1. Austria

COMMENTS BY REVIEWER Reviewer: Reviewer: Volker Holubetz Country/Organization: Country/Organization: Austria, Federal Ministry for Sustainability and Tourism Date: 10. 4. 2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1	3.14 – 3.33		Austria would like to emphasise that the concepts of “near regional-” , “site vicinity-” and “site area” investigations” are very well explained, with state of the art definitions of “near regional”, “site vicinity” and “site area”, and that we fully support this section of the standard.	X			
2	3.35	Current Text: “3.35. A specific ‘Project Earthquake Catalogue’ should be developed as result of the seismological investigations and as an end-product of the seismological database, including all earthquake related information developed for the project covering all the temporal scales defined in para. 3.35.”	The para refers to itself, for definition of temporal scales, probably another para is meant.	X	Changed to “... defined in para. 3.34.”		

3	Footnote 3	Current text: Footnote The nuclear engineering community uses the term annual frequency of exceedance when mathematically the term annual exceedance probability is more accurate. At the low values of interest here, both terms can be used interchangeably and so this guide refers generally to annual frequency of exceedance in recognition of the expectations of the nuclear audience likely to use this guide.	Please consider defining what is meant by "annual frequency of exceedance" within the current standard instead of mentioning that another term is more accurate, but not used in the text.	X	Changed to "The nuclear engineering community uses the term annual frequency of exceedance (derived from statistical data) when mathematically the term annual exceedance probability (derived from statistical data and a probability function to model how this data supports future seismic activity) is more accurate. ..."		
4	5.19	Current Text: "…with rupture that evolves in space and time. **Both** methodologies …" The para only introduces one methodology (stochastic simulation).	Understanding, please clarify which second methodology is meant or change accordingly	X	Changed to "This methodology should include the development of …"		
5	Para 7.12 – 7.18	Capable faults at sites with existing nuclear installations	Austria would like to support the text, we welcome that the standard recommends 1.) to include assessment of fault displacement potential in a seismic safety evaluation programme for a site with an existing nuclear installation, 2.) to follow the approach for new builds if a new nuclear installation were to be built on a site of an existing nuclear installation. Please consider providing more guidance on how to make use of the safety evaluation for a site with an existing nuclear installation, if hazards from capable faults have been evaluated.			X	This guide is intended to cover the evaluation of hazards. Safety assessment is out of scope.

6	Section “Definitions”		Please include the definition of “capable fault”.			X	The definition of “capable fault” is already included in the IAEA Safety Glossary (2018 Edition).

2. Belgium

COMMENTS BY REVIEWER Country/Organization: ENISS Date: 30/04/2019				RESOLUTION			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1	7.5a)	Precise the notion of "areas where the observed activity is between these two rates (i.e. not as highly active as plate boundaries and not as stable as cratonic zones.	It has a direct impact on the times frame considered to look for capable faults in these regions.			X	Precision in terms of appropriate timescales to be considered isn't needed here. It is up to a competent analyst to form at judgment to match observed activity to appropriate time frames.
2	7.10	"During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e. primary) fault displacement <u>within the site area,</u> this issue should be treated as an exclusionary attribute (see para. 3.8 of IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations [9]) and an alternative site should be considered. <u>If reliable evidence is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e.</u>	Produce in depth analysis on capable faulting and its potential impact on systems, structures and materials important to safety.			X	The uncertainty around the analysis of fault rupture capability is extremely large, and future secondary fault ruptures associated with the primary fault are very difficult to predict. The radius of the site vicinity is taken as 5 km from SSR-1. In this guide, existence of secondary fault in the site vicinity is considered a discretionary criterion, but the existence of a primary fault in the site vicinity is an exclusionary

		primary) fault displacement within the site vicinity, additional investigation should be done to ensure that the structure, together with associated secondary faults, do not propagate within the site area.					criterion, following SSR-1.
3	7.11	If during the selection and evaluation stages of a proposed new site for a nuclear installation, reliable evidence is collected demonstrating the existence within the site vicinity area of a secondary fault belonging to a seismogenic capable fault located inside or outside the site vicinity, this issue may be treated as a discretionary attribute (see para. 3.8 of SSG-35 [9]). However, if reliable evidence shows that this secondary fault is traced or extended to the site area, this issue should be treated also as an exclusionary attribute and an alternative site should	Consequence to previous remark			X	See above.
4	7.12 and following	Give a definition of "potential capable fault"/"potentially capable fault"	Not clear enough regarding the definition given before concerning what is a capable fault			X	The two phrases have slightly different meanings in English: 1. 'potential capable fault' means that there might be a capable fault present 2. 'potentially capable fault' means that there

							is a fault that might be capable. However, it is too minor distinction to define.

3. Canada

COMMENTS BY REVIEWER Country/Organization: Canada Date: April 29, 2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	1.3 (d)	(d) A more coordinated treatment of the seismically induced geological and geotechnical hazards and concomitant events;	"induced associated" is confusing wording and have repeat meaning. One of them should be deleted.	X			
2.	2.1	For Requirement 2, replace ".... hazards that might challenge …" with "… hazards that are sufficiently credible to challenge …"	Use of "might" is too ambiguous.			X	This sentence is quoted from the published SSR-1.
3.	2.1	For Requirement 16, amend the draft text: " … seismic design or safety …" to add reference to qualification as follows: " … seismic design, qualification or safety …"	The term "qualification" is more encompassing than reference to "design."			X	This sentence is quoted from the published SSR-1.
4.	2.9	Edit draft text as follows: "2.9. In order to address the diversity of scientific interpretations, it is recommended that the centre, body and range of the technically defensible interpretations [6] are properly captured through a complexity-dependent graded approach. For this purpose, multidisciplinary teams of experts with appropriate qualifications in each of the relevant areas should be involved to develop a model that robustly represents the epistemic	This draft abstractly introduces the SSHAC process. Specific reference needs to be made to the application of a graded approach to avoid overreach. There is some risk in implicitly referring to (or adopting) the SSHAC process without explicitly enforcing all its limitations and caveats.	X	Concerning to the reference to expert elicitation, this sentence has been revised to make it more intelligible. The last sentence has been substantially accepted with minor modification.		

		uncertainties related to methods and models employed in the seismic hazard evaluation. ~~Approaches that use expert elicitation should avoid putting these experts in a role that might jeopardize the significance of their professional judgements as supported by the available earth science data.~~ Also, the adequate consideration of uncertainties using appropriate (e.g., conservative or best estimate) and credible models, methods and scenarios, based on the technically defensible interpretations concept should be made given the evaluation framework (i.e. deterministic or probabilistic) and the target confidence levels. The extent of the composition of the peer review team should follow a graded approach to be commensurate with the complexity of the project, e.g. hazard evaluation for a new plant vis-à-vis a minor periodic update of site hazard.”	Also applies to paragraph 10.18.				
5.	3.11 (b)	Also, studies of palaeo-liquefaction, paleo-landslides, and palaeo-tsunami can provide evidence of the recurrence and intensity of earthquakes.	Studies of paleo-landslides are common nowadays in studying prehistoric and historic earthquakes, which can provide information on the recurrence and intensity of earthquakes.	X	“palaeo-landslides” is added instead of “paleo-landslides”		
6.	3.19	Geological, geophysical and geotechnical investigations should be conducted in more detail in the near region to provide more detailed	Use of words “site specific” for investigations to be conducted in the near	X			

		information than the information available from the regional studies, with the following objectives:	region could cause confusion with investigations to be conducted in the site area where the words "site specific" is used. The words "site specific" should be removed.				
7.	3.28 (c)	(c) Identification and characterization of locations potentially exhibiting hazards induced by earthquake (e.g. landslide, subsidence, collapse of subsurface cavities or karstic features, failure of dams or water retaining structures).	Inaccurate description of some hazards induced by earthquakes.	X			
8.	3.30	Additional geological, geophysical, geotechnical, and seismological site specific studies should be……	Inaccurate use of the term "geotechnical seismological" in the sentence.	X			
9.	3.32 (a)	(a) Geological, geophysical and geotechnical investigations to define the detailed stratigraphy and the structure of the area. Borehole drilling, sampling and/or test excavations (including in situ testing), geophysical techniques and laboratory tests should be performed to determine the thickness, depth, dip, and physical and mechanical (static and dynamic) properties of the different subsurface layers as may be needed by engineering models (e.g. Poisson's ratio, Young's	Inaccurate term was used. Another important thing that should be emphasized on the site specific detailed investigations is that the investigation boreholes should be drilled deep enough to confirm no cavities and karstic features underlying the nuclear installation. If boreholes are not drilled deep enough and	X	Reflecting the proposal, "such as in limestone areas" is also added at the end of the last sentence.		

		modulus, shear modulus reduction or non-linear properties, dynamic damping properties, density, relative density, shear strength and consolidation characteristics, grain size distribution, P-wave and S-wave velocities). Boreholes should be drilled deep enough to confirm that no cavities or karstic features are underlying the foundation of nuclear installations.	then information on the potentially underlying cavities and karstic features might be missing, which could bring potentially safety concerns to the nuclear installation, although the drill data should be complemented with the geophysical survey data.				
10.	3.34	To be able to reliably characterize events that occur with very long recurrence periods (or very low annual frequencies of exceedance3), the seismological database should include the information on past events that might have generated seismic hazards at the site.	Confused meaning of the sentence with regard to past events. For past events, they might have either generated or not generated seismic hazards, but not have potential to generate seismic hazards.	X			
11.	3.34 (a)	a) Historical stage, i.e. the period that there are documented records of earthquake events. This period is further subdivided as:	The definition of historical stage appears to be inappropriate and confusion, and should be revised (please also see the reason for comment 10).	X	Changed to "a) Historical stage, i.e. the period for which there are documented records of earthquake events. …"		
12.	3.34 (b)	b) Pre-historical stage, i.e. the period that there are no documented records of earthquake events.	The definition of pre-historical stage appears to be inappropriate and confusion, and should be revised. The definition of pre-historical stage (also	X	Changed to "b) Pre-historical stage, i.e. the period for which there are no documented records of earthquake events. …"		

			historical stage for comment 9) should refer to the documentation of earthquake events, as the geological time that is much earlier than the pre-historical stage is described in written documents.				
13.	3.50	To acquire more detailed information on potential seismic sources, path effects, Green's function, ground motion prediction equation, and site responses, it is advantageous to install or have access to a seismic monitoring network of high sensitivity seismometers. The monitoring network, having a recording capability for micro-earthquakes and being capable of recording sufficiently high frequencies to estimate near surface attenuation, should be installed and operated at the near-region of the nuclear installation site.	The sentence is too long with confusing meanings. It should be broken into two sentences.	X	Reflecting the proposal, the text is modified adding more detailed express.		
14.	4.14	For seismogenic structures that have been identified as being relevant to determining the seismic hazards for the site, the associated characteristics of such structures should be determined.	Using wording "seismic hazards" instead of "earthquake generated hazards" is more consistent with the title of this Guide.	X			
15.	4.19	Regardless of the approach or combination of approaches used, the determination of the maximum potential magnitude might have significant uncertainty, which should	Geophysical data are important data for characterizing the seismic source and analyzing the	X			

		be incorporated into the analysis to the extent that it is consistent with seismological, geological, geophysical, and geomorphological data.	uncertainty that relates to the determination of maximum potential magnitude.				
16.	7.5, a), lines 7&8	In less active areas, it is likely that much longer periods (e.g. Pliocene toHolocene, i.e. the present) are appropriate.	While Pliocene is a term representing a geological Epoch, Quaternary is a term representing geological Period. They are not same category of terminology in geological time scale. Also Quaternary includes two Epochs that are Pleistocene and Holocene. Use of Quaternary, in comparison with Pliocene, is not clear in term of the geological time scale. Quaternary should be replaced with Holocene.	X			
17.	8.20, lines 3 to 5	These hazards include tsunamis, soil liquefaction, slope instability, subsidence, collapse of subsurface cavities and karstic features, and the failure of water retaining structures, which might be triggered either by ground motion or by surface faulting.	Inaccurate expression of some seismic-induced geological and geotechnical hazards. The seismic hazards are usually triggers for the associated hazards.	X			
18.	8.24	Non-cohesive soils in loosely deposited conditions below the water table are susceptible to liquefaction; if this is the case, the strength and stiffness of a soil are reduced when	More generally used terms related to the outcome of liquefaction, i.e. loss or reduction of the	X	Amended to reflect the proposal.		

		subjected to vibratory ground motions. Therefore, careful geotechnical investigations should be carried out in the site area to assess the liquefaction potential of soils including non-cohesive backfill materials, which might affect the safety of the systems, structures and components of the nuclear installation.	strength and stiffness of a soil, but not just bearing capacity of a soil, should be used, as liquefaction can also cause slope failures. In addition, some granular backfill materials may exist at an existing nuclear installation site. Their liquefaction potential should also be assessed.				
19.	References	Replace reference [6] NUREG-2117 with following updated report: NUREG-2213, Updated Implementation Guidelines for SSHAC Hazard Studies.		X			

4. Finland

COMMENTS BY REVIEWER Reviewer: M-L Järvinen Country/Organization: STUK Date:25th April 2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
	2.9	Add explanation of the terms "centre", "body" and "range" in the Guide and remove reference [6].	For a reader not familiar with the SSHAC procedures, it would be helpful to have the explanations of the terms in this Guide. Ref. [6] is the only reference to other than IAEA publications. If references are in general made only to IAEA publications, it is unnecessary to make an exception here. There are many other points where references to non-IAEA publications would be useful.			X	The Center, Body, and Range of Technically Defensible Interpretations (CBR of TDI) is considered very important element for probabilistic seismic hazard analysis and it is introduced in the SSHAC procedure in USA. The USNRC disseminate this concept as a part of their nuclear regulatory process. This concept is now widely accepted as the good practice in probabilistic seismic hazard assessments. It is considered appropriate to refer it as a source of explanation for the concept. Hence it is preserved in the references. Besides, several MSs suggest that the reference should be preserved.

	3.50	Check the first sentence, it is very long and some words seem to be missing.	Something is missing from the last part … , should be installed …	X	Changed to “To acquire more detailed information on potential seismic sources, it is advantageous to install or have access to a seismic monitoring network system of high sensitivity seismometers.”		
	ANNEX-TYPICAL OUTPUT OF PROBABILISTIC SEISMIC HAZARD ANALYSES TABLE A-1 Uniform hazard response spectra	Mean and fractile uniform hazard response spectra should be reported in tabular as well as graphic format. Unless otherwise specified in the work plan, the uniform hazard response spectra should be reported for annual frequencies of exceedance of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} ~~and~~**,** 10^{-6} **and** $\mathbf{10^{-7}}$ and for fractile levels of 0.05, 0.16, 0.50, 0.84 and 0.95.	Draft Safety Guide DS490, Seismic Design of Nuclear Installation, mentions annual frequency of exceedance of 10^{-7}. Perhaps it could be considered here also.			X	a 95% fractile at 10^{-7}/year would probably be a large earthquake in most parts of the world with enormous uncertainty. It’s not clear how this could be usefully applied to the safety analysis of a nuclear installation.
	ANNEX-TYPICAL OUTPUT OF PROBABILISTIC SEISMIC HAZARD ANALYSES TABLE A-1 Mean and modal magnitude	The mean and modal magnitudes and distances should be reported for each ground motion parameter and level for which the M–D deaggregated hazard results are given. Unless otherwise specified in the work plan, these results should be reported for response spectral frequencies of	From an engineering point of view, area from 10 Hz to PGA should be reported also, e.g. 25 Hz. The frequencies of interest depend on the site conditions (hard rock / soft soil / etc.).	X	Changed to “… e.g. 1, 2.5, 5, 10 Hz, and peak ground acceleration.”		

	and distance	1, 2.5, 5 ~~**and**~~**,** 10 Hz**, and higher than 10 Hz, the upper bound depending on the site conditions.**					

5. France

COMMENTS BY REVIEWER Country/Organization: FRANCE				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	General	DS507 quote SSR-1 which is not a published standard while NSR-3 is published: the relevant quotation should be done in final version of DS 507				X	This is a reasonable comment, but SSR-1 has already been published and the text cannot be amended at this stage.
2.	1.3.b	~~Recent developments and regulatory requirements on risk informed and performance based approaches for assessing the safety of nuclear installations;~~	Consider deletion of unuseful and confusing quotation in the context of this guide. A minima, complement with recognized reference that describe essential elements of these approaches applied within this context. Explain which part of this specific guide apply risk informed and performance based approaches			X	This safety guide is mostly about defining a probabilistic hazard, therefore it is most closely aligned philosophically with the PSA approach and therefore automatically sympathetic to a risk informed process. IAEA is moving in this direction.
3.	1.8 and reference	Quote the relevant version of glossary (not the 2016 one)	Reminder of the 2016 glossary preface : "*This 2016 Revision of the IAEA Safety Glossary 2007 Edition is not a new Edition of the IAEA Safety Glossary and it is not an official publication of the IAEA. The draft is made available online on the IAEA public web site*	X			

			(http://www-ns.iaea.org/standards/safety-glossary.asp) for informational purposes only. The 2016 Revision may be referenced and quoted as a web site. It is intended for use in the IAEA's official business only and may not otherwise be referenced, quoted or disseminated"					
4.	1.9	**If grading is performed** ~~**Also**~~, the level of detail and the effort devoted to evaluating the seismic hazards at existing installation sites should be commensurate with a number of factors, e.g. the level of radiological hazard**,** ~~**and**~~ the time remaining until it is remediated, ~~**the severity of the regional seismicity where the site is located,**~~ etc.	"Also" brings confusion in this paragraph, the last sentence being possibly interpreted as another case to degrade the level of seismic hazard analysis. Level of seismicity is not a criteria to decrease the level of detail and effort devoted to evaluate seismic hazards. Proposed text intends to avoid this possible misinterpretation of the graded approach.	X	'Also' is removed. 'hazard' is added after 'the regional seismic'.			
5.	3.17	Where existing data **are incomplete to properly** ~~**inadequate to**~~ characterize the identified potential geological features relevant to the seismic hazard at the site, ~~**and which are identified in the defined region in terms of location, extent and rate of ongoing deformation,**~~ a sensitivity analysis should be performed **based**	Location, extent and rate of deformation are adequate information for SHA at regional scale. Therefore, the first sentence is a bit confusing.	X	This amendment is more readable and easily understood. The text is modified reflecting the proposal.			

		on reasonable/defensible hypotheses.					
6.	3.30	Additional geological, geophysical and geotechnical seismological site specific studies should be conducted in the nuclear installation site area with the primary objective to provide: (i) detailed knowledge for assessing the potential for permanent ground displacement phenomena associated with earthquakes (e.g. ~~**fault capability**~~ **surface rupture**, liquefaction, subsidence or collapse due to subsurface cavities),...	Fault capability, mentioned in brackets, is a general term. Here we are describing concretely the impact of earthquakes, so surface rupture is the right term instead of fault capability.	X	'fault' is added in 'surface rupture'.		
7.	5.2	[…], which are physic**s**-based scaling to interpolate a smaller range of data. […]	TYPO. physic**S**-based	X			
8.	5.9.b	5.9 The selection of candidate GMPEs to be used in the seismic hazard assessment should be based on the following general criteria: (b) They should **have been** ~~be~~ determined by appropriate regression analysis to avoid that an error on a subjectively fixed coefficient will propagate to the other coefficients.	TYPO.	X			
9.	5.15	When available, macro seismic intensity data **may** ~~should~~ also be used to assign weights to GMPEs or calibrate the selected GMPEs in those regions where instruments for recording strong motion have not been in operation for a long enough period to provide sufficient amounts of instrumental data. These data may be used at least in a qualitative	Considering weak correlation between macro seismic intensity and ground motions, such approach should not be promoted.	X			

		manner to verify that the *GMPEs* used to calculate the seismic hazard are representative of the regional ground motion characteristics. However, care should be exercised when performing these comparisons as the uncertainty in translating macro-intensity data from to the desired ground motion intensity metric can be significant.					
10.	5.20	Alternative ground motion simulation methods utilize a more direct physical representation of the seismic source and wave propagation. These ‘physics-based’ methods use fault rupture modelling and path-specific wave propagation to estimate ground motions. These procedures may be especially effective in cases where nearby faults contribute significantly to the vibratory ground motion hazard at the site and/or where the existing empirical data is limited (on the hanging wall of a nearby fault for example). The physics-based methods **for fault rupture description** fall into two general categories, kinematic and dynamic. The kinematic simulation method should specify the following parameters:	This part makes a confusion between kinematic and dynamic rupture. Only the last one is a real "physics-based" description of the fault rupture. Kinematics rely on a more or less complex description of the dislocation spatio-temporal evolution which is not granted to be physics-consistent. However, let's keep the generic "physics-based" term at the beginning since the wave propagation in these methods can also be based on physics of wave propagation. The proposed modification clarifies the fact that kinematics and dynamics are related to the fault rupture	X			

11.	5.20	The ~~**kinematic**~~ simulation method should specify the following parameters: (a) [...] (b) Macro-parameters **for kinematics** (hypocenter, seismic moment) **or macro-parameters for dynamics (rupture initiation area)** (c) Micro-parameters **for kinematics** (**rupture time**, rise time, **local** dislocation **or local** stress drop) **or micro-parameters for dynamics (local** state of stress, **local friction law properties**)	5.20 addresses both kinematics and dynamics, while the list of parameters is given only for kinematic sources. The dynamic source parameters are later listed in 5.22. (a) and (d) items are common parameters to physics-based methods. (c) item lists the stress parameters for finite fault elements, which is not a kinematic parameter. (d) item is related to wave propagation method, independently of source description For the sake of exhaustivity of this paragraph, the (b) and (c) items should also indicate the dynamic macro and micro-parameters, and “kinematic” should be removed.	X	Respecting additional comments from France, paras 5.20 and 21 have been revised accordingly.		
12.	5.20.b	(b) Macro-parameters **for kinematics** (hypocenter, seismic moment, ~~**average dislocation, rupture velocity, average stress drop**~~) **or macro-parameters for dynamics (rupture initiation area)**;	The only true macro-parameters are the seismic moment and hypocenter. The others (dislocation, rupture velocity, stress drop) are actually local micro-parameters that can vary locally on the fault. For the sake of avoiding	X	Respecting additional comments from France, paras 5.20 and 21 have been revised accordingly.		

			misunderstanding, it is probably better to keep them in the 5.20.c, so if they are defined as micro-parameters, the macro average value will be defined as a consequence.				
13.	5.20.c	(c) Micro-parameters **for kinematics** (**rupture time**, rise time, **local** dislocation **or local stress drop**~~, stress parameters for finite fault elements~~) **or micro-parameters for dynamics (local** state of stress, **local friction law properties**);	Rupture time varies locally on the fault, so it should be in this item. Dislocation, stress drop, rupture times (micro parameter related to rupture velocity), rise time are local parameters of the kinematic model, the macro value is an average of the local values. Stress is not a parameter for kinematics	X	Respecting additional comments from France, paras 5.20 and 21 have been revised accordingly.		
14.	5.20.d	**Crustal** ~~subsurface~~ structure parameters **from source to site**, such as shear and compressional (alternatively, Poisson's ratio) wave velocities, density and anelastic attenuation factor (i.e. seismic quality factor Q).	The whole wave propagation medium is needed in any physics-based wave propagation techniques, not only the subsurface.	X	Respecting additional comments from France, paras 5.20 and 21 have been revised accordingly.		
15.	5.22	As with the kinematic simulation approach, these properties are unknown for future earthquakes on a specific fault and should be treated as ~~randomly~~ correlated **random** variables	TYPO.	X			

16.	6.8	Probabilistic approaches consider the rates of recurrence of events along with their estimated ~~maximum~~ size	Maximum size is not appropriate here. Each event has one size.	X	Modified as ‘seismic events along with values of relevant parameters’		
17.	6.9.1	The evaluation of the vibratory ground motion seismic hazard by probabilistic methods should include the following steps: 1) ~~**Select the level of effort, resources and details to be applied in the seismic hazard assessment project considering the safety significance of the nuclear installation, the technical complexity and the uncertainties in the hazard inputs, regulatory requirements and oversight, the amount of contention within the related scientific community, the degree of public concern and the availability of project resources**~~	This first part of 6.9 does not provide effective guidelines. It does not seem necessary. In addition, it would be difficult to select the level of effort using information on "technical complexities and the uncertainties in hazard inputs" which may not be known before perform the evaluation.			X	Selection of the level of PSHA is the first step of the process. This is necessary and considered good practice by most MSs.
18.	6.146.1	~~**1) Select the level of effort, resources and details to be applied in the seismic hazard evaluation project considering the safety significance of the nuclear installation, the technical complexity and the uncertainties in the hazard inputs, regulatory requirements and oversight, the amount of contention within the related scientific community, the degree of public concern and the availability of project resources**~~	Same as for 6.9.1. This first part of 6.14 does not provide effective guidelines			X	Selection of the level of DSHA is the first step of the process. This is necessary.
19.	6.16.4	4) Evaluate the maximum potential magnitude for each identified seismic source included in the seismic source model(s), t~~o be~~	Maximum magnitude distribution is not defined before in the guide. This	X	Changed to ‘uncertainty in maximum magnitude values’ instead ‘distribution’.		

		~~**determined considering the maximum magnitude distribution**~~	concept should be deleted if not clarified.				
20.	6.16.6.ii	(ii) For zones of diffuse seismicity **that do not include the site**, the associated maximum potential magnitude should be assumed to occur at the point of the region boundary closest to the site.	Unclear until the iii is read.	X			
21.	7.3	7.3 Fault displacement is the relative movement of the two sides of a fault at or near the surface, measured in any chosen direction, in relation to an earthquake ~~**(either directly or indirectly)**~~.	In the classical terminology (ESI scale for instance), fault displacement is a direct effect of earthquake, including on principal/primary or distributed/triggered ruptures. Indirect effect are landslides, liquefaction of soils etc.	X			
22.	7.14	7.14 If there is a potentially capable fault, ~~**either primary or secondary,**~~ within the site vicinity and site areas, it should first be determined whether the fault could potentially approach and subsequently cause surface displacement that affects items important to safety of the nuclear installation. This evaluation should be based on the characteristics of the fault, such as its sense of slip, geometry (length and width including strike dip and rake angles) ~~**and**~~**, for structurally related faults, their relationship with the causative fault,** ~~**and, for secondary faults, its structural relationship with the causative fault,**~~ and should use validated	Same as for 7.11, primary and secondary fault concept needs not to be confused with primary and secondary ruptures. Proposed text avoids using this concept.	X	The proposed texts were slightly modified to reflect the French second comments sheet. But substantial contents of the original text were preserved.		

		models (including dynamic rupture models) in a conservative way including due consideration of related uncertainties, both epistemic and aleatory.					
23.	8.13	8.13 The duration of an earthquake ground motion is determined by many factors, including the size of fault rupture (generally characterized by magnitude), crustal parameters along the propagation path (generally characterized by distance), and conditions beneath the site such as the presence of a significant sedimentary **basin** ~~**column.**~~	The term "sedimentary basin" used in the previous version of SSG9 is more appropriate than "sedimentary column".	X			
24.	5.20	5.20 Alternative ground motion simulation methods utilize a more direct physical representation of the seismic source and wave propagation. These 'physics-based' methods use fault rupture modelling and path-specific wave propagation to estimate ground motions. These procedures may be especially effective in cases where nearby faults contribute significantly to the vibratory ground motion hazard at the site and/or where the existing empirical data is limited (on the hanging wall of a nearby fault for example). The physics-based methods **for fault rupture description** fall into two general categories, kinematic and dynamic. **Some details on fault rupture modeling and example of methods are provided in IAEA Safety Reports Series No. 85, Ground Motion Simulation Based on Fault Rupture Modelling for Seismic Hazard Assessment in Site Evaluation for Nuclear Installations [*please add the reference to the reference list*].** ~~The~~	The list of parameters is only for kinematics, and too detailed, bringing some confusion to 5.20. The suppression of the list makes the 5.20 more general and less confusing The reader is advised to refer to SR-85 for technical information on fault rupture modelling.	X			

		~~kinematic simulation method should specify the following parameters:~~ ~~(a) Fault geometry parameters (location, length, width, depth, dip, strike);~~ ~~(b) Macro-parameters (hypocenter, seismic moment, average dislocation, rupture velocity, average stress drop);~~ ~~(c) Micro-parameters (rise time, dislocation, stress parameters for finite fault elements);~~ ~~(d)~~ **Crustal** ~~Subsurface structure parameters~~ **from source to site**~~, such as shear and compressional (alternatively, Poisson's ratio) wave velocities, density and anelastic attenuation factor (i.e. seismic quality factor Q).~~					
25.	5.21	5.21 **In the kinematic simulation approach**, **the slip velocity function and rupture time distribution on the finite fault should be defined**. ~~Most of the~~ **The model** parameters ~~mentioned above~~ cannot be known in advance for future ruptures on a specific fault. Hence the simulations should represent these parameters values ~~properties~~ as random variables with appropriate correlation **among them** ~~amongst some of the variables~~. The specific characteristics of the seismotectonic setting where the site is located should also be given due consideration. A sufficient number of simulations should be conducted to provide a stable estimate of the median ground motions at the site of interest as well as the variability about that median. Kinematic models typically utilize a	Proposed modification to be consistent with new proposed 5.20 and keep a similar description in 5.21 and 5.22	X	Modified accordingly, but the macro and micro parameters were carried over and preserved form SSG-9: In the kinematic simulation approach, the macro parameters (e.g. rupture area, seismic moment average stress drop, and inhomogeneity of the finite fault) should be identified, as well as, the micro parameters (e.g. **the slip velocity function and rise time distribution) on the finite fault should be defined.**		

		stochastic approach to model the high frequency portion of the spectrum.					
26.	7.16	In the probabilistic fault displacement hazard analysis, the following two types of possible displacements should be considered with careful and appropriate treatment of the involved uncertainties (both epistemic and aleatory): (a) ~~Primary displacement, typically in the form of direct seismogenic fault rupture;~~ **Principal displacement or faulting which occurs along a main plane (or planes) that is (or are) the locus of release of seismic energy.** (b) ~~Secondary displacement (also called indirect or subsidiary displacement), typically associated with induced movement along pre-existing slip planes (e.g. a triggered slip on an existing fault or a bedding fault plane from an earthquake that occurred on another fault).~~ **Secondary or distributed displacement or faulting which occurs in the vicinity of the principal faulting, possibly on splays of the main fault or antithetic faults. In some cases, triggered slip has been considered to be a form of secondary or distributed faulting (a triggered slip is a remote triggering of slip along a fault from a distant earthquake).** The fault displacement is generally characterized as a three-dimensional displacement vector that should be resolved into components of slip along the fault trace and along the fault dip, with the resulting amplitude equal to the total evaluated slip (for a given annual	Proposed modification of terminology to reflect the definitions adopted in the PFDHA TecDoc, currently at its final revision stage.	X			

		frequency of exceedance and for a given fractile of hazard).					

6. Germany

COMMENTS BY REVIEWER Reviewer: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) (with comments of Framatome GmbH, TUEV NORD EnSys, GRS, Öko-Institut and Physikerbüro) Country/Organization: Germany Date: 18.04.2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	3.15 Line 6	[...] the extent of this region is typically a few hundred kilometres in radius (generally 300 km), or in keeping with national requirements of Member States.	SSG-9 specifies 300 km (see para.3.7). From our point of view, a numerical guidance concerning the size of the radius is helpful. Few words about national requirements is Germany: KTA 2201.1 specifies 200 km. Furthermore, KTA 2201.1 also recommends to shift the epicentre of a decisive earthquake occurred in another seismotectonic region to a point on the borderline closest to the site investigated. Hence, distances larger than 200 km are considered as well.			X	After the Fukushima Daiichi accident, the radius needing to be investigated should be extended to more than 300km, hence a specific value has been eliminated. And it is for analysts to select an appropriate investigation area.
2.	3.17 Line 8	"…(i.e. palaeoseismology, see para 3.1~~0~~1)…"	Mistake in cross reference, para 3.11 deals with palaeoseismology.	X			

3.	3.21 Line 5	… For example, for studies to assess fault capability, the tectonic information through the Upper Pleistocene to Holocene may be adequate for high seismic regions, while for ~~low seismic~~ regions <u>of low seismicity</u> information through the Pliocene–Quaternary may be necessary.	Clarification			X	Quite similar meaning
4.	3.35 Line 4	"…defined in para 3.3~~5~~<u>4</u>."	Mistake in cross reference, temporal scales are handled in para 3.34.	X			
5.	3.46	As a summary, prior to the use of the Project Earthquake Catalogue to either estimate the magnitude–frequency relationship for a seismic source, or to estimate the ~~potential~~ maximum <u>potential</u> magnitude value for each seismic source, a thorough evaluation and data processing of the catalogue should be performed. …	Clarification			X	Whilst the revised text reads better, the word "potential" is a modifier on "maximum magnitude", not on "magnitude" alone.
6.	3.46 (f) Line 12	[...] All aspects of the development of the earthquake catalogue should be reported to justify the judgments that have been made in compiling it. Specific attention should be paid to the selection of empirical magnitude conversion relations~~,~~ <u>and</u> the selection of the magnitude scale for all catalogue entries~~,~~<u>.</u> ~~and~~ <u>A</u> comparison of the project catalogue with other similar catalogues relevant to the region <u>should be performed</u>.	Contrary to the "selection of empirical magnitude conversion relations" and the "selection of the magnitude scale for all catalogue entries" which have already been mentioned in previous paragraphs, the comparison with other catalogues is a new recommendation	X			

			and should therefore be mentioned separately.				
7.	4.21 Line 7	[...] For ‘a’ values, an approach based on strain rates can be used if such data is reliably available from geophysical investigation. ~~However, for many low seismicity areas, ‘a’ values are derived from the regional historical earthquake catalogue, since often this is the most reliable indicator of regional seismicity.~~ [...]	To determine ‘a’ and ‘b’ values from the seismicity is the usual approach. But this paragraph is about “different” approaches for regions with few registered earthquakes. In these regions determining ‘a’ values based on the earthquake catalogue might involve large uncertainties. Our suggestion is to delete this sentence	X	Not only this sentence but also the previous sentence moved to 4.31.		
8.	5.3	Individual models for the prediction of vibratory ground motions should include both an estimate of the median ground motion amplitude which - <u>in case of the commonly adopted log-normal model</u> - is the mean of logarithmic normal distribution, as well as a measure of the aleatory variability about the mean.	Clarification	X			
9.	6.2 Line 1	The approach to be used for assessing the vibratory ground motion hazard at the nuclear installation site should be defined at the beginning of the seismic hazard evaluation project. The vibratory ground motion hazard ~~may~~ <u>should</u> be evaluated by using probabilistic and~~/or~~ deterministic	It is state of the art to use both methods and not only rely on one of both, compare i.e. WENRA RL T3.2.			X	Better to do both, but not always by every Member States.

		methods of seismic hazard analysis. ~~The choice of the approach depends on the national regulatory requirements and the end user specifications, which should be documented in the project quality plan (see Section 10).~~					
10.	6.8 Line 8	"…the nature of cliff edge effects[4] and to ensure…"	First appearance of the term "cliff edge effect(s)". Footnote no. 4 should be put here, instead of referring "cliff edge effect" in para. 9.5 (i)/page 54.	X	Foot note is deleted since it is explained in the IAEA Safety Glossary.		
11.	6.9 Line 1	The evaluation of the vibratory ground motion seismic hazard by probabilistic methods should include the following steps: 1) Select the level of effort, resources and details to be applied in the seismic hazard assessment project considering the safety significance of the nuclear installation, the technical complexity and the uncertainties in the hazard inputs, regulatory requirements and oversight, the amount of contention within the related scientific community~~,~~ and the degree of public concern ~~and the availability of project resources~~. [...]	The availability of project resources shall not limit the effort required depending on the other listed criteria. Same for 6.16 1)	X	With a footnote		

12.	6.16 1) Line 8	[...] the degree of public concern– ~~and the availability of project resources~~. [...]	The availability of project resources shall not limit the effort required depending on the other listed criteria. /The same as for 6.9 1) /	X	With a footnote		
13.	6.23 (3) Line 14	[...] (3) Determine whether 1D equivalent linear analyses should be performed ~~for non-linearity~~, or more complex approaches are needed to account for non-linearity.	The sentence seems a little bit twisted as linear analysis is not well suited to account for non-linearity.	X			
14.	7.5 a), Line 9	[...] In less active areas, it is likely that much longer periods (e.g. including also the Pliocene ~~to Quaternary, i.e. the present~~) are appropriate. [...]	The Pliocene is a geological epoch (series) whereas the Quaternary is a geological period (system). To avoid the mixing of different geological timescales, it is recommended to reformulate the text in brackets.	X	Revised from 'Quaternary' to 'Holocene'		
15.	7.5 a), Line 10	[...] In areas where the observed activity is between these two rates (i.e. not as highly active as plate boundaries and not as stable as cratonic zones), the length of the period to be considered should be chosen on a conservative basis (i.e. tending to longer timescales including the Pliocene) ~~one way to calibrate the time frame for fault capability may be to check if the site is in the deformed area of~~	If the criterion for the selection of the timescale is too sophisticated, there is a significant risk to miss relevant seismic sources. Therefore, a conservative approach is to be preferred.	X	The sentence that it is proposed to delete is another legitimate approach to evaluating activity, hence it is preserved.		

		~~major regional faults. Longer time frames should be used when the site is far away from the potentially deformed areas of these regional structures~~.					
16.	7.17 Line 1	The annual frequency of exceedance corresponding to various amounts of displacement at or near the surface should be determined at the foundation points defined by the specific layout of foundations of structures, systems and components important to safety of the nuclear installation. The most up to date and reliable methods of probabilistic assessment, equivalent to a SSHAC Level 4 study, should be applied. These include empirical relationships, and/or engineering models (such as finite element analysis or Coulomb static stress transfer models) that are compatible with the faulting type and site area specific geologic setting and using all available data.	Surface displacement beneath a plant can lead to large and/or early releases (e.g. failure of containment and primary circuit). For this reason, it is considered an exclusionary criterion for new plants. Consequently, for existing plants it has to be shown with a high level of confidence that such event sequences are extremely unlikely to arise (cf. SSR-2/1 Para. 2.11).			X	The level of effort that needs to be devoted to a seismic hazard analysis depends on the competence of the analyst and the regulatory approach of the Member States.
17.	7.18 Line 1	The range of annual frequencies of exceedance, for which the amount of displacements is to be calculated, should be compatible with the safety principles of the nuclear installation. ~~From the hazard curve thus obtained, the annual frequency of exceedance corresponding to the level required for safety evaluation~~	Surface displacement beneath a plant can lead to large and/or early releases (e.g. failure of containment and primary circuit). For this reason, it is considered an exclusionary criterion for new plants.	X	The sentence that it is proposed to delete, is preserved since the hazard assessment is necessary for the safety evaluation. The additional sentence is supported.		

		~~purposes should be adopted to establish the corresponding surface rupture evaluation basis to conduct the safety evaluation of the installation.~~ Plant event sequences that could result in high radiation doses or in a large radioactive release have to be practically eliminated (cf. Ref. [7], Para. 2.11]).	Consequently, for existing plants it has to be shown with a high level of confidence that such event sequences are extremely unlikely to arise (cf. SSR-2/1 Para. 2.11).				
18.	8.4 Line 1	"…recommended in paras 6.~~16~~18-6.~~21~~23 provides…""	Mistake in cross reference, site response analysis is examined in paras 6.18 to 6.23.	X	Renumbered as 6.20-6.25		
19.	8.26 Line 1	The stability of natural and human-built slopes located in the site area and in the near vicinity of the site that can be affected by the vibratory ground motions should be investigated since landslides could seriously affect structures, systems and components important to safety. [...]	Depending on the topography also landslides from slopes outside the site area might reach the site and safety related SSCs.	X	Modified with 'and site vicinity'		
20.	9.1 Line 1	In consideration of the use of the graded approach described in para. 1.8, this section provides guidance on seismic hazard evaluation for a broad range of nuclear installations ~~(see para. 1.8)~~ other than nuclear power plants.	Since it is already referenced to para 1.8, this cross reference is obsolete.	X			
21.	9.9 Line 1	If the conservative screening process ~~(see para. 9.7),~~ indicates that a seismic hazard evaluation of the installation is to be carried out (see para. 9.7), a process [...]	Para 9.7 deals with the criteria of necessity of a seismic hazard evaluation. It doesn't deal with the	X			

			conservative screening process.				
22.	9.13 Line 1	The recommendations relating to seismic instrumentation installed on the site (see paras 3.5~~1~~0–3.5~~6~~5) should be applied in a manner that is commensurate with the category of the installation as defined in para. 9.10.	Mistake in cross reference, section 'site specific instrumental data' envelopes paras 3.50 to 3.55.	X	Renumbered as 3.51-3.56		
23.	10.16 Line 18	The reference subsurface rock site condition. For studies where site response analysis is performed, the output specification should include a definition of the rock conditions on the site (usually to ~~for~~ a depth significantly greater than 30 metres, corresponding to a specified value of the shear wave velocity consistent with firm rock). The analysis results prior to site response analysis should correspond to this reference condition.	Clarification	X			
24. 7	10.19 Line 4	[...] Participatory peer review will decrease the likelihood of the study being rejected at a late stage and should be the preferred peer review method.	In 6.9 2) and 6.16 2), preference for a participatory peer review is expressed. For consistency, this preference should also be stated in this paragraph which is explicitly dealing with peer review methods. This holds in particular as in the following paragraph a			X	This is already explained in the section 6.

			participatory review is implicitly presumed.					

7. Iran

COMMENTS BY REVIEWER Reviewer: Reza Saberi Country/Organization: IRAN/NNSD Date: 24 Apr. 19				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1	Geological, Geophysical and Geotechnical database	In this section, pages 12 to 15, it's better to mention the exact radius value of regional, near regional, site vicinity and site area investigations.	Based on RG-1.208, Appendix C			X	Considered to be too prescriptive, and reference to another MSs guidance, unless this is generally accepted good practise, is not appropriate as the sole reason for modifying the text.
2	Geological, Geophysical and Geotechnical database	In this section, information related to lithology of the regions should be presented. (there is no information about lithology of the regions)	Based on NUREG-0800, Section 2.5.1	X	Added "…of the lithology, geomorphology, stratigraphy, faulting etc., that might influence or relate to the seismic hazard at the site." At the end of Para 3.14		
3	Geological, Geophysical and Geotechnical database	In this section, information related to folding characteristics of the regions should be presented. (there is no information about folding characteristics of the regions)	Based on NUREG-0800, Section 2.5.1			X	It is not appropriate to literally encompass all aspects of NUREG-0800 for same reason as those made in response to comment 1.
4	Regional investigations	The data which contain a resolution consistent with a map developed	Based on RG1.208, Appendix C	X	Para. 3.24 identifies a suggested map scale for the near regional investigations, so it would be consistent to recommend a map		

	3.18	at a scale of 1:500,000 should be presented, in similar way with the other regions. "The data collected and the results obtained from the investigations performed at regional scale should have a resolution consistent with maps to be developed at a scale of 1:500,000 or larger" is proposed.			scale at this point for the Regional invitations. Suggested sentence is added to para. 3.18 with small amendment. But recently the regional scale is extended after the Fukushima Daiichi accident more than 300km. Therefore, the specific scale is not identified.		
5	Instrumental historical earthquake data, 3.39 (d)	"(d) All magnitude designations such as mb, ML, MS, MW" is proposed.	Based on NUREG-0800, Section 2.5.2			X	Already introduced in Para 3.37 (d) and Definitions.

8. Italy

COMMENTS BY REVIEWER Country/Organization: Italy Date: April 29, 2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
01	Parag. 1.10 line 5- 6- 7	(c) at temporary or permanent shutdown stage while radioactive material is still within the facility (in the core or the pool) or in the decommissioning stage.	The seismic hazards in site evaluation is an important issue to be evaluated also in the decommissioning phase of a nuclear installation for the design of new facilities (e.g. temporary interim storage facilities, waste management facilities,…).	X	Changed to "(c) at temporary shutdown, permanent shutdown, and decommissioning stages while … "		

9. Japan

COMMENTS BY REVIEWER Reviewer: Japan NUSSC member Country/Organization: Japan / NRA Date: 16 April. 2019				RESOLUTION			
Comment No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection
1.	Section 7	**In Section 7 of DS507, distinction between primary and secondary faults is an important element. However, there are scientifically different views on this distinction. Therefore, some of the recommended measures in DS507 are scientifically inaccurate and operationally impractical in actual evaluation of capable faults and site selection.** **This means that DS507 does not follow the principle "The IAEA Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures)". DS507 does not provide examples of internationally recognized good practices.** **Japan's NRA requests major redrafting of Chapter 7 of DS507.** **Detailed reasons for the above comment are described as follows.** 1. Scientific understandings on primary/secondary faults Section 7 of DS507 recommends evaluation of fault displacement on the basis that a secondary fault can be readily distinguished from a primary fault. However, there is no common understandings on the distinction between the primary and secondary faults in the field of structural geology and tectonic geomorphology for the purpose of evaluation of capable faults (Yeats et al., 1997 [1]; Scholz, 2019 [2]; Scholz et al., 2010 [3]; Mccalpin and Nelson, 2009 [4]; Serva et al.,2002 [5]). In addition, distinction between primary and secondary faults is applied in the fault displacement hazard				X	1) The Note Verbale requests comments with '**proposed new text**' on a paragraph by paragraph basis. The comments you provided are not in line with the agreed protocol for providing Step-8 comments that was approved by the NUSSC46 (Nov. 2018), in which the NRA participated. Ignoring the IAEA rules for Step-8 is not acceptable. 2) Since the inception of the IAEA Safety Standards, the requirements and guidance for selecting and evaluating the site for a nuclear installation have differentiated external hazards in two sets: (i) those external hazards against which design and operation measures can be undertaken to ensure safety (e.g., earthquake vibratory ground motion, flooding water levels, wind speed), and (ii), those external hazards for which no engineering solutions are available to assure safety (e.g., large surface faulting phenomena caused by capable faults at the site vicinity and site areas, lava flows, pyroclastic flows, etc.).

		evaluation researches conducted by Youngs et al. (2003) [6] and Petersen et al. (2011) [7]. In these two research papers, there are different views on which fault should be regarded as secondary fault that occurred in association with the movement of primary fault (e.g. triggered fault displacement is included in secondary fault or not.). Furthermore, the following difficulties exist when site investigation and evaluation should be implemented on the premise that a primary/secondary fault can readily be distinguished. **(1) Practically indistinguishable** In practice, it is sometimes not possible to identify explicitly whether a fault is primary or secondary, according to the developing processes of faults described in the research papers based on the field survey (Kolyukhin and Torabi (2012) [8]; Cowie et al. (2005) [9]; Einarsson and Eiriksson (1982) [10]). These are cases where faults can only be identified as a fault zone at best in spite of detailed geological mapping, observations and analyses. In addition, the findings from the rock fracture experiment (Tchalenko (1970) [11]) show that it is difficult to identify whether small cracks that appear in the beginning phase of the fault development process are primary or secondary. Distinction is also difficult even in fault investigation just after earthquakes (Meigs et al. (2006) [12]). It is, therefore, extremely difficult to judge whether a surface (or excavated) fault is primary or secondary before an earthquake occurs. These researches show that the approach recommended in DS507 is practically not applicable in safety evaluation of nuclear sites. **(2) Difficulties in applying the criteria** Paragraphs 7.10 and 7.11 of DS507 states that the “existence of a capable fault with potential for seismogenic (i.e. *primary*) fault displacement within the site vicinity, or within the site area, this issue should be treated as an exclusionary attribute (and				The existence of large uncertainties in the assessment of both types of external hazards were duly considered and, for the latter, minimum conservative screening distance values have been recommended. As an example, for surface faulting phenomena caused by earthquakes, this guide recommends a minimum screening distance of 5 km (This value almost certainly should be increased significantly for sites in Japan according to size of seismic sources.). Within this distance, the existence of a potentially capable fault is considered an exclusionary criterion. In this way, the selection of a suitable site will comply with the Principle 8 (principle of defense in depth) of the IAEA Safety Fundamentals. 3) The above mentioned general criterion was, and is, furtherly developed in corresponding safety requirements and safety guides in relation to the existence of potential capable faults close to a site that may generate large fault displacements below the foundation of installations important to safety, **and for which no proven engineering solutions are available in current nuclear installation designs**. This is considered at all stages of the siting and site evaluation process, as follows: • Regarding the site survey and selection stage, the SSG-35

		an alternative site should be considered) ", and "the existence within the site vicinity area of a *secondary* fault belonging to a seismogenic capable fault located outside the site vicinity, this issue may be treated as a discretionary attribute." However, because the distinction between primary fault and secondary fault is very difficult or practically not possible as noted above, this criteria of site selection becomes meaningless and cause confusion. These descriptions are not suitable for this Safety Guide. **2. Site vicinity always 5 km?** Paragraph 3.26 of DS507 defines the "site vicinity" as "typically not less than 5 km in radius from the border of the nuclear installation site area", but no evidence is shown for appropriateness of the 5 km distance to be used for capable (primary/secondary) fault evaluation for all nuclear sites over the world with extremely diverse geological and seismotectonic features. An appropriate distance of the "site vicinity" should be determined for each candidate site with sufficient geological and seismological evidence derived from historical and pre-historical earthquakes. DS507 should show scientific reasoning why the investigation area of capable faults is uniquely defined as "typically not less than 5 km" and, if not, should describe clearly that the distance should be determined in consideration of geological environment and seismotectonic setting for each site. **3. Folds and faults** Paragraph 7.3 of DS507 states that "tectonic relative displacements associated with folds (synclines and anticlines) are also included in term 'fault displacement". This statement is scientifically not clear, and requires further explanation. It is known that an active fault is frequently associated with a flexure of covering strata, but synclines and anticlines (especially of older strata) are not necessarily related to any active fault, and are not appropriate to be "included in term 'fault displacement". This paragraph should be totally revised with an additional, scientifically rational explanation, or				recommends that the existence of capable faults in the site area and site vicinity should be considered as an exclusionary criterion in the screening process for assessing site suitability, and gives 5 km as the recommended screening distance value. • At the site evaluation stage, the recently published SSR-1, approved by all MSs, prescribed that the suitability criteria for a site shall be as follows: Para 4.7 *The site shall be deemed unsuitable for a nuclear installation if one or more of the three aspects listed in para. 4.6 indicates that the site is unacceptable, and the deficiencies cannot be compensated for by means of a combination of measures for site protection, design features of the nuclear installation and administrative procedures.* Para 4.8 *Site suitability shall be assessed on the basis of relevant current data and methodologies. If relevant, conservative criteria shall be developed in relation to site specific accident scenarios, and the consistency of such criteria within the overall site suitability shall be demonstrated.* Para 4.9 *A decision regarding the suitability of the site shall be based on the characteristics of the nuclear installation, including planned operations at the site, the amount and nature*

		completely deleted. **4. Deterministic and Probabilistic methods** Paragraph 7.14 of DS507 recommends that it should first be evaluated deterministically whether the fault could potentially approach and subsequently cause surface displacement that affects items important to safety of the nuclear installation for sites with existing nuclear installations, and that this evaluation should use validated models (including dynamic rupture models). Subsequent paragraph 7.15 recommends application of probabilistic methods, if no sufficient basis is provided to decide conclusively that the fault is not capable. At present, however, the deterministic (numerical) and probabilistic methods described in DS507 do not have enough maturity and reliability to be applicable to nuclear safety evaluation. There are other applicable deterministic methods that do not depend on a certain model, and those models should also be described. **5. Regulation in Japan** The Japanese Islands are strongly influenced by tectonic plate movement, which is characterized by the continuous subduction of oceanic plates at an annual rate of up to 10 centimeters beneath the continental plate. As deformation accumulated in bedrock at the plate boundaries for a long period of time, sudden fault movement occurs with an earthquake. It is, therefore, expected that faults that have been active in the recent geological period is capable of moving in the near future. The present Japanese nuclear regulations require absence of any capable fault (see below for definition) directly beneath the structures, systems and components important to safety of nuclear installations. The term "capable fault" (that may potentially be activated in future) for the purpose of nuclear regulation is deterministically defined as a fault (including faults that induced permanent displacement in earthquake activities, and landslide slip surfaces with potential to cause displacement and				*of potential radioactive releases and their impact on people and the environment.* Specifically, for the case of surface faulting phenomena, the SSR-1 requires for a new installation: Para. 5.4 of Requirement 16: *A proposed new site shall be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear installation. If a capable fault is identified in the site vicinity of an existing nuclear installation, the site shall be deemed unsuitable if the safety of the nuclear installation cannot be demonstrated.* 4) In line with all IAEA safety standards indicated above, the current SSG-9 introduced the distinction between **new** and **existing** nuclear installations. a. For the site of a new installation, the existence of capable faults in the site vicinity is considered as an exclusionary criterion. b. For the site of an existing installation, located at or close to a capable fault, the safety of the installation should be

		deformation extending to the supporting basement) that has been activated one time or more within the recent 120-130 thousand years (Late Pleistocene and Holocene periods). The global climate was generally warm in the period of 120-130 thousand years ago, and the sea level remained higher than (or approximately the same as) that of the present time. As a result, a flat terrace and terrace deposits have been widely formed and are still preserved along the sea coast and along the river to the present time. The capability of a certain fault can be determined by the presence of displacement or deformation in these terraces, and stratigraphy of volcanic tephra in terrace deposits is useful in identifying age of the fault movement. In case that these terrace deposits cannot be used for estimation of fault activity due to erosion or other reasons, the geological relationship between the fault and the mineral vein (or igneous dike etc.) is considered. Information from geological relationships between the fault and terrace deposits, or the fault and mineral veins or dikes, has been used for evaluation of the capable faults suspected to be running beneath facilities important to safety. Other capable faults in the site or its vicinity (as well as those within 30 - 100 km distance) are also required to be included in the evaluation and the influence of the seismic ground motions and associated tsunamis to facilities important to safety should be evaluated. We believe these Japanese regulatory standards and practices could be useful for other member states. Please refer to Appendix A describing Japanese practices in detail and this appendix should be added to DS507 as an annex. References [1] Yeats, R.S., Sieh, K. and Allen, C.R., 1997, *The Geology of Earthquakes*. Oxford University Press, 576p. [2] Scholz, C.H., 2019, *The Mechanics of Earthquakes and Faulting (3rd ed.)*. Cambridge University Press, 491p. [3] Scholz, C.H., Ando, R. and Shaw, B.E., 2010, The				assessed based on a probabilistic evaluation of its consequences of failure. 5) The rationale described above implies that if a proven engineering solution can be developed that allows the installation to safely cope with capable faulting phenomena through all lifecycle stages, the issue can be considered resolved and the existence of a capable fault at, or close to, the site need not be an exclusionary criterion in the screening process. In this case, the onus is on the operator/designer to demonstrate that nuclear safety can be assured in line with IAEA principles generally. 6) In conclusion, IAEA safety requirements and guidance in relation to the definition of exclusionary criteria and the consideration of surface faulting phenomena caused by capable faults located in the site vicinity and site area being one of those exclusionary criteria, is clearly and consistently stated. And this has been the case since the capable faulting issue was first covered in IAEA guidance in 1979 (IAEA Safety Guides 50-SG-S1). It is for each MS to decide how to regulate the safety of its nuclear installations for these cases, and different criteria can be established in accordance with the specific conditions in each country and with regard to the design

		mechanics of first order splay faulting: The strike-slip case. *Jounal of Structural Geology*, Vol. 32, pp. 118-126. [4] McCalpin, J.P. and Nelson, A.R., 2009, *Chapter 1 Introduction to Paleoseismology*. In Dmowska, R., Hartmann, D. and Rossby, H.T. (ed.), *Paleoseismology*, International Geophysics Series Vol. 95. [5] Serva, L., Blumetti, A.M., Guerrieri, L. and Michetti, A.M., 2002, The Apennine intermountain basins: the result of repeated strong earthquakes over a geological time interval. *Bollettino della Società geologica italiana*, Volume speciale n. 1, pp. 939-946. [6] Youngs, R.R., Arabasz, W.J., Anderson,R.E., Ramelli, A.R., Ake, J.P., Slemmons, D.B., McCalpin, J.P., Doser, D.I., Fridrich, C.J., Swan, F.H., Rogers, A.M., Yount, J.C., Anderson, L.W., Smith, K.D., Bruhn, R.L., Knuepfer, P.L.K., Smith, R.B., dePolo,C.N., O'Leary, D.E., Coppersmith, K.J. Pezzopane, S.K., Schwartz, D.P., Whitney, J.W., Olig, S.S. and Toro, G.R., 2003, A methodology for probabilistic fault displacement hazard analysis (PFDHA), *Earthquake Spectra*, Vol. 9, no. l, 2003, pp. 191-219. [7] Petersen, M.D., Dawson, T.E., Chen, R., Cao, T., Wills, C.J., Scholz, C.H., and Frankel, A.D., 2011, Fault displacement hazard for strike-slip faults. Bulletin of the Seismological Society of America, Vol. 101, no. 2, pp. 805–825. [8] Kolyukhin, D. and Torabi, A., 2012, Statistical analysis of the relationships between faults attributes. *Journal of Geophysical Research*, Vol. 117, no. B05406, 14p. [9] Cowie, P.A., Underhill, J.R., Behn, M.D., Lin, J. and Gill, C.E., 2005, Spatio-temporal evolution of strain accumulation derived from multi-scale observations of Late Jurassic rifting in the northern North Sea: a critical test of models for lithospheric extension. *Earth and Planetary Science Letters*, Vol. 234, pp. 401-419. [10] Einarsson, P. and Eiriksson, L., 1982, Earthquake fractures in the districts Land and Rangarvellin in the South Iceland seismic zone. *Jokull*, Vol. 32, pp. 113-120. [11] Tchalenko, L.S., 1970, Similarities between shear zones of different magnitudes. *Geological Society of America Bulletin*, Vol. 81, no. 6, pp. 1625-1640.				characteristics of its nuclear installations. The proposal from Japan NRA to modify the above-mentioned safety criteria, requirements and guidance is thus rejected. Regarding the specific technical and scientific comments provided in the Note Verbale, they are not addressed in this resolution, because IAEA publications and safety review mission reports dealt with these topics extensively; it is not worthwhile repeating this here. The reader is referred to these resources for further information.

		[12] Meigs A., Krugh, W.C., Schiffman, C., Verges, J. and Ramos, V.A., 2006, Refolding of thin-skinned thrust sheets by active basement-involved thrust faults in the Eastern Precordillera of Western Argentina. *Revista de la Asociación Geológica Argentina*, Vol. 61, no. 4, pp. 589-603. [13] Burbank D.W. and Anderson R.S., 2011, *Tectonic Geomorphology (2nd ed)*. Wiley-Blackwell, 454p.					
2.	3.24	The data collected, and the results obtained from the investigations performed at near regional scale should have a resolution consistent with maps to be developed at a typical scale of 1:50,000~~, or larger,~~ and with appropriate cross-sections. Digital elevation models should also be part of the results obtained from this task. The data should be organized in the project geographical information system within the layer of near region scale information. A summary report should be prepared to describe the studies and investigations performed, the evaluation of information for inclusion in the models, and the results obtained, particularly in relation to the seismogenic structures further identified and characterized during this stage of the studies.	A specific value like 1:50000 is not suitable for an IAEA guide since the appropriate map scale may vary with different situations in member states. We suggest to modify as showed in the proposed new text.	X	Accepted with modifications.		
3.	3.29	The data collected, and the results obtained at site vicinity scale should have a resolution consistent with maps to be developed at a typical scale of 1:5000~~, or larger,~~ and with appropriate cross-sections. Digital elevation models should be also part of the results obtained from this task. The data should be organized in the geographical information system within the layer of site vicinity scale information and a summary report	A specific value like 1:5000 is not suitable for an IAEA guide since the appropriate map scale may vary with different situations in member states. We suggest to modify as showed in the proposed new text.	X	Accepted with modifications.		

		should be prepared to describe the studies and investigations performed, the evaluation of information for inclusion in the models, and the results obtained, particularly in relation to the seismogenic structures further identified and characterized during this stage of the studies.					

10. Netherlands

COMMENTS BY REVIEWER Country/Organization: Netherlands/ANVS Date: 24-04-2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1	2.8/6	*[…] for acquiring new data.* The project team for seismic hazard evaluation should evaluate, without bias, all hypotheses and models supported by the data compiled, and then develop an integrated evaluation that incorporates both knowledge and uncertainties.*[…] 2.9*	Increase clarity: It is important that only the relevant models are used, in order to avoid unnecessary work. The choice should of course be unbiased.	X	Changed to "The project team for the seismic hazard assessment should evaluate, without bias, all hypotheses and models supported by the data compiled, and then develop an integrated model that accounts for both existing knowledge and uncertainties in the data."		
2	3.50/6	*[…] should be installed and operated at the* site area of the nuclear installation and its surroundings, typically in the near-region. The design of the seismic monitoring network should be suitable for the geological setting to assess the seismic hazards at the site. *The data obtained […]*	The spatial extension and design of the seismic monitoring network is site specific and can differ depending on the geological setting in which the site is situated. This might mean that the network is at regional, near-region or site vicinity scale.	X	Changed to "This system should be installed and operated in the near-region around the nuclear installation site and within the site itself."		
3	6.16/ 6 (i)	*For each seismogenic structure, the maximum potential magnitude should be assumed to occur at the point of the seismogenic structure closest to the site area of the nuclear installation, with account taken of the physical dimensions of the seismic source.* When the seismogenic structure is within the site area, or within the site vicinity area and its location and extent cannot be determined with sufficient accuracy, the maximum potential magnitude should be assumed to occur beneath the site.	Avoid extreme conservatism: The maximum potential magnitude should be assumed to occur at the nearest distance to site where it cannot be excluded, given the results of the investigations that were carried out, and taking into account the limitation of resolution at depth.	X	Accepted with minor modifications.		
4	7.10	*During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence*	Consistency with SSR-1: For consistency with para. 5.4 of SSR-1 [1] as cited in	X	Inserted "and its effects cannot be compensated by proven		

		is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e. primary) fault displacement within the site vicinity, or within the site area, and its effects cannot be compensated by design/engineering protective measures, *this issue should be treated as an exclusionary attribute (see para. 3.8 of IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations [9]) and an alternative site should be considered.*	paragraph 7.2., the lines: "*and its effects cannot be compensated by design/engineering protective measures,*" is added. The presence of a capable fault may not pose a threat when the effects are covered by the design basis of the installation and the associated structures.		design/engineering protective measures,"		
5	7.11 / 2	*[…] a discretionary attribute (see para. 3.8 of SSG-35 [9]).* *However, if reliable evidence shows that this secondary fault is traced or extended to the site area,* and the effects of its potential fault displacement cannot be compensated by design/engineering protective measures, *this issue should be treated also as an exclusionary attribute and an alternative site should be considered.*	Consistency with SSR-1: Idem to comment no 4, for consistency with para. 5.4 of SSR-1 [1] as cited in paragraph 7.2., the line: "*and the effects of its potential fault displacement cannot be compensated by design/engineering protective measures,*" is added. The presence of a capable fault may not pose a threat when the effects are covered by the design basis of the installation and the associated structures.	X	Inserted "and its effects cannot be compensated by proven design/engineering protective measures,"		
4+5 alternative	Paragraph following 7.11	During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence is collected demonstrating the existence of a capable fault with potential for fault displacement within the site vicinity, or within the site area, and its effects can be compensated by design/engineering protective measures, this issue should be treated as a discretionary attribute (see para. 3.8 of SSG-35 [9]).	<u>ALTERNATIVE (second choice) to comments 4 and 5</u> As an alternative to the additions as suggested in comment 4 & 5 this paragraph can be added for consistency with para. 5.4 of SSR-1 [1] as cited in paragraph 7.2.			X	Comment 4 and 5 were accepted with slight modification.
7	Table A-1	A magnitude–distance (M–D) deaggregation defines the relative contribution to the total hazard of earthquakes (mean or appropriate	The deaggregation has to be performed for the specified hazard level of interest (mean or other centile)	X	Added "and at a specified frequency of exceedance" after (i.e. bins), but the deaggregation		

		centile) that occur in defined magnitude–distance ranges (i.e. bins).			for other fractiles is still rare for PSHA of the nuclear installations.		

11. Poland

COMMENTS BY REVIEWER Reviewer: Poland Country/Organization: Poland / PGE EJ1				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	2.4/6	It should be carried out by a team of experts, possessing knowledge in a number of disciplines: geology, seismology, geophysics, seismic hazard, engineering and other necessary (e.g. history) in given situation .	It is possible to be an expert in certain related areas of knowledge (an multidisciplinary expert).			√	This change does not add anything substantial to what is already there, and is editorial.
2.	DEFINITIONS	It is proposed to put into "Definitions" chapter e.g. as follows: 1. region 2. near region 3. site vicinity (vicinity of the site?) 4. site area 5. site 6. graded approach 7. border of the prospective selected site area 8. control point	Some are in the main body of the Draft Safety Guide No. 507, however it would be easier understandable (more user friendly) when the definitions are gathered together.	√	"Control Point" is introduced into the definitions table, but other terms are defined in the body text		.
3.	4.2	General question/comment: is it understood that for Seismic Hazard Assessment just one approach (weather it is Probabilistic or Deterministic way) is acceptable?				√	The issue of probabilistic/deterministic analyses is covered and answered elsewhere. Not relevant at this point.
4.		General comment: Would it be possible to put some more information within the guide with regard to the low seismicity area.				√	'low' and 'high' are relative adjective and are the Member State matter.
	FIG 1. – Flow chart for the seismic	It is proposed to define the various geographical areas – with regard to certain analysis	The areas are somehow defined within the main body of the Draft Safety Guide No. 507, however it would be easier understandable (more			√	The various geographical areas are listed in Fig. 1 but are not specific to different analysis types.

	hazard evaluation process for nuclear installations		user friendly) to gather them in FIG 1.				
	3.6/1 and 2	Question: Are the geotechnical analysis to be acquired within the region (e.g 300 km from the site)?				√	No change suggested. Answer to question is YES, but the level of detail is related to distance from the site and relevance to calculating the seismic hazard at the site.
	3.11/b/	**Old sentence:** Improve the completeness of earthquake catalogues for large events, using identification and age dating of fossil earthquakes. **New sentence:** Improve the completeness of earthquake catalogues for large events, using identification and age dating of fossil.	Editorial change	√	The term "fossil earthquake" is unfamiliar. However, fossil evidence is used in paleogeological investigations. Amend point (b) to include: "…age dating of geological markers such as fossils."		
	3.13	It would be worth mentioning how often the periodic safety review or probabilistic seismic hazard analysis for a seismic probabilistic safety evaluation, should be applied. How often the seismic hazard reevaluation process should be introduced?				√	This safety Guide is not the document to discuss the timing of PSRs, but the need to review the seismic hazard in a PSR is important to state in this document, as is done here.
	3.15	It is proposed to give some examples of region size and shape with regard to low and high seismicity areas.				√	Too detailed for a safety guide, more the domain of a TECDOC. Depends on the approach of individual MSs.

	3.20/5	**Old sentence:** the border of the prospective selected site area boundary **New sentence:** the border of the prospective selected site area		√	Agreed but amended further as: "… the boundary of the prospective selected site area."		
	3.21/5-8	**Old sentence**: For example, for studies to assess fault capability, the tectonic information through the Upper Pleistocene to Holocene may be adequate for high seismic regions, while for low seismic regions information through the Pliocene–Quaternary may be necessary. **New sentence:** For example, for studies to assess fault capability, the tectonic information through the Upper Pleistocene to Holocene may be adequate for high seismic regions, while for low seismic regions information through the Pliocene–Holocene may be necessary.	For consistency – The Quaternary is a System/Period, while the Holocene, Pleistocene and Pliocene is the Series/Epoch	√	Similar comment made by another MS. "Holocene" added to final sentence. Remainder of comment rejected because provides too much detail for a safety guide.		
	3.22/c	Subsurface data derived from borehole and geophysical investigations, such as high resolution seismic reflection and/or refraction profiles, and gravimetric, electric and magnetic tomography techniques, to characterize spatially the identified seismogenic structures considered to be relevant in terms of their geometry, extent and rate of deformation. Suggestions: 1. It would be worth mentioning whether the borehole depth is in range of shallow depths (e.g. up to 300 m) or deep (e.g. up to 3000, 4000 m).				√	Suggestions represent too much detail for a safety guide.

		2. Is the high resolution seismic reflection profile – the profile imaging the shallow'ish subsurface section (e.g. up to around 300 m depth)? If yes, it is worth mentioning also the reflection seismic profiles (standard for oil and gas industry) imaging deeper sections 3. Is it common to use 3D (or 3D/3C) seismic reflection surveys for tectonic imaging? Is it advisable (especially for sites or capable faults imaging)? If yes, it would be worth mentioning					
	3.22/c/5-6	It is proposed to move the below defined sentence from 3.22/c/5-6 to 3.22/a as point "a" refers to geomorphology: "Bathymetry information should also be obtained for geomorphological investigation in dealing with offshore areas for sites located on or near a coastline" Question – what is the extend and level of details of bathymetry data?		√	This comment seems consistent with 3.22 a), so moved to point a) as suggested. To extend the document to cover bathymetric investigations in more detail would represent too much detail for this safety guide.		
	3.22/e	Data derived from geodetic methods, such as the global positioning system and interferometry images, and strain rate measurements to assess the ongoing rate and type of tectonic deformation. Question: Do you mean the global positioning system monitoring? If yes could you please define the minimum duration time and the minimum no of stations?				√	This would add too much detail for this safety guide. Competent engineers would understand the restrictions of using the GPS and it is beyond the scope of this guide to cover in detail here. Reference now made to the collective term "Global Navigation Satellite Systems (GNSS)" of which GPS is an American example.
	3.22	The point "h" could be added: "seismic monitoring network"		√	Agree that 3.22 h) should be added, but not at the level of detail requested – this would be		

		Could you please also define what would need to be minimum duration time and minimum no of stations?			beyond what should be in a safety guide. However, this should refer to para. 3.51 et seq. for details. Add: “(h) Collection of instrumental data from seismic monitoring networks, see para. 3.51 et seq.”		
	3.24/3	What does it mean “appropriate cross-sections”? Does it involve the whole near region information based on reflection seismic and well data and also the full depths or certain shallow images.				√	This and several other comments request additional technical details of the data collection method or technique. These are beyond the detail that is appropriate in a safety guide document like this one.
	3.27	It is sometimes used e.g. site vicinity, site vicinity area or site vicinity scale area or the site vicinity geographical area. It is proposed for above to stay consistent within the whole document, if possible and applicable, unless those definitions can be used interchangeably.		√	Document has been amended to use ‘site vicinity’ throughout.		
	3.28/b/2	**Old sentence**: Age, type, amount and rate of displacement of all the seismogenic structures identified in the area; **New sentence**: Age, type, amount and rate of displacement of all the seismogenic structures identified in the site vicinity;	The change is proposed due to the fact that the sentence is included within the chapter regarding the site vicinity.	√			
	3.32/a	For what depth range?				√	Again, too much detail requested. The depth required would be whatever is needed to properly characterize the geological features needed to derive the seismic hazard at the

							site. It would be for competent project experts to determine this.
	3.34/b/1	**Old sentence:** Pre-historical stage **New sentence:** Pre-historical stage and archeological/geological	For consistency			√	This change makes the sentence any clearer. So not supported.
	3.35/4	**Old sentence:** 3.35 **New sentence:** 3.34	For consistency	√			
	3.36/3	**Old sentence:** prehistoric **New sentence:** pre-historical	For consistency	√	Accepted with minor modification.		
	3.50	It is proposed to develop the chapter “Site specific instrumental data” with regard to low seismicity area. e.g. seismic monitoring (near regional), with guidance of the minimum duration period and also the example of minimum no. of stations.				√	Again, comment is requesting very detailed information. Although it is noted that changes and extension to discussion of site data gathering have been made for other reasons.
	3.50	It is proposed to develop the chapter “Site specific instrumental data” with the information regarding maintaining continuity of seismic monitoring.				√	See above.
	4.9/3	“geodetic” - does it apply for GPS monitoring?				√	Addition of detailed discussion not supported as beyond scope of this safety guide.
	5.6/1-2	“Within the soil profile” – what is an average depth?				√	There is no need for an average depth and this term is not used in the text. It is up to individual MSs to decide how to proceed. Comment not accepted.

	5.24/4-5	Is the “available relevant 2-D or 3-D crustal structure model” mainly base on 2D, 3D reflection seismic survey correlated with the well data?		√	New para added at 3.32 (b).		
		General comment: It would be proposed for each main analysis to create the figure showing the main analysis flow (input data, analysis, output data and so on)				√	This would represent too much detail for a safety guide.
	6.15	It is suggested to put the information in which cases the deterministic method could be chosen to be used instead of probabilistic method				√	The choice of whether to use a probabilistic or deterministic method is down to individual Member States.
	7.1/4	Is it just for vicinity of the site (5 km)?		√	Yes. Second sentence amended to make link to definition of site vicinity clearer: “… vicinity of the site (see para. 3.27) for …”.		
	7.5(a)/7	It is proposed to change “Quaternary” to “Holocene”	For consistency – The Quaternary is a System/Period, while the Holocene, Pleistocene and Pliocene is the Series/Epoch	√	Accepted. Similar comment made by other Member States.		

12. Russia (1)

COMMENTS BY REVIEWER Reviewers: Bugaev E.G., Kishkina S.B. Country/Organization: Russian Federation, Moscow / Scientific and Engineering Centre for Nuclear and Radiation Safety Date: 20.03.2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1	General recommendations para 2.2	To include the criteria to define the size of the region additionally: the size of the region shall be defined by the size of maximum potential fracture in the region, which may cause seismic or geodynamic impact on the site of nuclear installation.	Otherwise, it isn`t possible to evaluate accurately maximum magnitude (Mmax) and frequency of the earthquake and maximum seismic hazard of the region where nuclear installation is sited.			X	The proposal is reasonable, but it is covered by the original text. Magnitude is a consequence of the size of maximum potential fracture.
2	General recommendations para 2.6	To include additionally the information that seismic regime during several dozens of years may change within 4-5 orders. The changing of the parameter of the seismic regime and the increase of the magnitude of seismic activeness up to 5 orders within 2-3 decades is a commonly known fact and at the same time seismic hazards increase with the estimates of seismic hazards in accordance with the data obtained with a due consideration of Gutenberg-Rihter law for the background seismic events.	This factor shall be considered in prediction of the possible changes in seismic hazards during the construction, operation and decommissioning of nuclear installation. Consistent estimation of the seismic hazards should be carried out on the basis of deterministic and probabilistic methods of the analysis of hydrodynamic conditions, seismotectonic precursors and existing available seismologic information that is not much statistic-representative.			X	This Para covers the uncertainty associated with aleatory and epistemic aspects, not the issue of non-stationarity. From the point of view of geodynamics, the severity of seismic hazards can possibly change, but is traditionally analyzed for practicality reasons by assuming that conditions are stationary.
3	General recommendations, para 2.8	To add the following phrase: as an alternative it is recommended to use formalized assessment of seismic hazards based on geodynamic and seismotectonic data with a consideration of the reliable	It will formalize Mmax estimation and frequency of the earthquake with the highest magnitude and characteristics of seismic regime in the region of siting	X	The range period of the collected data may not enough to evaluate low probability events and geodynamics or neotectonics may support the interpretations. The		

		but statistically non-representative information.	of the nuclear installation with a due consideration of scaling of the region structures, distortion conditions and a form of fracture as well as to provide physical interpretation of the nature of the expert assessment of the seismic hazards.		last sentence was added accordingly.		
4	Database of information and investigations, para 3.1	To add the para: add geodynamic and seismotectonic information	Genetic connection between geodynamic and seismic process allows to formalize an assessment of seismic hazard of the site of the nuclear installation.			X	SSG-9 introduced this Para, which is now the standard text employed here. Geodynamics and neotectonics aspects are covered in Para 2.8.
5	Database of information and investigations, para 3.8	To add the para: The scope of the research should include carrying out of the local monitoring high sensitive seismologic observations based on "seismic monitoring network", as well as geodynamic research of the region and the region of the siting of the nuclear installation based on the distance methods and morphostructural analysis	This research allows to obtain consistent assessment of seismic hazards on the basis of the use of deterministic and probabilistic methods			X	Geodynamics and neotectonics are already covered in Para 2.8. Seismic monitoring is discussed after para 3.51.
6	Database of information and investigations, para 3.17	To add according to the recommendations to para 3.8 section "DATABASE OF INFORMATION AND INVESTIGATIONS"	To add according to para 3.8 of the section «DATABASE OF INFORMATION AND INVESTIGATIONS»	X	Geodynamic investigations are added accordingly.		
7	Database of information on para 3.39, subpara h)	Add the phrase: Balance of the full length of fracture and length of generation area of the strong motion	It`s important for the understanding of the nature of the earthquake, conditions for its arrangement and occurrence	X	No objection on the importance. But to put it in SSG, it is too much detail. Based on the proposal, the IAEA SRS-85 has been referred.		
8	Database of information and	The seismic monitoring system of high sensitivity seismographs should be installed for new sites from the very beginning of the evaluation stage. For	It`s proposed to replace in para 3.51-3.54 «the seismic monitoring network» to «the seismic monitoring system».	X	'system's were added.		

	investigations Site specific instrumental data, p 3.51	existing sites, for which such systems were not originally deployed, the seismic monitoring system should be installed from the beginning of the seismic safety re-evaluation programme. This system should operate during the whole lifetime of the nuclear installation.	As the monitoring system may not be limited to seismic network, it seems more reasonable to use, small-aperture arrays or network of micro-arrays. It refers primarily to the assessment of seismic conditions of microactive territories and platforms in terms of seismic activity within which the occurrence of catastrophic earthquakes is possible.				
9	Database of information and investigations Site specific instrumental data para 3.52	It is advisable to link the operation and data processing of this seismic monitoring system to any existing regional and/or national seismic networks.		X	'system's were added.		
10	Database of information and investigations, Site specific instrumental data, p 3.53	If the selected instrumentation for the seismic monitoring system cannot adequately record strong motions, several strong motion accelerometers should be collocated with the high sensitivity seismometers.		X	'system's were added.		
11	Database of information and investigations Site specific	Earthquakes recorded within and near the seismic monitoring system should be carefully analyzed in connection with seismotectonic studies of the near region.		X	'system' was added.		

	instrumental data, p 3.54						
12	Construction of seismic source models, p 4.8	If the compiled geological, geodynamical, geophysical and seismological data…..	Additionally to include: geodynamic data. In conditions of microactive territory geodynamic data along with seismotectonic precursors allows to use alternative formalized assessment of seismic hazards.			X	Explicit application of the geodynamics in seismic hazard calculations is still to be too immature. This can be used to support interpretation of extreme low probability event or non-stationary seismitectonic aspects.
13	Construction of seismic source models, p 4.18	In the end to add the point with the phrase: «… and the results of the registration of micro earthquake at the site of nuclear installation, obtained with the use of small-aperture arrays and network of micro-arrays».	It is relevant for microactive territories with the diffusive seismic activity, where potential fractures can be which pose geodynamic and seismic hazard.			X	Micro earthquake is included within 'all the earthquake data'
14	Construction of seismic source models, p 4.19	To add in the end of the phrase «geodynamic» data.	Available file materials often underestimate geodynamic activity and, as the result seismic hazards.			X	This is noted in Para 2.8.
15	Construction of seismic source models, p 4.21	To add in the third phrase, along with the «geophysics research» «geologic and geodynamic research»	Reliable and proven geologic and geodynamic data allows to formalize the assessment of the parameter of seismic regime. Only in case of justification of absence in place of siting of nuclear installation of the large regional fracture, that could generate strong rare earthquake with the magnitude exceeding Mmax, set for the design.			X	This Para is the discussion of the G-R model. If geodynamic aspects are considered, G-R will be not applicable since it pre-supposes the assumption of stationarity in life time of the nuclear installations.
16	Construction of seismic source	To add the point with the recommendation on assessment of parameters of seismic regime based on geodynamic and seismotectonic data, structure of the region, conditions of the	Accepted assumption on the small change of b parameter bias in exact seismotectonic framework, doesn't consider possible changes of tectonic			X	From an engineering point of view, practical seismic hazard analyses can be evaluated on the

	models, p 4.31	deformation and the failure patterns to assess the impact of the natural conditions on seismic safety.	framework in the region of siting of nuclear installation during the whole life cycle of nuclear installation. The point should be added with the recommendations on the stability control of natural conditions in the region of siting of nuclear installation and consideration of the possible changes during carrying out of check calculations of seismic stability under the reconstruction and life extension of NPP				assumption of a stable seismological regime. Geodynamics are important but are considered of most use to interpret extreme events. Recommending its use as a quantitative input to the seismic hazard analysis is quite challenging at the present time. Generally, MS do not make use of geodynamics quantitatively at this time and therefore it is not pursued in this Safety Guide.

12. Russia(2)

COMMENTS BY REVIEWER Reviewer: Prusova Zhanna Valerievna, Organization/Country: State Atomic Energy Corporation ROSATOM, Russian Federation Date:25/04/2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	Section 2. General recommendations Clause 2.2	It is recommended that the last sentence in the paragraph includes the following wording: “ The analysis shall exclude the regions which fall into the belt of the newest tectonic movements composed of sedimentary-metamorphic flysch and flyshoid karst formations with recorded disjunctive dislocations of the earth's crust (Alpine-Himalayan seismic belt, etc.) as practically lacking in prospects for NPP location”	«2.2.The size of the region to be analyzed shall be determined on the basis of the types, magnitude and distances from the source to the site for a potentially hazardous phenomenon caused by an earthquake that may affect the safety of a nuclear installation. Thus, the length of the region shall be sufficient to include all seismic sources that are likely to affect seismic hazards at the site. It does not have to have predefined uniform dimensions, which should be determined depending on the specific site and conditions in the region. If necessary, the region shall include areas that extend beyond the borders of the state, as			X	The proposal is too specific, and the ‘shall’ statement is not applicable to SSG.

			well as the relevant coastal areas. ”				
2.	Section 3. Information and research database. Clause 3.12	In the part of the coordinate system, it is necessary to indicate the reference to the coordinate system accepted in the area of work performance or at the survey site.	«3.12.To ensure consistency in the presentation of information, the data shall be combined in a geographic information system with sufficient metadata. All data shall be stored in a single coordinate system to facilitate correlation and aggregation."			X	There is no inconsistency between the text proposed here and para 3.12. The comment is supported that all text should be compiled in to the GIS database.
3.	Section 3. Information and research database. Clause 3.12	Similar to the requirements for the coordinate system, it is necessary to establish the requirements for the system of heights. When monitoring modern movements of the earth's crust, monitoring and evaluation of vertical movements is carried out.	«3.12. To ensure consistency in the presentation of information, the data shall be combined in a geographic information system with sufficient metadata. All data shall be stored in a single coordinate system to facilitate correlation and aggregation."			X	As above, the comment is considerable, but there is no inconsistency between the proposed text and para 3.12.
4.	Section 7. Assessment of the potential fault displacement at the site.	It is necessary to indicate either geodetic methods or geodetic surveys / measurements. Geodetic studies (geodesy, as stated in the document) do not refer to geophysical studies, it is a separate type of survey works (research).	"Geophysical surveys (including geodesy, ..."			X	The Geodetic method is included as one of ‘any other appropriate up to date techniques’. No inconsistency between the proposal and this safety guide.

	Clause 7.8						

13. Slovakia

COMMENTS BY REVIEWER Reviewer: Slovakia Country/Organization: Slovakia / ÚJD SR Date: 26.4.2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	*para 3.48 and 3.49*	*We propose to move these two paragraphs from the subchapter "Project Earthquake Catalogue" to the chapter 4 after the existing par. 4.9.*	*The topic of paragraphs 3.48 and 3.49 are magnitude-frequency relationships. However, the calculation of the magnitude-frequency relationships is possible only after the establishment of a seismic source model. These two paragraphs should be therefore moved to the chapter 4, which deals with the construction of seismic source models.*			X	In section 3, the types of magnitude are discussed, whereas in the section 4, seismic source models are discussed and magnitude-frequency relationships for the seismic sources are described.

14. UK

COMMENTS BY REVIEWER Organization: UK Comments Date: 06/03/2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
ONR	Para. 1.1	Reference is made here to nuclear installations and nuclear power plants – what about geological disposal facilities either during their construction or after sealing? Perhaps this issue could be clarified?				X	This is not currently a nuclear installation category recognized by IAEA and is therefore out of scope. Nuclear waste disposal is considered in other safety guides.
ONR	Para. 1.9, last sentence	The term "severity of the regional seismicity" is ambiguous but will probably be interpreted as the level of seismic activity, in which case the text will imply that the level of detail and effort of a seismic hazard study should increase with the level of seismicity. For regions where strong earthquakes have long recurrence intervals, and where uncertainty will therefore be high, this would be a misleading message.		X	This is just an example, but will change from "seismicity" to "seismic hazard".		
Dounreay Site Restoration LTD	1.10, final sentence	(in the core, pool or other storage facility on site).	We have radioactive material that has been removed from its reactor core (or was created in a reprocessing facility) and is in storage rather than in a cooling pond.	X	Put "e.g." at the beginning of the brackets, but do not include additional text because in some cases such facilities will be considered in other waste management safety guides.		
ONR	Para 2.6, last 3 lines	This implies that epistemic uncertainty can be reduced by expert interaction, which is not true. What structured expert interactions can avoid is artificial inflation of the uncertainty estimates.		X	"Structured expert interactions can avoid artificial influence of uncertainty estimates." is add at the end with minor modification.		
ONR	Para 2.7	This is discouraging since using a GMPE derived from data from other regions does not mean that the equation cannot				X	The sentence does not discourage the use of data derived

		be adjusted to the target site (as is made clear later in the document (Chapter 5)					from other sites, but recognizes that this brings with it some uncertainty that cannot be reduced to zero (unless the donor site can be shown to be identical the target site in all important respects).
ONR	Figure 1	Tsunamis are missing from this flowchart				X	Tsunamis, including seismogenic ones, are considered in another safety guide, as part of flooding generally.
ONR	Para 2.8, 3rd last line	Shouldn't this be changed to "integrated model"		X			
ONR	Para. 2.9, 2nd line	As noted later in these comments, the new SSHAC implementation guidelines (NUREG-2213) should be cited		X			
ONR	Para. 2.9, middle	The sentence "Approaches that use expert elicitation…….earth science data" is not clear and needs expanding in order to be comprehensible		X	Sentence amended.		
Dounreay Site Restoration LTD	2.11, final sentence	For this reason, and regardless of any lower apparent exposure to seismic hazard, a minimum vibratory ground motion level should be recognized as the lower limit to define the Design Basis Earthquake (DBE) for the site to be used for seismic design, safety assessment and/or seismic safety evaluation of any nuclear installation and that minimum level should be adopted when applying the recommendations in NS-G-1.6 [5].	Without this clarification, a nuclear site in a seismically benign region (such as Dounreay, as demonstrated by the site's thorough site specific evaluation) will have to assess its lower radiological consequence events against a minimum level of ground motion more appropriate for a site in a far more seismically active region. I believe			X	The minimum vibratory ground motion level is not always the same as the DBE. The DBE should be set in light of knowledge of the minimum and other factors.

			this amendment will make this paragraph more consistent with Section 9.				
ONR	Para 3.3, 4th bullet	Perhaps climate change and sea level rise should be added to the list of potential future changes				X	Combining climate change effects and SHA is beyond the scope of the safety guide.
ONR	Para. 3.5, last sentence	Would it not also be true to say that site area investigations can also be relevant to capable faulting assessment?		X	Added at the end of sentence: "… for evaluation of vibratory ground motion and fault displacement"		
ONR	Para 3.9	Some reference to future sea level changes due to climate change is needed here?				X	Combination of climate change and SHA is beyond scope of this safety guide.
ONR	Para 3.11b	Surely the purpose of activities like trenching is to identify capable faults, so I would replace the words 'the identified' with 'potential'		X	Put 'potential' after 'the identified'		
ONR	Para 3.11c	What is the 'seismic landscape'?		X	Footnote added: "Seismic landscape is defined as the cumulative geomorphic and stratigraphic effect of the signs left on an area's physical environment by its past earthquakes over a geologically recent time interval."		
ONR	Para 3.17 and 3.18	The wording of these two items is not very easy to follow…how do you do a 'sensitivity analysis' for regional geological data?		X	Accepted. Paras changed in response to other MS comments as well.		
ONR	Para 3.19b	Suggest that reference to surface breaking faults needs to be added here and, as these could in theory be due to creep, this should say " latest movements of the seismogenic and/or potential capable fault structures identified"				X	This sentence refers to the "near region". Fault displacement at the surface away from the site area does not affect the displacement hazard for the nuclear installation, although the fault rupture in the near region does

							influences the vibratory ground motion.
ONR	Para 3.22b	Reference is made here to field mapping to identify geomorphological features, but what about to identify geological features – like faults in the outcropping bedrock?				X	‘Geomorphology’ as used here is a collective term to cover geological features as well – like faults.
ONR	Para 3.22d	Geochronological dating of what? This should refer to some example materials or things that you might date, e.g. fault rocks (like gouge), vein fills, mineral cements, etc Reference could be made to specific techniques, e.g. U-Pb dating of calcite; Re-Os dating of base metal sulphides; K-Ar dating of illite mineral size fractions in gouge, etc				X	This is a reasonable point to make, but the level of detail requested is beyond the scope of a safety guide and more apprirpiate to a TecDoc. TecDoc 1767 provides some relevant details. One of the rules relating to IAEA Safety Standards is that the such standards cannot refer (downwards) to TecDocs or even lower level reports.
ONR	Paras 3.24, 3.29, 3.33 last sentences	Should all read: “particularly in relation to the seismogenic **or potential capable fault** structures further identified and characterized during this stage of the studies”				X	The potential capable fault is a part of the seismogenic structure and therefore covered by the sentence as already written.
ONR	Para 3.28b	Should read: “Age, type, amount and rate of displacement of all the seismogenic **or potential capable fault** structures identified in the area”				X	Comment as above. The potential capable fault is a part of the seismogenic structure and therefore covered by the sentence as already written.
ONR	Para. 3.34, 2nd line (footnote)	The footnote is not very clear: PSHA calculates annual exceedance frequencies and one must be referring to frequencies rather than probabilities if the reciprocal				X	The point picked up in the footnote is that the nuclear engineering community almost

		is to be referred to as a recurrence or return period					exclusively use the term frequency, whether frequency or probability is intended. The comment is correct in stating that return (recurrence) periods are the reciprocal; of a frequency. But in a modern PSHA, this frequency information is input to a Poisson probability distribution on the assumption that the seismogenic processes are Poissonion, or stationary. Doing this results in the hazard information being expressed as a annualized probability of exceedance.
ONR	Para. 3.34 (a)	It might be helpful to note that in many regions (including the UK), the instrumental period begins in around 1970 rather than 1900 when the first seismographs came into operation				X	No need to specify a date. for example, Prof. Omori installed the seismometer in 1898. In the hazard analysis.
ONR	Para 3.34	Whilst there are significant national differences, should this section not allude to where at least some of the required earthquake data might be found in general terms, e.g. national geological surveys, etc? Also, some kind of indication as to how much new investigation might need to be carried out depending on how complete the existing records are?				X	Durations are different from individual MS, but the point of this Para is to explain the concept from a common-sense point of view.

ONR	Para. 3.37, 2nd last line	This sounds circular unless using data from the modern (instrumental) period		X	Thank for the comment. Last sentence moved to separate para. to help remove circular argument		
ONR	Para. 3.37 (a)	Suggest removing 'duration' since it is rarely available and even when it is subjective estimates of this parameter are notoriously unreliable. Moreover, it is unlikely to be useful even if an estimate is available?				X	Instrumental historical earthquake data usually record time history and information of duration is not rare. For social historical data in high seismic areas where earthquakes have significant duration, this is quite often recorded as well as intensity. Agree that in low seismic areas, social historical data is macro-seismic and does not include duration data.
ONR	Para. 3.37 (g)	Most modern intensity scales (e.g., EMS) exclude soil and landscape effects as being unreliable indicators of ground shaking intensity, so the purpose for specifying the inclusion of such observations is not clear				X	The most modern intensity scale is JMA intensity not EMS. Anyway, the EMS is the consequence of all effects of source, path and site. It should be archived with the site effects
ONR	Para. 3.38 (a)	Same comment as for Para. 3.37 (a)				X	See coment against para. 3.37(a).
ONR	Para. 3.43, 2nd last line	Rather than stating that care should be taken, it might be more appropriate to suggest that clear criteria be established		X	Sentence amended: "… care should also be taken when establishing the priorities for considering one data point preferable to another." With separate sentence added: "Where data from different existing catalogues is inconsistent or incompatible, clear criteria should be established to govern how such issues are resolved, so		

					that a defensible rationale exists for accepting or rejecting such data."		
ONR	Para 4.11	It could be stated here that the geological narratives developed in the investigation of seismogenic structures and in the investigation of potential capable faults need to be consistent with one another. This is implicit in what is written here but as per other areas of the document it could be spelt out clearly.		X	New sentence added: "The enhanced data collection for this purpose should be evaluated to see whether it is consistent with the data collected for the vibratory seismic hazard analysis. Any inconsistencies should be reconciled if they could adversely affect either analysis."		
ONR	Para. 4.17, last sentence	What is the purpose of such sensitivity analyses? Should the hazard analyst modify the distribution of M_{max} estimates based on the results? If such analyses are being specified, the criteria for interpreting the results should also be given				X	As described here, large uncertainty may exist in the estimation of the Mmax. Therefore, the sensitivity of this parameter to relevant factors should be evaluated. The criteria for doing this need to be identified by individual MSs.
ONR	Para. 4.18, 3rd line	Suggest changing "should" to "may" since there are many cases where statistical approaches to estimating M_{max} are not reliable		X	Should➔may		
ONR	Para 4.22	The last sentence would be clearer if the words *'be assumed'* were removed		X	Accepted with modification. Sentence replaced with "The seismic source model of each zone is constructed on the basis that it encompasses an area that possesses similar seismotectonics."		
ONR	Para. 4.28	Same comment		X	Changed from 'assumed' to 'based on'		
ONR	Para 5.2	Should it be "physics-based"?		X	Physic➔ Physics (Typo!)		
ONR	Para. 5.6, 4th last line	"site profile" rather than "soil profile" since it might be a horizon within a rock profile				X	Basically agree. But this guide is under SSR-1 named "Site Evaluation for Nuclear Installations" and the term 'site

							profile' is used with different meaning there. Therefore, an alternative term has been selected here.
ONR	Para. 5.7, 3rd line	"geometry of rupture plane (with respect to site)"		X			
ONR	Para. 5.9 (b)	This could be interpreted to imply that the NGA-West and NGA-West2 models should be rejected. This is not a helpful clause and should be removed				X	The NGA West models, their coefficients are well verified based on observed data and modeled with some basis in physics.
ONR	Para. 5.9 (d-f)	If host-to-target region and site adjustments are to be made (which is becoming standard practice) then it makes more sense to select GMPEs on the basis of their adaptability rather than their direct applicability.				X	These adjustments are currently popular to do, but are not the only way to proceed. It therefore seems inappropriate to make the suggested recommendation at this time.
ONR	Para. 5.10, 1st sentence	This is valid if the local data is from earthquakes covering a range of magnitude values.		X	Appreciate the comment. IAEA will strongly recommend the Member States acquire data at the site in this regard.		
ONR	Para. 5.10, 5th last line	Hybrid empirical and reference empirical both exist, but not hybrid reference empirical		X	Accepted but modified by addition of following footnote: "In the high seismicity region, there are many NPP sites where plenty of strong ground motion records have been observed. At these sites, single station residuals can be determined by the ratio between the observed and predicted motions. The predicted ground motion by GMPEs can be corrected with the single station residuals. This site correction method is already introduced in the MS regulation and defined as the hybrid reference empirical methods in this publication."		

ONR	Para. 5.11, 2nd sentence	Not clear what the issue is here or what is intended with the recommendation – this is not helpful in its current form		X	Accepted, modified sentence as follows: “To avoid the propagation of errors arising from subjective evaluation of GMPE coefficients, these coefficients should be evaluated based on physics-based scaling”		
ONR	Section title (before 5.16)	The wording sounds a little strange since the TDI reflect (some of) the epistemic uncertainty				X	This subsection is intended to discuss particularly epistemic uncertainty within each technically defensible interpretation. The title is considered reasonable on this basis.
ONR	Para. 5.21	It should be specified that the aleatory variability should be comparable to that associated with empirical GMPEs since a potential weakness of simulations is the inability to capture the variability and it would be unwise to enable hazard estimates to be artificially lowered through use of these approaches that may yield lower hazard estimates by virtue of artificially lower sigmas		X	Comment is correct. Added: “However, the aleatory variability should be comparable to that associated with empirical GMPEs since a potential weakness of simulations is the inability to capture the variability.”		
ONR	Para. 6.6	This is a remarkably short paragraph on a complex and hugely important topic! Some more specific guidance—even if only identifying the specific issues that should be considered—would be helpful.		X	Accepted. Following text added: “… which is normally identified by specifying a control point or layer beneath the site, where the seismic hazard analysis specifies the ground motion and the site response and/or soil-structure interaction analysis takes this as its input motion, see NS-G-1.6 [5]. Amplification by decreasing impedance (seismic wave velocity and density) and the attenuation in the subsurface strata should be evaluated for the ground motion estimation close to the control point or layer except at the hard rock site. Actual subsurface strata		

					are not always horizontally homogeneous and the inhomogeneity of the subsurface structure including non-linear effects may influence the wave propagation. Vertical borehole array measurements of the seismic waves are useful to evaluate the wave propagation characteristic at the site.”		
ONR	Para 6.9 and 6.16	Up to this point sub-sections have been labelled a), b), c) etc, not 1), 2), 3) – this is because a series of steps are being described, but worth highlighting.		X	Will be changed if necessary to comply with IAEA formatting policy at publication stage.		
ONR	Para. 6.9 (7)	The amplification functions from the site response analyses can also be embedded in the hazard integral, in which case the order specified here would not apply.		X	Add: "… in the case of the site response functions not being included in the ground motion evaluation.”		
ONR	Para 6.10 last part	Parentheses are not closed off here – missing close brackets after ‘Frequency’?		X	Typo corrected.		
ONR	Para. 6.12, 1st sentence	This first statement is incorrect and misleading. If this were true, then it would also follow that M_{max} would correspond to the upper bound of applicability of the GMPE, which would clearly be nonsense. The only purpose of M_{min} is to remove hazard contributions from non-damaging events (see Bommer & Crowley, 2017). At both ends of the magnitude interval of the hazard integrations, GMPEs need to be extrapolated as appropriate.		X	Accepted. Change “To stay within the range”➔ “To extrapolate or bound the range”		
ONR	Para. 6.12, middle	In addition to CAV, PGV, SI, etc., another option is to use a vector of ground-motion parameters				X	This is an example list and is representative, rather than being exhaustive.
ONR	Para. 6.15 (3)	It is not necessary to define magnitude-frequency relationships for a deterministic hazard assessment		X	Believe para. 6.16 (3) is intended. Although deterministic, the characteristics of the occurrence should be investigated. “if possible” should be added at the end of last sentence.		

ONR	Para. 6.15 (6iii)	This is troublesome since it allows arbitrary decisions regarding the minimum distance to be used in a DSHA for diffuse seismicity, which is a decision that exerts an extremely strong influence on the hazard results				X	This decision is actually very challenging, but the existing deterministic practices in MSs are represented in the existing text.
ONR	Para. 6.15 (6iv)	A little vague: should some specification regarding the minimum number of standard deviations be specified?				X	It should be the matter for MSs.
ONR	Para. 6.22	The suggestion that simply plugging in site-specific values of proxy parameters such as VS30 into a GMPE would be considered adequate for a nuclear site, at least without the addition of considerable epistemic uncertainty since the implicit assumption would be that the amplification factor embedded in the GMPE would actually be applicable to the site. Given that the site profile and the dynamic site response characteristics are one part of the assessment of shaking hazard that can be constrained without the occurrence of earthquakes, it seems irresponsible to allow generic amp factors to be used instead.				X	VS30 is simple and may be useful for conventional installations. It can be applied as part of the graded approach. However, nuclear installations such as NPP may require more careful evaluation. IAEA cannot encourage a specific methodology.
ONR	Para. 6.23 (3)	What would be the criteria for determining whether 1D EQL is sufficient? And should there not be some advice on how to handle the considerable additional complexity of 2D and/or fully non-linear site response analyses?		X	Typo: Sentence amended to remove “non-linearity” from association with 1D linear analysis. And ‘to account for non-linearity’ is added at the end of the sentence.		
ONR	Para. 6.23 (5)	As noted on Para. 6.7 (7), the amp factors can also be embedded inside the hazard integral together with the rock GMPE, an option which should also be allowed (and which probably yields more accurate estimates of the hazard fractiles at the surface)		X	Instead 6.9 (new 6.10), 7): Replace with “Perform the site response analysis in the case of site response functions not being included in the ground motion evaluation.”		
ONR	Para 7.3 last sentence	This is not a very satisfactory statement – is a creeping fault capable or not? The wording here implies that it is somehow different by referring to it as a “slowly progressing geological hazard” which seems to suggest it isn’t important here.		X	Nuclear installation should not be built on a creeping fault. But this is not a seismic event and consideration of creep is therefore outside the scope of this safety		

		If such aseismic movement occurs at a sufficient rate, it too has the potential to create a surface break and cause significant damage to a nuclear facility; creeping faults are therefore potentially capable (IAEA 2015, ANS 2015). If fault creep isn't dealt with here as a hazard, where is it going to be dealt with?			guide, although it is a geological hazard. Last sentence amended to: "Fault creep, when demonstrated as such, is considered as a slowly progressing geological hazard that may affect the safety of nuclear installations but is not seismically induced and therefore not considered in this Safety Guide."		
ONR	Para 7.5a	What is meant by the "deformed area of major regional fault" in the present context? Does this refer to surface displacement or shaking or something else?? Clarify.				X	Rejected on basis that additional detail would be beyond the scope of this safety guide.
ONR	Para 7.8	A specific reference to the use of slip tendency analyses and to the mechanical testing of fault rock friction parameters could also be made here.				X	Rejected on basis that additional detail would be beyond the scope of this safety guide.
ONR	Para 7.9	This statement about reactivation surely also applies to potentially seismogenic faults, yet this issue is not mentioned in earlier sections when it probably should be.		X	Accepted. New para added under para. 6.6: "Consideration should be given to the possibility that ground motion hazard may be influenced by the fault rupture driven by anthropogenic activity, e.g. reservoir loading, fluid injection, fluid withdrawal or other such phenomena."		
ONR	After Para 7.9	There is nothing in Section 7 about what you are supposed to do once the investigations are complete – or how this relates to the seismic hazard analysis. This is important so some modifications are proposed as follows: - Some kind of statement should be added emphasizing that a logical argument should be developed that integrates the evidence determined from each of the methodologies used in order to provide a coherent evidence-based case.		X	Accepted. New para added in 7.10		

		- It should be reiterated that since surface rupture hazard is usually linked to earthquake hazard by having a common causative mechanism, the analyses and resulting narratives for both should be consistent. - It should also say that the criteria used for deciding whether a fault is capable or not should be clear from the analysis. It is important to include a discussion of the limitations of the investigations carried out and how these uncertainties will need to be considered when using the results. - Should there also not be some reference to independent peer review by appropriate experts?					
ONR	Para 7.16	What approach should be used in cases where there is – or could be – fault creep?				X	Creep is out of scope as noted above.
ONR	Para. 8.13 (b)	The 5-75% significant duration is considered a more useful measure by many – should it not also be mentioned?		X			
ONR	Para. 8.15	Para. 5.13 seemed to favour using H/V ratios whereas here they seem to be viewed as a fall back if there are no GMPEs for the vertical component available		X	Accepted. New sentence as below: “However, caution should be exercised if using GMPEs defined separately for each component, see para. 5.13.”		
ONR	Paras 8.21-23	Some reference to changing sea levels due to climate change could be made in these sections – or as a separate point relevant to coastal nuclear sites?				X	Rejected because combinations with climate change/flood hazards out of scope of this safety guide.
Dounreay Site Restoration LTD	9.1	In consideration of the use of the graded approach described in para. 1.9, this section provides guidance on seismic hazard	Editorial oversight.	X			

		evaluation for a broad range of nuclear installations (see para. 1.9) other than nuclear power plants.					
ONR	Para 9.14 second sentence	This also applies to creeping faults – add this?		X	Para and title amended to make clear that safety guide is only considering seismically induced fault displacement, since non-seismically induced effects are outside the scope of this safety guide.		
ONR	Para. 10.17, 3rd bullet	CAV is not a damage parameter, just a ground-motion parameter that may indicate damage potential		X	Accepted with minor modification.		
ONR	Para 10.18 (iii)	A critical issue is that the record should ensure that all challenges/queries raised during peer review process are fully addressed and closed out with the agreement of the peer review team.				X	Although the outliers can remain and not be closed out, it review process should be transparently reported to make this clear and establish the possible effects on the quality of the seismic hazard calculations.
ONR	Para 10.19 opening sentence	It would seem appropriate to suggest that "can" is replaced by the word "should'		X			
ONR	Definitions - seismogenic structure.	Most seismogenic structures are faults – I think that this definition should say so.		X	Accepted but modified to put 'fault' in to 'surface rupture'		
ONR	Definitions – surface faulting	"Permanent offsetting or tearing of the ground surface by differential movement across a fault in an earthquake or due to aseismic creep".				X	Creep is out of scope as noted above.
ONR	Reference [6]	Add a reference to NUREG-2213 (USNRC, 2018), which could also replace the reference to NUREG-2117		X			

15. USA

COMMENTS BY REVIEWER Reviewer: US Nuclear Regulatory Commission Country/Organization: United States of America/US NRC Date: Apr 23, 2019				RESOLUTION			
Comment No.	**Para/Line No.**	**Proposed new text**	**Reason**	**Accepted**	**Accepted, but modified as follows**	**Rejected**	**Reason for modification/rejection**
1.	6.15	A deterministic approach is another viable approach for seismic hazard assessment. The approach is more simplistic and does not systematically catalogue and model the uncertainty associated with the estimation of all potential earthquakes.	Bias on one approach. Both methods are used in the nuclear industry. Especially in developing generic design spectra, PSHA is not used.	X			