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United Kingdom of Great Britian and
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Informal document **GRVA-19-42**
19th GRVA, 25 June 2024
(For review during the
Troy meeting 20-24 May 2024)
Provisional agenda item 7

Proposal for a supplement to 01 series of amendments to UN Regulation No. 152 (Advanced Emergency Braking System for M_1 and N_1 vehicles)

The text produced below was prepared by the experts of the United Kingdom of Great Britain and Northern Ireland group and is based on the working document GRVA/2024/19. The proposal is aimed at allowing the applicant to use virtual testing methodology as alternative methodology to the physical tests.

I. Proposal

Add a new paragraph 2.19 to 2.22., to read:

"2.19. "Virtual testing" is the process of testing a system using one or more simulation models."

"2.20. "Model" is a description or representation of a system, entity, phenomenon or process.

"2.21. "Tool" is the implementation of a model.

"2.22. "Toolchain" is the combination of tools that emulate a vehicle function.

Add a new paragraph 6.11., to read:

"6.11. Virtual testing of dynamic tests

6.11.1. Virtual testing may be used by request of the vehicle manufacturer as an alternative for some of the tests described in paragraphs 6.4. to 6.6.~~.~~. The virtual testing shall be verified and validated according to Annex 4 and used in accordance with that annex.

6.11.2. Virtual testing may be used in the evaluation of the warning and activation tests in accordance with paragraph 1.8. of Schedule 3 and Schedule 8 of Revision 3 of the 1958 Agreement.

6.11.3. Physical tests may be replaced with virtual tests for a maximum of [70%] of the required tests. In order to demonstrate that the complete physical system can reliably deliver the required performance, at least the remaining [30%] of required tests must be performed physically.

6.11.4. Where virtual testing is used by the manufacturer, a separate report including at least the additional information specified in Annex 4 shall be annexed to the test report."

Add a new Annex 4, to read:

"Annex 4 - Virtual testing of dynamic tests

1. The development, management, verification and validation of the virtual testing method

1.1 General specifications

1.1.1 Credibility of the toolchain that is used for the virtual testing shall be demonstrated by the vehicle manufacturer to the Technical Service.

For this, the following five criteria shall be considered:

(a) Capability - what the toolchain can do, and what the associated risks are;

(b) Accuracy – how well the toolchain reproduces the target data;

(c) Correctness – how sound & robust the algorithms in the tools and any data used in the development of those tools are;

(d) Fit for Purpose – how suitable the toolchain is for the assessment (e.g. vehicle dynamic model, sensor model, system control model, environment model, scenario model, targets model, …) within its validity domain.

(e) Usability – The training and experience which is needed and the quality of the processes that manage its use.

1.1.2 Developing and using the toolchain is the responsibility of the vehicle manufacturer. The toolchain shall reflect the vehicle, system and components that are to be tested.

1.2 Toolchain Management

The following information shall be provided by the manufacturer to the technical service:

1.2.1 A description of the models and tools which constitute the toolchain and the method used to trace input data, parameters and output data back to the corresponding toolchain version.

1.2.2 The processes which ensure that the personnel developing, testing and validating the toolchain and its components have appropriate experience, expertise, and training and evidence that these processes are implemented and effective. If there are any activities not directly controlled by the manufacturer, there must be an explanation of measures taken to ensure confidence in the quality and integrity of these activities.

1.2.3 A description of the input parameters, along with any uncertainties in the model parameters, which have been used to validate the models included in the tools and toolchain. The manufacturer should also provide documentation demonstrating that the data used to validate the models covers the intended scope and functionality of the toolchain.

1.2.4 A description of the overall approach to data management.

1.2.5 A description of the management activities which describe the modifications between toolchain releases, version control and the review processes to ensure

those modifications result in a toolchain that is still suitable, i.e. meets the criteria in 1.1.1.

1.3 Description and analysis of toolchain and components

1.3.1 All parts of the toolchain, tools and models shall be described by the manufacturer.

1.3.1.1 The vehicle manufacturer shall define the validity domain on which the toolchain will be applicable. The description of this shall include at least:

a) A description of the validity domain taking into account AEBS performance influencing factors, and
b) how the validity domain has been derived including any assumptions, limitations and tolerances.

1.3.1.2 The documentation shall include a description of the key performance indicators which will be assessed during validation, such as time to collision, remaining distance or impact speed.

1.3.1.3 The documentation shall include a description of the accuracy requirements for the toolchain and its components, including comparison with physical tests.

1.3.1.4 The documentation of the toolchain shall include assumptions, limitations, uncertainties and the necessary levels of fidelity.

1.3.1.5 The manufacturer shall provide a description of the toolchain assessment methodology, including the impact of any errors and uncertainties on the results and the subsequent consequences for the compliance of the system with this regulation.

1.3.2. The manufacturer should review the information produced from addressing the requirements of paragraph 1.3.1.1. and document any implications for the use of the toolchain.

1.4 Verification

1.4.1 The models that are developed and tested shall be capable of accurately representing the relevant aspects of the physical AEBS system that is being modelled.

1.4.2 The manufacturer shall provide documentation on the code verification which demonstrates the numerical and logical implementation of the toolchain and its components is correct. They shall also provide documentation showing the variation of input parameters was sufficiently wide to identify combinations for which the toolchain or any of its components show unstable or unrealistic behaviour.

1.4.3 The manufacturer shall provide an estimation of the numerical errors affecting the toolchain and its components and analysis that the errors remain sufficiently bounded.

1.4.4 The manufacturer shall demonstrate the effect of variations of the model parameters on the output values and identification of the most critical parameters which will influence the results. This shall also include a robust calibration procedure for these parameters.

1.5 Validation

1.5.1 The vehicle manufacturer shall describe their overall approach to validation including performance measures and a validation strategy. The validation strategy shall be agreed by the technical service, including the number of physical tests used to demonstrate that the toolchain is an accurate representation of the physical system. The number of tests performed shall ensure a statistical comparison between physical and simulation results is possible.

1.5.2 The manufacturer shall demonstrate how the toolchain achieves the key performance indicators defined in 1.3.1.2 and accuracy requirements defined in 1.3.1.3. This shall include justification for the choice of key performance indicators and accuracy requirements, and what the criteria is for a successful validation, such as measures of performance and goodness of fit.

1.5.3 The manufacturer shall provide the list of validation scenarios. The manufacturer shall provide the parameter descriptions and accuracy requirements that were needed to perform the validation tests.

1.5.4 The manufacturer shall provide documentation describing the validation that was performed to establish the credibility of the toolchain. This shall include information related to the processes that were followed, physical tests that were performed and models and tools that were used.

1.5.5 The manufacturer shall provide documentation that demonstrates how they have characterised the uncertainty in the input data and evaluated the model parameters. The overall uncertainty of the results shall be quantified based on the toolchain structure and from the data and its flow through the toolchain. This uncertainty quantification should allow estimates of the likely errors and the required safety margins that should be applied to the results when the toolchain is used for virtual testing.

1.5.6 The overall validation strategy shall be based on scientific methods, defined by the vehicle manufacturer and agreed with the technical service.

1.5.7 At the request of the technical service, in addition to the documentation provided by the vehicle manufacturer, additional confirmatory validation shall be performed, which may include physical testing. The physical tests may be relevant to the entire toolchain, specific parts of the toolchain or any of its components.

1.5.8 The methodology used to generate physical validation data, such as data recording equipment, data processing, calculation of scalar values shall be documented as part of the validation documentation.

1.5.9 The output of the toolchain and its components shall be compared against these additional physical tests and the results assessed against the appropriate criteria.

2. Activity 2: the use of virtual testing to conduct part of the testing required for type approval

2.1 Compliance of the Advanced Emergency Braking System with the performance requirements as defined in Paragraphs 5.2.1 to 5.2.3 of this regulation may be demonstrated by the vehicle manufacturer to the Technical Service by making use of virtual testing of the dynamic manoeuvres described in paragraph(s) 6.5 to 6.7 of this Regulation.

2.2 All virtual testing results provided by the manufacturer in applying for an approval in accordance with paragraph 4. of this regulation shall refer to the toolchain evaluated and validated according to paragraph 1 of this annex.

2.3 For each approval application the manufacturer shall provide a confirmation that the virtual testing:

a) was conducted using a validated toolchain;
b) was performed by competent staff;
c) has been undertaken by a toolchain that has a unique identifier and sufficient information including scope, regulatory applicability and validation history to ensure that there is traceability and assurance that the toolchain is suitable and fit for purpose; and
d) has been used within its scope and in accordance with any restrictions.

II. Justification

1. The proposal, GRVA/2024/19, to incorporate virtual testing into UN Regulation No. 152 does not address all the aspects of a credible virtual testing capability and does not provide sufficient detail for those that are mentioned. This proposal has incorporated salient aspects of the New Assessment Test Methods (NATM) Annex from the Validation Methods for Automated Driving (VMAD) informal working group document ECE/TRANS/WP.29/2024/39 to address these.

2. The process of specifying, developing, deploying and managing a virtual testing capability is complex and it is important that all the relevant aspects are addressed in any proposal to ensure that a proper and complete assessment is made during the approval process.

3. The changes proposed restructure the document and help implementation by incorporating the requirements within appropriately designated sections. First off are general requirements that focus solely on the principles established by VMAD's NATM. Following that is a specific section on tool management which is a critical part of ensuring that any virtual testing is executed correctly. It has been elaborated from that in GRVA/2024/19 to detail the expected activities to be undertaken to ensure that there is appropriate and consistent approach taken by all manufacturers. The section on the description and analysis of toolchain and its components is ensuring that the assumptions and limitations with respect to the virtual testing are well understood as well helping to give direction as to what aspects need to be documented.

4. A section on verification has been introduced as this was not included in GRVA/2024/19 and is a fundamental part of modelling and simulation development. Its inclusion provides assurance that the models and tools have been developed and implemented correctly. The validation section has been expanded to provide clarity on what and how it should be conducted. It covers how the manufacturer should document the strategy employed, the criteria used, and the evidence that is involved, not only to the complete toolchain but also the models.

5. The final section specifically deals with the aspects concerning type-approval, in doing so avoids conflating the activities associated within generating a credible toolchain and those that are done when applying that toolchain. It also introduces specific provisions to require the manufacturer to properly consider the appropriate deployment of the toolchain in the virtual testing and that is it suitably documented.

6. It should be noted that it is a significant endeavour to create a credible toolchain. Any poor application of virtual testing as a substitute for physical type-approval testing could undermine the robustness of the system in question. Therefore, the provision concerning these activities should be such that it cannot be the case. The vague and inconsistent nature of GRVA/2024/19 could lead to such circumstances. This proposal will help mitigate such outcomes by setting out in more detail what is expected to be undertaken by the manufacturer and examined by the Type Approval Authority or Technical Service.