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/rejecti on	
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.	Х	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	Please include the	Х	The definition of
	"Definitions"	definition of "capable		"capable fault" is
		fault".		already included in
				the IAEA Safety
				Glossary (2018
				Edition).

2. Belgium

	COMMENTS BY REVIEWER Country/Organization: ENISS Date: 30/04/2019				RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on		
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 within the site area, 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. If reliable evidence is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e.	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		

Г			(1, 1) = (amitamian fallowing
			primary) fault displacement within				SCD 1
			the site vicinity, additional				SSK-1.
			investigation should be done to				
			ensure that the structure, together				
			with associated secondary faults,				
			do not propagate within the site				
			<u>area.</u>				
	3	7.11	If during the selection and	Consequence to		Х	See above.
			evaluation stages of a proposed	previous remark			
			new site for a nuclear	1			
			installation reliable evidence is				
			collected demonstrating the				
			existence within the site vicinity				
			area of a secondary fault				
			belonging to a seismogenic				
			canable 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				
			alea, uns issue snould be treated				
			also as an exclusionary attribute				
		- 10	and an alternative site should			X7	
	4	7.12	Give a definition of "potential	Not clear enough		X	The two phrases have
		and	capable fault"/"potentially capable	regarding the definition			meanings in English:
		followi	fault"	given before concerning			meanings in English.
		ng		what is a capable fault			1. 'potential
							capable fault'
							means that there
1							might be a
							capable fault
							present
							2 'potentially
1							capable fault'
							means that there

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

3. Canada

		COMMENTS BY REVIEWE Country/Organization: Canad Date: April 29, 2019	R la	RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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	Х		

		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.	Х		
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	Х	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	Х		

		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	Х	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.	Referen	Replace reference [6] NUREG-2117 with following updated report: NUREG-2213, Updated Implementation Guidelines for SSHAC Hazard Studies.		Х		

COMMENTS BY REVIEWER Reviewer: M-L Järvinen Country/Organization: STUK Date:25th April 2019				RESOLUTION				
Comme nt No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
	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	

Í	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 PROBABI LISTIC SEISMIC HAZARD ANALYS ES 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 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 PROBABI LISTIC SEISMIC HAZARD ANALYS ES 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	1, 2.5, 5-and, 10 Hz, and			
distance	higher than 10 Hz, the upper			
	bound depending on the site			
	conditions.			

5. France

		COMMENTS BY REVIEWE Country/Organization: FRAM	R NCE	RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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 referenc e	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/saf ety-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 <u>inadequate to</u> 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. <i>fault capability</i> - <i>surface rupture</i> , 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.	Х	'fault' is added in 'surface rupture'.	
7.		[], which are physics-based scaling		Х		
	5.2	to interpolate a smaller range of	TYPO. physic S -based			
		data. []				
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. 	ΤΥΡΟ.	Х		
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 <i>GMPEs</i> 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 addresses both	Х	Respecting additional comments	
			kinematics and dynamics.		from France, paras 5.20 and 21	
			while the list of		have been revised accordingly.	
			parameters is given only			
			for kinematic sources			
			The dynamic source			
			narameters are later			
		The kinematic simulation method	listed in 5.22			
		should specify the following	(a) and (d) items are			
		narameters.	common parameters to			
		(a) []	physics-based methods			
		(b) Macro-parameters for	(c) item lists the stress			
		kinematics (hypocenter seismic	narameters for finite fault			
		moment) or macro-narameters for	elements which is not a			
	5.20	dynamics (runture initiation area)	kinematic narameter			
		(c) Micro-parameters for kinematics	(d) item is related to			
		(runture time rise time local	wave propagation			
		dislocation or local stress dron) or	method independently			
		micro-narameters for dynamics	of source description			
		(local state of stress local friction	of source description			
		low properties)	For the sake of			
			expansivity of this			
			paragraph the (b) and (c)			
			itoms should also indicate			
			the dynamic macro and			
			micro parameters and			
			"kinomatic" should be			
			kinematic should be			
12			The only true macro	v	Paspacting additional comments	
12.			narameters are the	Λ	from France, paras 5.20 and 21	
		(b) Maara parameters for	parameters are the		have been revised accordingly.	
		(b) Macro-parameters for	by pagenter. The others			
		mematics (hypotenter, seismic	(dialogation musture			
	5.20.b	runture velocity everage strace	(uisiocation, rupture			
		dram) or macro noromotoro for	actually local micro			
		arop) or macro-parameters for				
		aynamics (rupture initiation area);	parameters that can vary			
			the value of a visition			
			the sake of avoiding			

- 10			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.	Х	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	ТҮРО.	X		

16.	6.8	Probabilistic approaches consider the rates of recurrence of events along with their estimated	Maximum size is not appropriate here. Each event has one size.	Х	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	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.
		degree of public concern and the availability of project resources					
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), tobe 	Maximum magnitude distribution is not defined before in the guide. This	X	Changed to 'uncertainty in maximum magnitude values' instead 'distribution'.		

		determined considering the	concept should be			
		maximum magnitude distribution	deleted if not clarified.			
20.		(ii) For zones of diffuse seismicity		Х		
		that do not include the site, the				
	C 4 C C "	associated maximum potential	Unclear until the iii is			
	6.16.6.11	magnitude should be assumed to	read.			
		occur at the point of the region				
		boundary closest to the site.				
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 If there is a potentially capable		Х	The proposed texts were slightly	
		fault, either primary or secondary,			modified to reflect the French	
		within the site vicinity and site areas,			second comments sheet. But	
		it should first be determined			substantial contents of the original	
		whether the fault could potentially			text were preserved.	
		approach and subsequently cause				
		surface displacement that affects	Same as for 7.11, primary			
		items important to safety of the	and secondary fault			
		nuclear installation. This evaluation	concept needs not to be			
	7.14	should be based on the	confused with primary			
		characteristics of the fault, such as	and secondary ruptures.			
		its sense of slip, geometry (length	Proposed text avoids			
		and width including strike dip and	using this concept.			
		rake angles)-and, for structurally				
		related faults, their relationship				
		with the causative fault, and, for				
		secondary faults, its structural				
		foult and chould use well-				
1		Fourt, and should use validated				

		models (including dynamic rupture				
		models) in a conservative way				
		including due consideration of				
		related uncertainties both enistemic				
		and aleatory				
23		8 12 The duration of an earthquake		v		
23.		8.15 The utilation of an eartinguake		21		
		ground motion is determined by				
		many factors, including the size of				
		fault rupture (generally	The term "sedimentary			
		characterized by magnitude), crustal	basin" used in the			
	8.13	parameters along the propagation	previous version of SSG9			
		path (generally characterized by	is more appropriate than			
		distance), and conditions beneath	"sedimentary column".			
		the site such as the presence of a				
		significant sedimentary basin				
		column.				
24.		5.20 Alternative ground motion		Х		
		simulation methods utilize a more direct				
		physical representation of the seismic				
		source and wave propagation. These				
		'physics-based' methods use fault	The list of a superstant is			
		rupture modelling and path-specific	The list of parameters is			
		wave propagation to estimate ground	only for kinematics, and			
		aspecially effective in cases where	too detailed, bringing			
		nearby faults contribute significantly to	some confusion to 5.20.			
		the vibratory ground motion hazard at				
		the site and/or where the existing	The suppression of the			
	F 20	empirical data is limited (on the hanging	list makes the 5.20 more			
	5.20	wall of a nearby fault for example). The	general and less			
		physics-based methods for fault rupture	confusing			
		description fall into two general				
		categories, kinematic and dynamic.	The reader is advised to			
		Some details on fault rupture	refer to SB-85 for			
		modeling and example of methods are provided in IAFA Seferty Departs	technical information on			
		Series No. 85 Ground Motion	fault runture modelling			
		Simulation Based on Fault Rupture	Tadit Tupture modeling.			
		Modelling for Seismic Hazard				
		Assessment in Site Evaluation for				
		Nuclear Installations [please add the				
		reference to the reference list]. The				

	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 exceed	ance and for a given			
naethe of hazard).				

6.	Germany
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Reviewo Nuclear	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			
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on
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 3.10 <u>1</u>)"	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</u> <u>low seismicity</u> information	Clarification		X	Quite similar meaning
		through the Pliocene–Quaternary may be necessary.				
4.	3.35 Line 4	"defined in para 3.35 <u>4</u> ."	Mistake in cross reference, temporal scales are handled in para 3.34.	Х		
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 <u>potential</u> 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, and the selection of the magnitude scale for all catalogue entries, and \underline{A} comparison of the project catalogue with other similar catalogues relevant to the region should be performed.	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	[] For 'a' values, an approach	To determine 'a' and 'b'	X	Not only this sentence but		
	Line 7	based on strain rates can be used if	values from the		also the previous sentence		
		such data is reliably available from	seismicity is the usual		moved to 4.31.		
		geophysical investigation.	approach. But this				
		However, for many low seismicity	paragraph is about				
		areas, 'a' values are derived from	"different" approaches				
		the regional historical earthquake	for regions with few				
		catalogue, since often this is the	registered earthquakes.				
		most reliable indicator of regional	In these regions				
		seismicity[]	determining 'a' values				
			based on the earthquake				
			catalogue might involve				
			large uncertainties.				
			Our suggestion is to				
			delete this sentence				
8.	5.3	Individual models for the	Clarification	Х			
		prediction of vibratory ground					
		motions should include both an					
		estimate of the median ground					
		motion amplitude which - <u>in case</u>					
		of the commonly adopted log-					
		<u>normal model</u> - is the mean of					
		logarithmic normal distribution,					
		as well as a measure of the					
		aleatory variability about the					
		mean.					
9.	6.2	The approach to be used for	It is state of the art to			Х	Better to do both,
	Line 1	assessing the vibratory ground	use both methods and				but not always by
		motion hazard at the nuclear	not only rely on one of				every Member
		installation site should be defined	both, compare i.e.				States.
		at the beginning of the seismic	WENRA RL T3.2.				
		hazard evaluation project. The					
		vibratory ground motion hazard					
		may should be evaluated by using					
		probabilistic and/or deterministic					

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

		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, <u>equivalent to a SSHAC Level 4</u> <u>study, should be applied. These</u> 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.		

	1			1		
		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<u>18</u>- 6.21<u>23</u> 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 <u>and in the near vicinity of</u> <u>the site</u> 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	The recommendations relating to	Mistake in cross	Х	Renumbered as 3.51-3.56		
	Line 1	seismic instrumentation installed	reference, section 'site				
		on the site (see paras 3.54 <u>0</u> –	specific instrumental				
		3.565) should be applied in a	data' envelopes paras				
		manner that is commensurate with	3.50 to 3.55.				
		the category of the installation as					
		defined in para. 9.10.					
23.	10.16	The reference subsurface rock site	Clarification	Х			
	Line 18	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 <u>prior to</u>					
		site response analysis should					
		correspond to this reference					
		condition.					
24. 7	10.19	[] Participatory peer review will	In 6.9 2) and 6.16 2),			Х	This is already
	Line 4	decrease the likelihood of the	preference for a				explained in the
		study being rejected at a late stage	participatory peer				section 6.
		and should be the preferred peer	review is expressed. For				
		review method.	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				
	participatory review is						
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	implicitly presumed.						

7. Iran								
	C(Country/Orga	OMMENTS BY REVIEWEI Reviewer: Reza Saberi nization: IRAN/NNSD Dat	R te: 24 Apr. 19	RESOLUTION				
Comme nt No.	Para/Line No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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 investigation s	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	"(d) All magnitude designations such as	Based on NUREG- 0800 Section 2.5.2		Х	Already introduced in Para 3.37 (d) and
	earthquake	mb, ML, MS, MW" is	0000, Section 2.3.2			Definitions.
	data,	proposed.				
	3.39 (d)					

8. Italy	7						
COMMENTS BY REVIEWER Country/Organization: Italy Date: April 29, 2019			RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on
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 "		

	COMMENTS BY REVIEWER Reviewer: Japan NUSSC member Country/Organization: Japan / NRA Date: 16 April. 2019				RESOLUTION			
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejection	
1.	S ection 7	In Section 7 of DS507, distinction secondary faults is an important elec- scientifically different views on the some of the recommended me- scientifically inaccurate and oper actual evaluation of capable faults a This means that DS507 does not a IAEA Safety Guides provide recomm- on how to comply with the safety rec- international consensus that it is measures recommended (or measures)". DS507 does not internationally recognized good pra- Japan's NRA requests major red DS507. Detailed reasons for the above co- follows. 1. Scientific understandings on a Section 7 of DS507 recommen- displacement on the basis that readily distinguished from a there is no common understar between the primary and secon structural geology and tectonii purpose of evaluation of capable [1]; Scholz, 2019 [2]; Scholz et a Nelson, 2009 [4]; Serva et al., 20 In addition, distinction between faults is applied in the faults.	n between primary and ment. However, there are is distinction. Therefore, easures in DS507 are rationally impractical in and site selection. follow the principle "The mendations and guidance quirements, indicating an s necessary to take the equivalent alternative provide examples of actices. rafting of Chapter 7 of mment are described as primary/secondary faults ends evaluation of fault a secondary fault can be primary fault. However, ndings on the distinction dary faults in the field of c geomorphology for the e faults (Yeats et al., 1997 1, 2010 [3]; Mccalpin and 102 [5]). n primary and secondary lt displacement hazard			X	 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. 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 prehistorical 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

within the overall site

suitability shall be

demonstrated.

specific accident scenarios, and

the consistency of such criteria

Para 4.9 A decision regarding

the suitability of the site shall

of the nuclear installation.

be based on the characteristics

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



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	
denosite is useful in identifying are 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	
states. Please refer to Appendix A describing Japanese	
practices in detail and this annendix should be added to	
DS507 as an annex.	
References	
[1] Yeats, R.S., Sieh, K. and Allen, C.R., 1997, <i>The Geology</i>	

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

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

 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. 	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
 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), <i>Earthquake Spectra</i>, Vol. 9, no. 1, 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. <i>Journal of Geophysical Research</i>, 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. <i>Earth and Planetary Science Letters</i>, Vol. 234, pp. 401-419. [10] Einarson, P. and Eiriksson, L., 1982, Finder and State and State	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.
 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. 	

		 [12] Meigs A., Krugh, W.C., and Ramos, V.A., 2006, Refoldi sheets by active basement-invo Eastern Precordillera of Weste <i>la Asociación Geológica Argenta</i> 603. [13] Burbank D.W. and Ando <i>Geomorphology (2nd ed)</i>. Wiley 	Schiffman, C., Verges, J. ng of thin-skinned thrust olved thrust faults in the ern Argentina. <i>Revista de</i> <i>ina</i> , Vol. 61, no. 4, pp. 589- erson R.S., 2011, <i>Tectonic</i> 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 <u>typical</u> 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 <u>typical</u> 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 REVIEWE	R					
	(Country/Organization: Netherlands Date: 24-04-2019	ANVS	RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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	Х	Inserted "and its effects cannot be compensated by proven			

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

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

11. Poland

	C	COMMENTS BY REVIEWE Reviewer: Poland ountry/Organization: Poland / Po	R GE EJ1	RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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).			V	This change does not add anything substantial to what is already there, and is editorial.	
2.	DEFINIT IONS	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.	V	"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?				V	The issue of probabilistic/determi nistic 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.				V	'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			V	The various geographical areas are listed in Fig. 1 but are not specific to different analysis types.	

			1			
hazard		user friendly) to gather them in FIG 1.				
evaluatio						
n process						
IOr						
nuclear						
installati						
ons						
3.6/1 and 2	Question: Are the geotechnical analysis to be acquired within the region (e.g 300 km from the site)?				V	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	V	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?				1	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.				V	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		V	Agreed but amended further as: " the boundary of the prospective selected site area."		
	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	1	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).				V	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?	V	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?			V	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.				V	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.		V	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.	V			
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			V	This change makes the sentence any clearer. So not supported.
3.35/4	Old sentence: 3.35 New sentence: 3.34	For consistency	V			
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.				N	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?				V	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?				N	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? 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			New para added at 3.32 (b).	V	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				V	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)?		\checkmark	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	V	Accepted. Similar comment made by other Member States.		

12. Rus	ssia (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				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
1	G eneral recomme ndations 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	G eneral recomme ndations 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 recomme ndations, 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		last sentence was added accordingly.		
4	Database of informati on and investigat ions, 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 informati on and investigat ions, 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 informati on and investigat ions, 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 informati 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 informati on 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.		

	investigat	existing sites, for which such systems	As the monitoring system			
	ions	were not originally deployed, the seismic	may not be limited to seismic			
		monitoring system should be installed	network, it seems more			
	Site	from the beginning of the seismic safety	reasonable to use, small-			
	specific	re-evaluation programme. This system	aperture arrays or network of			
	instrume	should operate during the whole lifetime	micro-arrays. It refers			
	ntal data,	of the nuclear installation.	primarily to the assessment			
	p 3.51		of seismic conditions of			
			microactive territories and			
			platforms in terms of seismic			
			activity within which the			
			occurrence of catastrophic			
			earthquakes is possible.			
9	Database	It is advisable to link the operation and		Х	'system's were added.	
	of	data processing of this seismic monitoring				
	informati	system to any existing regional and/or				
	on and	national seismic networks.				
	investigat					
	ions					
	C:4-					
	Site					
	specific					
	ntal data					
	nara 3 52					
10	Database	If the selected instrumentation for the		x	'system's were added	
10	of	seismic monitoring system cannot		21	system s were added.	
	informati	adequately record strong motions several				
	on and	strong motion accelerometers should be				
	investigat	collocated with the high sensitivity				
	ions,	seismometers.				
	Site					
	specific					
	instrume					
	ntal data,					
	р 3.53					
11	Database	Earthquakes recorded within and near the		Х	'system' was added.	
	of	seismic monitoring system should be				
	informati	carefully analyzed in connection with				
	on and	seismotectonic studies of the near region.				
	investigat					
	ions					
	G .,					
	Site					
	specific					

	instrume ntal data, p 3 54					
12	Construct ion 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	Construct ion 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	Construct ion 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	Construct ion 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	Construct ion 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	deformation and the failure patterns to	framework in the region of		assumption of a
4.31	assess the impact of the natural conditions	siting of nuclear installation		stable seismological
	on seismic safety.	during the whole life cycle of		regime.
		nuclear installation. The		Geodynamics are
		point should be added with		important but are
		the recommendations on the		considered of most
		stability control of natural		use to interpret
		conditions in the region of		extreme events.
		siting of nuclear installation		Recommending its
		and consideration of the		use as a quantitative
		possible changes during		input to the seismic
		carrying out of check		hazard analysis is
		calculations of seismic		quite challenging at
		stability under the		the present time.
		reconstruction and life		Generally, MS do not
		extension of NPP		make use of
				geodynamics
				quantitatively at this
				time and therefore it
				is not pursued in this
				Safety Guide.

12. Rus	ssia(2)						
COMMENTS BY REVIEWER Reviewer: Prusova Zhanna Valerievna, Organization/Country: State Atomic Energy Corporation ROSATOM, Russian Federation Date:25/04/2019				RESOLUTION			
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on
1.	Section 2. General recom mendati ons 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. Informa tion and researc h databas e. 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. Informa tion and researc h databas e. 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. Assess ment of the potentia l fault displac ement 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			

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COMMENTS BY REVIEWER Reviewer: Slovakia Country/Organization: Slovakia / ÚJD SR Date: 26.4.2019				RESOLUTION			
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on
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.

COMMENTS BY REVIEWER Organization: UK Comments Date: 06/03/2019				RESOLUTION				
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on	
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 Restorati on LTD	1.10, final sentenc e	(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.		Х	"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	

14. UK

		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, 3 rd last line	Shouldn't this be changed to "integrated model"		X			
ONR	Para. 2.9, 2 nd 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 elicitationearth science data" is not clear and needs expanding in order to be comprehensible		X	Sentence amended.		
Dounreay Site Restorati on LTD	2.11, final sentenc e	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, 4 th 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?		Х	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'		Х	Put 'potential' after 'the identified'		
ONR	Para 3.11c	What is the 'seismic landscape'?		Х	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 followhow do you do a 'sensitivity analysis' for regional geological data?		Х	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	Reference is made here to field mapping		x	'Geomorphology' as
Ontr	3 22h	to identify geomorphological features		21	used here is a
	5.220	but what about to identify geological			collective term to
		factures like faults in the autoronning			
		hadroals?			footures of well like
		Dedrock?			features as well – like
0117	5				Taults.
ONR	Para	Geochronological dating of what? This		X	This is a reasonable
	3.22d	should refer to some example materials			point to make, but the
		or things that you might date, e.g. fault			level of detail
		rocks (like gouge), vein fills, mineral			requested is beyond
		cements, etc			the scope of a safety
		Reference could be made to specific			guide and more
		techniques, e.g. U-Pb dating of calcite;			apprirpiate to a
		Re-Os dating of base metal sulphides; K-			TecDoc. TecDoc
		Ar dating of illite mineral size fractions			1767 provides some
		in gouge, etc			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	Should all read: "narticularly in relation		X	The potential canable
onte	3 24	to the seismogenic or notential canable		21	fault is a part of the
	3 29	fault structures further identified and			seismogenic structure
	3.27, 3.33 last	characterized during this stage of the			and therefore covered
	5.55 last	studies"			by the sentence as
	sentences	studies			by the sentence as
ONID	Dava			V	already written.
ONK	Para	Should read: Age, type, amount and rate		Λ	Comment as above.
	3.286	of displacement of all the seismogenic or			The potential capable
		potential capable fault structures			fault is a part of the
		identified in the area?			seismogenic structure
					and therefore covered
					by the sentence as
					already written.
ONR	Para.	The footnote is not very clear: PSHA		X	The point picked up
	3.34, 2 nd	calculates annual exceedance frequencies			in the footnote is that
	line	and one must be referring to frequencies			the nuclear
	(footnote	rather than probabilities if the reciprocal			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
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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.

			T	·			
ONR	Para.	This sounds circular unless using data		X	Thank for the comment. Last		
	3.37, 2 nd	from the modern (instrumental) period			sentence moved to separate para.		
	last line				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?			to help remove circular argument	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
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	duration data. 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, 2 nd 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, 3 rd line	Suggest changing "should" to "may" since there are many cases where statistical approaches to estimating M_{max} are not reliable	Х	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	Х	Changed from 'assumed' to 'based on'		
ONR	Para 5.2	Should it be "physics-based"?	Х	Physic → Physics (Typo!)		
ONR	Para. 5.6, 4 th last line	"site profile" rather than "soil profile" since it might be a horizon within a rock profile			Х	Basically agree. But this guide is under SSR-1 named "Site Evaluation for Nuclear Installations" and the term 'site

ONR	Para. 5.7,	"geometry of rupture plane (with respect	X			profile' is used with different meaning there. Therefore, an alternative term has been selected here.
ONR	3 rd line Para. 5.9 (b)	to site)" 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, 1 st sentence	This is valid if the local data is from earthquakes covering a range of magnitude values.	Х	Appreciate the comment. IAEA will strongly recommend the Member States acquire data at the site in this regard.		
ONR	Para. 5.10, 5 th 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, 2 nd 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.		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'?	Х	Typo corrected.		
ONR	Para. 6.12, 1 st 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) Para. 6.15 (6iv)	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 A little vague: should some specification regarding the minimum number of standard deviations be specified?			X	This decision is actually very challenging, but the existing deterministic practices in MSs are represented in the existing text. 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?	Х	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)	Х	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.			Х	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.			Х	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.	Х	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	Х	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 of 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					
ONR	Para 7.16	What approach should be used in cases where there is – or could be – fault creep?				Х	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?				Х	Rejected because combinations with climate change/flood hazards out of scope of this safety guide.
Dounreay Site Restorati on 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			

ONR	Para 9.14	evaluation for a broad range of nuclear installations (see para. 1.9) other than nuclear power plants. This also applies to creeping faults – add	X	Para and title amended to make		
	second sentence	this?		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, 3 rd bullet	CAV is not a damage parameter, just a ground-motion parameter that may indicate damage potential	Х	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	Definitio ns - seismoge nic 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	Definitio ns – 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	Referenc e [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				RESOLU	ΓΙΟΝ	
Comme nt No.	Para/Li ne No.	Proposed new text	Reason	Accepted	Accepted, but modified as follows	Rejected	Reason for modification/rejecti on
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			