

Consolidated working draft text for the ADS GTR and UN Regulation

The following table provides:

- In the first column, the reference used to draft the proposed text;
- In the second column, the proposed regulatory text in which the track changes outline the modification compared to the GRVA-20-36e (Guidelines and recommendations for ADS safety requirements, assessments and test methods to inform regulatory development);
- In the third column, proposals for revision and comments.

Reference (GRVA-20-36e)	Proposed text (ADS-04-10)	Proposals and comments
	Definitions	
3.1.33. “ <i>Simulation</i> ” means the imitation of the operation of a real-world process or system over time.	3.34. “ <i>Simulation</i> ” means the imitation of the operation of a real-world process or system over time utilizing a software implementation for some (or all) of the models, tools or test environment.	
3.1.34. “ <i>Simulation toolchain</i> ” means a combination of simulation tools that are used to support the validation of an ADS.	3.35. “ <i>Simulation toolchain</i> ” means a simulation tool or a combination of simulation tools that are used to generate evidence supporting the manufacturer’s safety case’s claims	
3.1.44. “ <i>Virtual testing</i> ” means the process of testing a system using one or more simulation models.	3.44. “ <i>Virtual testing</i> ” means a type of testing that uses a simulation toolchain(s) to assess the performance of the ADS generate evidence supporting the manufacturer’s safety case’s claims	OPI 7/11/2024: revised definition
NEW (Adapted from UN-R 155)	3.XX. “ <i>Post-production phase</i> ” means the period in which an ADS vehicle is no longer produced until the end-of-life of all ADS vehicles of the same type. The phase ends when there are no longer any operational ADS vehicles of a specific ADS type.	OPI 21/11/2024: added definition to support 5.8.1.3.3.1.
	General Requirements	

NEW	4.6. The manufacturer shall demonstrate that the approach to testing is suitable for the demonstration of the safety case and the compliance with performance/functional requirements	
NEW	4.6.1. The manufacturer shall demonstrate that the physical testing (proving ground and/or public road) facilities and environment are suitable for the tests that are being conducted.	
NEW	4.6.2. The manufacturer shall demonstrate that the simulation toolchain(s) is suitable for conducting virtual tests. The requirements for the simulation toolchain(s) are listed in 5.8.1.	OPI: to check cross reference after structure is established
	Requirements/Specifications	
	5.8. Credibility and Suitability of Testing	
	5.8.1. Simulation Toolchain(s) Credibility Requirements	<p>Secy: Since the safety case involves supporting evidence that may have been generated by the manufacturer’s virtual testing, would it make sense for these requirements to be part of the safety case requirements? If the safety case relies on virtual testing, then the manufacturer must prove that the outcomes of this testing are credible....</p> <p>Secy: Deep numbering: reconsider headers/structure.</p>
Annex 5 – Appendix 1 – 21. The ADS manufacturer should provide a description of the complete toolchain along with how the M&S data will be used to support the ADS validation strategy.	5.8.1.1. The manufacturer shall describe the intended use(s) of virtual testing and its role in the overall testing strategy.	

<p>The ADS manufacturer should provide a clear description of the test objective.</p>		
<p>NEW</p>	<p>5.8.1.2. The manufacturer shall demonstrate that the simulation toolchain(s) is suitable to use for virtual testing by:</p> <ul style="list-style-type: none"> a) performing a criticality analysis that evaluates the potential risk and consequences of using the simulation toolchain(s) for the assessment of the ADS safety case and functional/user requirements; b) demonstrating that the simulation toolchain(s) fulfils the credibility requirements corresponding to the identified criticality as per the requirements listed in this section. 	
	<p>5.8.1.3. Simulation Toolchain(s) Management requirements</p>	
	<p>5.8.1.3.1. Simulation Toolchain(s) Data Management requirements</p>	
<p>Annex 5 – Appendix 1 – 10. It is recommended that any toolchain’s version used to release data for certification purposes should be stored. The virtual models constituting the testing tool should be documented in terms of the corresponding validation methods and acceptance thresholds to support the overall credibility of the toolchain. The developer should establish and enforce a method to trace generated data to the corresponding toolchain version</p>	<p>5.8.1.3.1.1. The manufacturer shall manage the data used to develop, verify, validate and update the simulation toolchain(s) throughout its lifetime. The manufacturer shall consider the completeness, accuracy and consistency of this data.</p>	
<p>Annex 5 – Appendix 1 – 20. The pedigree and traceability of the data and inputs used in the validation of the M&S is important. The manufacturer should have a record of these that allows the assessor to verify their quality and appropriateness.</p>	<p>5.8.1.3.1.2. The manufacturer shall maintain a record of the data used in the validation of the toolchain(s).</p>	

<p>Annex 5 – Appendix 1 – 16. If the ADS manufacturer’s toolchain incorporates or relies upon inputs from organizations or products outside of the manufacturer’s own team, it is recommended that the ADS manufacturer includes an explanation of measures it has taken to manage and develop confidence in the quality and integrity of those inputs.</p>	<p>5.8.1.3.1.3. If the simulation toolchain(s) incorporates or relies upon data/tools from other organizations which are not under the control of the manufacturer, the manufacturer shall demonstrate the measures taken to manage the quality and integrity of that data/tools.</p>	
<p>Annex 5 – Appendix 1 – 20 (a). Description of the data used for the M&S validation (i) The ADS manufacturer should document the data used to validate the models included in the tool or toolchain and note important quality characteristics; (ii) The ADS manufacturer should provide documentation showing that the data used to validate the models covers the intended functionalities that the toolchain aims at virtualizing; (iii) The ADS manufacturer should document the calibration procedures employed to fit the virtual models’ parameters to the collected input data.</p>	<p>5.8.1.3.1.4. With regards to input data management and parameters associated with the simulation toolchain(s), the manufacturer shall: a) document the data used to develop, verify and validate the simulation toolchain(s) and note important quality characteristics; b) provide documentation showing that the data used to develop, verify and validate the simulation toolchain(s) covers the intended functionalities that the virtual testing aims to assess; c) document the data and the calibration procedures employed to fit any parameters associated with the simulation toolchain(s); d) explain the reasons for data or parameters changing between releases.</p>	
<p>Annex 5 – Appendix 1 – 20 (b). Effect of the data quality (e.g. data coverage, signal to noise ratio, and sensors’ uncertainty/bias/sampling rate) on model parameters uncertainty The quality of the data used to develop the model will have an impact on model parameters’ estimation and calibration. Uncertainty in model parameters will be another important aspect in the final uncertainty analysis.</p>	<p>5.8.1.3.1.5. The manufacturer shall quantify the uncertainty in the simulation toolchain(s) and its outputs that occur because of the quality of the data (e.g. data coverage, signal to noise ratio, and sensors’ uncertainty/bias/sampling rate).</p>	

<p>Annex 5 – Appendix 1 – 19. (a) The ADS manufacturer should provide information on any data and scenarios used for virtual testing toolchain validation; (b) The ADS manufacturer should document the exported data and note important quality characteristics e.g. using the correlation methodologies;</p>	<p>5.8.1.3.1.6. With regards to the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall: a) maintain a record of the output from the simulation toolchain(s) during its validation and ensure that they are traceable to the input data that produced them; b) document the output data and note any important quality characteristics that can be deduced from analysis of the data, e.g. applying statistical methodologies.</p>	
<p>Annex 5 – Appendix 1 – 19 (i). Effect of the data quality M&S credibility: (c) The M&S output data should be sufficient to ensure the correct execution of the validation exercise. The data should sufficiently reflect the ODD relevant to the virtual assessment of the ADS. (d) The output data should allow consistency/sanity check of the virtual models, possibly by exploiting redundant information.</p>	<p>5.8.1.3.1.7. With regards to the quality of the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall: a) ensure it is sufficient to undertake any validation activity; b) ensure it is sufficient to allow consistency/sanity check of the simulation toolchain(s), possibly by exploiting redundant information; c) ensure it is sufficient to justify manufacturer's claims about their safety case.</p>	
<p>Annex 5 – Appendix 1 – 19 (ii). Managing stochastic models (e) Stochastic models should be characterized in terms of their variance; (f) The use of a stochastic models should not prohibit the possibility of deterministic re-execution.</p>	<p>5.8.1.3.1.8. With regards to the management of stochastic models, the manufacturer shall: a) characterize the variance in the simulation toolchain(s)'s output; b) ensure the possibility of a deterministic re-execution of the simulation toolchain(s).</p>	

Simulation Experience and Expertise	5.8.1.3.2. Simulation Competency requirements	OPI: Changed “experience and expertise” to “competency” to align notation to ISO standards
Annex 5 – Appendix 1 – 14. It is important to establish the basis for the ADS manufacturer’s confidence in the experience and expertise of: (a) The teams that will internally assess and validate the M&S toolchain and, (b) The teams that will use the validated simulation for the execution of virtual testing with the purpose of validating the ADS.	5.8.1.3.2.1. The manufacturer shall document and provide the rationale for their confidence in the competency of: a) the personnel that developed the simulation toolchain(s) and its components; b) the personnel that assessed the simulation toolchain(s) and its components; c) the personnel that used the simulation toolchain(s) to perform the testing with the purpose of validating the system.	OPI: link between SMS could be created here
Annex 5 – Appendix 1 – 17. (a) Organizational level The credibility is established by setting up processes and procedures to identify and maintain the skills, knowledge, and experience to perform M&S activities. The following processes should be established, maintained and documented: (i) Process to identify and evaluate the individual’s competence and skills; (ii) Process for training personnel to be competent to perform M&S-related duties.	5.8.1.3.2.2. The manufacturer shall have processes and procedures that identify and maintain the skills, knowledge, and experience needed to perform the various activities. The following processes shall be established, maintained and documented: a) process to identify and evaluate the necessary competencies that are required to perform the modelling and simulation activities; b) process for training personnel to be competent to perform the modelling and simulation activities.	OPI: link between SMS could be created here
Annex 5 – Appendix 1 – 17. (a) Team level Once a toolchain has been finalized, its credibility is mainly dictated by the skills and knowledge of the teams that will first validate the M&S and then use it for the validation of ADS. The credibility is established by documenting that these teams have received adequate training to fulfil their duties.	5.8.1.3.2.3. The manufacturer shall maintain records of the personnel in the various teams showing they have received the necessary training and have been deemed competent to perform the modelling and simulation activities assigned to those personnel.	OPI: link between SMS could be created here

<p>NEW</p>	<p>5.8.1.3.2.4. The manufacturer shall set up suitable arrangements with third-party organisations to ensure that the competency of their personnel is adequate to demonstrate the credibility of the simulation toolchain(s).</p>	<p>OPI: link between SMS could be created here</p>
<p>NEW</p>	<p>5.8.1.3.2.5. [Placeholder to ref SMS in case of third-party data/tools providers]</p>	
	<p>5.8.1.3.3. Simulation Toolchain(s) Release Management requirements</p>	
<p>Annex 5 – Appendix 1 – 8. The M&S lifecycle is a dynamic process with frequent releases that should be monitored and documented. As a result, it is recommended that management activities should be established to support the M&S through typical product management processes. Relevant information on the following aspects should be included in this section.</p>	<p>5.8.1.3.3.1. The manufacturer shall manage and support the simulation toolchain(s) used for virtual testing throughout the lifecycle of the simulation toolchain(s). This management and support shall also continue until the end of the post-production phase of the ADS.</p>	<p>SECY: undefined term “lifecycle”. What does “its” refer to?</p> <p>UK:Nov24 - The manufacturer shall manage and support the simulation toolchain(s) used for virtual testing throughout its development, testing and use. throughout its complete lifecycle</p> <p>OPI 7/11/2024: lifecycle here use with the product development general meaning same as ISMR/SMS. Rephrase requirement to avoid the use of the pronoun “its” and to make sure that the lifecycle of the simulation toolchain(s) also include the lifetime of the ADS to enable the possibility of the execution of virtual tests following, for instance, ISMR findings.</p> <p>OPI 21/11/2024: revised definition following meeting. Avoid use of “decommissioning”</p>
<p>Annex 5 – Appendix 1 – 9. It is recommended that this part should: (a) Describe the modifications within the M&S toolchain releases;</p>	<p>5.8.1.3.3.2. The manufacturer shall manage and document the simulation toolchain(s) release management process. The simulation toolchain(s) release management activity shall include:</p>	

<p>(b) Designate the corresponding software (e.g., specific software product and version) and hardware arrangement (e.g., XiL configuration); (c) Record the internal review processes that accepted the new releases; (d) Be supported throughout the full duration of the virtual testing utilization.</p>	<p>a) a description of the modifications associated with each toolchain(s) release; b) a record of any associated software (e.g., specific software product, designations and version) and hardware arrangements (e.g., XiL configuration); c) a record of the internal review activities that supported the toolchain(s) acceptance and release.</p>	
	<p>5.8.1.4. Simulation Toolchain(s) requirements</p>	
<p>Annex 5 – Appendix 1 – 24. The credibility of virtual tool should be enforced by a clearly defined scope for the utilization of the developed M&S toolchains.</p>	<p>5.8.1.4.1. The manufacturer shall describe the simulation toolchain(s) and identify its scope of applicability, its limitations, assumptions and the sources of uncertainty that can affect results.</p>	
	<p>5.8.1.4.1.1. Description of the Simulation Toolchain(s)</p>	
<p>Annex 5 – Appendix 1 – 21. The ADS manufacturer should provide a description of the complete toolchain along with how the M&S data will be used to support the ADS validation strategy. The ADS manufacturer should provide a clear description of the test objective.</p>	<p>5.8.1.4.1.1.1. The manufacturer shall provide a description of the simulation toolchain(s) and its components.</p>	
<p>Annex 5 – Appendix 1 – 21. The ADS manufacturer should provide a description of the complete toolchain along with how the M&S data will be used to support the ADS validation strategy. The ADS manufacturer should provide a clear description of the test objective.</p>	<p>5.8.1.4.1.1.2. The manufacturer shall provide a description of the approach adopted in the simulation toolchain(s) validation.</p>	
<p>Annex 5 – Appendix 1 – 25. The mature M&S should allow a virtualization of the physical phenomena to a degree of accuracy which matches the fidelity level required for certification. Thus, the M&S environment</p>	<p>5.8.1.4.1.1.3. The manufacturer shall provide a description of the acceptance tests and criteria that will be used to determine if the simulation toolchain(s) is considered credible based on the credibility framework.</p>	

<p>will act as a “virtual proving ground” for ADS testing.</p>		
	<p>5.8.1.4.1.2. Simulation Toolchain(s) Assumptions, known Limitations, and Uncertainty Quantification</p>	
<p>Annex 5 – Appendix 1 – 22. The ADS manufacturer should motivate the modelling assumptions which guided the design of the M&S toolchain.</p>	<p>5.8.1.4.1.2.1. The manufacturer shall describe the modelling assumptions and considerations that guided the design of the toolchain(s).</p>	
<p>Annex 5 – Appendix 1 – 22. The ADS manufacturer should provide evidence on: (a) How the manufacturer-defined assumptions play a role in defining the limitations of the toolchain; (b) The level of fidelity required for the simulation models.</p>	<p>5.8.1.4.1.2.2. The manufacturer shall provide information on: a) any assumptions made during the development of the simulation toolchain(s) and its components and the limitations that this places on its scope and applicability; b) the rationale for choices made about the level of fidelity of the simulation toolchain(s) and its components.</p>	
<p>Annex 5 – Appendix 1 – 22. The ADS manufacturer should provide justification that the tolerance for M&S versus real-world correlation is acceptable for the test objective</p>	<p>5.8.1.4.1.2.3. The manufacturer shall provide justification that the tolerances associated with the simulation toolchain(s) are appropriate and meet the acceptance tests and criteria.</p>	
<p>Annex 5 – Appendix 1 – 23. Finally, this section should include information about the sources of uncertainty in the model. This will represent an important input to final uncertainty analysis, which will define how the M&S toolchain outputs can be affected by the different sources of uncertainty of the M&S toolchain used.</p>	<p>5.8.1.4.1.2.4. The manufacturer shall provide details of the sources of uncertainty in the simulation toolchain(s) and its components and an assessment of their impact on the results.</p>	
	<p>5.8.1.4.1.3. Simulation Toolchain(s) scope</p>	
<p>Annex 5 – Appendix 1 – 20. The M&S analysis and description aim to define the whole toolchain and identify the parameter space that can be</p>	<p>5.8.1.4.1.3.1. The manufacturer shall document the scope of the simulation toolchain(s) and identify its limitations.</p>	

<p>assessed via virtual testing. It defines the scope and limitations of the models and simulation tools and the uncertainty sources that can affect its results.</p>	<p>It should refer to the ODD and identify any limitations about its applicability within the ODD.</p>	
<p>Annex 5 – Appendix 1 – 26. M&S toolchains need dedicated scenarios and metrics for validation. The scenario selection used for validation should be sufficient such that there is confidence that the toolchain will perform in the same manner in scenarios that were not included in the validation scope.</p>	<p>5.8.1.4.1.3.2. The manufacturer shall demonstrate how the simulation toolchain(s) imitates the relevant physical phenomena and meets the necessary level of accuracy.</p>	
<p>Annex 5 – Appendix 1 – 43 (c). The ADS manufacturer should define the logical scenarios used for virtual testing toolchain validation. They should be able to cover, to the maximum possible extent, the ODD of virtual testing for ADS validation</p>	<p>5.8.1.4.1.3.3. The manufacturer shall demonstrate that the test selection for simulation toolchain(s) validation is sufficient to justify the claim demonstrate that the simulation toolchain(s) it will perform effectively can be used within the defined scope.</p>	<p>UK:Nov24 – Maybe – “ ... demonstrate that the test selection for validation is sufficient to justify the claim that the simulation toolchain(s) can be used within its defined scope.</p> <p>OPI 21/11/2024: agree and rephrased to avoid referring to the validation</p>
<p>Annex 5 – Appendix 1 – 27. ADS manufacturers should provide a list of validation scenarios together with the corresponding parameter description limitations.</p>	<p>5.8.1.4.1.3.4. The manufacturer shall provide a list of tests used for validation and the corresponding parameters and any known limitation.</p>	
	<p>5.8.1.4.1.4. Simulation Toolchain(s) Criticality analysis.</p>	
<p>Annex 5 – Appendix 1 – 30. The simulation models and the simulation tools used in the overall toolchain should be investigated in terms of their impact in case of a safety error in the final product. The proposed approach for criticality analysis is derived from ISO 26262, which requires qualification for some of the tools used in the development process. In order to derive how critical the simulated data</p>	<p>5.8.1.4.1.4.1. The manufacturer shall review the error estimates of the simulation toolchain(s) to assess their criticality of prediction errors and the effect these would have on the manufacturer's claims about their safety case.</p>	<p>UK:Nov24 = maybe “The manufacturer shall review the error estimates of the simulation toolchain(s) to assess their criticality and the effect these would have ...</p> <p>OPI 7/11/2024: agree and rephrased accordingly</p>

<p>is, the criticality assessment considers the following parameters: (a) The consequences on human safety e.g. severity classes in ISO 26262; (b) The degree in which the M&S toolchain results influence's the ADS.</p>		
	<p>5.8.1.5. Simulation Toolchain(s) Verification requirements.</p>	
<p>Annex 5 – Appendix 1 – 33. The verification of M&S deals with the analysis of the correct implementation of the conceptual/mathematical models that create and build up the overall toolchain. Verification contributes to the M&S's credibility via providing assurance that the individual tools will not exhibit unrealistic behaviour for a set of inputs which cannot be tested. The procedure is grounded in a multi-step approach described below, which includes code verification, calculation verification and sensitivity analysis.</p>	<p>5.8.1.5.1. The manufacturer shall demonstrate that the simulation toolchain(s) will not exhibit unrealistic behaviour for valid inputs which have not been explicitly tested.</p>	
	<p>5.8.1.5.2. Simulation Toolchain(s) Code Verification requirements</p>	
<p>Annex 5 – Appendix 1 – 35. The ADS manufacturer should document the execution of proper code verification techniques, e.g. static/dynamic code verification, convergence analysis and comparison with exact solutions if applicable</p>	<p>5.8.1.5.2.1. The manufacturer shall document the execution of proper code verification techniques, used in evaluating the simulation toolchain(s) and its components, e.g. static/dynamic code verification, convergence analysis and comparison with exact solutions if applicable.</p>	
<p>Annex 5 – Appendix 1 – 36. The ADS manufacturer should provide documentation showing that the exploration in the domain of the input parameters was sufficiently wide to identify parameter combinations for which the M&S tools show unstable or unrealistic</p>	<p>5.8.1.5.2.2. The manufacturer shall provide evidence that the input parameter space was sufficiently explored to identify if there are any parameter combinations for which the simulation toolchain(s) shows unstable or unrealistic behaviour.</p>	

<p>behaviour. Coverage metrics of parameters combinations may be used to demonstrate the required exploration of the model's behaviours.</p>		
<p>Annex 5 – Appendix 1 – 37. The ADS manufacturer should adopt sanity/consistency checking procedures whenever data allows</p>	<p>5.8.1.5.2.3. The manufacturer shall provide information on any sanity/consistency checking procedures that are used.</p>	
	<p>5.8.1.5.3. Simulation Toolchain(s) Calculation Verification requirements.</p>	
<p>Annex 5 – Appendix 1 – 38. Calculation verification deals with the estimation of numerical errors affecting the M&S. The ADS manufacturer should document numerical error estimates (e.g. discretization error, rounding error, iterative procedures convergence). The numerical errors should be kept sufficiently bounded to not affect validation.</p>	<p>5.8.1.5.3.1. The manufacturer shall document numerical error estimates (e.g. discretization error, rounding error, iterative procedures, and convergence).</p>	
<p>Annex 5 – Appendix 1 – 38. Calculation verification deals with the estimation of numerical errors affecting the M&S. The ADS manufacturer should document numerical error estimates (e.g. discretization error, rounding error, iterative procedures convergence). The numerical errors should be kept sufficiently bounded to not affect validation.</p>	<p>5.8.1.5.3.2. The manufacturer shall review their analysis and demonstrate that the numerical errors are understood and sufficiently bounded to allow the simulation toolchain(s) to be used for virtual testing.</p>	
	<p>5.8.1.5.4. Simulation Toolchain(s) Sensitivity Analysis requirements.</p>	
<p>Annex 5 – Appendix 1 – 40. The ADS manufacturer should provide supporting documentation demonstrating that the most critical parameters influencing the simulation output have been identified by means of sensitivity</p>	<p>5.8.1.5.4.1. The manufacturer shall provide documentation demonstrating that the input data and parameters that most critically influence the toolchain(s) outputs have been identified by means of appropriate sensitivity analysis techniques.</p>	

<p>analysis techniques such as by perturbing the model's parameters;</p>		
<p>Annex 5 – Appendix 1 – 41. The ADS manufacturer should demonstrate that robust calibration procedures have been adopted and that this has identified and calibrated the most critical parameters leading to an increase in the credibility of the developed toolchain.</p>	<p>5.8.1.5.4.2. The manufacturer shall demonstrate that robust calibration procedures have been adopted for assigning appropriate value(s) to the most critical all the simulation parameters whilst ensuring that special attention is taken for the most critical parameters. This is to ensure that the simulation toolchain(s) imitates can be used to emulate the relevant real-world the physical system.</p>	<p>UK:Nov24 - The manufacturer shall demonstrate that robust calibration procedures have been adopted for assigning appropriate value(s) to all parameters to ensure that the simulation toolchain imitates the physical system. [Special attention may be needed for those parameters identified by the manufacturer as critical.]</p> <p>OPI 21/11/2024: rephrased to make sure there is no “unrobust” procedures but parameters might be treated differently depending on the sensitivity analysis outcome</p>
<p>Annex 5 – Appendix 1 – 42. Ultimately, the sensitivity analysis results will also help to define the inputs and parameters whose uncertainty characterization needs particular attention to characterize the uncertainty of the simulation results.</p>	<p>5.8.1.5.4.3. The manufacturer shall demonstrate that sensitivity analysis has been used to identify the critical input data and parameters that needs particular attention in order to characterize the uncertainty of the overall simulation toolchain(s) outputs.</p>	
	<p>5.8.1.6. Simulation Toolchain(s) Validation requirements.</p>	
<p>Annex 5 – Appendix 1 – 43. The quantitative process of determining the degree to which a model or a simulation is an accurate representation of the real world from the perspective of the intended uses of the M&S. It is recommended that the following items be considered when assessing the validity of a model or simulation:</p>	<p>5.8.1.6.1. The manufacturer shall perform a validation analysis to quantitatively determine the degree to which the simulation toolchain(s) is an accurate representation of the real-world system by means of a validation analysis. The validation analysis shall be based on quantitative metrics.</p>	<p>OPI 7/11/2024: rephrased following UK comment</p>

<p>NEW</p>	<p>5.8.1.6.2. The manufacturer shall provide evidence that the simulation toolchain(s) results are consistent and correlated with the results of the physical tests.</p>	
<p>NEW</p>	<p>5.8.1.6.3. The validation shall be performed on a sufficiently representative set of tests in order to substantiate the claims that about the capability of the simulation toolchain(s) is suitable and can be used within its scope.</p>	<p>UK:Nov24 – Maybe “... representative set of tests in order to substantiate the claims that the simulation toolchain(s) is suitable and can be used within its declared scope.”</p> <p>OPI 7/11/2024: rephrased following UK comment</p>
<p>Annex 5 – Appendix 1 – 43 (a). The Measures of Performance are metrics that are used to compare the ADS’s performance within a virtual test with its performance in the real world. The Measures of Performance are defined during the M&S analysis. Metrics for validation may include:</p>	<p>5.8.1.6.4. The manufacturer shall define the measures of performance (metrics) that will be used when comparing between the results of physical tests and the output of the simulation toolchain(s).</p>	
<p>NEW</p>	<p>5.8.1.6.5. The manufacturer shall use appropriate statistical techniques when comparing the results of the physical tests and the output of the simulation toolchain(s) and its components.</p>	
<p>Annex 5 – Appendix 1 – 43 (b). The analytical frameworks used to compare real world and simulation metrics are generally derived as Key Performance Indicators (KPIs) indicating the statistical comparability between two sets of data. The validation should show that these KPIs are met.</p>	<p>5.8.1.6.6. The manufacturer shall specify acceptance tests and criteria during the development of the simulation toolchain(s) and its components development activity and will demonstrate that they have been achieved.</p>	<p>UK:Nov24 – “The manufacturer shall specify acceptance tests and criteria during the development of the simulation toolchain(s) and its components and will demonstrate that they have been achieved”</p> <p>OPI 7/11/2024: rephrased following UK comment</p>
<p>Annex 5 – Appendix 1 – 43 (c). The ADS manufacturer should define the logical scenarios used for virtual testing toolchain validation. They should be able to cover, to the maximum possible extent, the ODD of virtual testing for</p>	<p>5.8.1.6.7. The manufacturer shall define the methodology and the tests used for the simulation toolchain(s) validation. It should be clear whether the full ODD is within scope of the toolchain(s) or only part of it.</p>	

<p>ADS validation. The exact methodology depends on the structure and purpose of the toolchain. The validation may consist of one or more of the following:</p> <ul style="list-style-type: none"> (i) Validate subsystem models e.g. environment model (road network, weather conditions, road user interaction), sensor models (Radio Detection And Ranging (RADAR), Light Detection And Ranging (LiDARs), Camera), vehicle model (steering, braking, powertrain). (ii) Validate vehicle system (vehicle dynamics model together with the environment model). (iii) Validate sensor system (sensor model together with the environment model). (iv) Validate integrated system (sensor model + environment model with influences from vehicle model). 	<p>The validation strategy may consist of one or more of the following:</p> <ul style="list-style-type: none"> a) subsystem model validation e.g. environment models, sensor models, and vehicle models; b) vehicle system model validation (vehicle dynamics model together with the environment model); c) sensor system validation (sensor model together with the environment model); d) integrated system validation (sensor model together with the environment model with influences from vehicle model). 	
<p>Annex 5 – Appendix 1 – 43 (d). Requirement for the correlation threshold is defined during the M&S analysis. The validation should show that these KPIs are met.</p>	<p>5.8.1.6.8. The manufacturer shall demonstrate that the accuracy criteria defined during the simulation toolchain(s) development have been met.</p>	
<p>Annex 5 – Appendix 1 – 43 (f). The documentation should not only provide evidence of the M&S validation but also should provide sufficient information related to the processes and products that demonstrate the overall credibility of the toolchain used. Documentation/results may be carried over from previous credibility assessments.</p>	<p>5.8.1.6.9. The manufacturer shall provide evidence that the processes related to the validation activity have been followed.</p>	
<p>Annex 5 – Appendix 1 – 43 (h). This section is concerned with characterizing the expected variability of the virtual toolchain results. The assessment should be made up of two phases.</p>	<p>5.8.1.6.10. The manufacturer shall document their uncertainty characterisation analysis and provide information about how the simulation toolchain(s) should be</p>	

<p>In a first phase the information collected from the “M&S Analysis and Description” section and the “Data/Input Pedigree” are used to characterise the uncertainty in the input data, in the model parameters and in the modelling structure. Then, by propagating all of the uncertainties through the virtual toolchain, the uncertainty of the model results is quantified. Depending on the uncertainty of the model results, proper safety margins will need to be introduced by the ADS manufacturer in the use of virtual testing as part of the ADS validation.</p>	<p>used and any safety margins that should be applied when it is used for virtual testing.</p>	
<p>Annex 5 – Appendix 1 – 43 (h-i). The ADS manufacturer should demonstrate they have estimated the model’s critical inputs by means of robust techniques such as providing multiple repetitions for their assessment.</p>	<p>5.8.1.6.11. The manufacturer shall demonstrate they have techniques to estimate the simulation toolchain(s)’s critical inputs.</p>	
<p>Annex 5 – Appendix 1 – 43 (h-ii). The ADS manufacturer should demonstrate that when a model’s critical parameters cannot be fully determined they are characterized by means of a distribution and/or confidence intervals.</p>	<p>5.8.1.6.12. The manufacturer shall demonstrate that they have characterised the critical parameters used in the simulation toolchain(s) and its components and where appropriate have identified these as distributions with confidence intervals.</p>	
<p>Annex 5 – Appendix 1 – 43 (h-iii). The ADS manufacturer should provide evidence that the modelling assumptions are given a quantitative characterization by assessing the generated uncertainty (e.g. comparing the output of different modelling approaches whenever possible).</p>	<p>5.8.1.6.13. The manufacturer shall provide evidence that a proper characterization of the uncertainty of the results of the simulation toolchain(s) and its components, because of any assumptions therein, has been made.</p>	
<p>Annex 5 – Appendix 1 – 43 (h-iv). The ADS manufacturer should aim to distinguish between the aleatory component of the uncertainty (which can only be estimated but not reduced) and the epistemic uncertainty deriving from the lack</p>	<p>5.8.1.6.14. The manufacturer shall demonstrate the that they have differentiated between the aleatory and epistemic uncertainties associated with the simulation toolchain(s).</p>	

<p>of knowledge in the virtualization of the process.</p>		
	<p>Assessment and Test Method</p>	
<p>Annex 5 – Appendix 1 – 4. The proposed credibility assessment framework provides a general description of the main aspects needed for assessing the credibility of an M&S solution together with guidelines of the role played by the relevant assessor in the validation process with respect to credibility. The assessor should investigate the documentation and evidence supporting credibility during the audit phase. It is understood that the actual validation tests will take place once there is sufficient evidence that a simulation tool or toolchain produces credible results.</p>	<p>6.4.1. The assessor shall review the manufacturer’s credibility framework to determine whether the simulation the toolchain(s) is suitable to undertake virtual testing.</p>	
<p>NEW</p>	<p>6.4.2. The assessor shall review the documentation and evidence supporting the manufacturer’s claims.</p> <ul style="list-style-type: none"> a) A successful outcome of the assessment will be a confirmation that the claims of the manufacturer about the capability of the simulation toolchain(s), including its scope, are correct and that it can be used to perform the virtual testing as part of the ADS assessment. b) The simulation toolchain(s) can only be used to undertake virtual testing once the credibility of the same has been established. 	
<p>Annex 5 – Appendix 1 – 43 (g). The assessor should audit the documentation provided by the manufacturer and may carry out tests of the</p>	<p>6.4.3. The assessor shall audit the information provided by the manufacturer and may request or carry out additional tests of the simulation toolchain(s) or</p>	

<p>complete integrated tool. If the output of the virtual tests does not sufficiently replicate the output of physical tests, the assessor may request that the virtual and/or physical tests to be repeated. The outcome of the tests will be reviewed and any deviation in the results should be reviewed with the manufacturer. Sufficient explanation is required to justify why the test configuration caused deviation in results.</p>	<p>physical tests. The outcome of the tests shall be reviewed and any concerns or discrepancies shall be raised and reviewed with the manufacturer.</p> <p>The manufacturer shall provide an explanation of the discrepancies in the results. If the results from the simulation toolchain(s) do not sufficiently replicate the output of physical test or does not have sufficient scope the assessor shall inform the manufacturer.</p> <p>The manufacturer shall conduct extra validation activity and resubmit their information for further assessment.</p>	