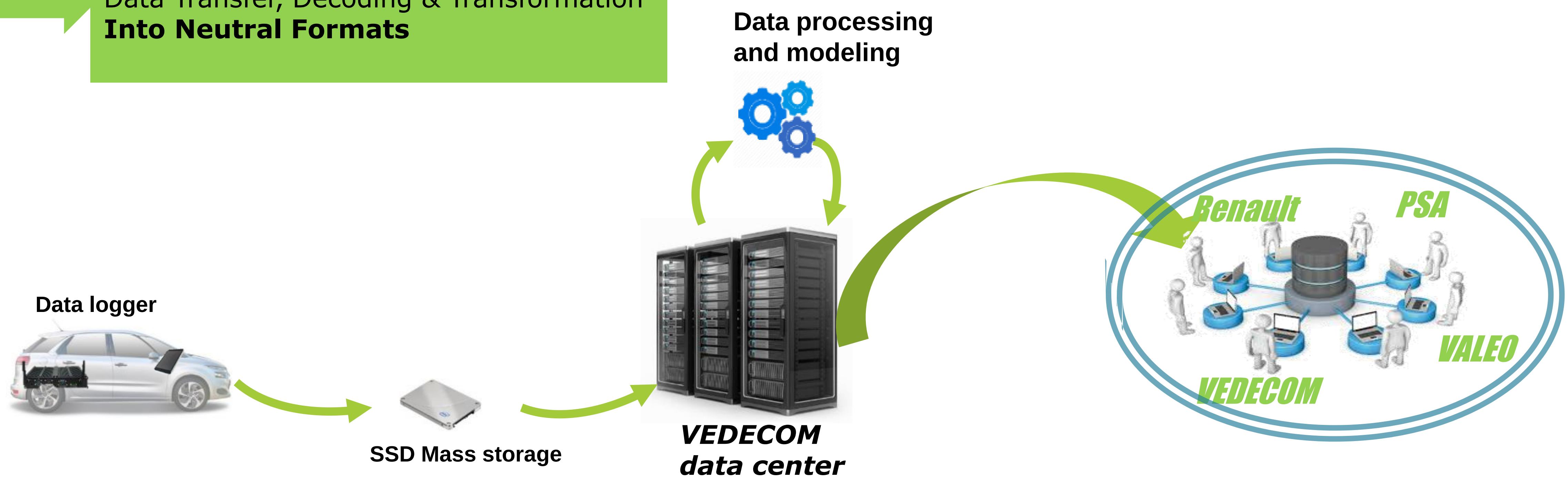


- Data acquisition status on 29/06/2018 :
  - 600.000 km
  - 12000 H

INSTITUT VEDECOM

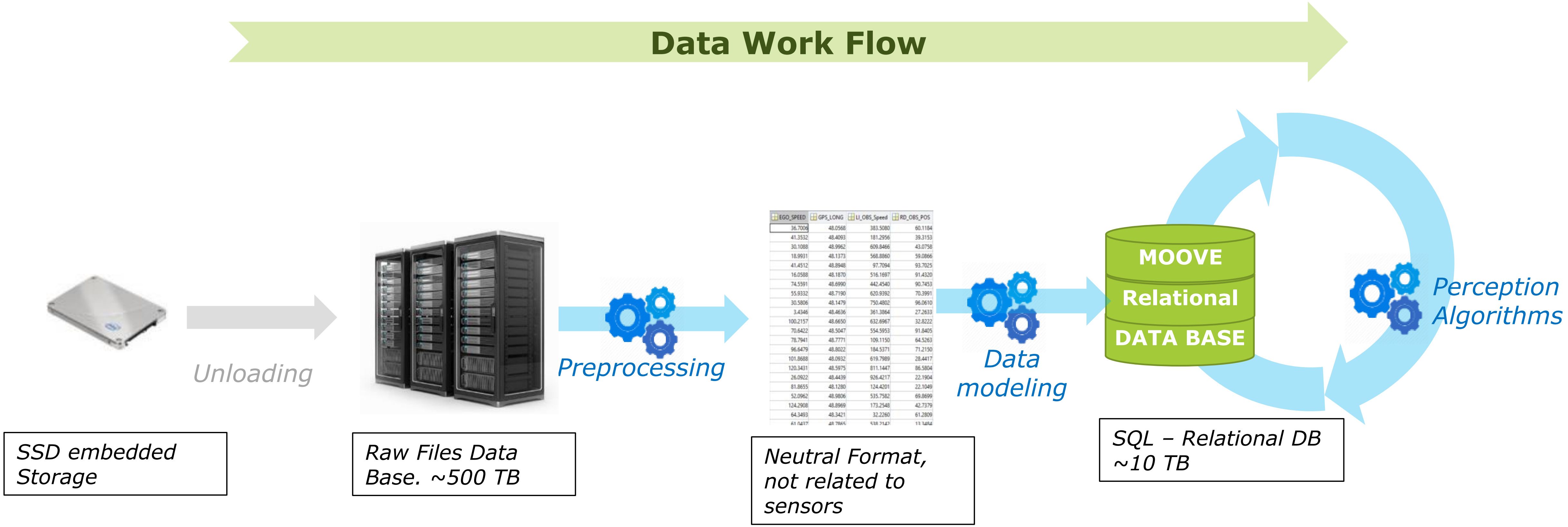
DATA ORGANISATION

2.
Preprocessing :
Data Transfer, Decoding & Transformation
Into Neutral Formats



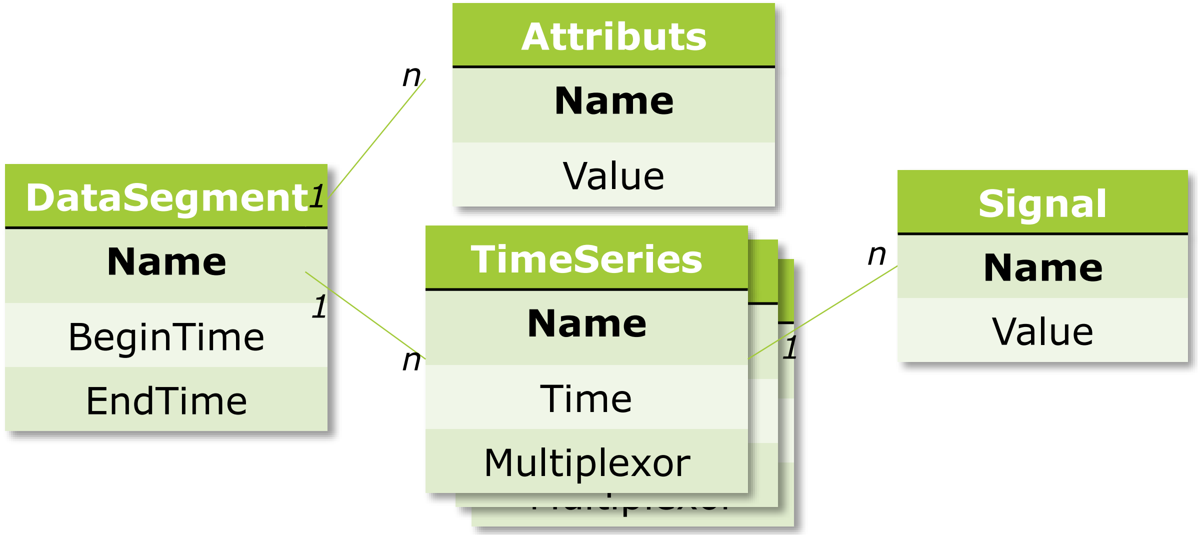
Collaborative analysis

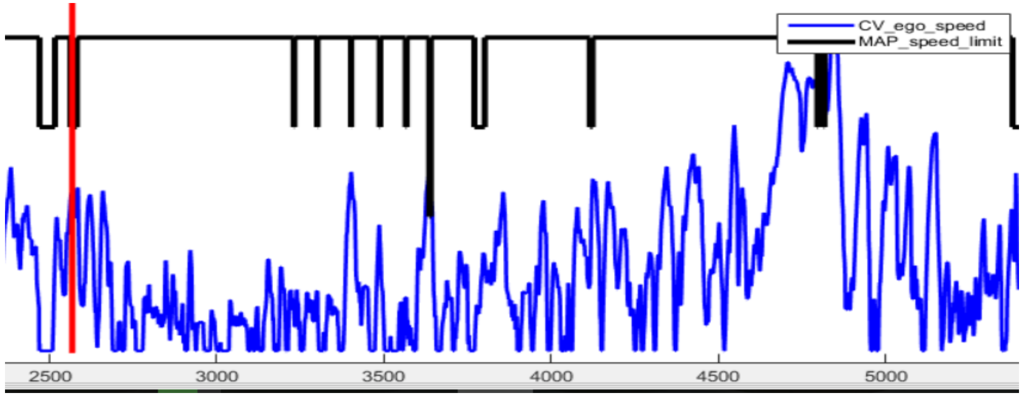
FROM RAW FILES TO A RELATIONAL DATA BASE



MOOVE DATA BASE’S SHEMA

- ❑ **Data stored in TimeSeries**
  - ❑ **Signals and Obstacles**
- ❑ **TimeSeries stored in Segment**
  - ❑ **Cropping a Record according to a real word driving situation**
  - ❑ **Attributes**
    - ❑ Scalar, Non-time related data(eg : Mean Speed)
  - ❑ **Available for query**

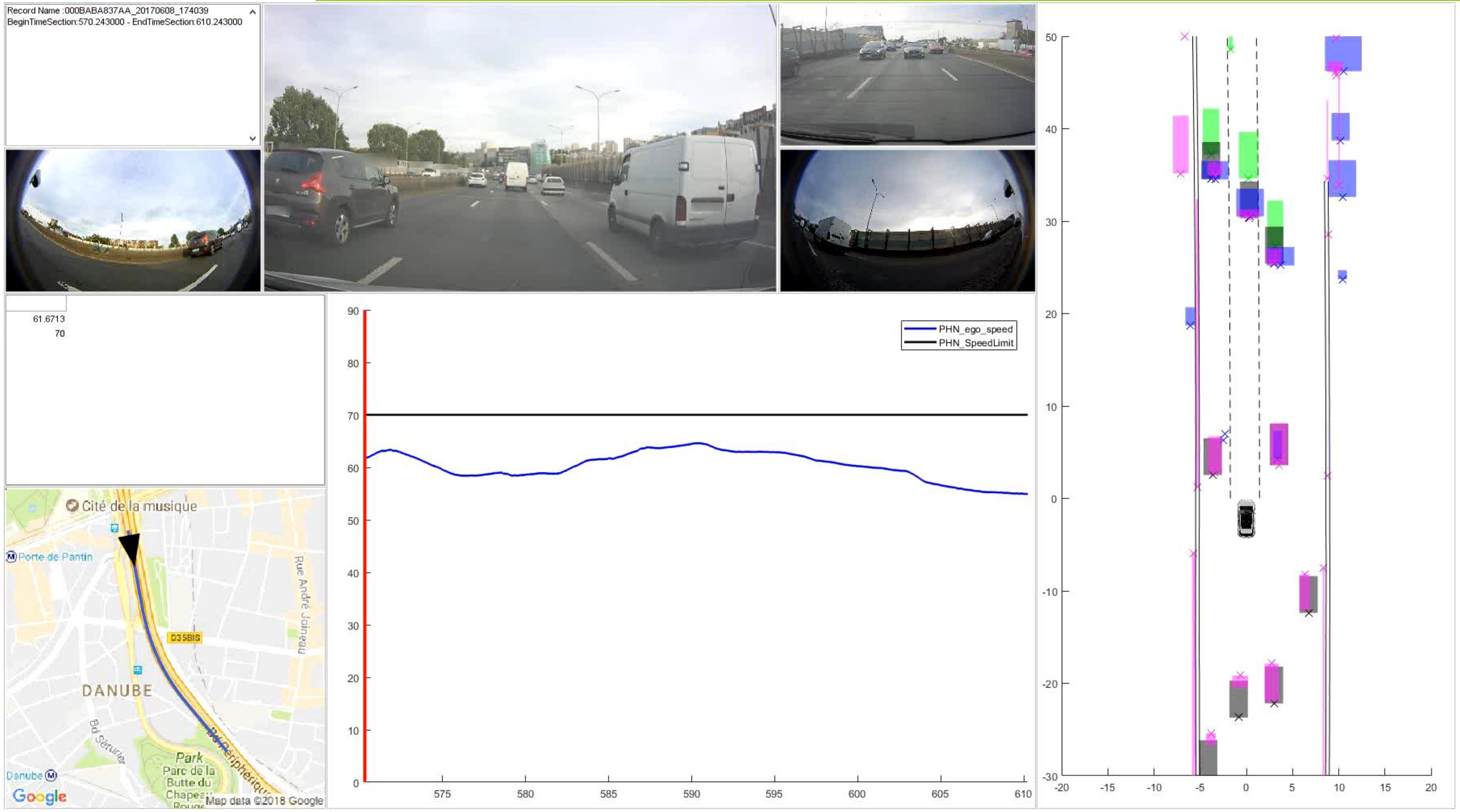




j

j + 1

DATA VISUALISATION

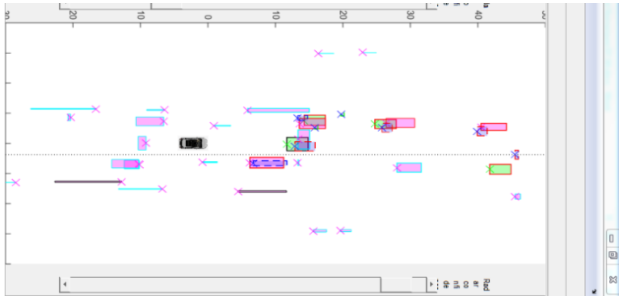


MOOVE DB : ALGORITHMS COMPUTATION

3. Perception algorithms for identification of mobile and static objects and infrastructure

MOOVE
Relational
DataBase

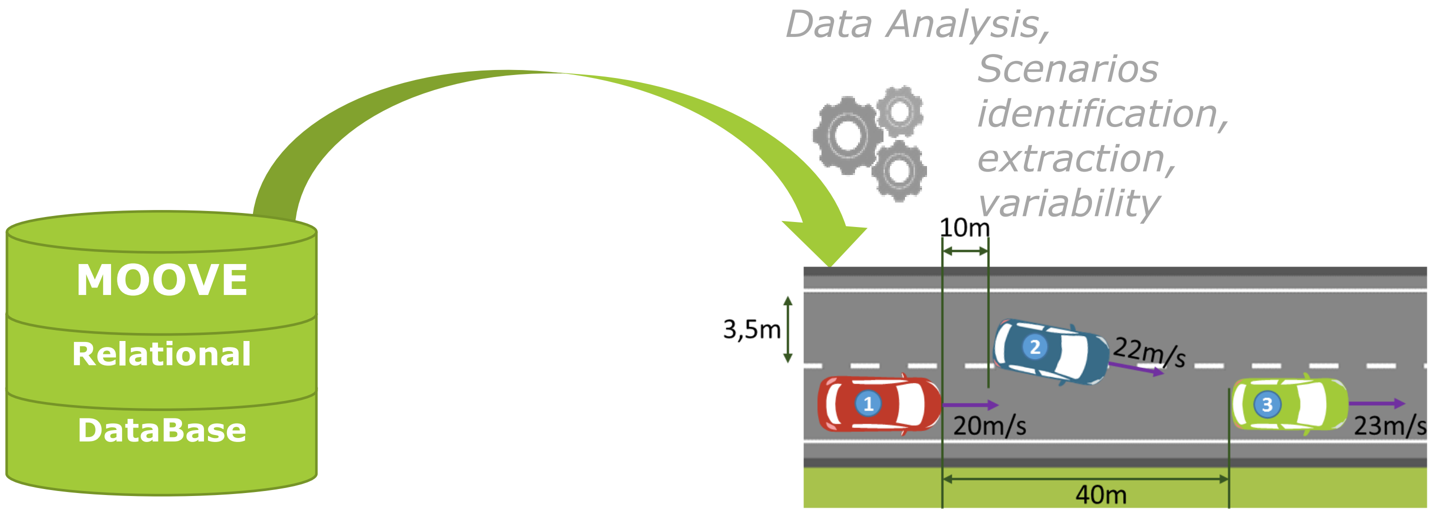
High Level Parameters
HLP_OriginalMultiplexor
HLP_UniqueID
HLP_AgeMax
HLP_AbsoluteSpeed
HLP_LaneShift
HLP_LengthCorrection
HLP_MobileObjectClassification
HLP_FixedObjectClassification
HLP_TimeBetweenVehicles
HLP_TimeToCollision
…



Mobil and Static objects from smart sensors

Filter, Perception, Fusion

- ❑ **A Data base containing**
  - ❑ **Thousands of occurrences for each scenarios, on divided Road**
  - ❑ **Autonomous Vehicle's data descripting those situations**
- ❑ **Analyze of this Data Base**
  - ❑ **Model Ego's Environment**
  - ❑ **Detect amongst our data Base studied SCS**



CLASSES OF HIGH LEVEL PARAMETERS

Road Infrastructure

- Traffic signs
- Other static equipment
- Lane

Ego

- Dynamics and Behavioral Data

Obstacles

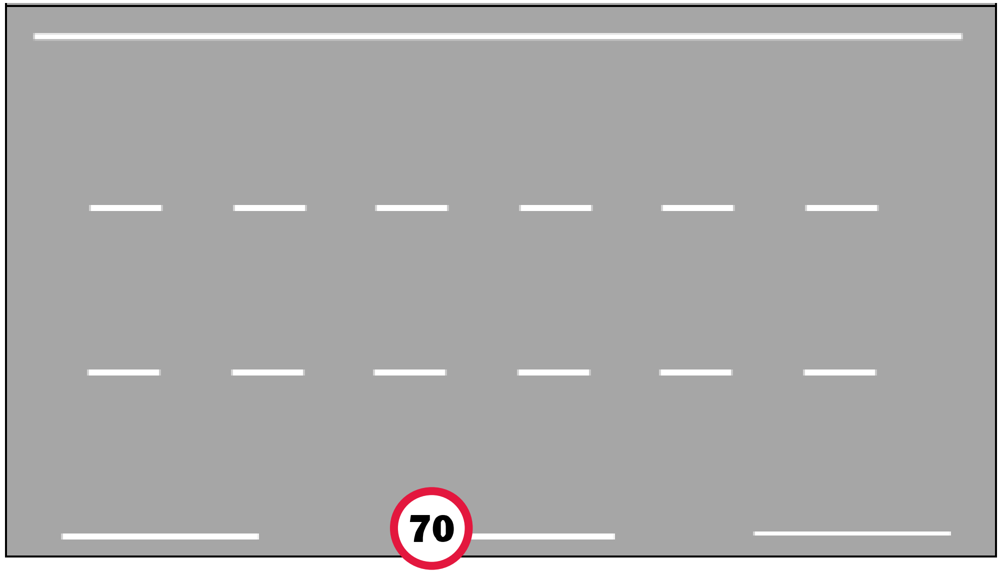
- Both Mobile and Statics Obstacles
- From Smart Sensors and Data Fusion

Climatic

- Stable for each scenario

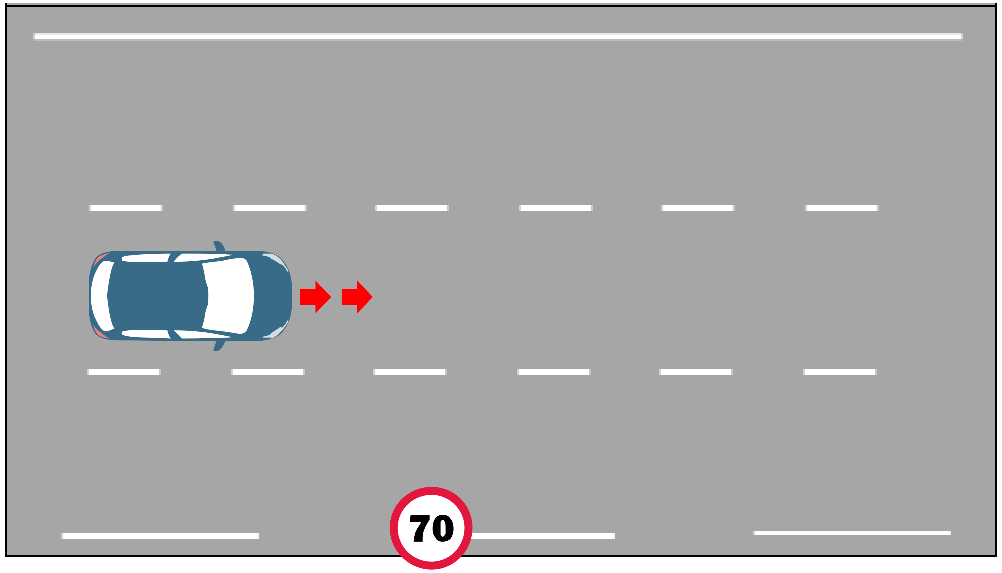
ROAD INFRASTRUCTURE

- **Definition**
  - **Characterization of :**
    - Lanes
    - Traffic signs
    - Other static equipment
  - **Fixed for a scenario**
  - **Road infrastructure attributes can have different values in a scenario**
    (*e.g* : Number of lanes)



- **Based on the following inputs :**
  - **Navigation Map database (HERE)**
  - **Traffic signs recognition**
  - **Static obstacles analysis (Road Boundries)**
  - **Post manual annotation ➔ Definition of Points of Interest**

- **Definition**
- **Characterization of ego's**
  - Dynamics
  - Position
  - Control
  - Communication
  - Relation to the surrounding

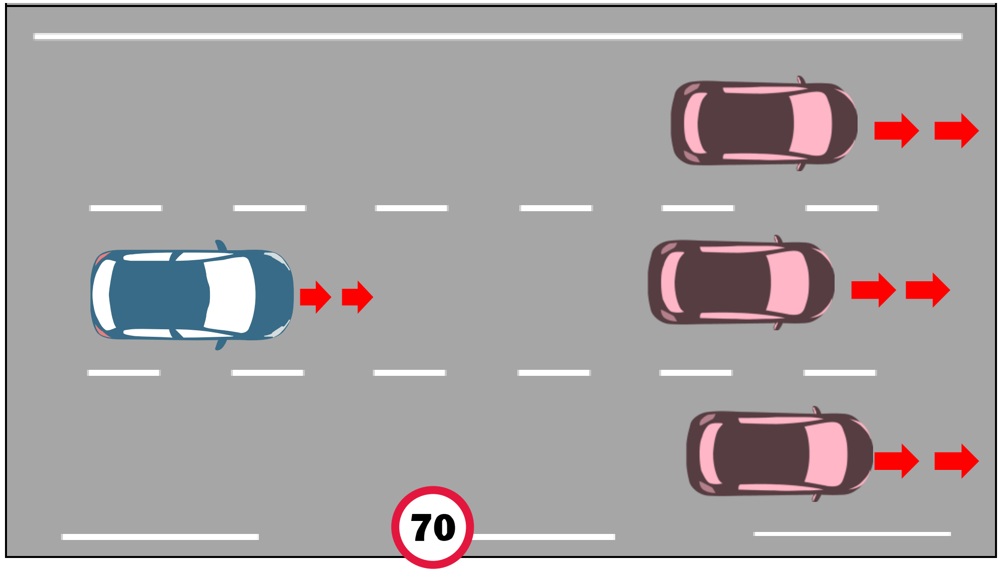


- **Based on the following inputs :**
- **Inertial measurement unit**
- **Vehicle CAN**
- **GPS**
- **Sensors data**

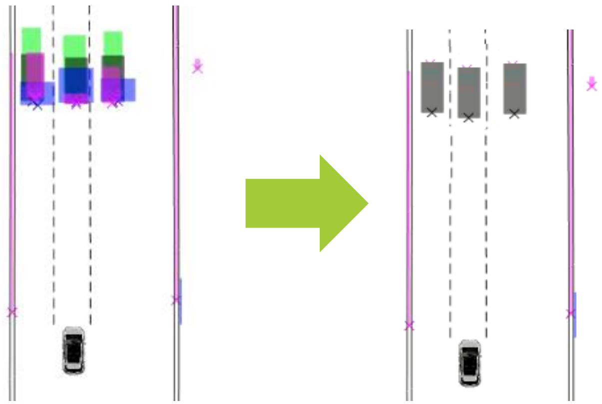
MOOVE

OBSTACLES

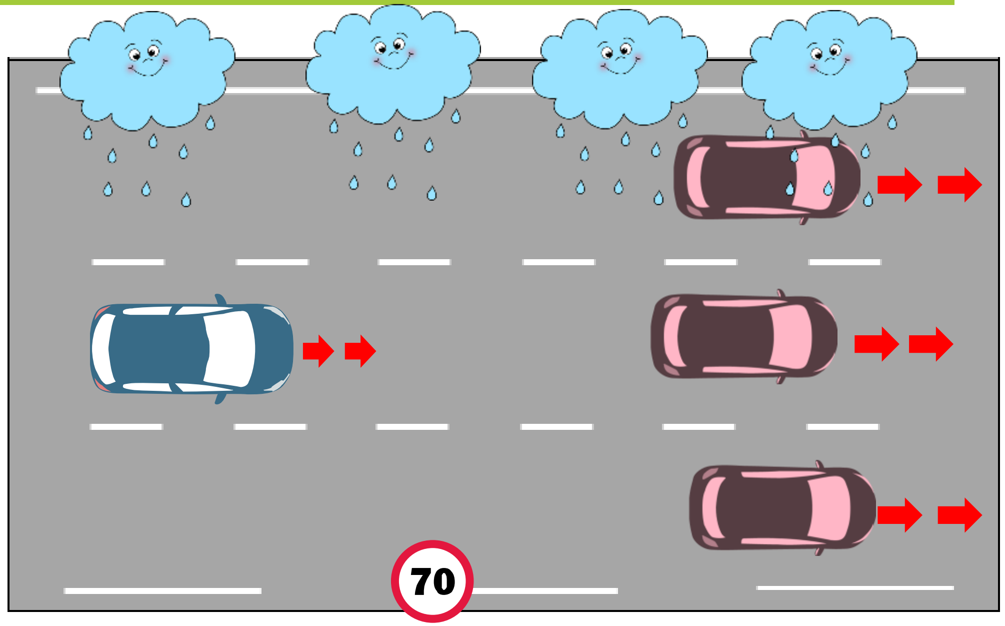
- **Definition**
  - **Characterization of obstacles:**
    - Dynamics
    - Position (in ego referential)
    - Communication
    - Classification (static/mobile, type…)



- **Based on the following inputs :**
  - **Ego’s Sensors Data**
  - **High Level Fusion**
    - Multi -sensors
    - Rear – Front tracking



- **Definition**
- **Characterization of the weather conditions:**
  - Rainfall
  - Sunlight
  - Temperature
  - Day period



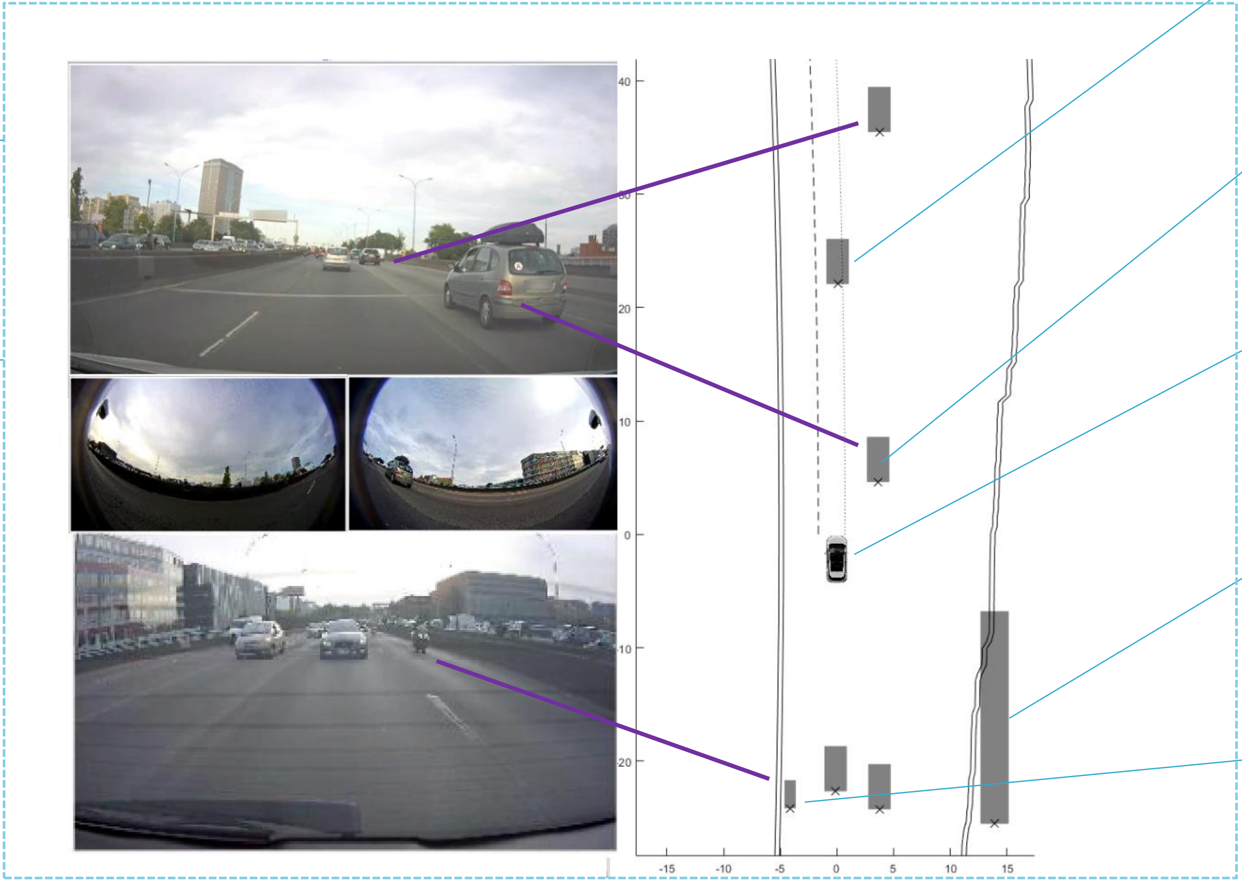
- **Based on the following inputs :**
- **Vehicle CAN**
- **GPS**

ENVIRONMENT MODELING WITH HIGH LEVEL PARAMETERS

- **Highway Driving**

Infrastructure	
Nb Of Lanes	4
Speed Limit	70km/h

Climatic	
Rain	No
Day Period	Day



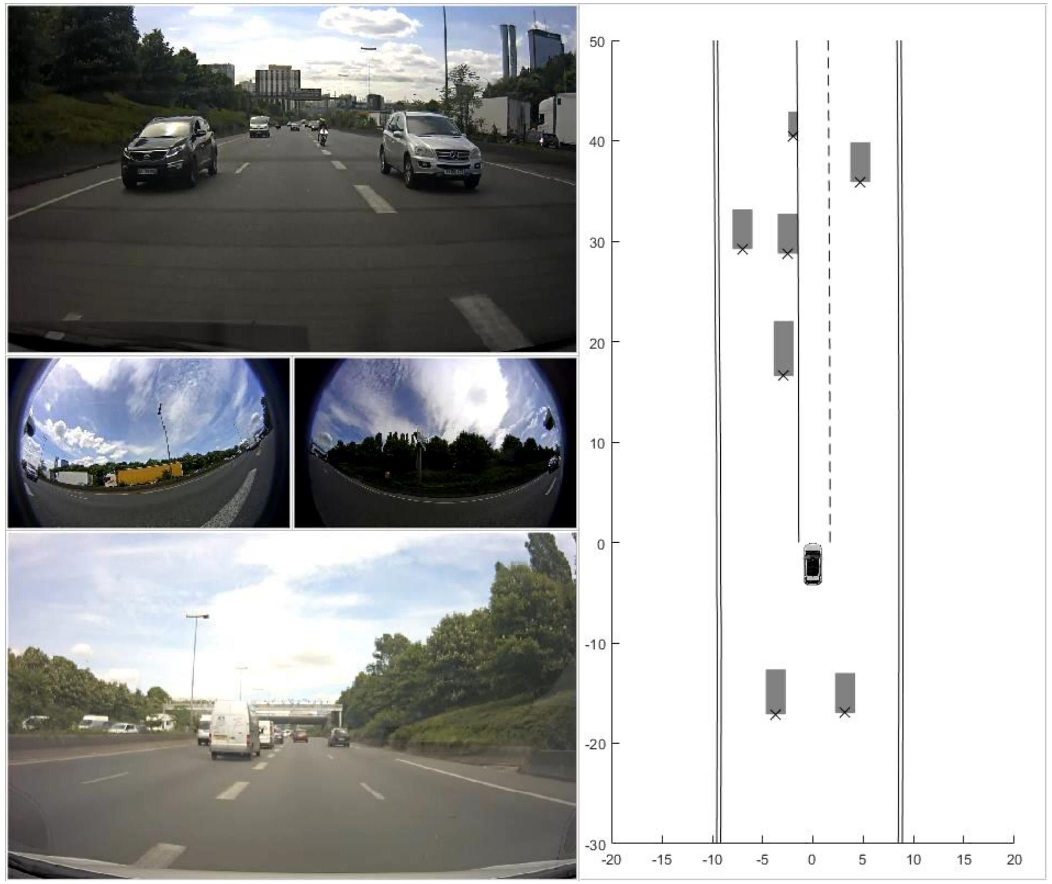
ID	2
Rel SpeedX	+2 m/s
Type	Car

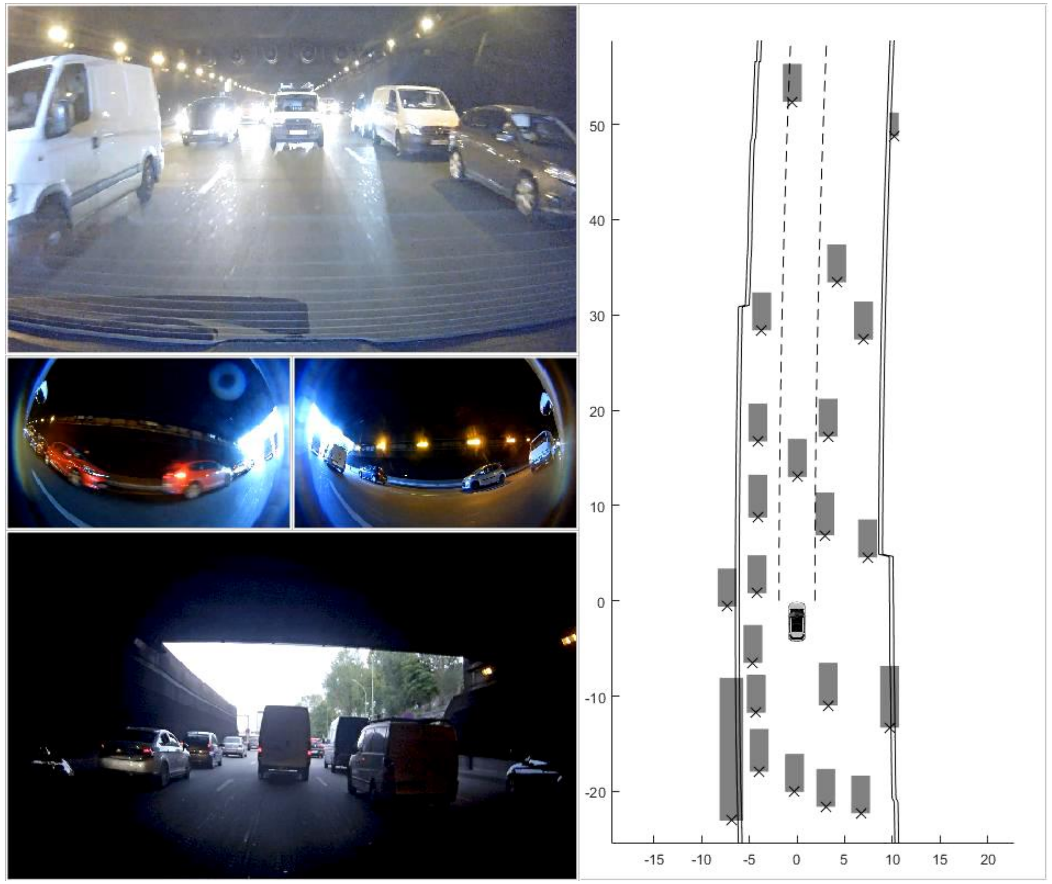
ID	122
Rel SpeedX	-12 m/s
Type	Car

Ego	
Dist MarkingL	1.86m
Lane	2

ID	84
ABS SpeedX	+0 m/s
Type	Guard-Rails

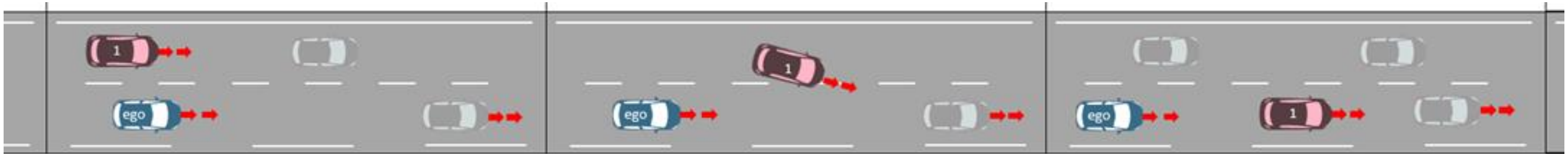
ID	130
ABS SpeedX	+0 m/s
Type	Guard-Rails


50
40
30
20
10
0
-10
-20
-30
-20 -15 -10 -5 0 5 10 15 20


50
40
30
20
10
0
-10
-20
-15 -10 -5 0 5 10 15 20

5.Scenario exploration: safety event, variability (HLP)

- **Logical rules applied on HLP define event**
- **Time sequence of events build each scenario**

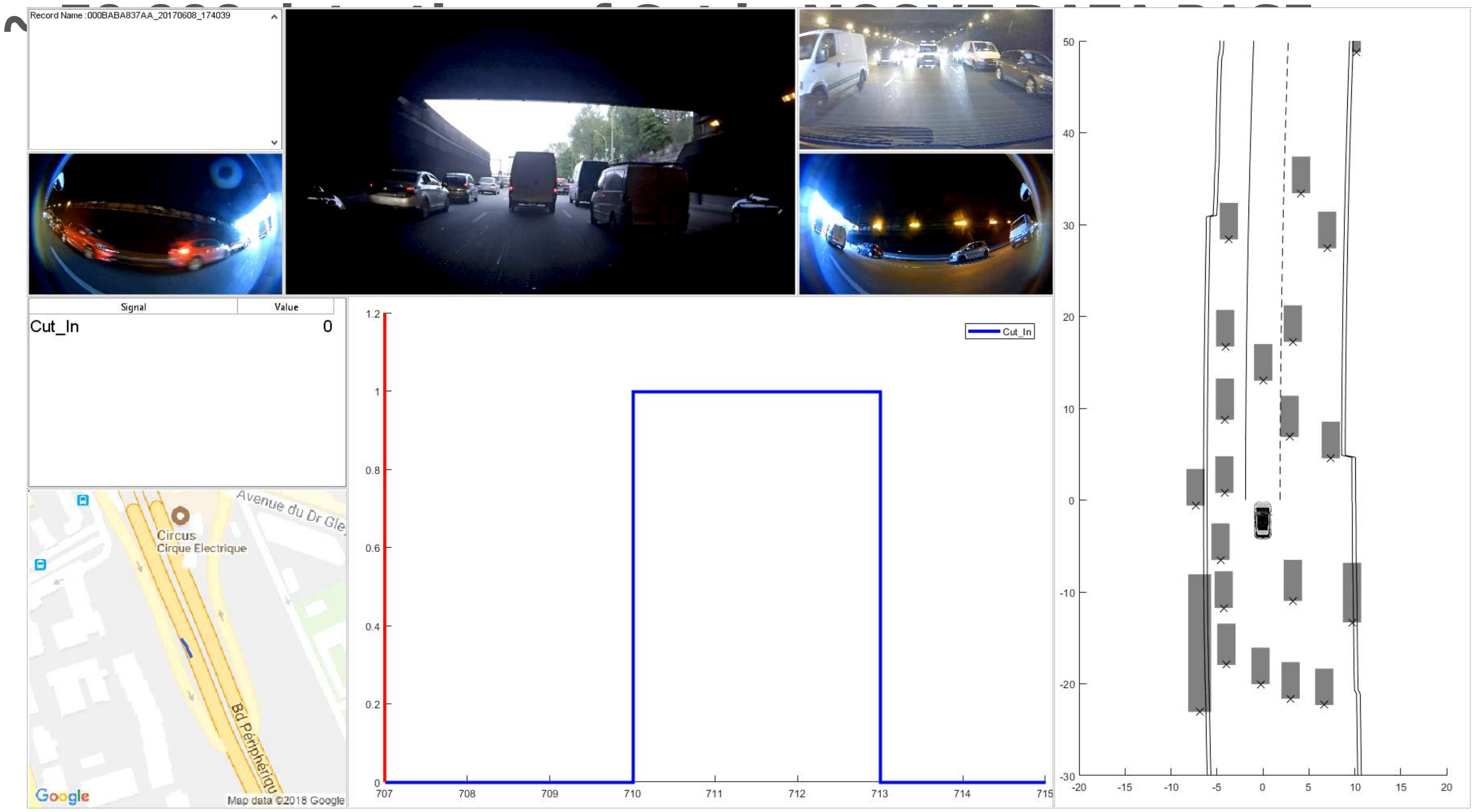


1 is in adjacent lane

1 Crossing Lane Marking

1 is the new target in ego's path

SCENARIOS DETECTION WITH HLP



MOOVE

CONCLUSION

- **Data collect ongoing, with 12.000 hours recorded**
- **A relational Database built from collected Data. Available for algorithms and analysis**
- **MOOVE’s Model of Ego’s environment based on High Level Parameters run on data base**
- **This Model allows SCS identification for later analysis**

INSTITUT VEDECOM