Proposal for amendments to the proposal for a second iteration of the New Assessment/Test Method for Automated Driving – Master Document

The text reproduced below was prepared by the Informal Working Group (IWG) on Validation Methods for Automated Driving (VMAD). It proposes amendments to the proposal for a second iteration of the Master Document on New Assessment/Test Method for Automated Driving. It is based on ECE/TRANS/WP.29/GRVA/2022/2.

 I. Proposal

*Paragraph 63.,* amend to read:

“63. As per paragraph ~~7.3~~ **62** as well as the strengths and limitation table, there are a number of reasons for including track testing in the NATM. For instance, track testing can be used to assess the performance of ADS in nominal and critical scenarios. Track testing can also provide a higher level of environmental fidelity than simulation. Unlike real-world testing, track testing can accelerate exposure to known rare events or safety critical scenarios.”

*Paragraph 64.,* amend to read:

“64. Although track testing is a mature process which is used to assess safety requirements for some existing technologies, testing of ADS vehicles is fairly new and may need to be further refined. For instance, it may be difficult to develop specific ODD elements, such as rain, fog, and snow to reliably test how an ADS interacts with these environmental elements. **For this reason, Annex VII outlines the approach envisaged for the development of the NATM’s physical testing pillars, including track testing.”**

*Paragraph 74.,* amend to read:

“74. Real world testing provides and opportunity to validate the safety of the ADS within its true operating environment, as set out in greater detail in paragraphs ~~8.3, 8.4, and 8.5~~ **68, 69, and 70**.”

*Paragraph 75.,* amend to read:

“75. Real-world testing is regularly conducted to assess the performance of human drivers. However, testing of ADS performance may pose some new challenges for this test methodology. Experiences could be drawn from other motor vehicle-related real-world testing schemes, such as real driving emissions (RDE) testing and market surveillance. **For this reason, Annex VII outlines the approach envisaged for the development of the NATM’s physical testing pillars, including real world testing.**”

*Insert a new Annex VII,* to read:

**Annex VII**

 **Outline of the Approach for the Testing Methods for Track Testing and Real World Testing**

 **I. Introduction**

An initial overview of best practices, procedures, technical resources and tools related to track testing and real world testing was prepared.[[1]](#footnote-1)

The overview showed that numerous test procedures and standards for track testing have been developed and used to assess the safety of vehicles with automated driving systems (e.g. ALKS) and particularly with advanced driver assistance systems, which can serve as input to the to-be-developed track testing methodology.

The overview furthermore showed that no test procedure to assess the safety of vehicles with automated driving systems on public roads has been developed yet[[2]](#footnote-2), with most of the available documentation concerning guidance or specifications on testing (i.e. trails) such vehicles by OEMs during the developmental stages of their systems, or the testing of human drivers.

This annex outlines the intended approach for the track testing and real world testing methods. The second part of this annex provides more detailed information on the chosen approach: the test matrixes. The third part provides considerations and next steps for the development of the testing methods.

 **II. The Test Matrixes**

The starting point for the development of the methods for track testing and real world testing is the test matrix approach. This approach proposes the use of one general matrix for physical testing, as well as two test matrixes specifically designed for respectively track testing and real world testing.

The purpose of the general matrix for physical testing would be to provide a clear overview of how the respective safety performance requirements set by FRAV could be assessed using track testing, real world testing, or both.[[3]](#footnote-3)

The test matrixes for respectively track testing and real world testing would differ in design, in order to take into account the different settings in which the tests are conducted, as well as to ensure that the strengths of each testing method can be utilized.

*Please note that the example test matrixes set out in this annex are merely illustrative and therefore include mock-up criteria.*

 **A. The General Matrix for Physical Testing**

The general matrix would provide a clear overview of the type or types of physical testing to be used for assessing compliance with the applicable safety requirements set by FRAV.

The example in table VII.1 illustrates the basic concept for the overview based on (a selection of) the initial 40 safety topics drafted by FRAV.[[4]](#footnote-4) Please note that the example is merely illustrative and should not be regarded as VMAD’s position on the applicability of each test method per safety topic.

Moreover, the example does not take into account any further development on the safety topics by FRAV since the 18th VMAD meeting. The safety topics are furthermore expected to be set out in more detail in the future, each topic containing one of more measurable requirements.

It is envisaged that, once developed, these measurable requirements would be listed in the left column of the table instead of the currently listed safety topics.

Table VII.1
**Example of the General Matrix for Physical Testing**

|  |  |  |
| --- | --- | --- |
| **(FRAV) Safety Requirement** | **Track Testing** | **Real World Testing** |
| 1.       The ADS should perform the entire Dynamic Driving Task. | Yes | Yes |
| 2.       The ADS should control the longitudinal and lateral motion of the vehicle. | Yes | Yes |
| (…) |  |  |
| 7.       The ADS should adapt its behavior in line with safety risks. | Yes | If encountered |
| 8.       The ADS should adapt its behavior to the surrounding traffic conditions. |  | Yes |
| (…) |  |  |
| 30.    The ADS should safely manage short-duration ODD exits. | Yes | Yes |
| 31.    Pursuant to a collision, the ADS should stop the vehicle and deactivate. | Yes | If encountered |
| (…) |  |  |

‘If encountered’, as used in the table above, would indicate that real world testing would not seek to assess the respective safety requirement, generally due to the undesirability from a safety perspective to assess such requirements on public roads. However, given that random traffic situations are encountered during real world testing, such traffic situations could organically occur and in this case, the performance with regards to the specific requirement should be assessed. The testing safety on public roads should also be taken into account, which the assessor or the driver should ensure and they should therefore take over the driving task if needed.

VMAD’s SG4 will elaborate in a next step on how the assessment of such ‘if encountered’ occurrences should be integrated in the testing method for real world testing, e.g. whether they would be included in the test matrix or whether the testing protocols would provide guidance/instructions on how assessors are expected to handle such cases.

Instead of “Yes” and “If encountered”, the table could also be structured to already provide more information on the intended purpose/aim of the test. For example:

Table VII.2

|  |  |  |
| --- | --- | --- |
| **(FRAV) Safety Requirement** | **Track Testing** | **Real World Testing** |
| XX.      The ADS should respond safely to the cut-in of another vehicle. | Verification of the ADS crash-avoidance response to a dangerous cut in. | Nominal verification that the ADS adapts the vehicle positioning in response to the cut in.Verification of the ADS crash-avoidance response to a dangerous cut in, if encountered. |

 **B. The Test Matrix for Track Testing**

The left column of the test matrix for track testing would refer to scenarios developed by VMAD’s SG1, which VMAD’s SG4 anticipates would include the traffic situation, infrastructure elements, objects, ODD elements, etc, etc.

The safety requirement(s) column would cross-reference the applicable safety requirement(s), to be set out by FRAV, that would be assessed in the respective scenario. VMAD’s SG4 anticipates that FRAV would provide requirements enabling determinations of the pass/fail criteria, which would in turn be set out in the assessment specification column.

If applicable, the additional test specification column would allow for any additional conditions or parameters to be specified, which were/could not be described in either the traffic scenario or the safety requirement(s), but which are necessary in order to conduct the track test (e.g. minimum duration of the test).

Please note that the example matrix on the next page is merely meant to illustrate the envisaged structure. The content provided is therefore intentionally non-specific and should not be regarded as VMAD’s position on the suitability of using track testing to assess the listed safety requirements.

The eventual scenarios, safety requirement(s) and assessment specifications are to be sourced from respectively VMAD’s SG1 and FRAV, with any additional test specifications to be added based on discussions within VMAD’s SG4.

Table VII.3
**Example of a Test Matrix for Track Test**

|  |  |  |  |
| --- | --- | --- | --- |
| **Traffic Scenario** | **Safety Requirement(s)** | **Additional Test Specifications** | **Assessment Specification** |
| This column would cross-reference the testing with the scenario upon which the testing is based. VMAD’s SG4 anticipates that the scenarios would cover the traffic situation, infrastructure elements, objects, ODD elements, etc. | This column would cross-reference the testing with the safety requirements relevant to the traffic scenario. SG4 anticipates that FRAV would provide requirements enabling determinations of the pass/fail criteria, to be set out in the assessment specification column. | This column would complement the description of the traffic scenario with additional information or parameters necessary for conducting the track test, if applicable. | This column would set out the assessment specification. |
| *The following examples illustrate the concept of the matrix for track testing. VMAD’s SG4 has intentionally provided non-specific examples. The scenarios and safety requirements would be sourced from VMAD’s SG1 and FRAV. The matrix would evolve in line with progress of these activities.* |
| Unobstructed travel on a straight path | * Safe lateral positioning in a lane of travel
 | * A minimum test duration of 5 minutes
 | The test shall demonstrate that the ADS does not leave its lane and maintains a stable position inside its ego lane across the speed range within its system boundaries. |
| Unobstructed travel along a curve | * Safe lateral positioning in a lane of travel
* Adapt to road conditions
 | * A minimum test duration of 5 minutes
 | The test shall demonstrate that the ADS does not leave its lane and maintains a stable position inside its ego lane across the speed range and different curvatures within its system boundaries. |
| Cut-in by another vehicle while traveling on a straight path | * Respond safely to the cut-in
* Safe longitudinal positioning relative to a lead vehicle
 | * Scenario with selected parameters to verify the ADS crash-avoidance response to a dangerous cut in per the safety requirements[[5]](#footnote-5)
 | The test shall demonstrate that the ADS is capable of avoiding a collision with a vehicle cutting into the lane of the ADS vehicle up to a certain criticality of the cut-in manoeuvre. |
| ODD exit scenario | * ADS detection of ODD boundary
* Automated response (if failed fallback user response or no fallback user)
 | * Test for failed fallback user response
 | The test shall demonstrate that the ADS is capable of bringing the vehicle to a safe stop, in case of a failed fallback user response. |

 **C. The Test Matrix for Real World Testing**

The left columns would set out the measureable safety requirements to be developed by FRAV.

The top rows on the right side would set out the traffic situations required to be encountered during real world testing. Given the dynamic nature of traffic on public roads, it is considered unlikely that traffic situations will occur exactly as described in the traffic scenarios developed by VMAD’s SG1, and these are therefore not referenced in the test matrix. Instead, the traffic situations listed in the second row would be further described in the testing protocols accompanying the test matrix, with the description envisaged be rather general in order to ensure that there is a near certainty of being encountered during real world testing. In order to prevent confusion with the detailed traffic scenarios developed by VMAD’s SG1, they have therefore (provisionally) been titled as “traffic situations” instead.[[6]](#footnote-6)

Please note that the five traffic situations set out in the example are merely illustrative.

The remaining fields of the matrix represent the assessment specification per safety requirement for the applicable traffic situations, which are to be sourced from FRAV. The assessment specification would summarize the desired performance in one sentence, with a more detailed description of the assessment specification to be set out in the testing protocols accompanying the test matrix, where necessary.

The inclusion of an assessment specification would reflect that the respective safety requirement would need to be verified for the respective traffic situation. As an illustration, in the example table’s Row 1.1, the compliance with the safety requirement on lane keeping would have to be verified in all the traffic situations. (Please note that the assessment specifications in the table are merely illustrative and moreover do not reflect VMAD’s position on whether compliance with the safety requirement should be verified in the respective traffic situations for which the mock-up assessment specifications are provided).

However, VMAD’s SG4 will further discuss how the “If encountered” situations can be appropriately reflected in the test matrix. This refers on the one hand to the assessment of safety requirements that are undesirable to be conducted on public roads, but which may nevertheless occur.[[7]](#footnote-7) As an illustration, in the example table’s Row 2.1 on the safe response to a cut-in, the table would require the assessment of the ADS’ response to a (nominal) cut-in of another vehicle during real world testing. The ADS’ response to dangerous cut-in would only need to be assessed if encountered during real world testing, as signalled by the addition of ‘, if applicable.’.

On the other hand, it refers to the assessment of safety requirements (during nominal traffic conditions) that cannot be assured (and therefore required) to be encountered during real world testing, but which may occur. As an illustration, in the example table’s Row 2.1 on the safe response to a (nominal) cut-in, such situation could also occur during any of the other traffic situations listed on top.

For both cases, VMAD’s SG4 will further discuss what the most efficient and clear way would be to signal such ‘Assess if encountered’ requirements. Suggestions made so far include:

* Handling such occurrences completely separate from the test matrix (e.g. only provide guidance/instructions in the testing protocols);
* Including them in the test matrix itself, but signalling their conditionality (e.g. Row 2.2 in the example table. Note in particular the assessment specification for lane changes, where both a required assessment and a conditional ‘if encountered’ assessment are included);
* Signalling the existing of ‘If encountered’ assessments (e.g. using ‘\*’), but setting out the conditional assessment specification as well as guidance/instructions in the testing protocols. (Please note that this latter option has not been illustrated in the example table).

Aspects related to routing (e.g. minimum duration, minimum frequency of a given traffic situation encountered during testing, etc.) would be set out in the accompanying test protocols.

Table VII.4
**Example of a Test Matrix for Real World Testing: Motorway Application**

|  |  |
| --- | --- |
|  | **Traffic Situations** |
| **Safety Requirements** | Driving on the motorway | Merging | Lane Change | Overtaking | Exiting Motorway |
| 1.1. | Safe lateral positioning in a lane of travel | The ADS demonstrates it does not leave its lane and maintains a stable position inside its ego lane across the speed range within its system boundaries. | The ADS demonstrates it achieves a stable position inside the target lane upon completion of the lane change procedure. | The ADS demonstrates it achieves a stable position inside the target lane upon completion of the lane change procedure. | The ADS demonstrates it achieves a stable position inside the target lane upon completion of the lane change procedure. | The ADS demonstrates it maintains a stable position in the off-ramp lane. |
| 2.1. | Respond safely to the cut-in of another vehicle | The ADS adapts the vehicle positioning in response to the (nominal) cut in.The ADS responds appropriately[[8]](#footnote-8) to a dangerous cut in, if applicable.[[9]](#footnote-9) |  |  |  |  |
| 2.2. | Safe longitudinal positioning relative to a lead vehicle | The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle. | The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle during and upon the completion of the lane change procedure. | The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle prior and during the lane change procedure.The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle upon the completion of the lane change procedure, if applicable. | The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle prior and during the lane change procedure. | The ADS demonstrates it maintains a safe longitudinal position relative to a lead vehicle, if applicable. |

III. Considerations & Next Steps

Populating the test matrix with safety requirements, traffic scenarios/traffic situations and the assessment specifications is the next step in the development of the test methods for track and real world testing. However, it will merely be the first of several steps before the test matrix approach as such could be used as an assessment method.

This section therefore outlines the next steps that are required in order to operationalize the test matrixes approach, together with some initial considerations.

 A. Populating the Test Matrix

In order to be able to advance with the development process of the test matrixes testing method, it is first necessary to populate the test matrixes with requirements, scenarios and assessment specifications. This is because most, if not all, of the subsequent steps depend largely on the content of the matrix itself. For example, without knowing what will be required to be tested and against which criteria, it would difficult, if not impossible, to determine the length and scope of the real world testing aspect.

The test matrix would be populated with the requirements and assessment specifications to be developed by FRAV, and for track testing the scenarios developed by VMAD’s SG1 as well. Given that FRAV and VMAD’s SG1 are currently still in the process of developing respectively the requirements and traffic scenarios, SG4’s work on the matrixes themselves will be largely on hold until the requirements and scenarios become available.

With regards to the populating the test matrixes in due time, the criteria to be included for testing would be selected in coordination with VMAD and FRAV, whereas the scenarios would be selected in coordination with SG1.

 B. Developing the Test Protocols

Once a test matrix has been populated, the accompanying test protocols[[10]](#footnote-10) will be developed by VMAD’s SG4. These test protocols would include, for example, the scope and length of testing, conditions for testing and routing (as far as not provided for by either the criteria or traffic scenario/traffic situation descriptions), as well as other aspects necessary in order for the persons conducting the testing to ensure a harmonized interpretation of the test matrix and protocols as well as in turn to ensure harmonized assessments.

 C. Validation of the Testing Approach

The test matrixes and accompanying test protocols would first need to be validated during try-outs, in order to ensure that they are indeed providing the desired assessment of the safety of the vehicles with automated driving systems on board. These validations are particularly important for real world testing, as no regulatory framework, procedure, or specification currently exists to assess the safety of the ADS.

The validation process will be developed further in a later stage, once (suitable drafts of) the test matrixes and accompanying test protocols have been developed. Questions for consideration during the development of the validation process would include:

* How many test organizations and test vehicles are required?
* How many times would the try-out need to be repeated?
* Who conducts these try-outs?
* Are there a certain number of countries that need to validate the test matrix and test protocols?
* Would each country need to conduct their own try-outs?

1. VMAD-SG4-06-05 [↑](#footnote-ref-1)
2. UN Regulation No. 157 on automated lane keeping systems (ALKS) provides provisions for a real world test. For the purpose of developing the NATM’s real world test, these provisions are however not detailed enough to be regarded as specifications including a procedure. [↑](#footnote-ref-2)
3. This general matrix for physical testing would only include applicable safety performance requirements suitable for physical testing, excluding those that are only to be assessed using other pillars of the NATM. Should VMAD decide to establish a general overview at VMAD/NATM level setting out which pillar/pillars should be used to assess compliance with the respective safety performance requirements set by FRAV, then this general matrix for physical testing could be integrated into such overview. [↑](#footnote-ref-3)
4. As set out in VMAD-18-03. [↑](#footnote-ref-4)
5. This inclusion assumes the traffic scenario does not prescribe the (range of parameters to be selected for the) occurrence of a safety-critical situation. If that were to be included in the scenario, this field could be empty. [↑](#footnote-ref-5)
6. Should VMAD’s SG1 develop general scenarios suitable for use in the test matrix for real world testing, VMAD’s SG4 would consider references to those general scenarios instead. [↑](#footnote-ref-6)
7. It should be possible for the assessor to interrupt the test on public roads, should the situation become dangerous. VMAD’s SG4 will further discuss this topic and may decide to provide guidance in the testing protocols. [↑](#footnote-ref-7)
8. What constitutes an ‘appropriate response’ would then be set out in the testing protocols that accompany the test matrix, sourced from FRAV. [↑](#footnote-ref-8)
9. To be determined whether ‘If encountered’ situations should be included in the matrix itself. Included here, as well as in other parts of the table, as an illustration. [↑](#footnote-ref-9)
10. Test parameters should take into account the ODD of the ADS under test. [↑](#footnote-ref-10)