Memorandum

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA

Subject: Docket Submission of Meeting with Robert Bosch LLC Date: 11/15/2023

From: Lawrence Blincoe
Director,
Office of Regulatory Analysis and Evaluation

LAWRENCE J BLINCOE
Digitally signed by LAWRENCE J BLINCOE
Date: 2023.11.15 14:30:30 -05'00'

To: Docket Number: NHTSA-2023-0021
Light Vehicle Automatic Emergency Braking

Through: Terrence Sommers
Assistant Chief Counsel
Vehicle Safety Standards and Harmonization

SARA R BENNETT
Digitally signed by SARA R BENNETT
Date: 2023.11.15 14:52:50 -05'00'

On November 2, 2023, staff from the National Highway Traffic Safety Administration (NHTSA) met with Robert Bosch LLC (Bosch). The subject of the meeting focused on additional information related to NHTSA's Notice of Proposed Rulemaking (NPRM) proposing to require improved automatic emergency braking (AEB) performance in light vehicles. During the meeting Bosch presented slides discussing their AEB systems and issues related to vehicle testing including repeatability, concerns over false positives, and test speeds among others. A copy of this presentation is docketed together with this memorandum. In addition, Bosch discussed various issues related to hardware requirements that might be needed to meet the requirements of the NPRM. Bosch noted that the portion of their system sales that are single camera only were estimated to be less than 5%. Bosch also noted that the performance of available integrated systems (involving either dual cameras or cameras and radar), evolves over time and that upgraded systems with more advanced performance would typically not cost significantly more than previous integrated systems due to cost learning over time.

Please submit this memorandum to Docket No. NHTSA-2023-0021.

Attendees included:

NHTSA

- Larry Blincoe
- Thomas Kang
- Sean Puckett
- Natalia Leszczyszyn
- Markus Price
- Jay Chen
- Joshua Fikentscher

- Sara Bennett

ROBERT BOSCH LLC

- Ana Meuwissen, Director of Federal Government Affairs
- Ryan Rummer, Engineering Vice President, Cross Domain Computing Solutions
- Dr. Stephan Benz, Chief Expert Political Consulting, Cross Domain Computing Solutions,
- Mariana Eichel, Marketing and Strategy Manager, Cross domain Computing Solutions
- Clayton Lindgrin, Senior Analyst, Federal Regulatory Affairs
- Angela Dragen, Legal Counsel, Robert Bosch LLC

Vehicle safety technology

Automatic emergency braking

Ryan Rummer
Engineering Vice President
Regional Business Unit Leader ADAS & Automated Driving
Cross-Domain Computing Solutions

Dr. Stefan Benz
Chief Expert Political Consulting
Cross-Domain Computing Solutions

Mariana Eichel
Marketing and Strategy Manager
Cross-Domain Computing Solutions

Ana Meuwissen
Director of Federal Government Affairs

Clayton Lindgren
Senior Analyst, Federal Regulatory Affairs

Angela Dragan
Legal Counsel Robert Bosch LLC

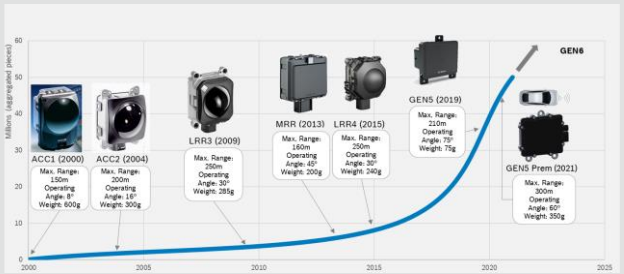
BOSCH

NHTSA NPRM AEB and PAEB
Agenda

1. Introduction
2. Bosch's general feedback
3. AEB systems
4. Car-to-car scenarios
5. Car-to-pedestrians
6. Questions

Bosch Automotive Radar

Over 25 Years of Experience and Excellence in Radar Business



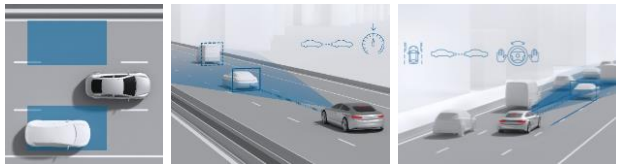
>25 years experience with 77 GHz sensors

>70 million Radars produced & integrated by end of 2022

>50 vehicle brands

Local production locations in all major regions

>290 vehicle models



Bosch Radar sensors are key components from **safety** features (e.g., AEB, BSD), **comfort** features L1-L2 (e.g., ACC), up to **automated** features L3

Automotive Radar Generation 6 & 7

We address all relevant sensor configurations & trim levels

AEB: Automatic emergency braking; BSD: Blind spot detection; ACC: Adaptive cruise control

BOSCH

Bosch Automotive Cameras

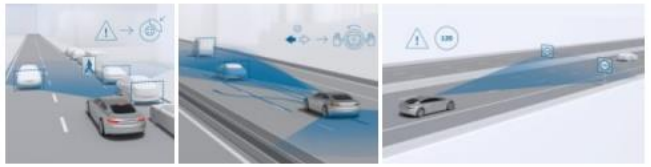
Bosch video experience

>18 years experience with automotive cameras

Local production locations in all major regions

>70 million cameras produced & integrated by end of 2022

>18 years of series experience with various camera products



Bosch Automotive Cameras are key components for **safety** features (e.g., AEB, BSD), **comfort** features L1-L2 (e.g., ACC), up to **automated** features L3

Automotive Camera

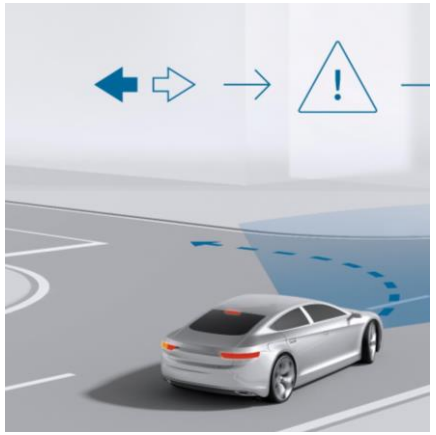
We address all relevant sensor configurations & trim levels

AEB: Automatic emergency braking; BSD: Blind spot detection; ACC: Adaptive cruise control

NHTSA NPRM AEB and PAEB
Bosch Comments Highlights

1) Bosch strongly supports the goals of NHTSA's proposal

New FMVSS requiring AEB and PAEB for passenger vehicles



2) Current AEB systems

The NPRM indicates NHTSA's understanding that all vehicles already possess the necessary hardware for AEB. However, it is important to note that while some vehicles in the market are already equipped with high-end AEB systems with advanced capabilities, certain other models in the market might require significant hardware updates, such as the inclusion of more advanced sensors

3) Higher performance

From the perspective of robustness and reproducibility, the proposed regulation would reach the technical performance limits of current series AEB and PAEB systems

4) Car-to-Car

- We suggest allowing multiple repetitions of a scenario and collision mitigation instead of avoidance at higher velocities.
- Reduce relative velocity reduction of AEB/CIB to 60 kph
- Reduce relative velocity reduction of EBA/DBS to 70 kph
- Increase the headway to >16 m for a time gap >0.7 s for higher ego velocities for the decelerating lead vehicle scenarios
- Specify the tests under realistic road conditions including road-markings on the test track

5) Car-to-Pedestrian

We suggest the following requirements for technical feasibility in Car to Pedestrian scenarios.

- Allow repetitions for failed tests
- Allow additional lighting like Euro NCAP or allow automatic high beam

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Bosch Comments
AEB requirements through SW updates

Current
AEB voluntary agreement (U.S.)

- Intelligent speed assistance
- Emergency lane keeping
- AEB

- The NPRM infers that all vehicles already possess the necessary hardware
- Some vehicles on the market are already equipped with high-end AEB systems with advanced capabilities, **others are not.**
- Certain models may require **significant hardware updates**, such as the inclusion of more advanced sensors (e.g., radar, cameras), increased computing power, and/or improved brake systems to meet the specified requirements.
- Majority of AEB systems are designed based on 2017 NHTSA-IIHS voluntary agreement*

Future
Outlook on AEB passenger car and pedestrian proposal

- Large field of view for detection of crossing VRU (AEB pedestrian).

- Radar with higher performance
- **Increased sensitivity** for robust & stable detection in longer ranges & at higher speeds

- Potential need for hardware updates in addition to software upgrades to ensure that new vehicles can meet the proposed requirements.

*Passenger vehicles and light trucks
Source: Wards Automotive Intelligence

Bosch Comments
Lead Vehicle AEB Performance Tests

Lead vehicle AEB performance tests

- Achieving collision avoidance at higher relative velocities is nearing the technical feasibility of current series production technology.

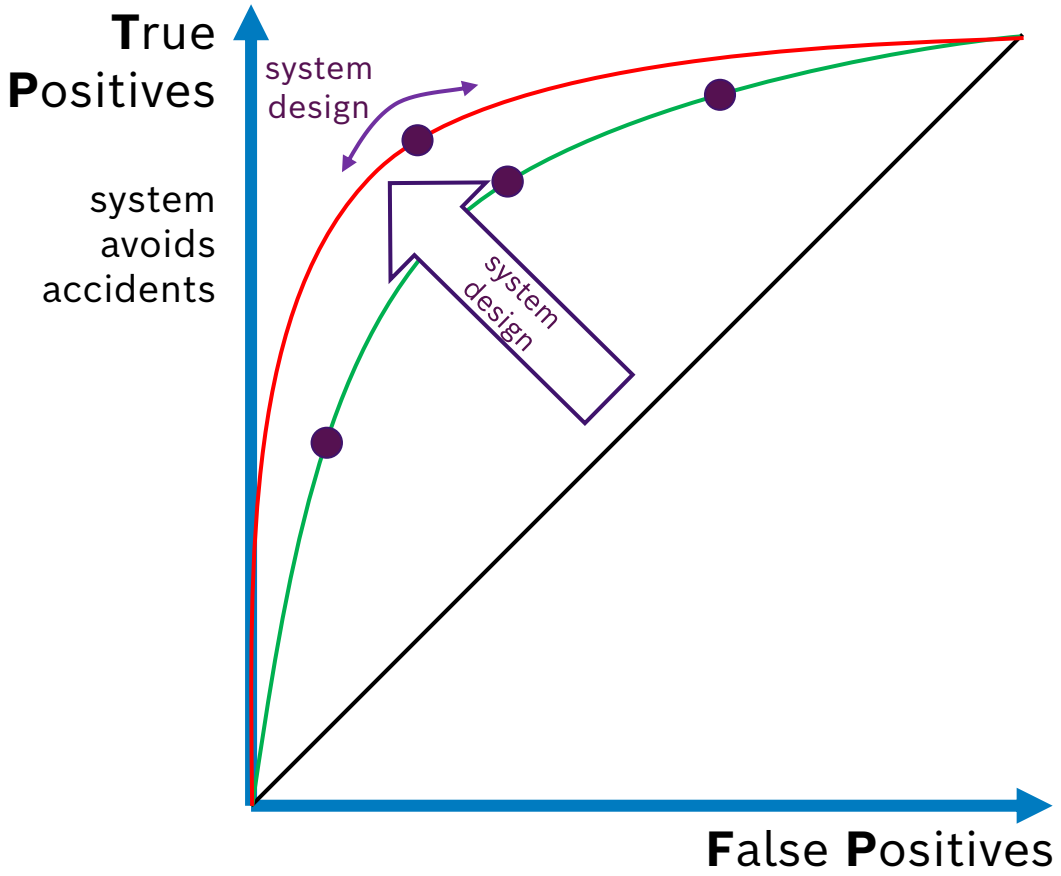
AEB Maximum speeds

- Increasing AEB/CIB relative velocity reduction to 80kph may lead to more “**false positives**”
- Suggested reductions to address these challenges: AEB/CIB to 60kph and EBA/DBS to 70kph

Forward collision warning

- FCW may be more beneficial >30kph to help driver take appropriate action before the “last time to steer” occurs

Bosch Comments
True Positives vs False Positives



- An increase in **F**alse **P**ositives affects
  - system acceptance
- Possible measures to address high **F**alse **P**ositive rate
  - reduce **T**rue **P**ositives
    => possible approach for NCAP
  - improve system
    => developmental limitation
- Development limitations exist
  - robustness
    => need for repetition of tests

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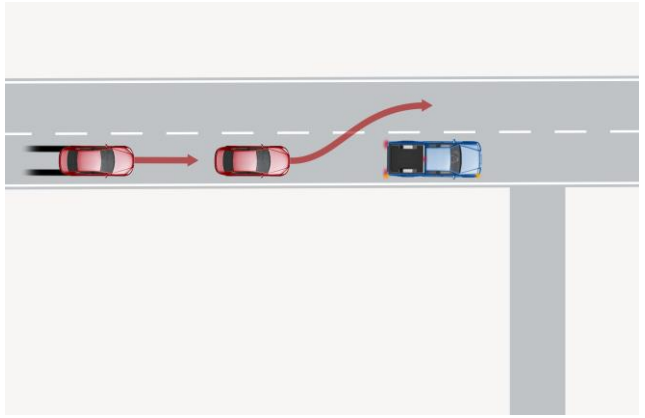
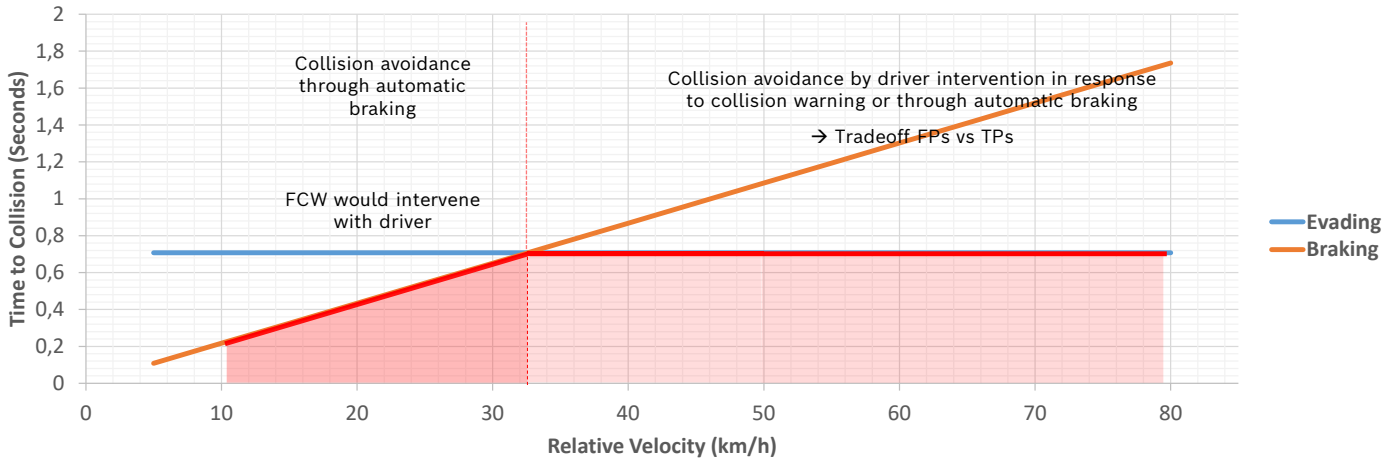
Bosch Comments
Last Point to Steer vs Last Point to Brake

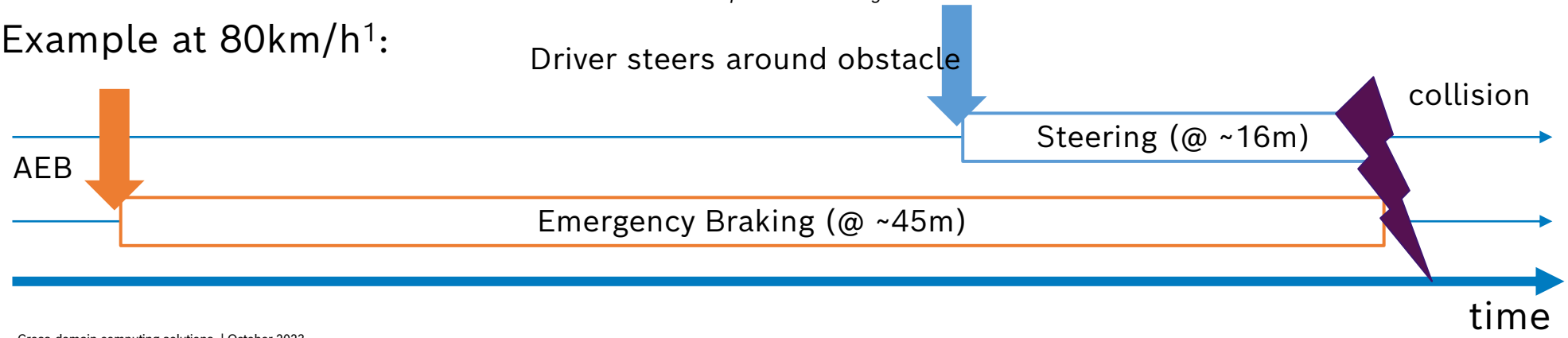
- Example sudden turn





Assumptions: Braking Level = 6.4 m/s² Lateral Acceleration = 10 m/s² Lateral Offset = 2.5m

Example at 80km/h[1]:

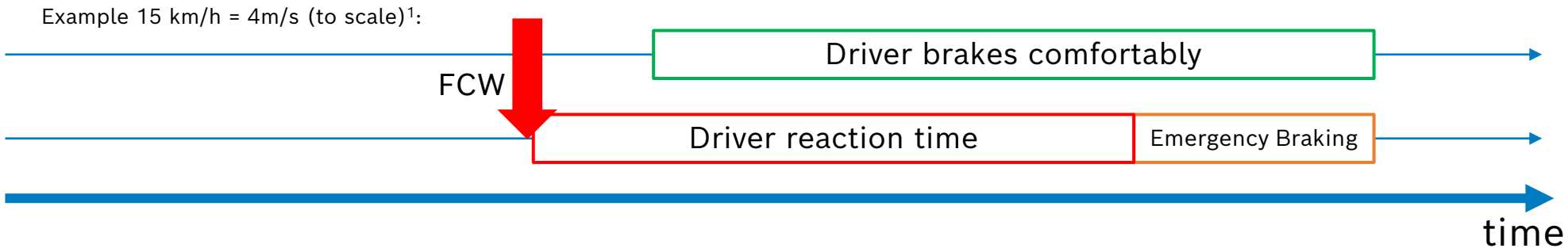


1: simplified for illustration of principle

Bosch Comments
Warning dilemma of FCW

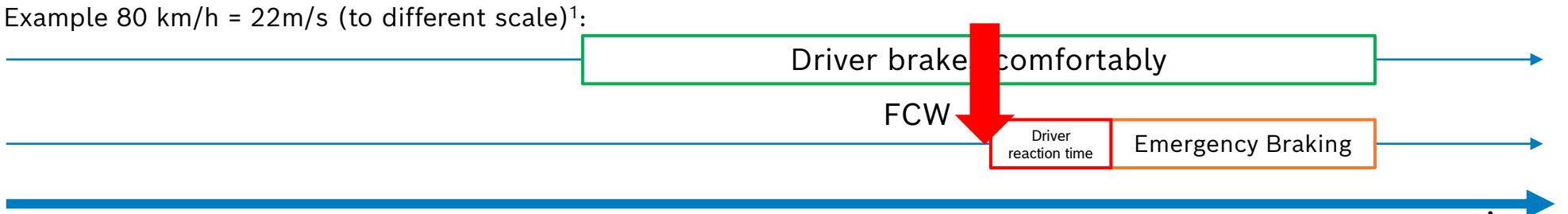
- **Low speed** – FCW before planned action of typical driver

  ➡ **no FCW at low speeds (less than ~30kph)**



- **High speed** – FCW after a possible planned action of typical driver

  ➡ **use FCW for high speeds (more than ~30kph)**



1: simplified for illustration of principle

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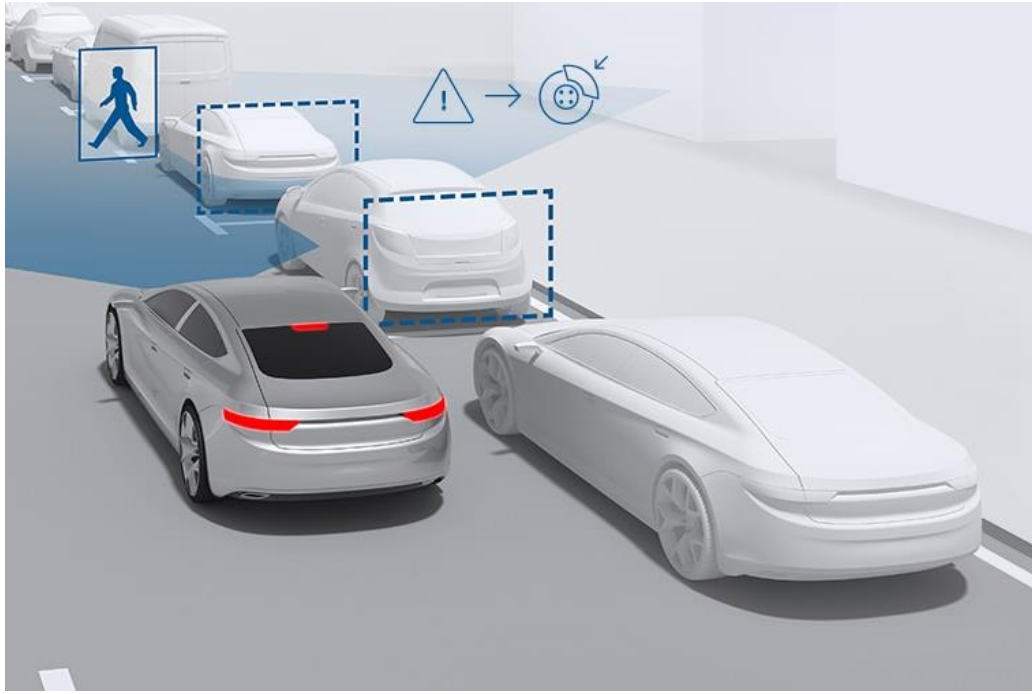
Bosch Comments
Repetition of tests for both AEB and PAEB

Repetitions of tests

- Multiple repetitions of a scenario as well as collision mitigation instead of avoidance at higher velocities should be allowed (e.g., 2 out of 3, or 5 out of 7)

What is the problem?

- Mandating many test cases that all need to be passed in a single test run might lead to problems for vehicles with otherwise good AEB systems.
- Due to the nature of systems relying on environment sensors the probability to pass a test is (slightly) lower than 100%.



Bosch Comments
Repetition of single tests

Discussion at UNECE for UN R152

Single test per test case ➡ 9.6% chance of testing failure

- Mandating a large number of test cases that all need to be passed in a single test run might lead to problems for vehicles with otherwise good AEB systems.
- Let's assume the following parameters (example, not a real system):
- Probability p_{single} to pass a single test case $p_{single} = 99\%$
  even an otherwise good AEB system might fail single tests, as this is a design constraint of systems based on environment sensors
- Total number of tests n needed to pass $n = 10$

- Probability p_{fail} to fail testing (with an otherwise good system)

$$\mathbf{p_{fail}} = 1 - p_{single}^{n} = 1 - 99\%^{10} = \mathbf{9.6\%}$$

Almost **one out of ten vehicles** (with an otherwise good system) **will fail testing.**

Bosch Comments
Repetition of single tests

Discussion at UNECE for UN R152

Two out of three per test case

- If you allow per test case a two out of three rule for tests to be passed:

- Using the same parameter:
- Probability p_{single} to pass a single test case p_{single} = 99%
  even an otherwise good AEB system might fail single tests, as this is a design constraint of systems based on environment sensors

- Test case is passed for:

Pass	Pass	Pass	in the three single tests
Pass	Pass	**Fail**	in the three single tests
Pass	**Fail**	Pass	in the three single tests
Fail	Pass	Pass	in the three single tests

Bosch Comments
Repetition of single tests

Discussion at UNECE for UN R152

2 out of 3 per test case ➡ 0.3% chance of testing failure

- Probability p_{pass} to pass a test case:

$$\mathbf{p_{pass}} = p_{single}^3 + 3 * p_{single}^2 * (1 - p_{single}) = 97.03\% + 2.94\% = \mathbf{99.97\%}$$

(Pass*Pass*Pass + Pass*Pass*Fail + Pass*Fail*Pass + Fail*Pass*Pass)

- Probability p_{fail} to fail testing (with the same system)

$$\mathbf{p\_fail} = 1 - p_{pass}^n = 1 - 99.97\%^{10} = \mathbf{0.3\%}$$

Only 3 out of 1000 vehicles (with an otherwise good system) will fail testing.

Bosch Comments
Repetition of single tests

Discussion at UNECE for UN R152

Does this make AEB systems less effective?

- „Wait a minute; This means that the system will be quite bad, as it only needs to work for 66% of all tests.“
- Let’s do the same math with 66% for p_{single}: p_{single} = 66%
- Probability p_{pass} to pass a single test case:

$$\mathbf{p_{pass}} = p_{single}^{3} + 3 * p_{single}^{2} * (1 - p_{single}) = 28.75\% + 43.12\% = \mathbf{71.87\%}$$

- Probability p_{fail} to fail testing (with a system with only 66% probability to pass a single test):

$$\mathbf{p\_fail} = 1 - p_{pass}^{n} = 1 - 71.87\%^{10} = \mathbf{96.32\%}$$ → **Almost all cars would fail testing**

Limiting the max. number of failed tests could address the concern that, otherwise, systems with insufficient performance might enter the market.

Bosch Comments
Critical headway at braking scenario

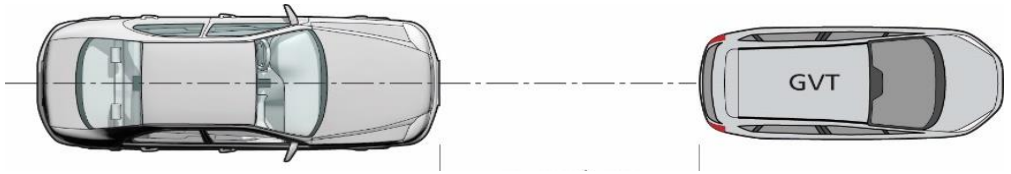
Headway for braking vehicle

Scenario as proposed by NHTSA:

- Both vehicle speeds 80 km/h
- Headway 12m
  => time gap of 0.54s

Comments

- Increase the headway to > 16 m for a time gap > 0.7 s for higher ego velocities for the decelerating lead vehicle scenarios



Issues:

1. Robust detection of deceleration of lead vehicle needs time
   - For **time gaps <0.7s** brake activation required before situation can be assessed robustly (e.g., multiple measurements, target tracking, etc.); latencies need to be taken into account
   - For **time gaps >0.7s** a robust detection would be possible
     => increase headway for this scenario to 16m
2. At 80 km/h, 0.54s time gap is not generally appropriate => many systems would trigger a driver warning to increase time gap
   - Suggestion to solve 0.5 s time gaps in the field by mandating “latent information systems” (informing the driver to increase time gap before the target brakes)

Bosch Comments
General feedback

Test conditions

- Specify the tests under realistic road conditions
- Allow additional lighting like Euro NCAP or allow automatic high beam
  - Critical hardware limitations for night-time PAEB is the performance of radar-vision fusion systems, where headlight quality has a significant impact on system performance.
  - Include repetitions for failed tests (e.g., 5 out of 7) and to allow additional lighting, or to allow automatic high beam for a better reproducibility and a more representative test scenario.

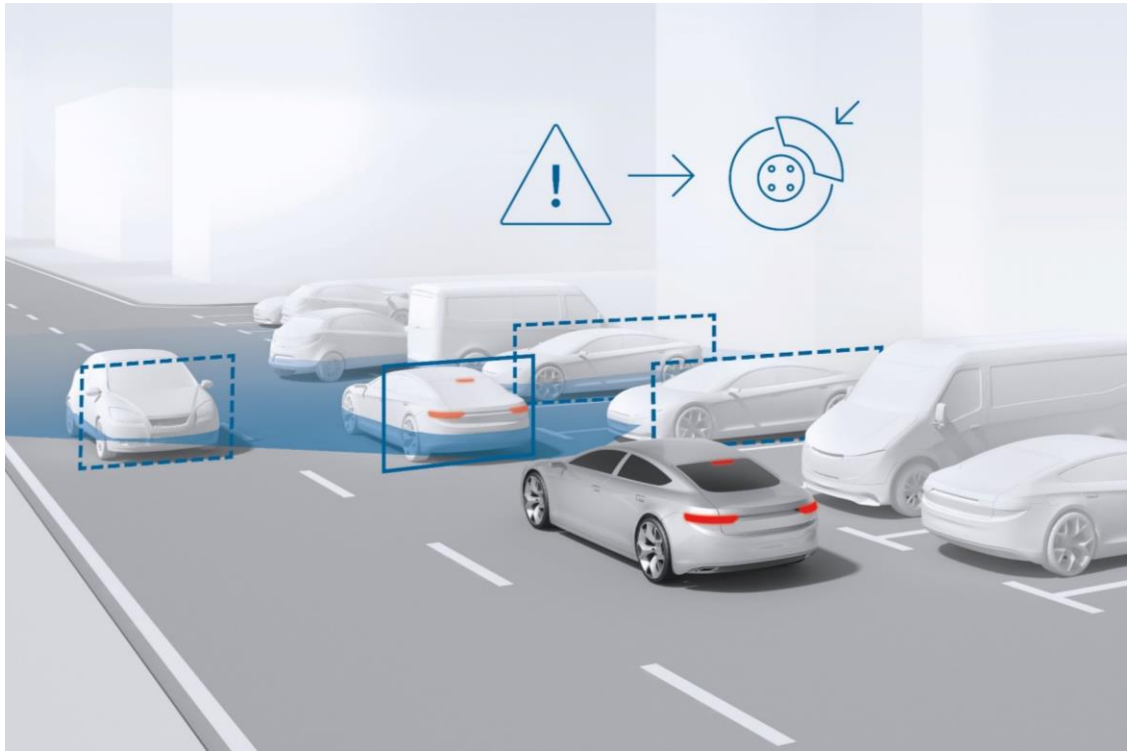
Mannequin appearance

- Outline of the NHTSA-approved testing equipment
  - Requirements for pedestrian testing equipment, specify the approved platforms, such as belt systems and launchpads, and the corresponding approved manufacturers of the devices
  - Use only the latest test targets (acc. to ISO 19206)

Bosch Comments
Conclusion

Bosch strongly supports NHTSA's goals

- New FMVSS requiring AEB and PAEB for passenger vehicles
- Engage with the industry to move forward with the adoption of this technology
- Supports a stepwise introduction of the proposed regulation to seamlessly integrate the required hardware



Thank you!