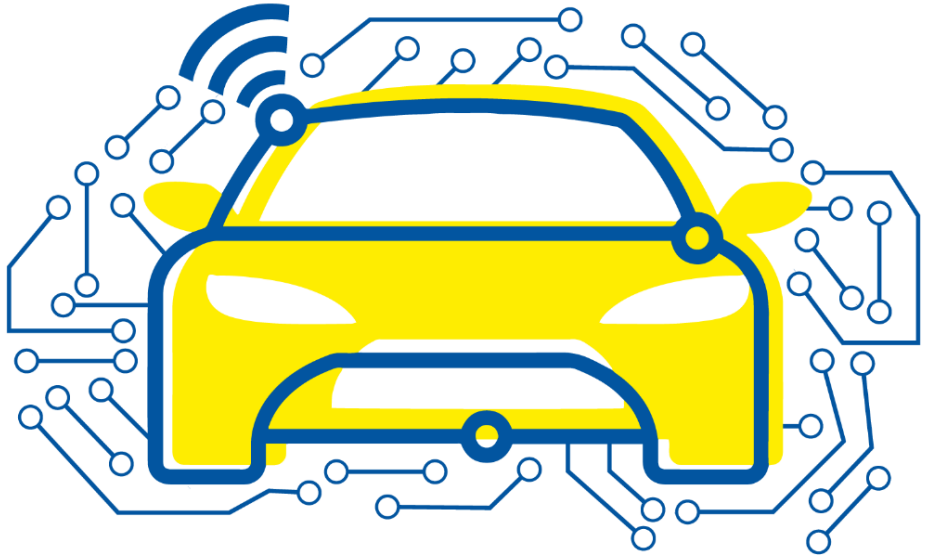
Automated and Connected Driving Challenges

Section 2 – Sensor Data Processing

Localization

Introduction



Bastian Lampe

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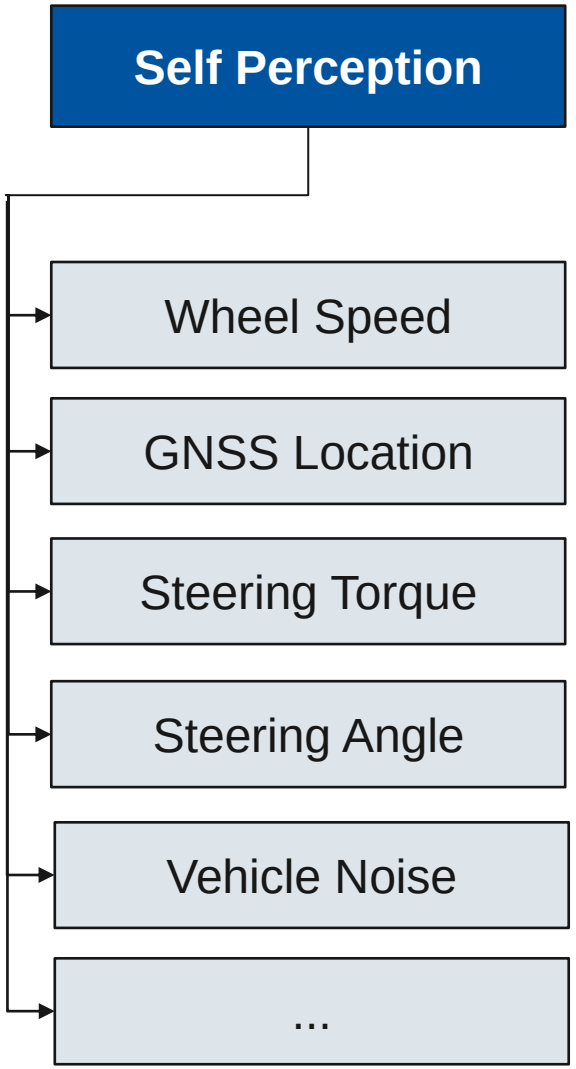
Localization - Introduction

Recap – Taxonomy of Self Perception

Use Sensor-Input to **estimate** the current state of the **ego-vehicle:**

- Dynamic vehicle state (e.g. current velocities and accelerations)
- Actuator control values (e.g. current steering angle)
- Current vehicle pose
  - in a global reference frame or relative to a previous vehicle pose

→ **Vehicle Localization is sub-problem of self-perception**



Localization - Introduction

Fundamentals – Definition of Robot Localization

Localization is defined as the **determination** of a position and orientation in a specific reference system

- In robotics the **combination of position and orientation** of a robot is defined as ***pose***
  - A 2D-Pose can be defined as $\mathbf{x} = [x, y, \psi]^T$

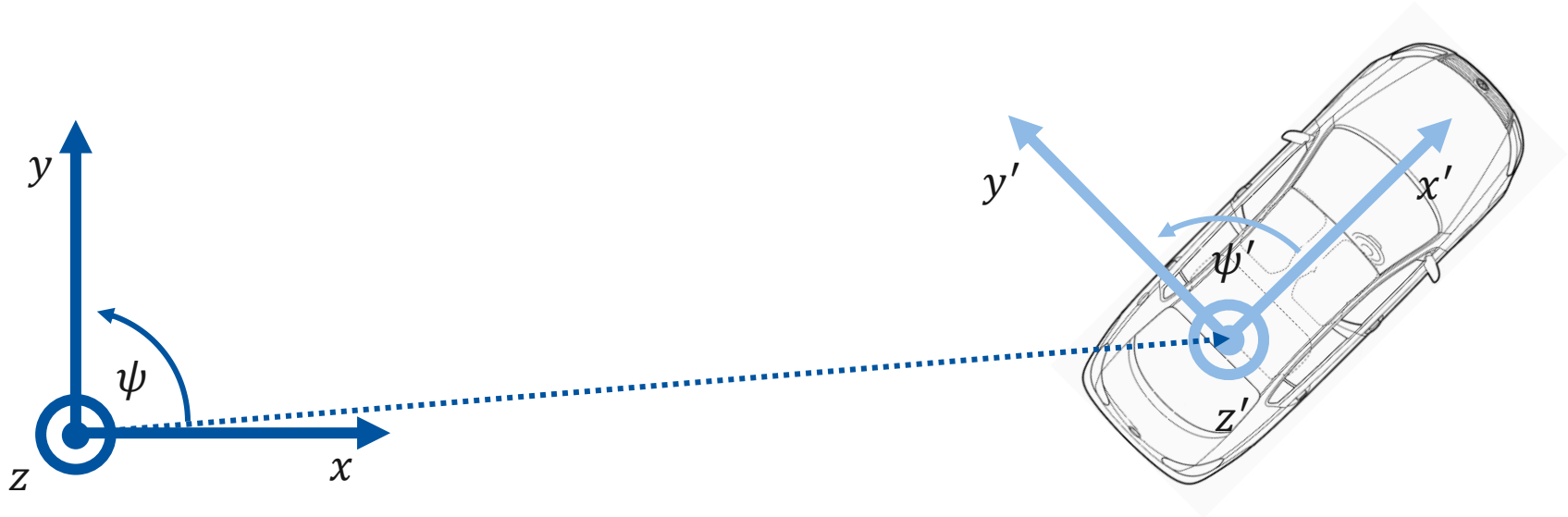


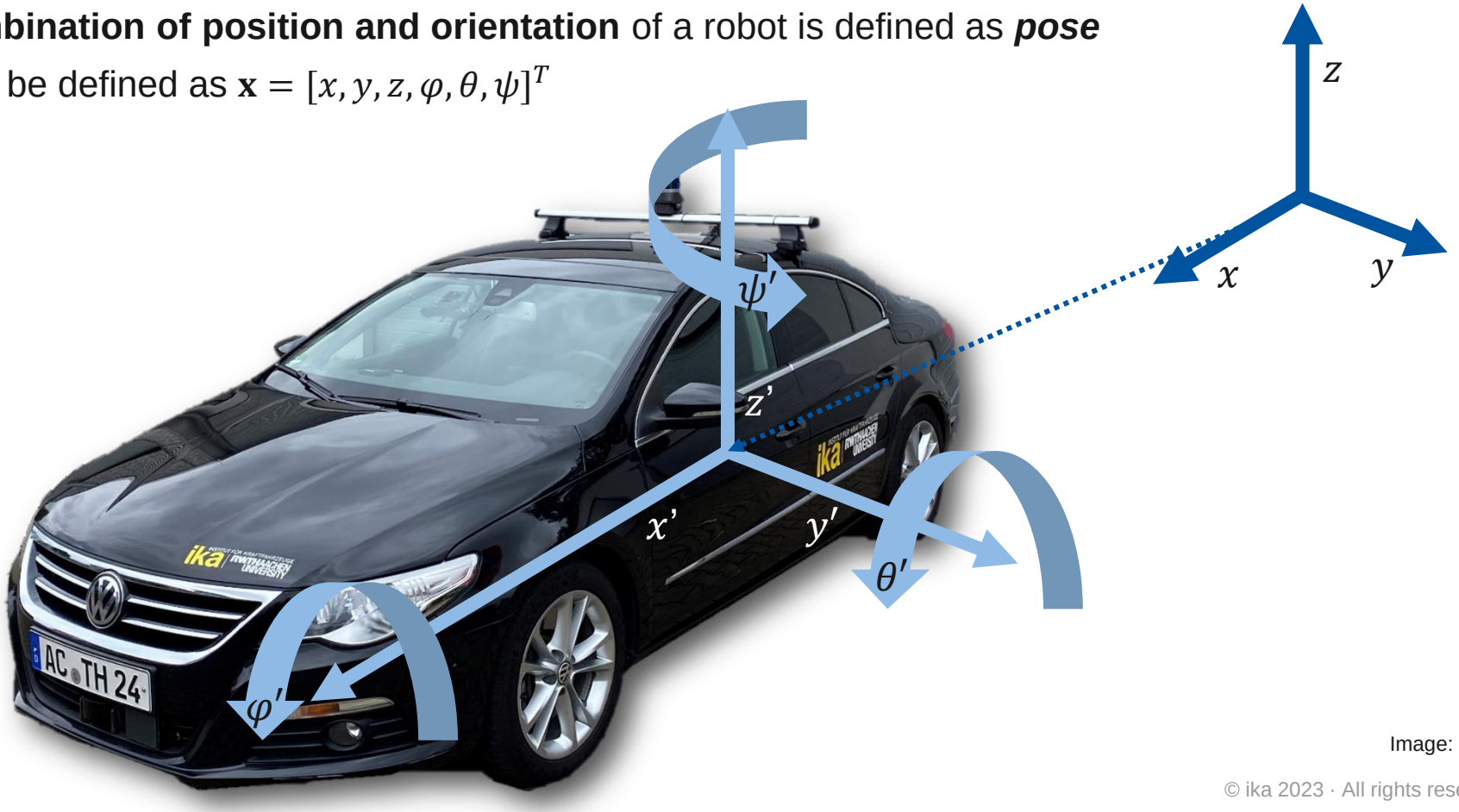
Image: ika

Localization - Introduction

Fundamentals – Definition of Robot Localization

Localization is defined as the **determination** of a position and orientation in a specific reference system

- In robotics the **combination of position and orientation** of a robot is defined as ***pose***
  - A 3D-Pose can be defined as $\mathbf{x} = [x, y, z, \varphi, \theta, \psi]^T$



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Localization – Introduction

Motivation: Localization as a Prerequisite for Vehicle Guidance

Navigation

Guidance

Stabilization

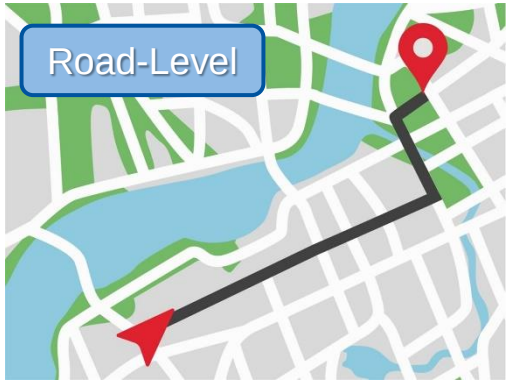

Image: businessrole.us

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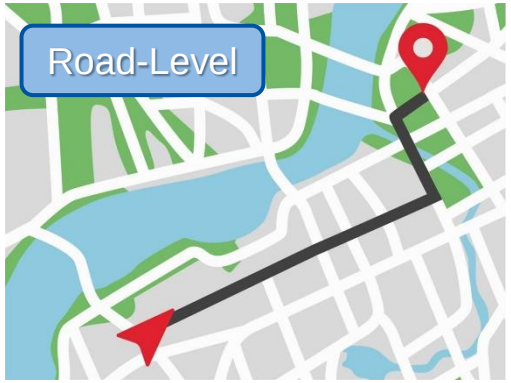

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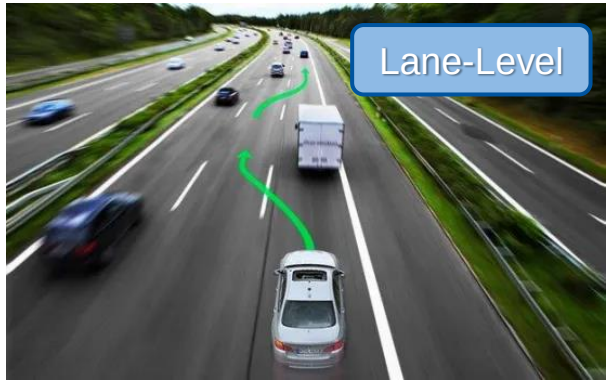


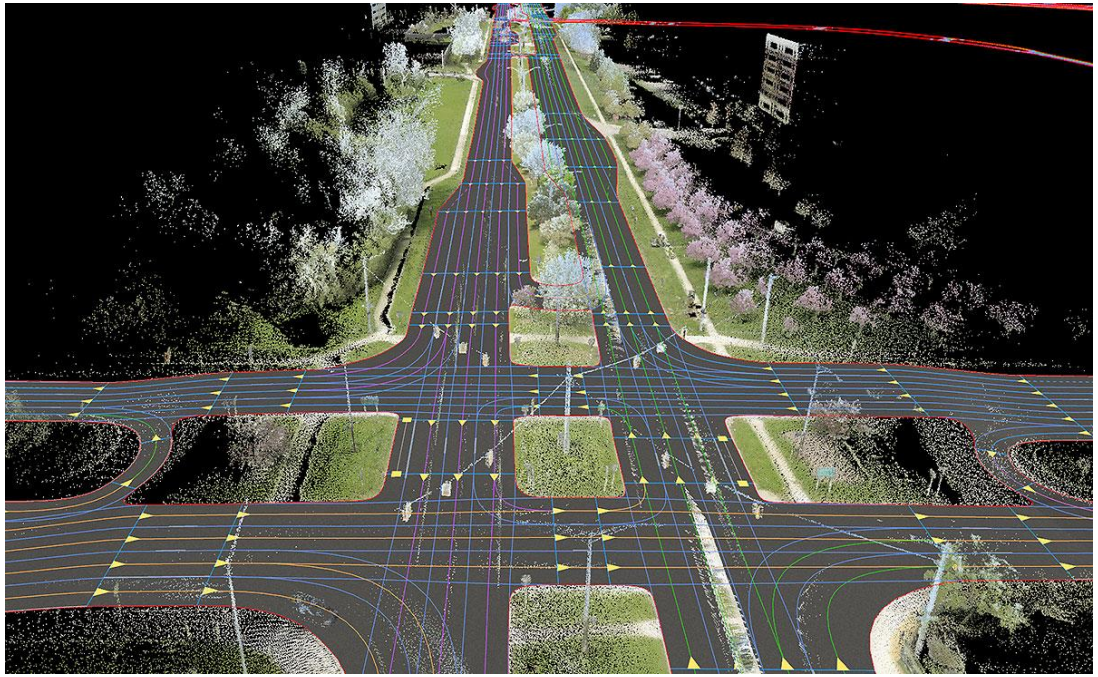
Image: towardsdatascience.com

Image: univdatos.com

Localization – Introduction

Fundamentals – Digital Maps

- **Lane network topology** and **geometry**
  - Lane connections
  - Lane width, curvature
- **Road and lane attributes**
  - Road types (highway, urban road, …)
  - Lane types (regular, carpool, bus, …)
- **Regulatory elements** that may be occluded
  - Speed limits, warning signs
  - Traffic lights



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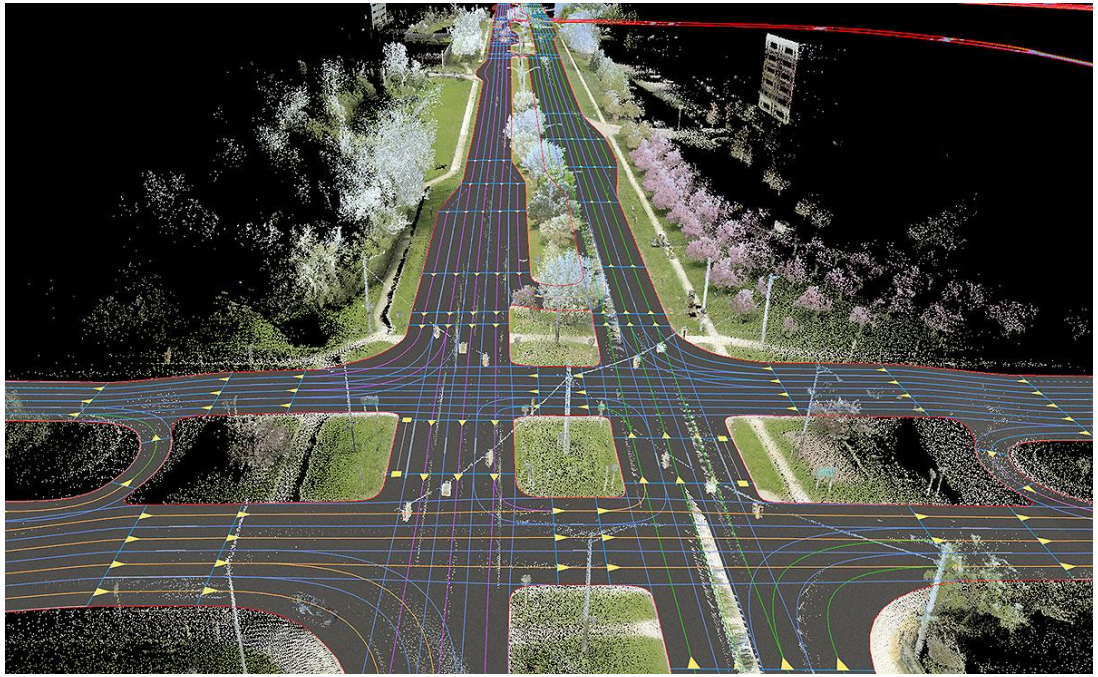
  - Traffic lights
- **Static objects** that rarely change
  - Curbs, Walls
  - Trees



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→ Digital maps can **increase robustness** of the system
→ **Localization** in the map **necessary** to utilize the map

Localization – Introduction

Fundamentals – Taxonomy and Classification

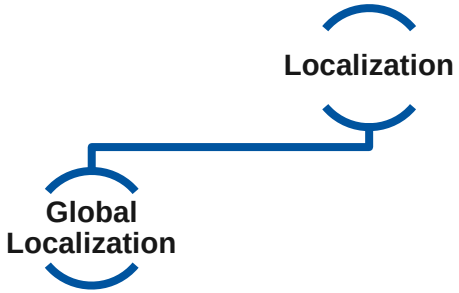
Approaches for vehicle localization can be categorized into:

Global Localization

Determination of the vehicle pose in
a global reference frame

Common Approaches:

- GNSS
- Landmark-Based Localization



Source: Zekavat 2019

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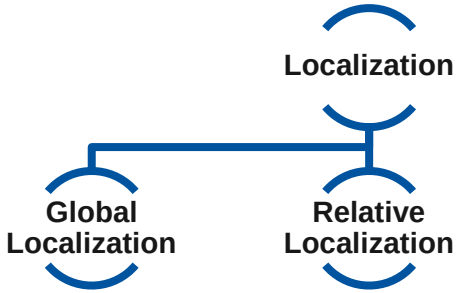
- Odometry
- Inertial Navigation



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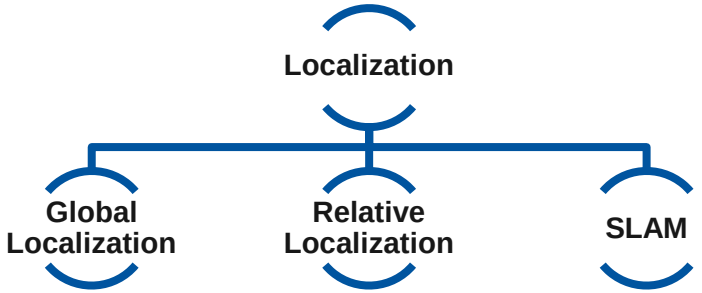
Simultaneous Localization and Mapping (SLAM)

Creation of a map with simultaneous location within it

- Common Approaches:
  - Kalman-Filter
  - Particle-Filter
  - Graph-based SLAM



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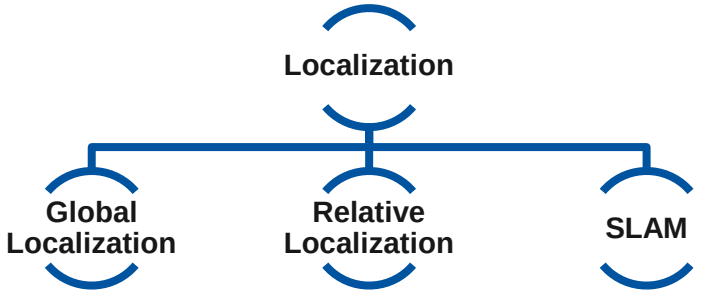


Source: Zekavat 2019

Localization – Introduction

Fundamentals – Sensors for Vehicle Localization

Source: Zekavat 2019

Exteroceptive Sensors

- GNSS Receiver
- LiDAR
- Radar
- Cameras
- Compass

Proprioceptive Sensors

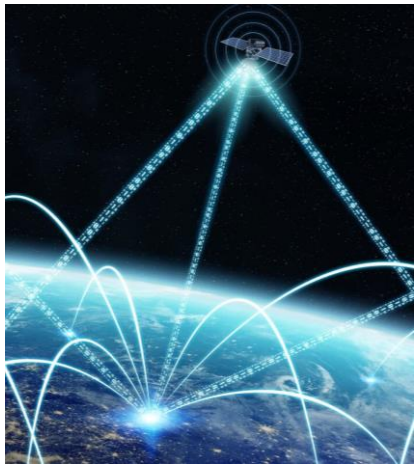


Image: Novatel

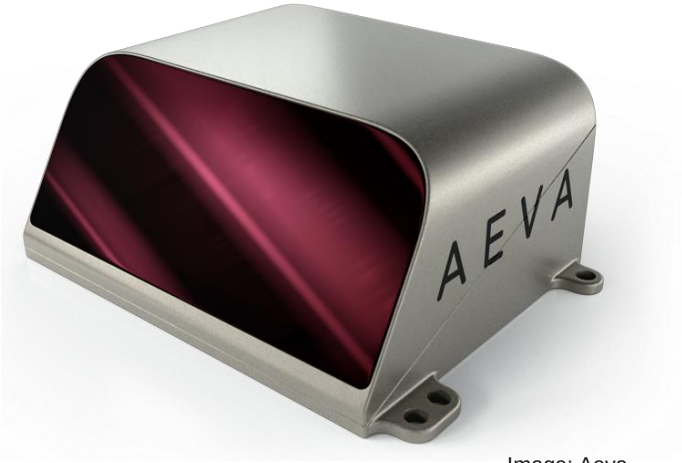


Image: Aeva

Localization – Introduction

Fundamentals – Sensors for Vehicle Localization

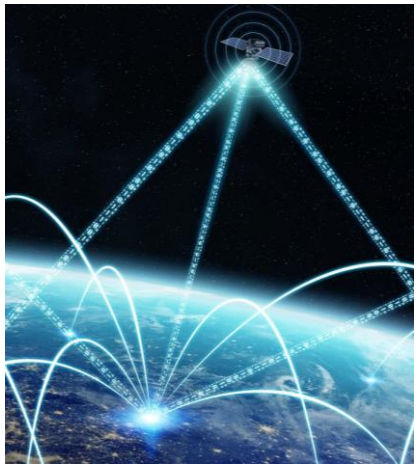
Source: Zekavat 2019

Exteroceptive Sensors

- GNSS Receiver
- LiDAR
- Radar
- Cameras
- Compass

Proprioceptive Sensors

- Vehicle Motion Sensors
  - Velocity and Steering Encoder
  - Odometer
- Inertial Sensors
  - Inertial Measurement Unit (IMU)
    - Usually composed of three accelerometers and three gyroscopes



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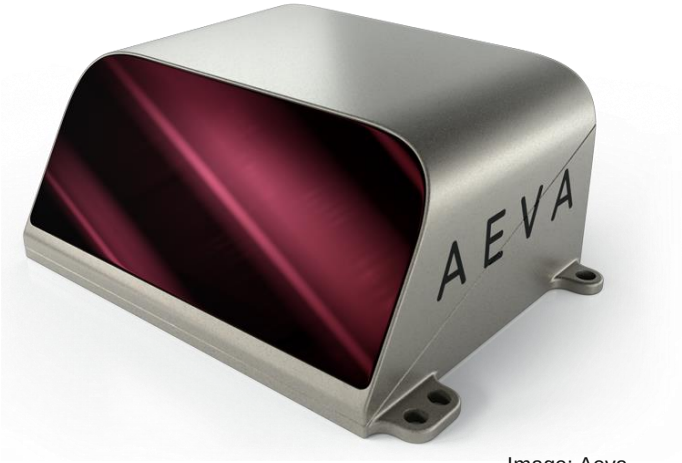

Image: Aeva

Image: Continental

Image: Bosch