

# Real world driving scenario identification for AV functional safety

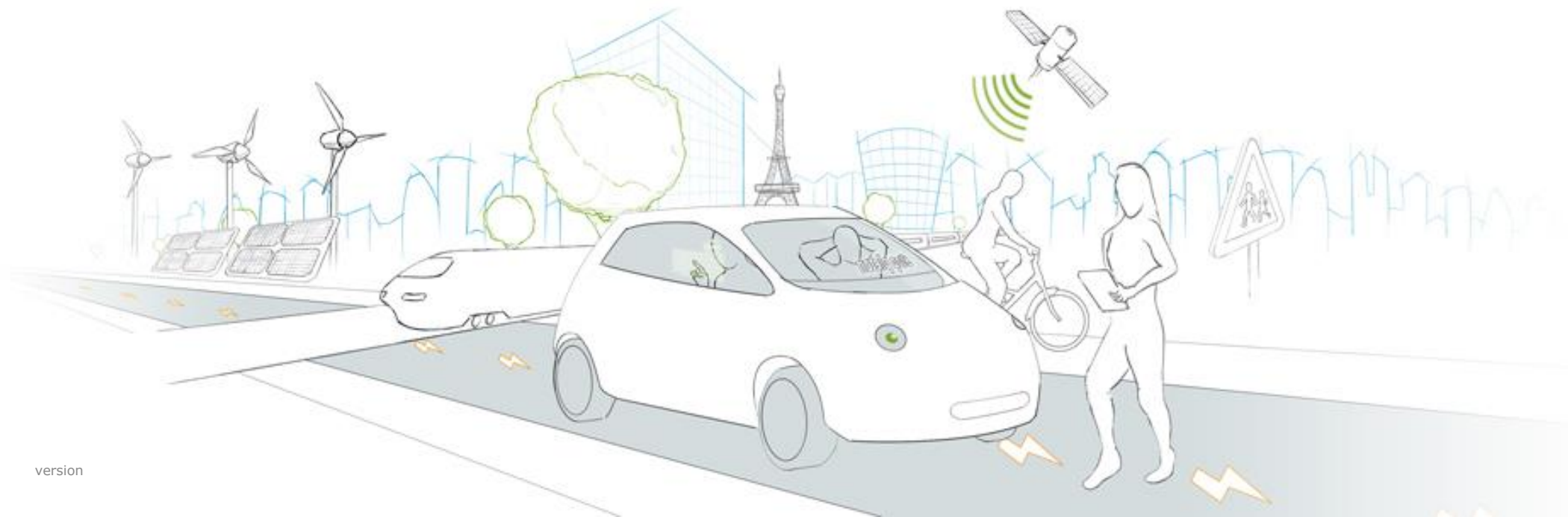
Autonomous Vehicle Test & Development Symposium

06/06/2018

Speaker: Gildas Tholon

Project Manager: Annie Bracquemond

**MOOVE**



# VEDECOM EN BREF



**VEDECOM, hub de recherche coopérative, créé en 2014**  
*VEDECOM, a cooperative research hub, created in 2014*



**Industriels**  
Industrials



**Académiques**  
Academics



**Territoires**  
Local authorities

**50**  
membres &  
partenaires

**3 domaines de recherche - 3 fields of research**  
**1 centre de formation - 1 training center**



**Vehicle**  
electrification



**Driving delegation and**  
connectivity



**Shared mobility**  
and energy

**FORMATION**  
TRAINING



**175 collaborateurs**

**110 R&D**  
**45 Doctorants**  
**20 Staff**

€  
**30**  
millions /an

**7 000 m<sup>2</sup>** of workshops  
and offices dedicated to research



**En 2017**  
**14 modules de formation**  
**120 heures animées**  
**242 personnes formées**

**Depuis 2014**  
**> 100 publications**  
**69 thèses**  
**28 brevets**  
**18 logiciels déposés**

- **La sûreté est un impératif**
- **Elle doit être construite**
  - Par des analyses préalables
  - Par la mise en place de redondances à tous les niveaux du VA
  - Par la collecte de données issues des roulages réels
- **Elle doit être démontrée**
  - Par des expérimentations
  - Par des simulations virtuelles



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

## 1. Big data : Specific Data Collect

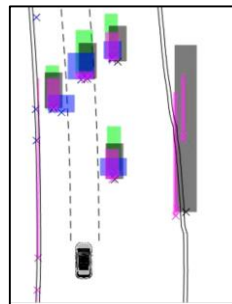


## 2. Preprocessing : Data Transformation at common format

Time	Lat	Lon	Alt	Speed	Accel	Yaw	Roll	Pitch	Temp	Humid	Pressure
2018-01-01 00:00:00	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
2018-01-01 00:00:01	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
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2018-01-01 00:00:03	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
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2018-01-01 00:00:05	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
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2018-01-01 00:00:09	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
2018-01-01 00:00:10	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
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2018-01-01 00:00:22	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
2018-01-01 00:00:23	48.8566	2.3510	100	0	0	0	0	0	15	60	1013
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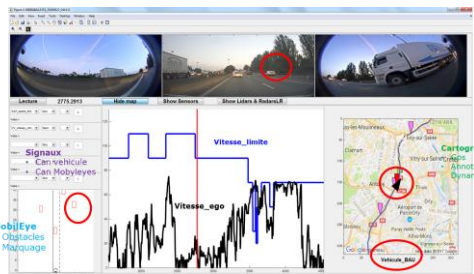
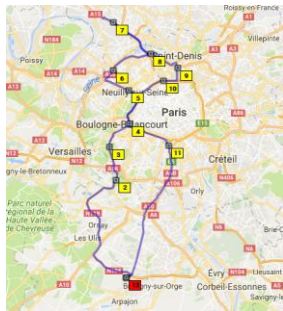
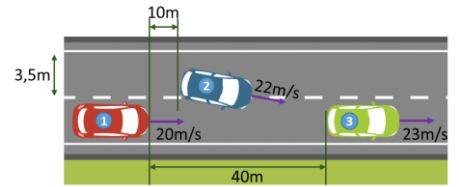
## 3. Perception algorithms for identification of mobile and static objects and infrastructure



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

- Road Infrastructure
- Ego
- Obstacles
- Climatic

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

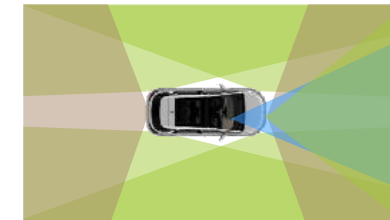
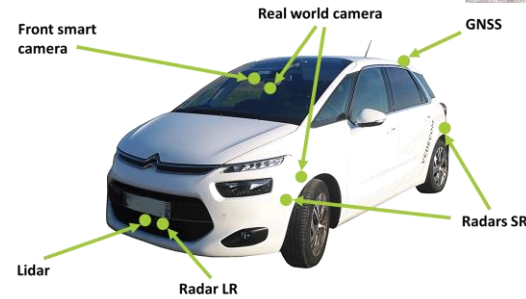




**1.**  
**Big data :** Specific  
Data Collect

## 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

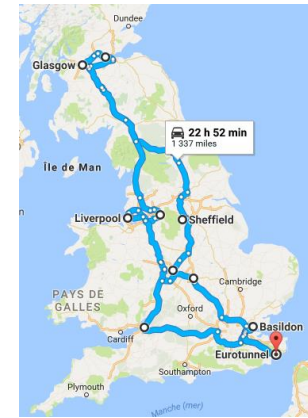


## Professional Drivers

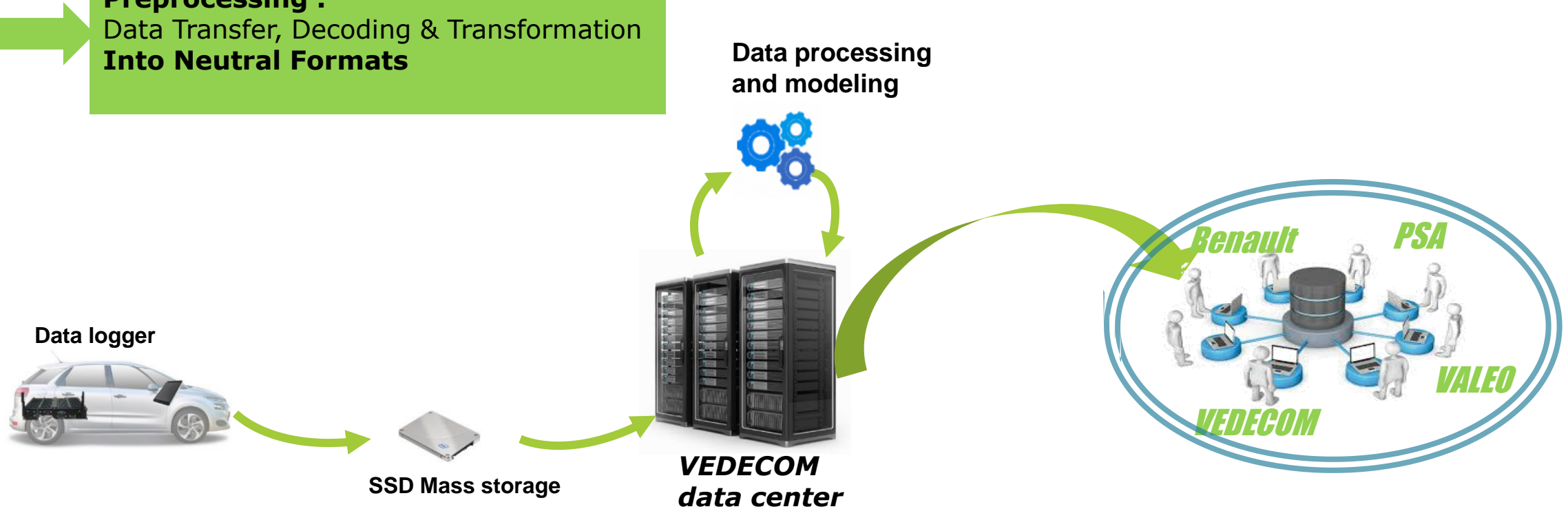
- Driver's head
- Driver's hand
- Driver's feet
- Critical dynamic annotation screen by the driver



- ❑ 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

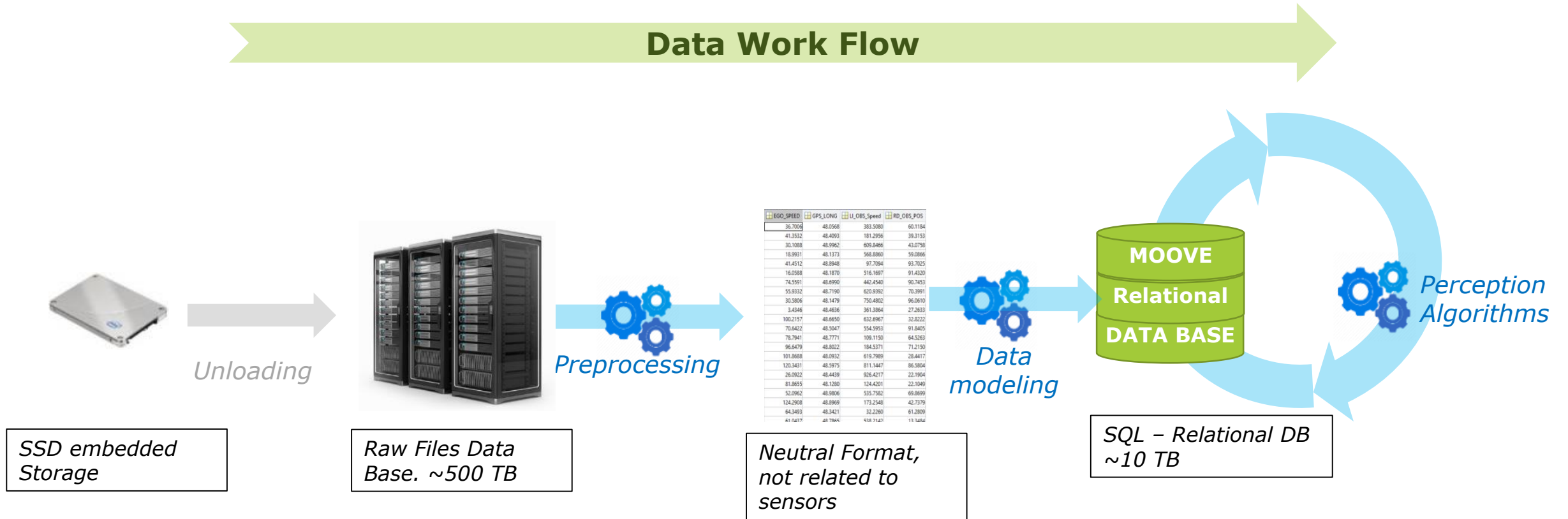


## 2. Preprocessing : Data Transfer, Decoding & Transformation Into Neutral Formats



Collaborative analysis

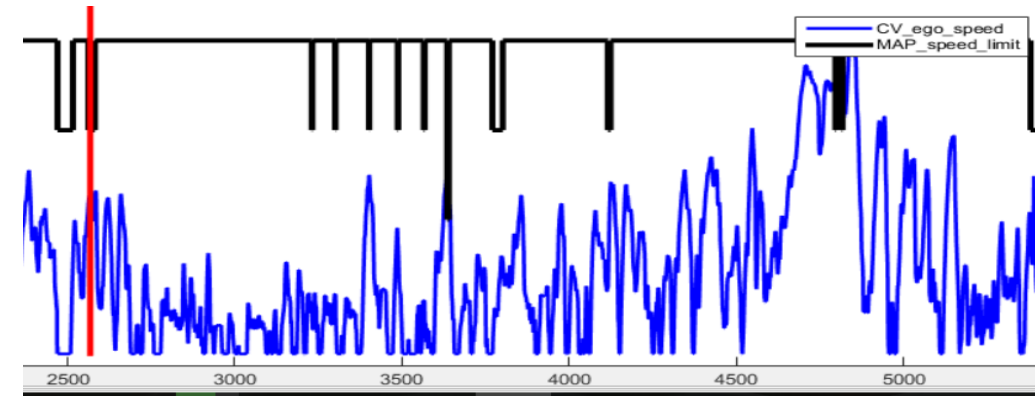
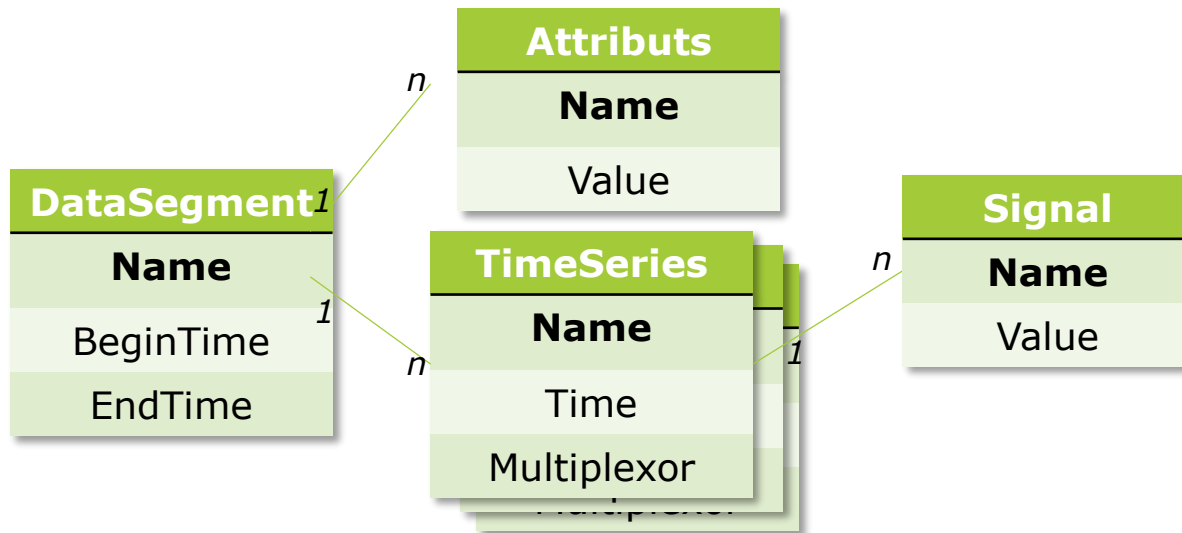
# FROM RAW FILES TO A RELATIONAL DATA BASE



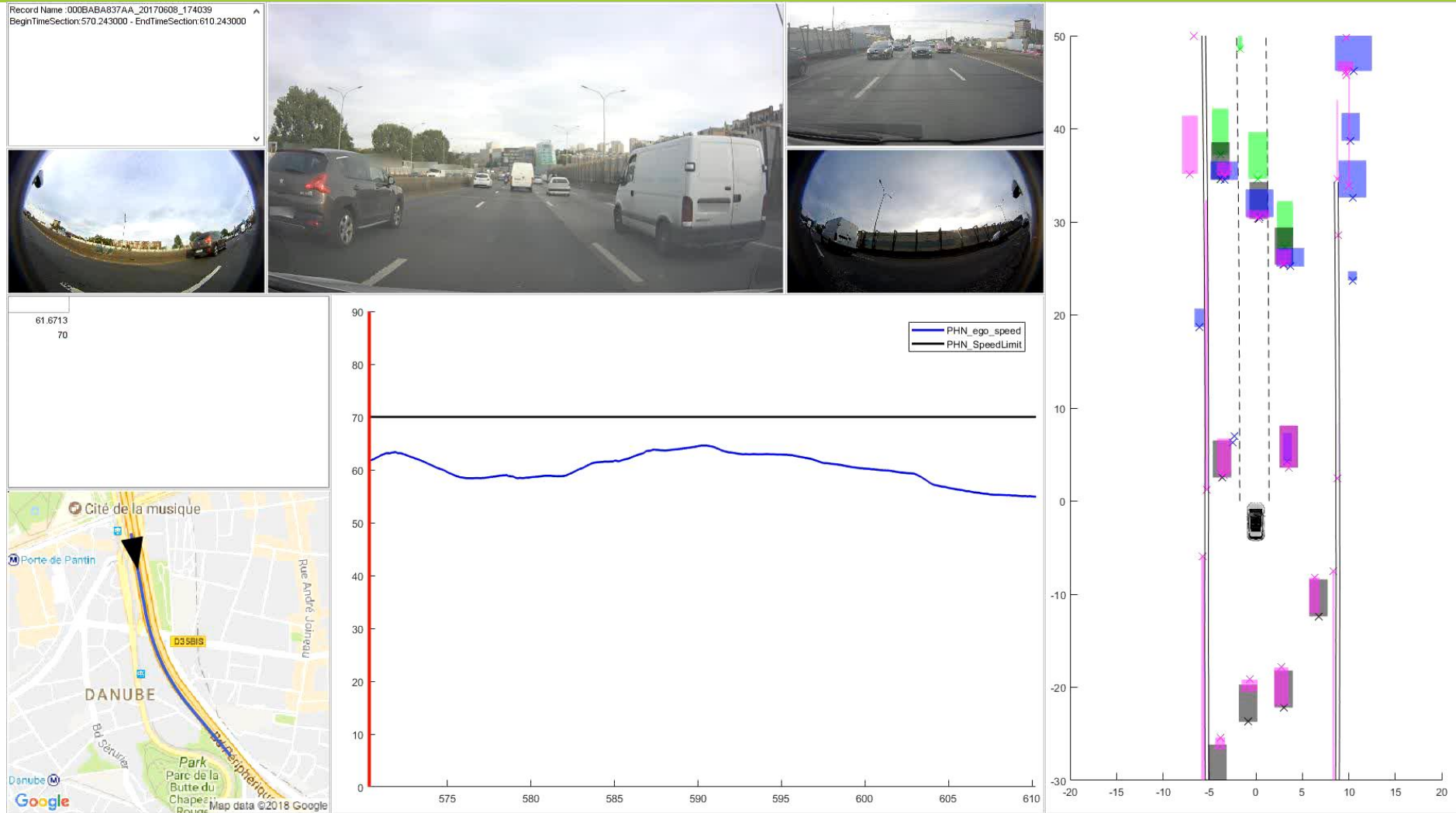


# MOOVE DATA BASE'S SHEMA

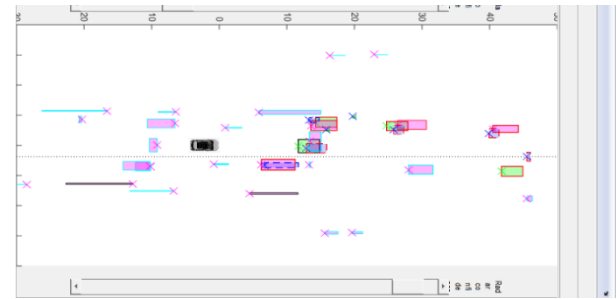
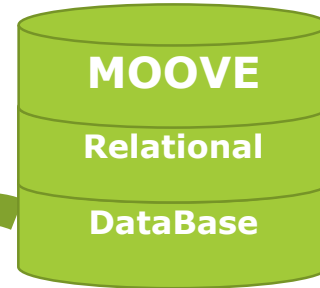
- ❑ **Data stored in TimeSeries**
  - ❑ **Signals and Obstacles**
- ❑ **TimeSeries stored in Segment**
  - ❑ **Cropping a Record according to a real word driving situation**
  - ❑ **Attributes**
    - ❑ Scalar, Non-time related data(eg : Mean Speed)
  - ❑ **Available for query**



# DATA VISUALISATION



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



Mobil and Static objects from smart sensors

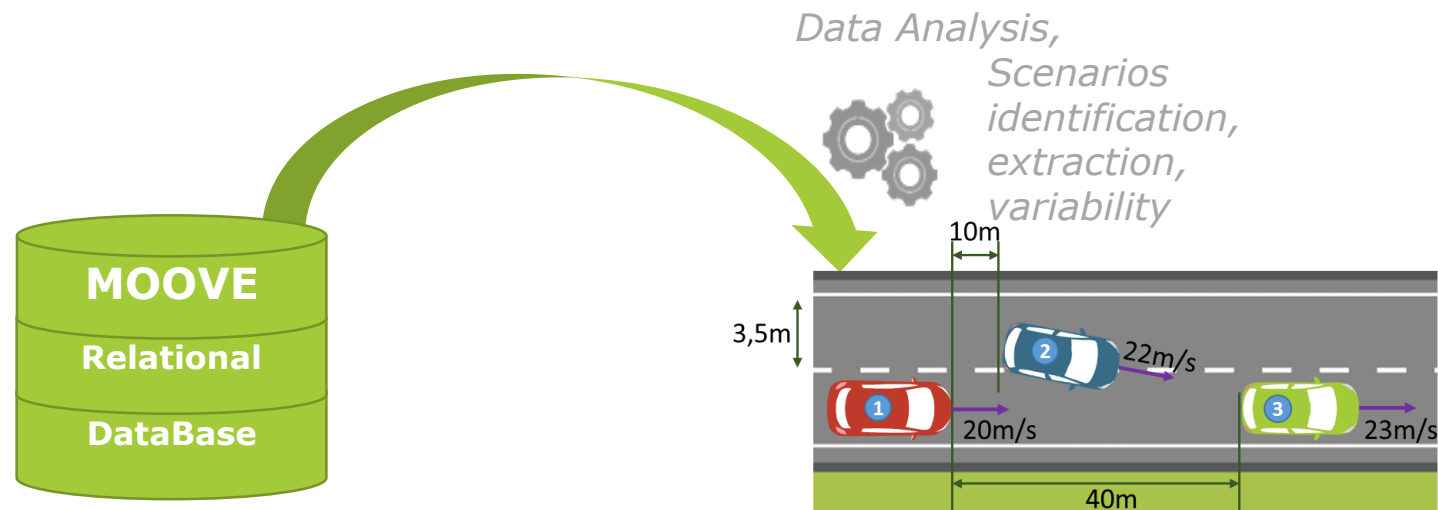


*Filter, Perception, Fusion*

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

# FROM DATABASE TO SCENARIOS


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



An icon representing road infrastructure, showing a grey road with white dashed lane markings and a circular speed limit sign with the number 70.


**Road Infrastructure**

- Traffic signs
- Other static equipment
- Lane

An icon representing the ego vehicle, showing a white car with various sensors labeled: 'Real world camera', 'GNSS', 'Radar SR', and 'Radar LR'. There is also a small 'int smart mera' label on the left.


**Ego**

- Dynamics and Behavioral Data

An icon representing obstacles, showing a top-down view of a road with several vehicles of different colors and shapes, including a truck, a car, and a van.

**Obstacles**

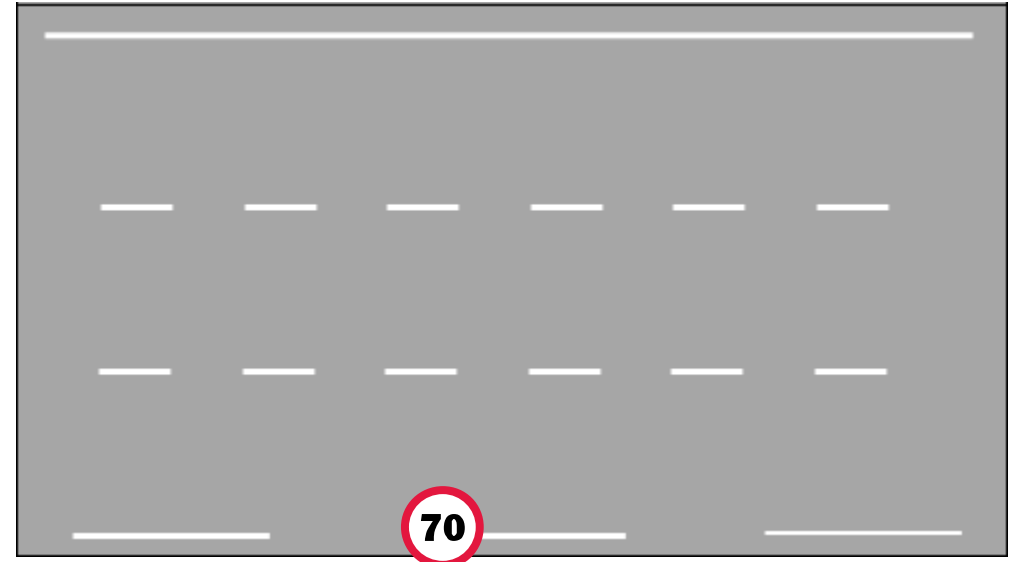
- Both Mobile and Statics Obstacles
- From Smart Sensors and Data Fusion

An icon representing climatic conditions, showing a blue sky with a yellow sun, a white cloud, and blue raindrops falling from the cloud.

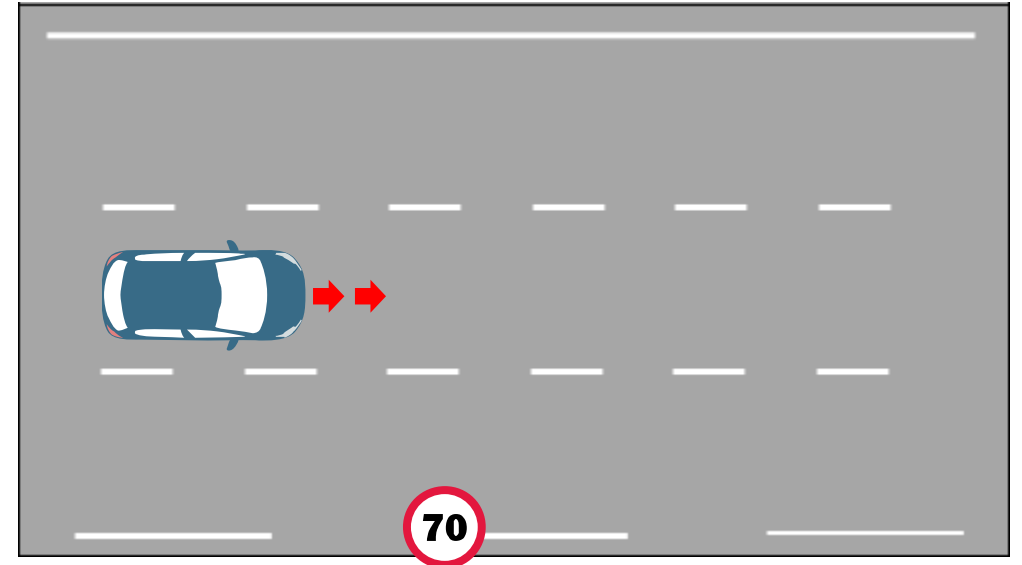
**Climatic**

- Stable for each scenario

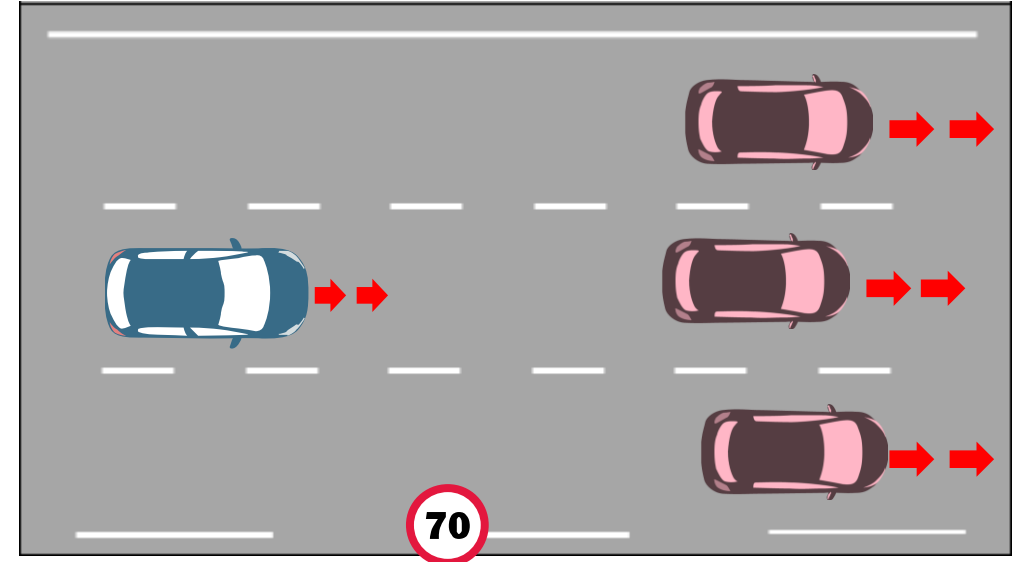
- **Definition**
- **Characterization of :**
  - Lanes
  - Traffic signs
  - Other static equipment
- **Fixed for a scenario**
- **Road infrastructure attributes can have different values in a scenario**  
(*e.g* : Number of lanes)
- **Based on the following inputs :**
  - **Navigation Map database (HERE)**
  - **Traffic signs recognition**
  - **Static obstacles analysis (Road Boundries)**
  - **Post manual annotation → Definition of Points of Interest**



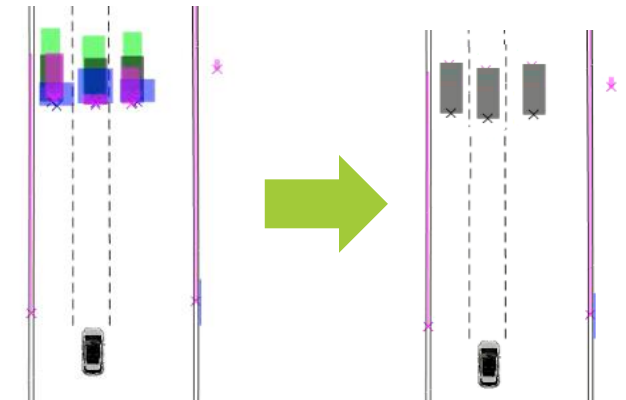
- **Definition**
- **Characterization of ego's**
  - Dynamics
  - Position
  - Control
  - Communication
  - Relation to the surrounding
- **Based on the following inputs :**
  - **Inertial measurement unit**
  - **Vehicle CAN**
  - **GPS**
  - **Sensors data**



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

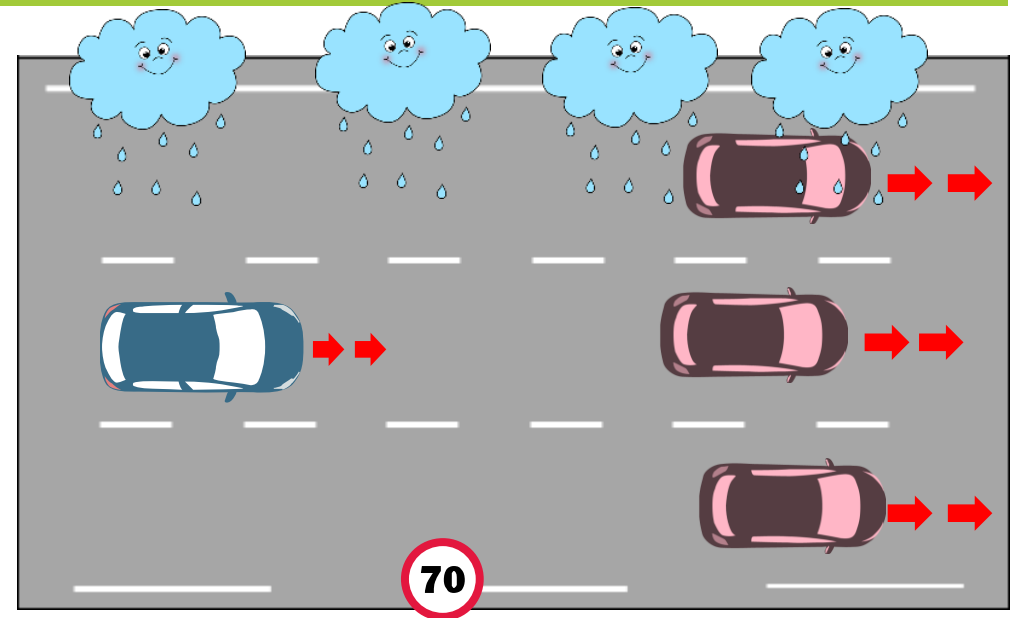


- **Based on the following inputs :**
- **Ego's Sensors Data**
- **High Level Fusion**
  - Multi -sensors
  - Rear – Front tracking





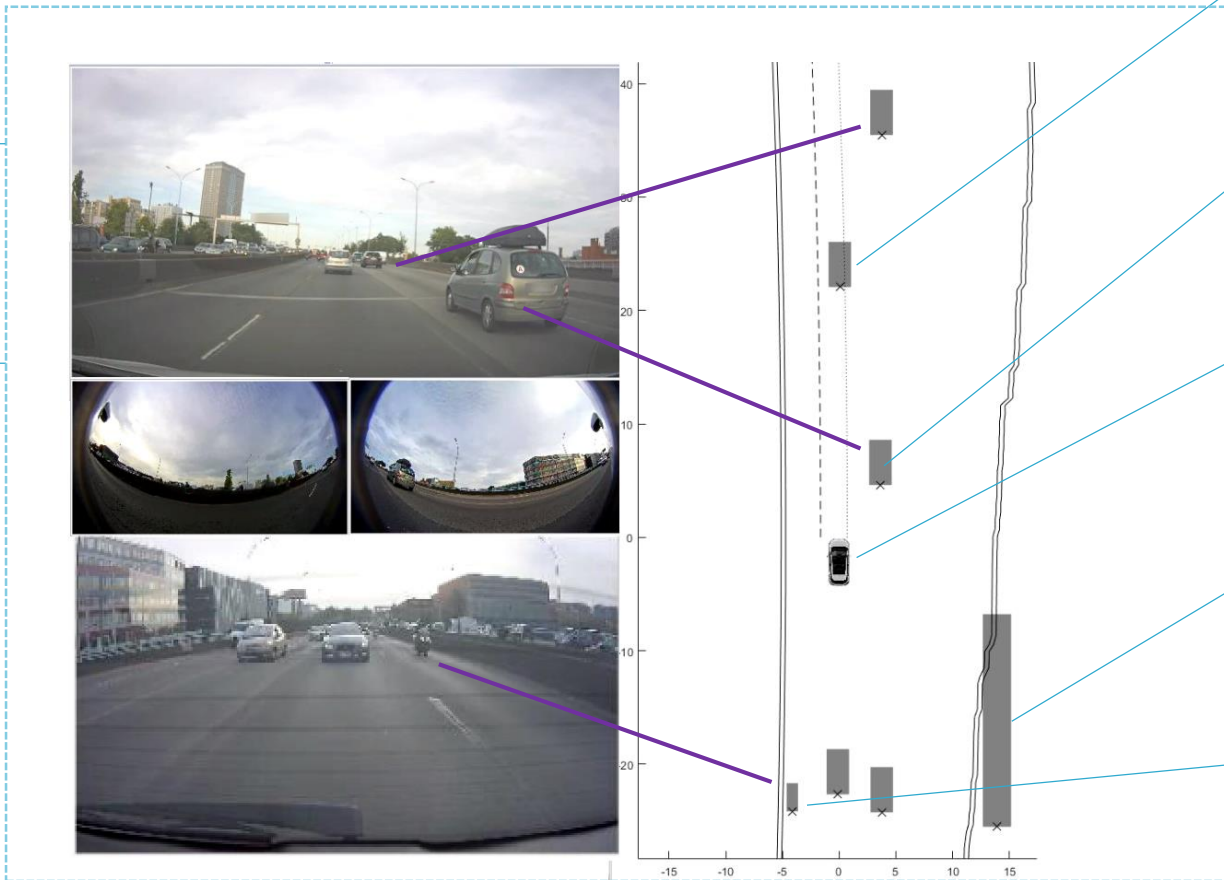
- **Definition**
- **Characterization of the weather conditions:**
  - Rainfall
  - Sunlight
  - Temperature
  - Day period
  
- **Based on the following inputs :**
  - **Vehicle CAN**
  - **GPS**



- Highway Driving

Infrastructure	
Nb Of Lanes	4
Speed Limit	70km/h

Climatic	
Rain	No
Day Period	Day



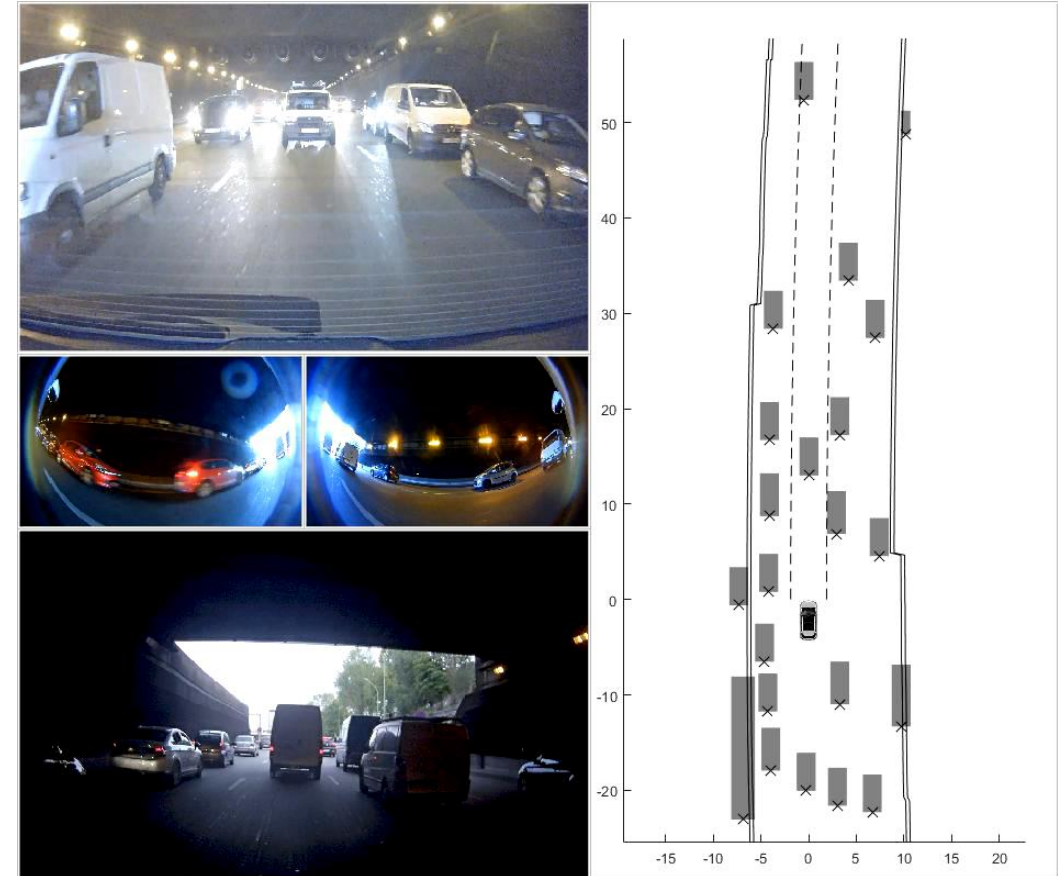
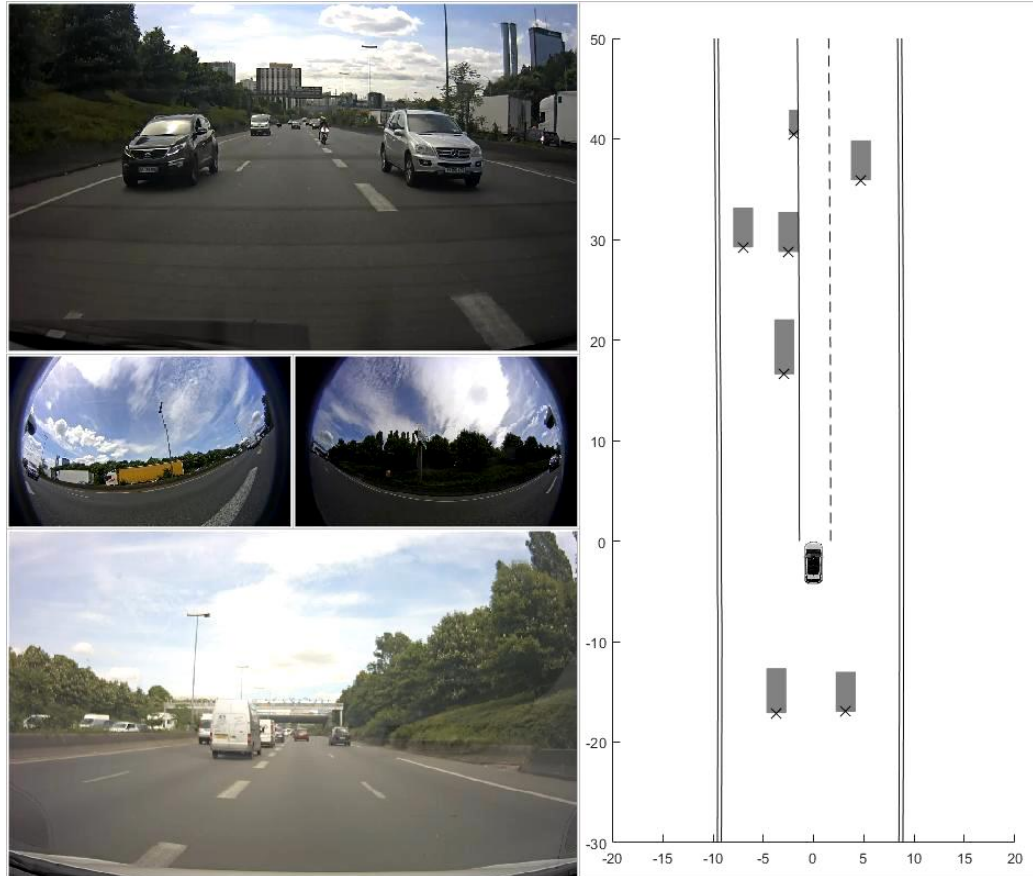
<b>ID</b>	<b>2</b>
Rel SpeedX	+2 m/s
Type	Car

<b>ID</b>	<b>122</b>
Rel SpeedX	-12 m/s
Type	Car

Ego	
Dist MarkingL	1.86m
Lane	2

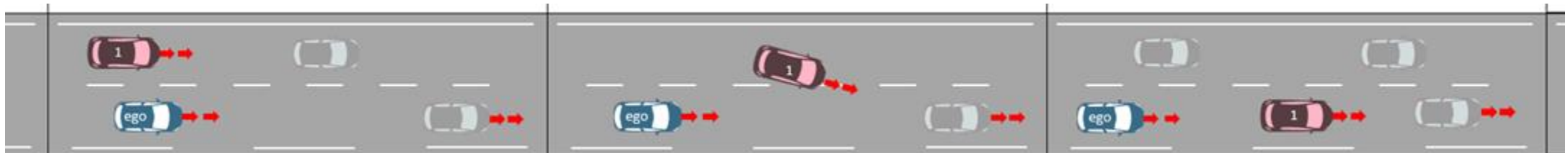
<b>ID</b>	<b>84</b>
ABS SpeedX	+0 m/s
Type	Guard-Rails

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



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

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

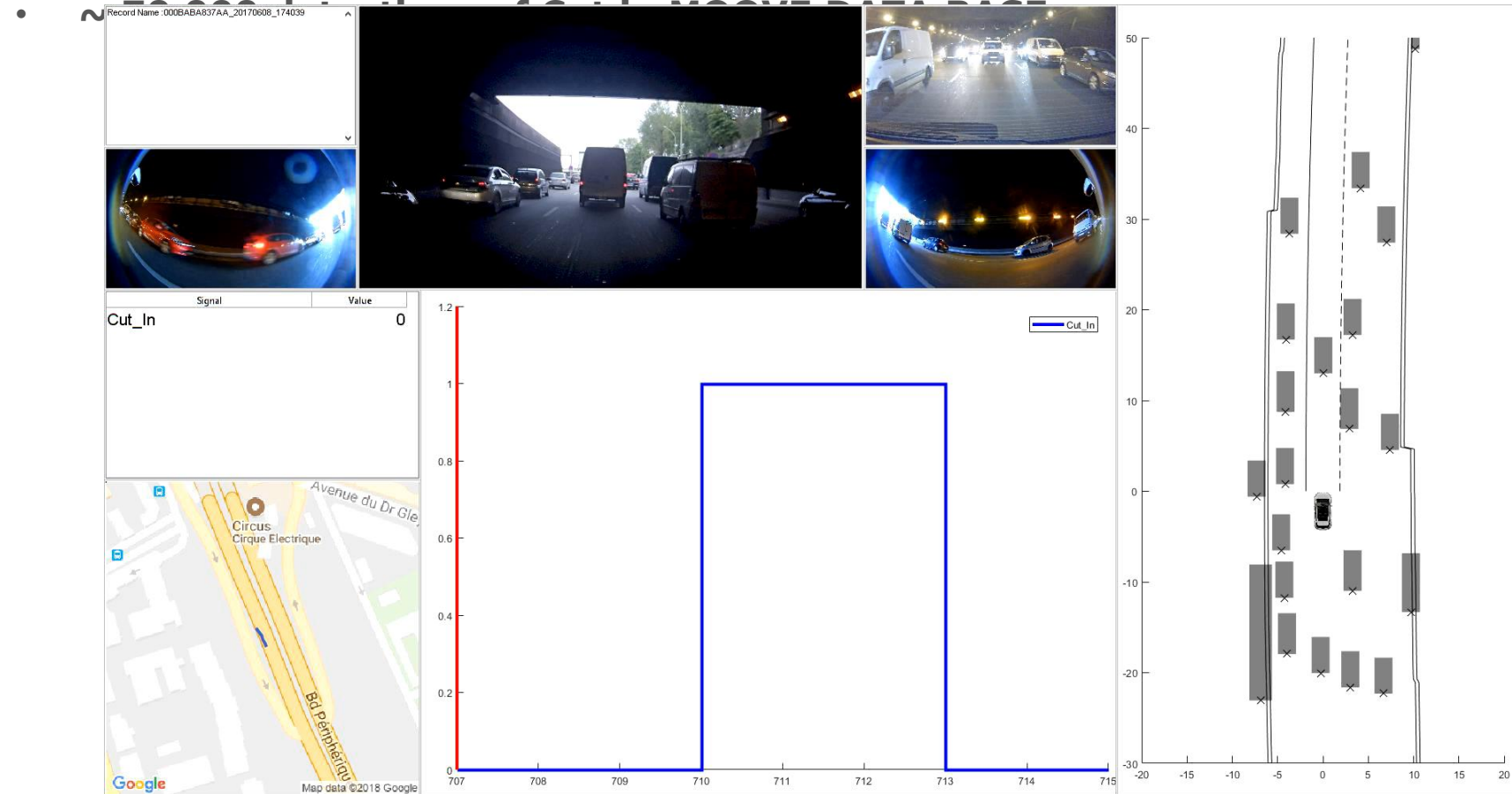


**1** is in adjacent lane

**1** Crossing Lane Marking

**1** is the new target  
in ego's path

# SCENARIOS DETECTION WITH HLP



- **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**
- **Key factor of safety for digital validation before real conditions experimentation**



**Merci de votre attention**

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**Ensemble pour accélérer les mobilités de demain !**

