The University of Hong Kong

institute for SOFTWARE RESEARCH

How Do Driverless Cars Work?

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Background

- Ph.D., Yale University (computer science, 1978)
- Developed Computational Geometry, a basic driverless car technology
- J.D., Duquesne University (law, 1981)
- Carnegie Mellon computer science faculty since 1975
- Visiting Professor, University of Hong Kong (2001-)

- Director, Master's Program in eBusiness Technology
- Annual course, "Internet of Things"
- Expert witness in over 220 court cases involving computer technology, including traffic surveillance

PCWorld FROM IDG

FEB 10, 2017

Ford to pump $1B into AI for driverless cars

Former Google and Uber engineers will work with Ford on a system for 2021

Ford plans to spend US$1 billion over the next five years on the development of an artificial intelligence system for driverless cars.

Ford will investment the money in Argo AI, a start-up founded by former leaders from Google and Uber's self-driving car research units, and they will work toward the goal of a system that's ready for deployment in 2021.

The research will be focused on a virtual driver system capable of operating at what's called "SAE level 4." It's one of five levels defined for self-driving cars and specifically describes an autonomous car that's capable of completely controlling the vehicle in almost any condition. After it has been engaged, drivers do not need to pay attention to the driving.

Argo AI will have about 200 employees working on the project once it gets up and going.

Ecns.cn 2017-03-01

Baidu restructure focuses on intelligent driving

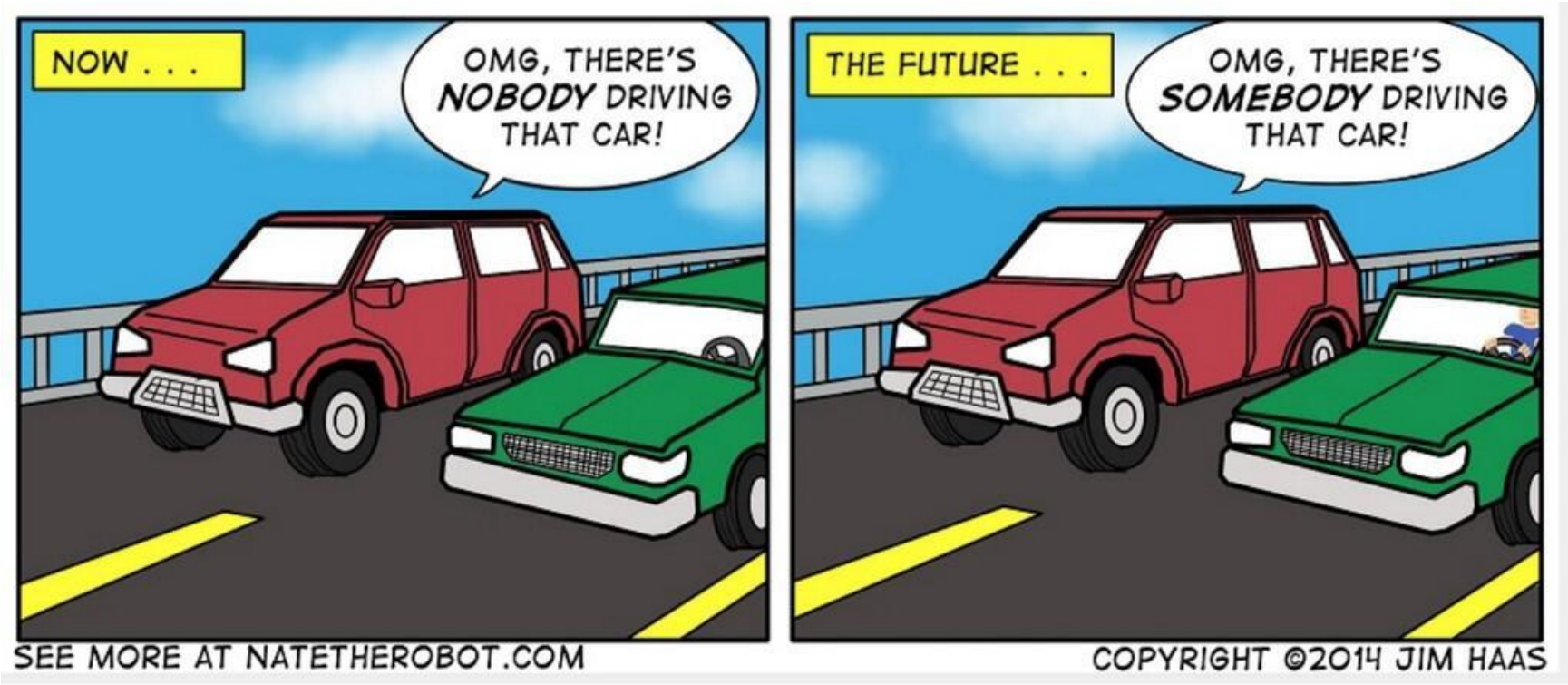
Search engine Baidu has announced it will establish an intelligent driving group, headed by company president and artificial intelligence expert Lu Qi.

The move signals Baidu's latest push to transform itself into an AI-first company, days after chairman Robin Li flagged artificial intelligence as a strategic priority.

The newly formed group will comprise three business units focusing on autonomous driving, intelligent automobile, as well as internet of vehicles.

"Self-driving, intelligent transportation and internet of vehicles are major forces for industrial upgrade and they define Baidu's business strategy and core competence," a company statement said.

Future of Driverless Cars



Cars Aren’t Safe

- US 2010: 6 million car crashes, 93% human error
- World: 1.3 million deaths per year; 50 million injuries
- 4**D**s: **D**istraction, **D**runkenness, **D**rowsiness, **D**river error
- Expected decrease in auto insurance premiums from driverless cars: 75%

Driverless Car History

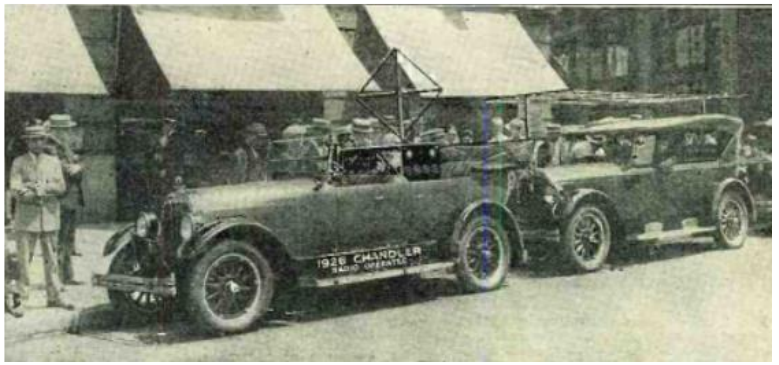
1925 – Houdina Radio Control Co. demonstrated the “American Wonder” on 5th Ave. in NY

1939 – Norman Bel Geddes guided car at the NY World’s Fair

1950s – General Motors & Radio Corporation of America test automated highways

1990s – VaMP driverless car at Univ. of Munich

1995 – Carnegie Mellon Navlab car goes 5000 km across the U.S. autonomously



Driverless Car History

2009 – Google begins driverless car project

2010 – Four cars drive 16,000 km from Parma (Italy) to Shanghai

2013 – VisLab (Univ. of Parma) vehicles navigate downtown Parma (Italy)

2016 – Uber deploys 20 driverless cars (free) in Pittsburgh (US)

Problems a Car Faces

- Where am I? (location)
- Where should I be going? (route planning)
- What is that in the road?
- What are the other cars doing?
- Am I going to hit something?
- What does that sign say?
- What is the speed limit?
- Can I change lanes?
- Is that a policeman ahead?

Weather

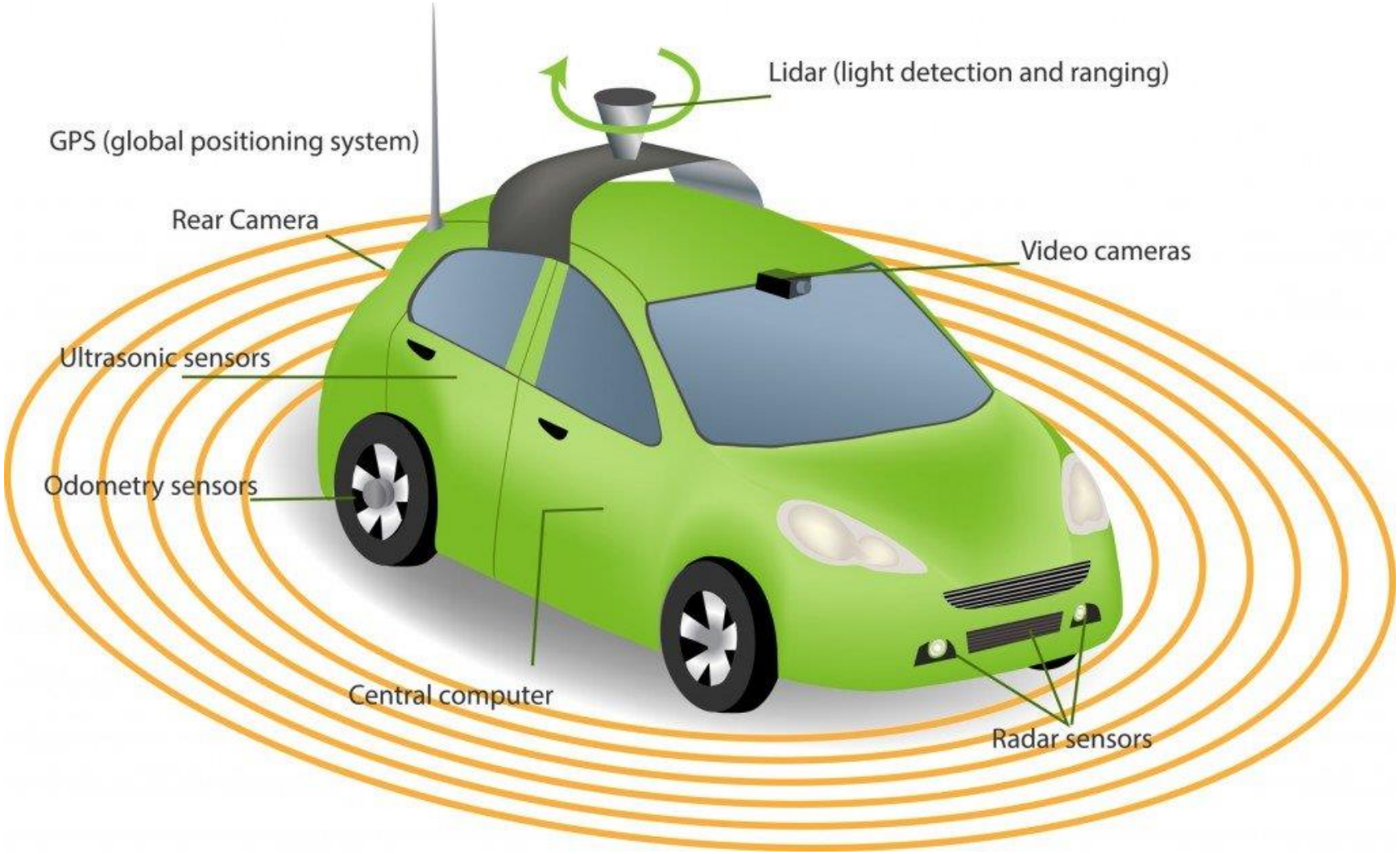
Solution

- Plan a route to the destination
- Generate a “model” of the surroundings
  - Requires multiple types of sensors
- Continuously monitor conditions
- Communicate with nearby cars
- Communicate with the transportation infrastructure
- Receive and process road information

VIDEO:

Priscilla Knox: A Ride in the Google Self-Driving Car

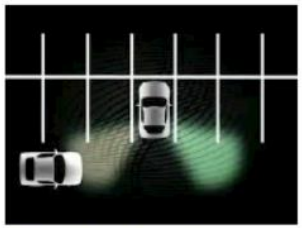
Car Sensors



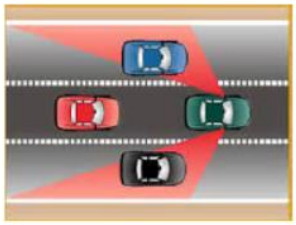
SOURCE: SCIENCE ABC

Car Sensors

Lane Keeping



Parking Assist



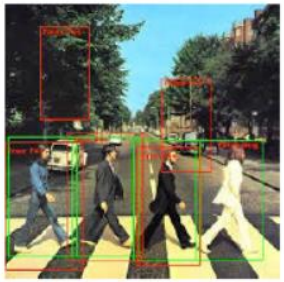
Blind Spot Detection

Adaptive Cruise Control
& Traffic Jam Assist

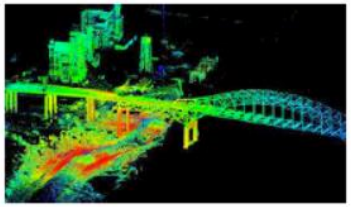
Front/Rear Collision Avoidance

Cross Traffic Alert &
Intersection Collision Avoidance

Autonomous Emergency Braking
& Emergency Steer Assist



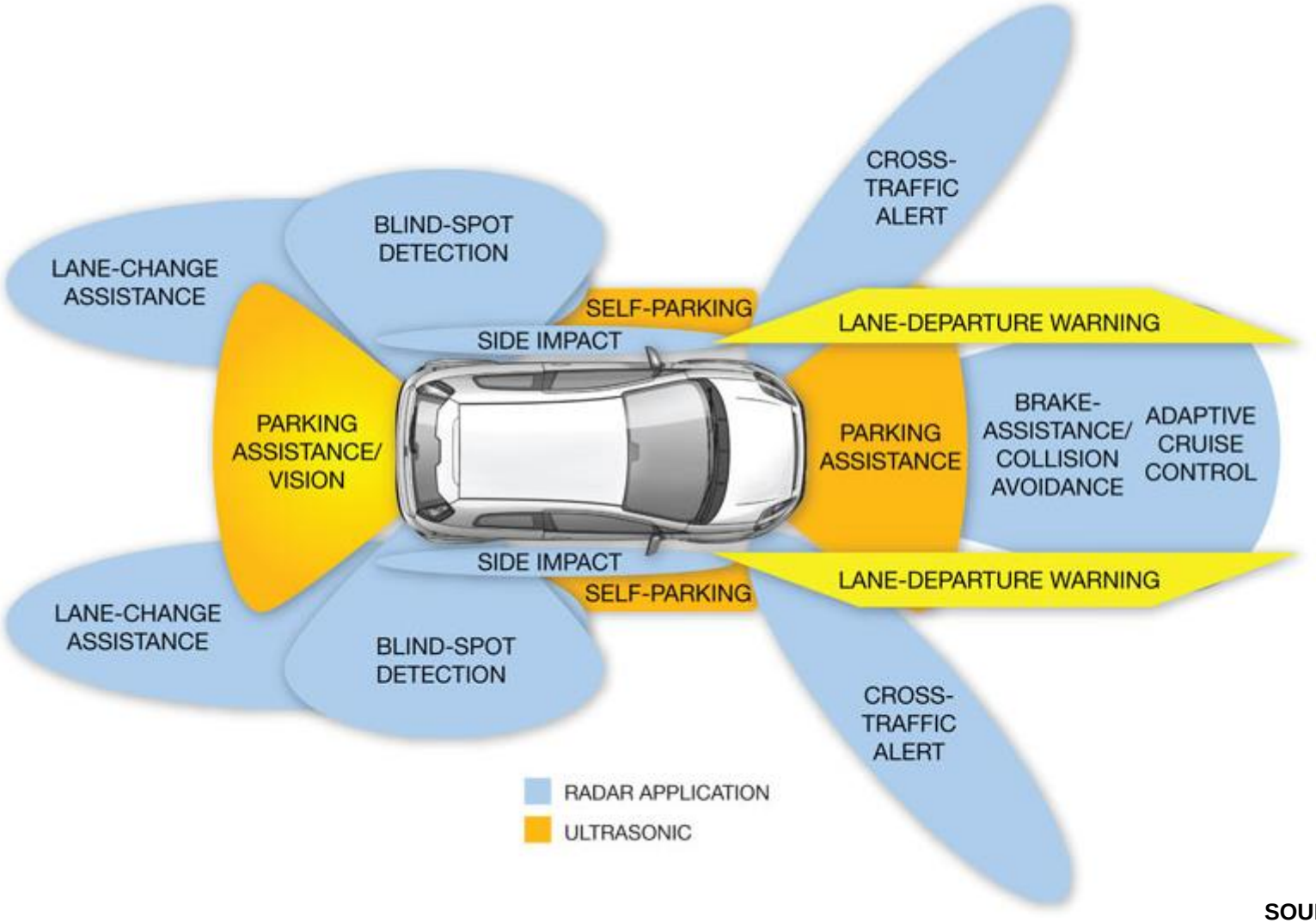
Object Detection,
Tracking, Classification



Scene Capture &
Accident Reconstruction

SOURCE: QUANENERGY SYSTEMS

Car Sensors

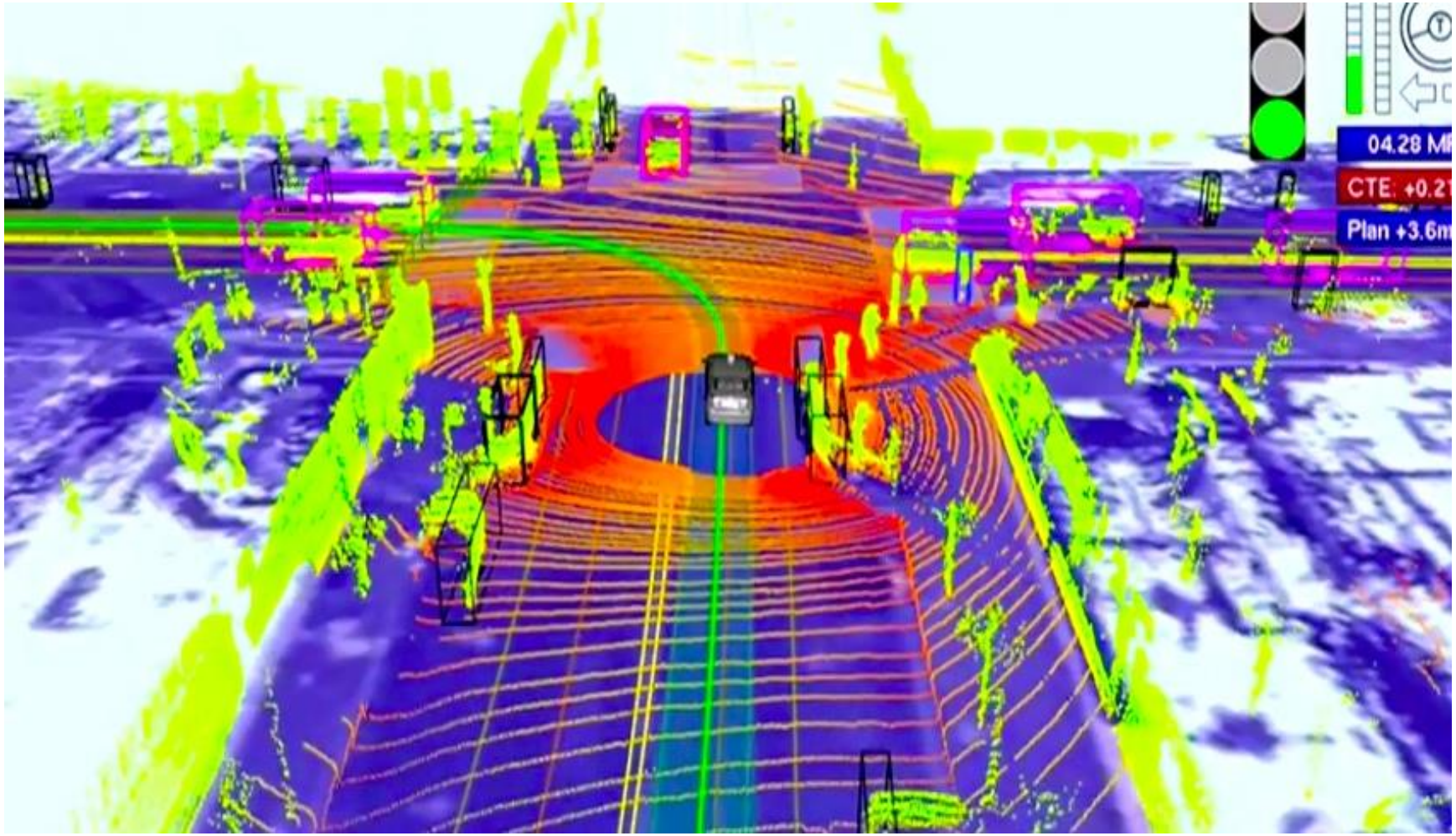


SOURCE: GOOGLE

VIDEO:

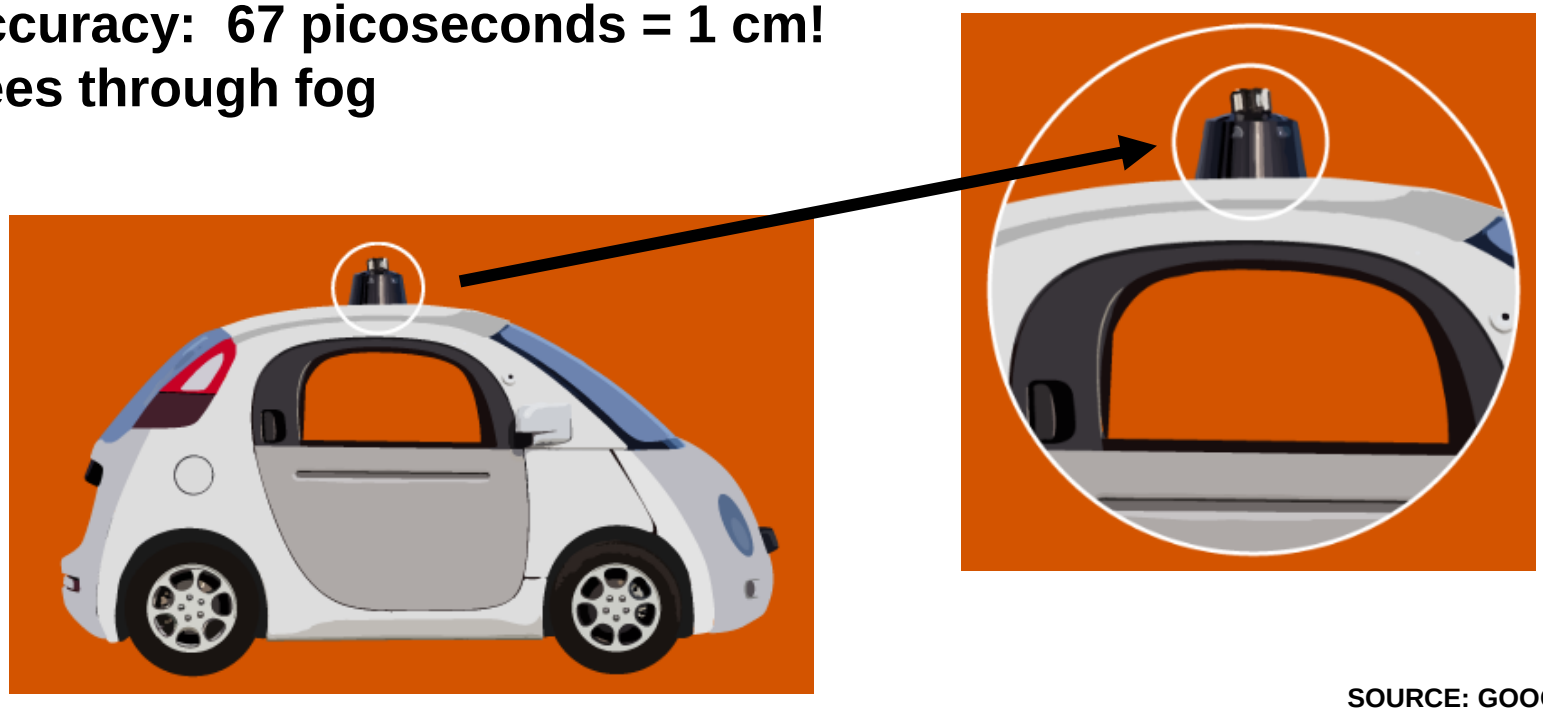
Chris Urmson:
TED Talk
How a Driverless Car Sees the Road

What the Car Sees



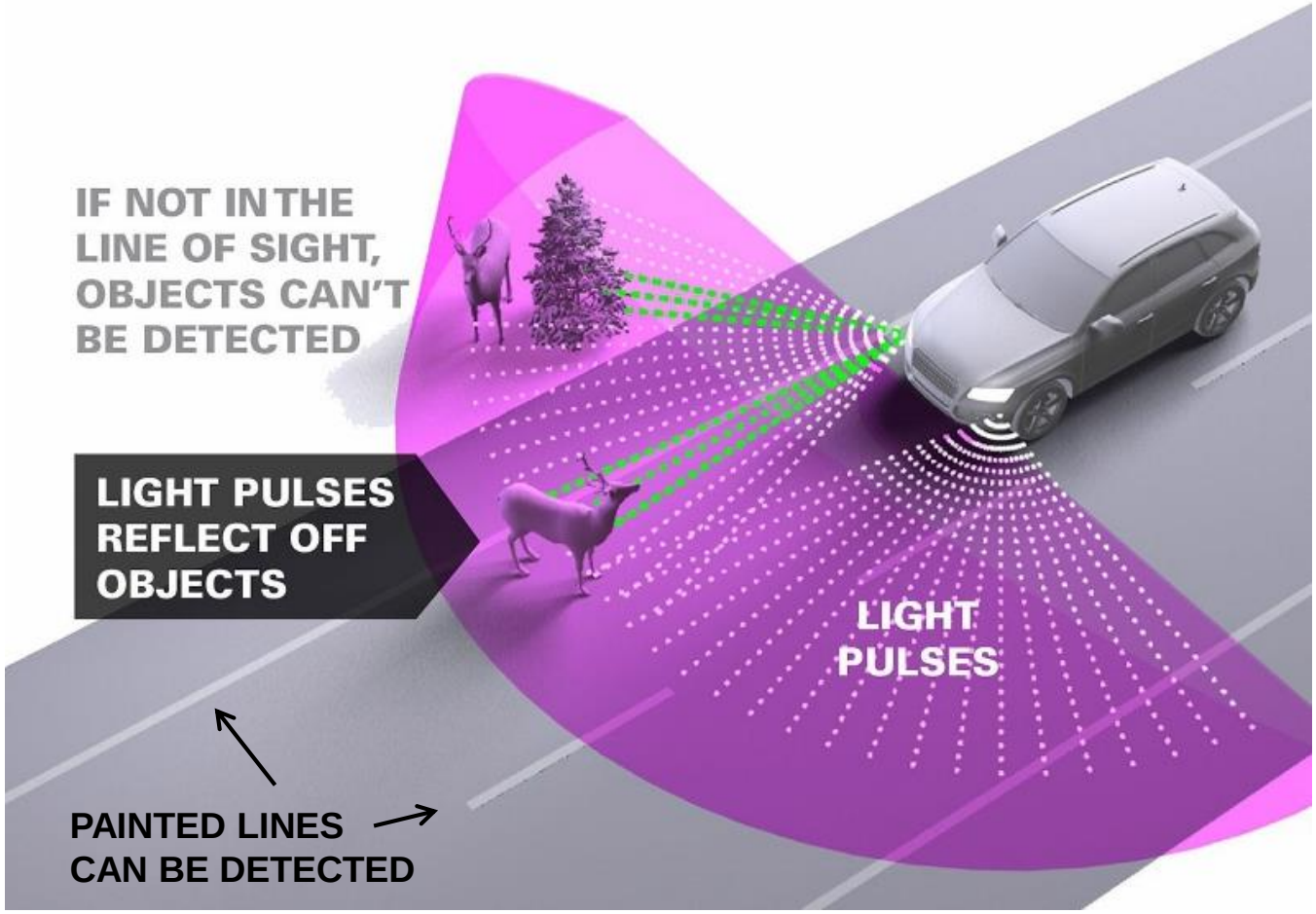
LIDAR

- **Calculates distance from the car based on speed of light**
- **64 infrared, harmless laser beams rotate at 900 rpm to generate a 3D image.**
- **150,000 pulses per second**
- **Range: 200 meters**
- **Accuracy: 67 picoseconds = 1 cm!**
- **Sees through fog**



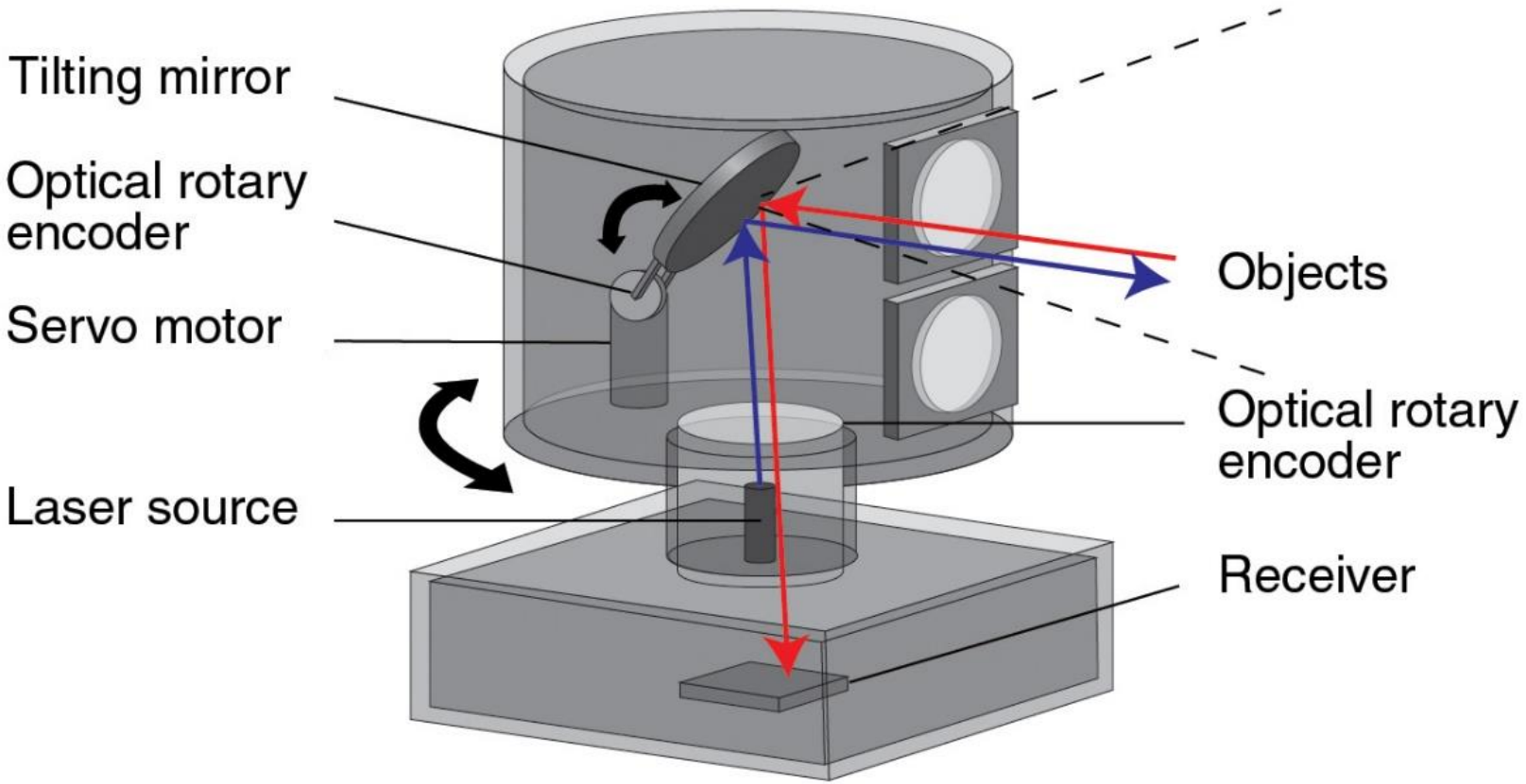
SOURCE: GOOGLE

Vision by LIDAR



SOURCE: DELPHI

LIDAR Rotating Mirror



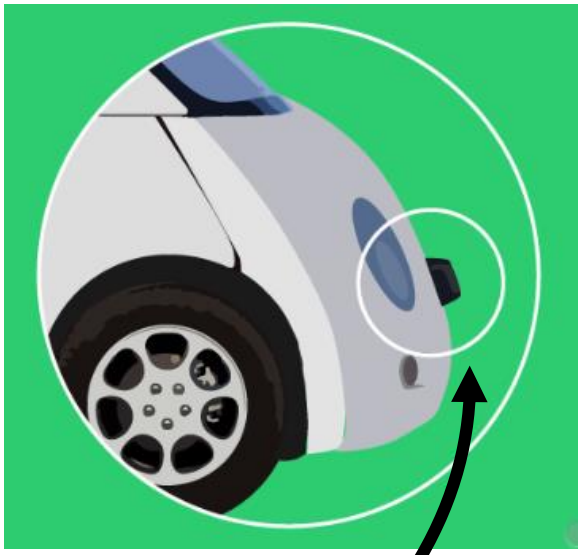
SOURCE: RENISHAW

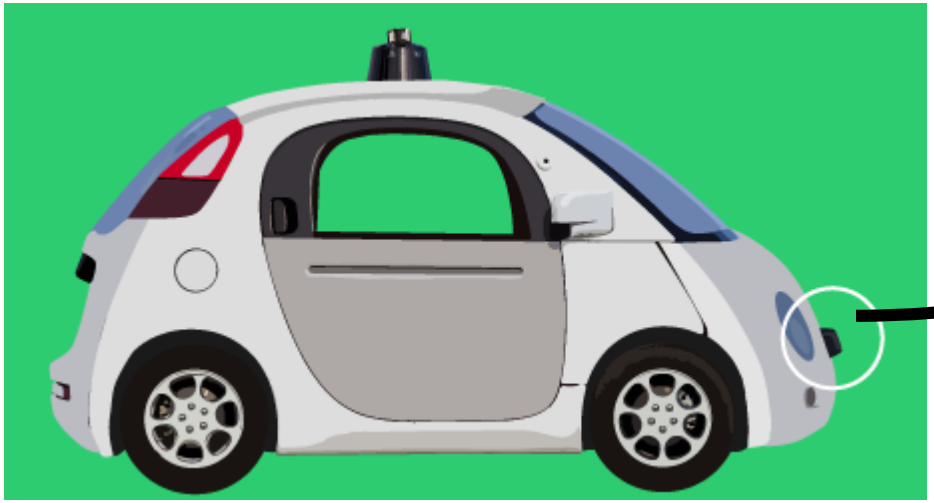
LIDAR Sensing Speed

SOURCE: DELPHI

Front Near-Vision Camera

- See pedestrians & other vehicles
- Detects and records information about road signs and traffic lights
- Differentiates people, bicycles & cars
- Interprets gestures, e.g., hand signals





SOURCE: GOOGLE

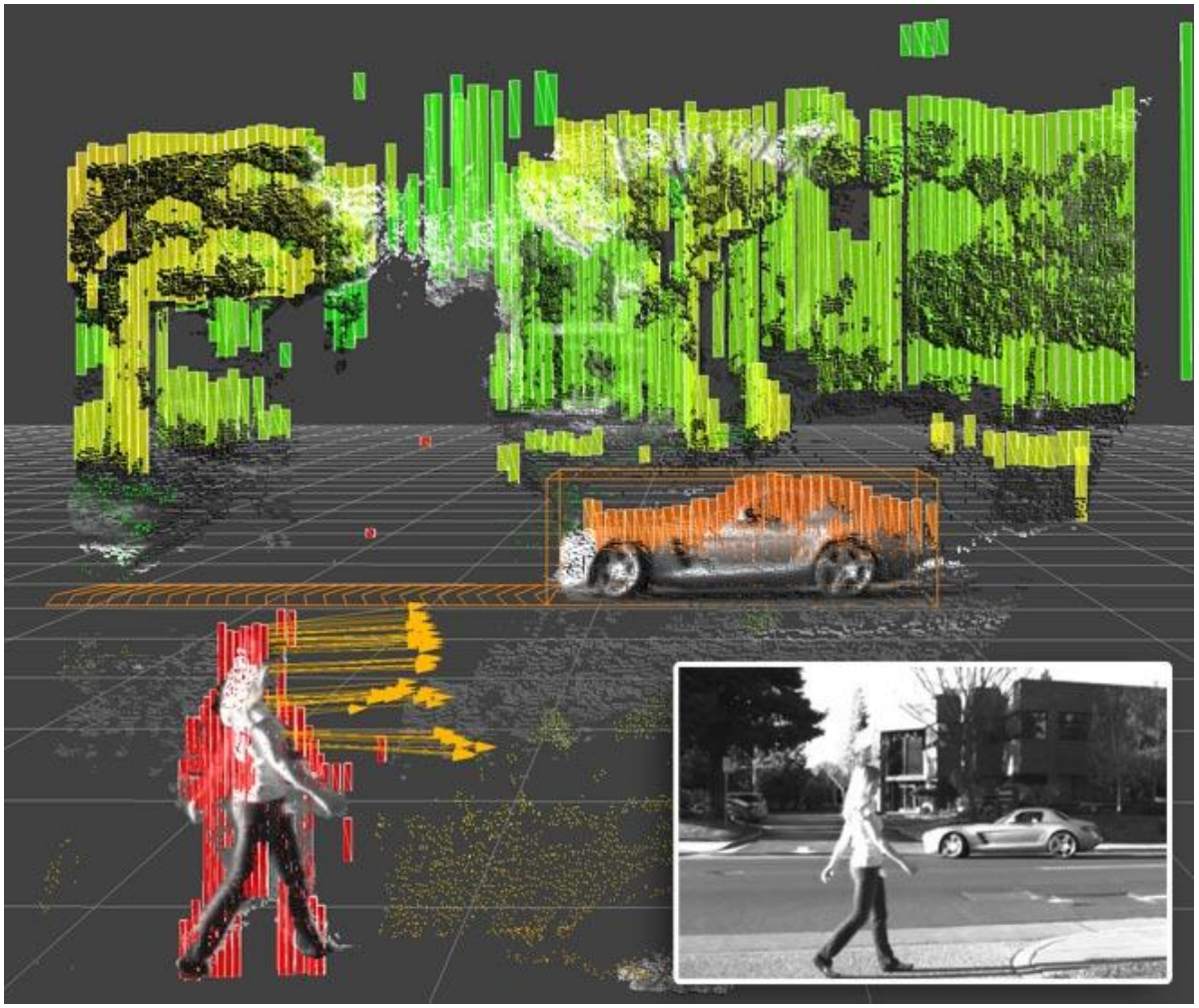
Optical Cameras

- **Mono or stereo-vision**
- **Watch nearby vehicles, lane markings, speed signs, high-beam lights etc.**
- **Warn the driver when the car is in danger of a collision with a pedestrian or an advancing vehicle.**

- **Advanced camera systems predict object trajectories.**

What the Car Sees

IDENTIFY STATIONARY OBJECTS



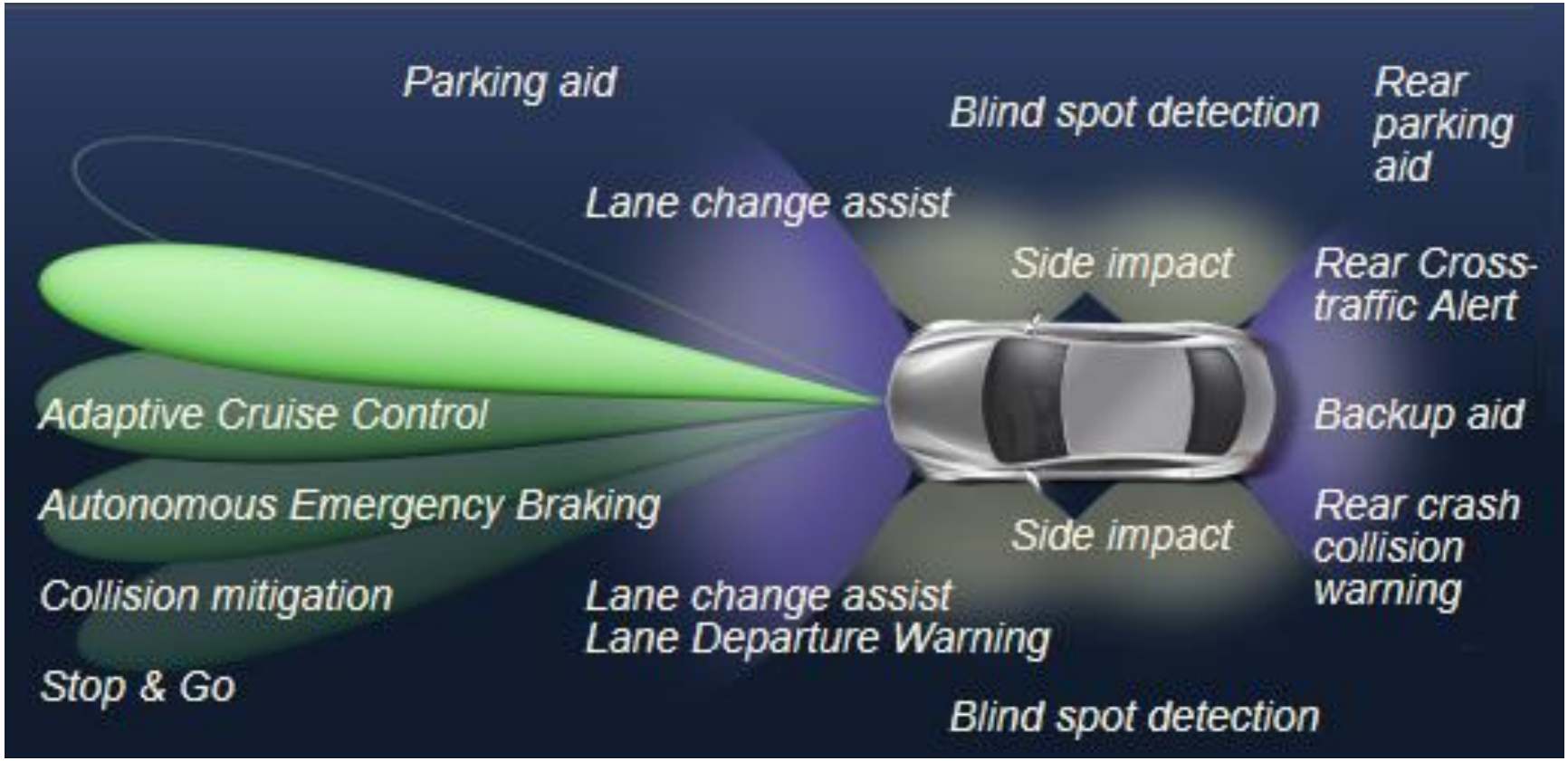
IDENTIFY VEHICLES, THEIR DIRECTION AND SPEED

IDENTIFY PEDESTRIANS, THEIR DIRECTION AND SPEED

SOURCE: MERCEDES

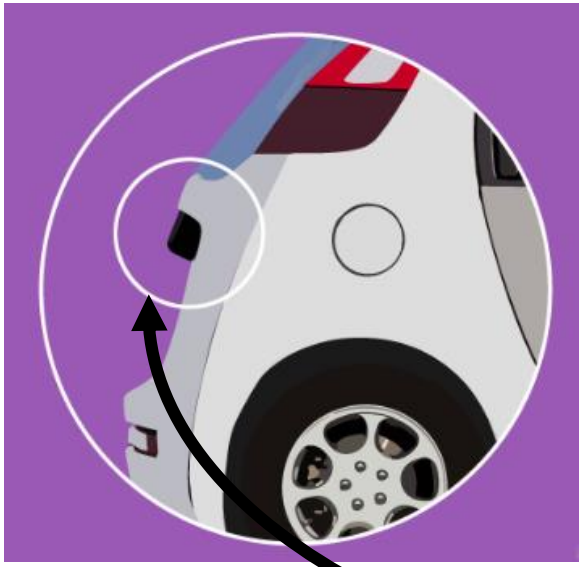
Radar

- **Works in all weather conditions**
- **Handles many functions:**

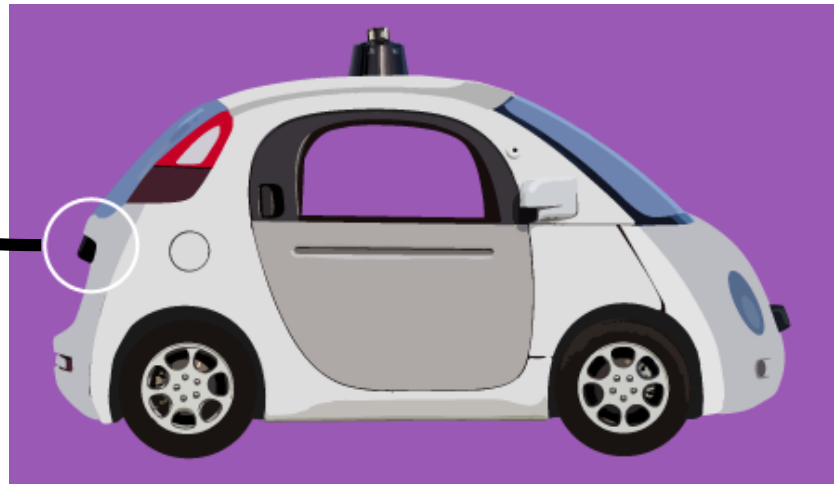


SOURCE: RADARTUTORIAL.EU

GPS Positioning



- **GPS estimates may be off by several metres.**
- **GPS data is compared with sensor map data previously collected from the same location to update the vehicle's internal map with new positional data.**

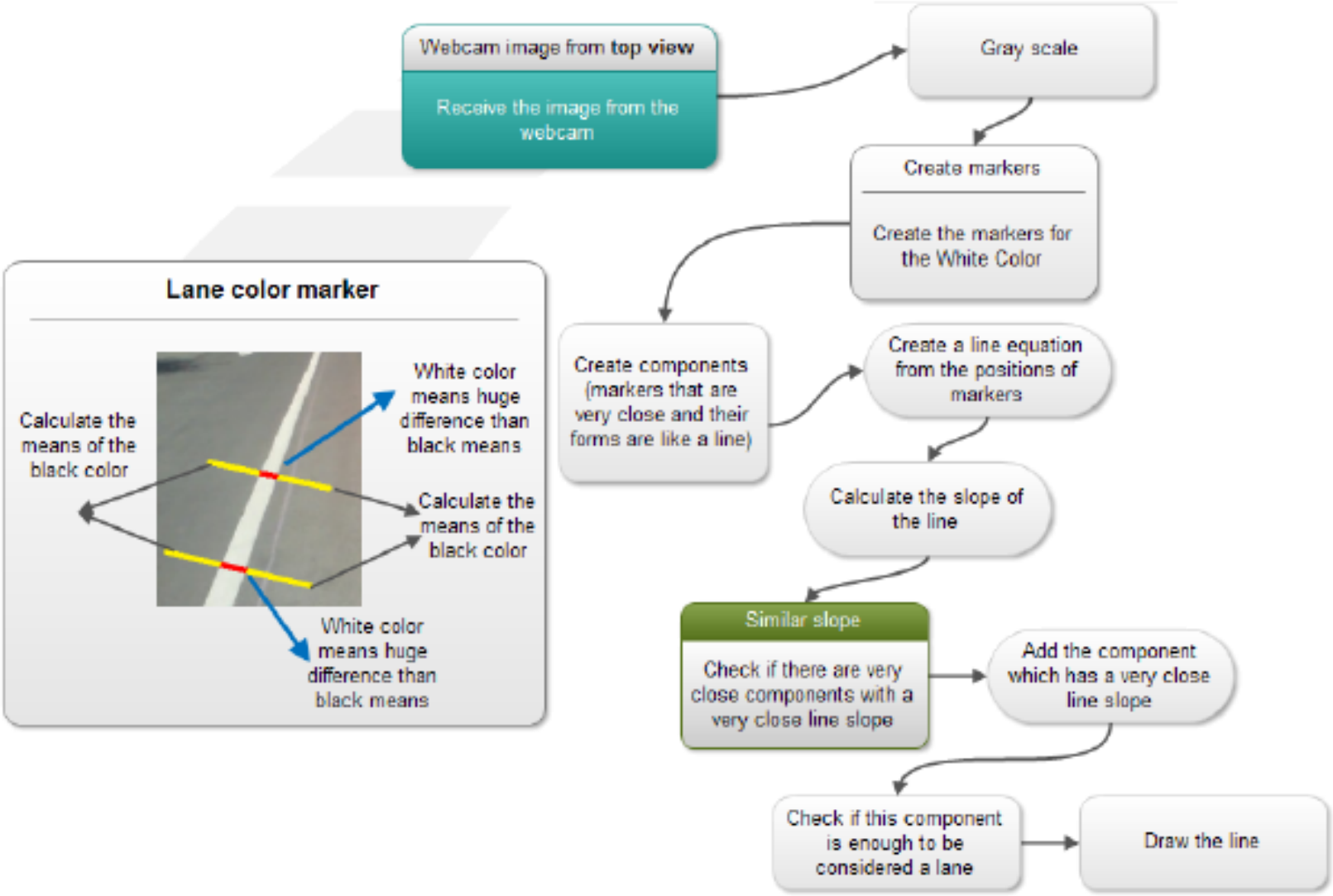


SOURCE: GOOGLE

Man v. Machine Accuracy

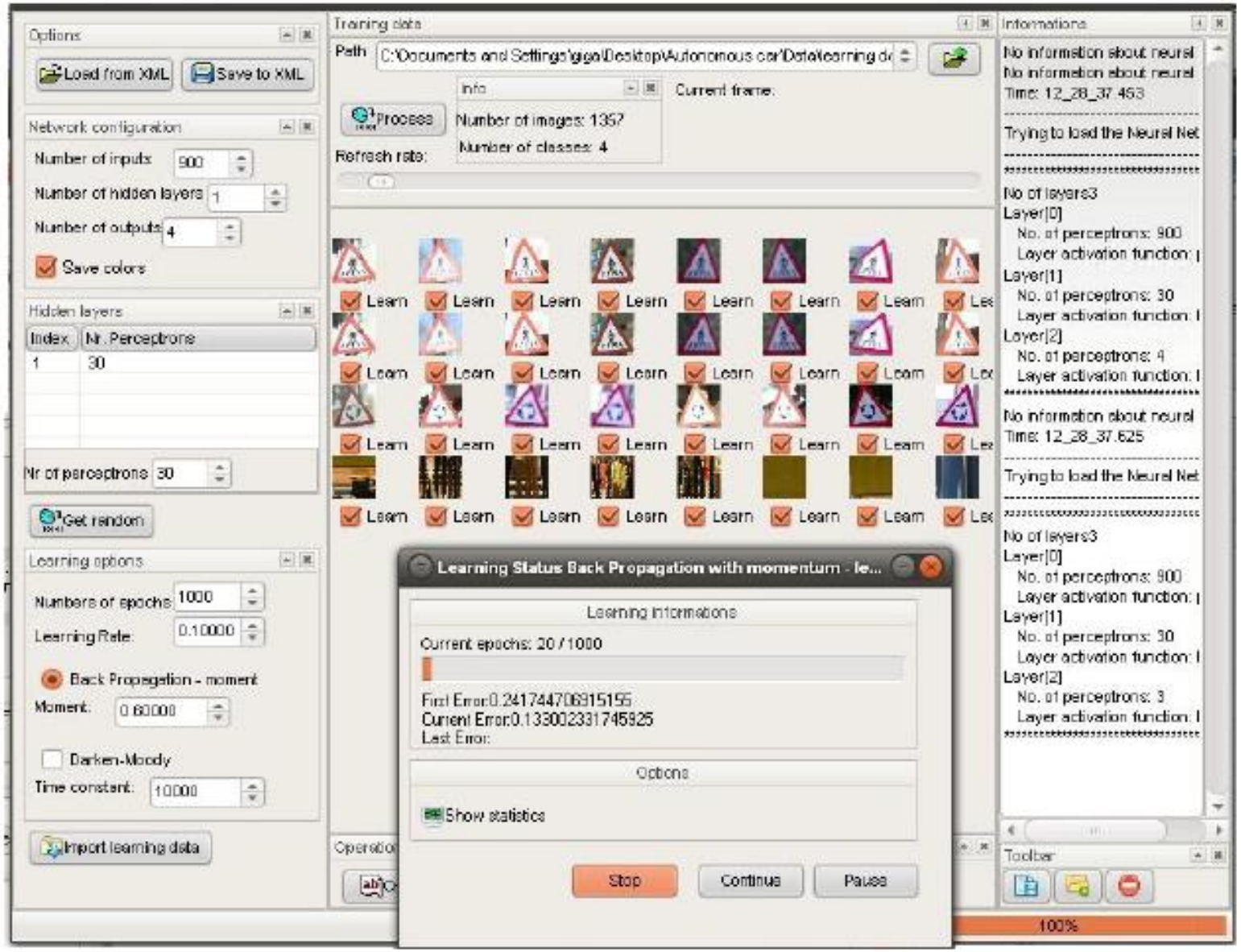
- GPS coordinate accuracy 5-10 meters – insufficient for driving
- Much more detail is needed, obtained from satellites and street scanning. Illegal in PRC.
- Facial recognition
  - Human error: 0.8 percent
  - Machine error: 0.23 percent
- Visibility
  - Human: 50 meters
  - Machine: 200 meters

Recognizing Lanes



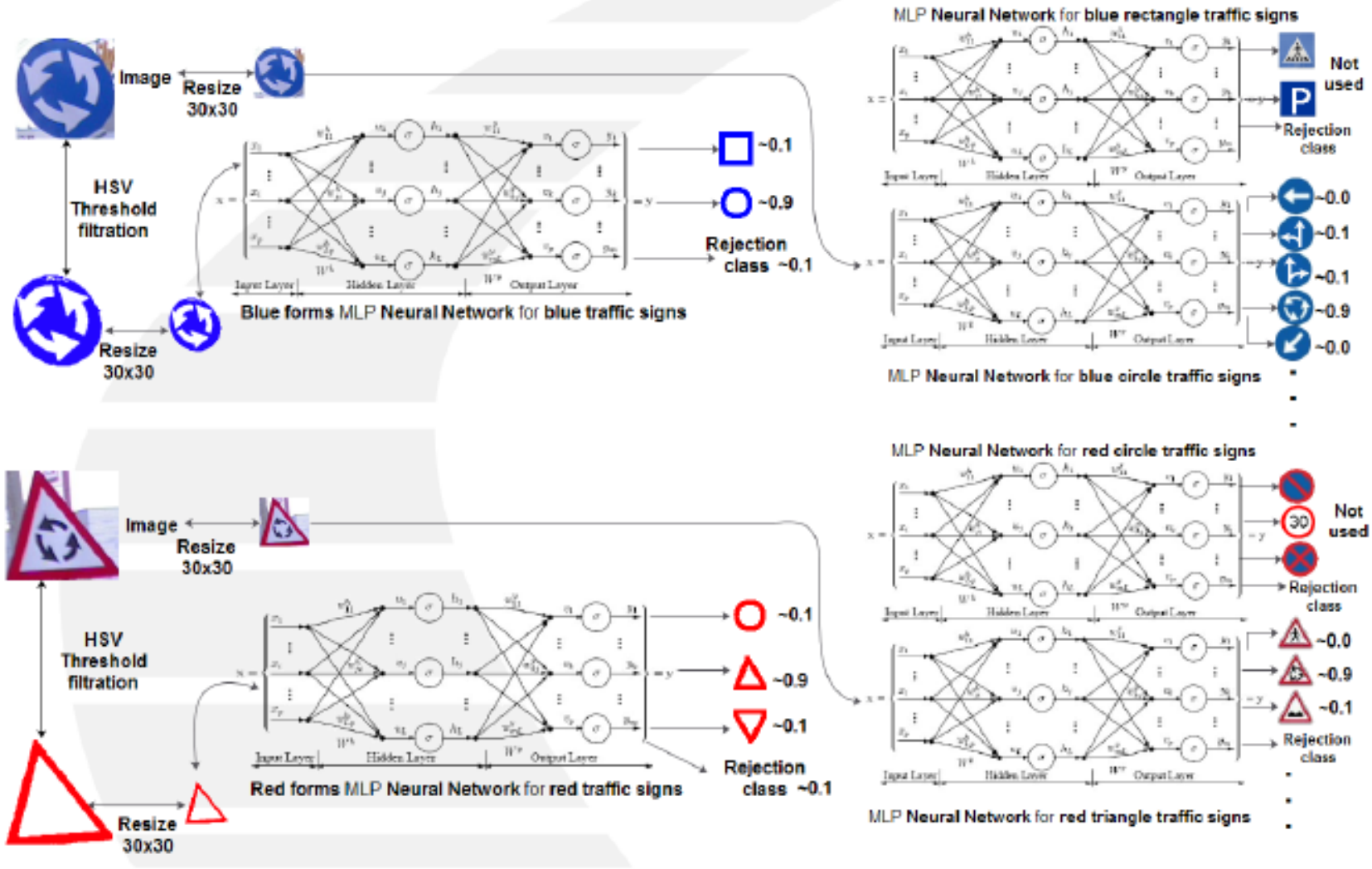
SOURCE: BUDISTEANU.NET

Learning to Read Signs



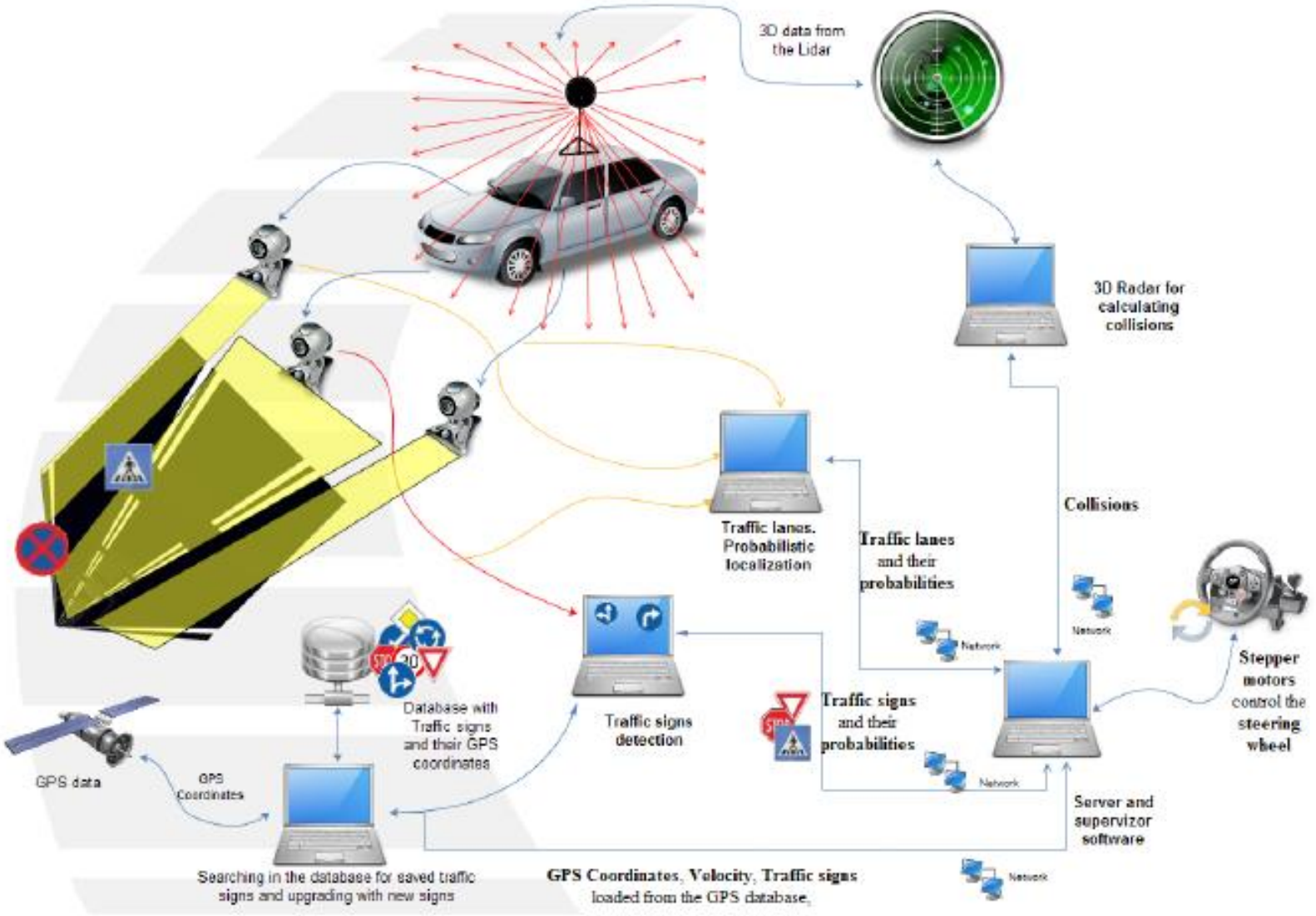
SOURCE: BUDISTEANU.NET

Reading Signs by Neural Networks



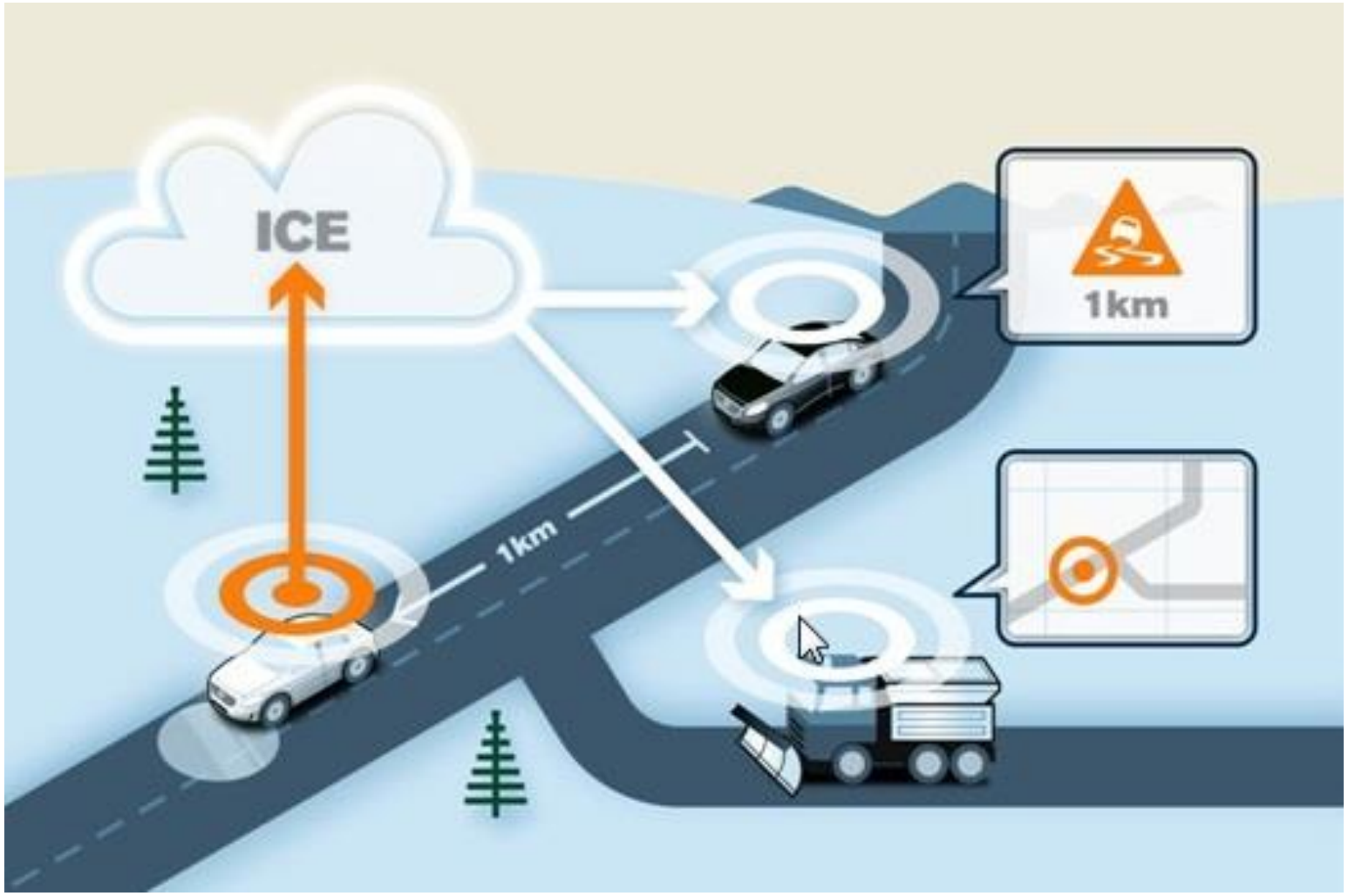
SOURCE: BUDISTEANU.NET

How Does the Car Respond?



SOURCE: BUDISTEANU.NET

V2V Communications

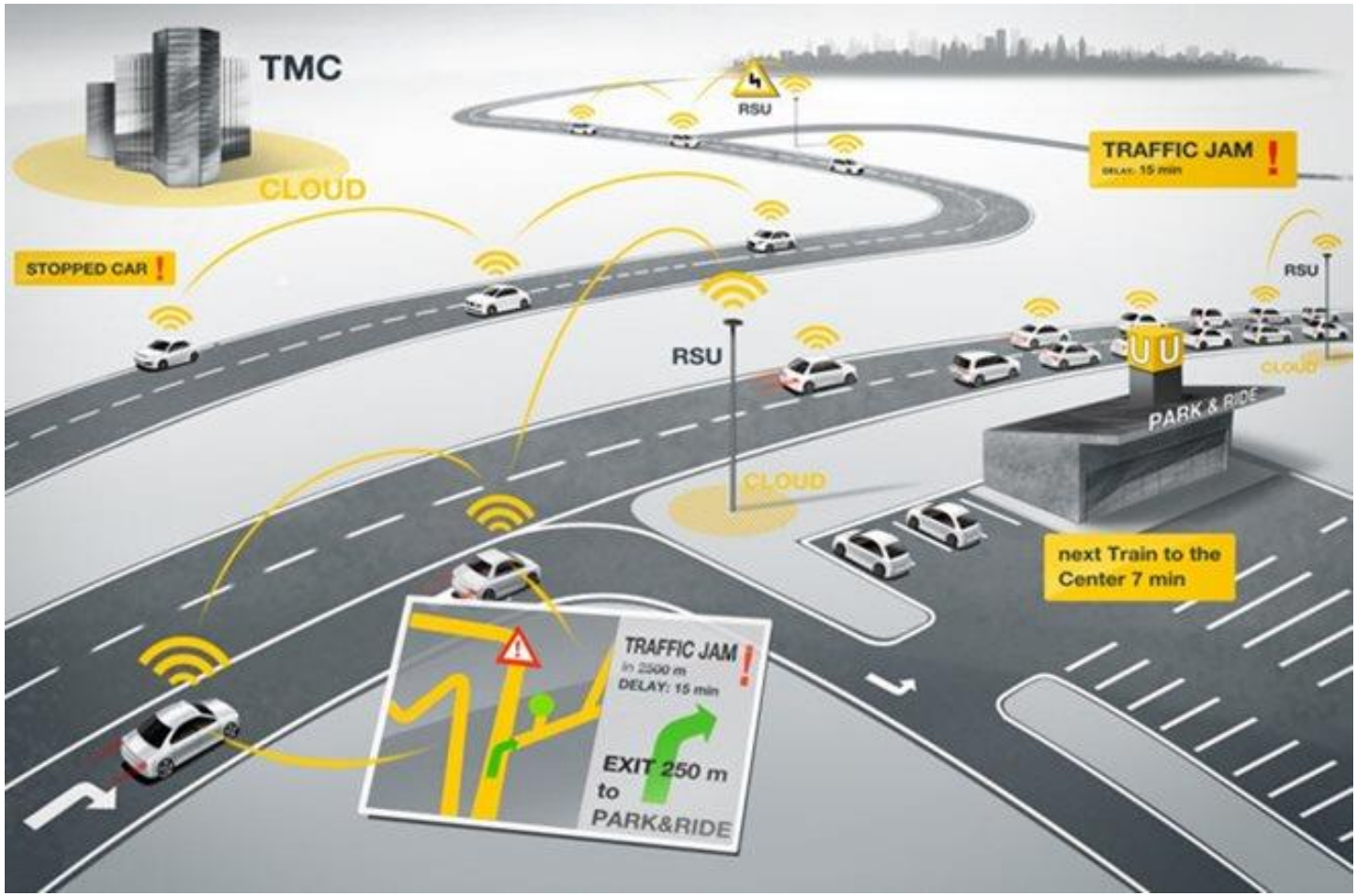


SOURCE: TELEMATICS NEWS

Vehicle-to-Vehicle Cloud

SOURCE: 33RD SQUARE

V2V, V2I, I2I Communications



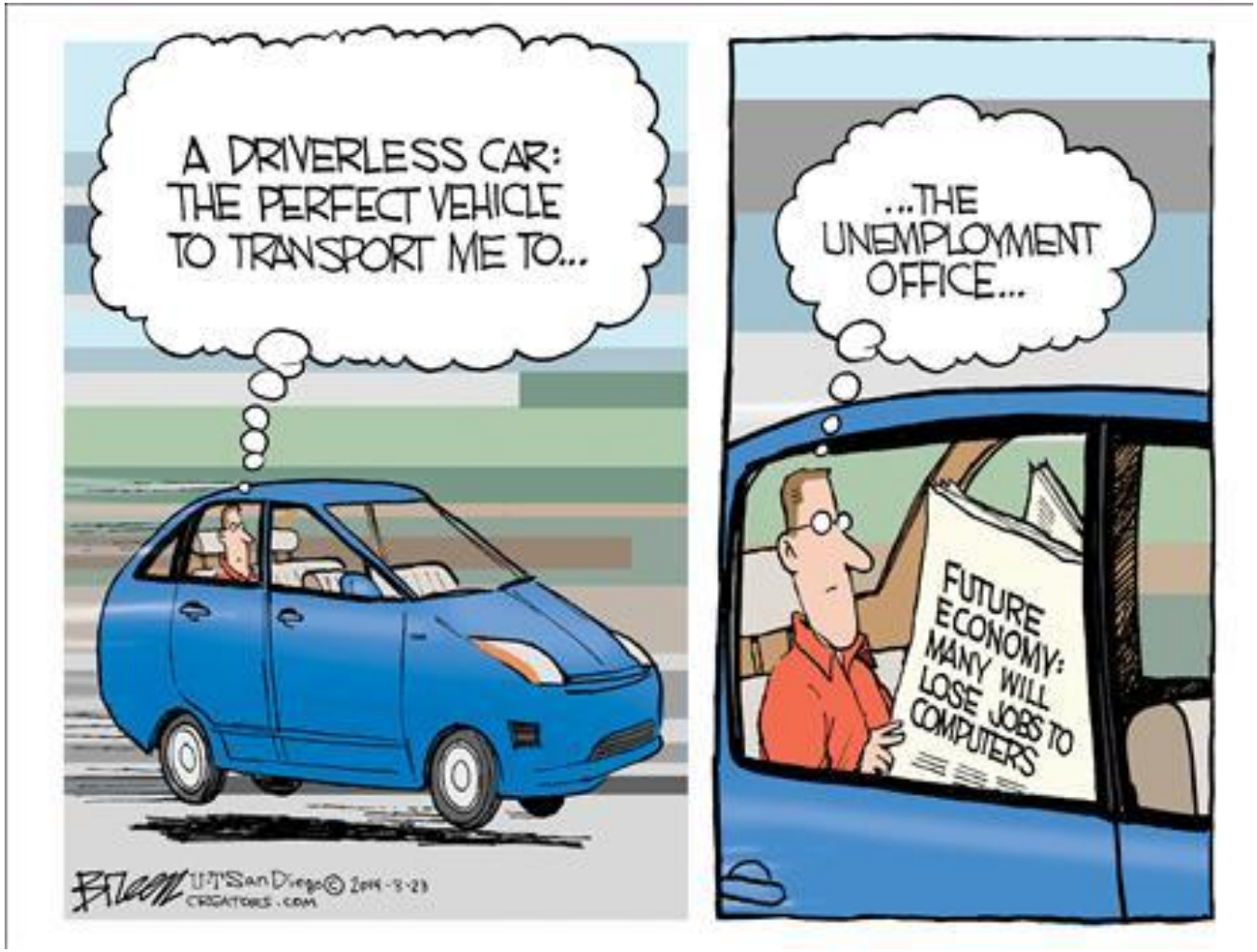
RSU = ROADSIDE UNIT **TMC = TRAFFIC MESSAGE CHANNEL**

SOURCE: KAPSCH.NET

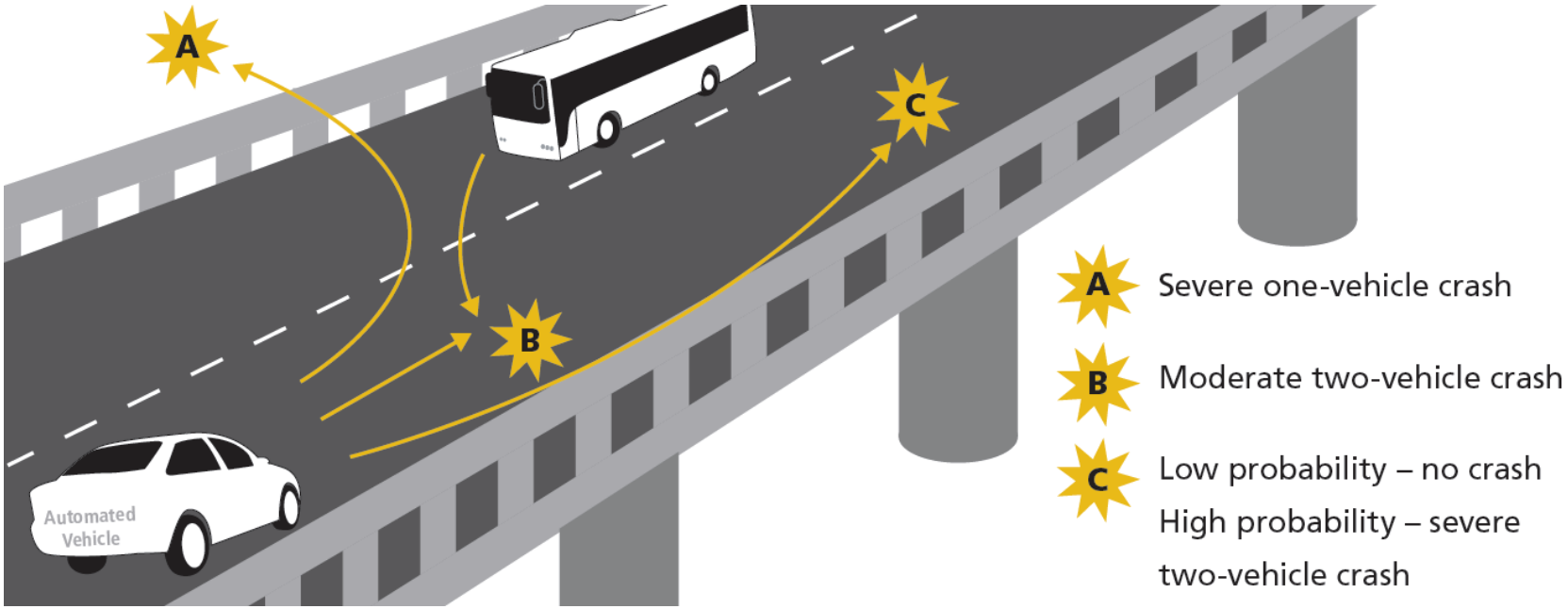
Driverless Benefits

SOURCE: HCLTECH.COM

Effect of Driverless Cars



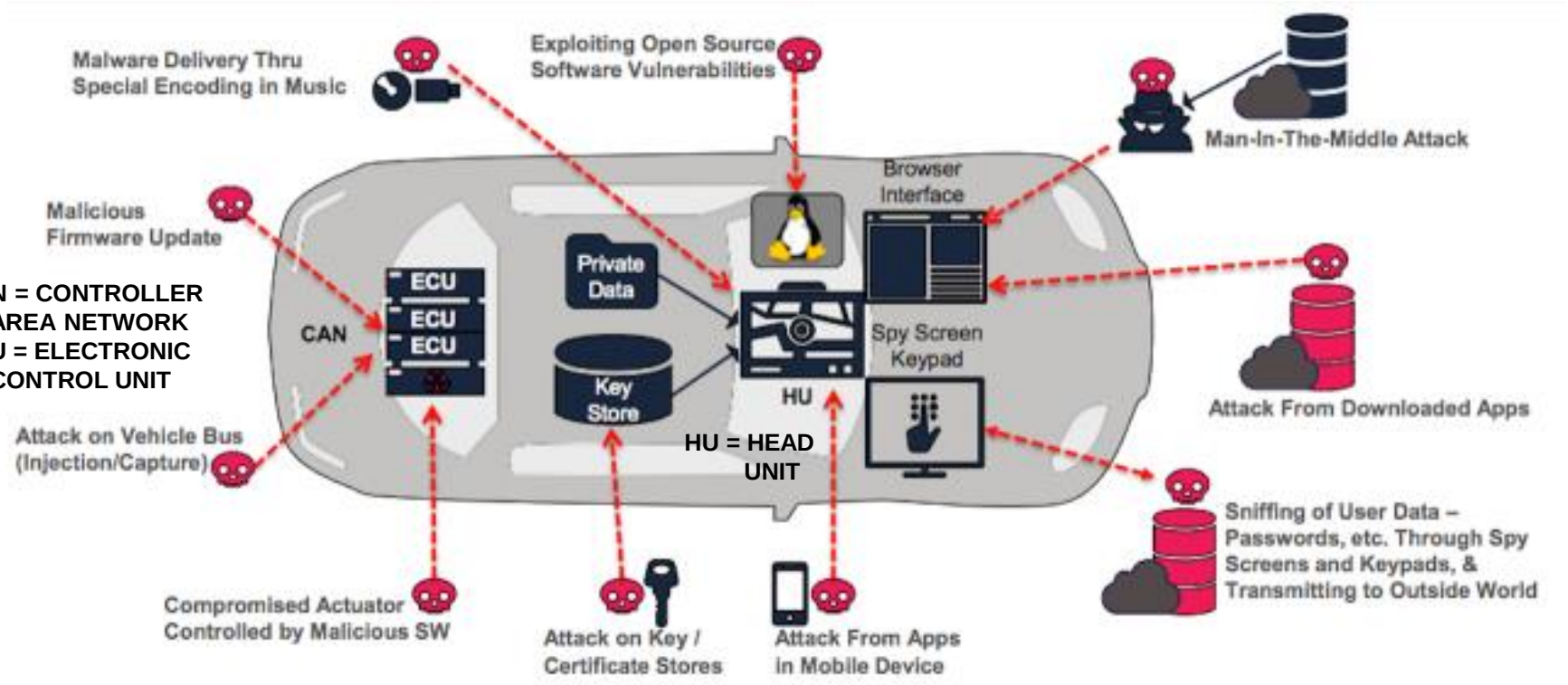
Ethical Issues



What should the car do?
What should the bus do?
Should they negotiate?
Suppose it's a school bus?

SOURCE: NOAH GOODALL

Vehicle Hacking Potential



Also: jamming radar, spoofing V2I and V2V, blinding LIDAR with IR

SOURCE: HARMAN

South China Morning Post
ECONOMY

03 October, 2016,

Hong Kong not ready for trial of driverless cars, government says, as Singapore aims for fully autonomous taxi fleet by 2018

Experts claim driverless taxis could replace cabbies in less than a decade, but government says hardware and software advancements likely needed first

Driverless technology is not yet developed enough to justify the government facilitating a trial in Hong Kong, the Transport and Housing Bureau has told the *Post*.

The bureau said it was aware of the use of driverless cabs in other places and would continue to keep a close eye on such technology, but was not yet ready to implement any trial in Hong Kong.

"As far as Hong Kong is concerned, the government keeps an open mind and will facilitate the trial and development of such technology subject to safety and legal considerations, which has to be assessed on a case-by-case basis," a bureau spokeswoman said.