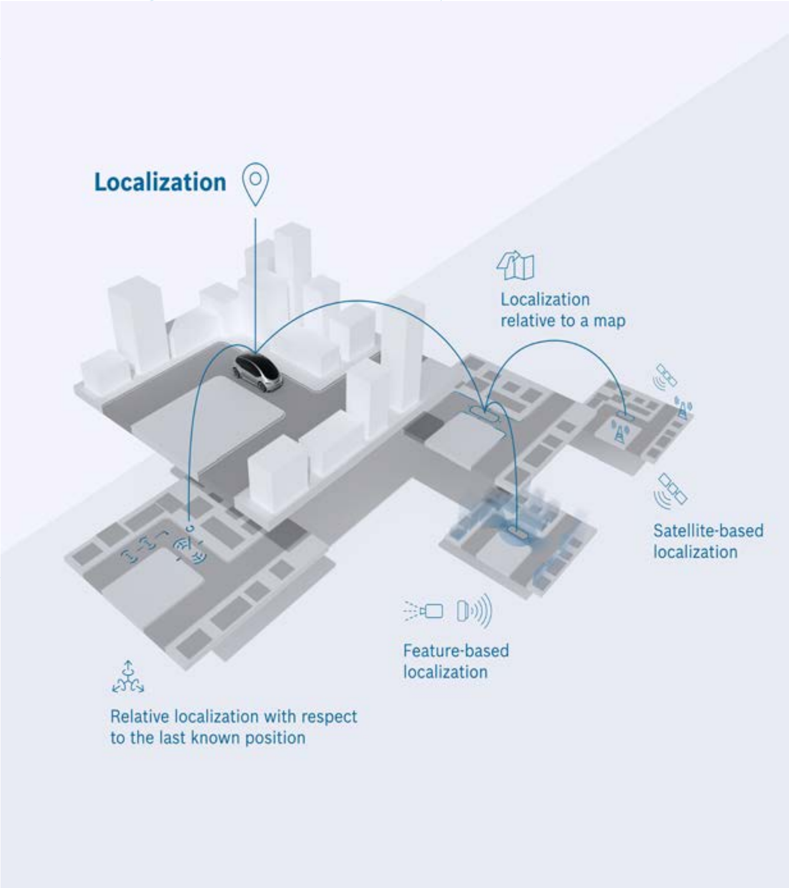
BOSCH
Invented for life

SMU inertial sensors for localisation functions

In cooperation with: THE 21st INTERNATIONAL CONFERENCE ON SOLID-STATE SENSORS, ACTUATORS AND MICROSYSTEMS TRANSDUCERS 2021 ONLINE VIRTUAL CONFERENCE

Automated Driving and Localization

Localization



Three pillars of localization

1. Satellite-based navigation

Detection of GNSS signals in open-sky environments

2. Feature+map based localization

Detection of objects with camera, Lidar, or radar. Position of this object is inferred from a map.

3. Motion-based localization

Change of position from last known position is calculated by integrating signals of inertial sensors, or wheel speed sensors.

> Localization needs to be safe, precise, and available for all driving and weather situations.

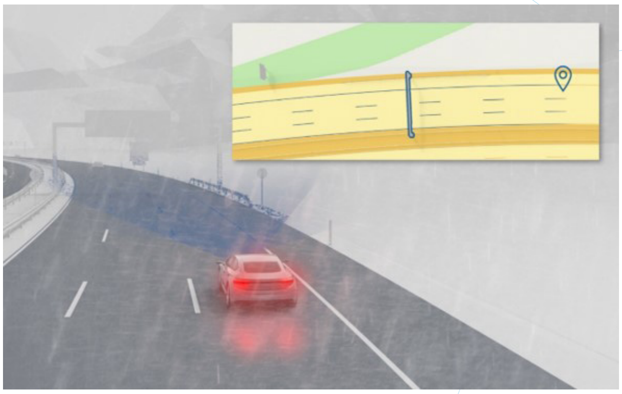
Automated Driving and Localization

Extrinsic availability

Systems might not be available due to external conditions

- Cameras: poor scene illumination, absence of features, bad weather
- Lidar: Prone to disturbances by dust, rain etc.
- GNSS: outages in tunnels, reflections in urban canyons

The performance of inertial sensors is independent from these factors.

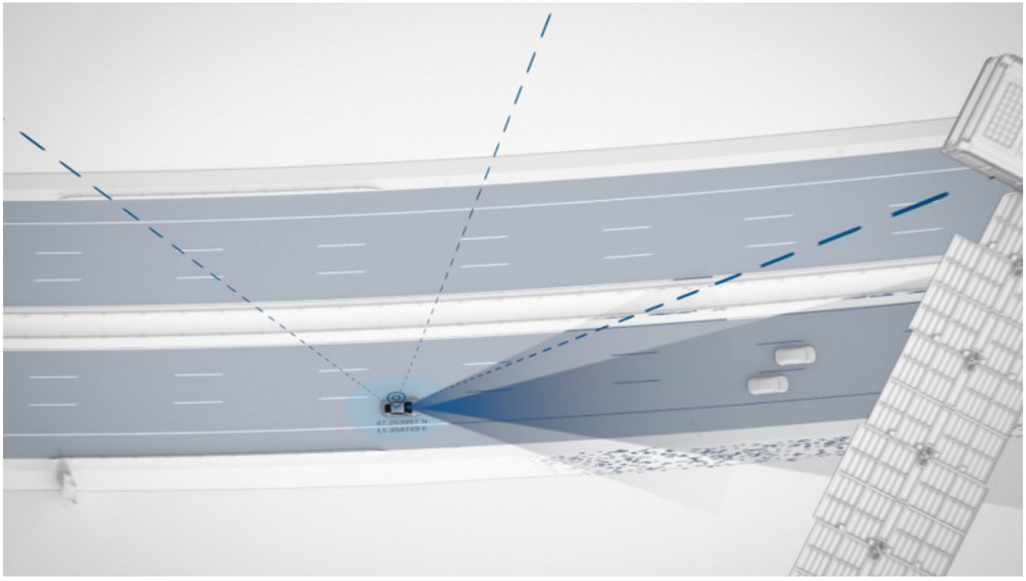


Automated Driving and Localization

Localization - typical driving situations

Decimeter localization with inertial navigation is possible by permanently re-calibrating inertial sensors with external sources for position coordinates

- Open Sky environments: position provided by GNSS position in combination with RTK correction service.
- Feature-based localization: position is provided by feature recognition in combination with high-resolution maps.



Satellite based localization in open-sky environment

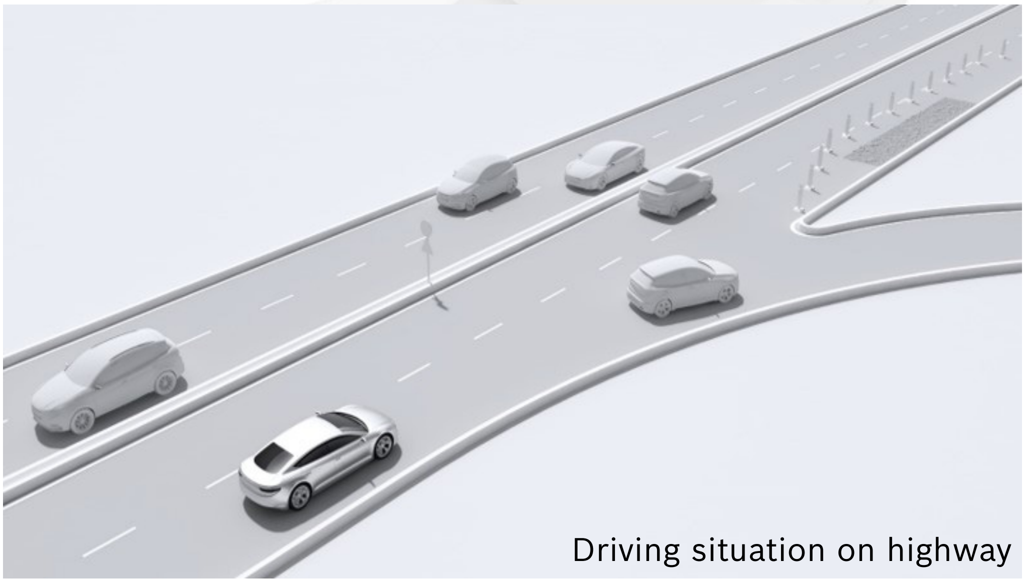
Feature based localization: object recognition plus map

Automated Driving and Localization

Locating myself in relation to others - everywhere and every time

Typical driving situation:

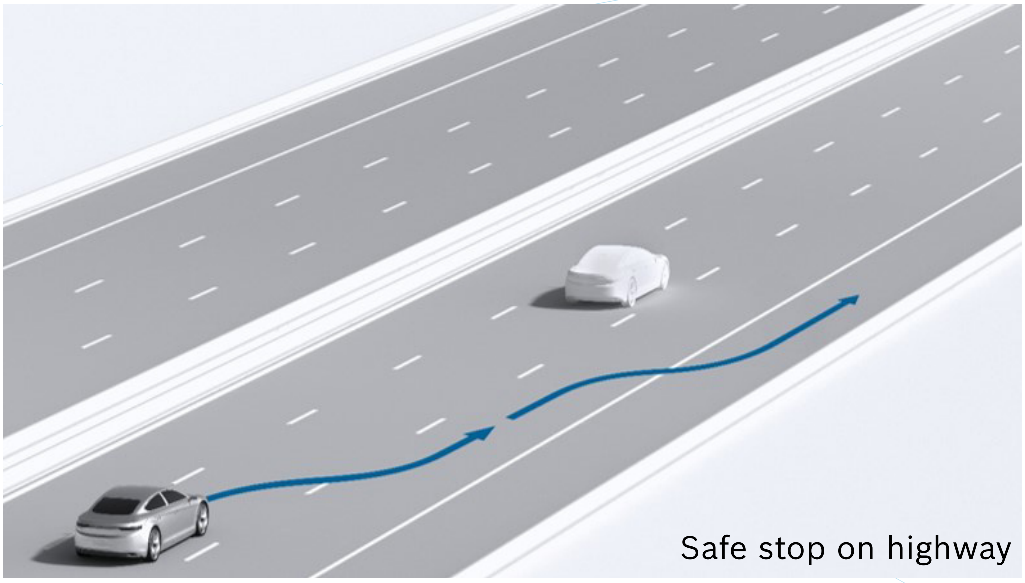
- all sub-systems available and performing
- complete system over-determined



Driving situation on highway

Fall-back situations:

- not all sub-systems available
- IMU only, + wheel speed, + other sensors

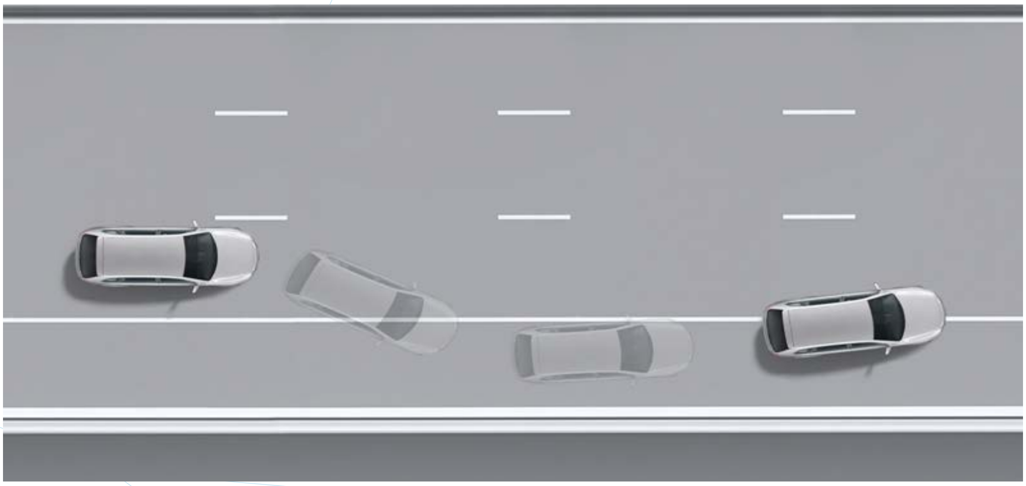


Safe stop on highway

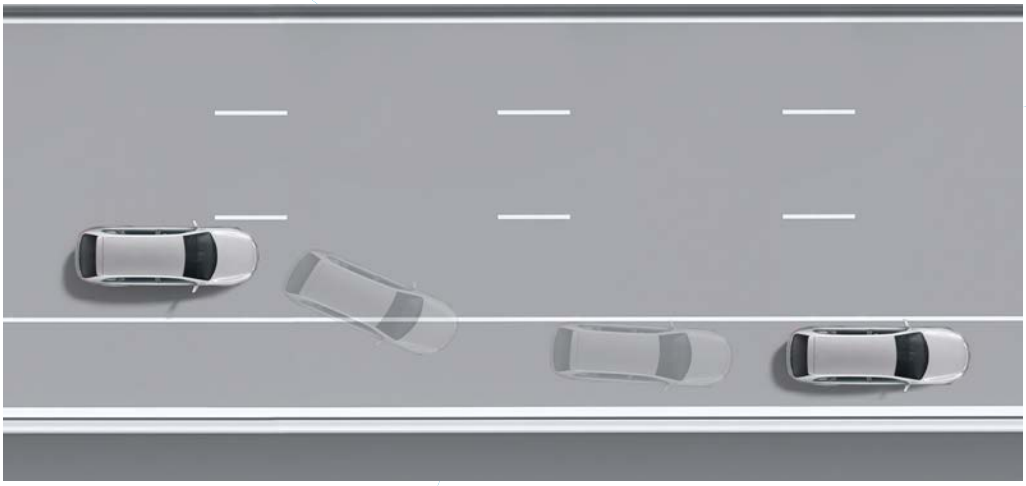
Automated Driving and Localization

Simulation of safe-stop with standard and with high-performance sensors

Less Accurate MEMS Gyroscope (2-sigma lat.-path)



High-Performance MEMS Gyroscope (2-sigma lat.-path)

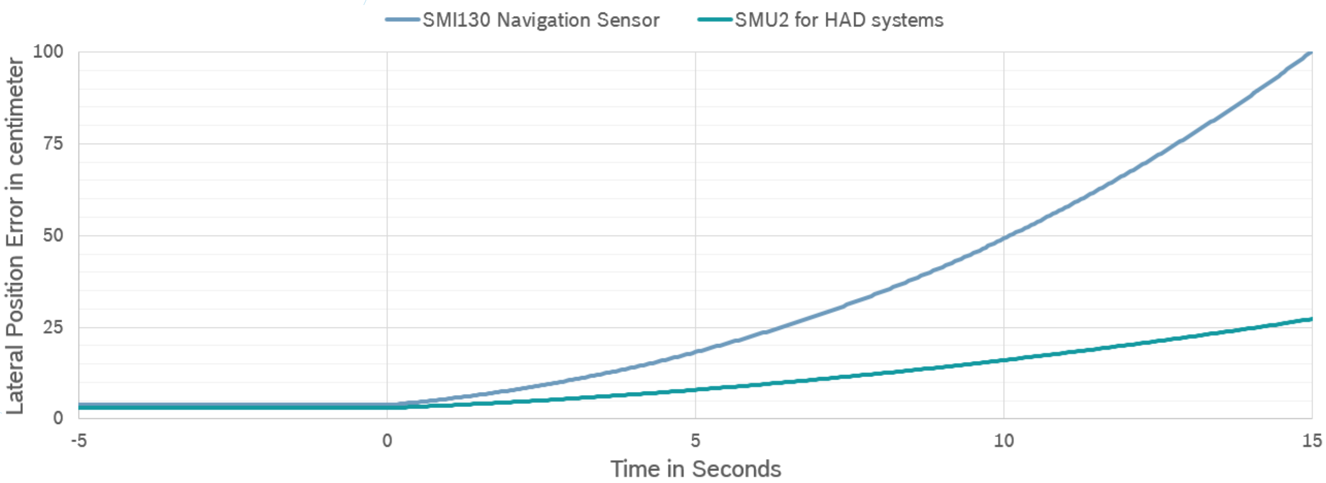


Safe Stop requires high performance sensors – otherwise the car leaves its lane.

Lateral position error

A standard navigation sensor with 1m precision is insufficient for lane keeping
only a high performance sensor ensures safe stopping maneuvers

1σ Lateral position error



Lateral position error*[cm]	Before outage	10 s outage	15 s outage
SMI130 **navigation sensor**	<5 (due to GNSS reference)	Ca 50	Ca 100
SMU2 **+advanced algo**		Ca 15	Ca 25

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SMU2 High Performance Inertial Sensor

Specification

- SMU2: 4-axes sensors
  - Yaw rate sensor — SMU200 (Ωz, Axyz)
  - Roll/pitch rate sensor — SMU210 (Ωx,Axyz)
  - CLCC 8x8 mm², 16 pins

- Optimum vibration robustness
- Applicable in systems with ASIL D requirements

- IMU optimized for
  - Small offset variation
  - Minimum offset drift
  - Small hysteresis

Parameter	Unit	SMU200 Target Spec	
Highest ASIL		D	
Max op. temp.	°C	125	
Rate channels			
Range	°/s	300	
Sensitivity tolerance	%	1	
Offset (over all)	°/s	0.25	
RMS Noise	°/s	0.05	
Bias stability	°/h	<1	
Angular random walk	°/√h	0.2	
Acceleration channels			
		xy	**z**
Range	g	6	6
Sensitivity tolerance	%	1	1
Offset (over all)	mg	20	40
RMS Noise	mg	1	1

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