

DRIVERLESS DEVELOPMENT

CONSTRAINING THE CONVERSATION: TERMINOLOGY AND INTRODUCTION TO TECH

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NAIOP Northern Virginia: Autonomous Vehicles
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TERMINOLOGY

Automated Vehicles

At least some aspect of a safety-critical control function occurs without direct driver input

Autonomous Vehicles

CLOSED-LOOP SYSTEMS! No requirement for driver input OR connectivity

All Autonomous vehicles feature automation; not all Automated vehicles are Autonomous

FUTUREPROOFING CONCEPTS:

**AUTONOMY VS.
AUTOMATION**

Safety-critical Functions Steering, Braking, Accelerating



*Many vehicles on the market today already include some level of automation
 [(C)ACC, Lane Keep, Park Assist]*



BMW



Mercedes-Benz



Nissan



Google



General Motors

Vehicles

5 Series
(modified)

S 500 Intelligent
driver research
vehicle

Leaf EV
(modified)

Prius and
Lexus
(modified)

Cadillac SRX
(modified)

KEY
Technologies

- Video camera tracks lane markings and reads road signs.
- Read sensors detect objects ahead.
- Side laser scanners.
- Ultrasonic sensors.
- Differential GPS.
- Very accurate map.

- Stereo camera sees objects ahead in 3-D
- Additional cameras reads road signs and traffic lights.
- Short and long range radar.
- Infrared camera,
- Ultrasonic sensors.

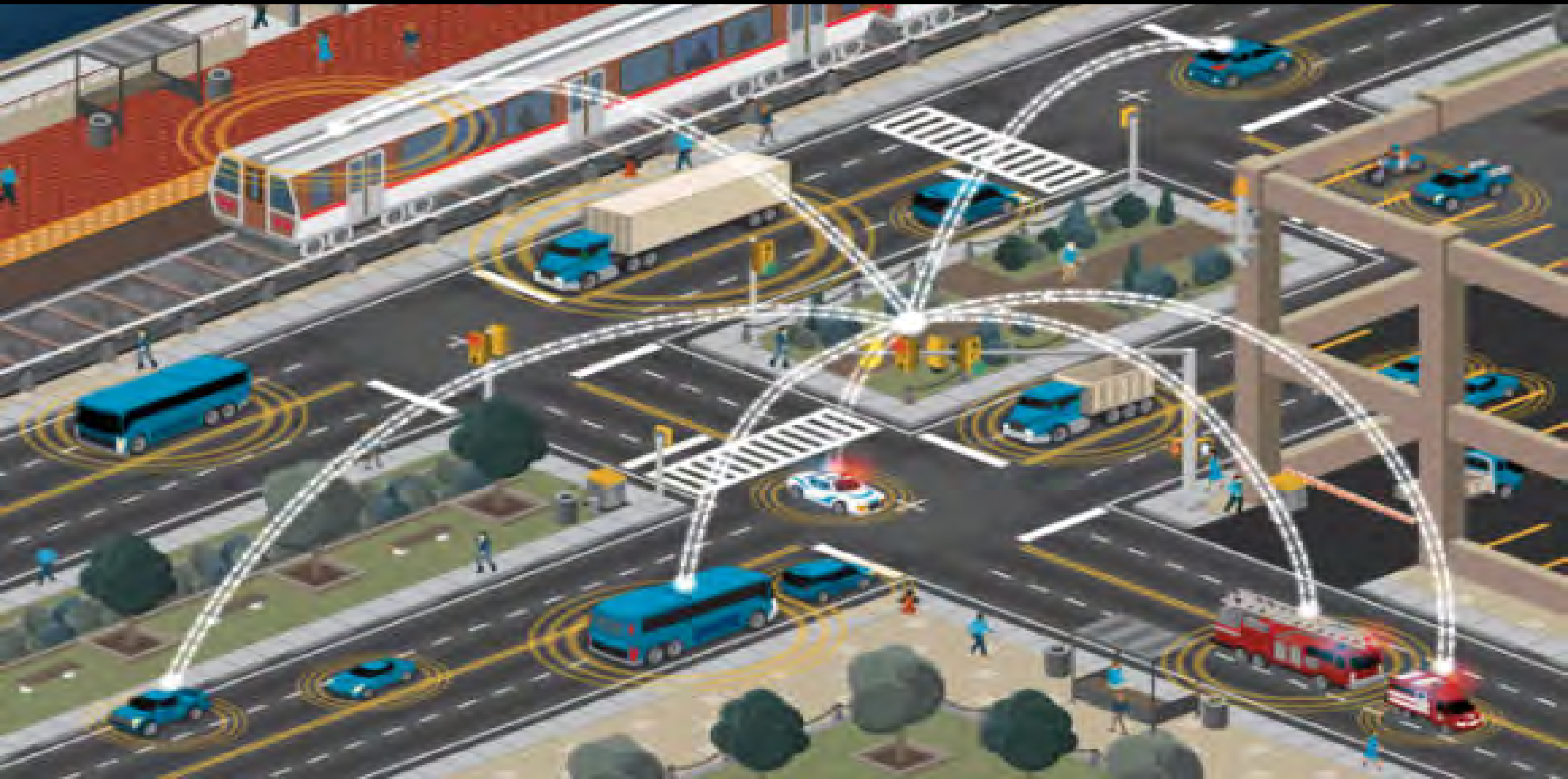
- Front and side radar.
- Camera
- Front, side and rear laser sensor,
- Fore wide angle cameras shows the driver the car's surroundings

- LIDAR on the roof detects objects around the car in 3-D
- Camera helps detect objects.
- Front and side radar.
- Inertial measuring unit tracks position,
- Wheel encoder tracks movement.
- Very accurate map.

- Several laser sensors.
- Radar
- Differential GPS
- Cameras
- Very accurate map.

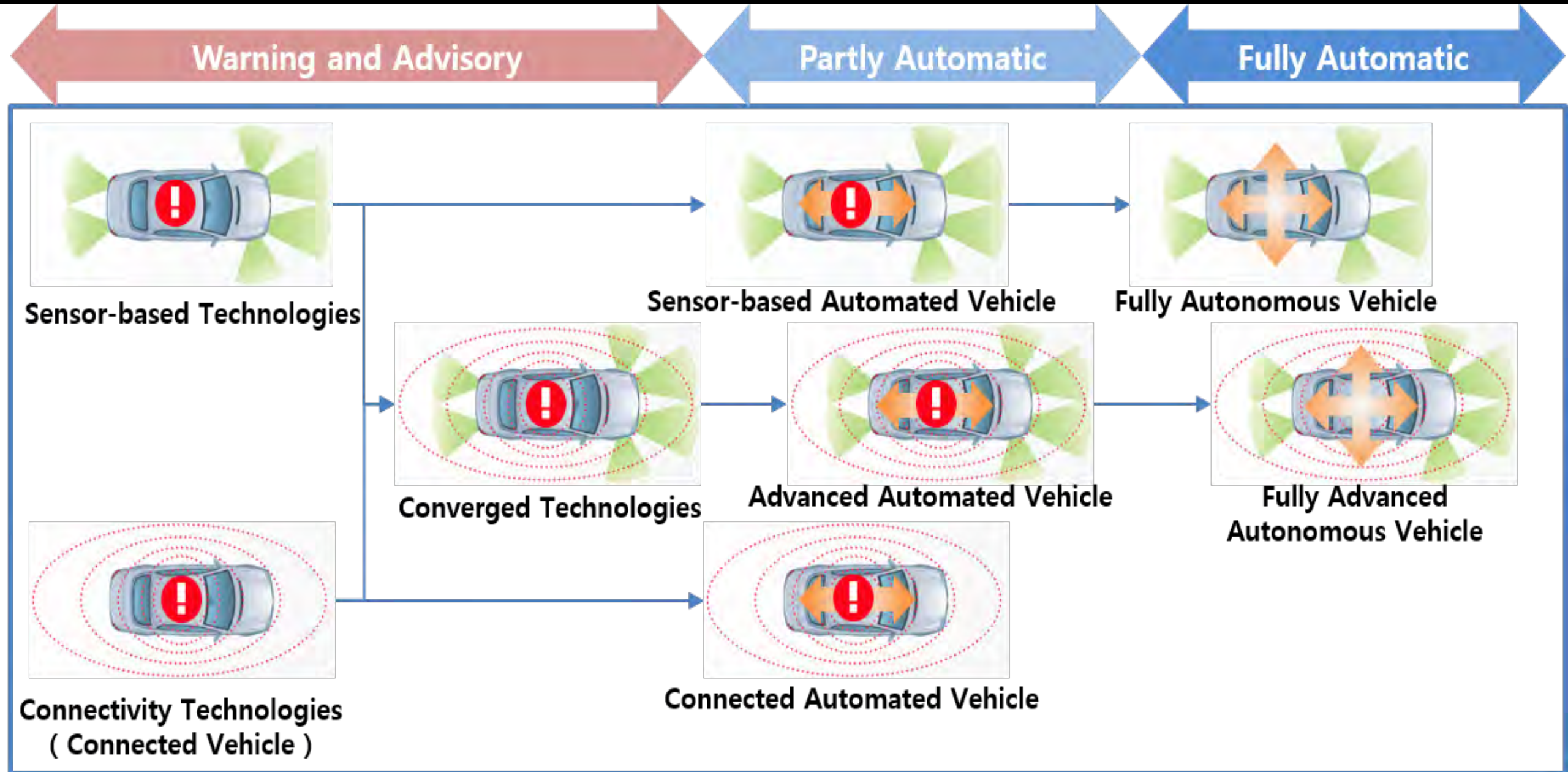
Connected Vehicles

Wireless technology to communicate among road users and roadside infrastructure



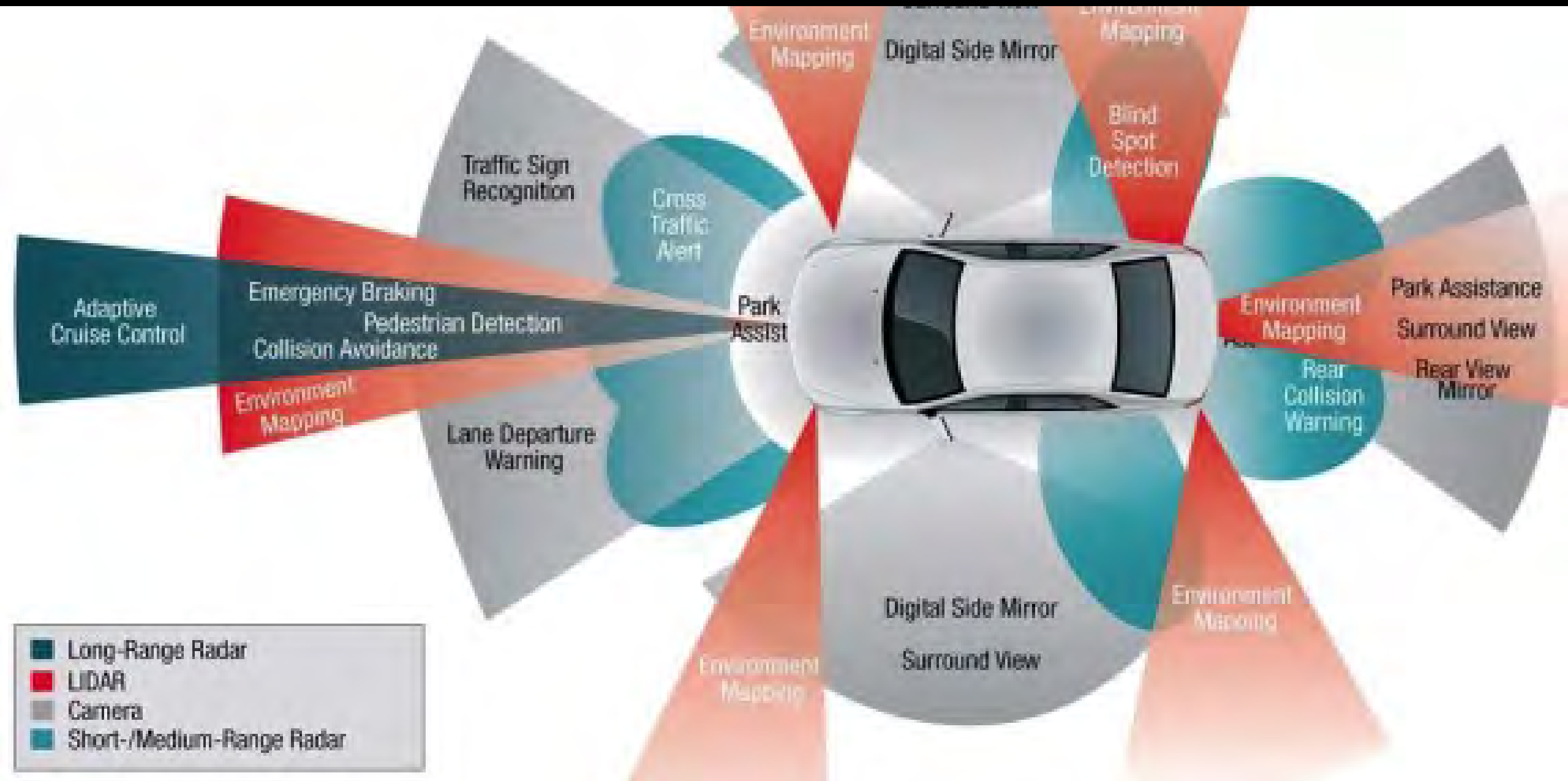
Connected Automated Vehicles

Leverage automated and connected vehicle capabilities to realize all potential benefits



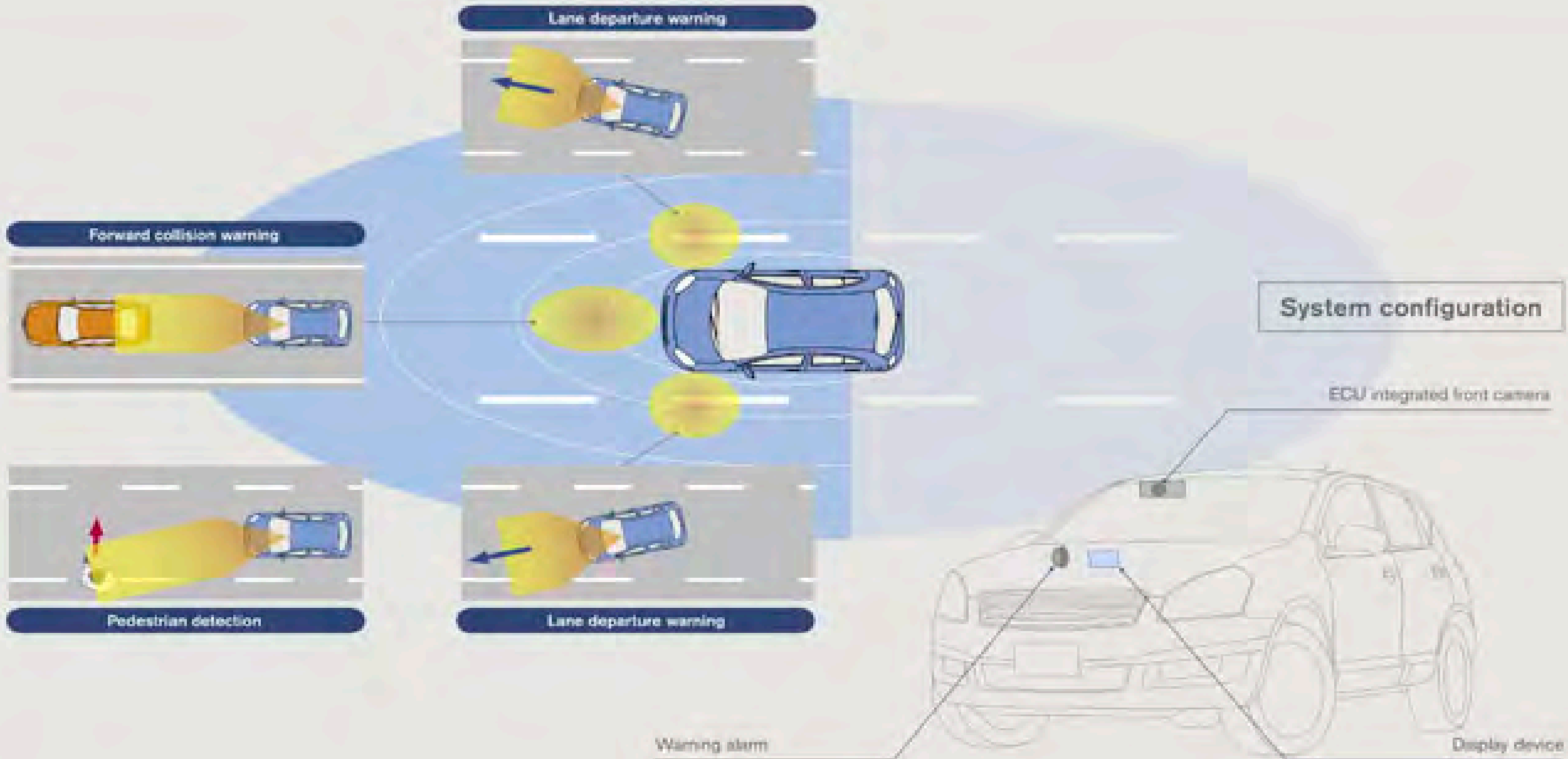
Driver Assistance Systems

Aid the driver in the driving process



Driver Support Systems

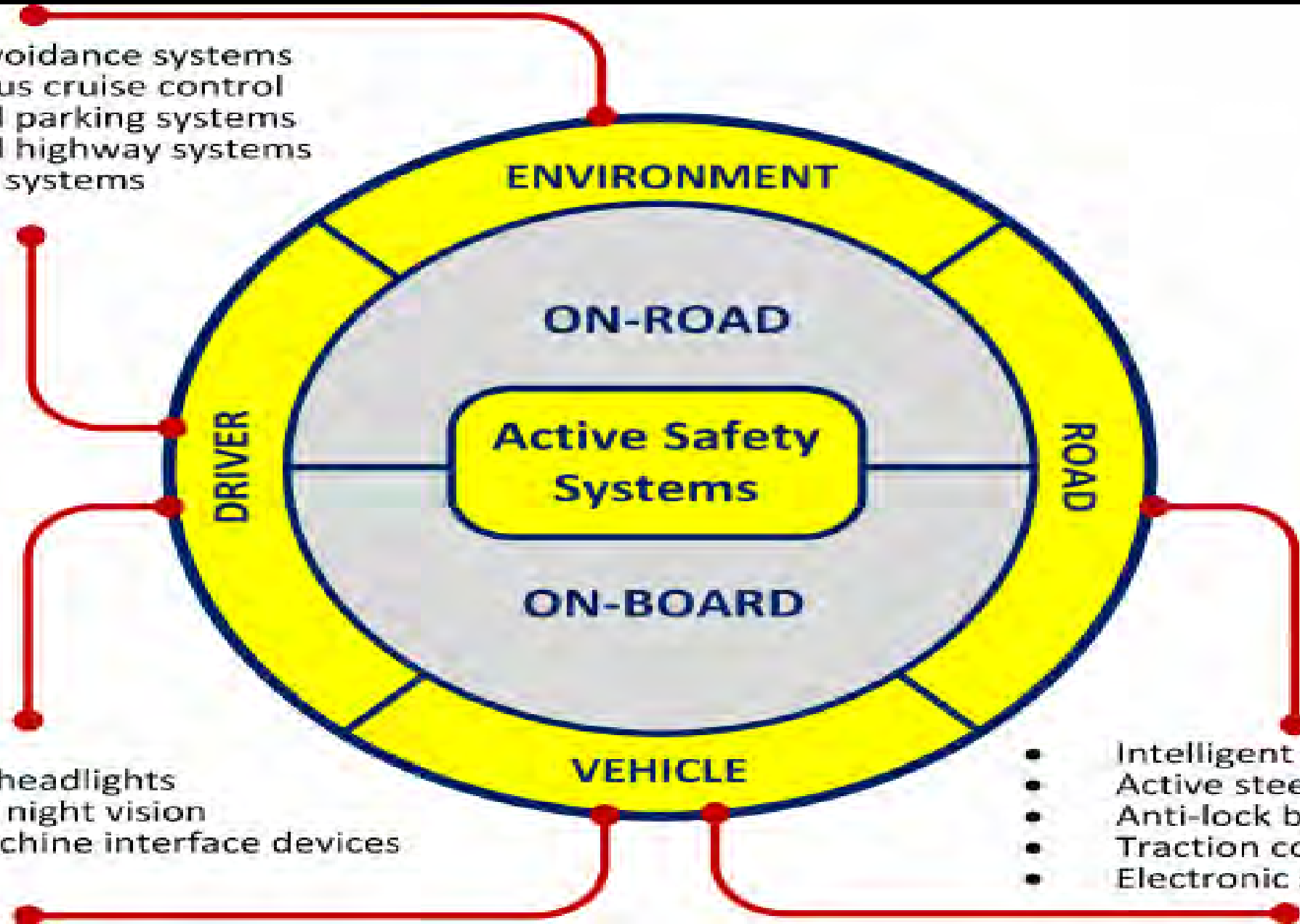
Warn the driver of particular situations



Active Safety Systems

Aim to prevent collisions from ever occurring

- Collision avoidance systems
- Autonomous cruise control
- Automated parking systems
- Automated highway systems
- Navigation systems



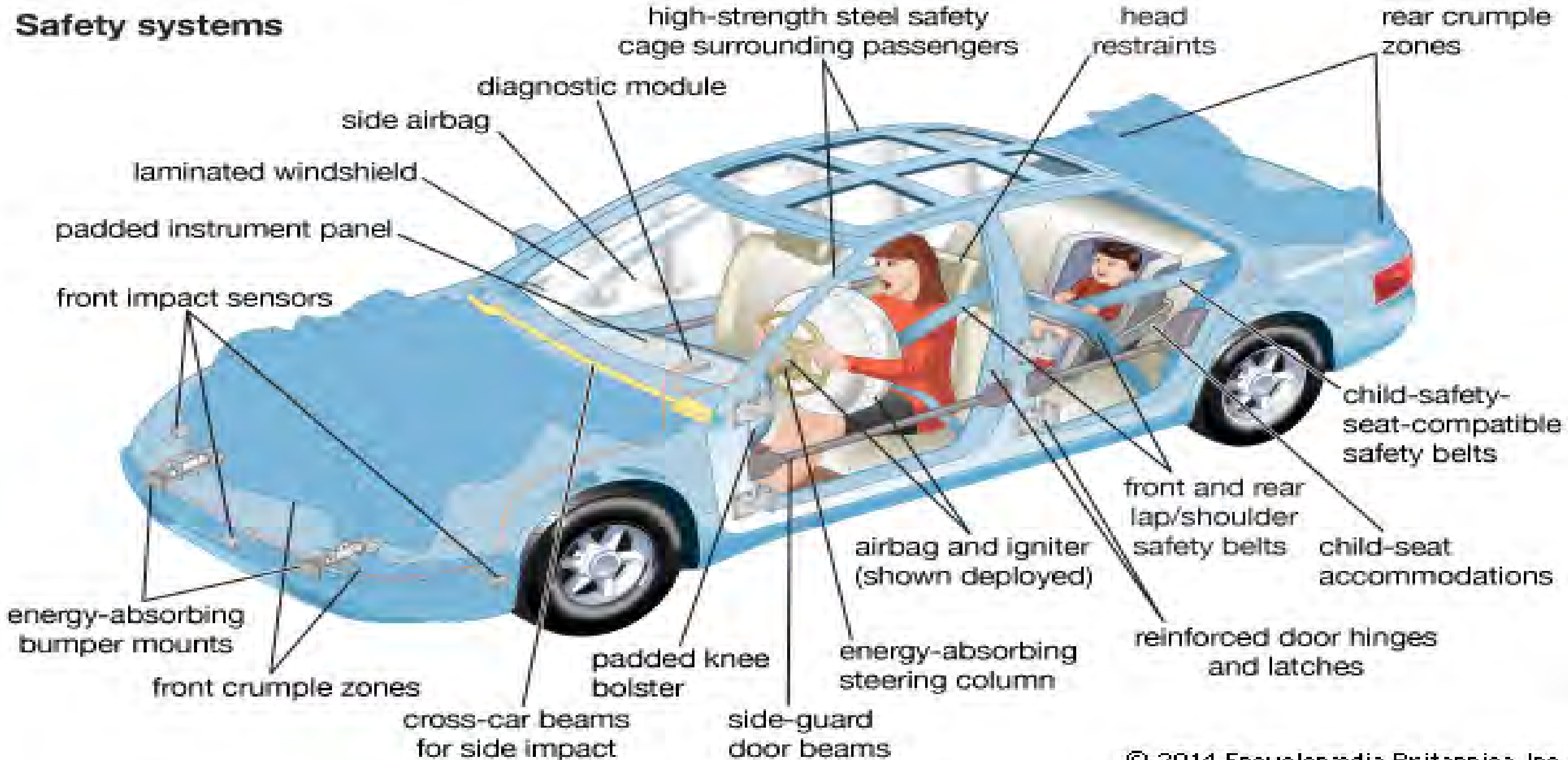
- Intelligent headlights
- Systems of night vision
- Human machine interface devices

- Intelligent throttle control
- Active steering
- Anti-lock braking systems
- Traction control systems
- Electronic stability control

Passive Safety Systems

Help to protect occupants during a collision or reduce the severity of the collision

Safety systems



MONITORED DRIVING

NON-MONITORED DRIVING



Driver is continuously exercising longitudinal AND lateral control

Driver is continuously exercising longitudinal OR lateral control

Driver has to monitor the system at all times

Driver does not have to monitor the system at all times; must always be in a position to resume control

Driver is not required during defined use case

AUTOMATED VEHICLES

AUTONOMOUS VEHICLES

Lateral or longitudinal control is accomplished by the system

System has longitudinal and lateral control in a specific use case

System has longitudinal AND lateral control in a specific use case. System recognizes the performance limits and requests driver to resume control within a sufficient time margin

System can cope with all situations automatically in a defined use case

System can cope with all situations automatically during the entire journey. No driver required

LEVEL 0

1

2

3

4

5

DRIVER ONLY

ASSISTED

PARTIAL AUTOMATION

CONDITIONAL AUTOMATION

HIGH AUTOMATION

FULL AUTOMATION

DRIVER ROLE

VEHICLE ROLE



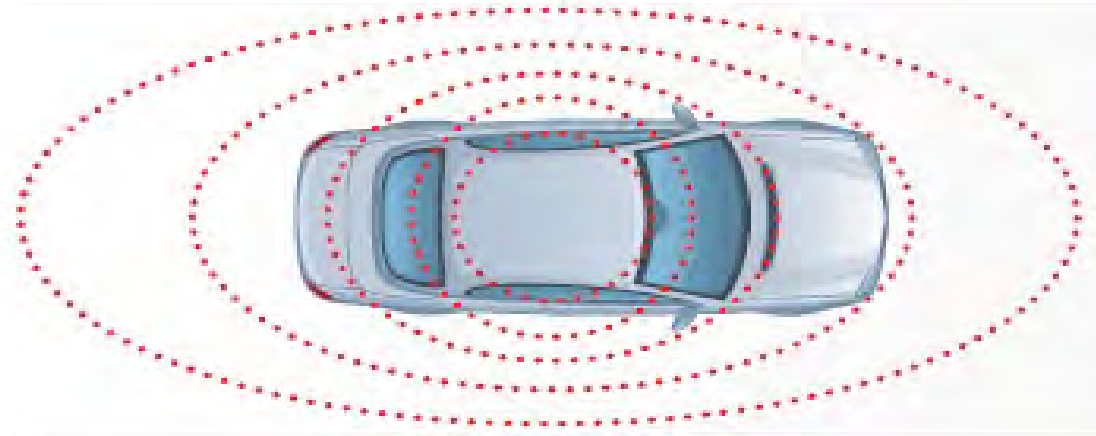
Realizing a “Complete” Framework

Requires the Convergence of Sensor-Based and Communication-Based Systems



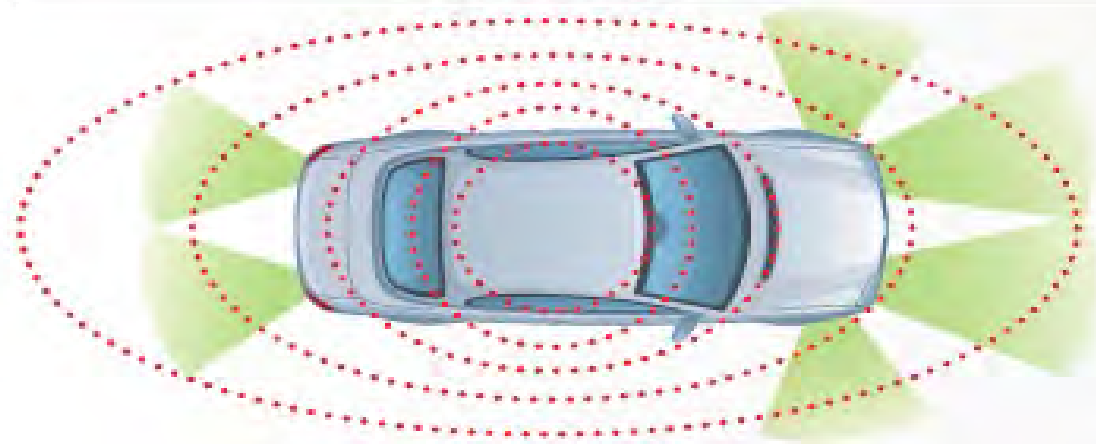
Sensor-Based Solution Only

- Cannot sufficiently mimic human senses
- Not cost-effective for mass market adoption
- Lack of adequate 360° mapping of environment in urban grids



Connected Vehicle Solution Only

- DSRC does not currently work with pedestrians, bicyclists, etc.
- DSRC-based V2I might require significant infrastructure investment
- V2V requires high market penetration to deliver value reliably

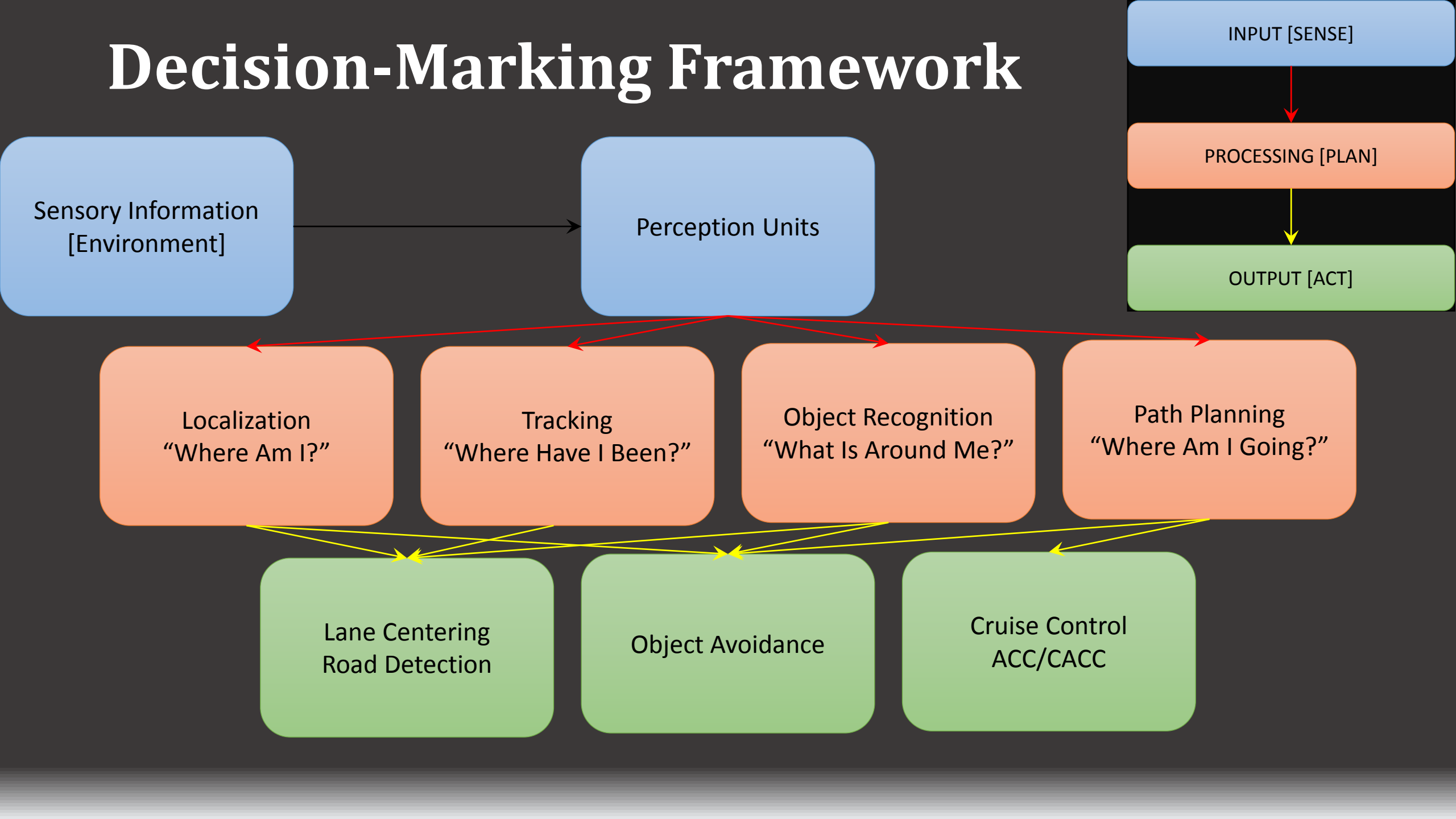


Converged Solution

- Convergence will facilitate adequate mimicking of human senses
- Convergence will reduce need for an expensive mix of sensors and reduce the need for blanket V2I investment
- Convergence will provide the necessary level of functional redundancy to ensure that the technology will work 100 percent of the time

TECH BRIEF

Decision-Marking Framework



Sensors

LIDAR

RADAR

ULTRASONIC

INFARED

GPS

ODOMETERS

VIDEO CAMERAS

Sensor Type \ Application	Vision	Infrared / Thermal	Long Range Radar 76..81MHz	Short / Mid Range Radar 24.26 / 76..81 GHz	Lidar
Adaptive Front Lighting (AFL), Traffic Sign Recognition (TSR)	X				
Night vision (NV)	X	X			
Adaptive Cruise Control (ACC)	X		X	X	X
Lane Departure Warning (LDW)	X				
Low-Speed ACC, Emergency Brake Assist (EBA), Lane Keep Support (LKS)	X			X	X
Pedestrian detection	X	X		X	
Blind Spot Detection (BSD), Rear Collision Warning (RCW), Lane Change Assist (LCA)	X			X	X
Park Assist (PA)	X			X	X
Camera monitor systems (CMS)	X				



LRR
1 to 280m

Infrared
0.2 to 120m

Video
0 to 80m

SRR/MRR
0.2 to 160m

Lidar

SRR
0.2 to 90m

Video
0 to 80m

GOOGLE CAR

Top Mounted Lidar: Distance to surrounding objects

Front Vision Camera: Detects pedestrians, motorists, traffic signs, traffic signals

Bumper Mounted Radar's (4): For gap keeping, throttle changes (2-4 second gap)

DGPS System: For location tracking – Advanced mapping provides differential

Rear Wheel Ultrasonic Sensors: Monitors vehicle movement – Park Assistance

Altimeters, gyroscopes, and tachymeters: Precise vehicle location

On-Board CPU: For syncing and processing data

Object Classification: Senses various objects and makes subsequent intelligent decisions



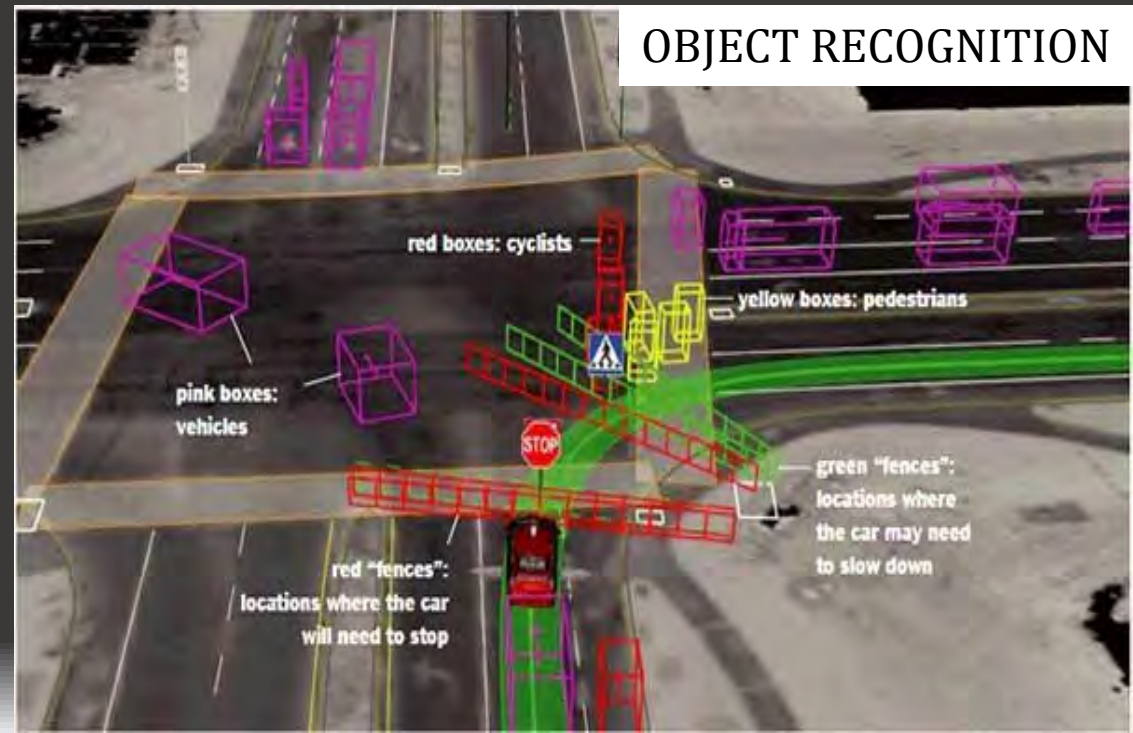
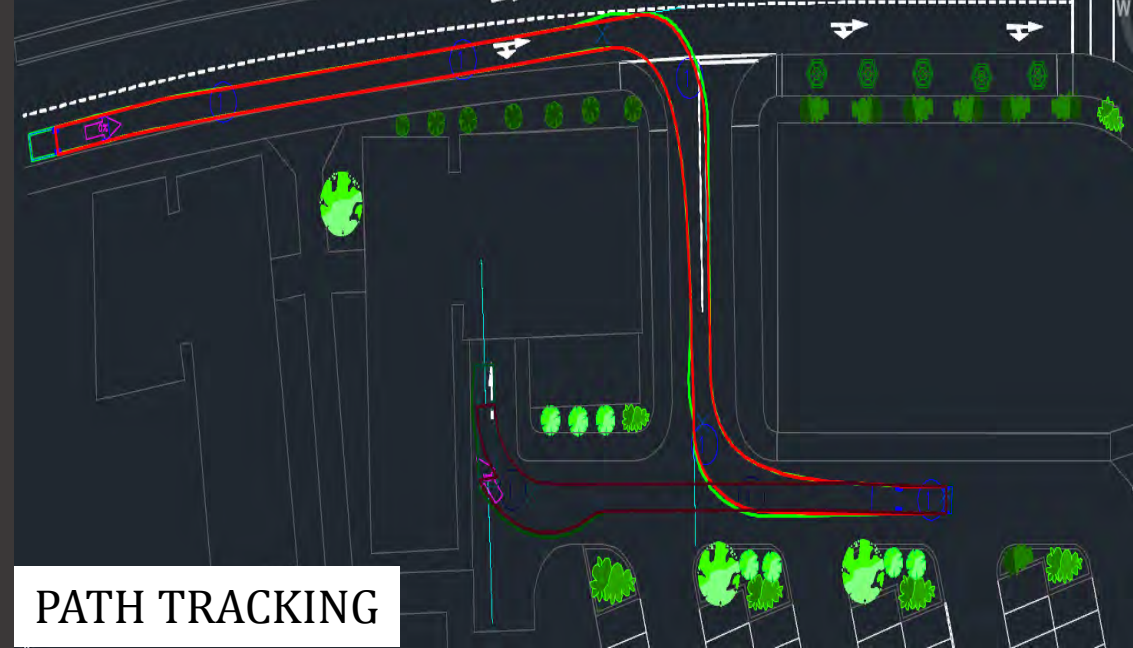
[TRUST THE] Processing

Localization: "Where am I?"

Path Planning: "Where am I going?"

Tracking: Where have I been

Object Detection and Recognition: "What is around me?"



Output

Acceleration Control

Object Avoidance

Road Detection

Lane Centering



Road detection leads to lane centering

