§6.2. Testing environment

Green means no change to the text (including no numbering change)

Blue means an editorial proposal.

Orange means an open issue or substantive proposal for amendment.

Sec: General remark-The ADS regulation differentiates between management requirements and requirements specific to the assessment of a given ADS. It would be helpful to review this text to decide whether provisions refer generally to the management of any testing programme or refer specifically to the testing conducted to generate evidence to support the safety case of the ADS under assessment.

The IWG has discussed the risk that a safety case might be rejected due to inadequate testing (i.e., the testing environment/set up/procedures might not be deemed credible). To mitigate this risk, the IWG has discussed assessing the testing programme independently of/prior to assessing the safety case for the ADS.

6.	Manufacturer requirements				
6.2.	Testing Environment	6.2.	Testing environments	Sec: There is more than one environment.
6.2.1.	Virtual Testing and Simulation Toolchain Credibility Requirements	6.2.1.	Virtual testing	Sec: The header does not need to be so wordy. Virtual testing is defined as being based on simulation toolchains.
6.2.1.1.	The manufacturer shall describe the intended use(s) of virtual testing and its role in the overall testing strategy.			This implies a need for a section on the testing strategy and its components.
6.2.1.2.	The manufacturer shall demonstrate that the simulation toolchain(s) is suitable to use for virtual testing by:	6.2.1.2.	The manufacturer shall demonstrate that each simulation toolchain is suitable to use for virtual testing by:	

	(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.		Sec: and/or? What does this mean? We are not assessing the "functional/user requirements" (we are assessing ADS compliance with the requirements). Does this relate more specifically to the claims made under the safety case? What "risks and consequences" does this provision aim to address? Given that this section has requirements for criticality analysis, this provision seems redundant.
	(b) Demonstrating that the simulation toolchain(s) fulfils the credibility requirements corresponding to the identified criticality as per the requirements listed in this section.		Where does the reader find the "credibility requirements"? Can this be cross-referenced?
6.2.1.3.	Simulation Toolchain Data Management	6.2.1.3. Data management	
6.2.1.3.1.	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.		This provision sets a management requirement. Can this be reflected under the SMS section?
6.2.1.3.2.	The manufacturer shall maintain a record of the data used in the validation of the toolchain(s).		
6.2.1.3.3.	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.	6.2.1.3.3. The manufacturer shall describe the measures taken to ensure the quality and integrity of data or tools integrated into the simulation toolchain(s) from organisations that are not under the control of the manufacturer.	

6.2.1.3.4.	With regards to input data management and parameters associated with the simulation toolchain(s), the manufacturer shall:	**6.2.1.3.4.** Management of input data 6.2.1.3.4.1. The manufacturer shall document the input data used to develop, verify, and validate the simulation toolchain(s).	Sec: Does "With regards…" clause add any value. The listed items seem sufficient to understand the requirements.
	(a) Document the data used to develop, verify and validate the simulation toolchain(s) and note important quality characteristics;	6.2.1.3.4.2. The documentation shall note important quality characteristics of the input data.	
	(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;	6.2.1.3.4.3. The documentation shall show that the input data covers the intended functionalities that the virtual testing aims to assess.	Sec: Define "intended functionalities".
	(c) Document the data and the calibration procedures employed to fit any parameters associated with the simulation toolchain(s);	6.2.1.3.4.4. The documentation shall describe the calibration procedures used to fit parameters associated with the simulation toolchain(s);	
	(d) Explain the reasons for data or parameters changing between releases.	6.2.1.3.4.5. The documentation shall explain the reason(s) for changing data and/or parameters between releases.	Sec: Check this against the "release management" subsection for redundancy.
6.2.1.3.5.	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).	6.2.1.3.4.6. Uncertainty in the output of the simulation toolchain(s) due to the quality of the input data (e.g., data coverage, signal-to-noise ratio, sensor uncertainty/bias/sampling rate) shall be quantified.	Sec: The provisions under 6.2.1.3.4. concern input data. It seems clearer to include this provision within the "input data" subset since the next provision shifts attention to the outputs.
6.2.1.3.6.	With regards to the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall:	**6.2.1.3.5.** Management of output data 6.2.1.3.5.1. The manufacturer shall record and validate the output data from the simulation toolchain(s).	

(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;	6.2.1.3.5.2. Each output record shall be traceable to the input data that produced the output.	
(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.	6.2.1.3.5.3. The manufacturer shall conduct statistical analysis of the output data and note any important quality characteristics deduced from this analysis.	
6.2.1.3.7.	With regards to the quality of the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall:		Sec: How is this clause different from 6.2.1.3.6.?
(a)	Ensure it is sufficient to undertake any validation activity;	6.2.1.3.5.4. The manufacturer shall show that the output data is sufficient to…	Sec: "Any" validation activity? Is this a companion to showing that the input data covers the intended functionalities (i.e., the output is sufficient to validate the intended functionalities)?
(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.		Sec: Reconcile with 6.2.1.2.(a).
6.2.1.3.8.	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).		
6.2.1.4.	Competency of Personnel		This subsection should be moved to the SMS. Para. 7.1.3. stipulates that the audit of the SMS "shall verify that the manufacturer has suitable processes, resources and competent personnel in place for the testing".
6.2.1.4.1.	The manufacturer shall document and provide the rationale for their confidence in the competency of:		Sec: What is the explicit expectation? Is this about providing the qualifications required to hold positions in the organisation and describing the procedures to ensure that personnel have those qualifications? Or is it expected that personal information on each individual involved anywhere in the virtual testing programme would be provided?
	(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.		
6.2.1.4.2.	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:		Sec: Check this against the SMS requirements. This provision reads as a management requirement. Sec: Rewrite to state the explicit requirement for approving the virtual testing programme. What are the "various activities"?

	(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.		
6.2.1.4.3.	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.		Sec: This reads like an SMS requirement. What are "the various teams"? Needs further work.
6.2.1.4.4.	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).		Sec: This is a requirement to outsource human resources management. Is the aim really to require an outside firm to ensure that the manufacturer's employees are "competent to demonstrate the credibility" of their virtual testing?
6.2.1.5.	Simulation Toolchain Release Management	6.2.1.5. Release management	Sec: Connection with 6.2.1.3.4.(d)? Change location for logical order?
6.2.1.5.1.	The manufacturer shall manage and support the simulation toolchain(s) used for virtual testing throughout the lifecycle of the simulation toolchain(s).		"lifecycle of the simulation toolchains"?? This seems like to convoluted way to say that the toolchains shall be maintained. How does this provision relate to "release management"?
6.2.1.5.1.1.	This management and support shall also continue until the end of the post-production phase of the ADS.		Seems unnecessary given the preceding requirement. "Useful life" definition seems applicable.
6.2.1.5.2.	The manufacturer shall manage and document the simulation toolchain(s)		Documenting a process belongs under the SMS.

	release management process. The simulation toolchain(s) release management activity shall include:		
	(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.		
6.2.1.6.	Description of the Simulation Toolchain		Sec: Check against 6.2.1.2.
6.2.1.6.1.	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.		
6.2.1.6.2.	The manufacturer shall provide a description of the simulation toolchain(s) and its components.		
6.2.1.6.3.	The manufacturer shall provide a description of the approach adopted in the simulation toolchain(s) validation.		
6.2.1.6.4.	The manufacturer shall provide a description of the acceptance tests and criteria that will be used to determine if a simulation toolchain is considered		Where is this "credibility framework"? This provision states that the manufacturer does not have to provide anything if the toolchain is not considered credible.

	credible based on the credibility framework.		
6.2.1.7.	Simulation Toolchain Assumptions, Known Limitations, and Uncertainty Quantification		
6.2.1.7.1.	The manufacturer shall describe the modelling assumptions and considerations that guided the design of the toolchain(s).		
6.2.1.7.2.	The manufacturer shall provide information on:		
	(a) Assumptions made during the development of each simulation toolchain and its components and the limitations that these place on its scope and applicability;		
	(b) The rationale for choices made about the level of fidelity of each simulation toolchain and its components.		
6.2.1.7.3.	The manufacturer shall provide justification that the tolerances associated with the simulation toolchain(s) are appropriate and meet the acceptance tests and criteria.		
6.2.1.7.4.	The manufacturer shall provide details of the sources of uncertainty in each simulation toolchain and its components and the assessment of their impact on the results.		
6.2.1.8.	Simulation Toolchain Scope		

6.2.1.8.1.	The manufacturer shall document the scope of each simulation toolchain and identify its limitations.		
6.2.1.8.1.1.	The scope shall refer to the ODD and identify any limitations about its applicability to the ODD.		
6.2.1.8.2.	The manufacturer shall demonstrate how each simulation toolchain imitates the relevant physical phenomena and meets the necessary level of accuracy.		
6.2.1.8.3.	The manufacturer shall demonstrate that the test selection is sufficient to justify the claim that the simulation toolchain(s) can be used within the defined scope.		
6.2.1.8.4.	The manufacturer shall provide a list of tests used for validation and the corresponding parameters and any known limitations.		
6.2.1.9.	Simulation Toolchain Criticality Analysis		Check against 6.2.1.2.(a)
6.2.1.9.1.	The manufacturer shall review the error estimates of the simulation toolchain(s) to assess their criticality and the effect these would have on the manufacturer's claims about their safety case.		Only one provision. See about deleting header.
6.2.1.10.	Simulation Toolchain Verification		
6.2.1.10.1.	The manufacturer shall demonstrate that the simulation toolchain(s) will not exhibit unrealistic behaviour for valid inputs which have not been explicitly tested.		Only one provision. See about deleting header.

6.2.1.11.	Simulation Toolchain Code Verification		
6.2.1.11.1.	The manufacturer shall document the execution of proper code verification techniques used in evaluating each simulation toolchain and its components (e.g., static/dynamic code verification, convergence analysis and comparison with exact solutions if applicable).		
6.2.1.11.2.	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.		
6.2.1.11.3.	The manufacturer shall provide information on any sanity/consistency checking procedures that are used.		
6.2.1.12.	Simulation Toolchain Calculation Verification		
6.2.1.12.1.	The manufacturer shall document numerical error estimates (e.g., discretization error, rounding error, iterative procedures, and convergence).		
6.2.1.12.2	The manufacturer shall review the analysis and demonstrate that the numerical errors are understood and sufficiently bounded to allow the simulation toolchain(s) to be used for virtual testing.		
6.2.1.13.	Simulation Toolchain Sensitivity Analysis		

6.2.1.13.1.	The manufacturer shall provide documentation demonstrating that the input data and parameters that most critically influence the toolchain outputs have been identified by means of appropriate sensitivity analysis techniques.		
6.2.1.13.2.	The manufacturer shall demonstrate that robust calibration procedures have been adopted for assigning appropriate value(s) to all the simulation parameters while ensuring that special attention is taken for the most critical parameters. This is to ensure that the simulation toolchain can be used to emulate the relevant real-world system.		
6.2.1.13.3.	The manufacturer shall demonstrate that sensitivity analysis has been used to identify the critical input data and parameters that need particular attention in order to characterize the uncertainty of the overall simulation toolchain outputs.		
6.2.1.14.	Simulation Toolchain Validation		
6.2.1.14.1.	The manufacturer shall perform a validation analysis, based on quantitative metrics, to determine the degree to which each simulation toolchain is an accurate representation of the real-world system.		
6.2.1.14.2.	The manufacturer shall provide evidence that the simulation toolchain(s) results are consistent and		

	correlated with the results of the physical tests.		
6.2.1.14.3.	The validation shall be performed on a sufficiently representative set of tests in order to substantiate the claims that the simulation toolchain(s) is suitable and can be used within its scope.		
6.2.1.14.4.	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).		
6.2.1.14.5.	The manufacturer shall use appropriate statistical techniques when comparing the results of physical tests and the corresponding output of the simulation toolchain and its components.		
6.2.1.14.6.	The manufacturer shall specify acceptance tests and criteria during the development of each simulation toolchain and its components and demonstrate that they have been achieved.		
6.2.1.14.7.	The manufacturer shall define the methodology and tests used for each simulation toolchain validation.		
6.2.1.14.7.1.	It should be clear whether the full ODD is within scope of the toolchain(s) or only part of it.		
6.2.1.14.7.2.	The validation strategy may consist of one or more of the following:		

(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 form vehicle model).		
6.2.1.14.8. The manufacturer shall demonstrate that the accuracy criteria defined during each simulation toolchain development have been met.		
6.2.1.14.9. The manufacturer shall provide evidence that the processes related to the validation activity have been followed.		
6.2.1.14.10. The manufacturer shall document their uncertainty characterisation analysis and provide information about how the simulation toolchain(s) should be used and any safety margins that should be applied when it is used for virtual testing.		
6.2.1.14.11. The manufacturer shall demonstrate it has techniques to estimate each simulation toolchain's critical inputs.		
6.2.1.14.12. The manufacturer shall demonstrate that they have characterised the critical		

	parameters used in each simulation toolchain and its components and where appropriate have identified these as distributions with confidence intervals.		
6.2.1.14.13.	The manufacturer shall provide evidence that a proper characterization of the uncertainty of the results of each simulation toolchain and its components, because of any assumptions therein, has been made.		
6.2.1.14.14.	The manufacturer shall demonstrate that they have differentiated between the aleatory and epistemic uncertainties associated with each simulation toolchain.		
6.2.2.	Physical testing facilities and environment		
6.2.2.1.	The manufacturer shall demonstrate that the physical testing facilities (proving ground and/or public roads) and environments are suitable to conduct testing and gather evidence to support the safety case . In particular the manufacturer shall demonstrate that:		
6.2.2.1.1.	the physical testing facilities includes static and dynamic elements representative of the ODD and the expected operating conditions and as relevant to the tests being performed;		
6.2.2.1.2.	the facilities and capabilities are suitable to assess the aspects of the safety case under test;		

6.2.2.1.3.	the facilities have all the relevant equipment and accreditations;		
6.2.2.1.4.	the equipment undergoes periodic calibrations to ensure that the measurements are characterized by sufficient accuracy and precision.		