February 2022

The third column below includes suggestions on how VMAD could provide very high-level illustrations of test methods and scenarios for each of the 24 FRAV ADS safety recommendations. (In some cases, the same test method and scenario can be designed to test for more than one of the safety requirements.) This would demonstrate alignment between FRAV and VMAD by showing that the full range of VMAD’s test methods have clear applicability to all of FRAV’s requirements. The VMAD recommended test methods would be at a very high level (i.e., they would likely not involve scenarios other than at the functional level). A subsequent dialogue between FRAV and VMAD experts could refine the recommended tests, perhaps adding verifiable criteria where appropriate.

At the end of the process, FRAV and VMAD could effectively show how the work of the two groups has been complementary and that recommended test methods contained in VMAD’s guidelines are available for each ADS safety requirement recommended by FRAV.

Table 1. ADS Safety Recommendations and Development of Detailed Provisions (from FRAV-24-05)

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|  | Safety Recommendations | Detailed Provisions (under discussion) | Testable case illustrating VMAD test methods |
| The ADS should drive safely. | | |  |
| 1. | The ADS shall be capable of performing the entire Dynamic Driving Task (DDT) within the ODD of its feature(s). | * The capability of the ADS to perform the entire DDT should be determined in the context of the ODD of the ADS * As part of the DDT, the ADS should be able to:   + Operate at safe speeds.   + Maintain appropriate distances from [other road users] by controlling the longitudinal and lateral motion of the vehicle.   + Adapt its behaviour to the surrounding traffic conditions (e.g., by avoiding disruption to the flow of traffic).   + Adapt its behaviour in line with safety risks (e.g., by giving all road users and passengers the highest priority). | * Lane keeping scenario may be used to show capability to control longitudinal and lateral motion within lane (although lane keeping itself implies just lateral control) |
| 2. | The ADS shall recognize the conditions and boundaries of the ODD of its feature(s) pursuant to the manufacturer’s declaration under paragraph 3.3. | * The ADS should be able to determine when the conditions are met for activation. * The ADS should detect and respond when one or more ODD conditions are not or no longer fulfilled. * The ADS should be able to anticipate planned exits of the ODD * The ODD conditions and boundaries (measurable limits) should be established by the manufacturer. * The ODD conditions to be recognized by the ADS should include:   + Precipitation (rain, snow)   + Time of day (light intensity, including the case of the use of lighting devices)   + Visibility   + Road and lane markings | * VMAD can provide suitable test method and scenario (e.g., road test to attempt to activate system outside of ODD or operate vehicle to limit of ODD, such as a geographic limit); mere lane keeping scenario does not test this |

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| 3. | The ADS shall detect and respond to objects and events relevant to its performance of the DDT. | * Objects and events might include, but are not limited, to:   + Vehicles, motorcycles, bicycles, pedestrians, obstacles   + Road accidents   + Road safety agents / enforcement agents   + Emergency vehicles * The ADS shall detect objects in and around its path of travel that exceed a minimum size. * The ADS shall recognize objects as static or mobile. * The ADS shall recognize markings and signals used to indicate priority vehicles within the ODD of its feature(s). * The ADS shall classify priority vehicles within the ODD of its feature(s) in accordance with the relevant traffic law(s). * The ADS shall yield the right of way to priority vehicles in service in accordance with the relevant traffic law(s). | * VMAD can provide a method and scenario to test the ADS’s ability to detect and respond to a stopped vehicle in the lane (this can build on lane keeping scenario, but lane keeping itself is not the same as detecting and responding to objects) |
| 4. | The ADS shall comply with safety-relevant traffic laws according to the ODD of the feature in use. | * ADS should comply with the traffic laws in nominal conditions, except when in specific circumstances or when necessary to enhance the safety of the vehicle’s occupants and/or other road users. | * VMAD can provide a simple test method and scenario (e.g., adherence to speed limit, which could be based on lane keeping scenario, but need not be) |
| 5. | The ADS shall interact safely with other road users. | * The ADS shall avoid collisions with safety-relevant objects where possible. * The ADS shall signal intended changes of direction. * The ADS shall signal its operational status (active/inactive) as needed. | * VMAD can provide a test method and scenario to test ADS interaction (e.g., signaling before a lane change or turn); again, this could build on a lane keeping scenario, but mere lane keeping does not involve interaction with ORUs |

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| The ADS should interact safely with the ADS vehicle user(s). | | |  |
| 6. | User interaction with and the interface of ADS (features) shall have a high-level commonality of design. | * The ADS should be designed to foster a level of trust that is aligned with its capabilities and limitations to ensure proper use of the system. * The operation of the interaction shall have in common:   + use of common sequence of states in the transition/activation/overriding/… * The interaction should be simplified:   + Limit the number of roles   + Limit the number of potential transitions   + Limit the number of settings   + Limit the number of different interaction modes | * VMAD can provide a method and scenario that tests user interaction (e.g., whether transition of control follows common sequence); lane keeping scenario not useful here |
| 7. | The ADS HMI shall provide clear and unambiguous information to the user. | * The vehicle shall indicate its ADS capabilities in terms of their automated features and their ODD. * The ADS shall inform the user on the current conditions:   + ADS status information   + The availability of ADS features   + User Role   + Responsibility   + Permitted NDRA   + Potential roles to activate   + “Standard” information:     - Vehicle speed, range and Time to Fuel   + ADS failure information * The ADS shall inform the user on the upcoming conditions:   + ODD boundaries   + Upcoming actions or change in roles   + Oncoming decisions/manoeuvers   + Estimated time until take over in normal conditions   + Transition related communication. * The ADS shall ensure that safety related information is prioritized and presented in a clear and unambiguous manner. | * VMAD can provide a method to test ADS’s provision of information to the user (e.g., a road test requiring a clear signal to the user of on upcoming ODD exit); lane keeping scenario not useful here |
| 8. | The ADS shall be designed to prevent misuse and errors in operation. | * The ADS shall be designed to prevent inadvertent activation or deactivation. * The controls dedicated to the ADS shall be clearly distinguishable from other controls. * The ADS shall provide feedback when the user attempts to enable unavailable functions. | * VMAD can provide a test method and simple scenario (e.g., feedback to user who attempts to engage ADS outside of its ODD); lane keeping scenario not useful here |

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| 9. | The ADS shall be designed to ensure safe ADS feature activation. | * The ADS shall inform the user that preconditions for activation are met. * The activation should follow a common sequence of actions and states:   + Common sequence to be a pass/fail criterion. * The ADS shall provide confirmation that the system is activated. | * VMAD can provide a test method and scenario that requires ADS to inform user that preconditions are met (no relevance to lane keeping) |
| 10. | An ADS which permits a transition of control shall be designed to ensure safe transitions of control. | * The interaction shall follow a common sequence of actions and states in the Transition of control (change of user roles):   + Common sequence to be a pass/fail criterion.   cid:image001.jpg@01D773FA.2A967280   * Transition of control shall return to a common default user role (to prevent mode confusion and other risks):   + This shall normally be fully engaged driving (conventional driver).   + Common default user to be a pass/fail criterion. * The ADS shall continuously verify whether the user is available for the transition of control and warn the user if not available when required. * The ADS shall verify that the driver is in stable control of the vehicle to complete the transfer of control to the user. * During transition, the ADS shall remain active until the transition of control has been completed or the ADS reaches a minimal risk condition. | * VMAD can provide a test method and simple scenario to test successful performance of transition sequence; suggest that this test involve ADS-initiated request to intervene to distinguish this from requirement #11; lane keeping scenario could be expanded to cover this, but lane keeping is not inherently related to this requirement |

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| 11. | An ADS which permits user takeovers of control shall be designed to ensure safe user-initiated takeovers. | * Under safe conditions the user is allowed to initiate a takeover of the ADS. * The deactivation should follow a common sequence.   + Common sequence to be a pass/fail criterion. * The ADS should prevent and warn a user for a user-initiated takeover that would likely lead to an unsafe situation. * The ADS should provide a clear feedback of the successful user initiated takeover.   + The clear feedback should be a pass/fail criterion. * The user-initiated takeover should return to a common default user role (to prevent mode confusion and other risks)   + This should normally be fully engaged driving (conventional driver).   + Common default user role to be a pass/fail criterion. | * VMAD can provide a test method and scenario to test performance of user-initiated takeover using a common sequence and feedback to user; lane keeping not relevant |
| 12. | The use of the ADS shall be supported by documentation and tools to facilitate the user in understanding the functionality and operation of the system. | Documentation:   * The following information should be documented: * description of the possible educational approach: * Theoretical and practical training * How it aligns with common HMI and interaction * Operational Description of ADS (features) capabilities and limitations (the information should also refer to specific scenarios) * Description on roles and responsibility of driver/user and ADS when ADS (feature) is on/off * description of allowed transition of roles and procedure for the transition (activation/deactivation, ToC, Override) * general overview list of NDRA allowed when an ADS feature is active.   Tools:   * The ADS supports the user in correct operation (coaching). * The ADS gives prompt feedback on erroneous operation. | * VMAD can provide a test method (e.g., use of the audit and assessment pillar) and simplified checklist of appropriate documentation; lane keeping not relevant |

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| The ADS should manage safety-critical situations. | | |  |
| 13. | The ADS shall execute a fallback response in the event of a failure in the ADS and/or other vehicle system that prevents the ADS from performing the DDT. | * In the absence of a fallback-ready user, the ADS should fall back directly to a Minimal Risk Condition (MRC) * If the ADS is designed to request and enable intervention by a human driver, the ADS should execute an MRM in the event of a failure in the transition of control to the user   + Upon completion of an MRM, a user may be permitted to assume control of the vehicle   + The user should be permitted to override the ADS to assume full control over the vehicle | * VMAD can provide a test method and scenario(s) to demonstrate ADS’s detection of the ADS failure or other vehicle system failure (see item #16 below, which would likely be combined with this for test purposes) and performance of fallback response; could require two scenarios (one with no fallback-ready user, one with a fallback-ready user); these tests will need to be at a high level of abstraction, given complexity of inducing the failures, safety concerns if real-world testing is contemplated, etc.; lane keeping not relevant |
| 14. | The ADS shall signal its intention to place the vehicle in an MRC. | * The ADS should signal its intention to place the vehicle in an MRC to:   + ADS user or vehicle occupants   + Other road users (e.g., by hazard lights) | * VMAD can provide a test method and scenario (likely combined with #13) to demonstrate the ADS’s ability to provide the proper signal; lane keeping not relevant |
| 15. | Pursuant to a traffic accident, the ADS shall stop the vehicle. | * ADS reactivation should not be possible until the safe operational state of the ADS has been verified. | * VMAD can provide a test method and scenario; presumably this will involve a combination of virtual testing and the audit pillar; lane keeping is not relevant |
| The ADS should safely manage failure modes. | | |  |
| 16. | The ADS shall detect and respond to system malfunctions and abnormalities relevant to its performance of the DDT. | * The ADS should perform self-diagnosis of faults in accordance with the OEMs prescribed list * The ADS should detect system malfunctions/abnormalities and evaluate system’s ability to fulfill the entire DDT | * VMAD can provide a test method and scenario to determine whether malfunctions are appropriately detected and the ADS’s ability to do entire DDT is maintained; complexities of fault injection and analysis may require combination of track and virtual testing; lane keeping not relevant |
| 17. | The ADS shall be designed to protect against unauthorized access. | * The measures ensuring protection from unauthorized access should be provided in alignment with engineering best practices. | * VMAD can provide a test method (and possibly a scenario) to test adherence to best practices, likely involving use of audit pillar; lane keeping not relevant |
| 18. | The ADS shall signal [faults/failures] compromising its capability to perform the entire DDT relevant to the ODD of its feature(s). |  | * VMAD can provide a test method and scenario to signal failures affecting ADS performance of DDT; likely combined with #16 and second bullet of #20, and perhaps #13 or #14; lane keeping not relevant |
| 19. | The ADS shall be designed to protect against unauthorized modifications to safety-critical hardware and software. |  | * VMAD can provide at test method, likely to be focused on audit pillar; lane keeping not relevant |
| 20. | The ADS may continue to operate in the presence of [faults/failures] that do not prevent that ADS from fulfilling the safety recommendations applicable to the ADS. | * The limited operation of the ADS should comply to the normally applicable safety requirements. * For situations where the ADS is not able to perform the DDT safely, the ADS should have the function to prevent activation. If the ADS has OTA functionality, this function may be activated remotely if the authorities or the vehicle manufacturer determine that the ADS is unsafe. | * VMAD can provide a test method and scenario, perhaps as a scenario related to #16; lane keeping is not relevant |
| 21. | The ADS shall signal [faults/failures] compromising its ability to execute the DDT. | * The ADS should signal [faults/failures] affecting the ability to execute the DDT. | * Is this a duplicate of # 18? If not, how does it differ? |
| The ADS should maintain a safe operational state. | | |  |
| 22. | The ADS should signal required system maintenance to the user. |  | * VMAD can provide a test method to test whether the ADS provides this signal, whether relying on the audit pillar or use of a scenario involving injection of a maintenance item; lane keeping is not relevant |
| 23. | The ADS should be accessible for the purposes of maintenance and repair to authorized persons. |  | * VMAD can provide a test method for accessibility to authorized persons, perhaps combined with a test for #17 on unauthorized access; lane keeping is not relevant |
| 24. | ADS safety should be ensured in the event of discontinued production/support/maintenance. |  | * VMAD can provide a test method, most likely using the audit pillar; lane keeping is not relevant |