INPERCEPT

INTELLIGENT PERCEPTION

PERCEPTION IN THE ERA OF AUTONOMOUS VEHICLES

Jorge Pinazo[1], Adolfo Lerín[1], Francesc Xavier de Gibert[2], Álvaro Moliner[2], Daniel Sevilla[1], Antonio Jurado[1], Iván Rios[1], Rodrigo Jerez[1], Jaime Santiago[1], Álvaro Linuesa[1], Antonio Cano[1], Federico Dios[2], Adolfo Comerón[2], Josep R. Casas[2], José A. Lázaro[2]

1: Capgemini Engineering | R&D Dept. | Automotive, Infrastructure & Transportation| Barcelona – Madrid | Spain
2: UPC | School of Telecommunication Engineering (ETSETB)| Barcelona, Spain

Contact email: jorge.pinazodonoso@capgemini.com

INDEX

1. AUTONOMOUS VEHICLES & PERCEPTION

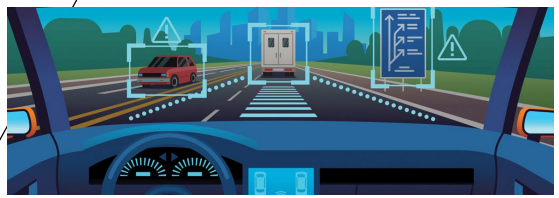
SELF DRIVING CAR EVOLUTION

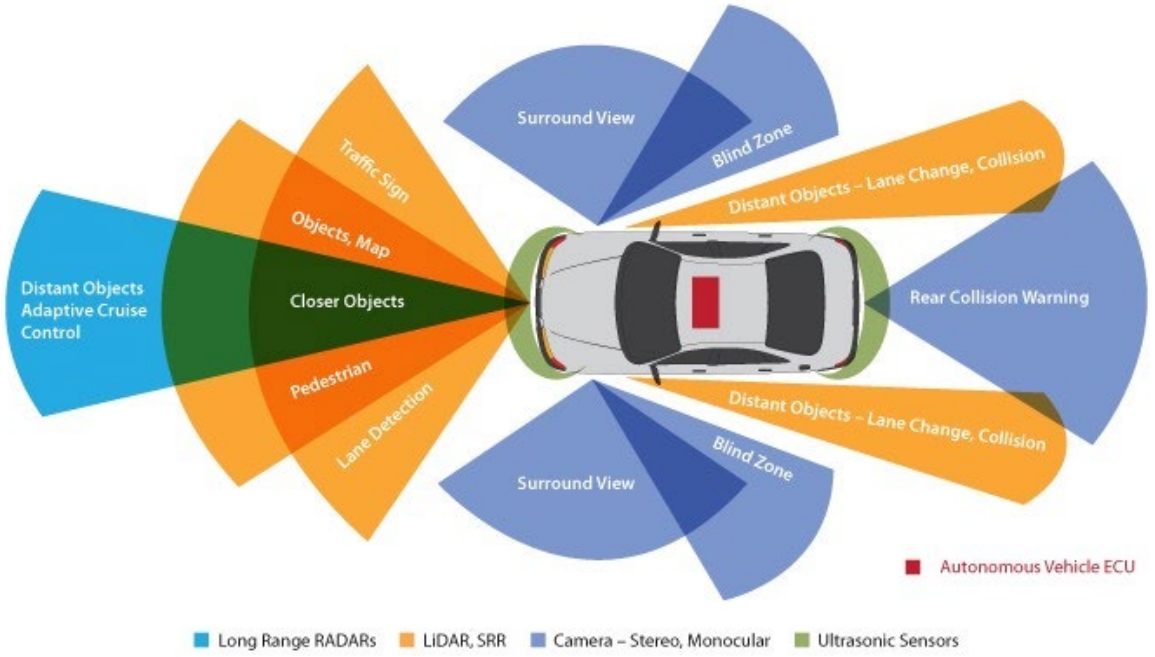
- No OEM achieved Level 4 Autonomy
- Time have shown difficulties to perceive the reality so well like the human brain
- Need for robust and precise sensors
- Autonomous Driving functions increase Car costs

2. "SENSOR AS A SERVICE“ KEY ON PERCEPTION

PERCEPTION TECHNOLOGIES FOR AUTONOMOUS VEHICLES

- Complexity to understand reality
- Need for innovative sensors
- Need to develop new skills in semiconductors and digital signal processing
- LIDAR, Radar and Camera technologies need to improve
- Electronics and Photonics sensor fusion





3. HIGH RESOLUTION CAMERAS AS VISION DATA SOURCE

CAMERA AS A SENSOR

- **Cameras** play the role of human eyes for visual perception

  Capturing scene waveforms (**light**, colors) in high resolution and providing signals (**pixels**) to the processor.

  These signals convey **features** (edges, texture, object contours) which are also used for perception by human eyes.

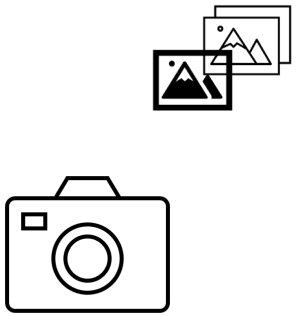
- **Computer vision** plays a role similar to human brain

  Extracting features from pixels with the aim to **detect/classify** objects and **recognize** scenes.

  Colors, textures and edges help vision processing, enabling to **extract** interesting **objects** for autonomous driving such as lanes or pavement markings, signs or traffic lights.

- **Low cost**: Cameras are cheaper than other sensors

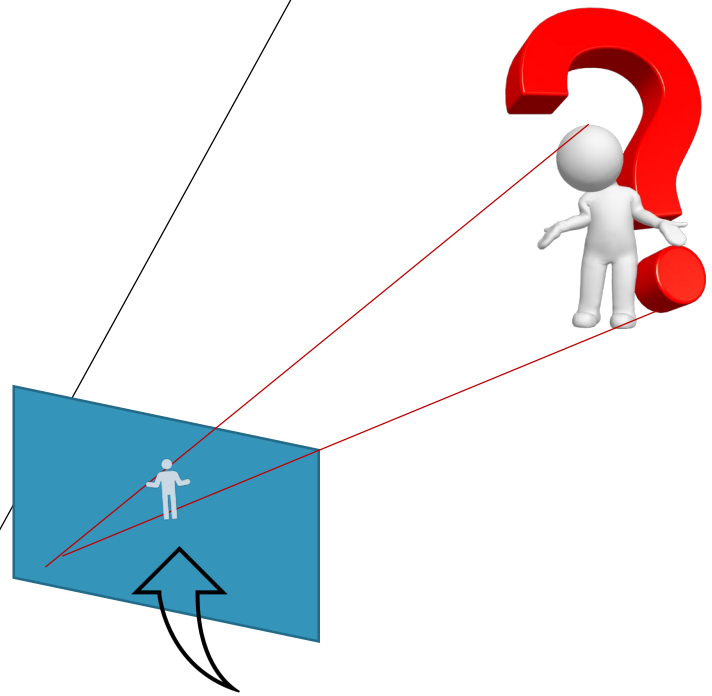
  Multiple cameras or fisheye lenses can be installed to achieve 360º vision.



COMPUTER VISION EVOLUTION

- Camera images project the scene into an image plane.
  On the plane, computer vision techniques have evolved to efficiently perform:
  - Feature **extraction**: object boundaries, colors, textures...
  - Object **detection**: localizes objects in the image
  - Image/object **classification**: into predefined object classes
  - Instance **segmentation**: different occurrences of same class
  - Video **motion analysis**: motion trajectories and attitudes for moving of objects or bodies (tracking, pose, gestures...)

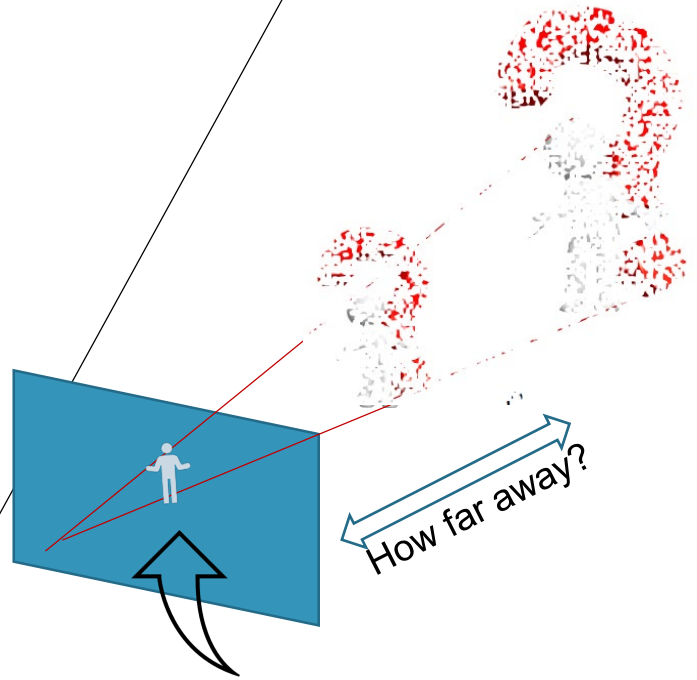
- Deep learning facilitates these operations by:
  - **Automated learning** of features from annotated datasets.
  - Speeding up image analysis with **inference** networks.



4. NOT ENOUGH FOR RANGE AND SPEED PERCEPTION

RANGE AND SPEED PERCEPTION

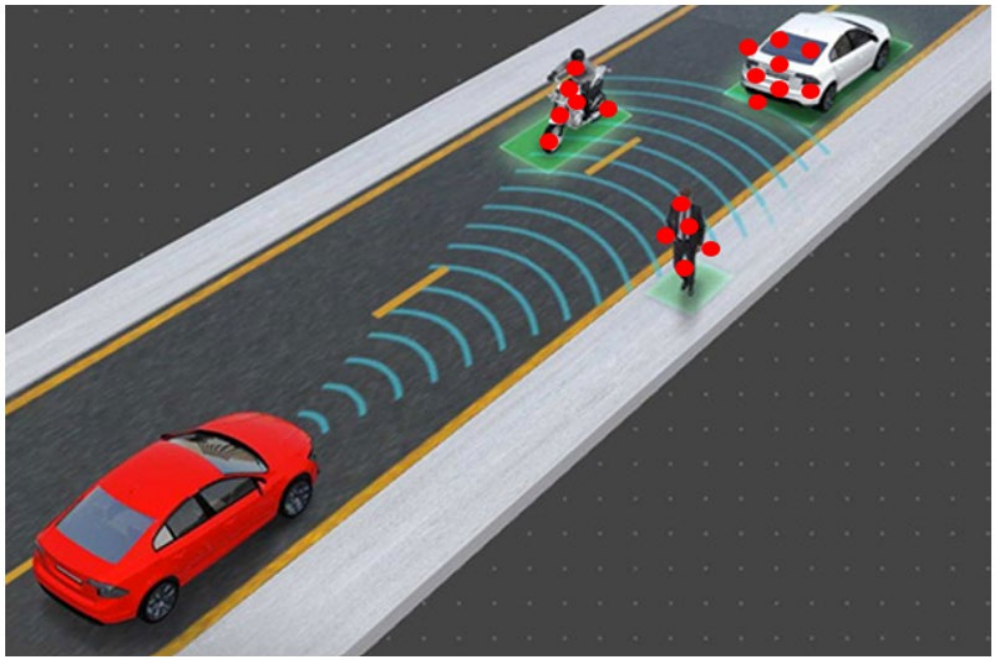
- **Cameras** don't provide direct measurements of distance/size of objects in the scene
  - In autonomous driving, it is essential to properly estimate **distances** of objects, pedestrians and other vehicles around
- **Range sensors, such as Lidar or Radar,** directly compute actual sizes and distances of objects
  - Range sensors capture distance to points, providing a type of data known as **point clouds**
  - Lidars have higher resolution (and cost) than radars, but radars can provide estimated **velocities** of objects
- **Radars** are a convenient complement to cameras for autonomous driving
  - Provide **speeds** and **distances** at a lower cost



5. IMAGING RADAR & LIDAR AS RANGE SENSORS

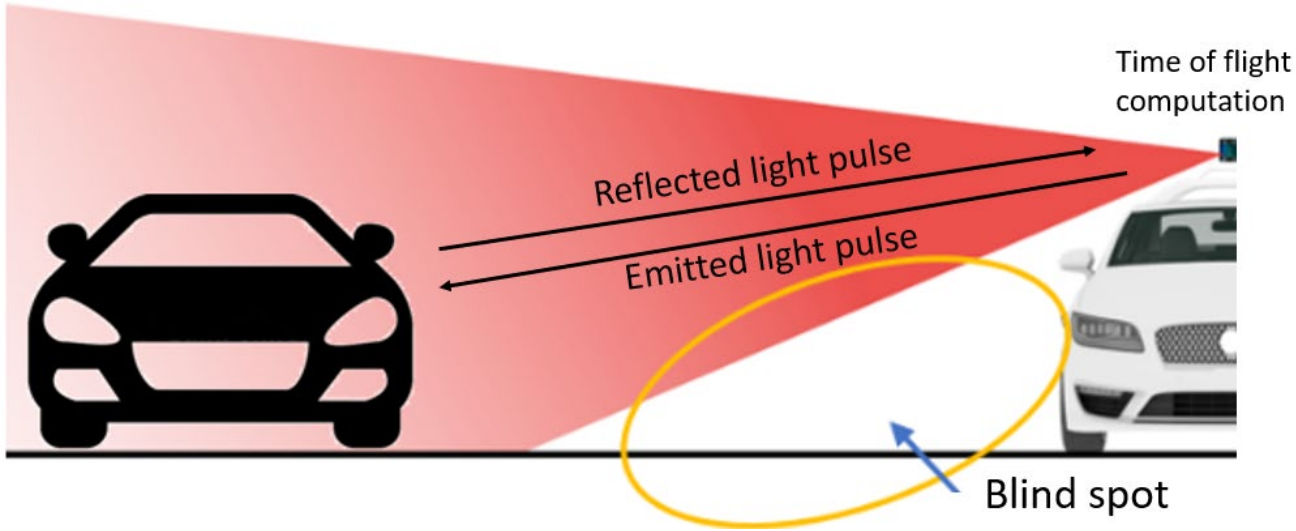
FMCW RADAR

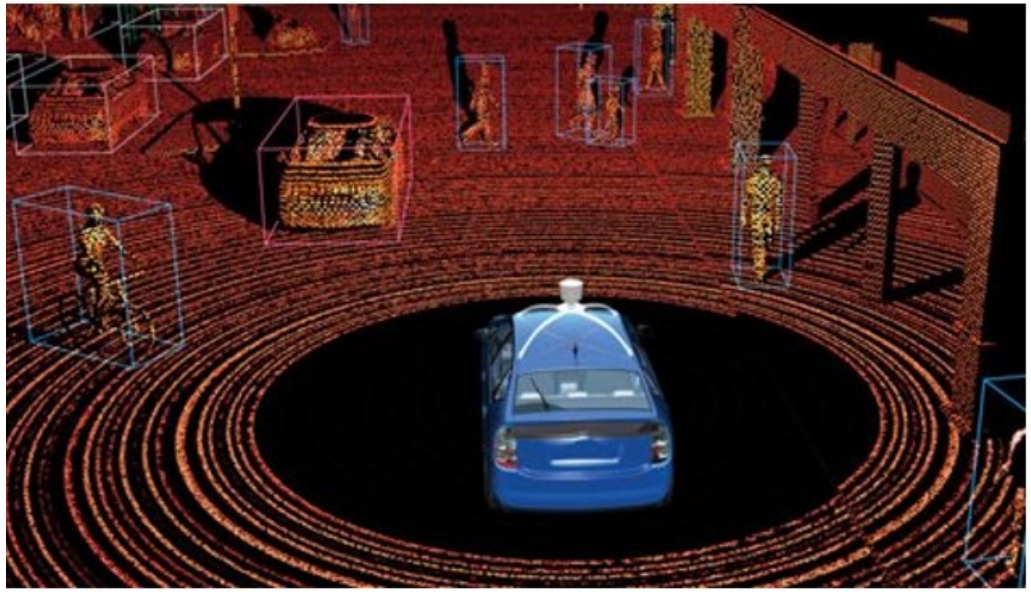
- Can estimate range, angle and velocity of several targets
- Strong to adverse weather conditions (rain, fog, etc…)
- Compact device. High operating frequency (77 GHz)
- TDM and antenna beamforming capabilities
- Several equipped in a single car
- Range up to 300 m



LIDAR

- Uses a rotatory pulsated laser (360º field of view)
- Can estimate distances and map the surroundings with high precision
- Higher angular resolution than radar (narrow beam)
- Profile of detected objects
- Expensive technology
- Weak against adverse weather conditions





6. DATA FUSION FOR PERCEPTION

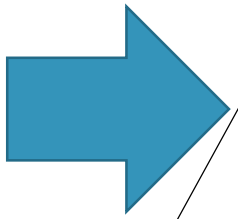
BENEFITS OF SENSOR FUSION

Sensor Fusion allows cars to create a more accurate picture of what's happening around them to be able to make better driving decisions in complex or unpredictable situations.

-Radars measure distance and speed of obstacles

-Cameras provide a lot of details from the surroundings

-LIDARs have great resolution for object detection



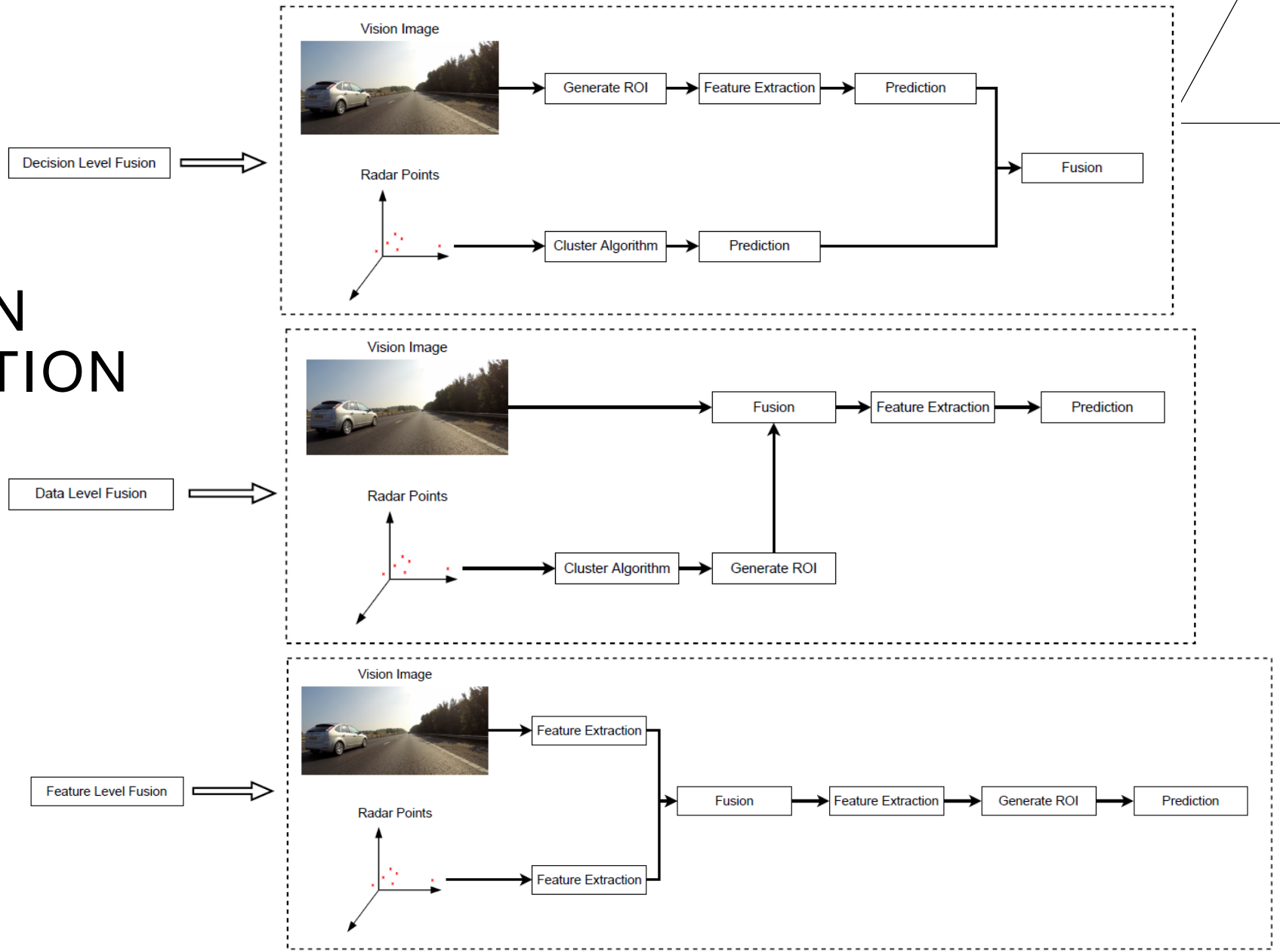
Less uncertainty

More reliability

More accuracy

Challenges: Sensor Calibration, Sensor Noise and Sensor Data Processing

DATA FUSION CLASSIFICATION



7. GLOBAL VISION OF INPERCEPT PROJECT

GLOBAL OBJECTIVES

Technical Objectives of the Project:

-Develop new exterior perception Systems

-Develop an interior Perception System to monitor driver and other passengers

-Develop connectivity and localization advanced technologies

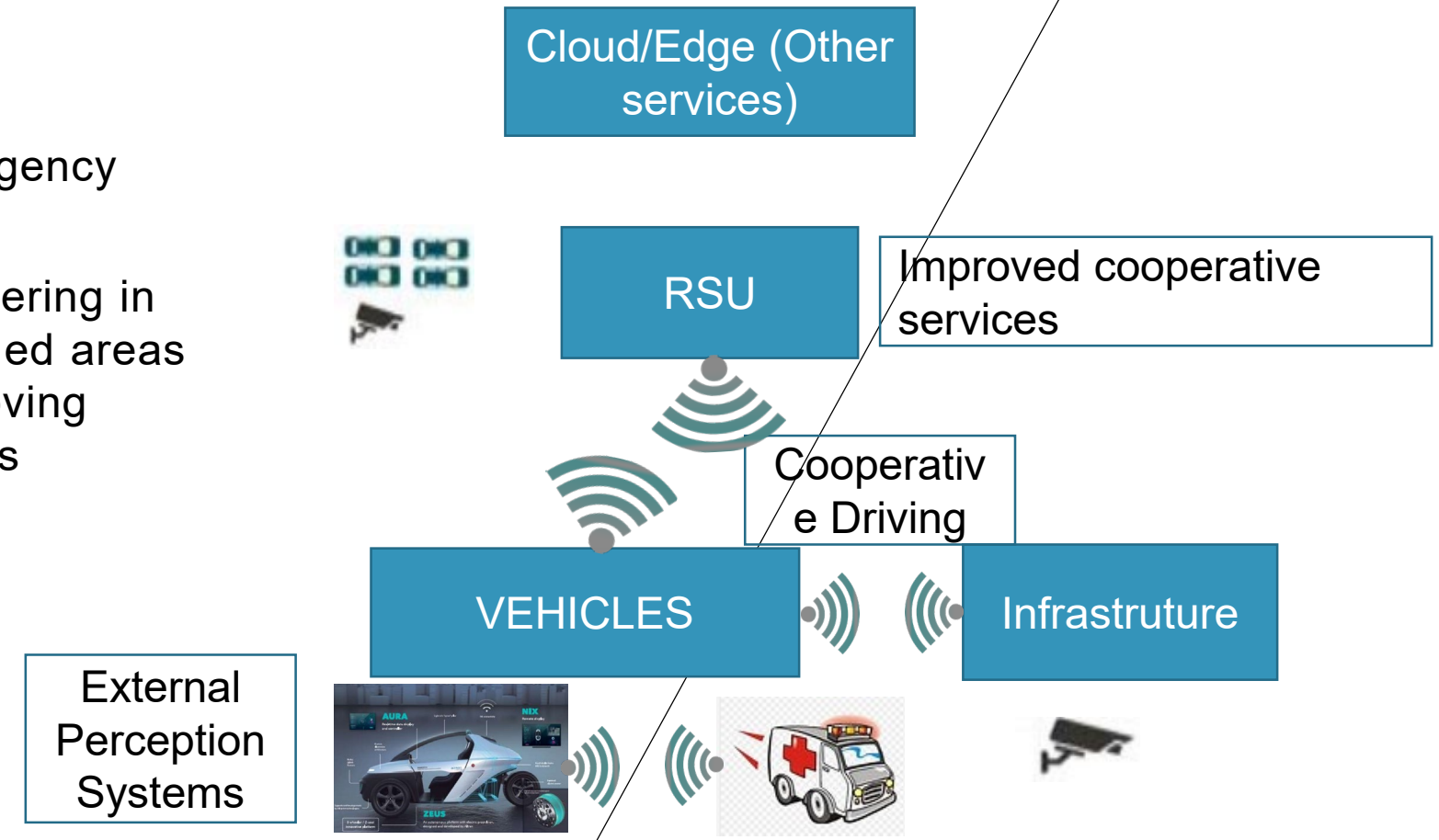
-Develop and improve Autonomous Driving functions with the help of IA

-Show the positive impact of the developments in Use Cases for Smart Cities and Fleet management

SMART CITY USE CASE

Improved interaction with Emergency vehicles

Improved planning and maneuvering in low visibility areas and in crowded areas reducing travel times and improving safety of Vulnerable Road Users

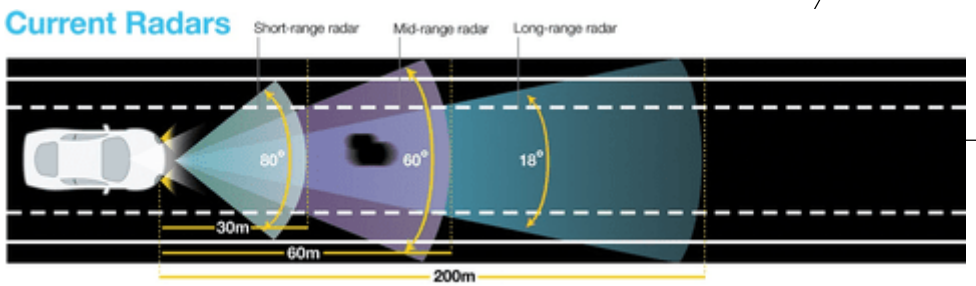


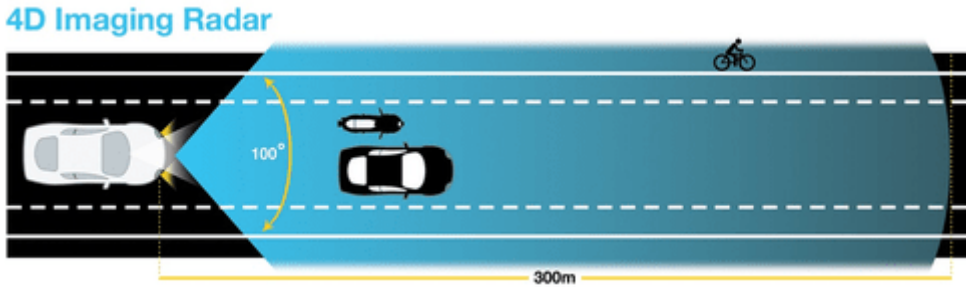
8. DEVELOPING OF IMAGING RADAR AT INPERCEPT PROJECT

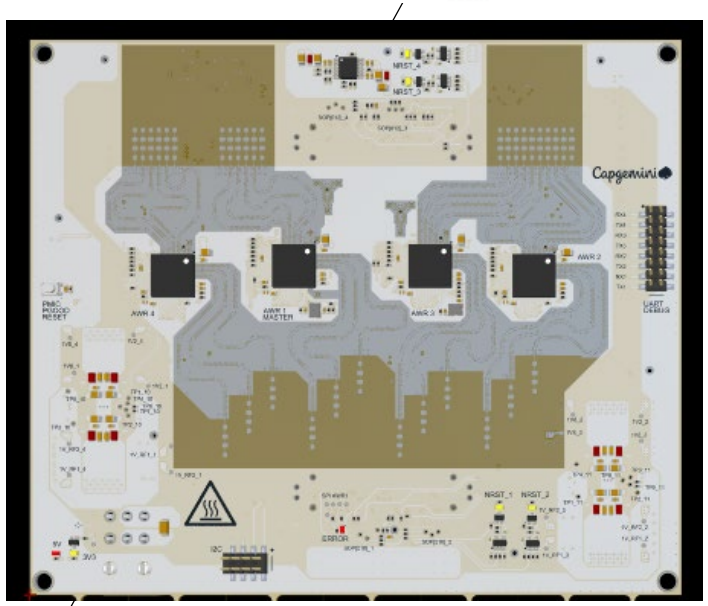
IMAGING RADAR (HW)

A **4D Imaging radar** allows for 3D space detection with **high resolution, range and field of view**. Ideally provides the combined advantages of a short, medium and long-range radar.

A **high number of transmitters** and receivers is required to achieve these specifications.







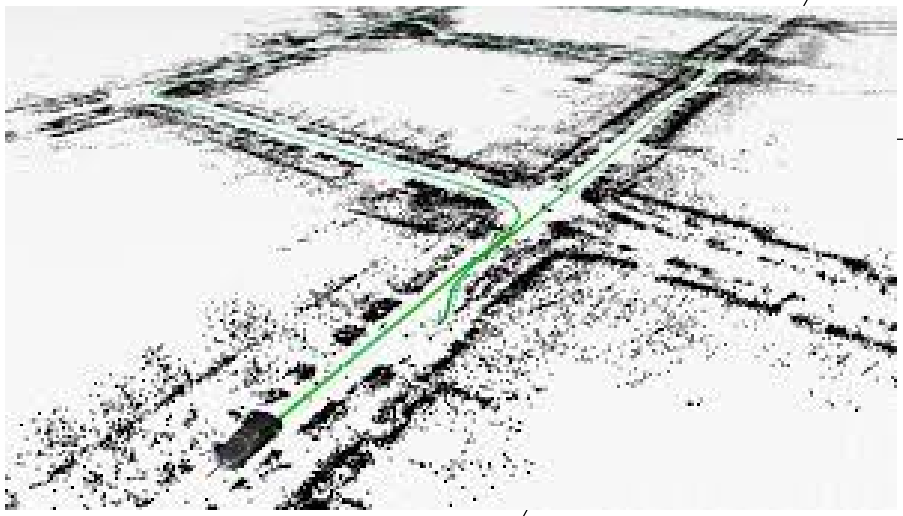
SAR AND SLAM (SW)

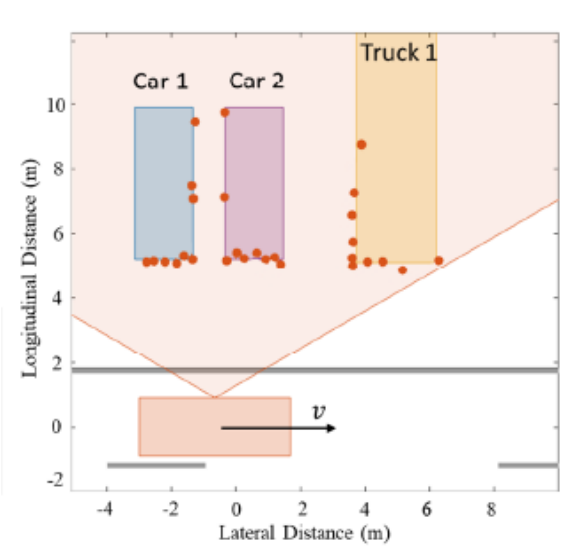
Imaging radar allows to obtain high resolution images which can be used to improve perception of the environment. However, **HW has its limitations**.

SLAM is used to continuously map the radar(s) contributions to increase likelihood of detections.

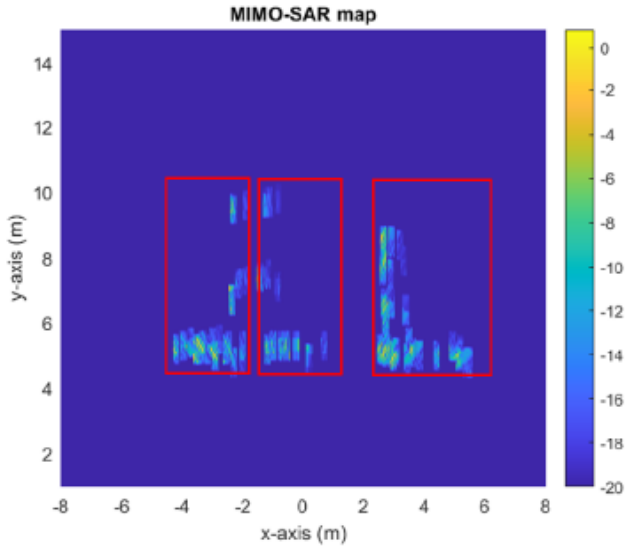
SAR is used to improve generated images resolution by coherently combining them.

Both techniques make use of the **vehicle motion** to compensate and combine different images and require a good estimation of it.



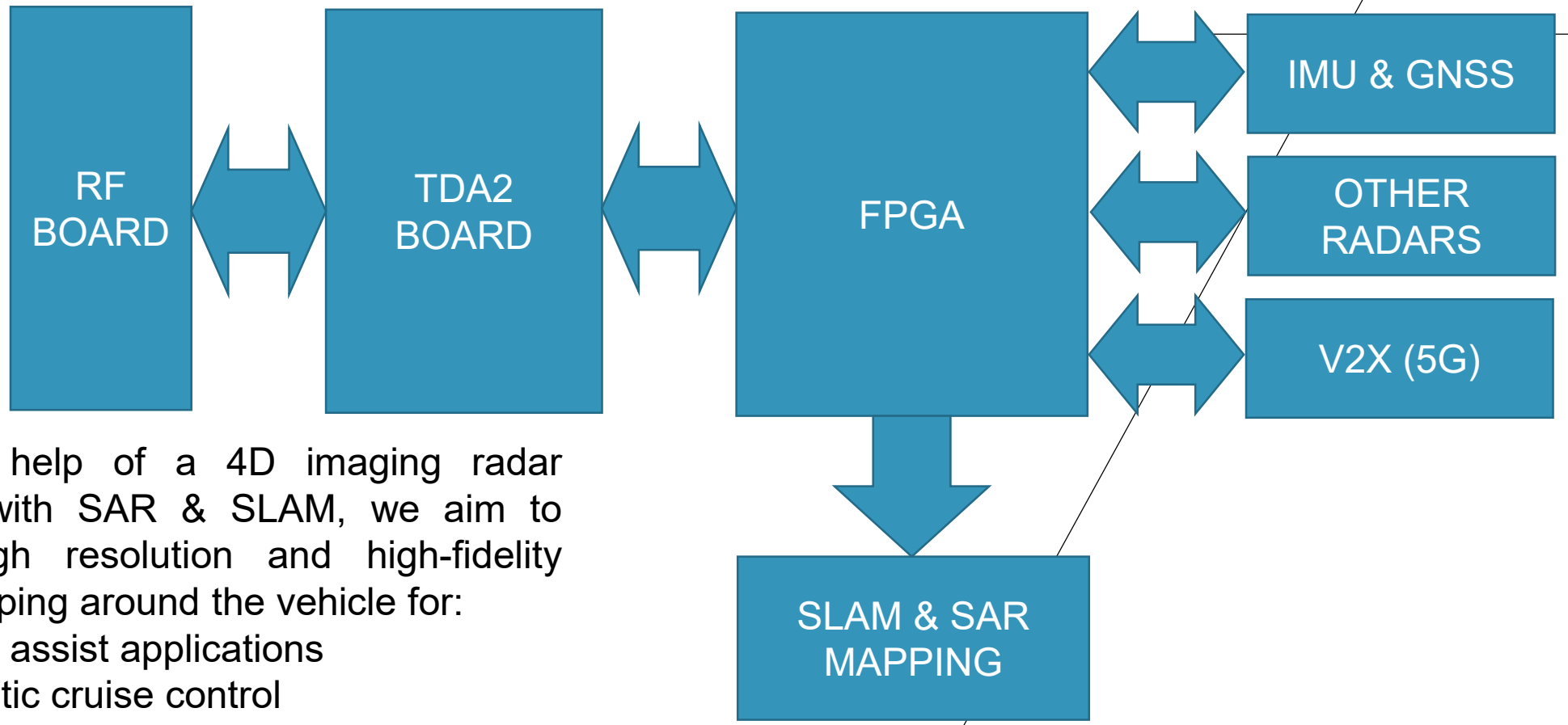


(b)



(c)

GENERAL ARCHITECTURE

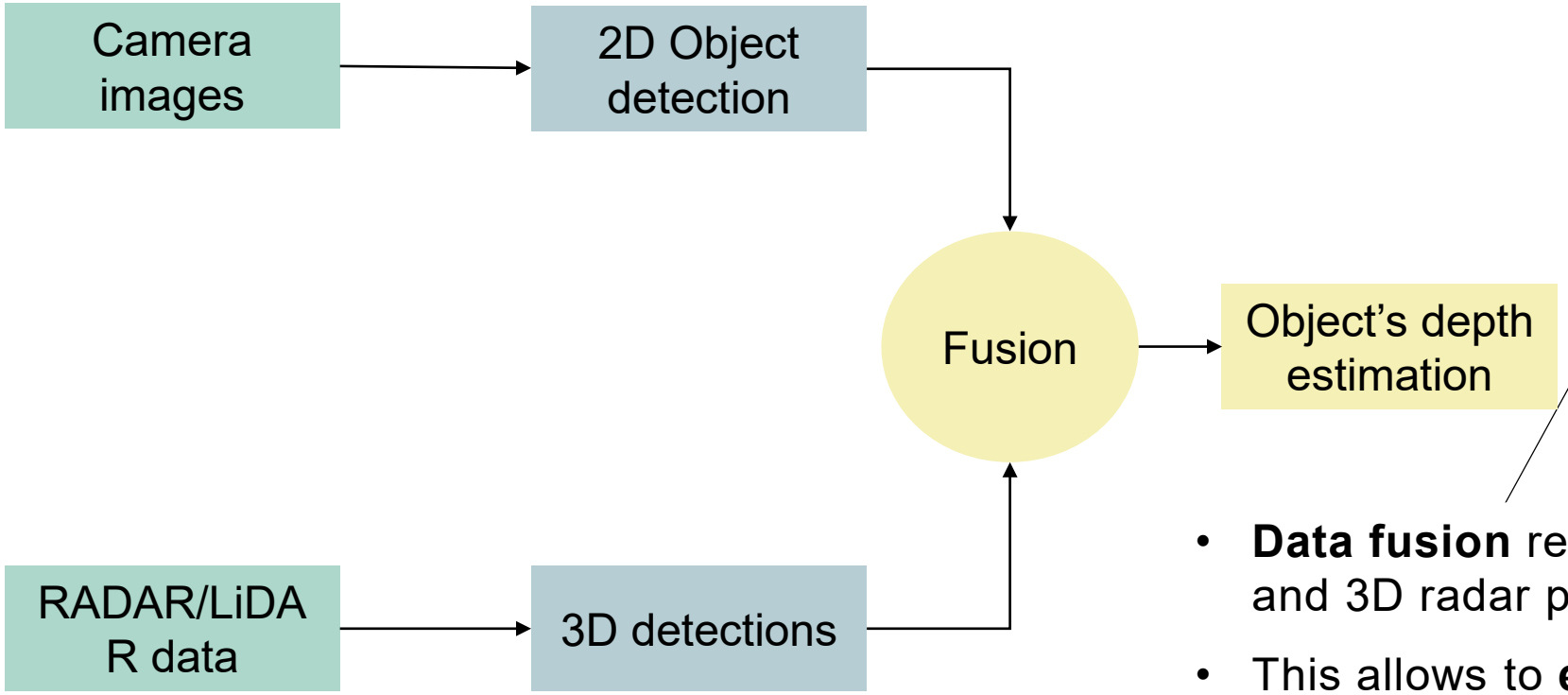


With the help of a 4D imaging radar together with SAR & SLAM, we aim to obtain high resolution and high-fidelity radar mapping around the vehicle for:

- Parking assist applications
- Automatic cruise control
- Automatic emergency braking
- Front collision warning
- Automatic lane change

9. DEVELOPMENT OF RANGE AND VISION DATA FUSION AT INPERCEPT

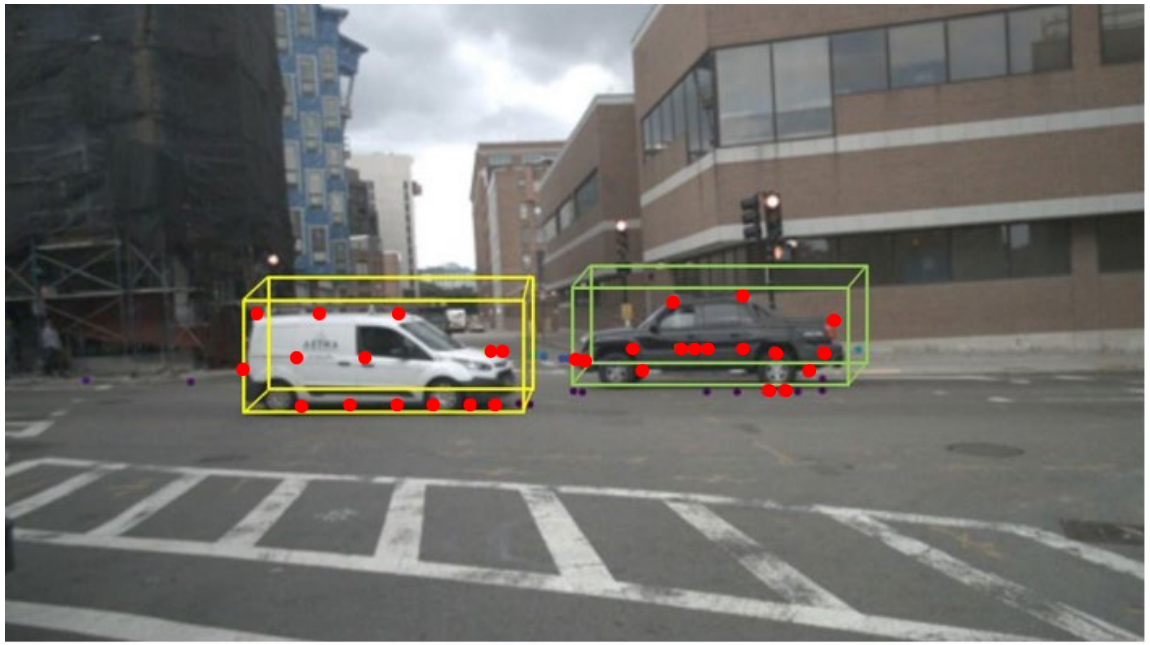
DATA FUSION



- **Data fusion** registers 2D object detections and 3D radar points on a video frame
- This allows to **estimate object's depth** from the registered coocurrences

SIMULATION

- **Video object detections** on a video frame (bounding boxes)
- **3D RADAR points projected** in the corresponding frame (coloured points)
- Registered coocurrences allow **estimating object's distances**



10. OTHER R&D INITIATIVES

VigIA

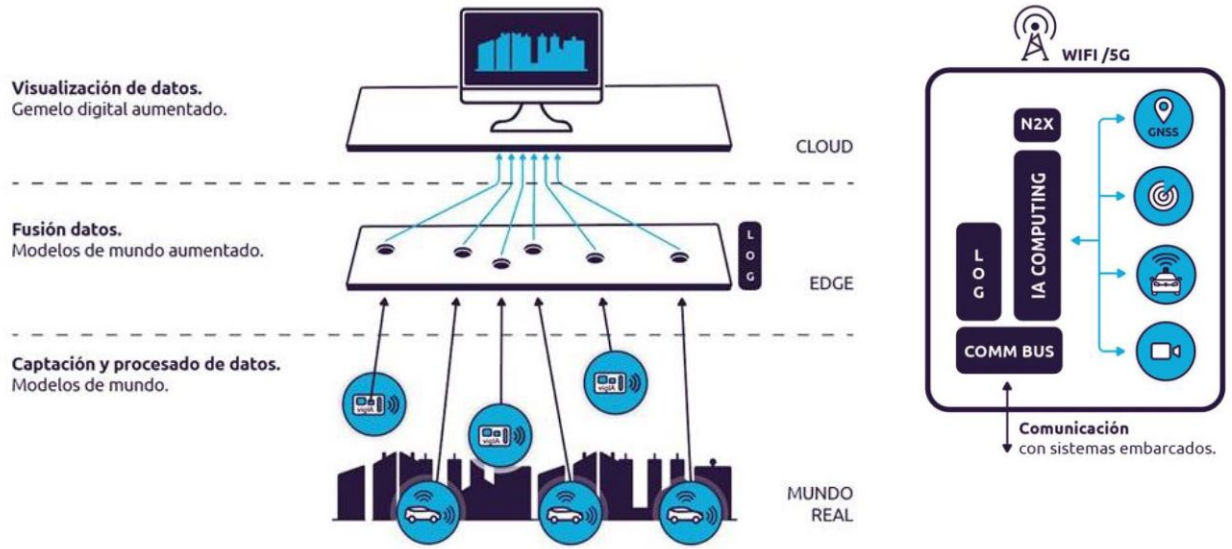
incorporation of the connected and autonomous vehicle to the mobility value chain in Spain through the use of digital twins with Artificial Intelligence

The project aims to facilitate to different actors in the chain the transition from the traditional automotive value chain to the new mobility value chain.

Solution allowing the generation of **augmented digital twins**, which simulate in real time and in a reliable way the environment in which a vehicle and other elements of the road, based on the data captured by a **perception device** (node).

Applications:

- Scenario generation for training AI
- Extended ODD for autonomous vehicle functions
- Simulation of traffic management strategies
- New business models data-based



Capgemini engineering

GOBIERNO DE ESPAÑA MINISTERIO DE ASUNTOS ECONÓMICOS Y TRANSFORMACIÓN DIGITAL SECRETARÍA DE ESTADO DE DIGITALIZACIÓN E INTELIGENCIA ARTIFICIAL

red.es

UNIÓN EUROPEA
Fondo Europeo de Desarrollo Regional
Una manera de hacer Europa

THANK YOU

Jorge Pinazo[1], Adolfo Lerín[1], Francesc Xavier de Gibert[2],
Álvaro Moliner[2], Daniel Sevilla[1], Antonio Jurado[1], Iván Rios[1], Rodrigo Jerez[1],
Jaime Santiago[1], Álvaro Linuesa[1], Antonio Cano[1], Federico Dios[2],
Adolfo Comerón[2], Josep R. Casas[2], José A. Lázaro[2]

1: Capgemini Engineering | R&D Dept. | Automotive, Infrastructure & Transportation| Barcelona – Madrid | Spain
2: UPC | School of Telecommunication Engineering (ETSETB)| Barcelona, Spain

Contact email: jorge.pinazodonoso@capgemini.com