Section 5
DS491 Step 7: Deterministic Safety Analysis for NPPs

COMMENTS BY REVIEWER				RESOLUTION			
Reviewer: Page.... of.... Country/Organization: Date:							
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
Observer ENISS2	General comment	A/ Quality of code development and maintenance : from #5.7 to #5.12, #5.40 B/ Verification and Generic Validation Verification : from #5.13 to #5.18 Validation : #5.4 (to be mixed with #5.23), #5.20, beginning of #5.19, from #5.26 to #5.28, #5.30, #5.34 C/ Uncertainty Quantification : #5.21, #5.29, from #5.31 to #5.33, from #6.21 to #6.29 D/ Code documentation : #5.2, #5.38, #5.36, #5.37, #5.39 E/ Adequate use of the code for safety studies Qualification of the code : code fitted to the study (#5.1, #5.4, end of #5.19, #5.22, #5.24, #5.25), accuracy of the results of interest for the study (#5.3, #6.7, #6.26, #6.29) Compliance with the users' guidelines : #5.6, #5.35 Users' technical and scientific					*No specific suggestions*

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		competence : #5.5					
Observer ENISS 3	General comment	Examples of terms needing definition: Verification (#5.13 and #9 don't use the same meaning for verification) Validation Review, inspection and audit (#5.14) Error (#5.29) Robust (#5.2(e))			*"error" (5.29) will be replaced by "uncertainty".* *See ENISS-32* *The term "robust" is used in reports such as [10], meaning in general "without oscillations or non-convergence or results with large differences when only small disturbances are input"*		*The use of these definitions is consistent with other Safety Standards, Safety Reports and with the Safety Glossary. Specific definitions for these terms are outside the scope of this SG.*
Canada53	5.1		This clause suggests a graded approach in software qualification such that the requirements for validation and verification depend on the type of application and purpose of analysis. The concept of graded approach can be extended beyond software qualification to the actual deterministic safety				*No specific proposal*

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			analysis as well.				
Madagascar 1	5.1	"Any calculational methods and computer codes used in the safety analysis shall undergo verification and validation to a sufficient degree"	The meaning of the sentence can be different if the word "to a sufficient degree" is not included in the reference, it is better to put the full sentence form GS-R Part 4			X	*Requirement 18 from GSR Part 4 (Rev.1) is "Any calculational methods and computer codes used in the safety analysis shall undergo verification and validation".*
Observer EC-JRC 53	5.2/1	Regarding the selection ~~and use~~ of computer codes…	The use of computer codes is not treated in listed bullets of section 5.2. Rather, para 5.6 specifically addresses this topic.	X			
Observer ENISS 32	5.2 (e)	Ask for clarification	What means "robust"? (to include in a Glossary)		*The term is used in reports such as [10], meaning in general "without oscillations or non-convergence or results with large differences when only small disturbances are input"*		
Canada 54	5.3 bullets (b), (c)	Suggest the following changes, *The assessment of the accuracy of individual codes should include a series*	Estimation of uncertainties associated with numerical approaches and key models are not always			X	*As far as possible to avoid compensatory effect, overall code uncertainties should*

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		of steps, some of which are related and may be considered as a whole:	separate steps and their contributions to overall code uncertainties may not readily established.				*not be performed*
Observer EC-JRC 54	5.3/All	*Remove/Replace*	The goal of para 5.3 is unclear: code uncertainty assessment –if this is what pursued as it can be likely derived from bullets (a) to (d)– only concerns BEPU approach hence guidance concerning this issue should not be included without previously making explicit the specific code approach underlying such guidance.			X	*This para is related to accuracy of the results which is to be verified whatever the approach of the code is.*
Observer EC-JRC 55	5.4/All	*Replace*	Entire para 5.4 should be regrouped under para 5.2. Para 5.4 focuses on code validation through benchmarking activities, thereby in intimate relation of para 5.2 bullets on the minimal capabilities to be met by the code in order to be selected.			X	*Paras 5.2 and 5.4 have different objectives. Para 5.2 is for selection of computer codes. Para 5.4 is for validation of the selected computer codes. No need to combine both paras*
Switzerland 6	5.5	(a) The users have received adequate training and that they appropriately understand the code, (b) The users are sufficiently	Full understanding of a very complex code is difficult to achieve by a user.			X	*Changes may not add relevant value*

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		experienced in the use of the code and ~~fully~~ suitably understand its uses and limitations,					
PL 1.	5.5. (d)	The users follow the recommendation for use of the code and especially the ones relative to the application ~~the user are carrying out the analysis~~ for which the analysis are carried out	Clarification	X			
Germany 22	5.6 (c)	(c) The ~~nodalization,~~ selected models and assumptions match the ones chosen for SET and IET used for the qualification of the application	The nodalization of a plant modelling will be different to the nodalization for test sections of single effect tests and integral effect tests. E.g. the core region is subdivided into several rings of thermal hydraulics channels, larger amount of fuel assemblies has to modelled, internals of RPV has to be modelled, different injection and discharge of reactor coolant, etc. Thus, the demand of equal nodalization should be deleted.			X	*The nodalization of a plant modelling will be different to the nodalization for SETs, IETs and NPPs. However the consistency of nodalization is necessary.*
PL 2.	5.6. (c)	(c) The nodalization, selected models and assumptions ~~match~~ are consistent with the ones chosen for SET and IET	Consistency is the better word when You describe two nodalizations		"(c) The nodalization, selected models		

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		used for the qualification of the application			and assumptions ~~match~~ are consistent, to the extent practicable, with the ones chosen for SET …”		
Observer EC-JRC 56	5.5, 5.6/All	Even though substantial progress in the development of more accurate and reliable computer codes has been made, user effects still have a dominant influence on the final results. This is why quality assurance to code users dealing with safety analysis applications should be required. Since performing transient simulations in complex system codes basically consists of fitting certain real processes with theoretical models implemented in the code, the main categories where user effects concentrate can be structured in 'reality' and 'code': a. 'Reality' category comprises: a.1. Plant: The user should have very good knowledge of plant characteristics including SSCs performance in order to prepare a good input deck. For instance, deviations in input and boundary conditions can lead to strong deviations in the outputs; a.2. Physics: The user should have very	Importance of user effects has been remarked by many international activities dealing with code uncertainty assessment, e.g. within CSNI, CNRA, European Nuclear Regulators, etc. This Safety Guide instead puts no emphasis on such delicate topic which takes even more important when talking about severe accident codes such MELCOR or MAAP (due to the higher freedom assumed by the user compared to the frame of DBA-oriented codes). Therefore, it is the opinion of this reviewer that a fundamental gap is currently found when stressing how important is			X	*Detail out of the scope of this Safety Guide. Some suggestions not clear (QA for code user)*

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		good knowledge on phenomena governing accident evolution; b. 'Code' category comprises: b.1 *Software*: The user should be fluent in constructing and understanding modelling aspects to build up an input deck. For instance, nodalization mesh plays an important role in adequately capturing the most important phenomena driving accident evolution; b.2. *Hardware*: Not only knowledge on nuclear reactor neutron and thermalhydraulics is fundamental, but also to be familiar with code calculation structure scheme, i.e. employed set of continuity equations or time step size, and code phenomena models. For instance, the user has to make many choices on selecting the most suitable model for a specific phenomenon. Also state and transport property data, i.e. range of reference points for property tables, could be also defined by the user. This user effect source plays an even more critical role in severe accidents where the number of phenomenon where alternative models are available for user's choice hugely increases in proportion to a much lesser reliable state of the art supporting code	that code users are well trained in the three independent fields pointed out in my suggested writing. In fact, different countries such Finland, USA or The Netherlands have already given a step forward and started working in developing quality assurance programs for code users. Suggested text should therefore constitute a new subsection –just, for instance, as 'VALIDATION OF COMPUTER CODES'– .				

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		modelling validation.					
Japan14	5.13-5.15	(new) 5.13.a. In accordance with GSR Part 4 (Rev. 1), § 4.60 [2] verification of the code should consist of model verification and system code verification. (new) 5.13.b. The model verification should be performed by examining solution characteristics and making comparisons of outputs of the code with reference analytical solutions or outputs of other verified code to assure the fidelity of numerical solutions of the code, e.g., time and space discretization, solution symmetry, and dependencies or robustness on initial conditions and boundary initial conditions, etc. 5.14. The ~~verification of the code~~ system code verification should be performed by means of review, ... 5.15. ~~Verification of the code~~ The system code verification should be performed to review the source coding...	To be consistent with GSR Part 4 para 4.60, divide verification into model verification and system code verification. And add paragraph related to the model verification.		(new) 5.13.a. In accordance with GSR Part 4 (Rev. 1), § 4.60 [2] verification of the code should consist of both model verification and system code verification.		*The scope of the para 5.13b suggested does not relates to verification but to validation.* *5.14 and 5.15 are common to both model verification and system code verification. Suggested changes are not applicable*

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Observer ENISS 33	5.13	Verification is the process of determining that a computational model accurately represents the underlying mathematical model and its solution. Verification of the code should be …	The definition of verification is lacking. The proposed new text is internationally accepted. Both code verification and solution verification must be taken into account. Nothing is said about solution verification. It could be integrated in the glossary.			X	*See Japan-14.* *Better not to add this clarification/ definition, which is not related to DSA*
Canada 55	5.14	Suggest the following changes, *The verification of the code should be performed by an independent verifier, by means of review, inspection and audit. Checklists might be provided for review and inspection. Audits might be performed on selected items to ensure quality.*	Verification of computer code should be performed by an independent verifier			X	*It depends on the specific QA procedure from the code development organization. GSR Part 4 (Rev.1) requires independent verification of safety assessment. (Requirement 21).*
Observer ENISS 34	5.14/1	Need of a glossary	"review, inspection and audit": the definition of these words must be provided			X	*Used according Safety Standards and Safety Glossary*
Belgium 3	5.16	" … software platform …"	What is a "software platform"? Is it clear for the readers?		"… or software platform (e.g. operating system) other than that…"		
Observer	5.17/2	Verification of the source code should	One can find standards for		"… conforms to		

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ENISS 35		be performed to demonstrate that it conforms to ~~programming standards and~~ language standards, and that is logic is consistent with the design specification.	code development and maintenance but there are no standards for programming (except internal specific standards within a development team)		accepted programming practices- ~~programming standards and language standards…”~~		
Japan15	5.19	... scope of validation might be relaxed for codes used in severe accident analysis, taking into account the limited relevant experimental data. When validation is limited due to above reason, review of model applicability by experts considering experience and the level of knowledge on the model might be encouraged.	Add recommendation where validation is limited.			X	*Out of scope of this Safety Guide. It can be found in dedicated documentation*
France 15	5.19	5.19. Validation of the computer code should provide confidence in the ability of a code to predict, realistically or conservatively, the values of the safety parameter or parameters of interest. The level of confidence provided by the validation should be appropriate to the type of analysis; ~~scope~~ accuracy of validation might be relaxed for codes used in severe accident analysis, taking into account the limited relevant experimental data ; nevertheless,	It is needed to get a reasonable confidence that provisions for severe accident or DEC are efficient.			X	*“scope” is more appropriate than “accuracy”. This sentence says that full validation of a severe accident computer code may not be feasible due to limited experimental data.* *Also, the*

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		validation shall be sufficient for the demonstration of the effectiveness to the design provisions.					*requirements for computer codes are established in GSR Part 4 (Rev.1); no requirements can be added here*
Observer ENISS 36	5.19 and 5.20	Reverse 5.19 and 5.20	5.20 (definition of validation) should come before 5.19 and include the first sentence of 5.19. We suggest to reverse their order in the document.	X			
Observer ENISS 37	5.19/4	Validation of the computer code … type of analysis; scope of validation might be relaxed for codes ~~used in severe accident analysis, taking into account the~~ with limited relevant experimental data (for example, codes used in severe accident analysis).	The recommendation is larger than the scope of severe accident			X	*Validation cannot be 'relaxed' for codes used in DBA*
Canada 56	5.21 Line 2	Suggest the following changes, *Outputs of the code are compared with relevant ~~experimental data~~ measurements from tests or operational transients for important phenomena expected to occur.*	As noted in para 5.23, nuclear power plant transients should also be used in addition to experimental data for separate effect tests and integral effect tests.		**"…**Outputs of the code are compared with relevant experimental data and with operational transients, if possible, for the important phenomena expected to occur."		"experimental data" *is also used in other paragraphs. Better not to change it.*

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Observer ENISS 38	5.21/1	5.21. Validation of the code ~~should be performed~~ may help, when the conservative approach is not sufficient, to assess the uncertainty of values predicted by the code. Outputs of the code are compared with relevant experimental data for important phenomena expected to occur.	The aim of validation is not uncertainty quantification. The acronym VVUQ (Verification Validation and Uncertainty Quantification) means that UQ is a step forward VV but is not included in Validation. Nethertheless, Validation may help UQ.			X	*To meet Requirement 18 form GSR part 4 (Rev.1), comparison of model prediction with experimental data is needed in validation process.*
Canada 57	5.22	Suggest the following changes, *… the development phase, in which the assessment is done by the code developer, and the independent assessment phase, in which the assessment is performed by the code user. Consideration should be given as to whether separate tests must be applied for the validation for the separate phases.*	The two phase approach for validation certainly has merits for complex analyses. Considerations should be given on whether validation exercises must be quarantined between the two phases, and whether there are sufficient independent tests for this purpose.			X	*It is not easy to determine the benefit from this consideration and to implement it, as not many tests are available for complex analyses*
Egypt 3	Para 5.22 page 27	**…in which the assessment is performed by the user code.**	By the user code instead of by the code user, and the same comment at para 5.25			X	*Code user seems better than 'user code'*
Korea 3	§5.23, Second sentence	[errata] (4)…~~nuclear~~ Nuclear power plant	[errata] nuclear -> Nuclear	X			
Canada 68	5.23 item (4)	Nuclear power plant level tests and operational transients. nuclear power	Suggested addition to clarify expectations for new		"…actual nuclear		*To include also other phases and the cold*

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		plant level tests are performed on an actual nuclear power plant during, for example, the fuel-in (hot) commissioning phase . Validation through operational transients together with nuclear power plant tests are important means of qualifying the plant model.	designs that such testing will be expected as part of the Commissioning program for the first of a kind prior to commencing to commercial operation.		power plant, for example during the commissioning phase. Validation through operational…"		*phase w/o fuel*
Observer ENISS 39	5.23	(3) Integral effect tests. Integral tests … boundary conditions. In the absence of experimental data, sufficient conservatisms, based for example on code-to-code comparison or bounding engineering judgement, should be allowed to cover the deficiencies on the means to support a full validation. (4) NPP level tests and … qualifying the plant model. In the absence of data, sufficient conservatisms, based for example on code-to-code comparison or bounding engineering judgement, should be allowed to cover the deficiencies on the means to support a full validation.	The sentence in (2) line 4 : "In the absence … full validation" should be common to (2), (3) and (4)		*Last sentence from (2) will be deleted.*		*Better not to add those sentences. §5.23 indicates "The validation should* ***ideally*** *include …". Deviations are not part of §5.23.*
Observer ENISS 40	5.24	Ask for clarification in the document.	We agree with the 5.24 sentence, but there is confusion elsewhere in the document between Generic Validation and Qualification.			X	*No specific suggestion is provided. There is no 'generic' validation; the code is validated only for*

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			Difference should be made between generic validation (first sentence) and specific validation for a specific safety study (second sentence). The first one is related to the validation of the code, the second one is related to the qualification of the code for a safety study.				*the applications for which the validation is performed. Qualification of the code does not apply.*
Observer ENISS 41	5.26	For complex applications, a validation matrix… The validation matrix should be adjusted to the safety case.	The validation must be optimized: not too large, not too small		"5.26 For complex applications …be inaccurate for other data sets. The validation matrix should be adjusted to the application for which the code is validated."		
Japan16	5.29	When performing a validation against experimental data, ~~allowance for errors~~ uncertainty in the measurements should be included in the determination of the uncertainty of the computer code.	Editorial	X			
Observer ENISS 42	5.29/1	Definition of "error" to be added	Glossary		*See Japan-16 and ENISS-3.* *The term "errors"*		"

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					has been replaced by "uncertainties".		
Observer ENISS 43	5.29 2nd sentence	When performing … of the computer code. In *addition,* ~~*the evaluation*~~ *explanations should be provided about the transposition of uncertainties based on scaled experimental results* ~~*has to be transposed and justified to the uncertainty*~~ *to the uncertainties relative to the real power plant application*"	Real justification is seldom possible.			X	*It would change the meaning. The term "explanations" may be ambiguous and does not provide 'quantitative assessment'; transposition bias should be evaluated (or conservatisms included) to cover the fact that 'justification is seldom possible'.*
Observer ENISS 44	5.33/1	Replace "range" by "*scope*"				X	*The change doesn't seem to enhance the wording. "Range" is a more quantitative term whereas "scope" has larger meaning, it is not very precise.*
Observer EC-JRC 57	5.33/All	*Remove*	Uncertainty is code-specific but also plant-specific and sequence-specific. Otherwise the entire uncertainty assessment process would be straightforward. Therefore,			X	*To meet Requirement 18 form GSR part 4 (Rev.1), uncertainties of the code should be known through validation process.*

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			para 5.33 should be removed.				
Canada 58	5.34	Suggest the following changes, *For a code intended to be conservative regarding certain acceptance criterion, it should be demonstrated that the code prediction ~~bounds~~ is conservative when compared against the experimental data.*	For a code intended to be conservative, it is sufficient to demonstrate that the code predictions are conservative with respect to the experimental. The requirement to demonstrate predictions are bounding is quite onerous and not always attainable.	X			
PL 3.	5.35	Procedures include issues such as the way to compile the input data set, the means of selecting the appropriate models in the code and general rules for preparing the nodalization.	Although nodalization techniques are usually covered by user guidelines more specifically, nevertheless general guidelines for preparing good nodalization should be in the procedure	X			
Japan17	5.35 and 5.36	Para 5.35 and 5.36 should be moved from "VALIDATION OF COMPUTER CODES" to a new part named "NODALIZATION AND USER EFFECT".	The contents of para 5.35 and 5.36 are not limited to the validation of computer codes.			X	*Nodalization is also part of the validation of the code and cannot be separated from it. If the user does not follow the recommended nodalization (on*

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							which the code is validated) the application is no longer providing reliable results. It seems better to keep both paras in this subsection ('VALIDATION')
Observer EC-JRC 58	5.35, 5.36/All	N/A	According to the rationale of comment 57 on user effects, contents referred in these two paras should be replaced into an independent additional subsection.		*See resolution to Japan-17*	X	
Observer ENISS 45	5.35 and 5.36	Move the paragraphs to another section, as requested in general comment n° 2.	These paragraphs do not fit with the title of the section "validation of computer codes".		*See resolution to Japan-17*	X	
PL 4.	5.36 Line 3	The nodalization should be sufficiently detailed so that all the important phenomena of the scenario and all the important design characteristics of the nuclear power plant analysed are represented. However overcomplicating of nodalization should be avoided as it may have negative impact both on the computational time and the results.	Additional sentence on nodalization – it may appear to the reader that the more detailed and complex nodalization (for example 20 nodes instead of 10) is always welcome, but that is not always the case, and it should be stated in the document.			X	*It seems better not to add the clarification. Computational time is not to be considered; on the other hand this may open the possibility to adopt 'simple' nodalization for the sake of computer time*

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							whereas the results may be not reliable. It seems also better not to use 'negative impact' on the results