Assisted driving and autonomous driving, a short introduction

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- Driver Assistance Systems (DAS)
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- Autonomous cars and the fundamental robotic cycle (Sensing, Reasoning, Acting)
- Sensing for localization
- Most used sensors for autonomous vehicles: LIDARS and cameras
- The quest for reliability and dealing with sensors crazy outcomes

Levels of automation in driving

Distinction is based on the amount of driver intervention and attentiveness required

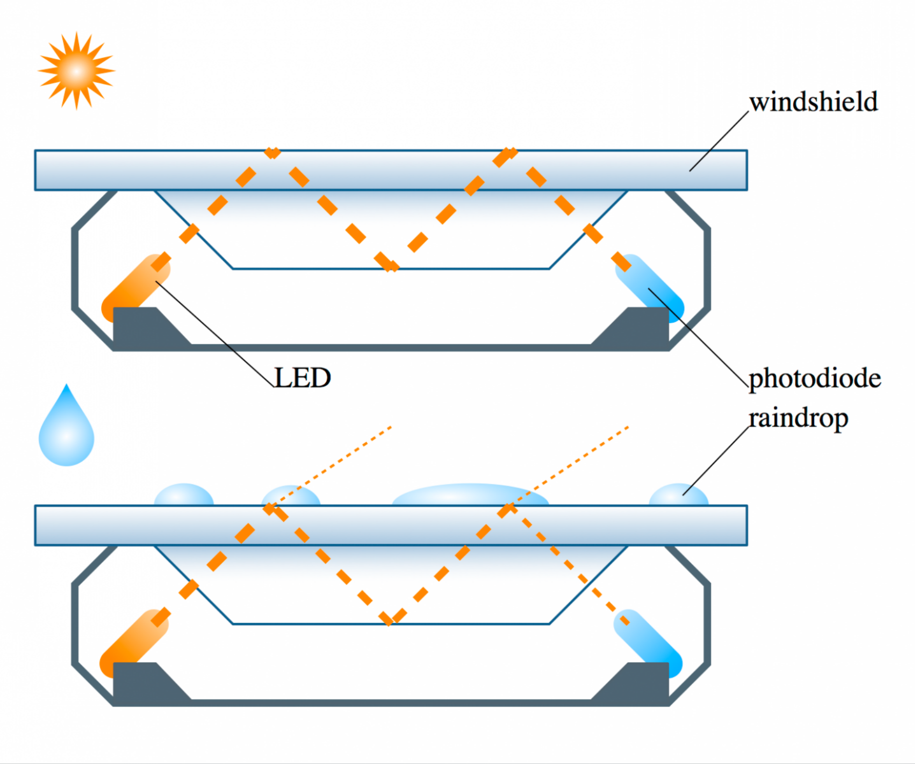
- Level 0: Automated system issues warnings but has no vehicle control.
- Level 1 ("hands on"): Driver and automated system shares control over the vehicle. An example would be be Adaptive Cruise Control (ACC) where the driver controls steering and the automated system controls speed. Using Parking Assistance, steering is automated while speed is manual. The driver must be ready to retake full control at any time. Lane Keeping Assistance (LKA) Type II is a further example of level 1 self driving.
- Level 2 ("hands off"): The automated system takes full control of the vehicle (accelerating, braking, and steering). The driver must monitor the driving and be prepared to immediately intervene at any time if the automated system fails to respond properly.
- Level 3 ("eyes off"): The driver can safely turn their attention away from the driving tasks, i.e. the driver can do texting or watch a movie. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so.
- Level 4 ("mind off"): As level 3, but no driver attention is ever required for safety, i.e. the driver may safely go to sleep or leave the driver's seat. Self driving is supported only in limited areas (geofenced) or under special circumstances, like traffic jams. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip, i.e. park the car, if the driver does not retake control.
- Level 5 ("wheel optional"): No human intervention is required. An example would be a robot taxi.

DAS (Driver Assistance Systems)

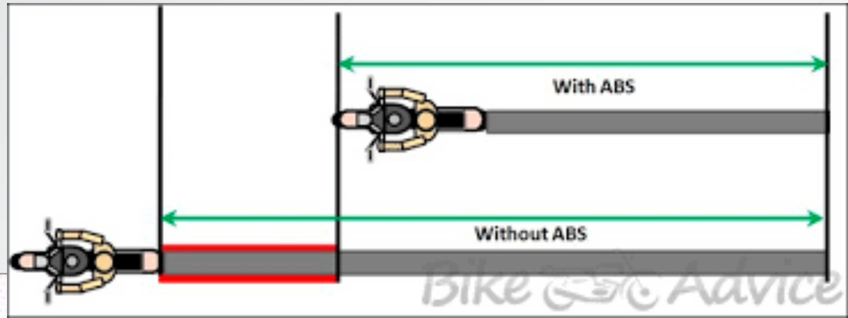
- Basic DAS functionalities:
  - Cruise Control
  - rain-light-sensor
  - Tire Pressure Monitoring
  - Anti Blocking System (ABS)
  - Traction Control System (TCS)
  - Electronic Stability Control (ESC / ESP)
  - etc.

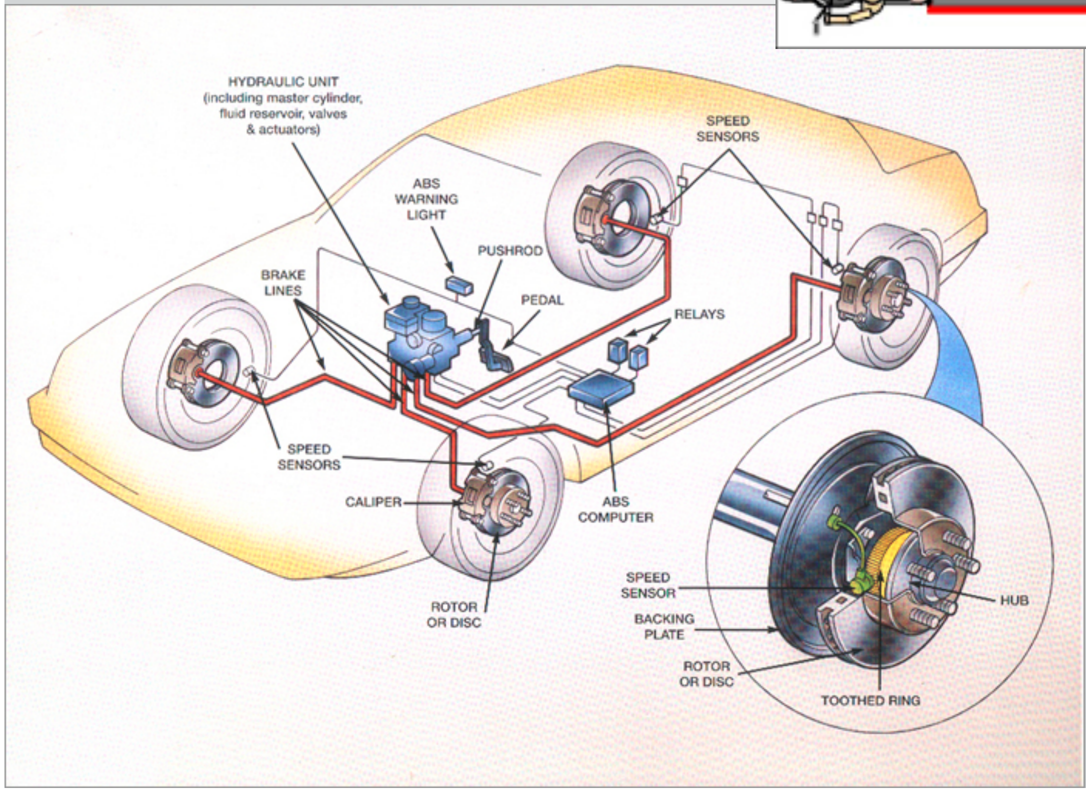
Cruise Control

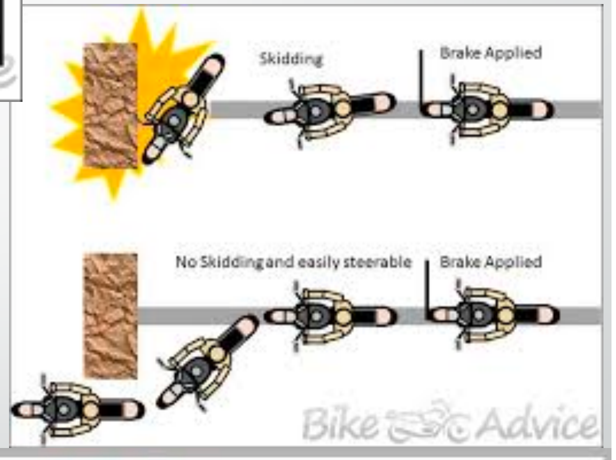
rain-light-sensor

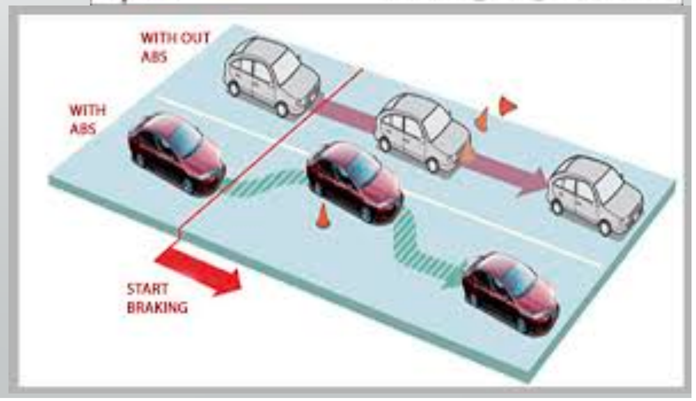


Anti Blocking System (ABS)

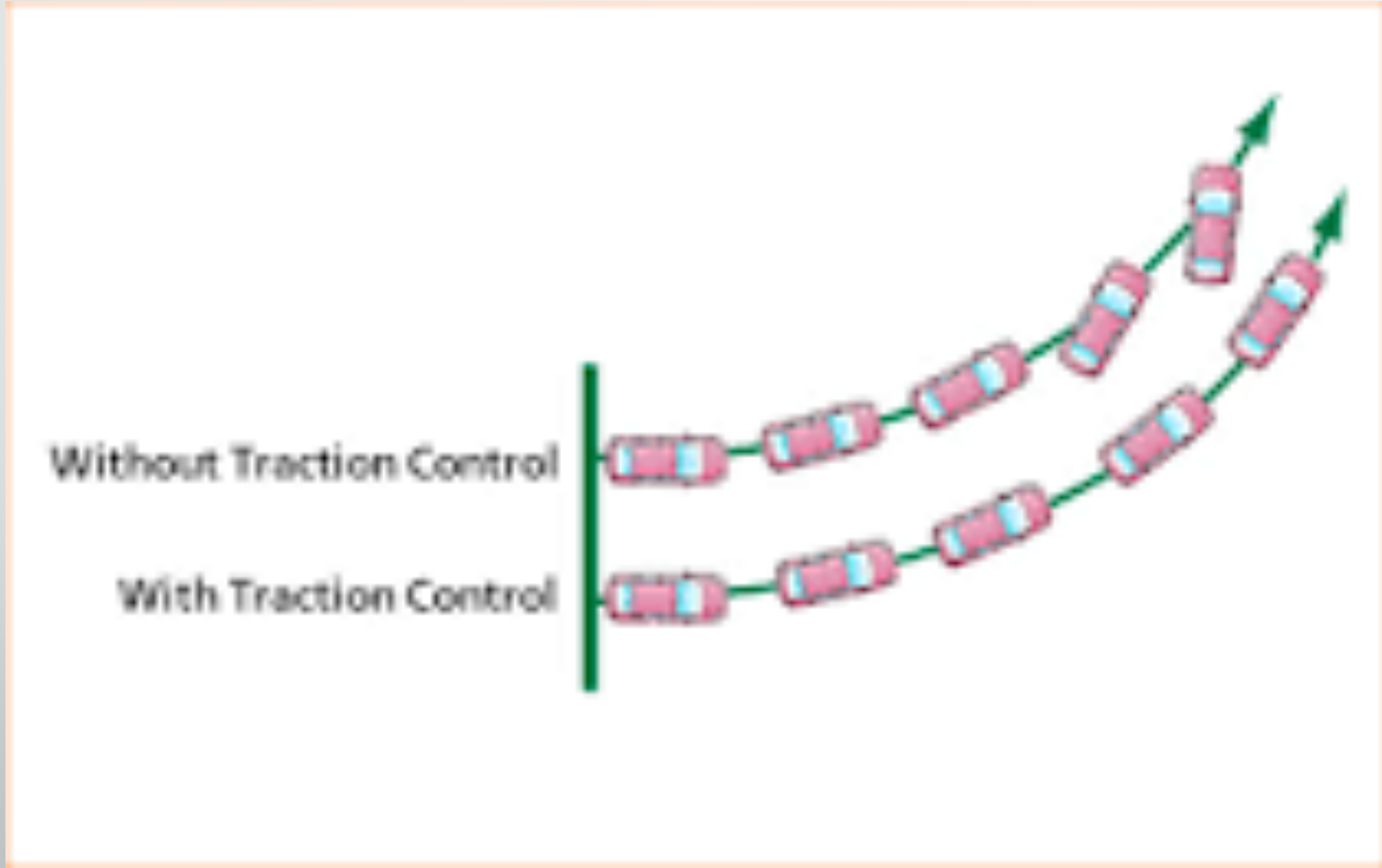








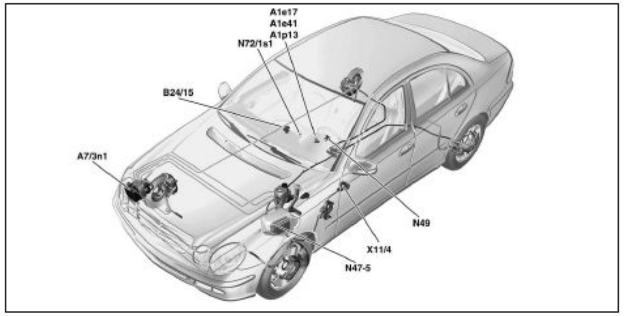
Traction Control System (TCS)



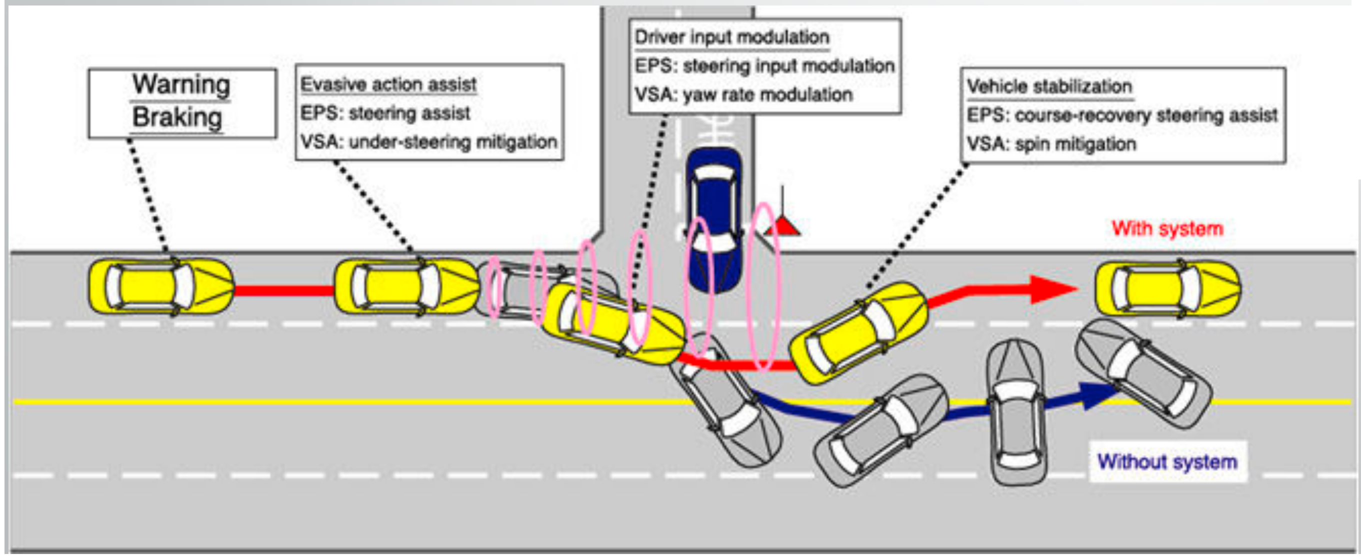
Electronic Stability Control (ESC / ESP)

Very effective!
One-third of fatal accidents could be prevented by its use.

ESP Electronic Components



A1e17 ABS malfunction indicator lamp
A1e41 ESP and ABS warning lamp
A1p13 Multifunction display
A7/3n1 SBC control module
B24/15 Lateral acceleration and yaw rate sensor
N47-5 ESP, BAS and SPS control module
N49 Steering angle sensor
N72/1s1 ESP OFF switch
X11/4 Diagnostic data link connector



DAS => ADAS (Advanced DAS)

ADAS cover a wider range of situations and allow less supervision by the driver.

=> more sophisticate perception!

ADAS

- Adaptive Cruise Control (ACC)
- Traffic sign recognition
- Lane Keeping assistant
- Curve Speed Control
- Adaptive light control: swivelling curve lights
- Automatic parking / Parking assistant
- Automotive navigation system
- Automotive night vision
- Blind spot monitor
- Collision avoidance system
- Crosswind stabilization
- Driver drowsiness detection
- Driver Monitoring System
- Emergency driver assistant
- Forward Collision Warning
- Intersection assistant
- Hill descent control
- Lane Departure Warning system
- Lane Change Assistance
- Pedestrian protection system
- Surround View system
- Turning assistant
- Wrong-way driving warning

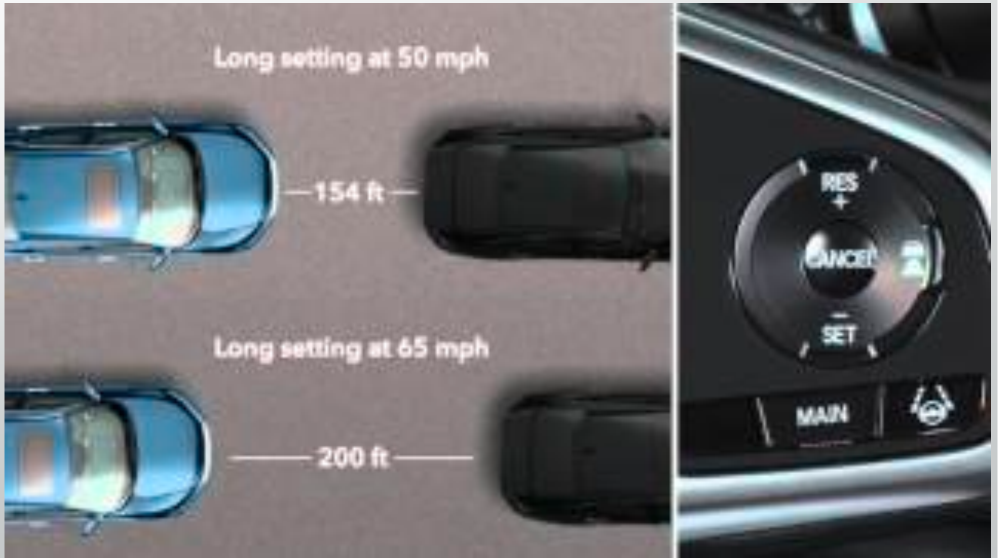
ADAS for helping the driver to drive

- Traffic sign recognition
- Lane Departure Warning system
- Lane Change Warning
- Curve Speed Control
- Adaptive light control: swivelling curve lights
- Automotive night vision
- Blind spot monitor
- Crosswind stabilization
- Driver drowsiness detection
- Driver Monitoring System
- Emergency driver assistant
- Forward Collision Warning
- Hill descent control
- Surround View system
- Wrong-way driving warning

ADAS for freeing the driver from driving

- Adaptive Cruise Control (ACC)
- Lane Keeping Assistant
- Lane Change Assistant
- Automatic parking / Parking assistant
- Collision avoidance system
- Autonomous Emergency Braking
- Intersection assistant

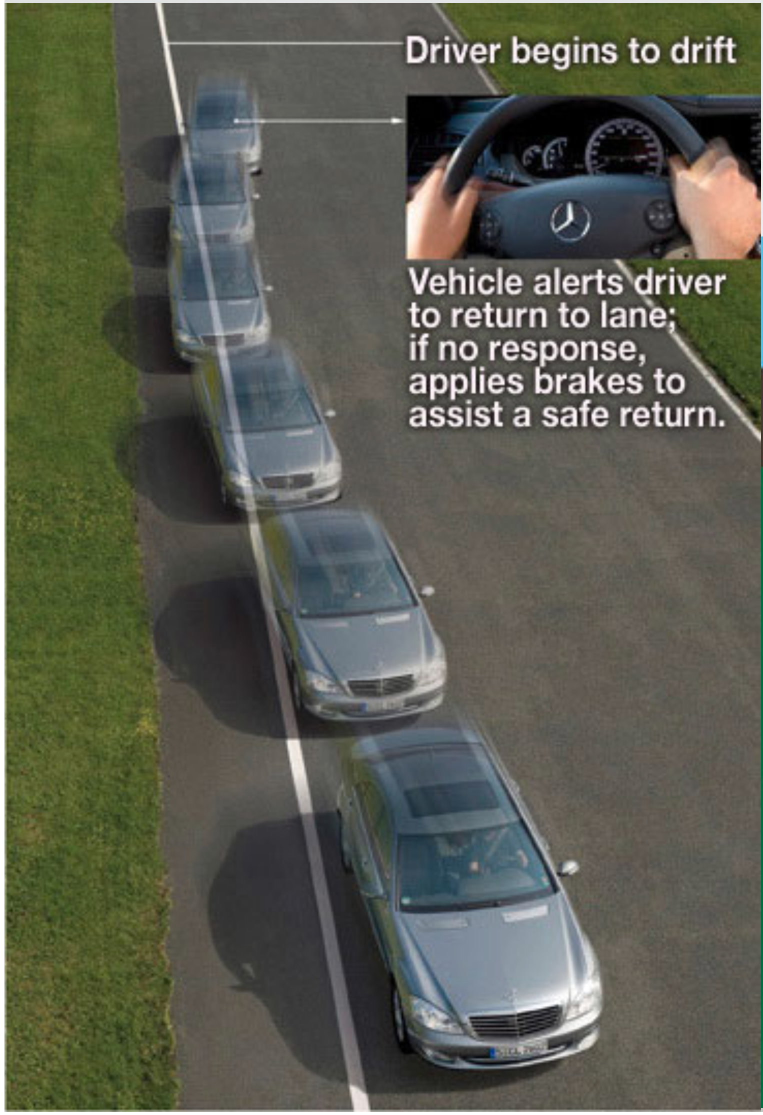
Adaptive Cruise Control (ACC)

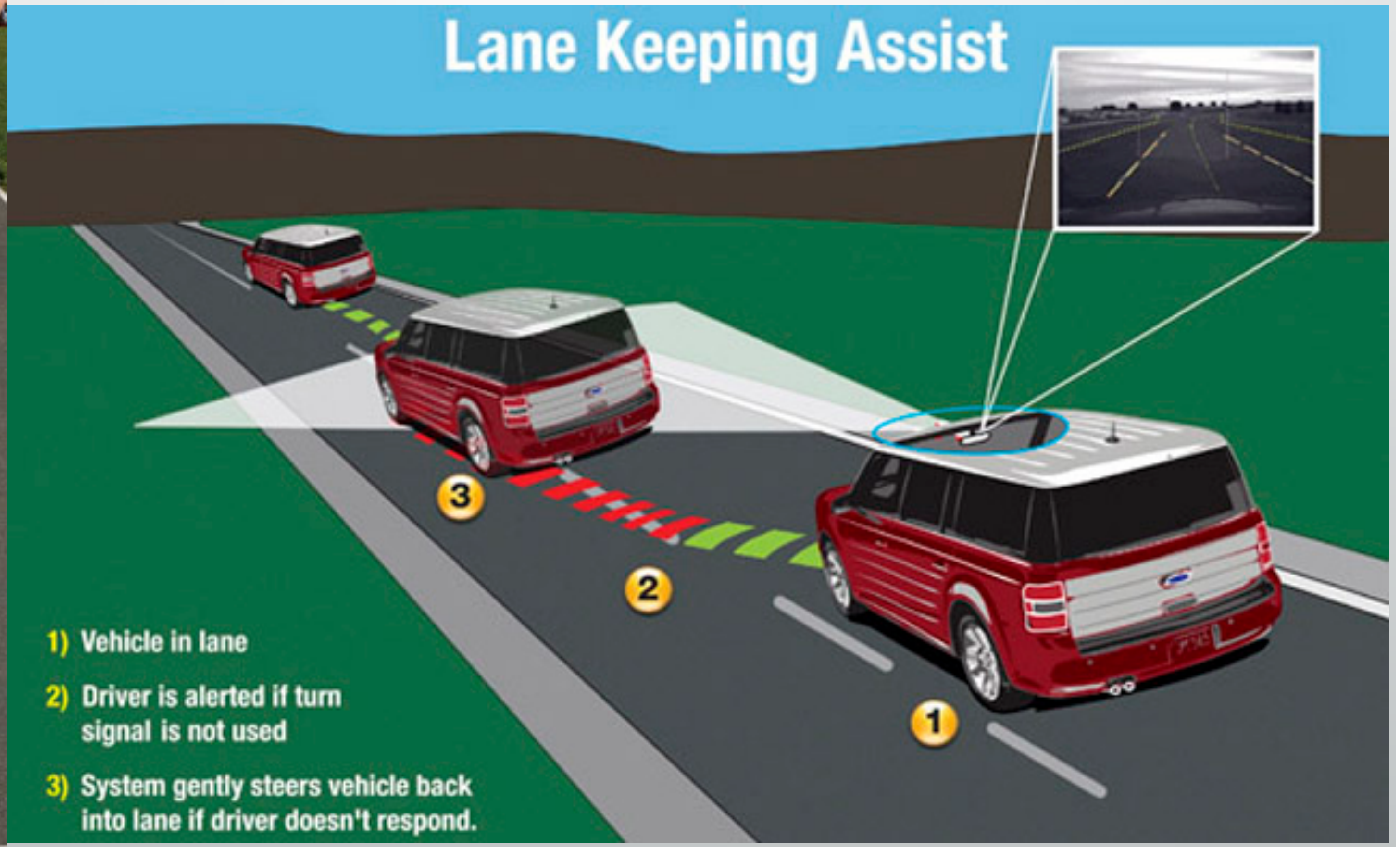


Lane Keeping Assistant (LKA)

- Evolution of Lane Departure Warning (LDW)
- The driver remains responsible for controlling the vehicle.
- A configuration that emphasizes convenience generates torque forces at either side of the lane center line in order to keep the vehicle in the middle of the lane.
- A configuration that emphasizes safety, on the other hand, does not intervene until the vehicle is close to the lane markings. In this case, a much stronger steering support torque is applied.

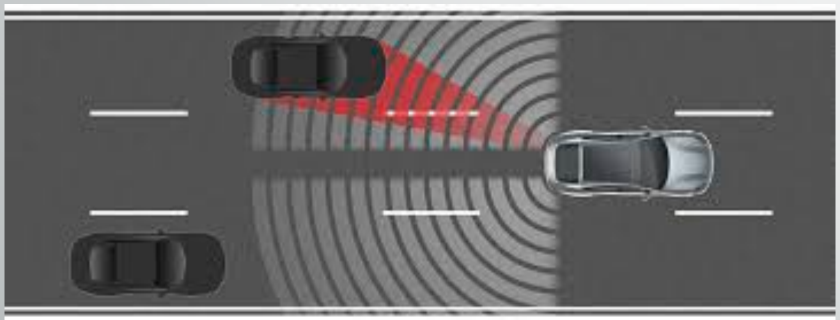
Lane Keeping Assistant (LKA)

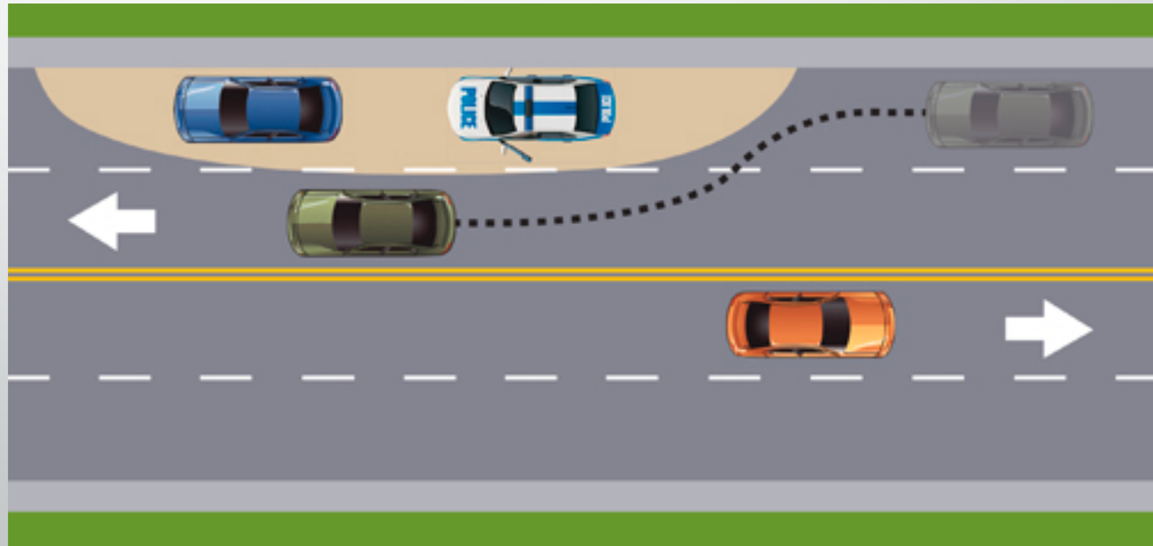




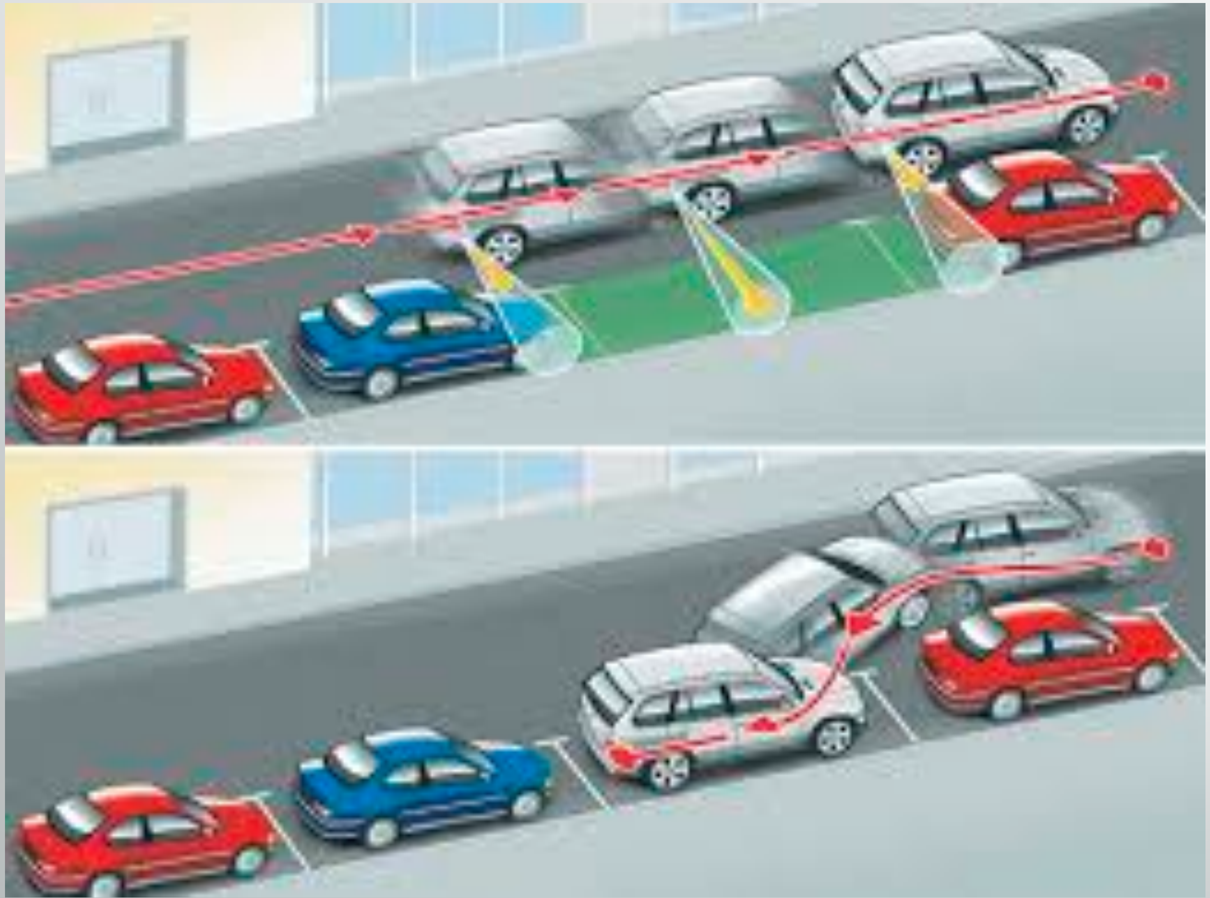
Lane Change Assistant / Warning

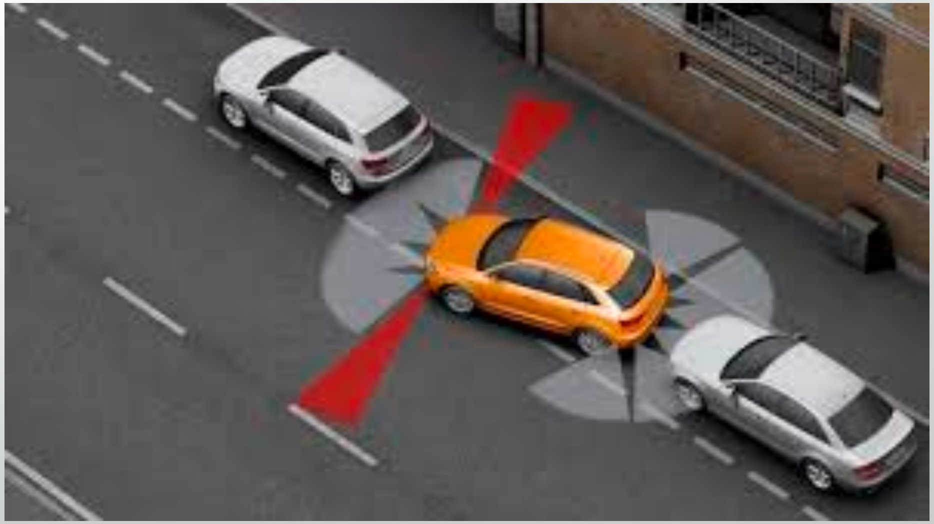
- Reduces the risk of accidents when changing lanes
- Avoids side collisions with vehicles in blind spot
- Prevents accidents due to misjudgment of the speed of approaching vehicles



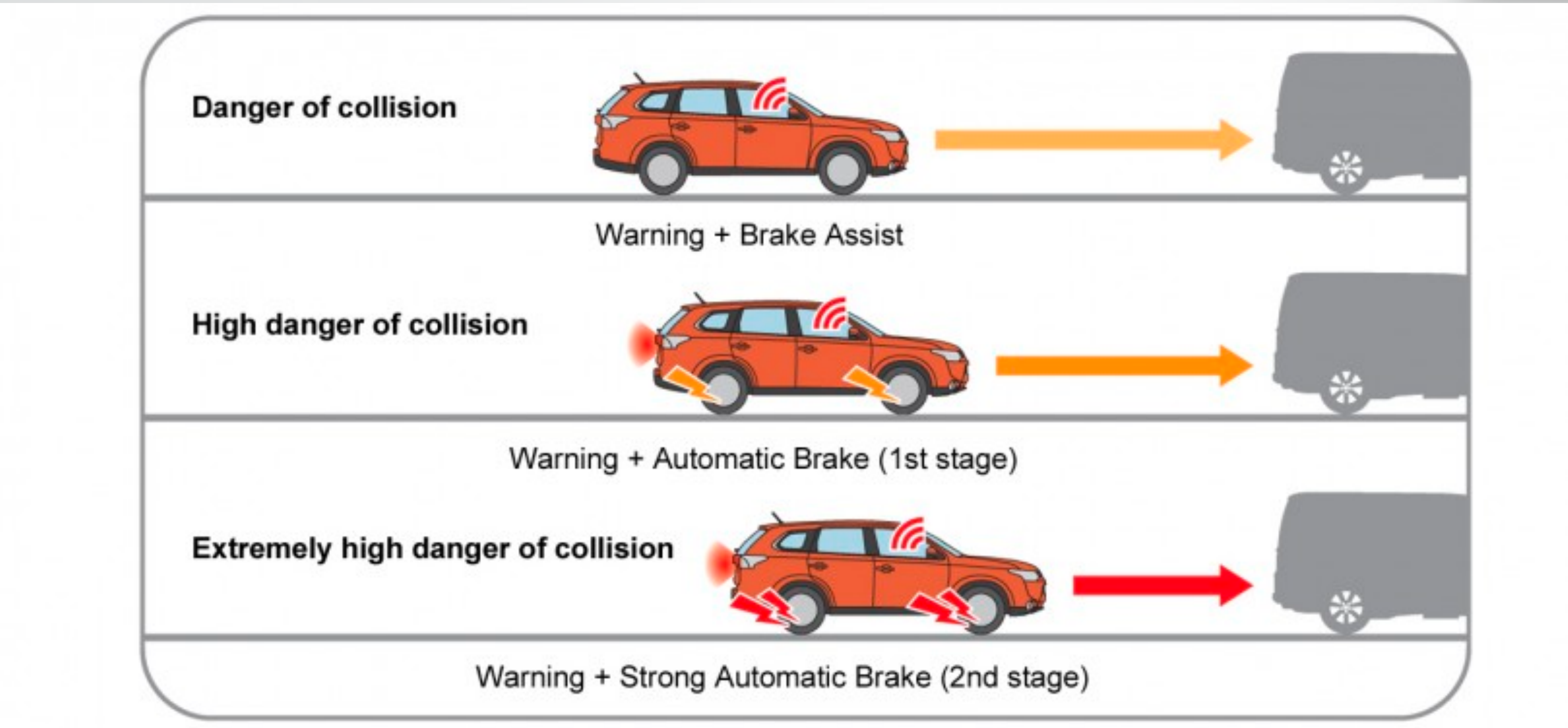


Automatic parking / Parking assistant

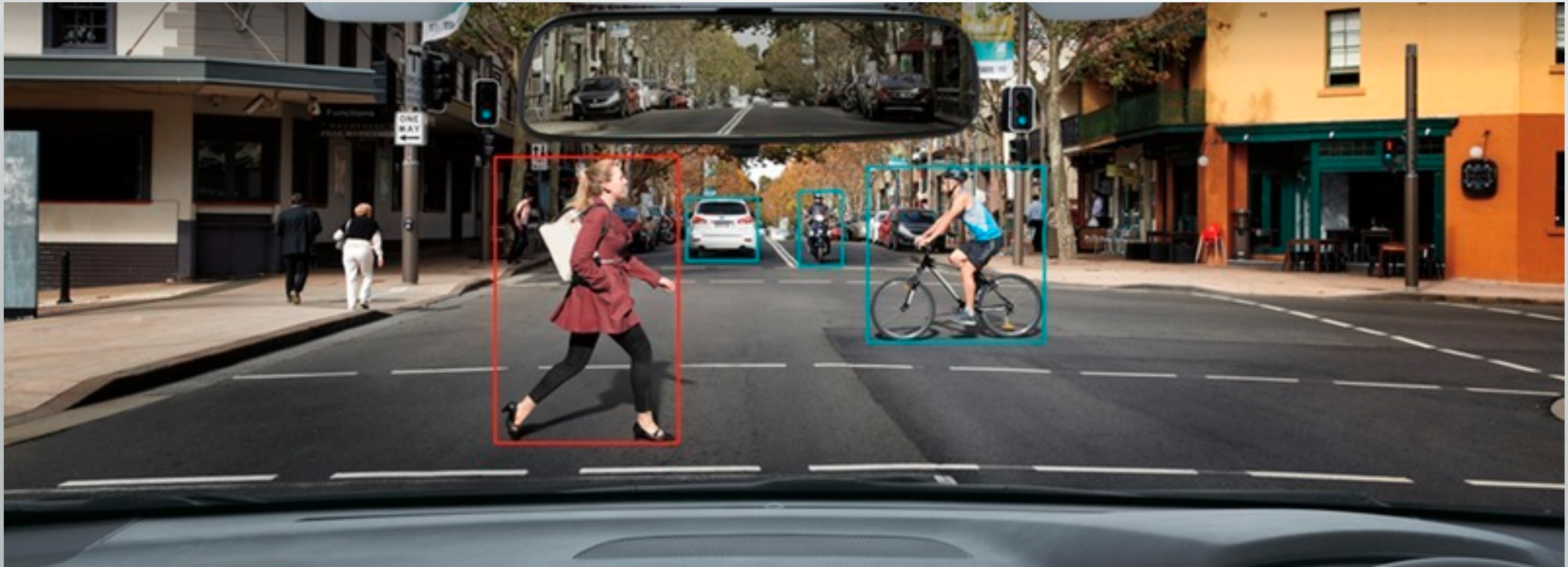




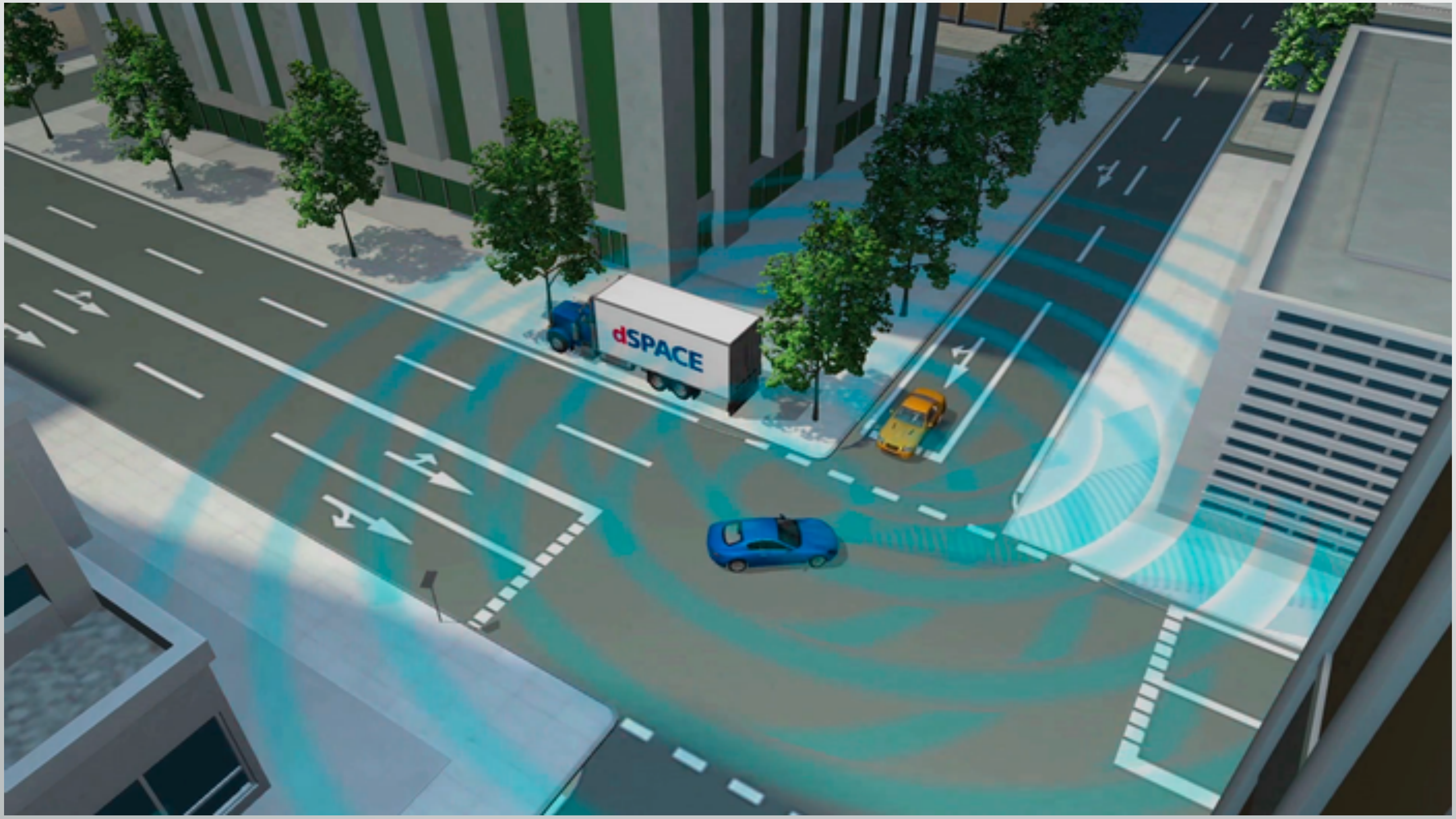
Forward Collision Avoidance



Forward Collision Avoidance



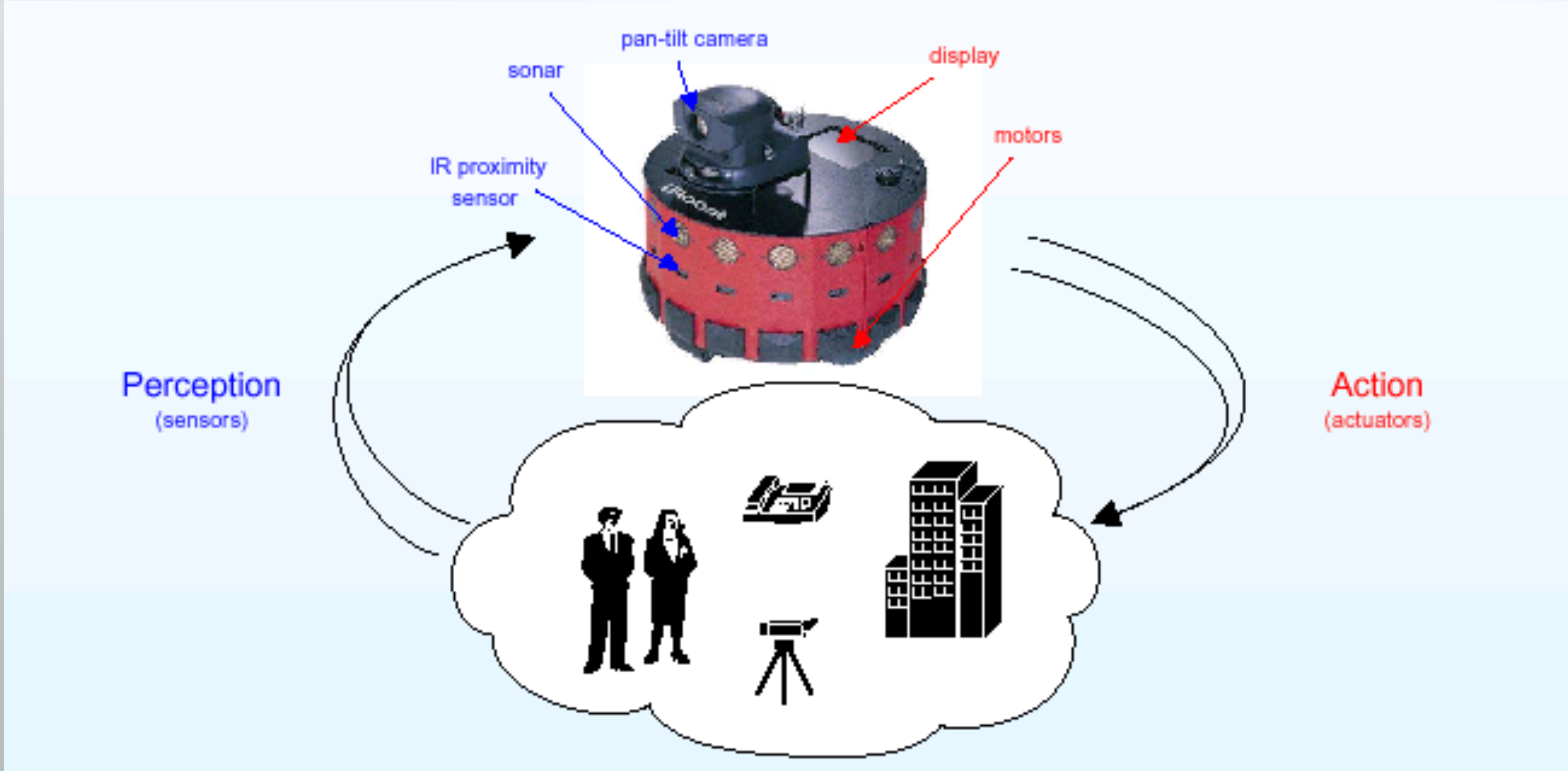
Intersection Assistant



Autonomous driving functions

An autonomous car is a robot (autonomous)

Autonomous robot



Onboard a robot sensors are needed

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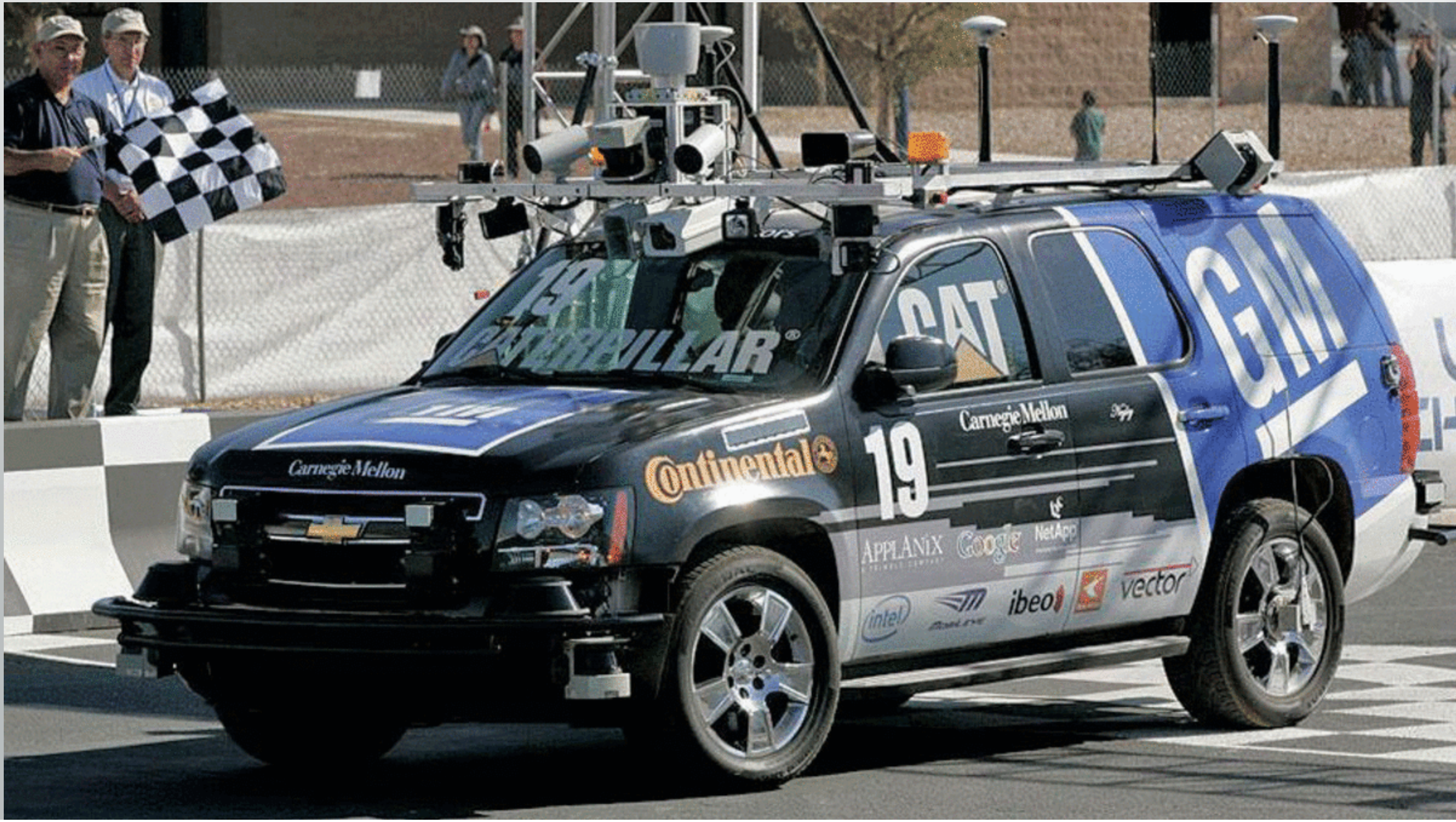
There are indeed a lot of sensors!



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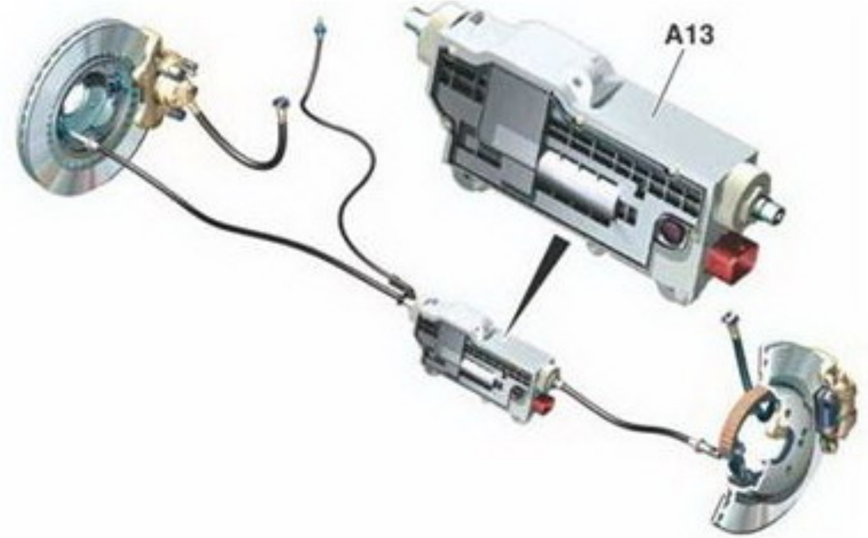
Stator
Wheel Bearing
Rotor
Vehicle Suspension
Coils & Power Electronics/
Micro Inverters
Conventional Alloy Wheel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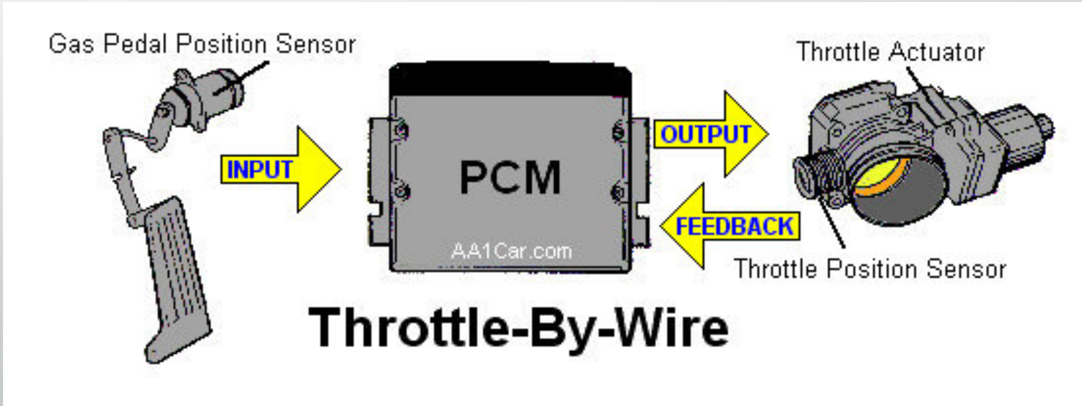
Gas Pedal Position Sensor
INPUT
PCM
AA1Car.com
OUTPUT
FEEDBACK
Throttle Actuator
Throttle Position Sensor
Throttle-By-Wire

Stator
Wheel Bearing
Rotor
Vehicle Suspension
Coils & Power Electronics/
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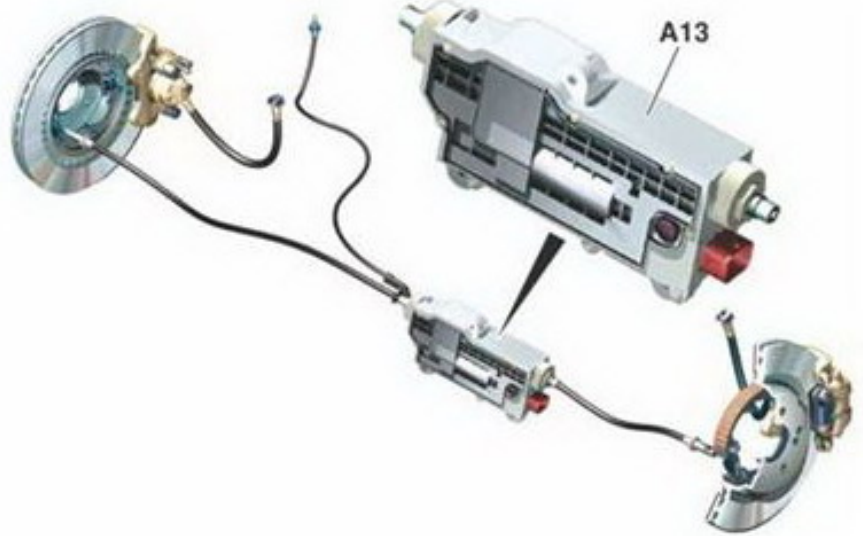

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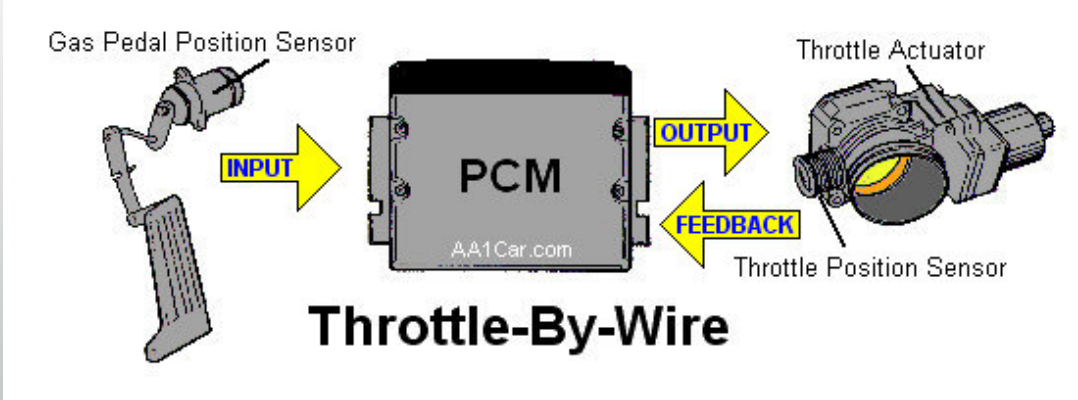

Gas Pedal Position Sensor
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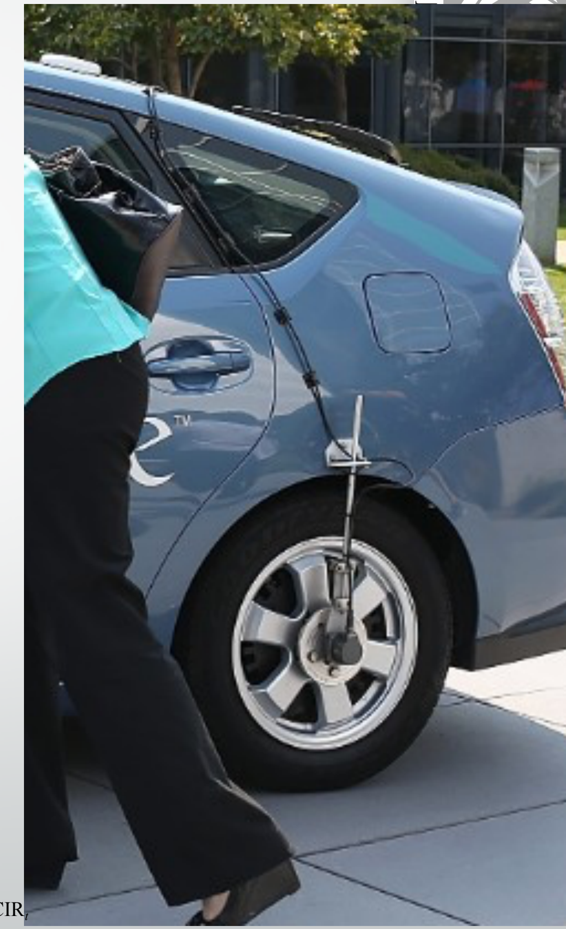
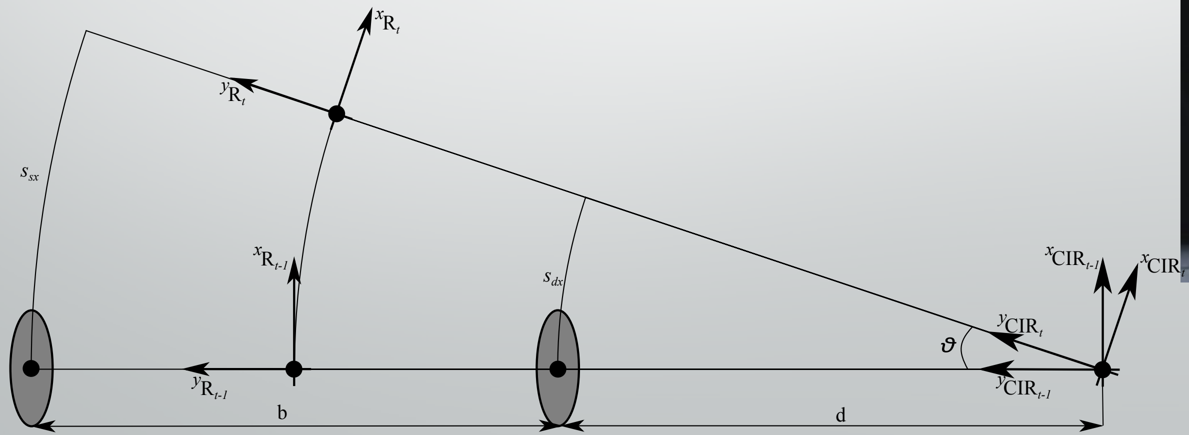
Perception

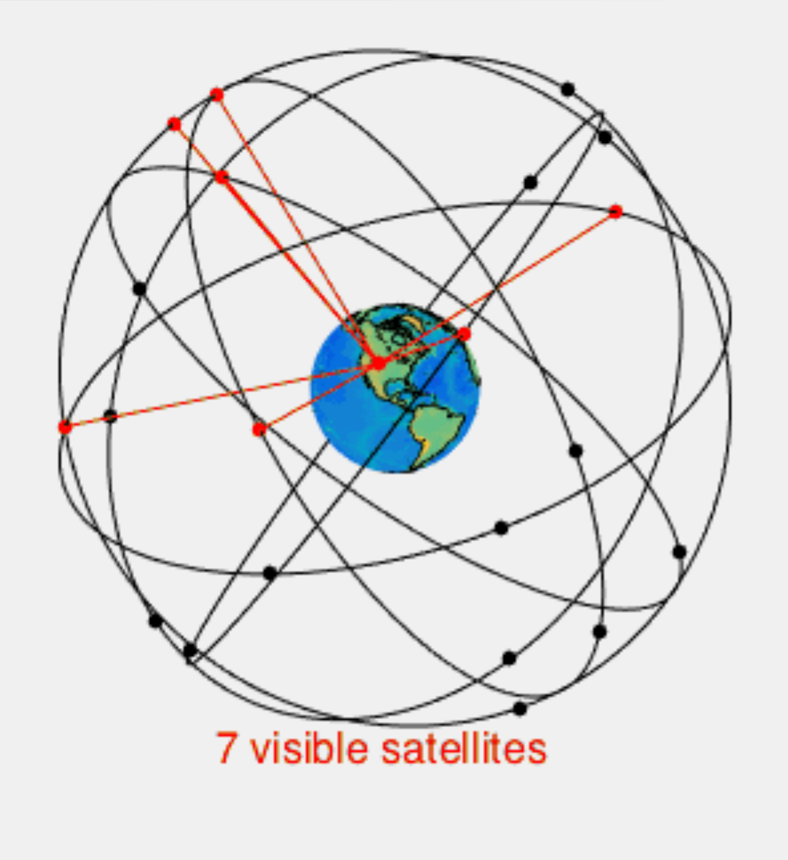
- Simplest idea for localization: proprio-perception.
- Position estimation based on proprio-percetion is not enough.
- Global localization by GNSS.
- Global localization by GNSS is not reliable enough.
- The vehicle is not alone, other objects need to be perceived.
- Sensors for observing the world outdside the robot (car), for both localization and world modeling.

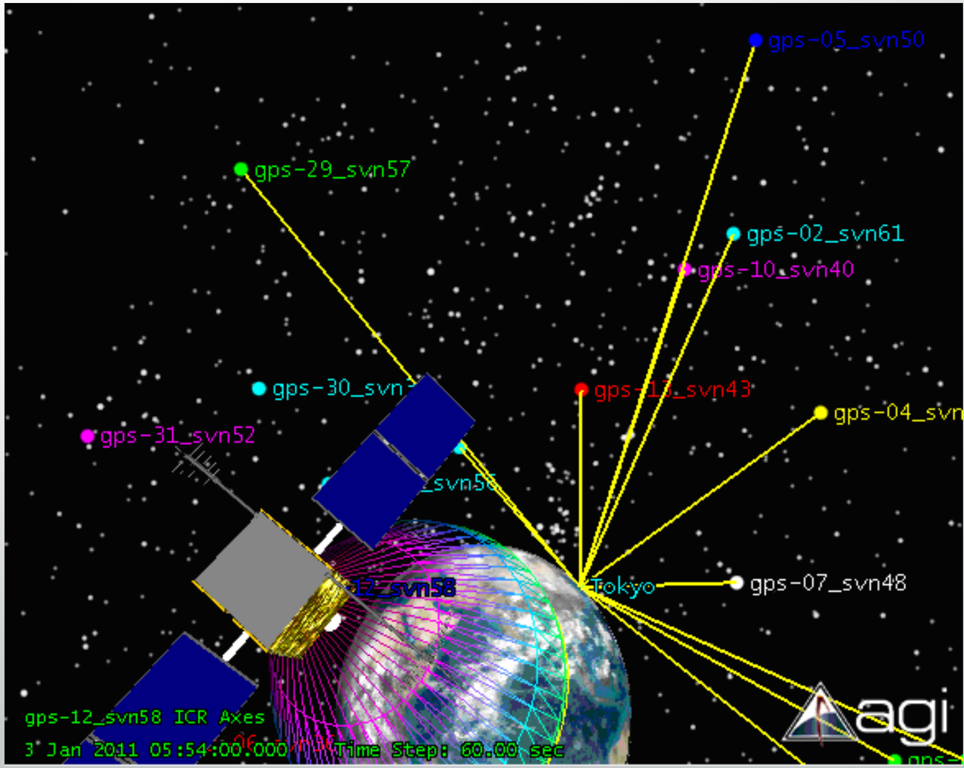
Proprioperception of motion





GNSS: GPS, Galileo, Glonass, Beidu





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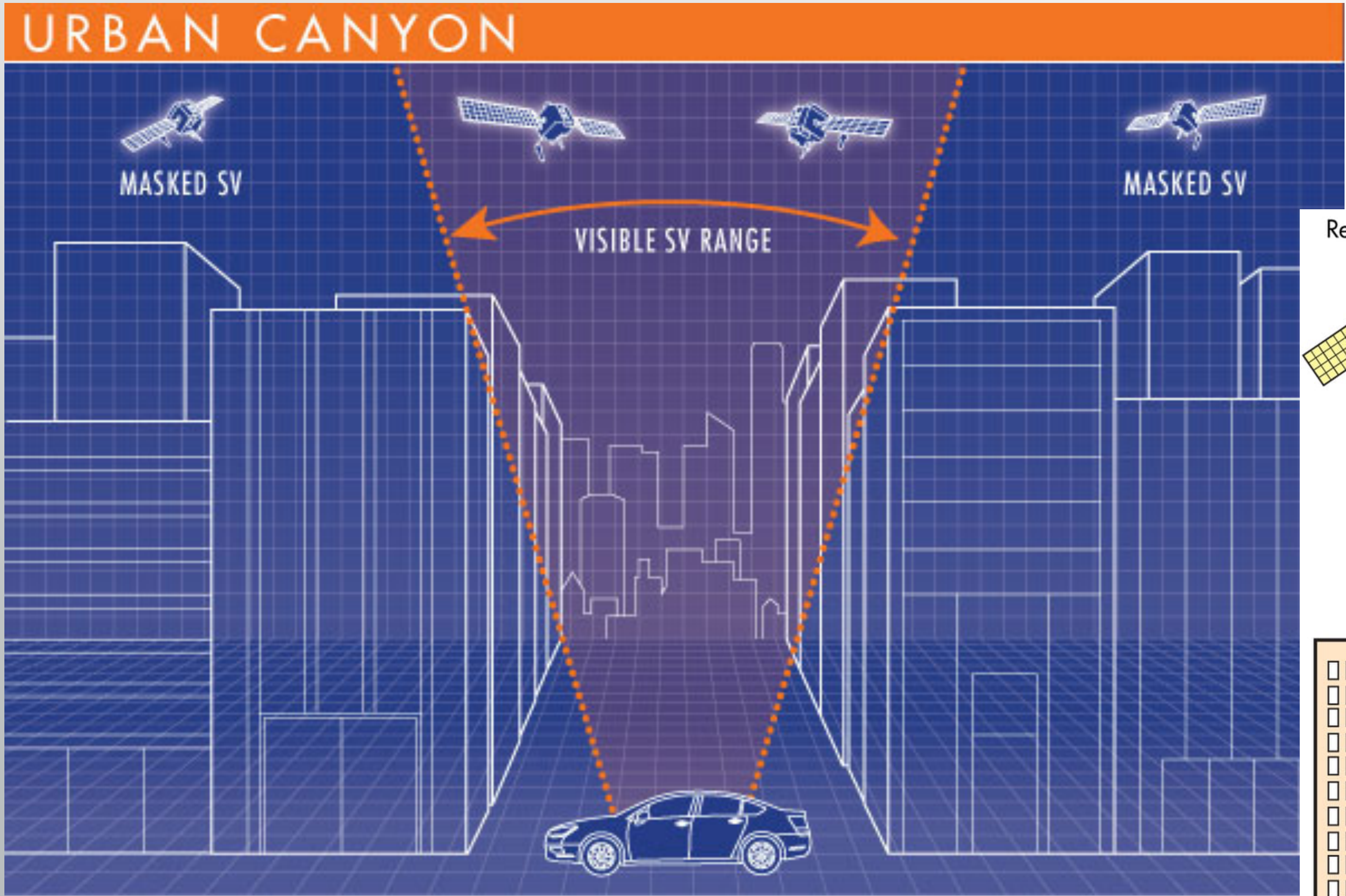

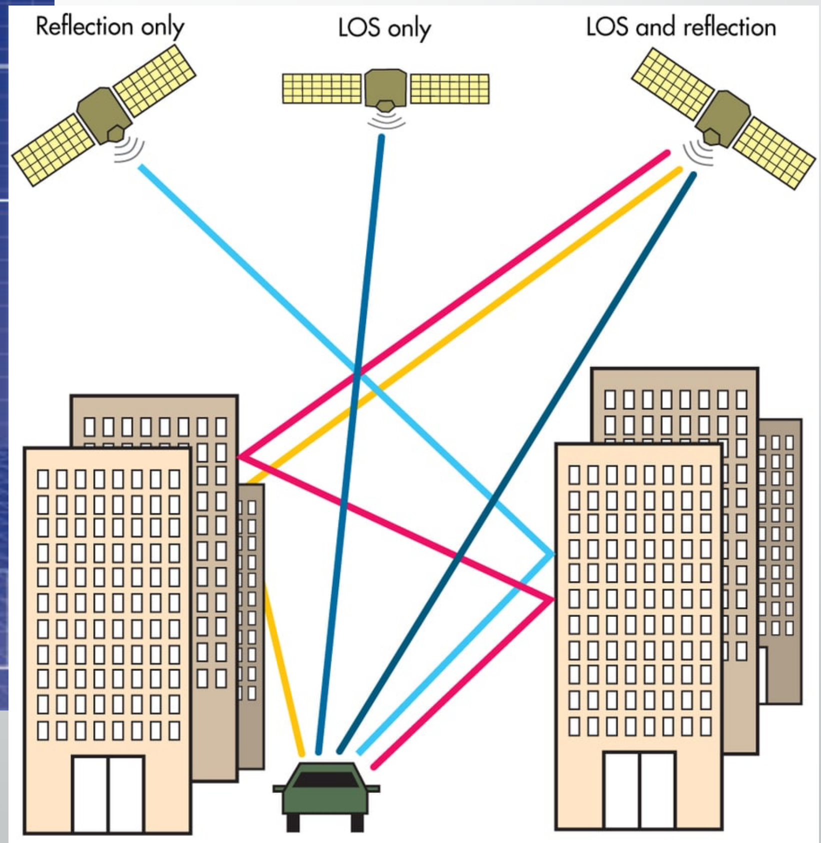

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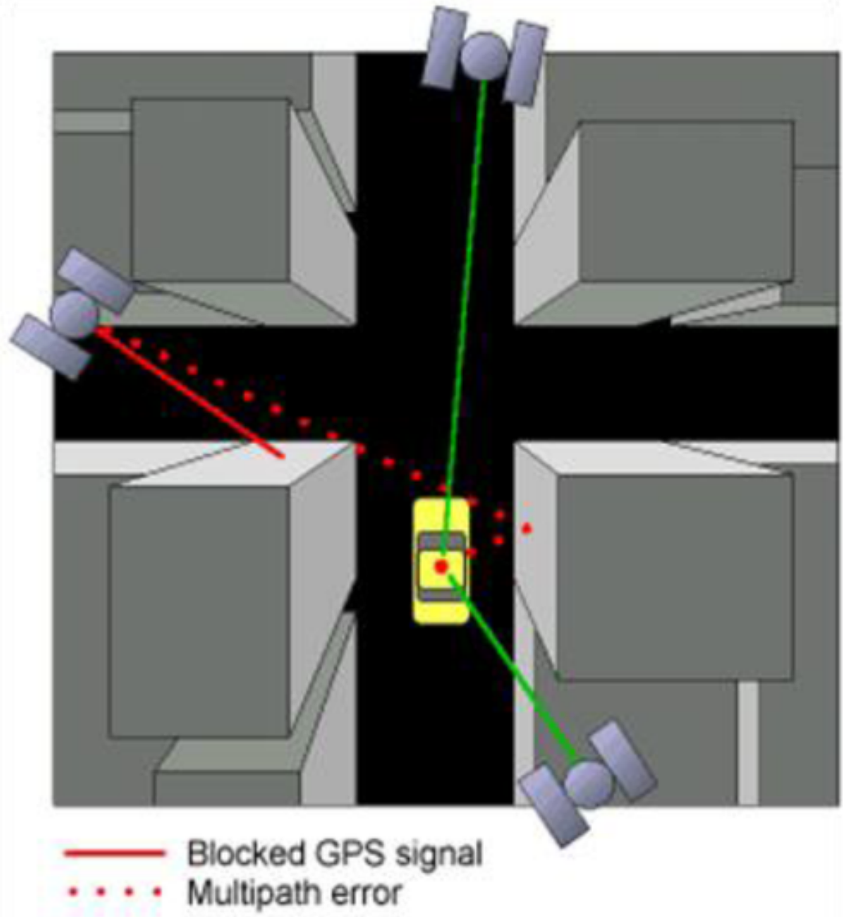
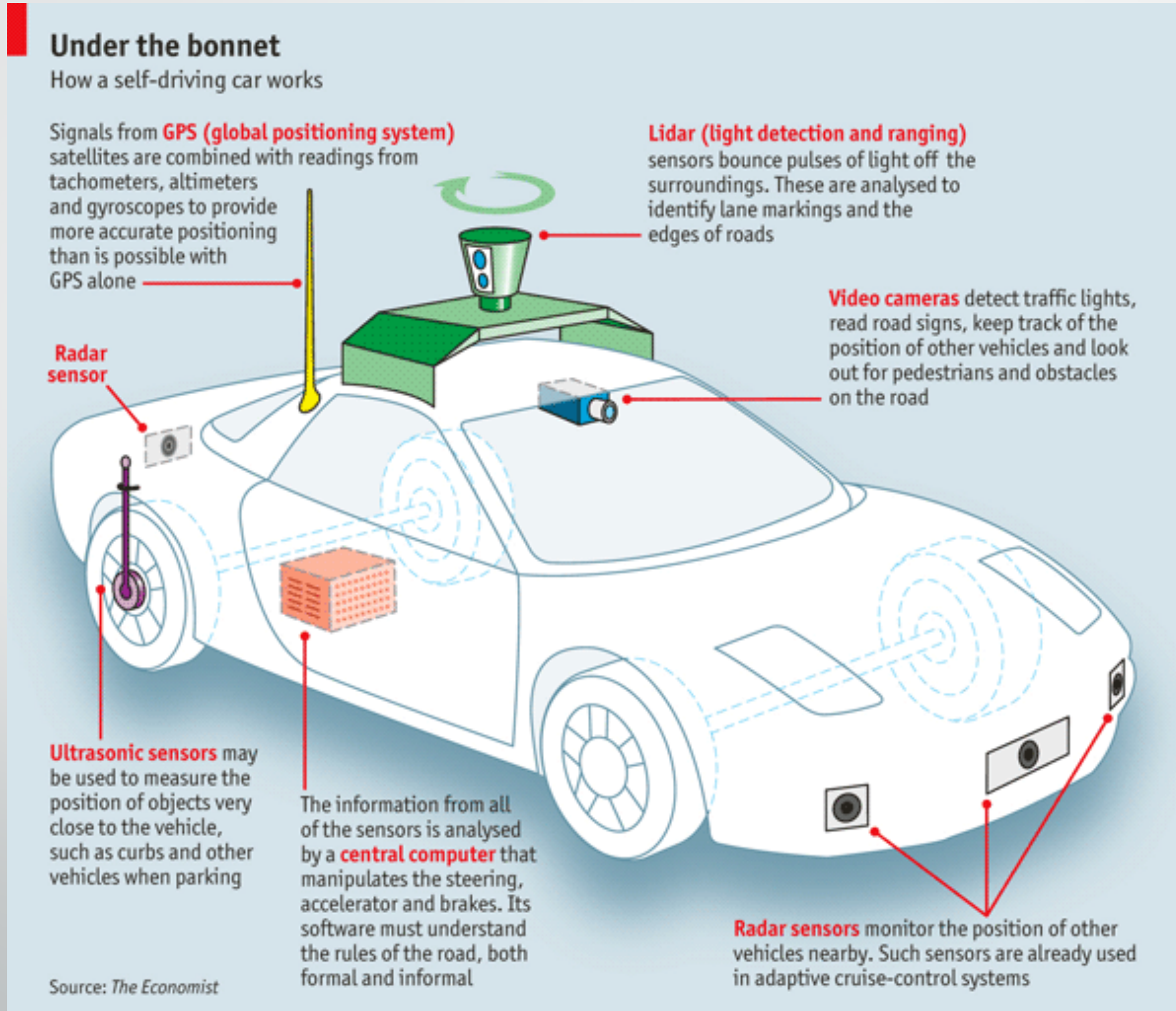
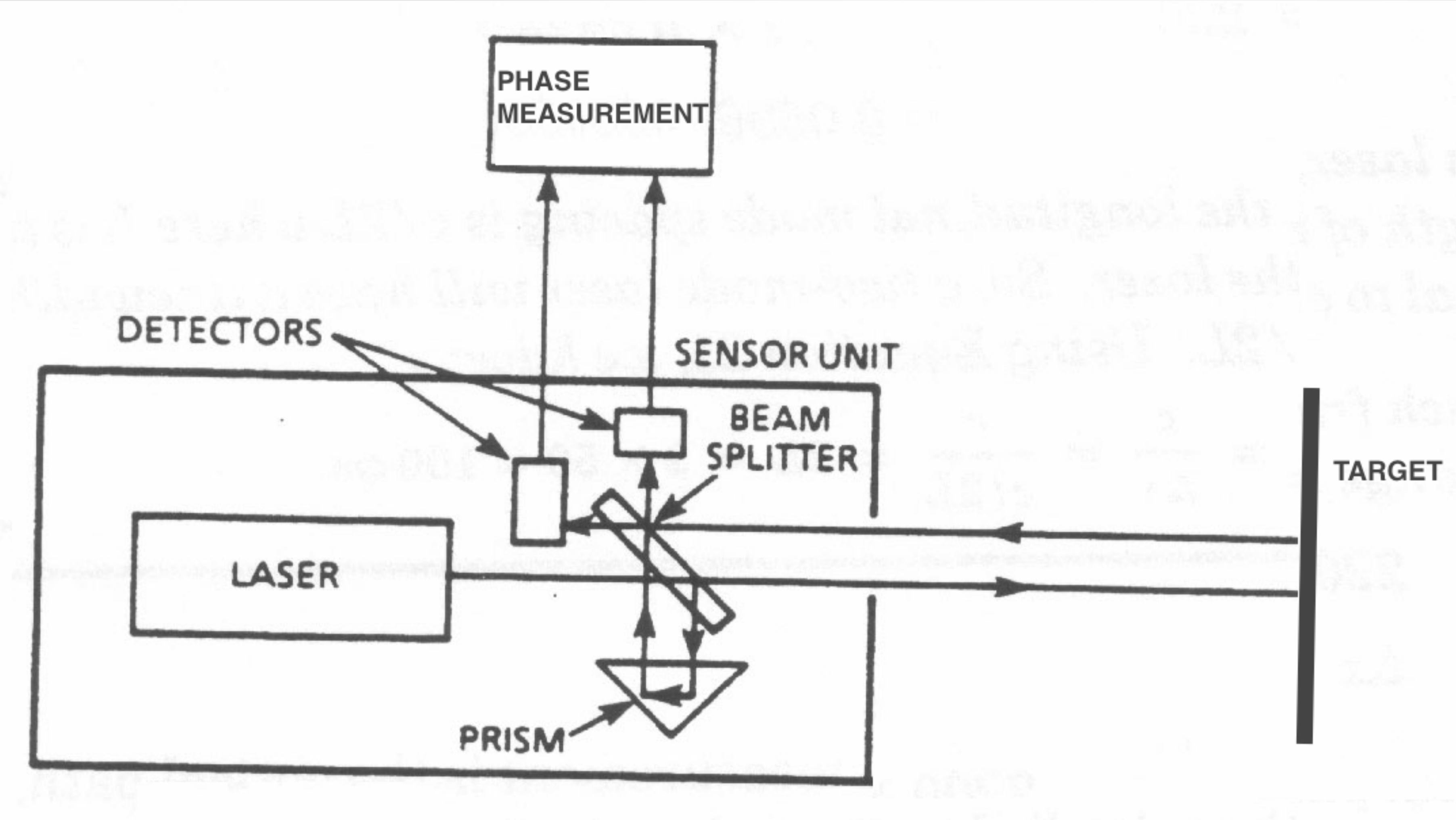


Most used sensors

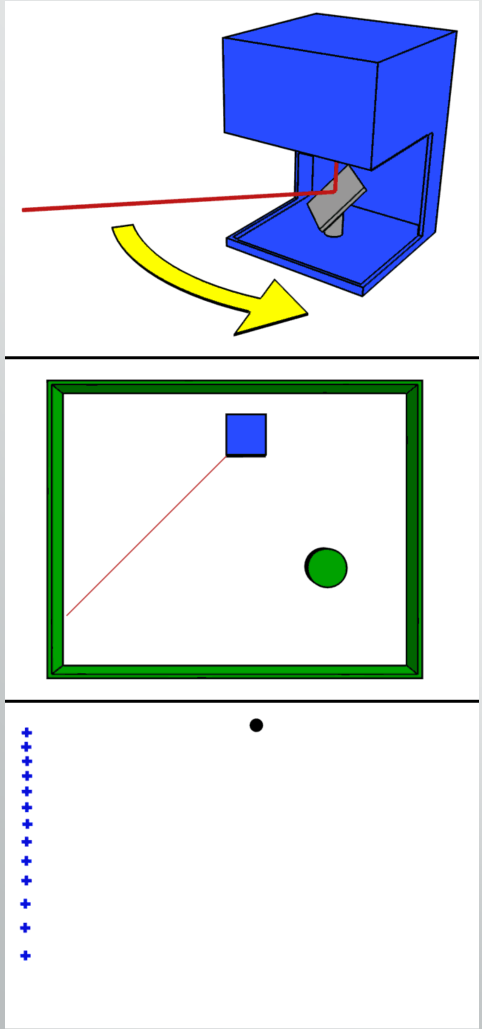
- RADARs
- LIDARs
- Cameras



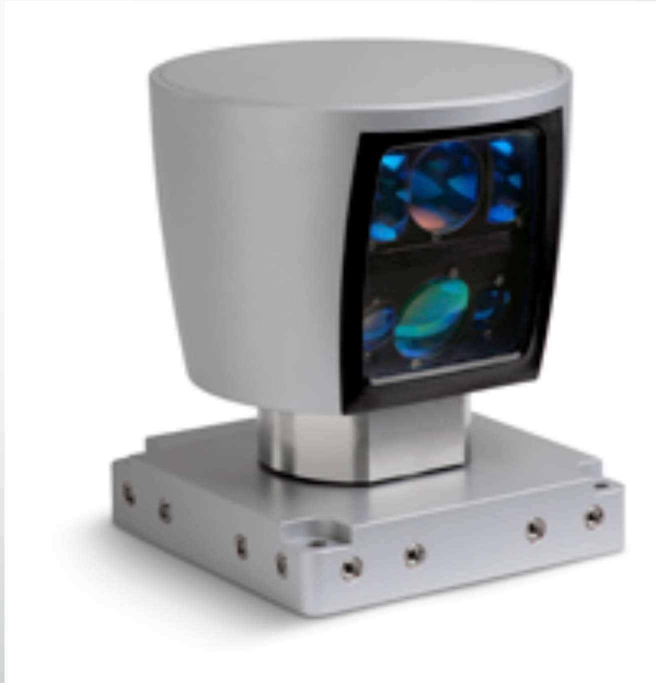
Physics of LIDARS



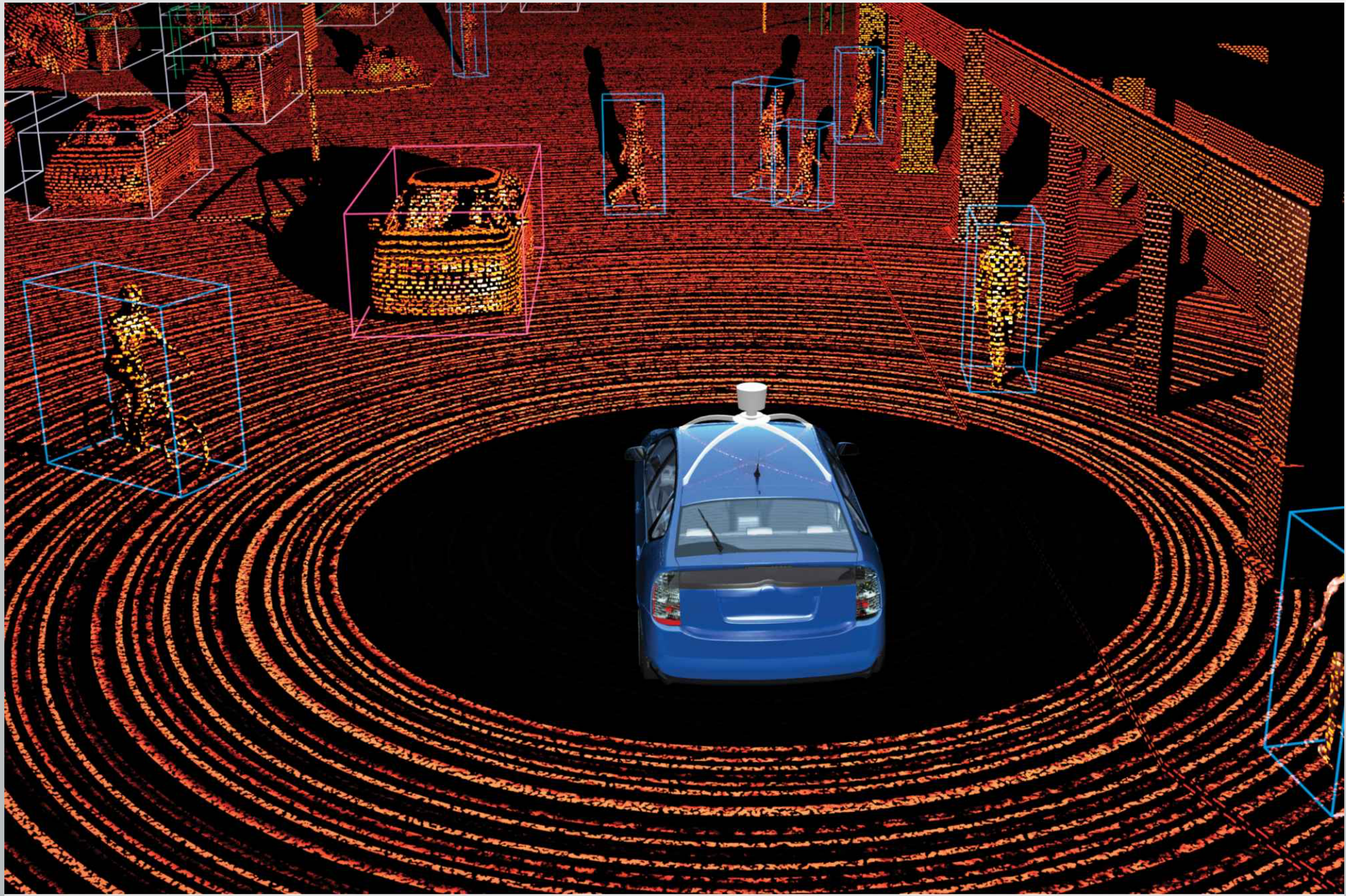
Physics of LIDARS

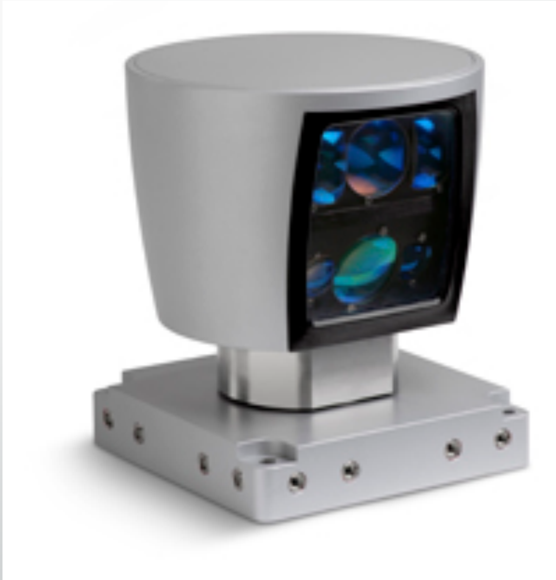


- Beam steering
  - Solid state (phased array)
  - MEMS mirrors



LIDARS

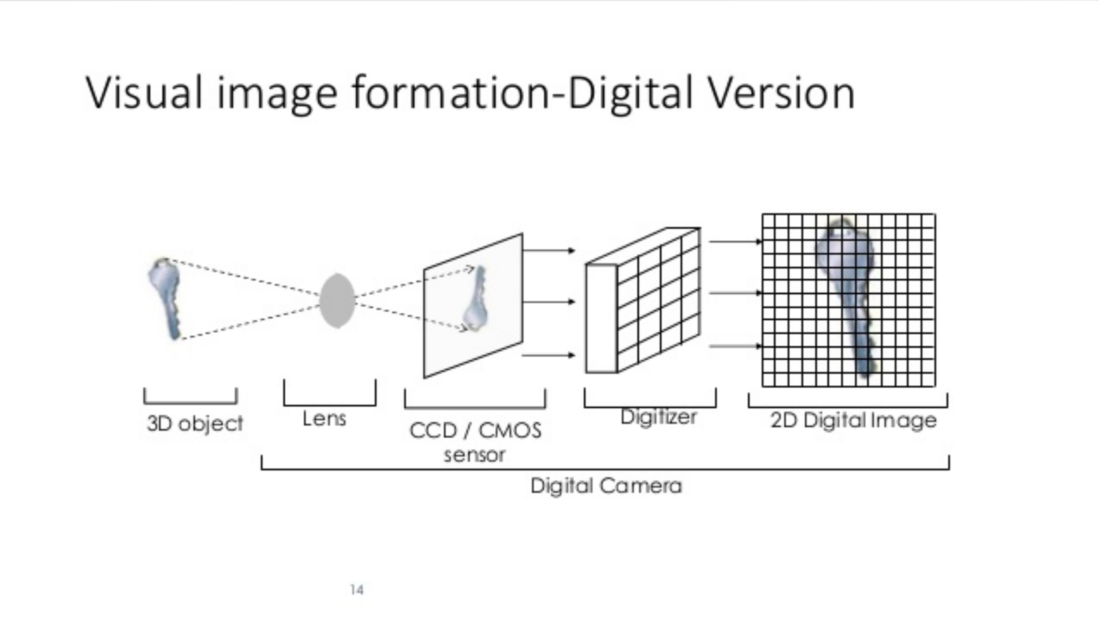


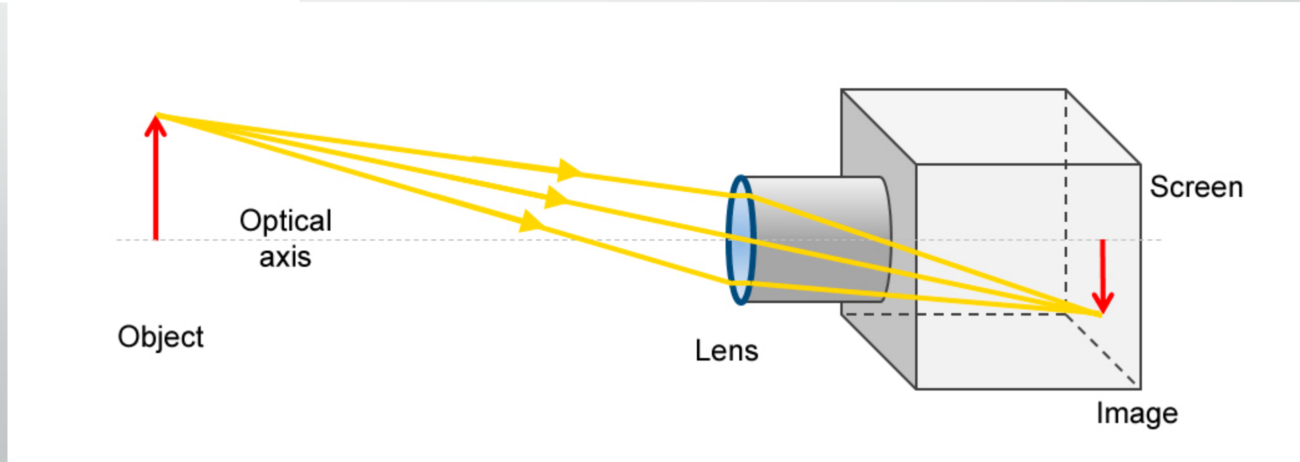


LIDAR defects

- Echo is too attenuated (light absorbed in the target)
- Echo is too attenuated (light reflected somewhere else by the target)
- Echo comes from a multi-path reflections, bringing-in crazy measures
- Unexpected obstacle (for localization)

Physics of cameras





Camera defects

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

Smearing (blooming)

- Sensor
  - Smearing
  - Not enough dynamic range
  - Defective pixels
  - Etc.
- Lenses
  - Chromatic aberrations
  - Geometric distorsions
  - Vignetting
  - Etc.

How to deal with all these complications?

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Correct model of the probability of each error

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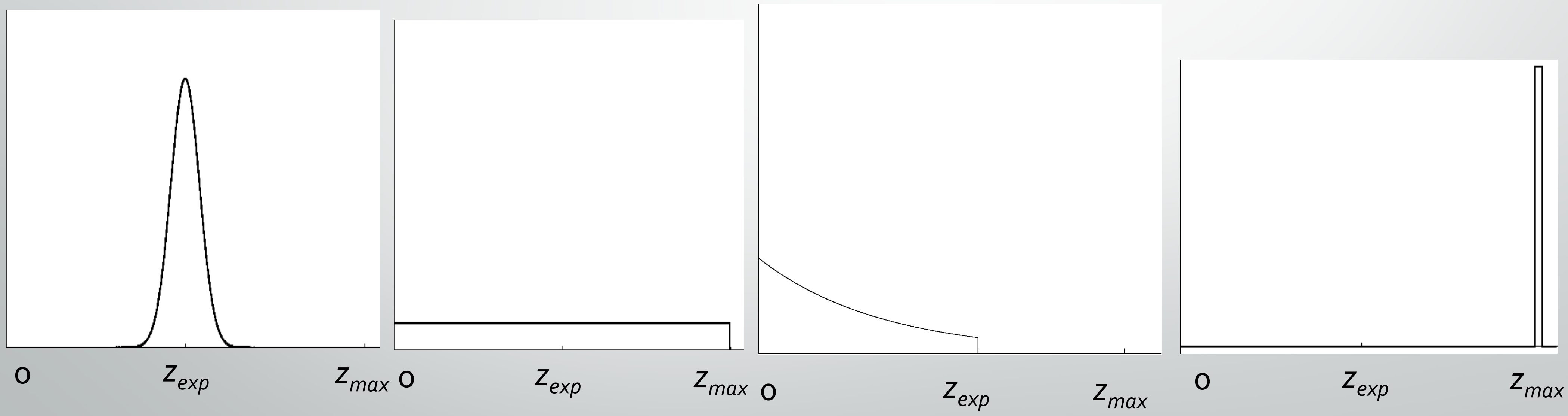
Correct model of the probability of each error

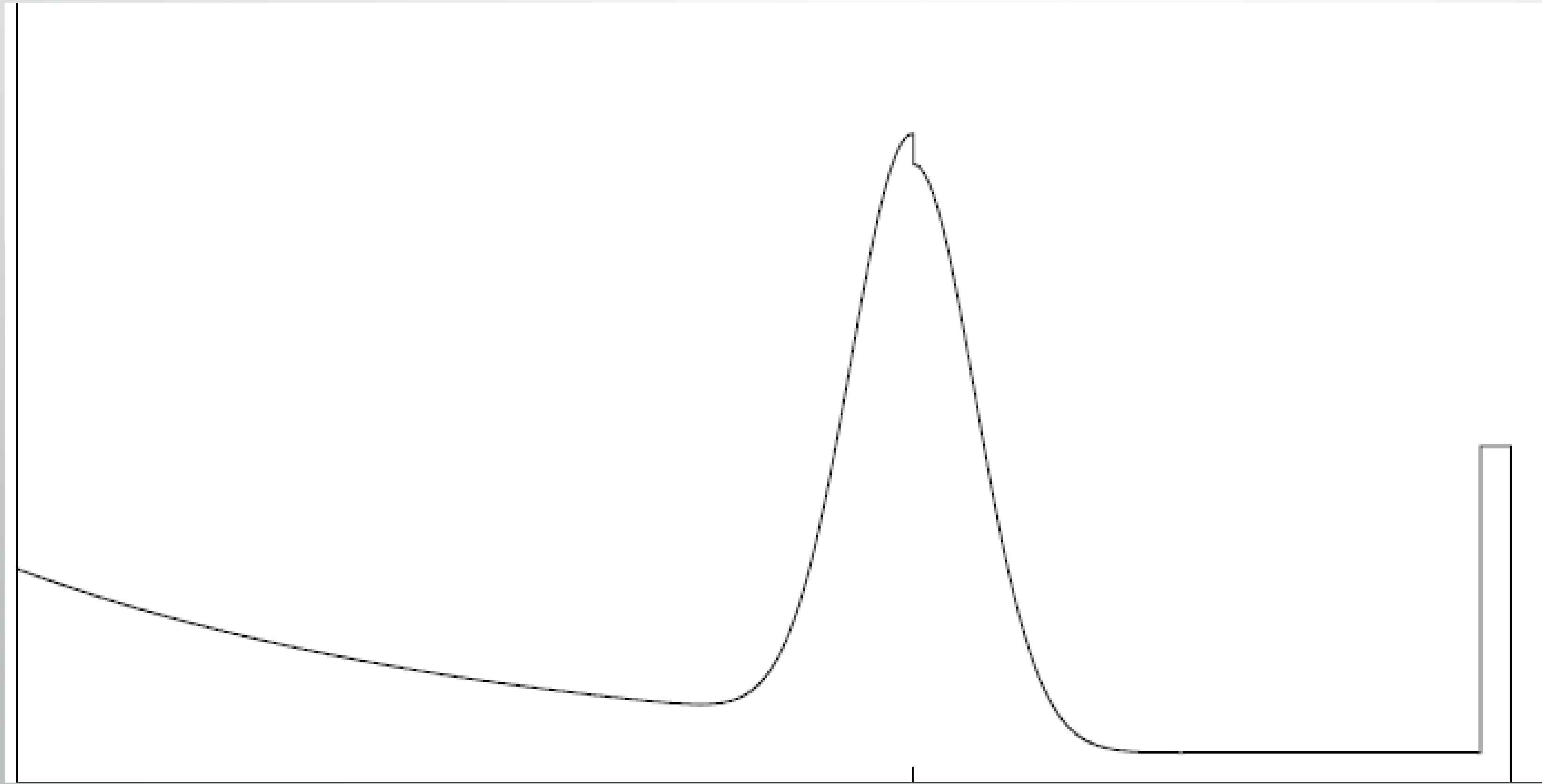
RANGE MEASUREMENTS



How to deal with all these complications?

Correct model of the probability of each error

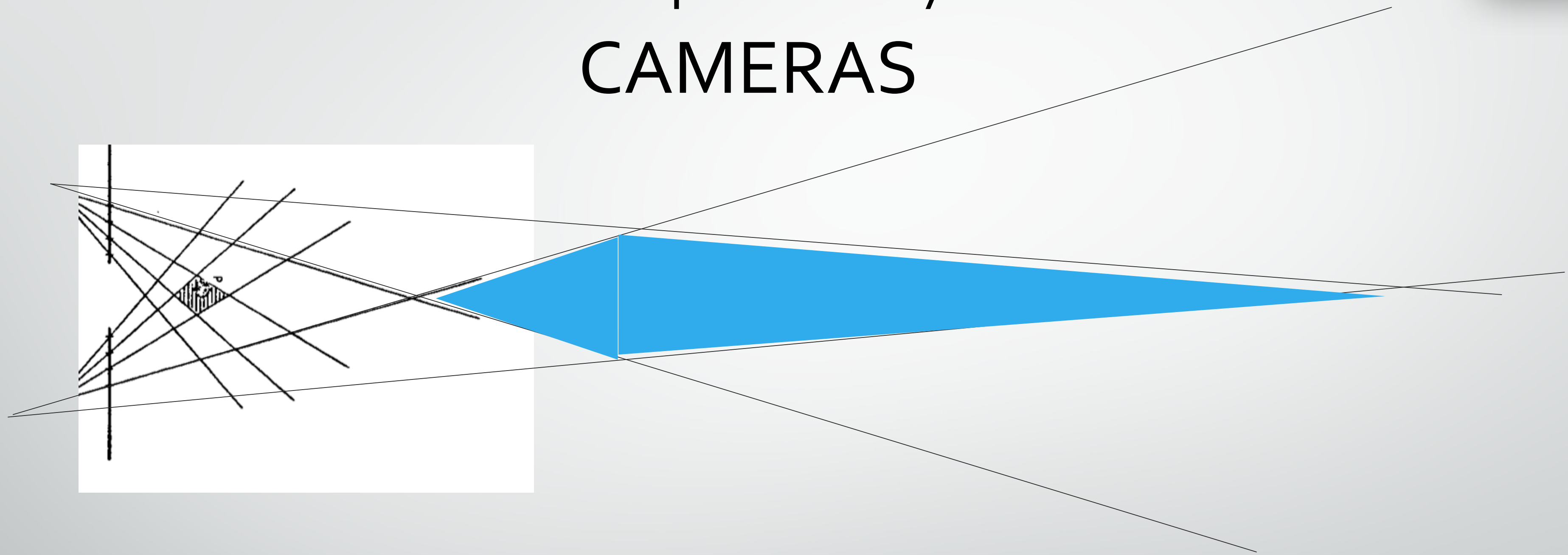
RANGE MEASUREMENTS: BEAM MODEL



How to deal with all these complications?

Correct model of the probability of each error

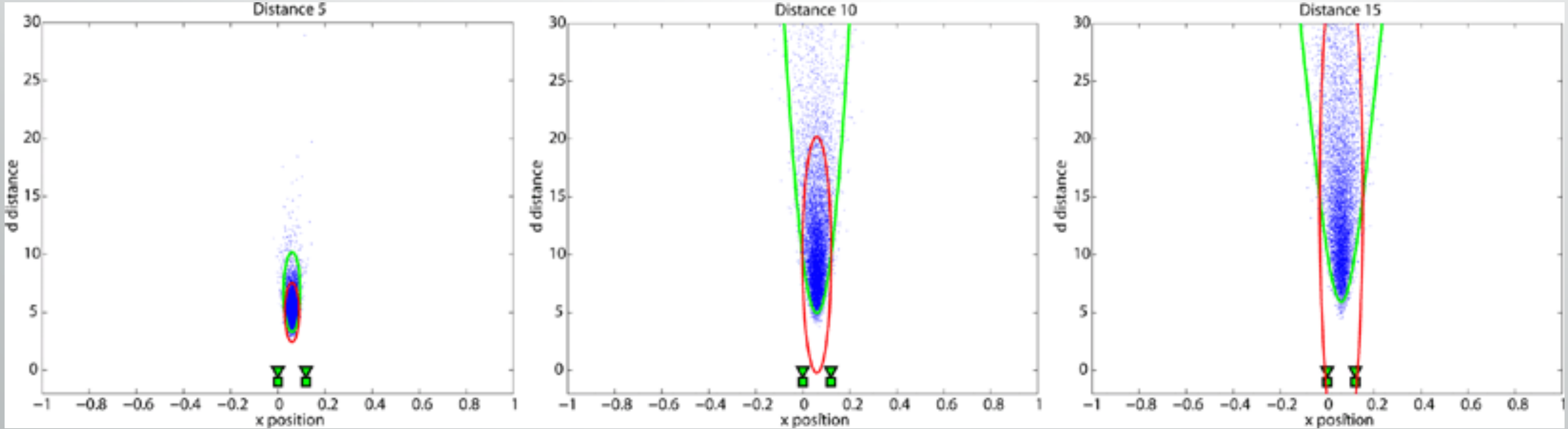
CAMERAS



How to deal with all these complications?

Correct model of the probability of each error

CAMERAS



THANKS FOR YOUR ATTENTION