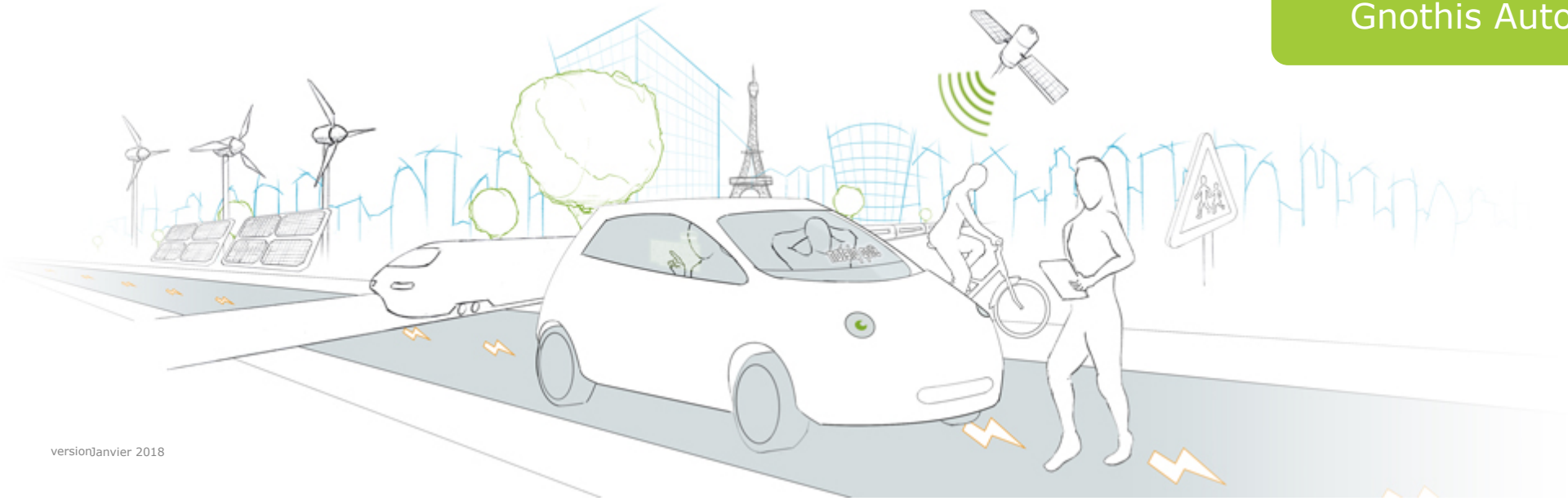
INSTITUT VEDECOM
DU VÉHICULE DÉCARBONÉ ET COMMUNICANT ET DE SA MOBILITÉ

GETTING THE MOST FROM THE LIDAR

Gilles Le Calvez – VEDECOM Vehicle Program Director

Gnothis Auton …



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AGENDA

1. INTRODUCTION
2. LIDAR BASICS
3. OPPORTUNITIES
4. CONCLUSION

VEDECOM: COLLABORATIVE RESEARCH HUB

Foundation of the Université de Versailles Saint-Quentin-en-Yvelines (UVSQ)

Certified as **Institute for Energy Transition** in 2014 by the French National Research Agency (ANR)

Launched within the governmental programme **Investments for the Future**

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

- **Industriels** / Industrials
- **Académiques** / Academics
- **Territoires** / Local authorities

Ecosystem of 50 members
30 M€ budget
175 employees
>100 researchers

VEDECOM IN THE CENTER OF 3 MAJOR SOCIETY CHALLENGES

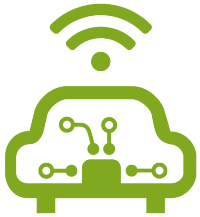
To contribute to air quality improvement in urban areas and CO2 massive reduction

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**, with or without driver



Driving delegation and connectivity

To optimize mobility systems on territories

By **analysing** and **experimenting new services** linked with green, autonomous and connected vehicles

Shared mobility and energy

TRAINING

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SELF-DRIVING AND CONNECTIVITY

Research goal : Boost the emergence of the levels 4 and 5 applications to propose safer and more efficient mobility solutions
(increase free time) : Level 4 for passenger cars – Level 5 for "robot-taxis"

Breakthrough

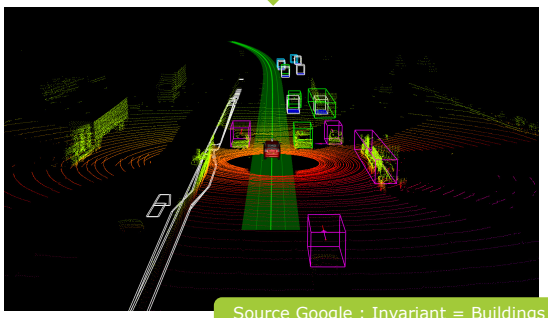
- **Technologies** (sensors-IA-ECU, etc.)
  - Operational safety => SOTIF
  - Human factors compatibility
  - Connectivity : 5G and/or G5
  - Infrastructure

- **Societal acceptance**
  - Responsibility / Liability
  - Law and regulation
  - Insurance
  - Ethics

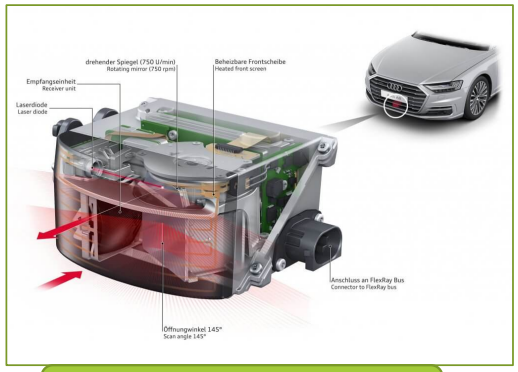
INTRODUCTION

Context : ADAS & AUTONOMOUS VEHICLE :

Environment perception



Source Google : Invariant = Buildings / Variant : mobile obstacles



An Enabler

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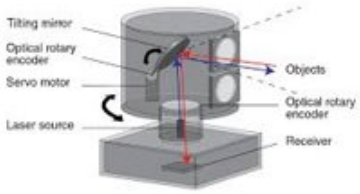
LIDAR BASICS

Reminder !...

LIDAR : Light Detection and Ranging

LIDAR is a Sensor : Initial Dedication is Perception



Mechanical LIDARs

MEMS LIDARs

Flash LIDAR

Flash uses a single light source that illuminates the field of view in a single pulse

Solid state LIDARs

Solid-state electronics by definition have no moving parts.

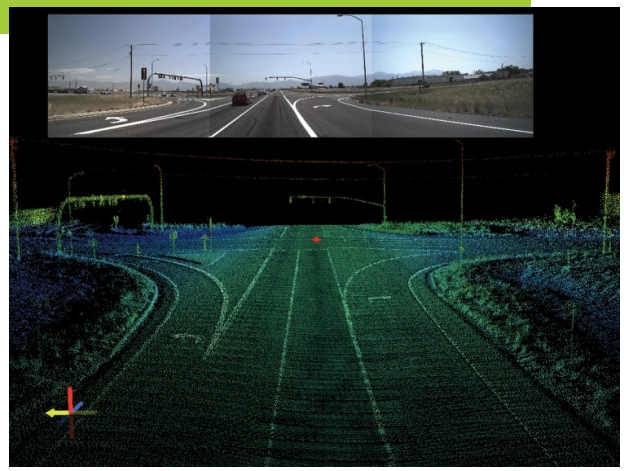
LIDAR BASICS

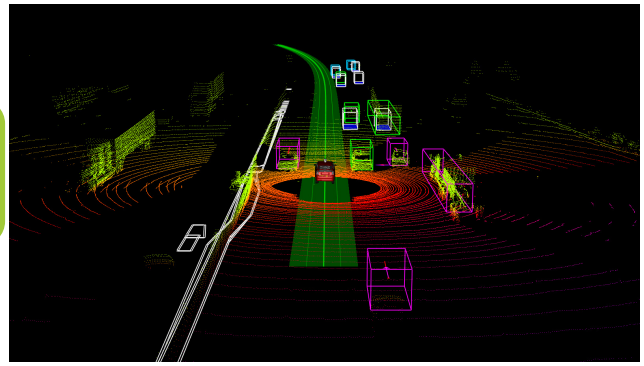
<u>Main Current Function :</u> Building a 3D representation of The surrounding Environment

→ **Detecting Obstacles :**

- **Mobile objects**
- **Static objects and road markings**
- **Buildings (invariant static objects)**
- **Road Markings**

SLAM (Localisation)



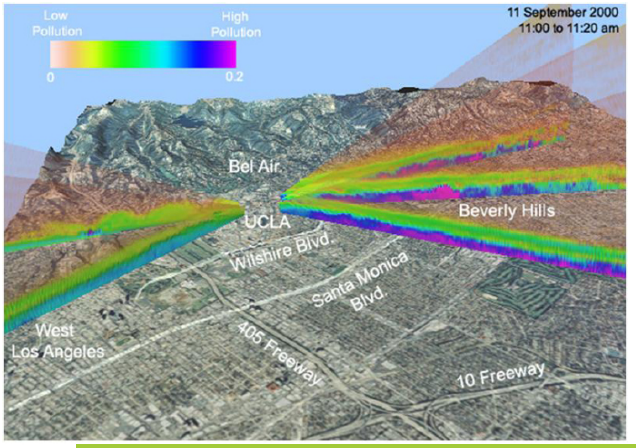


LIDAR is a **Sensor** with **high performance** regarding the **Position of detected objects**

AUTOMOTIVE … YES BUT NOT ONLY : LIDAR'S ADDITIONAL FUNCTIONS

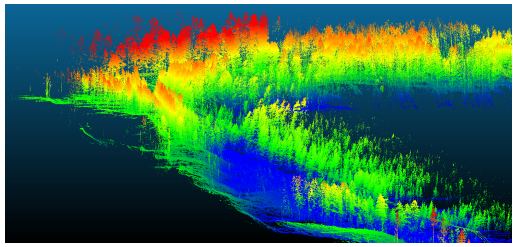
Domains other than Automotive use LIDARs :

POLLUTION DETECTION (fine particles / airborne)



Detecting pollution and fine particles by Lidar-equiped drones (the more it is blue, the less you want to breathe it !)

HUMIDITY / WATER



Forest area, with water and vegetation

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PROS AND CONS OF THE LIDARS

	Cost	Resolution	Field of view	2D/3	Effort to classify objects
Mechanical	---	- to +++ for Velodyne 64 and more +++	360°/ 100		+++ (3D) -- (2D, 2.5D)
Solid state	+++	+	to m	3D	++
Flash	+++	+	80°/ 50 to 150m	3D	++
MEMS	+++	+	120°/ 50 to 150 m	2D / 3D	++

OBSOLETE ! (under constant evolution)

LIMITATIONS :

- **Impacted by Weather conditions → Fog / Intense rain → noisy measures**
- **Detection BUT no identification as a basis → Classification requires clustering the cloud of points and shape recognition (in 2D, this can be tricky … <u>but</u> refer to pitch 19/11/2018 !)**
- **Direct line of sight is required (optical sensor) → « Everything that is behind a detected object becomes a zone of uncertainty »**

OPPORTUNITIES ARE REQUIRED

« Alone we go fast … Many we go far »

COLLABORATE (DATA FUSION) TO OVERCOME LIDAR LIMITATIONS :

- **LIDAR + Caméra**
  → **Detection + Classification**
  → **Complementarity : LIDAR supports filtering data « above the road plan » (or another plan)**

- **LIDAR + RADAR**
  → **LIDAR precise in position / RADAR precise in Acceleration & Speed**
  → **« See-through » / Specific detection**

- **LIDAR +V2X**
  → **« See-Through » / « See Farther » → Anticipate better**

- **LIDAR + RADAR / Camera**
  → **Complementarity at short distance for getting rid of limitations due to bad weather conditions**

OPPORTUNITIES ARE REQUIRED

« Alone we go fast … Many we go far »

COLLABORATE (DATA FUSION) TO PROVIDE NEW FUNCTIONNALITIES :

- **LIDAR + GPS / IMU low cost**
  → **Precise location (« amers visuels »)**
  → **Enrichment with frequent recalibration of the IMU**
- **COMMUNICATION**
  → **LiFi (to be investigated versus LEDs)**
- **Air quality measurements (Humidity / Particles / CO2 …)**
  → **Using Vehicle fleets – Cloud qualification of the « noise level » of the measure leading to detection of pollution level**
  → **to take into consideration on confidence level of the sensor info**
  → **to adapt data fusion strategies AND vehicle behavior**

SAFETY CRITICAL SCENARIOS : EVALUATING / COMPARING / VALIDATING

MOOVE

PSA GROUPE RENAULT

GROUPE Valeo

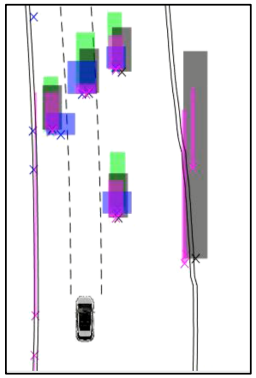
1. Big data :
Specific Data Collect (6 equipped cars, with Lidars, radars, smart camersa,…) :
> 700.000 km
12000 h / 200To

2.Preprocessing :
Data Transformation **at common format**

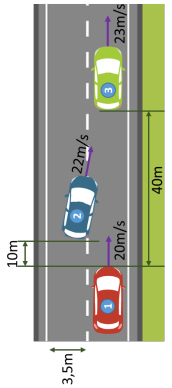
3. Perception algorithms for identification of mobile and static objects and infrastructure

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

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



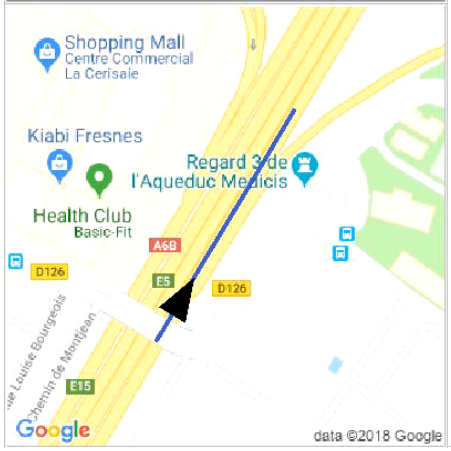
High Level Parameters
HLP_OriginalMultiplexor
HLP_UniqueID
HLP_AgeMax
HLP_AbsoluteSpeed
HLP_LaneShift
HLP_LengthCorrection
HLP_MobileObjectClassification
HLP_FixedObjectClassification
HLP_TimeBetweenVehicles
HLP_TimeToCollision

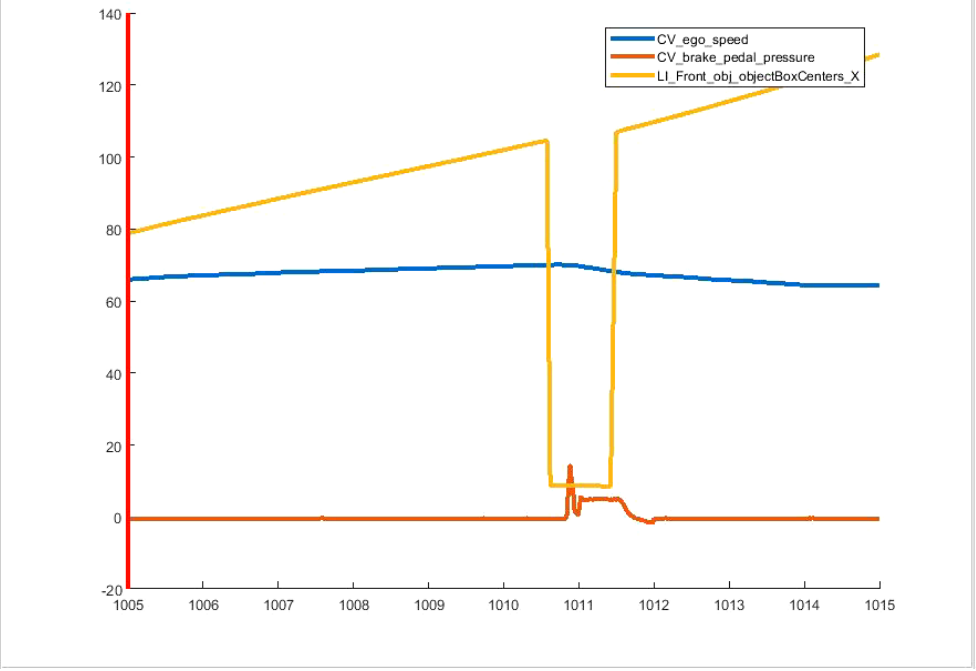


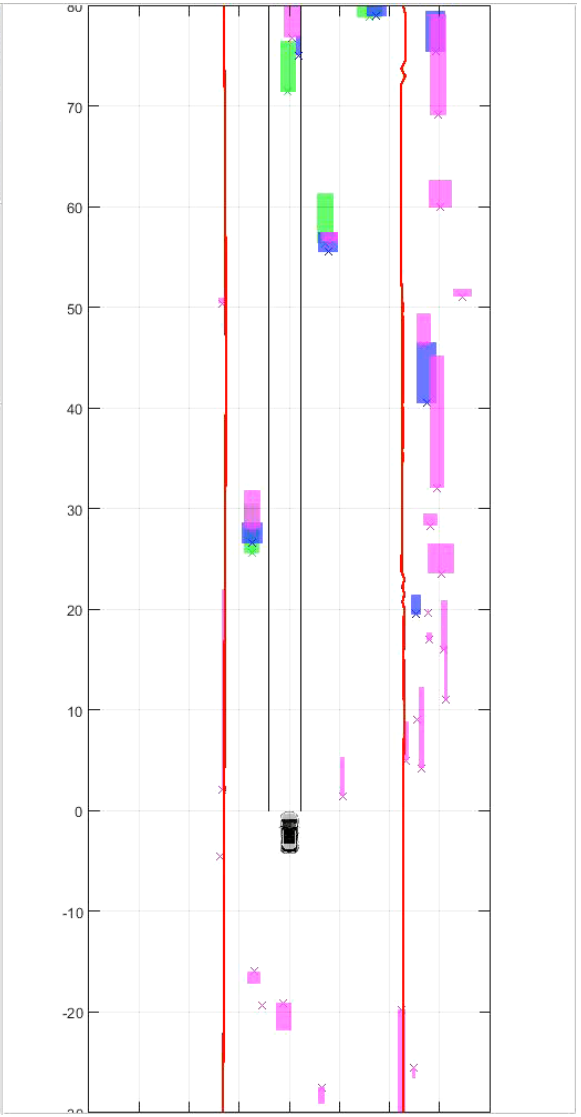
LET'S SEE A CONCRETE EXAMPLE …

MOOVE

Signal	Value
CV_ego_speed	
CV_brake_pedal_pressure	
LI_Front_obj_objectBoxCent...	





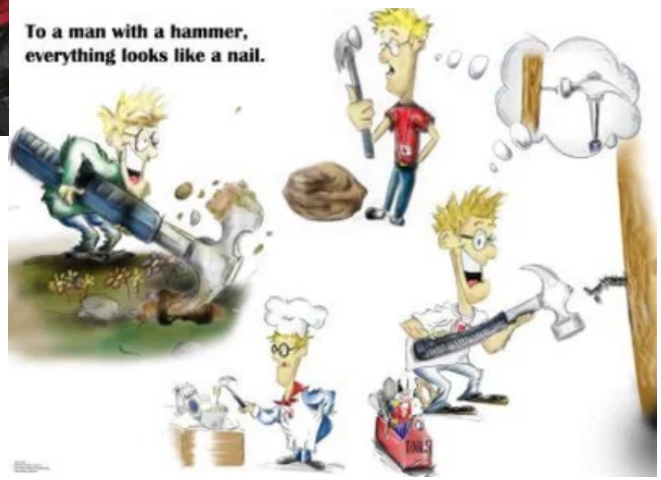


CONCLUSION

<u>PROS</u> are obvious

<u>CONS</u> will be addressed :

- **COST**
- **MASS PRODUCTION**
- **INCREASED PERFORMANCE**
- **ADDITIONAL FUNCTIONALITIES**



Lidar is a **MANDATORY ENABLER to AV** (dependability ISO 26262 + SOTIF…)
But it must efficiently **COLLABORATE** through a **GLOBAL SYSTEM APPROACH**
And it **requires « standardized » VALIDATION Methods**

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Thank you for your attention

Together to accelerate the mobility of tomorrow!