Welcome to our study!

Our study consists of two parts:

1. **Mandatory training and test (today)**
2. **Drive in our large simulator (in 3-5 weeks)**

The aim of the study is to improve our self-driving technology.

In near future…

… fully self-driving cars will be available for everyone.

For our study we ask you to **imagine** that you're at a car dealership today and just bought a self-driving car. Now you need to finish a mandatory training & test for owners of self-driving cars.

In 3-5 weeks (second session) you will come back to pick up your vehicle and enjoy your first ride home.

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THANK YOU FOR PURCHASING A SELF-DRIVING CAR TODAY!

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Contribute to a greater good

This technology can potentially save the lives of millions

- In fact, if about 90% of cars on American roads were self-driving, the number of accidents would fall from 6 million a year to 1.3 million.

Improved traffic and fuel efficiency

- Self-driving cars may result in fewer cars on the road (more shared driving, more effective fleet coordination).

Good for the environment

- Optimized efficiency in acceleration and braking helps improving fuel efficiency and reducing carbon emissions (300 million tons less CO2 emissions per year, according to McKinsey).

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FEDERALLY MANDATED TRAINING

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Why do you need training?

New federal regulations require buyers of self-driving cars to do a standardized training as an add-on to your existing driving license.

The purpose of this theoretical and practical training is to help you understand how self-driving cars work and how to operate them.

Once you pass the test after the training you will be ready to go!

Content

1. HOW DOES YOUR SELF-DRIVING CAR WORK?
    a. LOCALIZATION
    b. PERCEPTION
        Lidar
        Radar
        3D Cameras
    c. DATA FUSION

2. HOW TO OPERATE YOUR SELF-DRIVING CAR

3. SAFETY
    a. Technical Fails
    b. External problems

1. HOW DOES YOUR SELF-DRIVING CAR WORK?

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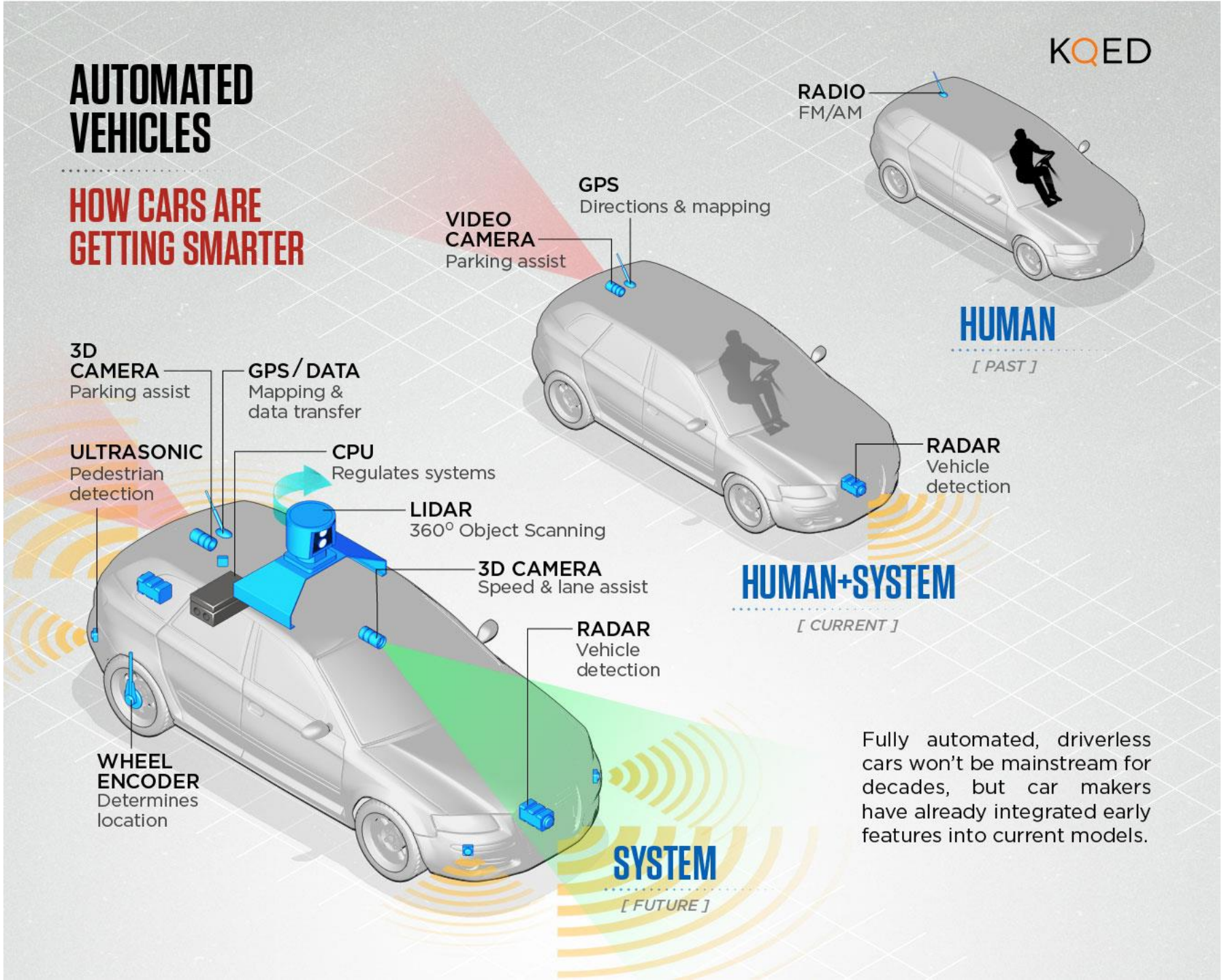
Perception & Localization

The two most important capabilities of a self-driving car are:

Localization:
High-fidelity maps help your car to locate itself in the world, and plan a route to your destination. This is information about the *static* features of its environment.

Perception:
Different sensors perceive the car's environment to make sure that your car navigates in a correct manner. This is mostly information about the *dynamic* features of its environment.

a. LOCALIZATION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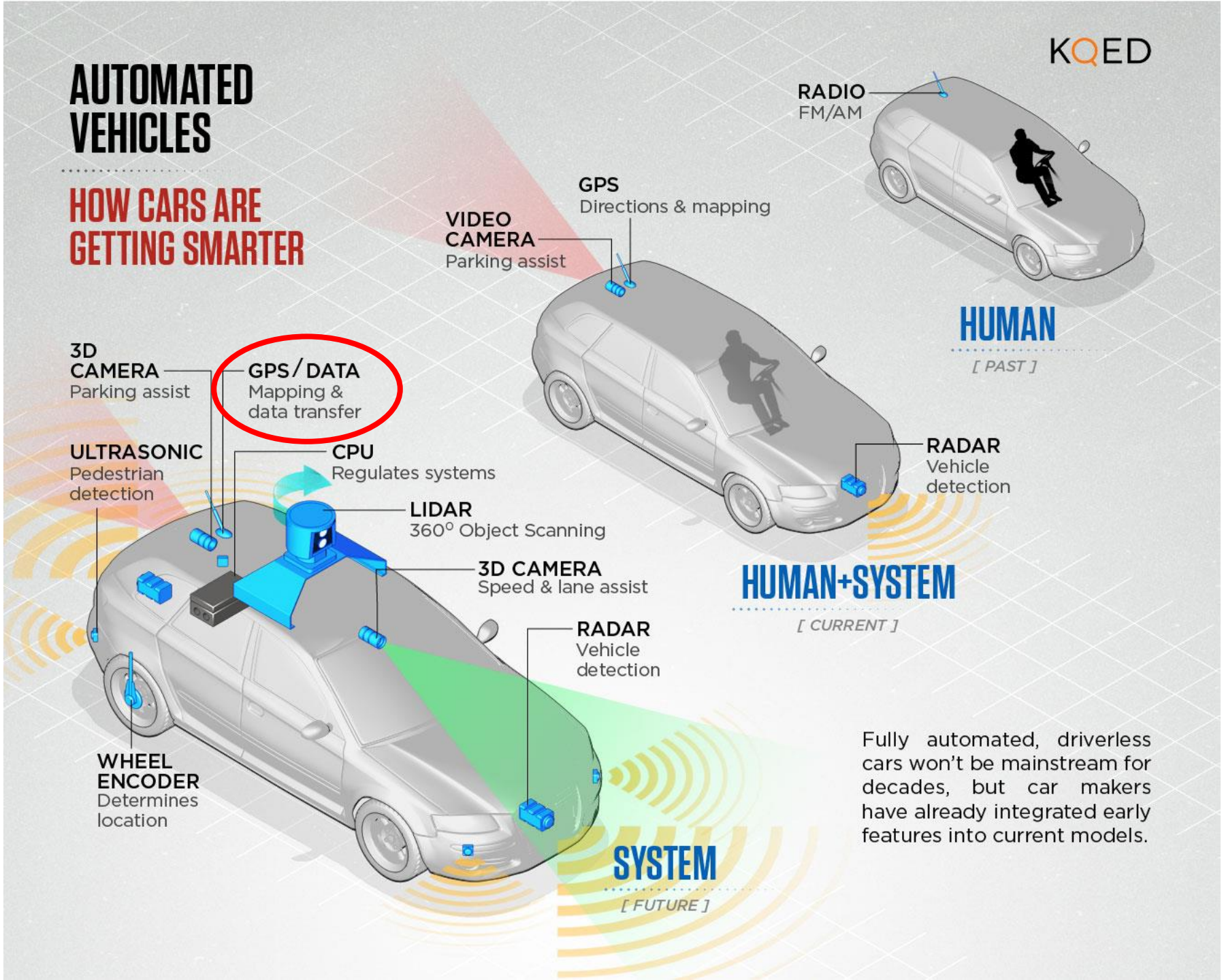
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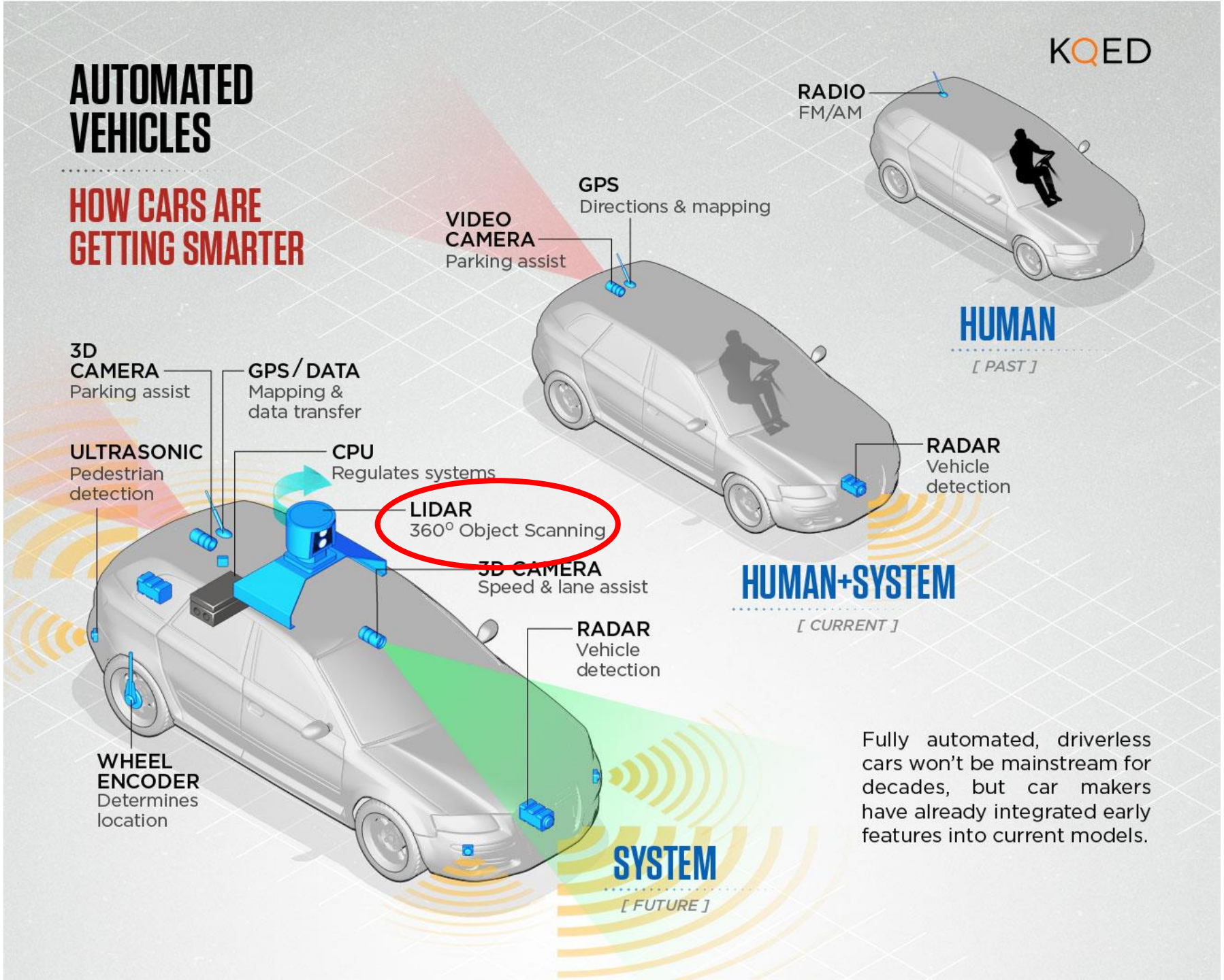
GPS provides Localization

- GPS uses distances from satellites to provide global position
- It requires line of sight to at least 3 satellites
- The atmosphere affects accuracy. As a result, the true position may be not exact. This is why GPS data are fused with other sensors to increase accuracy.

b. PERCEPTION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Perception: Lidar

Lidar is the master of 3D mapping

- Short for **Li**ght **D**etection **A**nd **R**anging
- 360 degree vision
- Generates a precise 3D map of the car's surroundings
- This information is then used by the car to make intelligent decisions about what to do next

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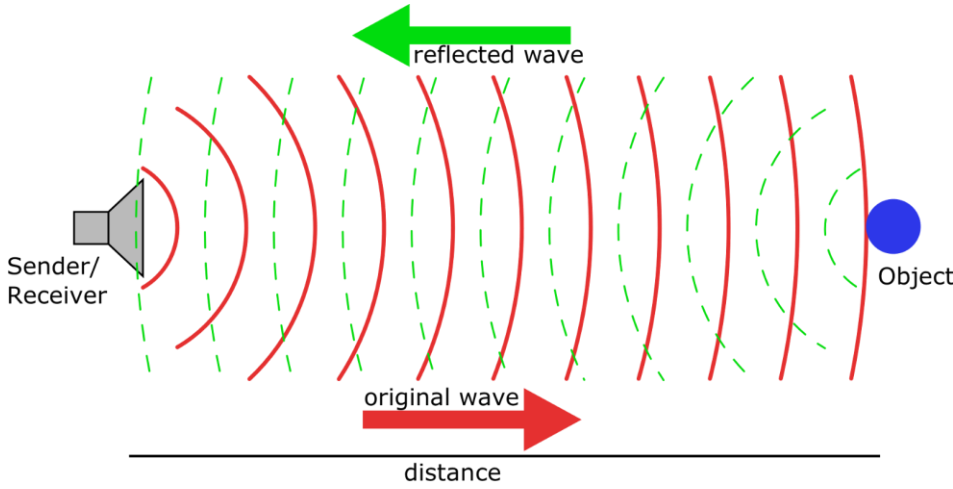
Perception: Lidar

Lidar measures distance using laser light

- LiDAR bounces a laser off an object at an extremely high rate—millions of pulses every second—and measures how long the laser takes to reflect off that surface. This generates a precise, three-dimensional image of the object, whether a person, vehicle, aircraft, cloud, card box, or mountain.
- Always knows the precise distance (to an accuracy of ±2 cm) of objects in relation to you
- Can scan up to 200 meters in all directions



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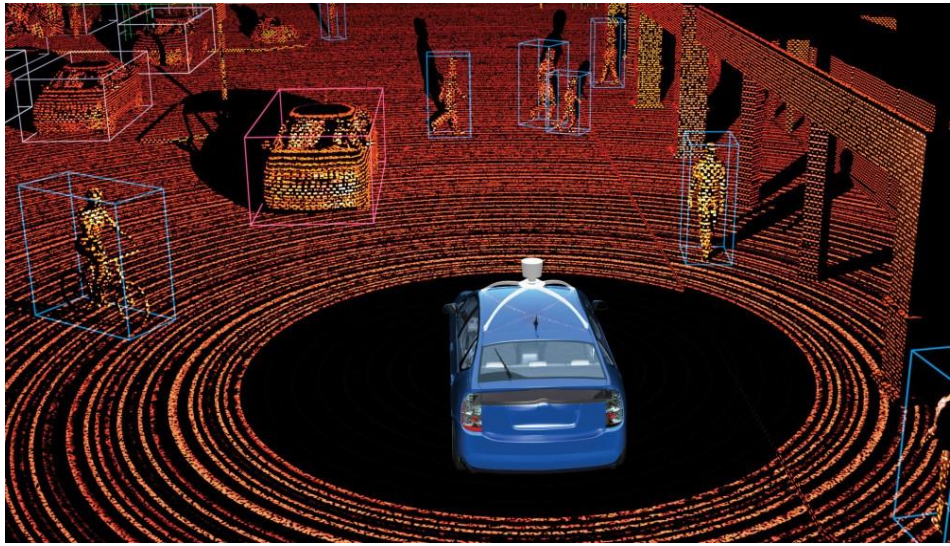
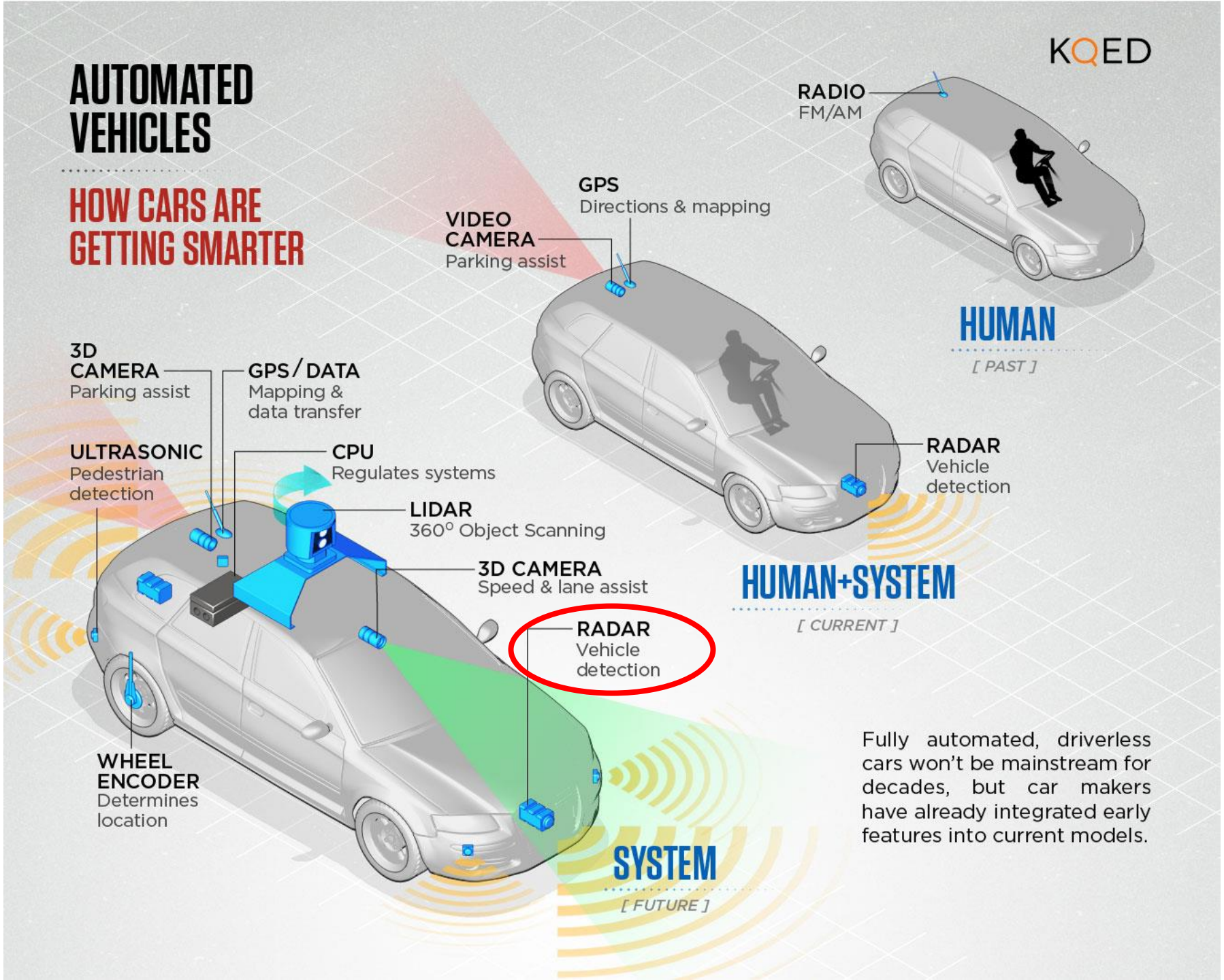
Perception: Lidar

The Lidar maps the 3D environment

- Modern LIDAR technology makes it possible to recognize a variety of objects such as other cars, bikes, pedestrians or lane markings, traffic lights etc.
- Traveling at 75 mph on the freeway, this system has the resolution to translate into a picture that would give a self-driving car a full seven seconds to respond to something it's approaching.

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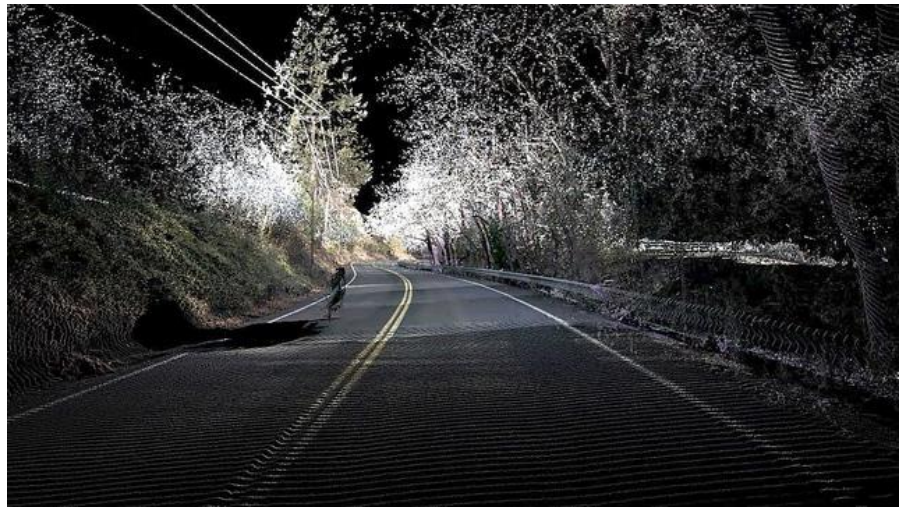
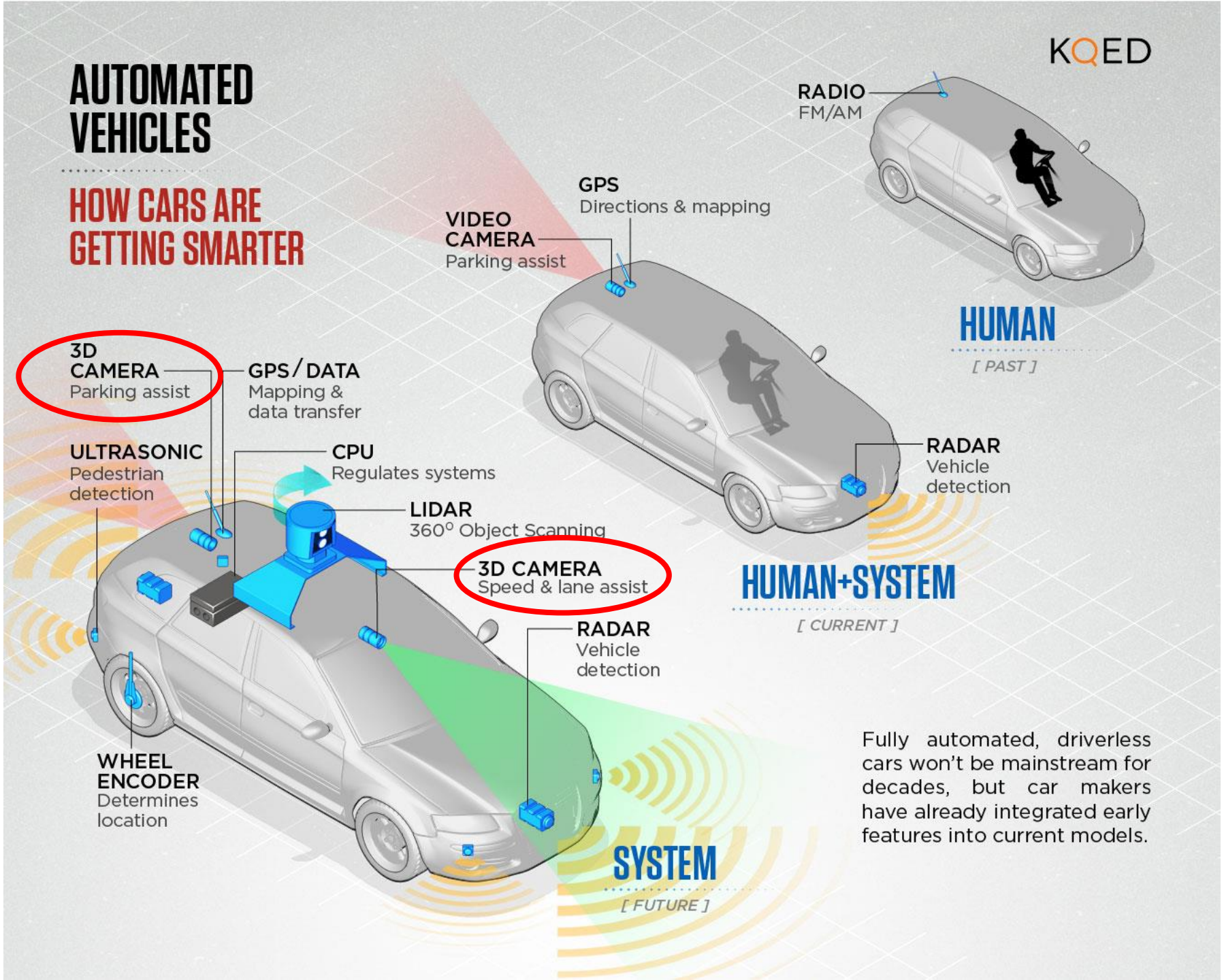
Perception: Radar

Radar is the master of motion measurement

- Short for **Ra**dio **D**etection **A**nd **R**anging
- Uses radio waves to determine the velocity, range and angle of objects
- Radar is computationally lighter than a camera and uses far less data than a Lidar.
- While less accurate than Lidar, radar can work in every condition and even use reflection to see behind obstacles.

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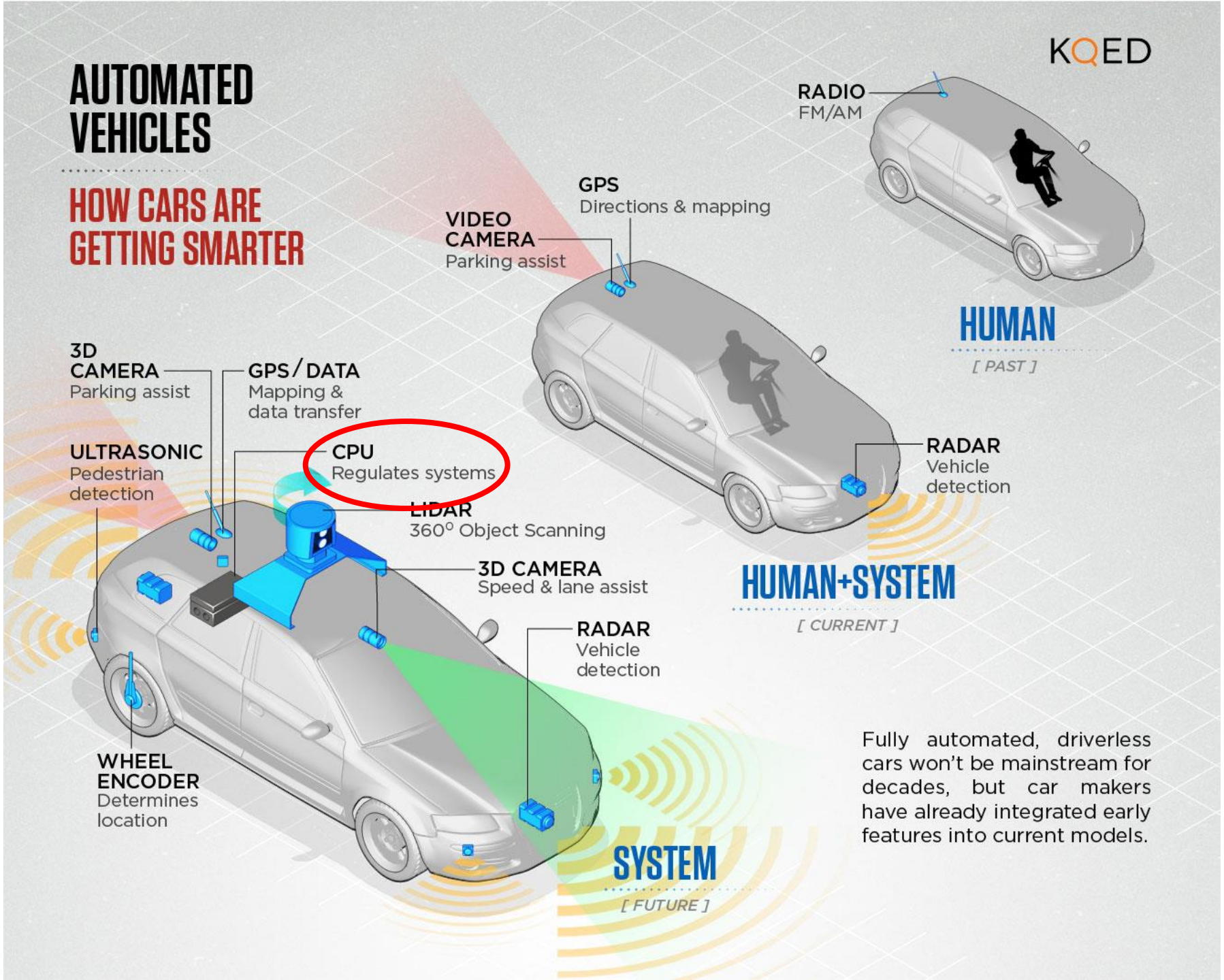
Perception: Cameras

The 3D Camera is the master of classification and texture interpretation

- The cheapest and most available sensor
- Records massive amounts of data, making processing a computationally intense and algorithmically complex task
- Can identify color, thus best for scene interpretation

c. DATA FUSION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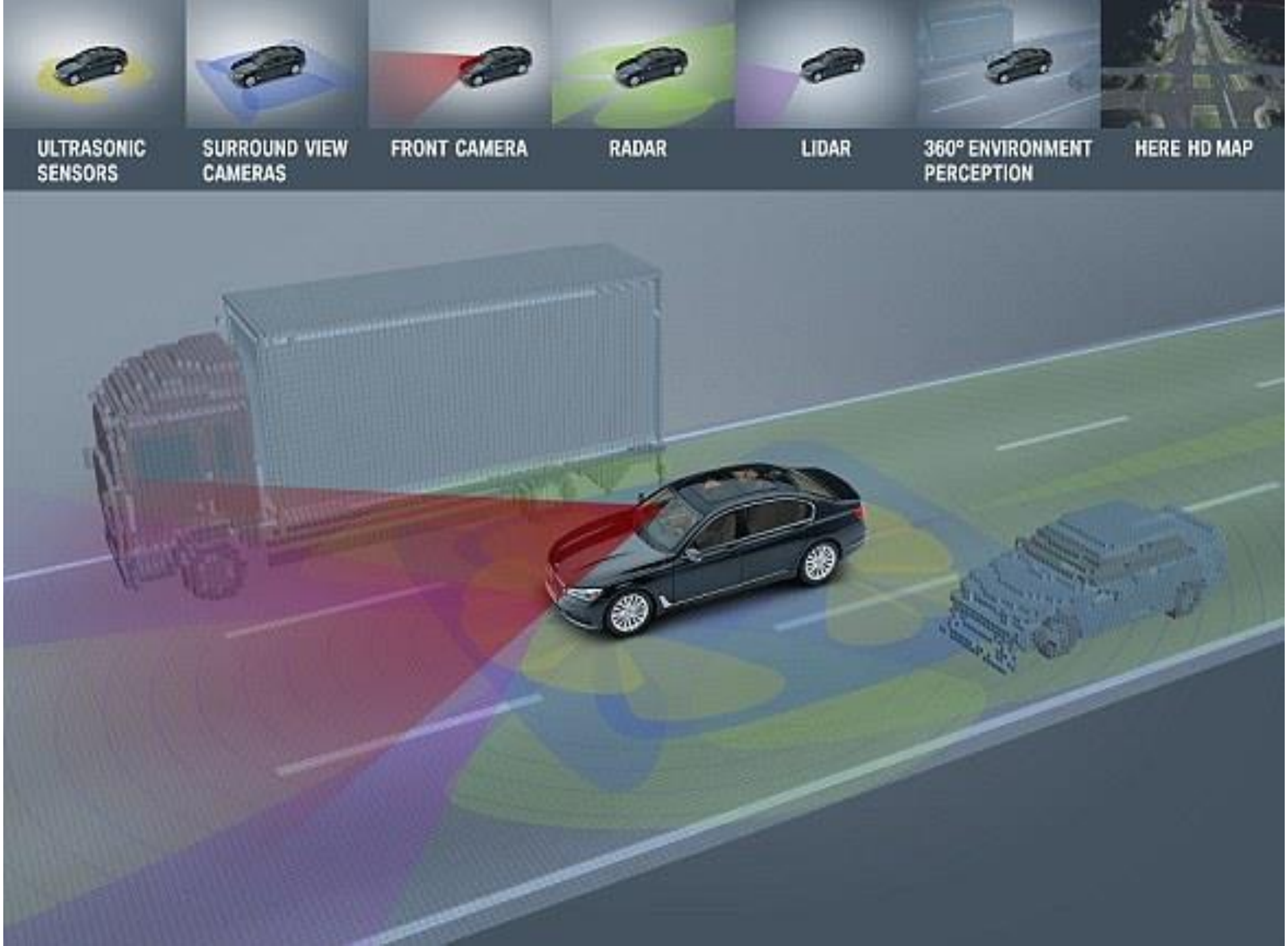
Data Fusion

The data from the systems around the vehicle are fed into a central high performance controller (CPU) that combines the signals coming from different sensors (cameras, LIDAR, RADARs) for better performance (“cross validation”).

The fused information is then used by your board system to control and generate situation appropriate behavior based on algorithms.



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2. HOW TO OPERATE YOUR SELF-DRIVING CAR

Driving in “manual mode”

You can drive your self-driving car in conventional mode whenever you wish to.
This mode when you are in full control of your vehicle is called “**manual mode**”.
The mode when you enable automation is called “**self-driving mode**”.

It’s generally advised to turn on automation whenever possible.
Remember, self-driving technology is aiming at

- Causing less accidents and less congested roads
- Maximize traffic and fuel efficiency

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Enabling the self-driving mode

This is what your car's interface looks like in **manual driving mode:**

Before turning on the self-driving mode, make sure the car is **centered** in the lane to maximize the sensors' road detection.

Enable self-driving mode by pressing the **green button** on the steering wheel:

This is what your car's interface looks like in **self-driving mode**:

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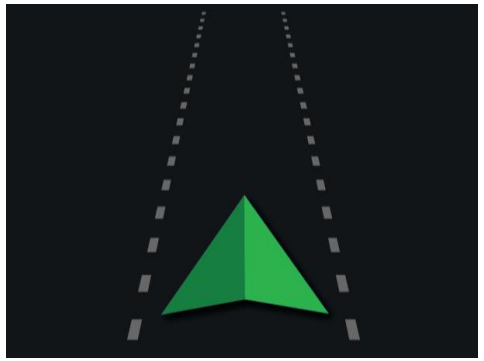
Disabling the self-driving mode

The self-driving system will **automatically control** acceleration, braking and steering.



Your steering wheel will move as it is controlled. Touching of the steering wheel (steering under 15°) does not have any effect.

Disable self-driving mode by pressing the **blue button**, **breaking**, or **steering** more than 15°.

Before turning off the self-driving mode, make sure that you have enough awareness about the situation around you.

This is what your car's interface looks like when you are back in **manual driving mode**:

Please, remember to use the self-driving mode as much as possible.

3. SAFETY

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Safety is our first priority!

Like any other technical system, your self-driving system can fail. For these rare cases, your system is designed to minimize the effect for you.

It is still important for you to know to difference between failure types and their outcomes:

a. Technical failures
Several safety layers protect your system from a technical failure.

b. External problems
Even a perfectly functional system cannot work if it doesn’t get the information that it needs to operate accurately.

a. TECHNICAL FAILURES

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Technical Failures

1. ***Localization failure***: The perception can still navigate your car for a while. If the problem persists, the system will warn and ask you to take over within *15 seconds*.

2. ***Perception failure***: In case of fail, there is a backup for each sensor type (redundancy). The system will notice the sensor failure and warn you. You are legally required to bring your car to a licensed workshop within the next 48 hours. In the meantime, if something happens to your backup sensor too, you will get an alert that asks you take over control within *15 seconds*. A failure of both sensors of the same type is highly unusual.

In all of these cases the system will be aware of its problem and will warn you. You will have enough time to take back control from your car. If you do not take back control, it will pull over or stop safely.

Technical failures are not considered to pose immediate danger.

b. EXTERNAL PROBLEMS

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External Problems

1. **Weather:** Your Lidar cannot work properly when rain or snow particles interrupt its laser signal. In this case, the system will warn you in advance and ask you to take over.
2. **Extreme light conditions**: Driving into the sun (sunrise) might blind your camera. The system will warn you and ask you to take over.
3. **Insufficient, conflicting or misleading information:**
    a. **Transient problems of system behavior** can occur when the system picks up insufficient, conflicting or misleading information. This might happen when lane markings (white markings, cones, pylons, etc.) are inconclusive or traffic lights do not work properly. Information externally fed into the system over GPS/WIFI ***will usually correct*** misbehavior right away. This means, you might notice an initial slight inaccuracy in your car's behavior but **you don't have to do take back control** because it will immediately self-correct.

b. External problems

b) Sustained problems of system behavior

Rarely, information is not available and your system might ***keep displaying incorrect behavior***. In this case, there are two different outcomes:

Conflicting information:

If the system detects *conflicting information*, it will initiate an immediate safety stop. You can then start driving manually before you enable the self-driving mode again.

Without conflicting information:

If the system is **not aware of its incorrect behavior**, you are required to take back control immediately in order to avoid a potentially dangerous situation.

Luckily you can learn to foresee such rare incidents by paying attention to cues that might **predict** problems of system behavior.

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Predicting incorrect system behavior

Please, pay attention to road conditions and signs indicating

- bad weather conditions
- extreme light conditions
- improper or unfinished street alignment: Missing, inconclusive, covered, extremely angled (hairpin curves) or faded lane markings or street marks
- dysfunctional street lights

If you see such predictors please **simply place your foot above the break and your hands on the steering wheel.** Observe whether your system can handle the situation or self-correct itself. This way you will be prepared for intervening if you prefer to take back control.

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THANK YOU!

YOU ARE DONE WITH THE TRAINING!