Informal document **GRVA-04-11**
4th GRVA, 24-27 September 2019
Agenda item 7

# UN Regulation No. 152
## (AEBS for M1/N1)

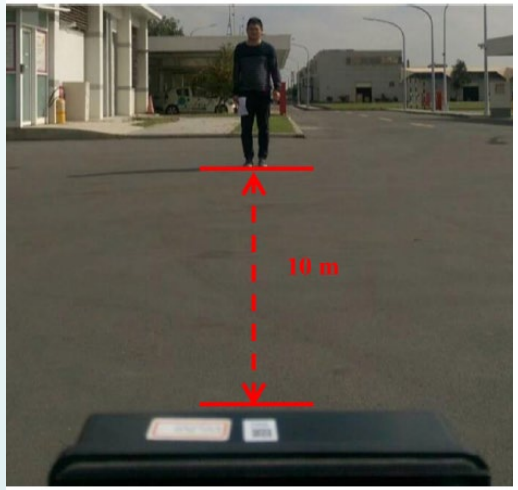
Presentation supporting the proposal for repetition of a limited number of unsuccessful test runs

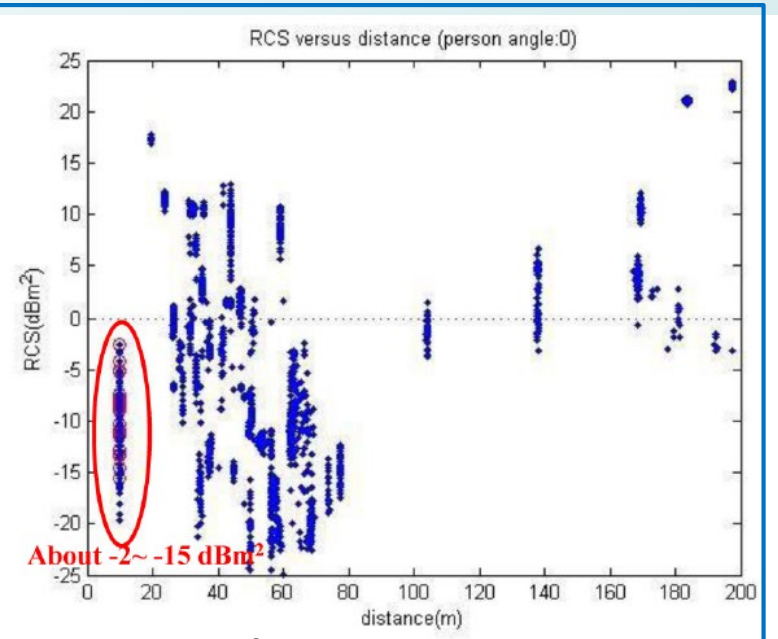
# The following slides will explain…

- why regulating AEBS is different from other systems,
- why it cannot be ensured that every test run is performed under the exact same conditions,
- what is required for UN-R152 type approval testing,
- what would be the outcome of the one-test-run per scenario approach,
- what is the current proposal,
- how can we be sure that the approved system performs well enough, and
- why the suggested approach is already well established and is suitable to ensure that approved systems demonstrate sufficient robustness.

# Why is AEBS different from conventional systems?

- AEBS relies on environmental sensors delivering a reliable representation of the real world.
- Object detection is not a black or white, 1 or 0 digital input value.
  - If you activate the turn indicator, this is a “digital” input signal and the reaction to that input can be expected to always be the same.




A radar transmits electromagnetic waves which are reflected by objects and returned to the receiver. These received electromagnetic waves have to be interpreted to determine e.g. the range, angle or velocity of objects.

  - Object detection is not a digital input, how a sensor detects an object depends on many factors, some even imperceptible to the human being.

- Since the AEBS in not only required to achieve high performance, but also to avoid false activations, the system needs to carefully evaluate whether to activate or not based on what its sensors detect. Classification of an object can be crucial when assessing whether to start an intervention or not, so an object’s characteristics play a big part in system performance.

# Why isn’t every test run 100% the same?

## Unexplainable influences when emulating the real world

There are influences on the test setup that cannot be measured. Experience of different test labs has shown that even if all conditions are seemingly the same, performance occasionally deviates.

With evolving sensor technology with better performance and reduced numbers of false detections, sensors become more sensitive if the test setup doesn‘t resemble the real world.

Therefor what tells an artificial test setup apart from the real world, can influence „what the sensor sees“, e.g.

- a pedestrian with only moving legs, not moving arms
- a pedestrian that is attached to a stick on a platform
- small damages to the target that affect its characteristics

Picture: Bosch / licensed by Bosch

Due to external influences it is simply impossible to ensure that every test run is performed under the exact same conditions, which is why it cannot be guaranteed that AEBS always achieves maximum performance.

# What is required for UN-R152 type approval testing?

10 performance tests for Car2Car
6 performance tests for Car2Ped

The higher the number of performed tests, the greater the probability to fail overall type approval by failing one single test for even the best of systems, due to the influence of external factors.

| Approval | No. | Scenario | Subject vehicle speed | Target speed | Load condition |
|---|---|---|---|---|---|
| **Car2Car** | 1 | **stationary** | **20** | 0 | **Mass in running order** |
| | 2 | | 20 | 0 | **Maximum mass** |
| | 3 | | **42** | 0 | Mass in running order |
| | 4 | | 42 | 0 | Maximum mass |
| | 5 | | **60** | 0 | Mass in running order |
| | 6 | | 60 | 0 | Maximum mass |
| | 7 | **moving** | **30** | 20 | Mass in running order |
| | 8 | | 30 | 20 | Maximum mass |
| | 9 | | **60** | 20 | Mass in running order |
| | **10** | | 60 | 20 | Maximum mass |
| **Car2Ped** | 1 | **crossing** | **20** | 5 | Mass in running order |
| | 2 | | 20 | 5 | Maximum mass |
| | 3 | | **30** | 5 | Mass in running order |
| | 4 | | 30 | 5 | Maximum mass |
| | 5 | | **60** | 5 | Mass in running order |
| | **6** | | 60 | 5 | Maximum mass |

# Probability to pass homologation with a single test per scenario approach

Let us assume the following two example parameters:

- Probability $p_{single}$ to pass a single test case

  $p_{single,\,1} = 95\%$ $\qquad$ $p_{single,\,2} = 99\%$

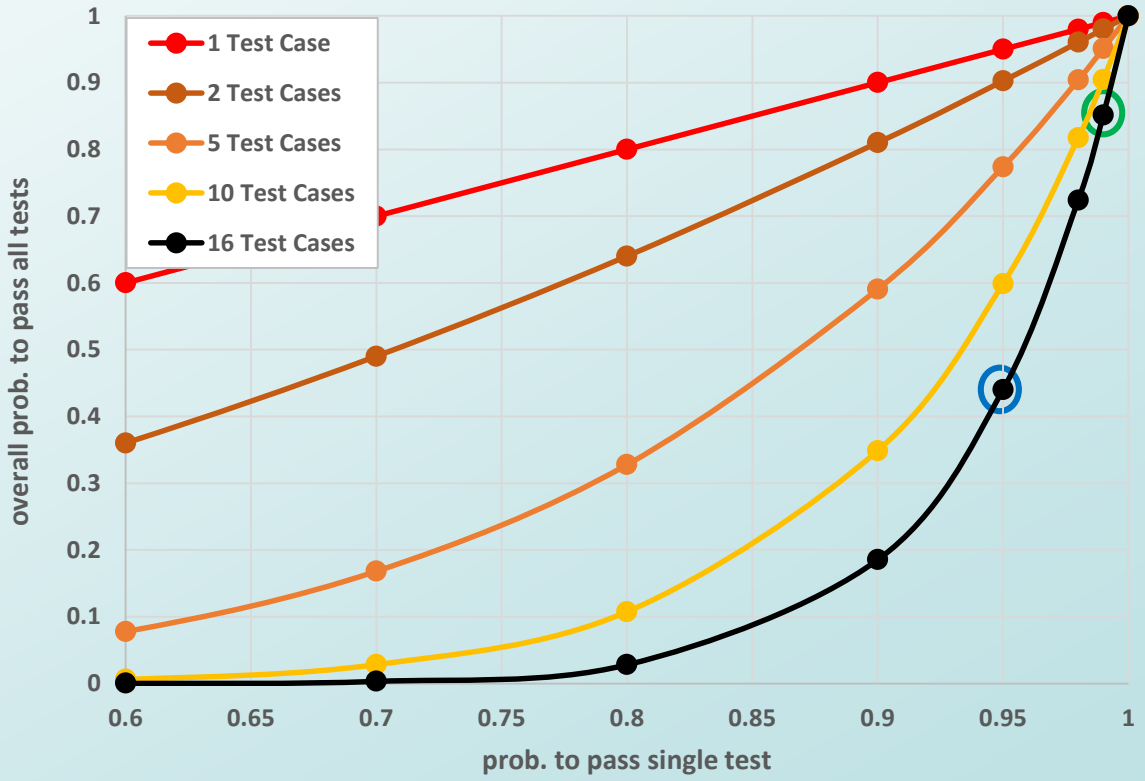
- Total number of tests n needed for homologation

  **n = 16**

- Probability $p_{pass}$ to pass homologation

  $p_{pass} = p_{single}^{n}$

  $P_{pass,1} = 95\%^{16} = 44\%$ $\qquad$ $P_{pass,2} = 99\%^{16} = 85\%$




Only 1 out of 2 vehicles (with a 95%-robust system) would pass homologation.
And even if the system was almost perfect (99%), still 1 out of 6 vehicles would fail homologation, due to the large number of performed tests.

# What is the suggested proposal for R152?

**[6.10. Repeatability of test runs**

**6.10.1. Any of the above test scenarios [,where a scenario describes one test setup at one subject vehicle speed at one load condition] shall be performed two times. If one of the two test runs fails to meet the required performance, the test may be repeated once. A test scenario shall be accounted as passed if the required performance is met in two test runs. [The total number of failed test runs shall not exceed [10%] of all performed test runs of all Car to Car and Car to Pedestrian scenarios in all load conditions.]**

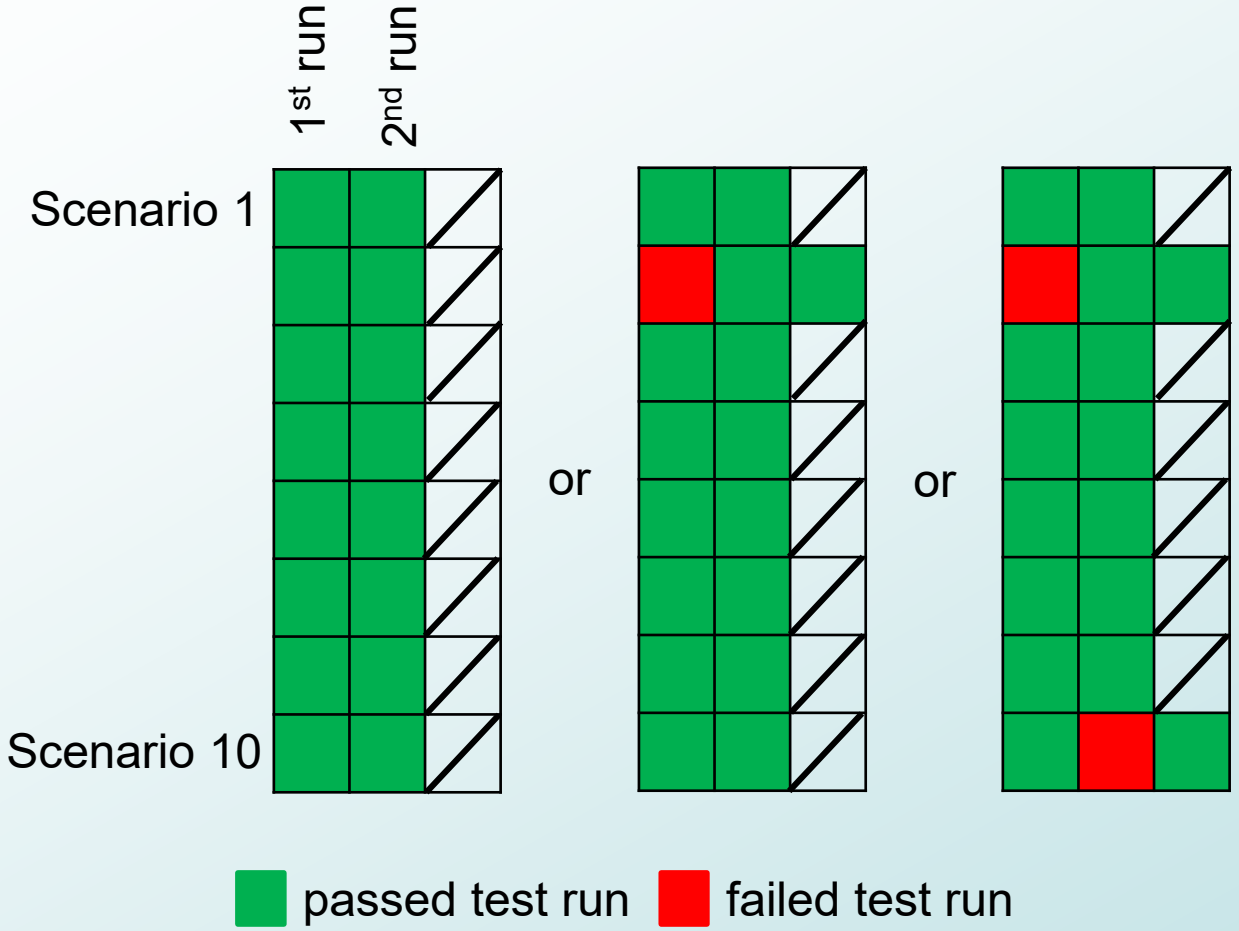
**6.10.2. The root cause of any failed test run shall be analysed.**

**6.10.3. During the assessment per Annex 3, the manufacturer shall demonstrate via appropriate documentation that the system is capable of reliably delivering the required performances.]**

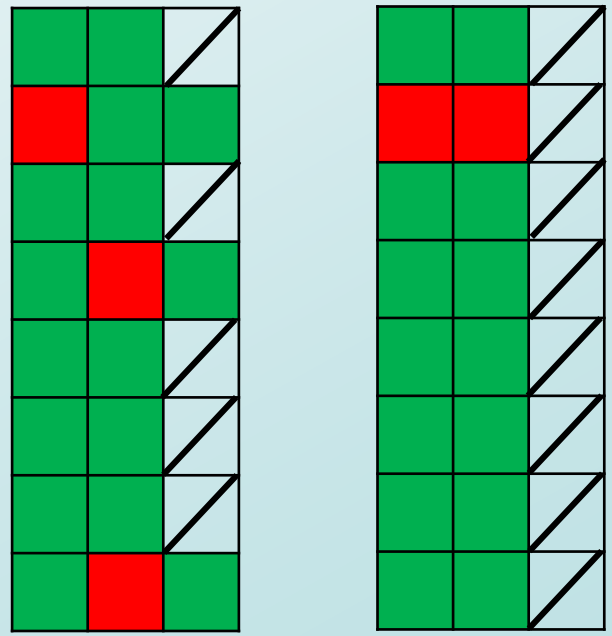
# Illustration of suggested Proposal

- in the following diagrams labelled “2 out of 3 and 10%” of test runs -

**Passing Type Approval testing**




**Failing Type Approval testing**



insufficient robustness

insufficient performance

The example above is with regard to the number of scenarios representative for an approval for Car2Car

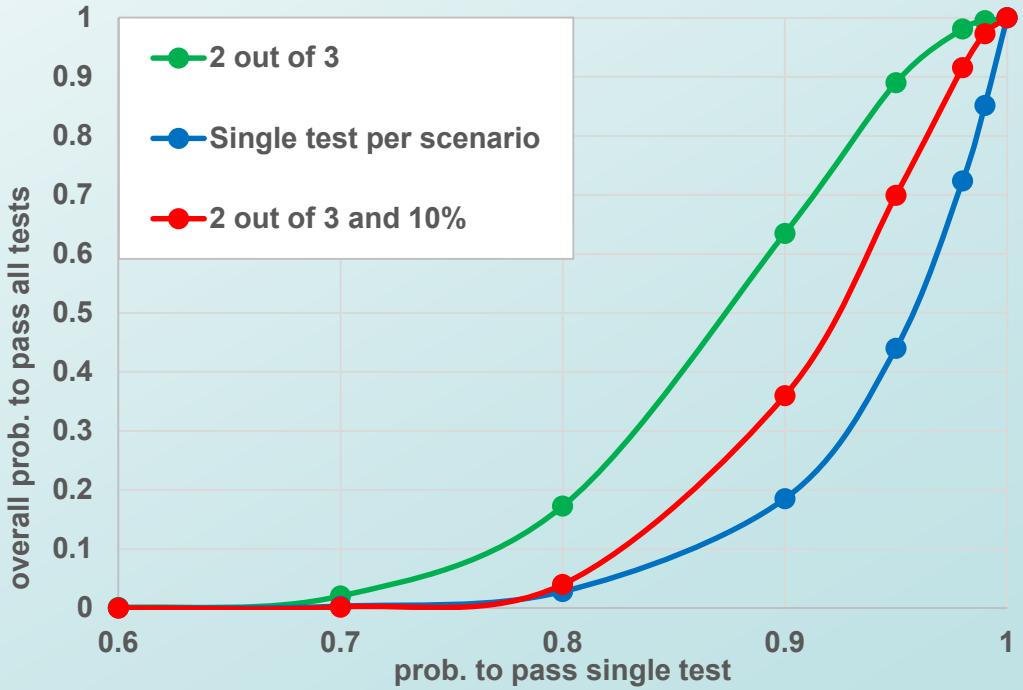
# How can we be sure that systems perform well enough?

## How can we be sure the system performs robustly well?

**What we need to accept:** We cannot determine the probability of the system to pass a single test (e.g. 95%) by test.

**Why not?** Because in order to determine that value you'd have to perform thousands of tests.

(If you flip a coin, you could end up having 6 heads in a row, but if you throw often enough, you will see that the ratio of heads to tails actually is 50/50)



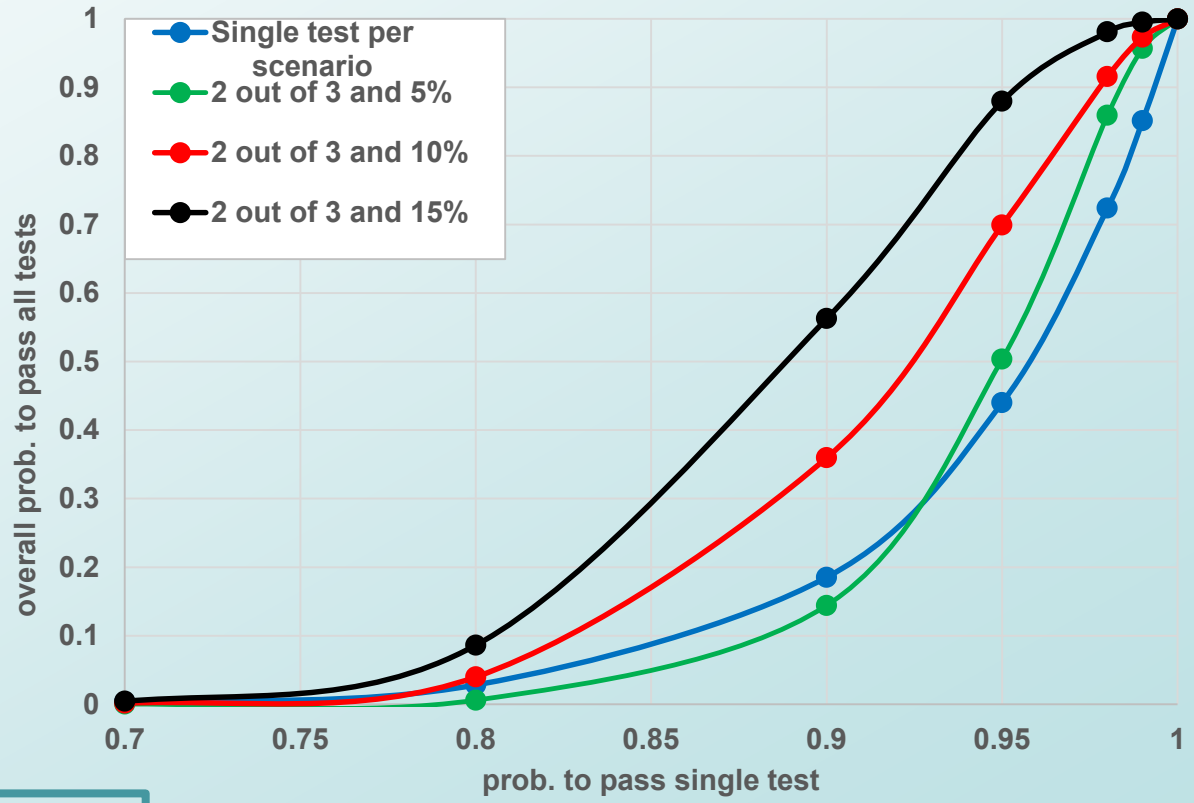

**Why will the proposed scheme lead non-robust systems to fail type approval testing?**

If a system was only 80% reliable to pass a single test, it would result in a 95% probability of failing type approval according to the suggested approach, which is about the same as with a single test run per scenario approach.

# How can we be sure that systems perform well enough?

**Why allow for 10% of maximum repeated tests?**

- The overall number of repeated test runs should be limited in order to ensure sufficient robustness of the AEBS.
- The overall number of tests for Car2Pedestrian is 12, so if less than 10% were permitted, that would result in no permitted repetition for an approval for Car 2 Pedestrian at all.




Limiting the overall number of unsuccesful test runs to 10% while requiring two passed test runs per scenario ensures sufficient robustness of AEBS without unreasonably increasing the test effort.

# Why is this a well-established approach?

**GB/T AEB Draft Standard**

4.3.2.4 **At least 3 of 5 times of tests** shall meet the provisions in Article 4.3.2.1-4.3.2.3.

**NCAP Test Protocol – AEB VRU Systems (Version 2.0.3, Nov. 2018)**

Where the predicted speed reduction in the tests above 40 km/h is at least 20km/h (sufficient to score points), but the actual speed reduction measured in the test is between 15 and 20km/h, the test shall be repeated a further two times and the middle value will be used in the assessment.

**ECE-R43 Safety Glazing**

Annex 14 - Rigid Plastic Panes:

6.1.4. A set of test pieces for approval shall be considered satisfactory if one of the following conditions is met:

(a) All test pieces meet the requirements or

**(b) One test piece having failed, a repeat of the tests on a new set of test pieces gives a satisfactory result.**

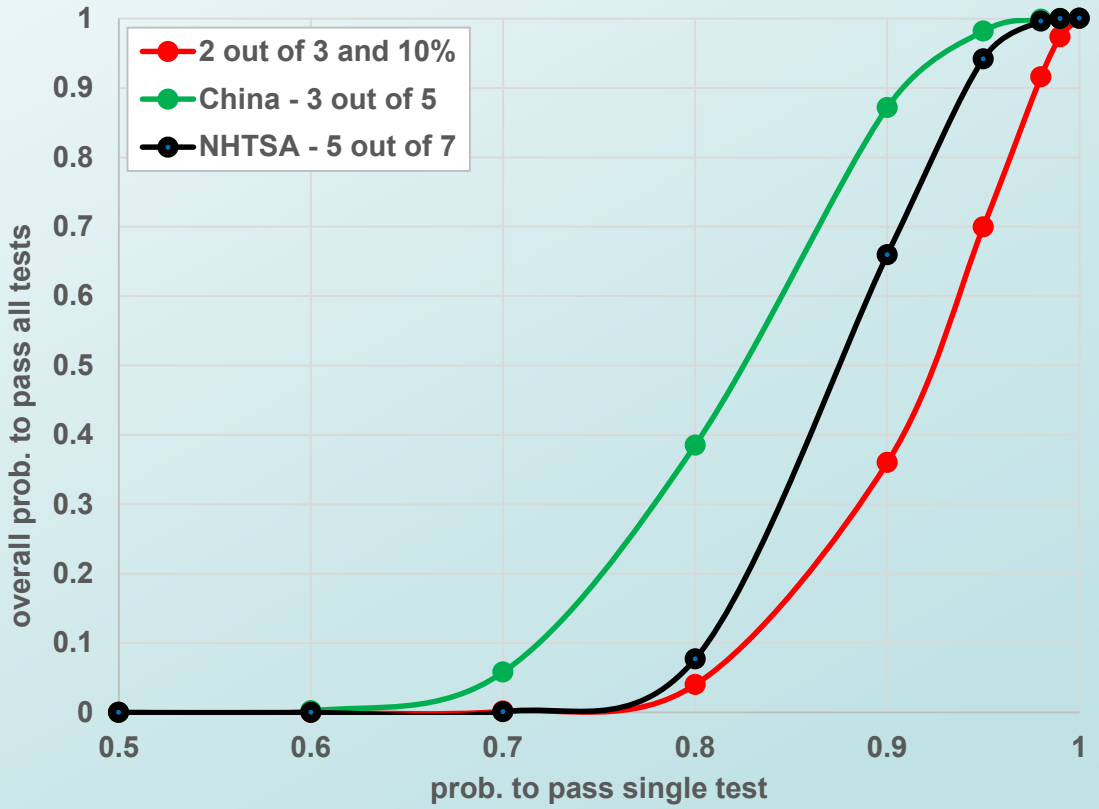
**NHTSA: Crash Imminent Brake System Performance Evaluation for the New Car Assessment Program**
(Link: https://www.regulations.gov/document?D=NHTSA-2015-0006-0025)

**12.6 CIB Performance Requirements**

The SV speed reductions (calculated using the methods described in S12.2.9, S12.3.9, and S12.4.8) shall be documented for each Stopped, Slower-Moving, and Decelerating POV test trial, respectively. SV decelerations within the validity period described in S12.5.6 shall be documented for each test trial performed over the steel trench plate. Tables 3 and 4 provide a summary of acceptable SV performance for each test scenario. **Five (5) of seven (7) valid test runs** must meet the performance requirements for each test scenario. However, once five (5) trials have satisfied the performance requirements for a given scenario, performing additional trials within that scenario is not required.

# Comparison of the R152 proposal to other AEBS standards

It can be recognized that the proposed approach for UN R152 will lead to the most severe requirements regarding performance robustness compared to other existing AEB standards.



# Summary

The proposed provisions regarding the repeatability of a very limited number of unsuccessful test runs:

[6.10. Repeatability of test runs

6.10.1. Any of the above test scenarios [,where a scenario describes one test setup at one subject vehicle speed at one load condition] shall be performed two times. If one of the two test runs fails to meet the required performance, the test may be repeated once. A test scenario shall be accounted as passed if the required performance is met in two test runs. [The total number of failed test runs shall not exceed [10%] of all performed test runs of all Car to Car and Car to Pedestrian scenarios in all load conditions.]

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will

- **ensure** that approved systems provide **sufficient robustness** with regard to their performance, by
- **defining a standardized procedure** for the repetition of unsuccessful tests, which will
- **benefit the harmonization of type approval testing** by giving a clear framework how unsuccessful test runs are to be handled.

# Appendix

Excel Sheet used for calculations:

Microsoft Excel Worksheet