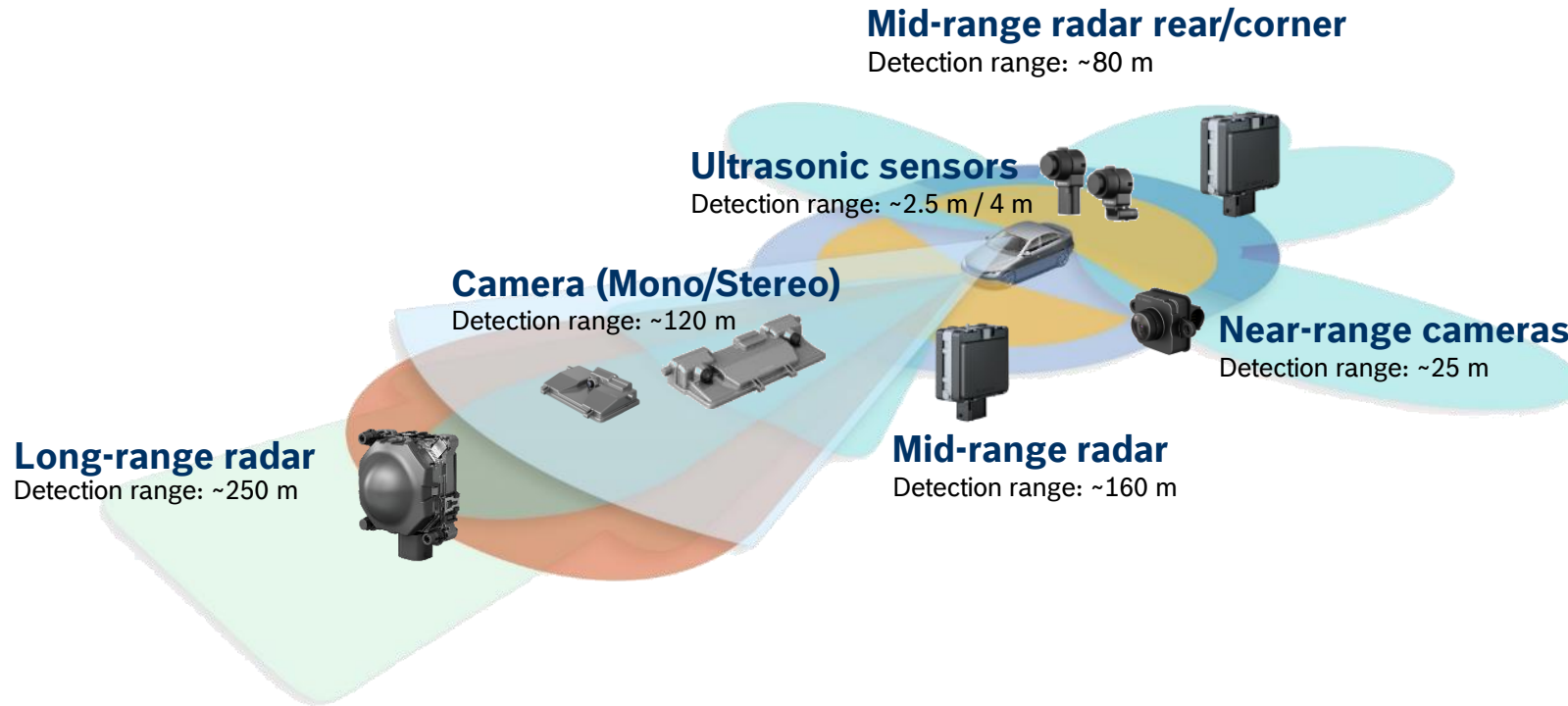


NTSB SAFETY FORUM

BOSCH PEDESTRIAN
PROTECTION

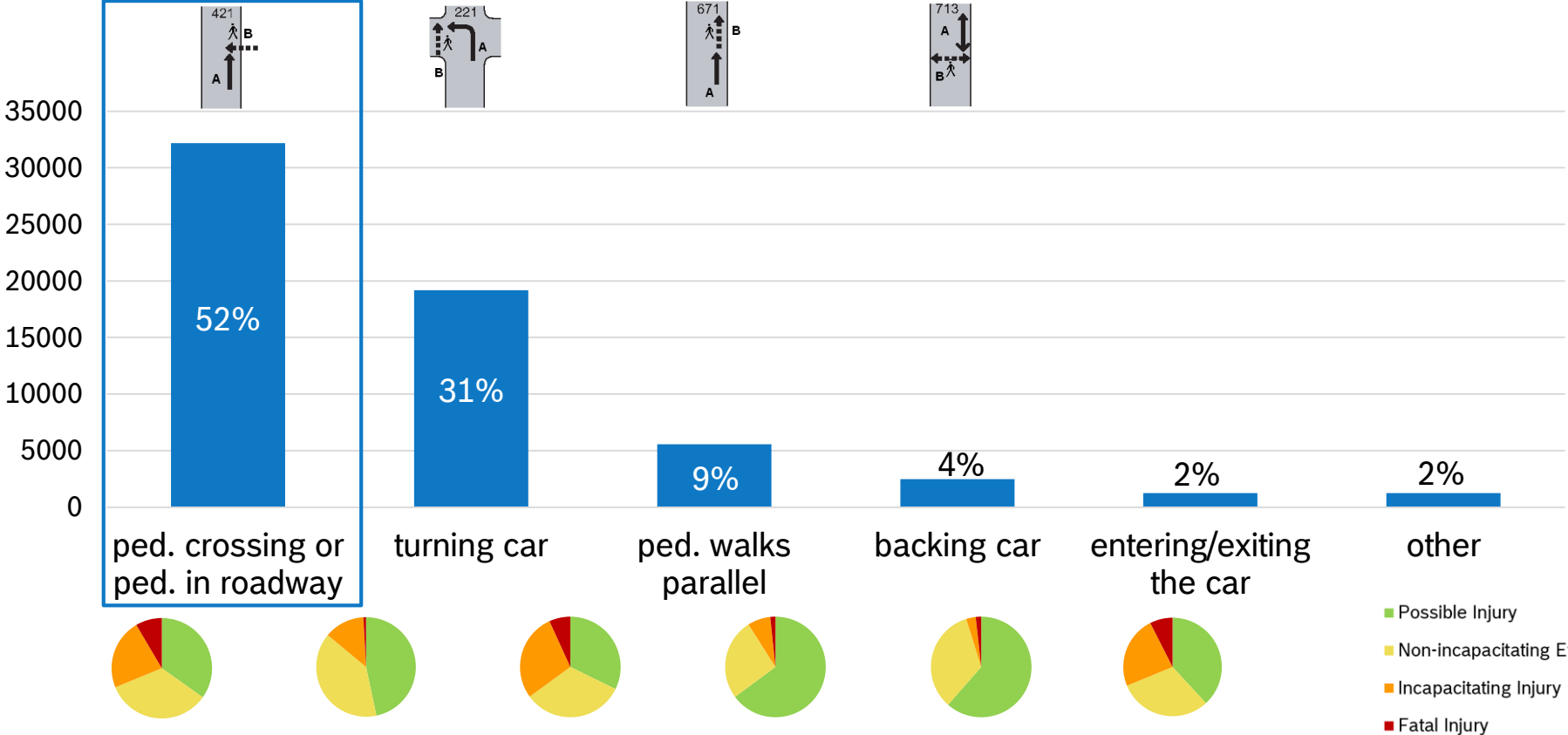
NTSB Safety Forum – Bosch Pedestrian Protection Sensors for 360 degree surround sensing



- **Dependent on DA functionality, different sensor set necessary (different range, field of view, ...)**
- **For Pedestrian AEB, target is to have robust and highly reliable sensor set**

NTSB Safety Forum – Bosch Pedestrian Protection

Distribution of pedestrian crashes in the US

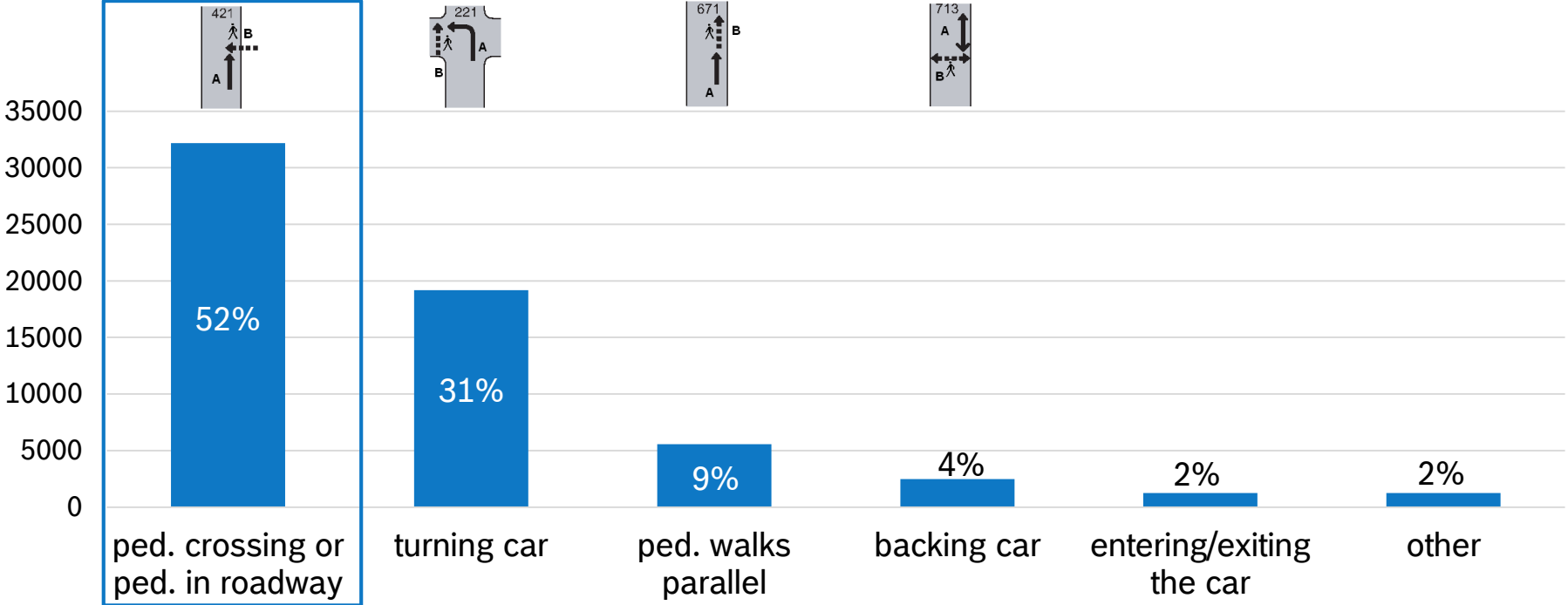


Source: GES 2012 Report prepared by Bosch Accident Research
 Pedestrian accidents (n = 66 260) w/ primary collision of passenger car, utility vehicle, van, transporter or light truck.



NTSB Safety Forum – Bosch Pedestrian Protection

Distribution of pedestrian crashes in the US



→ Based on crash statistics, Bosch is currently focusing on front crossing pedestrian scenarios

Source: GES 2012 Report prepared by Bosch Accident Research
 Pedestrian accidents (n = 66 260) w/ primary collision of passenger car, utility vehicle, van, transporter or light truck.

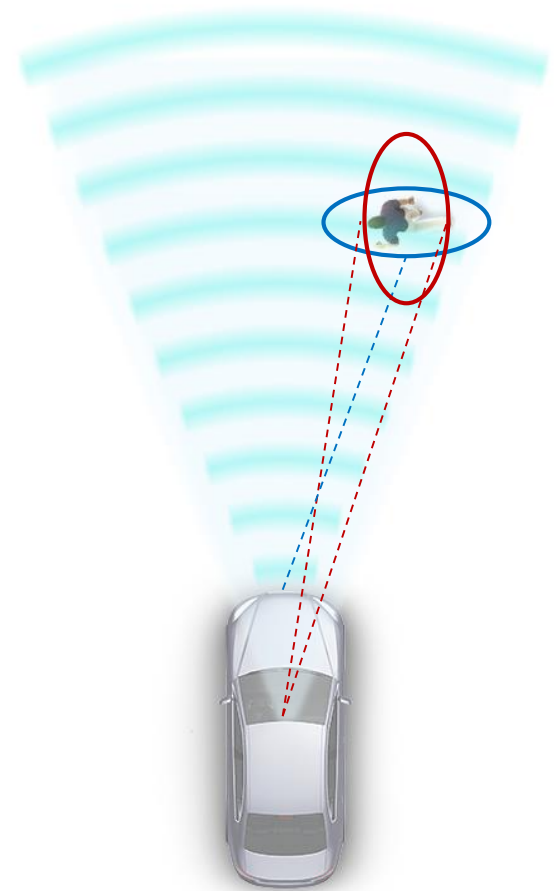
NTSB Safety Forum – Bosch Pedestrian Protection Radar / Video Standalone

→ Radar:

- Precise longitudinal distance and velocity in different weather and light conditions
- Less exact lateral position
- Classification as pedestrian based on micro-doppler

→ Video:

- Precise lateral position
- Angles of object edges
- Less exact longitudinal values
- Good object type classification



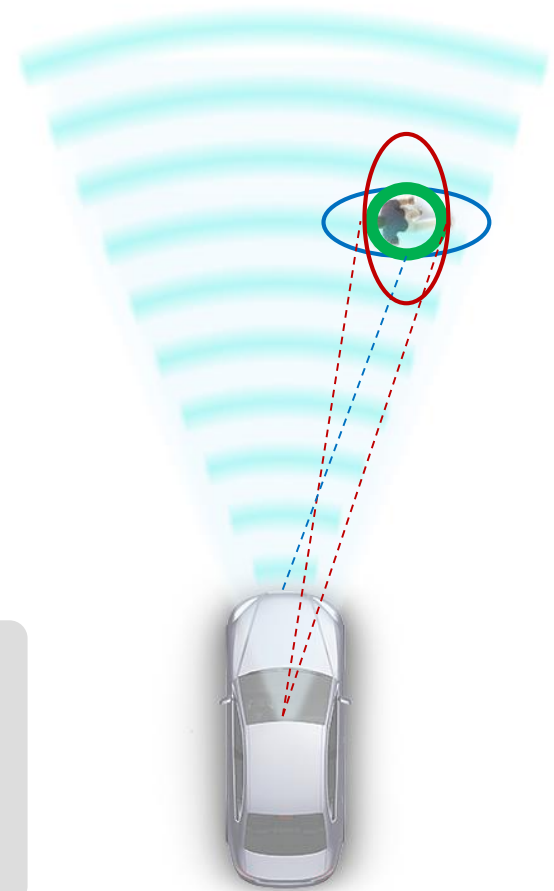
NTSB Safety Forum – Bosch Pedestrian Protection Radar / Video Fusion

→ Fusion

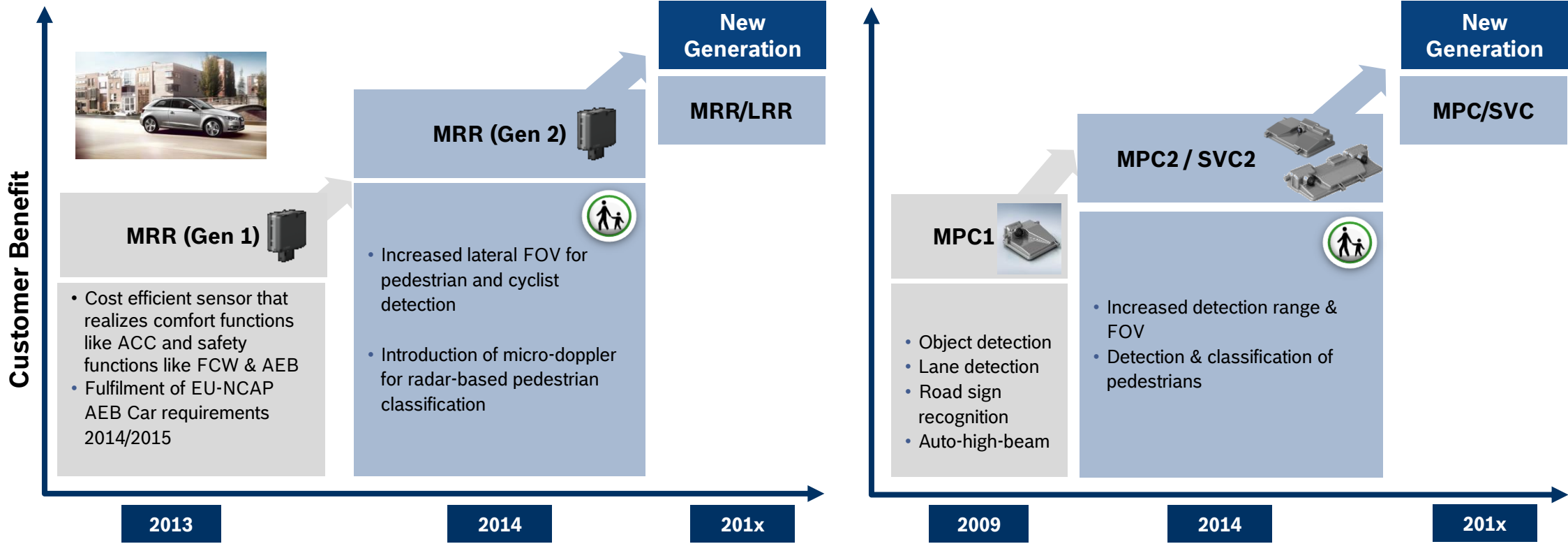
- Combines the advantages of both sensors
- Precise longitudinal distance & velocity measurement
- Precise lateral distance & velocity measurement
- Robust classification
- Best possible true/false performance



- Fusion between Radar and Camera required to achieve best possible AEB pedestrian performance
- AEB pedestrian can also be realized with single sensor solutions (may have limitations)



NTSB Safety Forum – Bosch Pedestrian Protection Evolution Steps Mid Range Radar / Cameras



➔ Bosch improving sensor technology to realize AEB pedestrian scenarios

NTSB Safety Forum – Bosch Pedestrian Protection

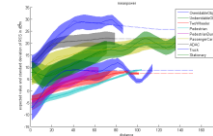
Object classification w/ Radar

Classification

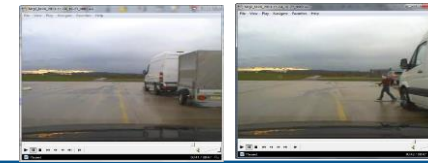
Features for robust and reliable classification on crossing objects (e.g. pedestrian)

Radar Cross Section (RCS)

- ~ 10-20dB difference between car rear and pedestrian

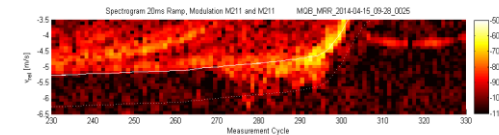


Patterns regarding **motion/dynamic** of locations



Micro-doppler

- Direct measurement of arm/leg movement

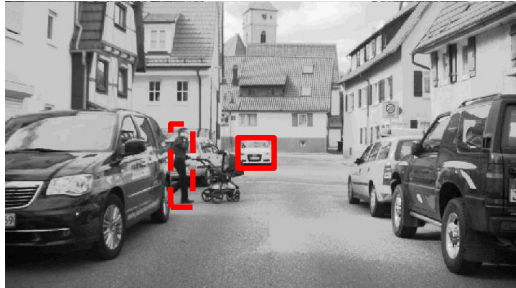


Articulation of pedestrian dummies critical for pedestrian classification with Radar

NTSB Safety Forum – Bosch Pedestrian Protection

Object classification w/ Video

Classification



“Learn patterns and find it”

- Only trained objects are recognized
- Huge training-database is necessary

Optical flow, Structure from Motion



“Compare one image with next”

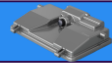
- Ego-vehicle motion and its precise measurement necessary
- No exact measurement, only estimation

Disparity

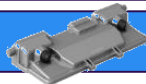


“Measure by triangulation”

- Exact measurement of the 3D position for each picture element; also if host vehicle in standstill



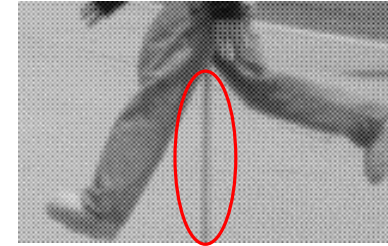
Mono



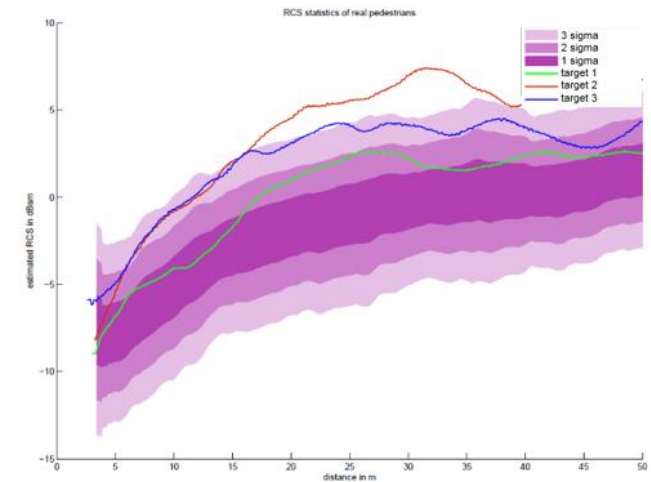
Stereo

NTSB Safety Forum – Bosch Pedestrian Protection Targets / Harmonization

- Bosch has evaluated several artificial test targets
- Some targets are not representative of real pedestrians



- **Realistic appearance, poses and articulation** are critical to ensure robust pedestrian classification.
- A **harmonization** of the pedestrian targets & test procedures between US and EU NCAP could reduce development and testing efforts.



Radar cross section (RCS) of artificial test targets compared to real pedestrians
(Source: ACEA pedestrian target specification and Bosch testing data)

NTSB Safety Forum – Bosch Pedestrian Protection Summary

- Bosch utilizes its Corporate Research activities to identify and develop relevant technologies to **prevent collisions and minimize accident severity**.
- The current development focuses on **front crossing scenarios** which is in line with the recent US NCAP proposal.
- **Harmonization** of test procedures and pedestrian targets with Euro NCAP will ensure the earlier introduction of already available pedestrian protection technologies to the US market.
- Scenarios with a turning vehicle require additional technologies and further research to realize robust systems.
- Bosch's vision is **Accident-free Driving**.

