**VMAD SG4 on Track and Real World Testing**

Outline Test Method Approach for   
Track Testing and Real World Testing

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| 1. | Introduction |
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|  | In VMAD’s “New Assessment/Test Method for Automated Driving (NATM) - Master Document”, section 7 concerns the testing of automated vehicles on test tracks, whereas section 8 concerns real-world testing.[[1]](#footnote-1) Both sections were based on SG4’s Concept Paper.[[2]](#footnote-2)  In line with the subgroup’s work plan[[3]](#footnote-3), an initial overview of best practices, procedures, technical resources and tools was prepared by the subgroup.[[4]](#footnote-4) 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 SG4’s to-be-developed track testing methodology.  The overview furthermore showed that no test procedure to assess the safety of vehicles with automated driving systems has been developed yet, with most of the available documentation concerning guidance or specifications on testing (ie. trials)) of such vehicles by OEMs during the developmental stages of their systems, or the testing of human drivers.  This present document outlines the intended approach for the (development of the) track and real world testing methods, as agreed upon by members of SG4 during the subgroup’s meeting on 29 July 2021. This document’s second section provides more detailed information on the chosen approach – the test matrix – and the third section provides considerations and next steps for the development of the testing method. As the test matrix can be used for both track testing and real world testing, the description of the approach applies to both testing methods, unless an explicit differentiation is made. |
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| 2. | The Test Matrix |
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|  | The starting point for the development of the track and real world testing methods, as agreed upon by SG4 during its meeting on 29 July 2021, is the test matrix approach. Examples of possible approaches for the test matrix are set out on the next pages. *Please note that these examples are merely illustrative and includes therefore mock-up criteria.* |
|  | The test matrixes set out the safety requirements to be assessed, the traffic scenarios/traffic situations during which they will be assessed, as well as the assessment specifications such as pass/fail criteria, for the safety requirements per traffic scenario/traffic situation. The test matrix is based on the testing methods for human drivers, and is to be adapted to take into account the specificities of (testing) vehicles with automated driving systems. |
| [2.1 | *Approach 1* |
|  | The safety requirements will be developed and provided by FRAV. The left of the two criteria columns represent the safety topics established by FRAV, whereas the right column represent the specific, measurable criteria per safety topic, to be developed by FRAV. |
|  | The traffic scenarios/traffic situations on top reflect the applicable scenarios/situations for the use case – for this example the motorway application. For track testing, these scenarios represent the appropriate safety-critical scenarios to be developed by VMAD’s SG1. For real-world testing these will represent more general traffic situations, given the dynamic situation with no pre-set conditions on the road. |
|  | The assessment specification per safety requirement for the given traffic scenario/traffic situation are set out in the remaining parts of the matrix, where applicable. For the illustrative purpose of this example, the assessment specifications have a simple “sufficient/insufficient” grading, however more precise pass/fail criteria appropriate for the given criteria could also be used (e.g. specific minimum/maximum values). These assessment specifications are to be developed by FRAV as well. |
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**Example Test Matrix: Motorway Application**

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|  | | **Traffic Scenarios / Traffic Situations** | | | | |
| **Criteria** | | Driving on the motorway | Merging | Lane Change | Overtaking | Exiting Motorway |
| **Lane keeping** | a. Driving straight | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient |
|  | b. Driving curves | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient |
|  | c. (…) |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | Driving on the motorway | Merging | Lane Change | Overtaking | Exiting Motorway |
| **Respecting traffic rules** | a. Traffic signs | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient |
|  | - The ADS interprets the sign according to the meaning of the sign |  |  |  |  |  |
|  | - The ADS reacts conform to the meaning of the sign |  |  |  |  |  |
|  | - The ADS reacts in time |  |  |  |  |  |
|  | - (…) |  |  |  |  |  |
|  | b. Traffic agents (e.g. police officers) | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient | Sufficient / Insufficient |
|  | - (…) |  |  |  |  |  |
|  | c. (…) |  |  |  |  |  |
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| 2.2 | *Approach 2* |
|  | During an email exchange following the SG4 meeting on 5 October 2021, the following example for the test matrix was proposed as alternative. |
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| **Traffic Scenario** | **Safety Requirement(s)** | **Test Method** | |
| This column cross-references the testing with the scenario upon which the testing is based. SG4 anticipates that the scenarios would cover the traffic situation, infrastructure elements, objects, ODD elements, etc. | This column cross-references 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. | This column describes the test type (real-world or track). SG4 would base this allocation on the safety risk inherent in the testing and the qualitative/quantitative data necessary to determine fulfilment of the safety requirement(s). | |
| *The following examples illustrate the concept of the matrix. SG4 has intentionally provided non-specific examples. The scenarios and safety requirements would be sourced from SG1 and FRAV. The matrix would evolve in line with progress of these activities.* | | | |
|  |  | Track | Real-World |
| Unobstructed travel on a straight path | * Safe lateral positioning in a lane of travel * Comply with traffic laws |  | Nominal verification that the ADS maintains the vehicle positioned in the lane and complies with prevailing traffic laws (e.g., speed limit) |
| Unobstructed travel along a curve | * Safe lateral positioning in a lane of travel * Comply with traffic laws * Adapt to road conditions |  | Nominal verification that the ADS maintains the vehicle in a safe position along the curve, adapts its speed to the curvature, and complies with the prevailing speed limit in accordance with the requirements |
| 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 | Nominal verification that the ADS adapts the vehicle positioning in response to the cut in |
| ODD exit scenario | * ADS detection of ODD boundary * Transfer of control (if fallback user) * Automated response (if failed fallback user response or no fallback user) | Test for failed fallback user response | Verification of nominal transfer of control in case of ADS designed for use with fallback user or of automated response in the case of ADS without fallback user] |

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| 3. | Considerations & Next Steps |
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|  | Populating the test matrix with safety requirements, traffic scenarios/traffic situations and the assessment specifications is the next step in the development of SG4’s 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 matrix approach, together with some initial considerations. |
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| 3.1 | Populating the Test Matrix |
|  | In order to be able to advance with the development process of the test matrix testing method, it is first necessary to populate the test matrix with requirements, scenarios and assessment specifications. This given that 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 whichcriteria, 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 SG1 as well. Given that FRAV and SG1 are currently still in the process of developing respectively the requirements and traffic scenarios, SG4’s work would be largely on hold until the requirements will become available. |
|  | With regards to the populating a(n eventual) non-mock-up test matrix 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. |
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| 3.2 | Test Protocols |
|  | Once a (mock-up) test matrix has been populated, the accompanying test protocols[[5]](#footnote-5) will be developed by 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. |
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| 3.3 | Validation |
|  | The test matrix and accompanying test protocols would first need to be validated during try-outs, in order to ensure that they indeed are 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 vehicle’s safety. |
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1. GRVA-09-07 [↑](#footnote-ref-1)
2. VMAD-12-05 [↑](#footnote-ref-2)
3. VMAD-SG4-06-06 [↑](#footnote-ref-3)
4. VMAD-SG4-06-05 [↑](#footnote-ref-4)
5. Test parameters should take into account the ODD of the ADS under test. [↑](#footnote-ref-5)