8 surround cameras
12 ultrasonic sensors
Forward facing radar

DARPA Grand Challenge

TESLA Elon Musks ROADSTER

TESLA Model S

Autopilot 1 HW1-MobileEye (*)

Autopilot 7 HW2-NVIDIA-CUDA

Autopilot 7 HW3-TESLA

TESLA SAE Level 5 ?

2004   2005   2008   **2009**   2011   **2012**   2013   2014   2015   2016   2017   **2018**   2019   **2020**

Google WAYMO
LIDAR VeloDyne

Google WAYMO Toyota Prius

Led by Sebastian Thrun
Co-inventor StreetView
Member winning team
DARPA 2005

WAYMO announces
20.000 Jaguar I-Pace
62.000 minivans
For ride-hailing service

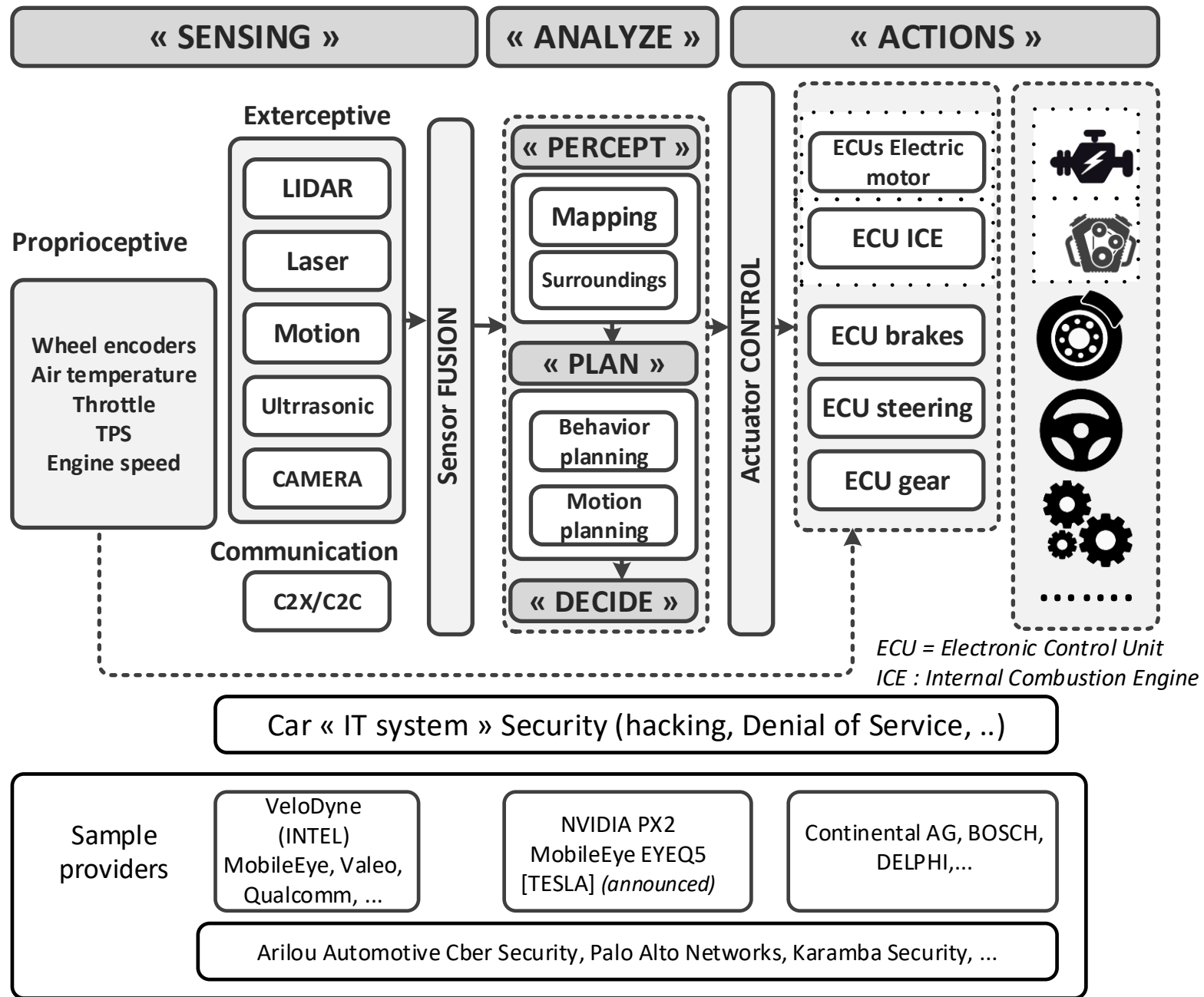**WAYMO Self Driving ride hailing SAE level 5**

Advanced Driver Assistant Systems [ADAS]
Adaptive cruise control (ACC), Automatic parking, Collision avoidance system, Forward Collision Warning , Traffic sign recognition, Lane departure warning system, Night Vision ,Pedestrian protection system, ….

Regular car vendors have their own self driving roadmap as an enhancement on their ADAS roadmap

(*) MobileEye (now Intel) partnership ended in 2016
(**) Google partners with INTEL for chip production, targets a full SDV offering for car vendors

« SENSING »   **« ANALYZE »**   **« ACTIONS »**

Exterceptive

Proprioceptive

Wheel encoders
Air temperature
Throttle
TPS
Engine speed

LIDAR
Laser
Motion
Ultrasonic
CAMERA

Communication

C2X/C2C

Sensor FUSION

« PERCEPT »

Mapping
Surroundings

« PLAN »

Behavior planning
Motion planning

« DECIDE »

Actuator CONTROL

ECUs Electric motor
ECU ICE

ECU brakes
ECU steering
ECU gear

ECU = Electronic Control Unit
ICE : Internal Combustion Engine

Car « IT system » Security (hacking, Denial of Service, ..)

Sample providers

VeloDyne (INTEL)
MobileEye, Valeo, Qualcomm, ...

NVIDIA PX2
MobileEye EYEQ5
[TESLA] *(announced)*

Continental AG, BOSCH, DELPHI,...

Arilou Automotive Cber Security, Palo Alto Networks, Karamba Security, ...

SAE level	Name	Execution of steering and acceleration/deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability (driving mode)

HUMAN driver monitors the driving environment

0	No automation	(human)	(human)	(human)	N/A
1	Driver Assistance	(human + car)	(human)	(human)	Some driving modes
2	Partial Automation	(car)	(human)	(human)	Some driving modes

AUTOMATED driving system MONITORS the driving environment

3	Conditional Automation	(car)	(car)	(human)	**Mapped** environment Driver ALWAYS alert
4	High Automation	(car)	(car)	(car)	MOST Use cases. **Human** can take-over
5	Full Automation	(car)	(car)	(car)	ALL driving modes under all conditions

2	**Level 2** automation vehicles take over both steering and acceleration/deceleration capabilities **in fixed scenarios**. Although level 2 vehicles can take over certain "driving modes" or tasks, **the driver is still in control over the vehicle at all times**. Tesla's Enhanced Autopilot or Volvo's Pilot Assist II are Level 2 automation features.
3	**At level 3** automation, cars safely control all aspects of driving **in a mapped environment**. Human drivers still need to be on board monitoring and managing changes in road environments or unforeseen scenarios. *Question is if it is realistic to expect a driver to remain as alert as needed, if they're only passively monitoring.*
4	**In level 4** vehicles, **no driver interaction is needed**. A level 4 car can stop itself if the systems fail. These cars will be able to handle driving from point A to point B **in most use-cases**. However, the cars will include functional driving apparatus, like wheels, brakes and gas pedals. So humans can still manually drive if desired or needed.
5	**Level 5 cars** are completely autonomous. Besides controlling the destination, humans have no other involvement in driving a level 5 car – **nor can they intervene**. Prototypes of level 5 vehicles look nothing like the cars that we drive today. There are no steering wheels, gas or brake pedals.

Sources : drawing inspired on SAE / level desciption from dryve glossary

Where am I ?
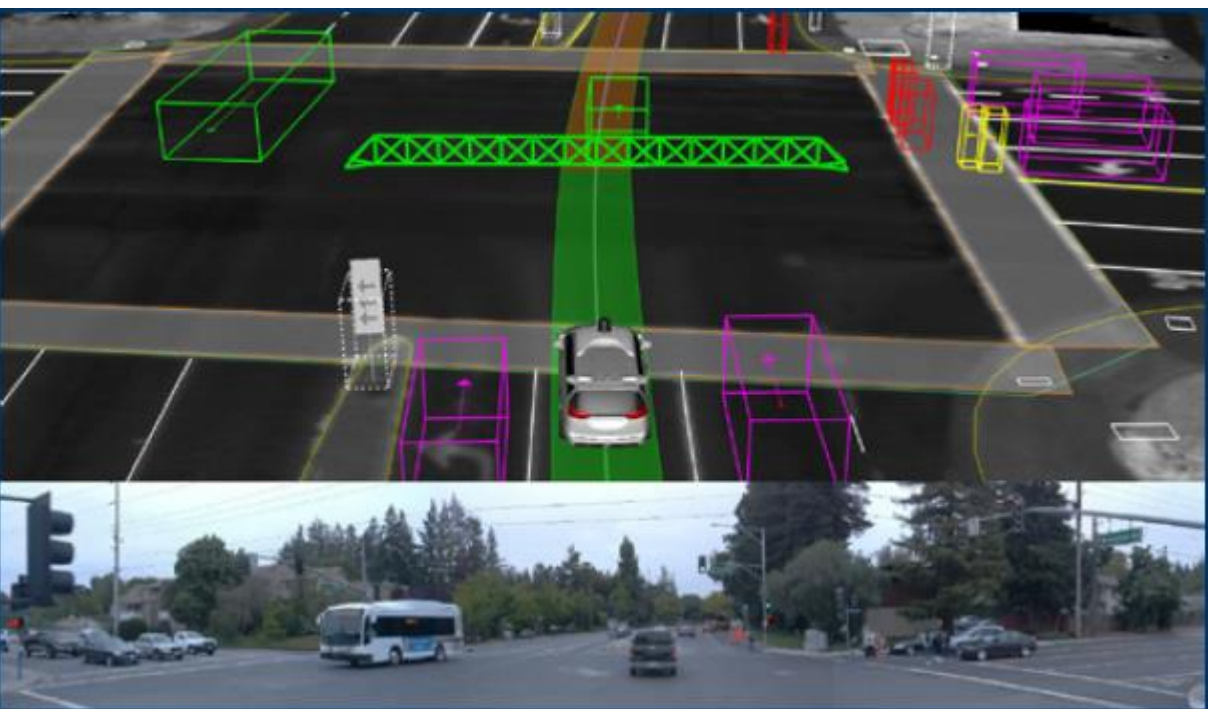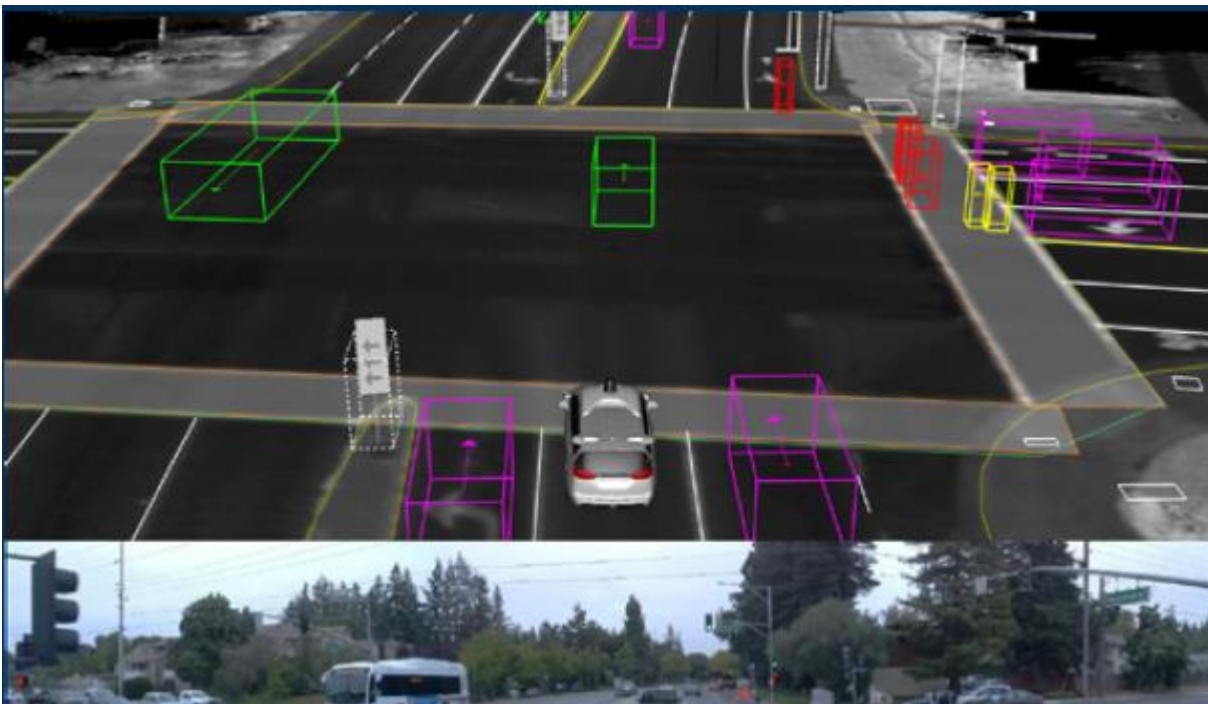
Me willing to investigate the world of self driving vehicles

VUB accepted request for internalship

2

Chapter 2: State of the art of Self Driving Vehicles
Studied the working principles and building blocks of self driving vehicles [SDV]

*VUB proposal to work on **motion control** on the existant VUB electric REVA prototype.*

3

Chapter 3: REVAi electric vehicle presentation
Analysis of possibility to use in-place Curtis Induction Motor Controller for speed control

Problem with using Curtis IMC by lack of

4

Chapter 4: Speed control
[What was done exactly]

CONCLUSION