DRIVERLESS DEVELOPMENT

CONSTRAINING THE CONVERSATION: TERMINOLOGY AND INTRODUCTION TO TECH

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NAIOP Northern Virginia: Autonomous Vehicles
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TERMINOLOGY

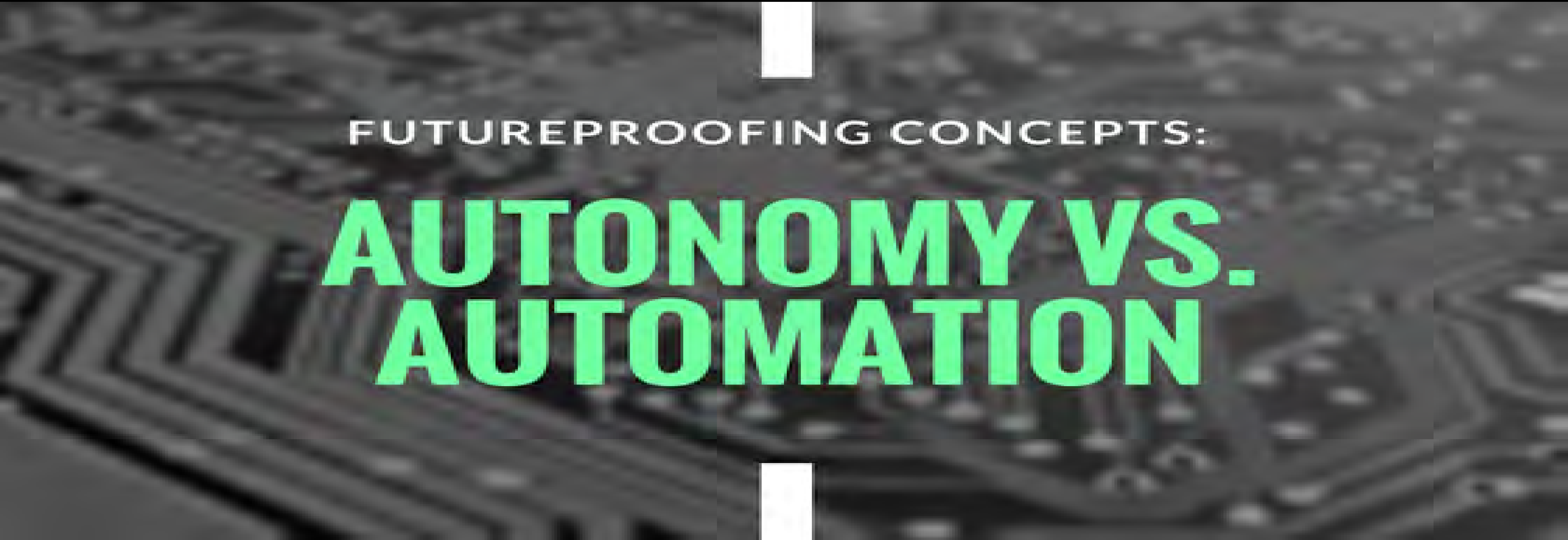
Automated Vehicles

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

Autonomous Vehicles

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

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



Safety-critical Functions

Steering, Braking, Accelerating

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

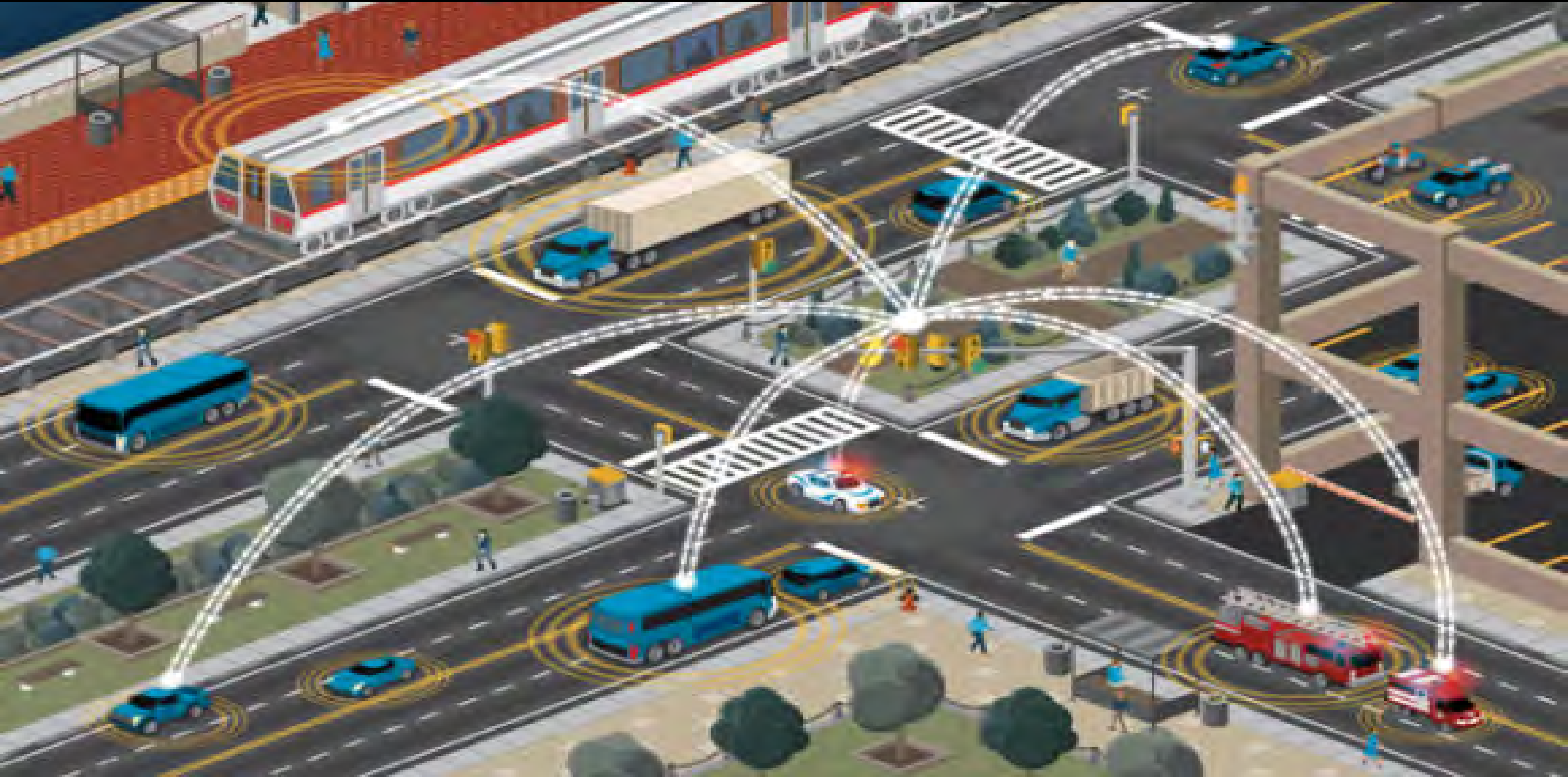




	BMW	Mercedes-Benz	Nissan	Google	General Motors
Vehicles	5 Series (modified)	S 500 Intelligent driver research vehicle	Leaf EV (modified)	Prius and Lexus (modified)	Cadillac SRX (modified)
KEY Technologies	• Video camera tracks lane markings and reads road signs. • Read sensors detect objects ahead. • 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.

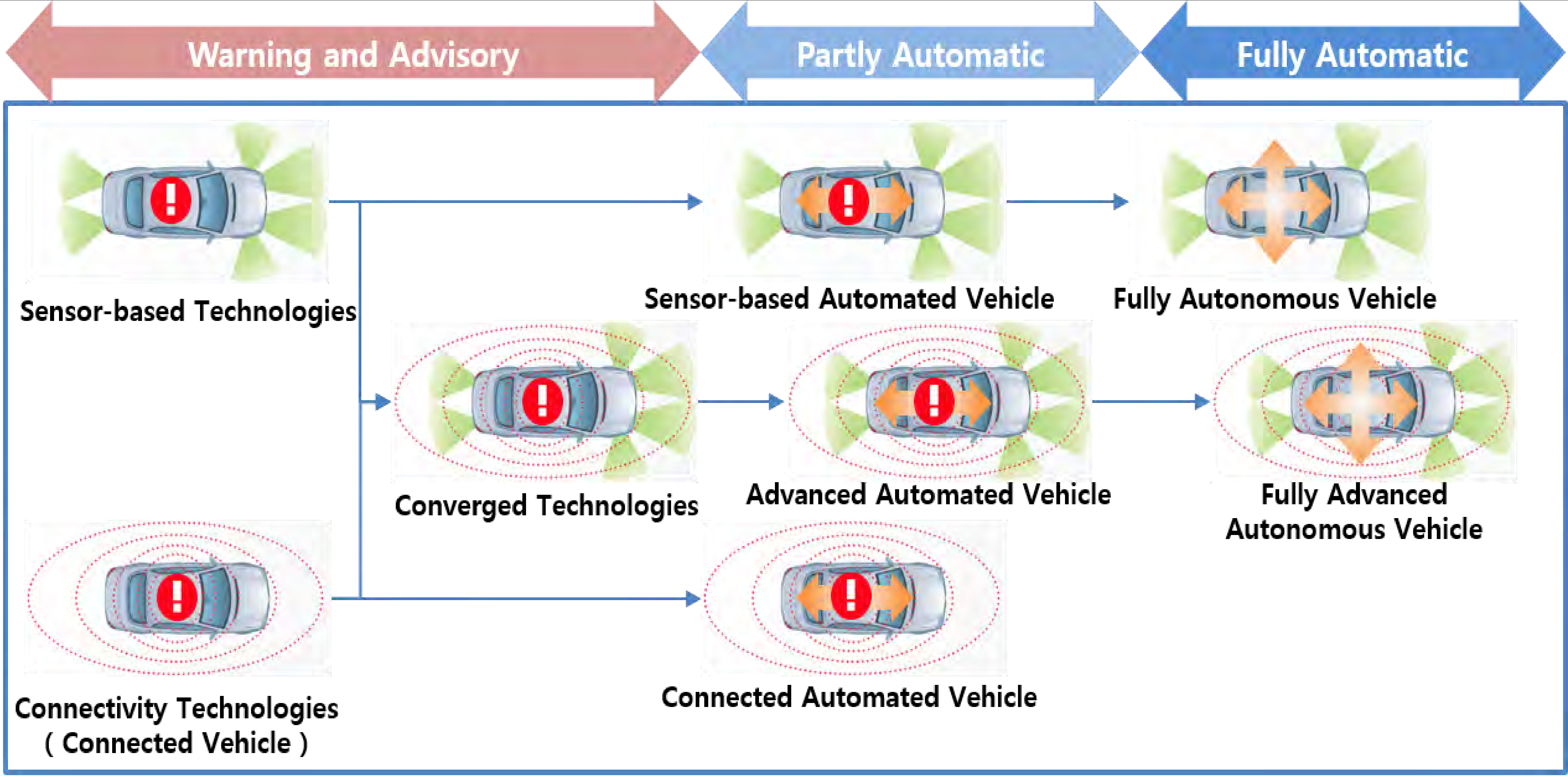
Connected Vehicles

Wireless technology to communicate among road users and roadside infrastructure



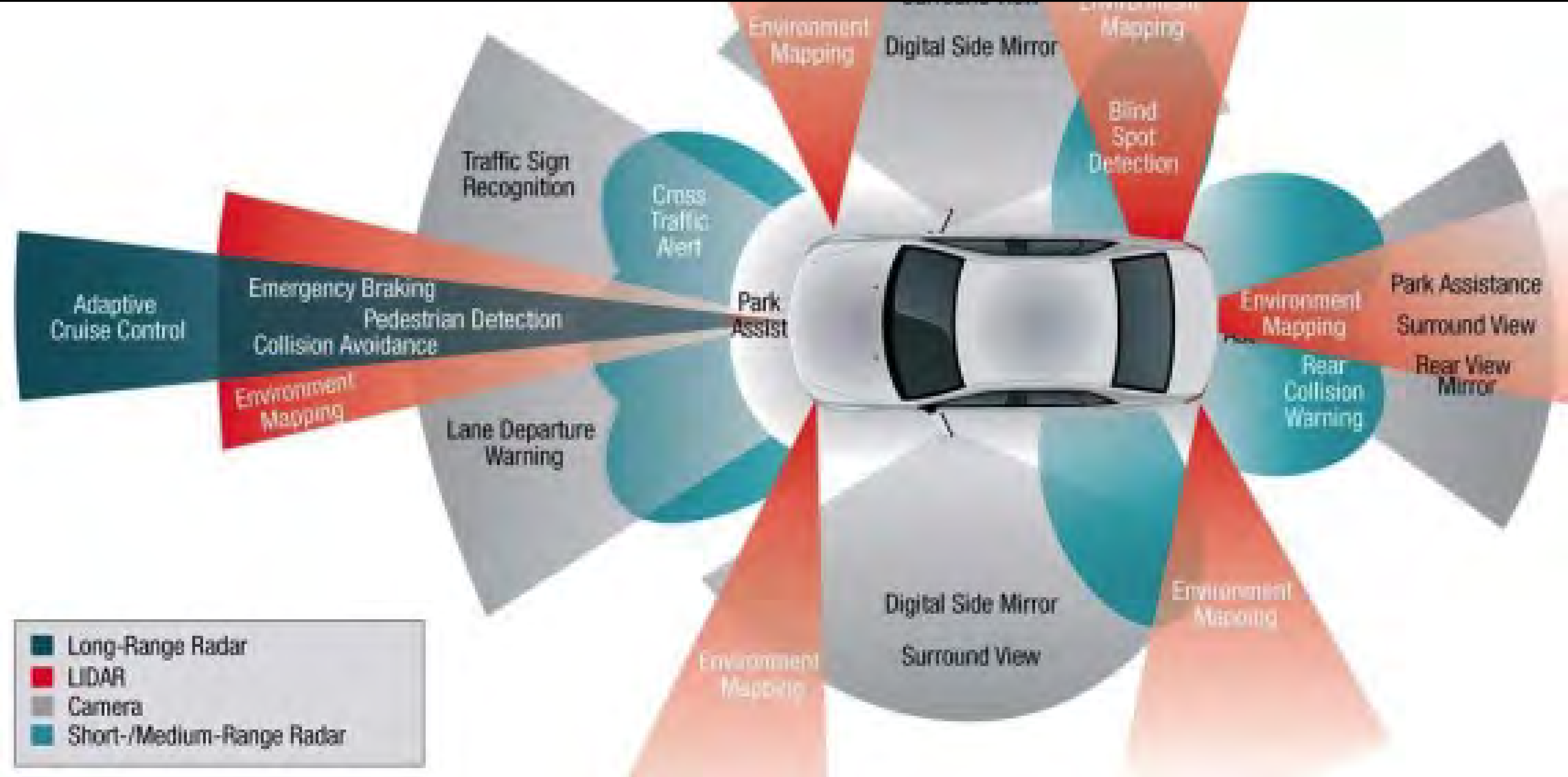
Connected Automated Vehicles

Leverage automated and connected vehicle capabilities to realize all potential benefits



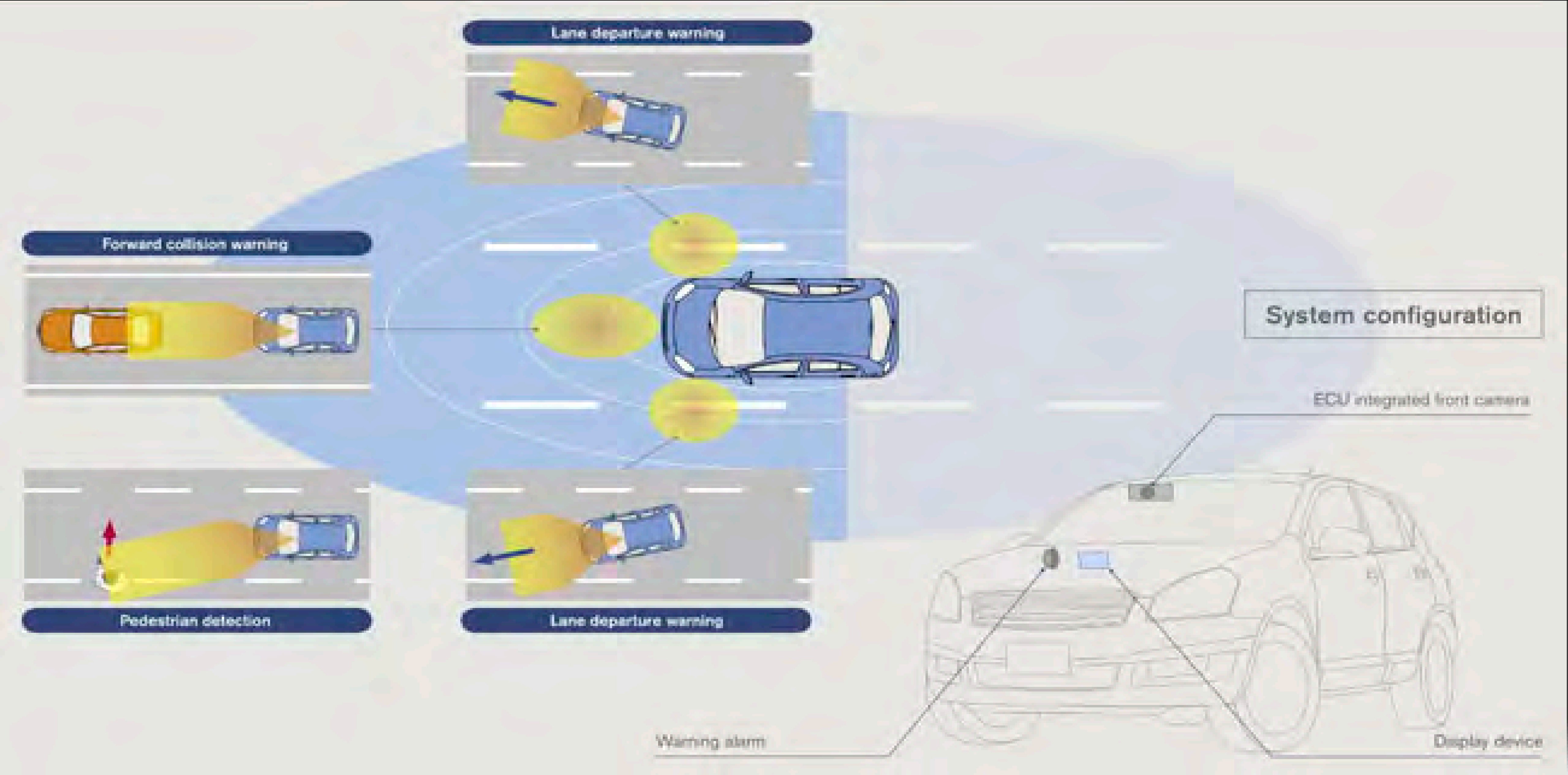
Driver Assistance Systems

Aid the driver in the driving process



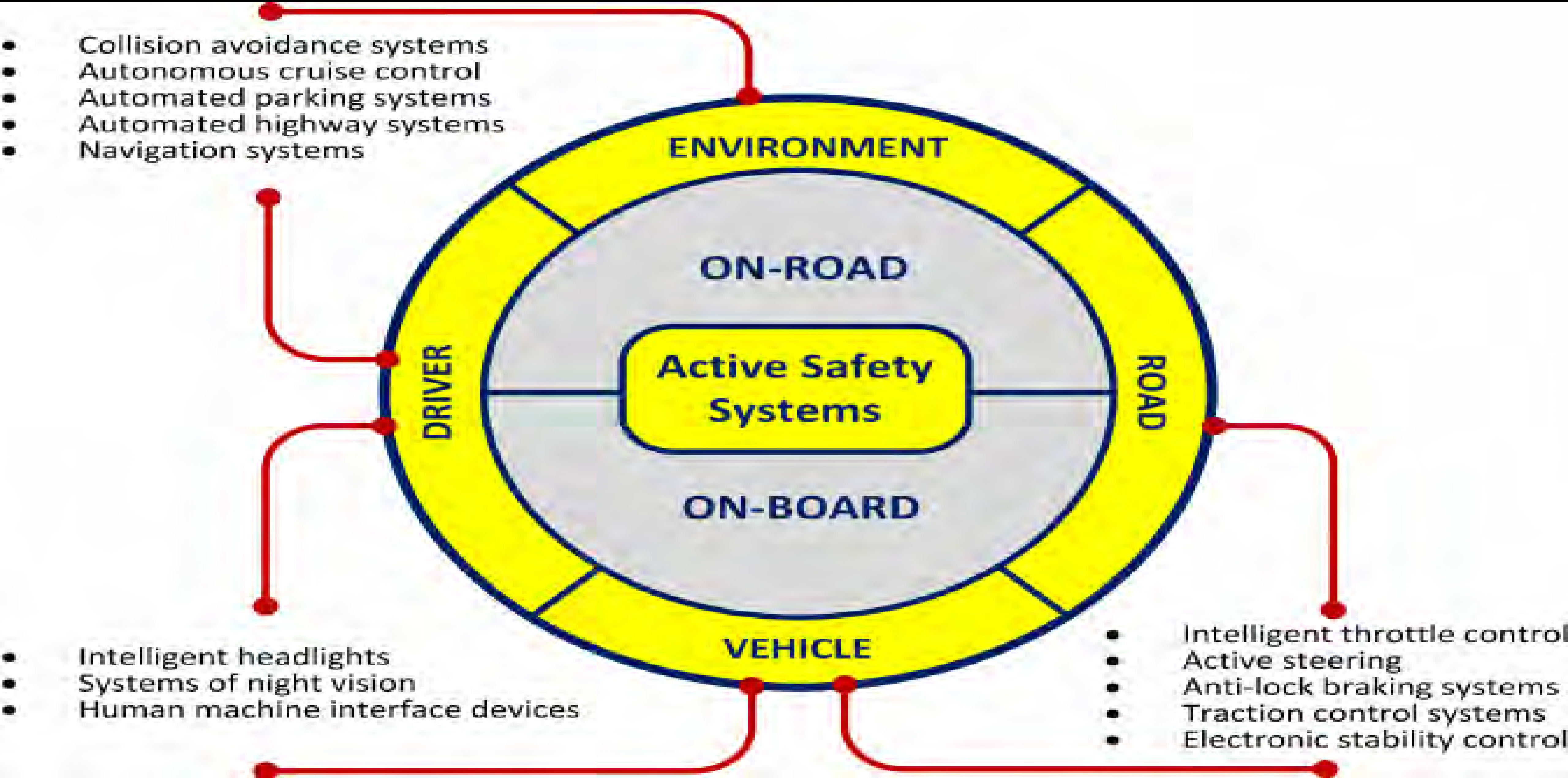
Driver Support Systems

Warn the driver of particular situations



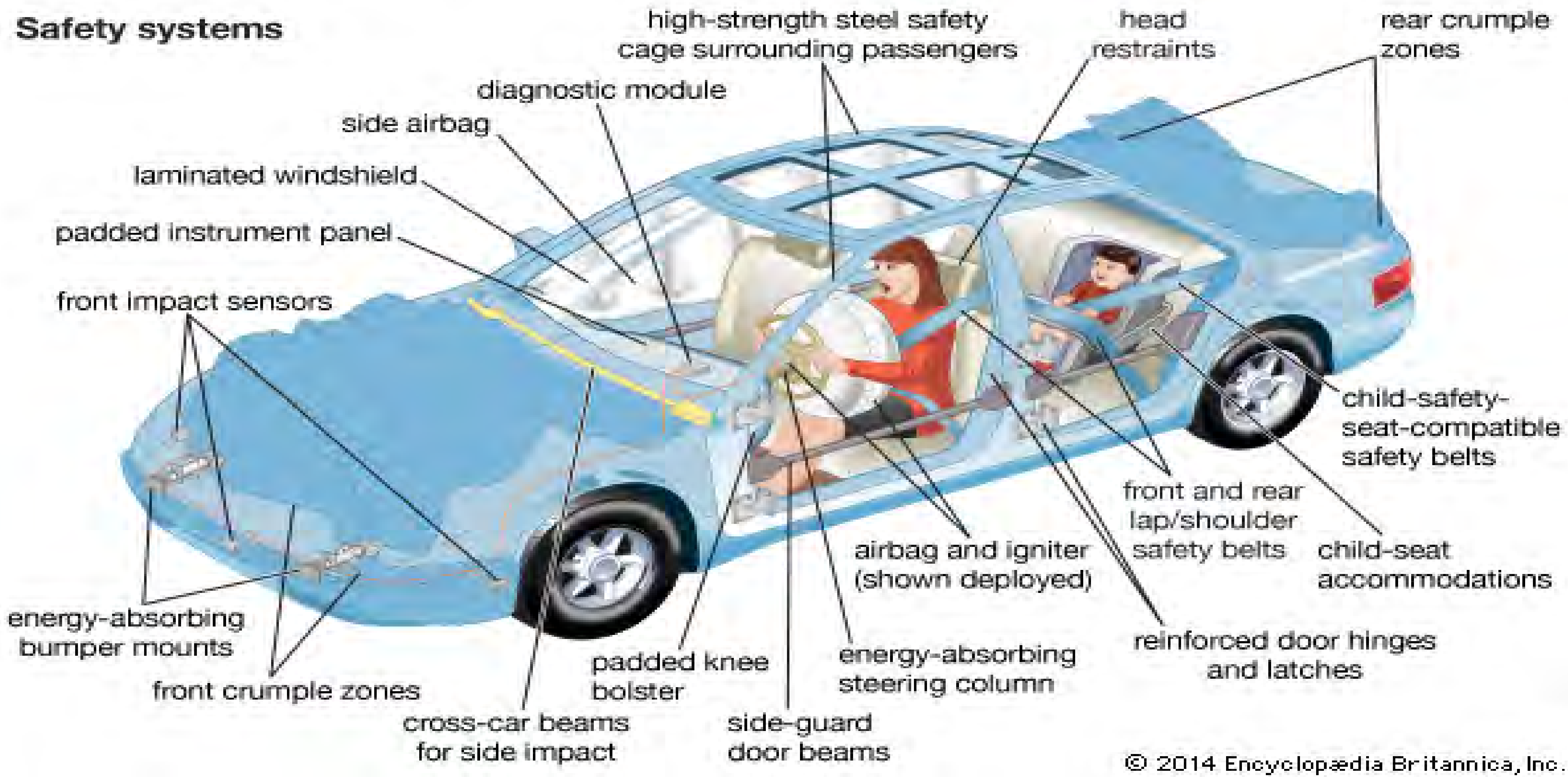
Active Safety Systems

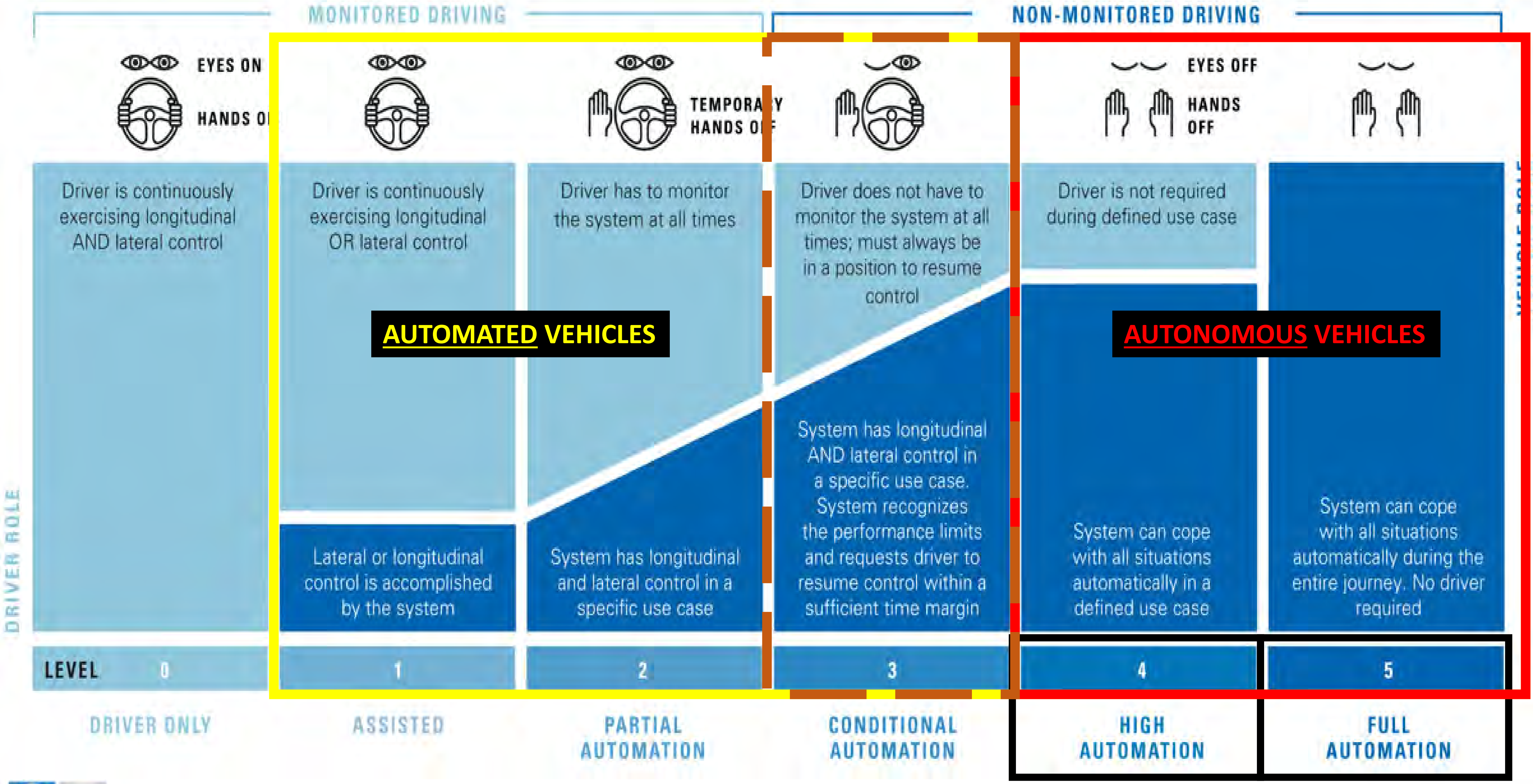
Aim to prevent collisions from ever occurring



Passive Safety Systems

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





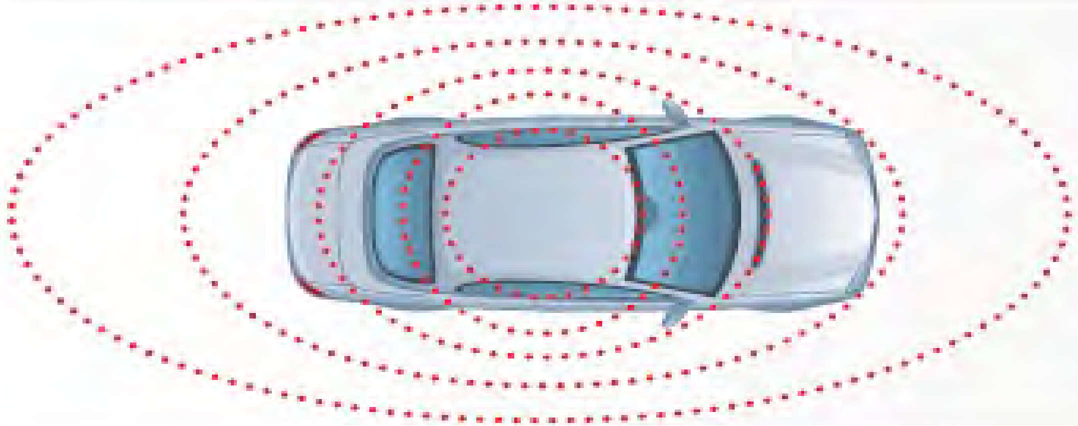
Mike Lemanski

Realizing a *“Complete” Framework*

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

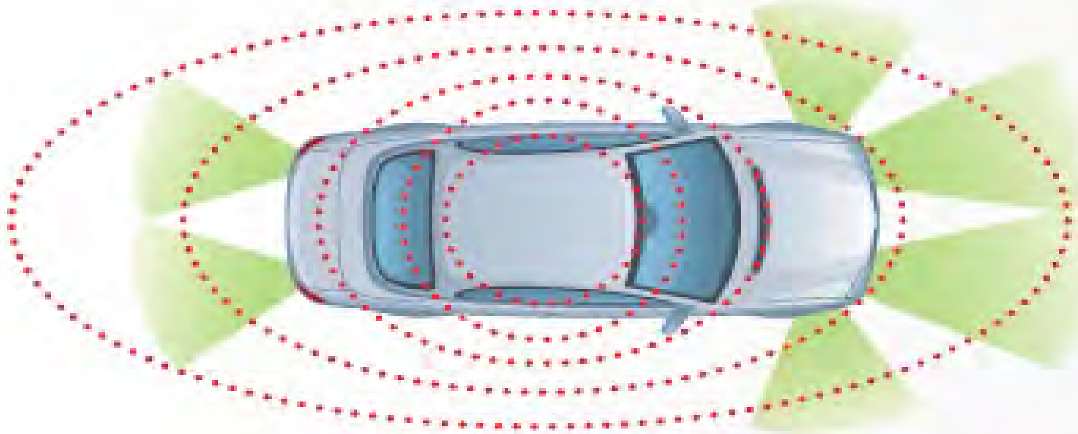
Sensor-Based Solution Only

- 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

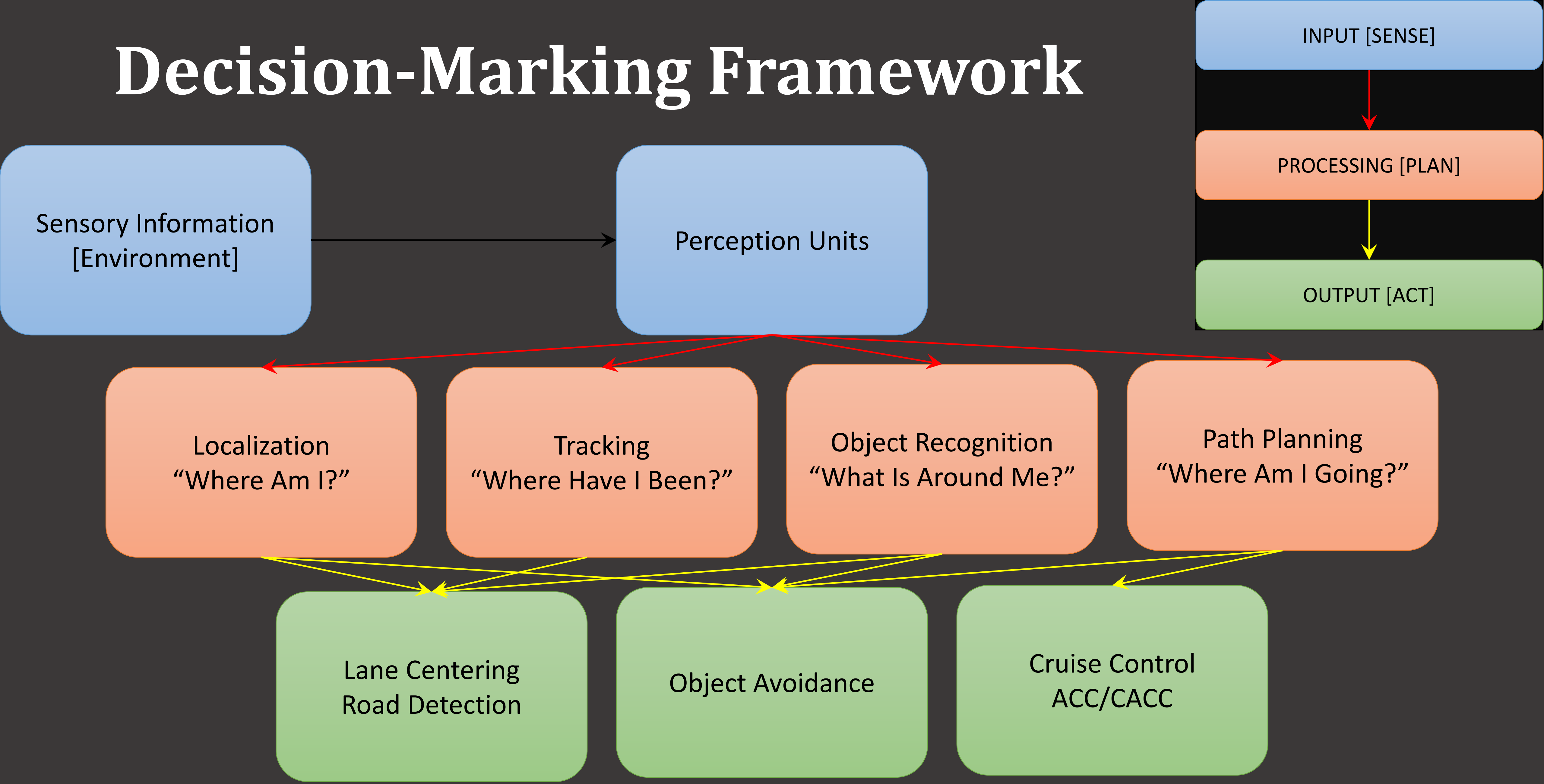


Converged Solution

- 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

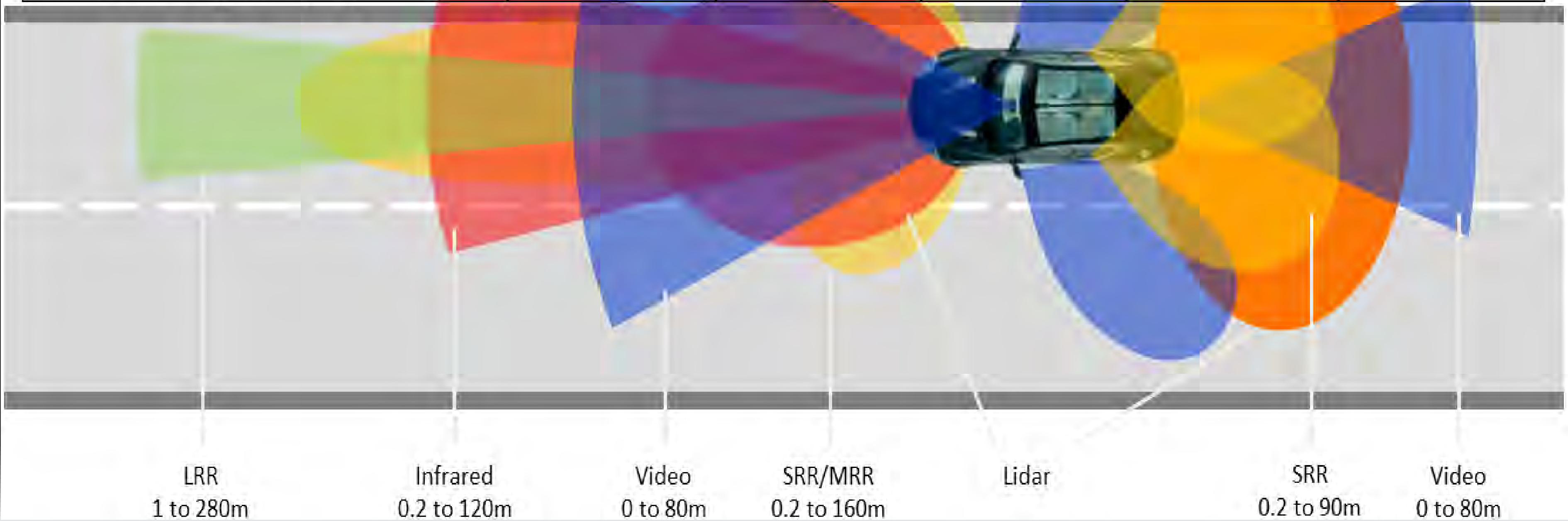
INFARED

GPS

ODOMERTERS

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				



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

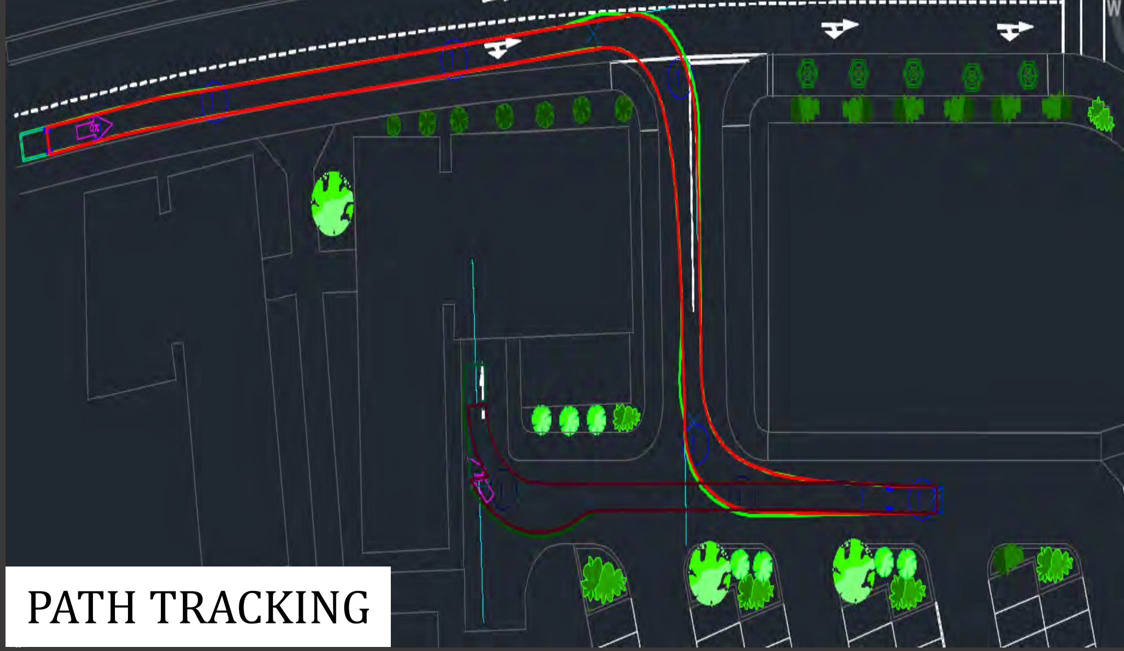
[TRUST THE] Processing

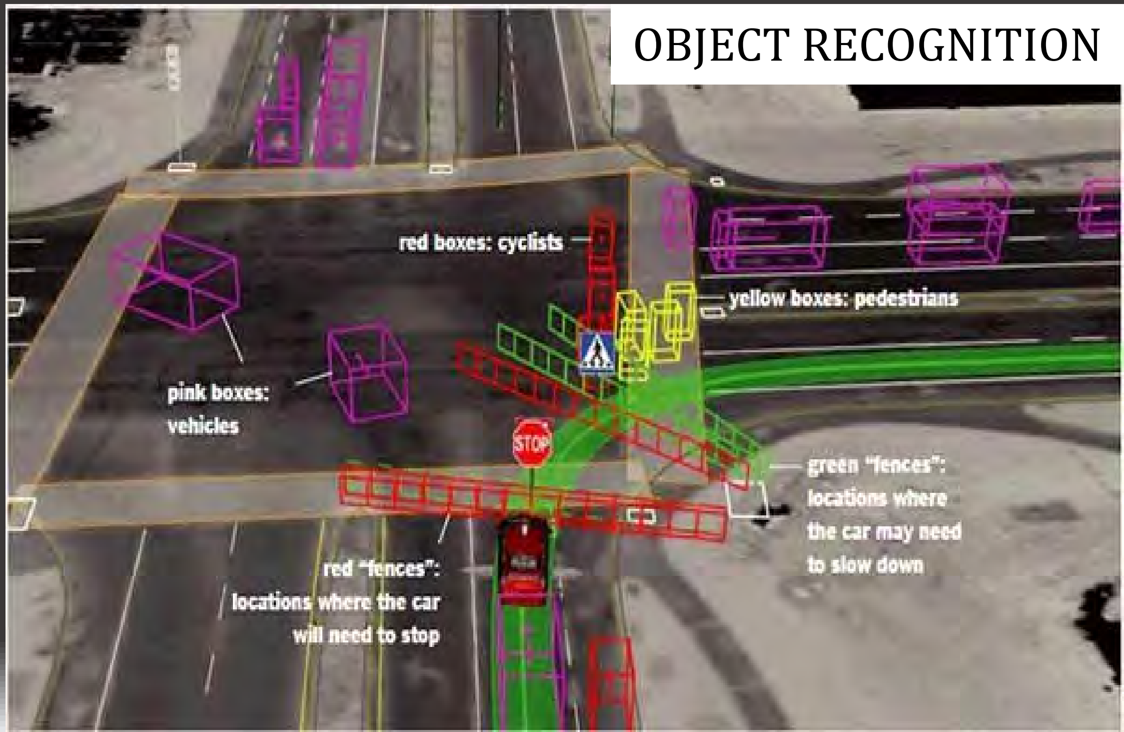
Localization: “Where am I?”

Path Planning: “Where am I going?”

Tracking: Where have I been

Object Detection and Recognition: “What is around me?”





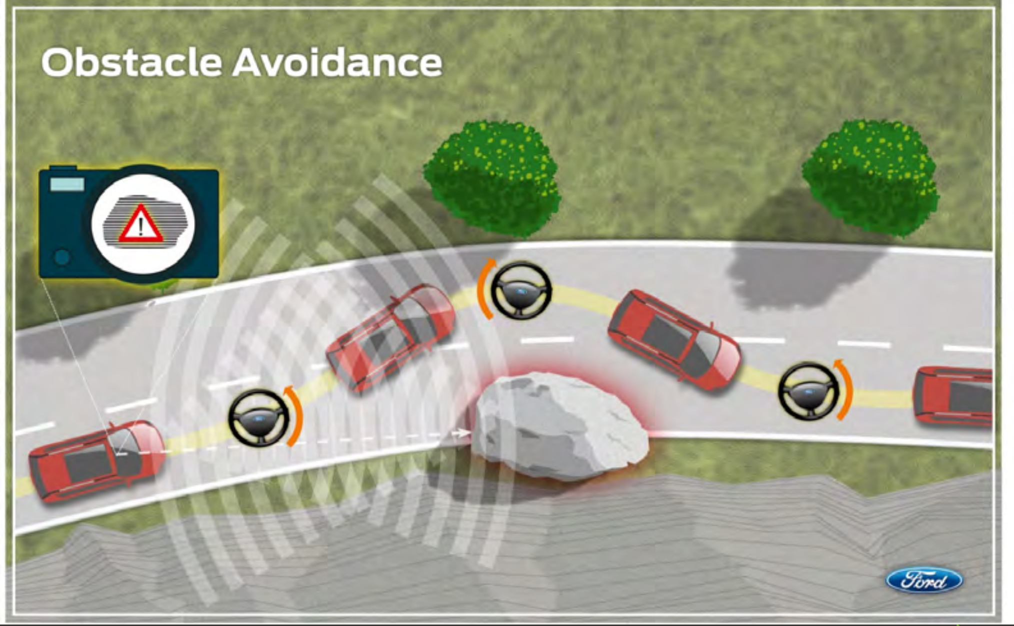
Output

Acceleration Control

Object Avoidance

Road Detection

Lane Centering



Road detection leads to lane centering