Horizon 2020 Programme

METIS

Research and Innovation Action (RIA)

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Summary of the recommendations by the Advisory Board

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METIS - Contract Number: 945121

Project officer: Katerina PTACKOVA

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Summary

Summary of actions following the questions and recommendations from EAB

Approval

Date	By
2024-11-18 15:50:14	Dr. Irmela ZENTNER (EDF)
2024-11-18 15:50:56	Dr. Irmela ZENTNER (EDF)

Summary of EAB Review Meetings

- This document gathers the slides summarizing the outcome from the EAB review meetings
- The material has been presented to the METIS consortium in seperate meetings where METIS EAB shares recommendations with consortium

EAB members

- John Richards, EPRI, USA
- Tadeusz Szczesiak, ENSI, Switzerland
- Robert Budnitz, senior seismic risk expert, retired LBNL, USA
- Nilesh Chokshi, senior seismic risk expert, former USNRC, USA
- Paolo Conti, Zeynep Gulerce, IAEA
- Gernot Thuma, ETSON
- Pekka Valikangas, STUK, Finland
- Abhinav Gupta, NCSU, USA

METIS

Seismic Risk Assessment
for Nuclear Safety

1st EAB Meeting (20 April 2021)

Considerations and Recommendations based on the 2nd METIS Project Meeting

Presented at the METIS EAB Review Meeting,
21 April 2021

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WPs not Discussed in the EAB Meeting

- WP 1 - Management
- WP 2 - Dissemination, Exploitation & Training

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WP 3 - Case Study (1)

- Options presented in the plenary meeting
  - KKNPP ⇒ access to data uncertain
  - ZNPP ⇒ very low seismicity
  - Hybrid solution (ZNPP @ Montalto di Castro) ⇒ not a real site
- The hybrid solution seems reasonable; there are pros and cons
  - New insights regarding seismic hazard and seismic capacity of the plant have no regulatory consequences
  - Certain parameters could be adjusted to fit the needs of the project

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WP 3 - Case Study (2)

- The hybrid solution seems reasonable; there are pros and cons (cont.)
  - Caution needs to be exercised interpreting the SPSA results
  - Comparison with real world data is difficult
- A hybrid solution with KKNPP @ Montalto di Castro might also work
  - This would avoid confidentiality issues with respect to the structural model
- If a real plant is preferred, there might be a fourth option:
  - A NPP that has just been permanently shut down

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WP 4 - Seismic Hazard (1)

- It might be beneficial to specify the added value of the project results compared to current practices
  - Holds in particular for Task 4.1 (e.g. with respect to earthquake catalogue declustering) and its consequence on WP 6 work on damage assessment in relation to aftershocks
  - Could help to align the individual activities with the overall project goals
- Epistemic uncertainties and Bayesian updating were mentioned in the plenary meeting
  - Will the SSHAC approach be used?
  - How will Bayesian updating be incorporated into the logic tree approach?

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WP 4 - Seismic Hazard (2)

- Task 4.4 is dedicated to the hazard assessment with respect to aftershocks
  - In the SPSA context, aftershocks are particularly relevant with respect to fragility analysis (WP 6) and the development of event sequences (WP 7)
  - Continued coordination between WPs should ensure that the output of Task 4.4 is in line with the needs of WP 6 and WP 7

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WP 5 - Site Response & Ground Motion (1)

- In the plenary meeting the focus was on Task 5.1
  - The intended use of the various intensity measures is not completely clear
  - Intensity measures might be used in the context of fragility analyses, therefore coordination with WP 6 should be ensured

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WP 5 - Site Response & Ground Motion (2)

- Task 5.3 - Site response modelling
  - The work on Task 5.3 has not yet started
  - Site response analysis is very important for a realistic hazard assessment
    - High-quality soil model
    - Suitable consideration of soil-structure interaction
    - Avoiding double-counting of uncertainties (coordination between WP 5 and WP 6)
    - Consideration of the κ factor: its use in lieu of explicit site effects, SSI, etc.

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WP 6 - BDB and Fragility Analysis (1)

- In-structure response was not addressed in the plenary meeting
  - Currently information on the link between site response / SSI and the fragility analysis of SSCs is missing
  - A clear distinction between building response and response of components might be beneficial
- The EAB encourages close collaboration between WP5 and WP6 to ensure consistency between the hazard definition and the assessment of the structural response

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WP 6 - BDB and Fragility Analysis (2)

- For the EAB it is not clear how the results from WP 4 regarding aftershocks will be incorporated in the modelling of fragilities (different frequency content and damaging effect, fatigue effects, post-earthquake assessment practice, etc.)
- The failure probability / fragility of SSCs is affected by ageing effects
  - Will ageing be taken into account in WP 6?
    - If so, how (by explicit modelling or modified failure probabilities)?

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WP 7 - PSA Tools and Methodology (1)

- Seismic correlations will be considered in the SPSA model
  - As correlations might depend on floor response spectra and other factors, coordination with the corresponding WPs (e.g. WP 6) should eb ensured
- Human factors play a major roll in SPSA event sequences and should be considered
  - Currently no information on the approach to incorporate human reliability analysis is available
  - Operator reactions in case of an earthquake depend on the level of ground motion and the experience of operators with earthquakes

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WP 7 - PSA Tools and Methodology (2)

- Risk testing (Task 7.5) might be problematic
  - There are very few NPPs that experienced significant ground motion
  - Level 3 PSAs would be required to use fatalities as a risk metric
  - Clarification on the intended approach and the expected outcome would be appreciated

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METIS

Seismic Risk Assessment
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METIS EAB Review Meeting (21 April 2021)

Summary of actions following the questions and recommendations from EAB

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METIS case study

- In a addition to the possible case study candidates presented by WP3, a real plant under decomisionning would be a good option -> Investigate possibility to consider shut down plant
- This option has not yet been considered, need to check possibility to get data and models, to be done in the next weeks:
  - France: Fessenheim -> Emmanuel Viallet (EDF)
  - Switzerland: Mühleberg->Tadeusz Szczesiak
  - USA: Pilgrim NPP -> Bob Budnitz

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Interaction between WPs – establish flow charts

Flow chart 1

- Consideration of aftershocks in SPRA : better connection between WPs for consideration of aftershocks, check literature for state of the art **-> WP3 with all technical WPs**
  - Conditional probability of occurrence (two events)
  - Account for accumulated damage in fragility curvers
  - Multi hazard approach for SPSA system analyses (cf Tsunami) aftershock occurs after mainshock, plant in different state when secondary shaking occurs (shut down)
- Meeting to be organized with partners from WP4,5,6,7

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Interaction between WPs – establish flow charts

Flow chart 2

- Incorporation of site response in the analysis chain (hazard on bedrock - site response – SSI / floor spectra) **-> EDF**
  - Avoid double/triple counting of uncertainties in successive hazard, site response, SSI analysis
  - Clarify input and output for each step of analysis and assure coherency (sets of ground motion on bedrock and soil surface/foundation level, soil columns)

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Organisation of EAB activity

- Meetings
  - Plan EAB meetings ahead in time to better accomodate agendas, 16:00-18:00 Paris time is fine
  - Organisation of the two EAB meetings: assure to have 2 days between the meetings to allow for interaction of the EAB members in the elaboration of the slides with feedback & recommendations
  - Gernot Thuma (GRS) agreed to prepare draft of slides after EAB meeting#2 in october/november 2021 (Thank you very much!)
  - Next plenary and EAB#2: avoid 8,9,11,12nov2021 (PSA meeting in US) and 13-20th november

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Project Partners

EDF

ENERGORISK

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

GÉODYNAMIQUE & STRUCTURE

GFZ
Helmholtz-Zentrum
POTSDAM

GRI
Geo-Research Institute

IRSN
INSTITUT DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

IUSS
Scuola Universitaria Superiore Pavia

LGi
sustainable innovation

NC STATE
UNIVERSITY

PEER

SSTC
NRS

TECHNISCHE UNIVERSITÄT
KAISERSLAUTERN

Univerza v Ljubljani

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THANK YOU

Reach out for more information!

Project coordinator: Irmela Zentner, EDF
contact@metis-h2020.eu

Follow the project on LinkedIn
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All project reports will be available for download on the METIS website: **www.metis-h2020.eu**

METIS

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2nd EAB Meeting (23 Nov. 2021)

Considerations and Recommendations based on the 3rd METIS Project Meeting

Presented at the METIS EAB Review Meeting,
1 December 2021

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WPs not Discussed in the EAB Meeting

- WP 1 - Management
- WP 2 - Dissemination, Exploitation & Training

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Choosing a Methodology

- The EAB recommends that the METIS partners consider the question, what criteria will determine that a proposed methodology is better and more suitable and worth the additional effort under certain conditions?

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Case Study (WP 3)

- 4 options were discussed since the last plenary meeting
  - KKNPP ⇒ access to data uncertain
  - ZNPP ⇒ very low seismicity
  - Hybrid solution (ZNPP @ Italian site) ⇒ not a real site
  - Plant under decommissioning ⇒ no plant accepted to participate in METIS
- It was decided to chose the hybrid solution
  - The EAB recommends that the interface between the Italian site and the Ukrainian NPP should incorporate the following features:
    - Rock ground motion and soil behaviour from Italy
    - Buildings / structure, systems and components from ZNPP

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Case Study (WP 3) contd.

- Data for the Italian site
  - Data will be provided and site can be fully characterized
  - Site must not be mentioned explicitly
    - The EAB believes that his might cause some problems for data exchange / publication of METIS results. This issue requires careful guidance to all participants.

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Case Study and Aim of the METIS Project

- Depending on the aim of the METIS Project (purely methodological vs. methodological but with additional conclusions to be drawn), the plant might be "too weak" for the seismic hazard
- The EAB believes that the important parameter to select is the Reference Earthquake (RE) used to develop in-structure response spectra
  - A possible - but not the only - approach is described on the next slides

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Determination of a Reference Earthquake

- Estimate seismic CDF (SCDF, and SLERF if necessary) using the best available information
- Estimate a plant level fragility for SCDF from pervious similar SPSAs or by trial and error convolution of the hazard with several candidate fragilities within a reasonable range of Am and β values
- Convolve the plant level fragility with the hazard and review the results looking for where the cumulative SCDF reaches 50% of the total, and/or where the largest SCDF contribution, and/or where the slope of the plant level fragility is highest

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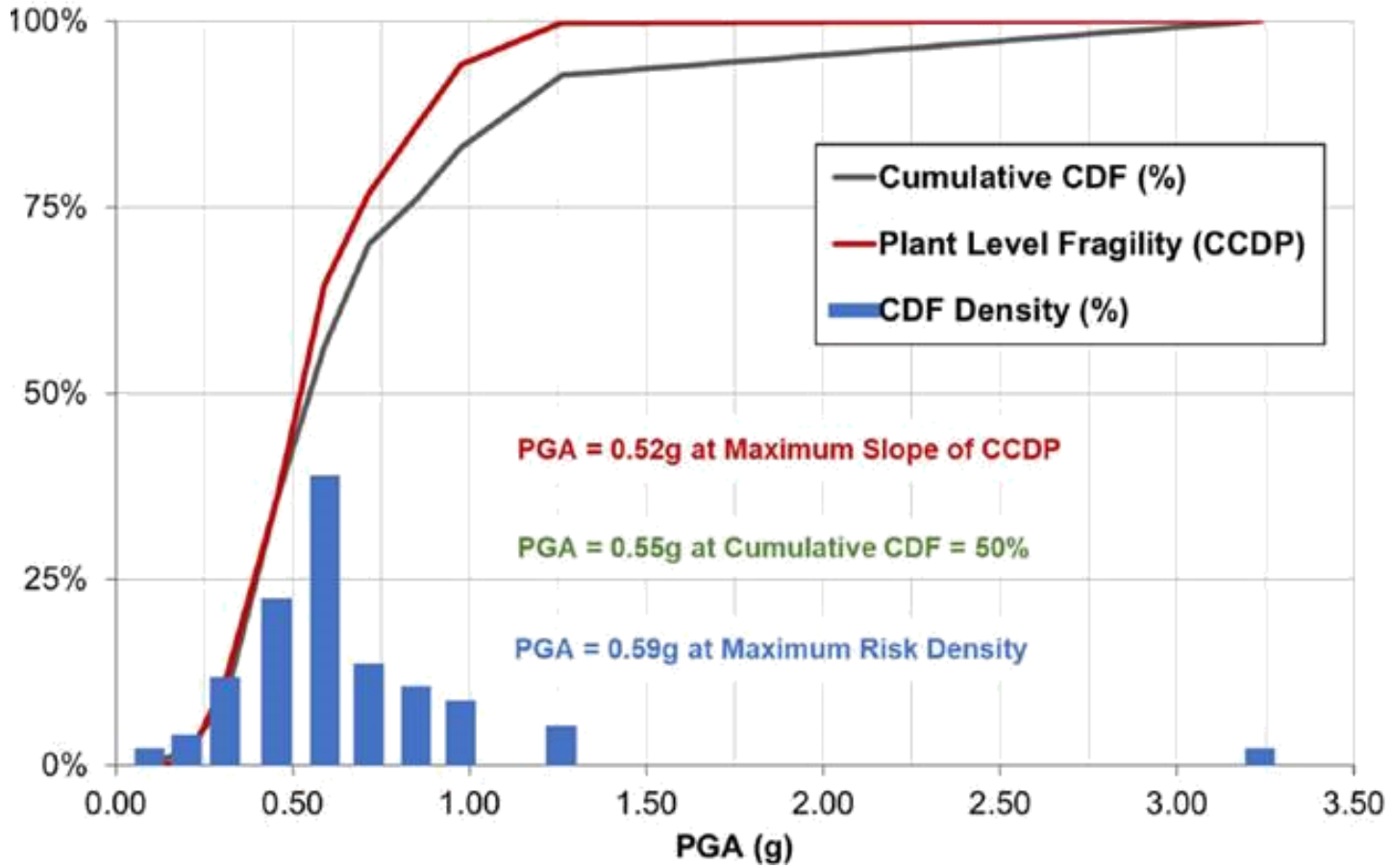
Use of Fragility Curves in Determining a RE



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Determination of a RE (contd.)

- Select a uniform hazard response spectrum with an annual exceedance probability reasonably aligned with that acceleration bin (around 0.5g or 0.6g in the example)
  - This is frequently around 10^{-4} or 10^{-5}, but it doesn't have to be

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Intensity Measures (WP 4 & 5)

- Intensity measure (IM) need to be used so that they relate to functionality needs (fragilities) of SSCs
  - The EAB recommends the use of several IMs. This seem desirable from a scientific and engineering point of view
  - Consideration of several IMs (in a vectorial way) in the PSA model might be very difficult
    ⇒ The EAB believes that it is a reasonable exercise to explore the issue, but due to increased complexity may not be suitable for practical applications
- The EAB recommends that the consequences of using several IMs should be explored first in a simplified exercise

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Consideration of Aftershocks (WP 4 & 5)

- ►The EAB recommends to consider various effects of aftershocks
  - Fatigue-like effects due to repeated mechanical loading
  - Shifted natural frequencies of SSCs damaged by the main shock
  - Different plant states (in the process of shutting down, hot shutdown, cold shutdown) with different SSCs needed to ensure safety
  - Temporal effects (time difference between mainshock and aftershock)
  - Realistic accounting for mitigation capabilities / accident management strategies
  - Damage to other SSCs due to different frequency content and duration
- ►The EAB recommends that the consequences of considering aftershocks should be explored in a simplified exercise

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Consideration of Aftershocks (WP 4 & 5) contd.

- ►Furthermore, the EAB recommends to
  - Be careful about double counting of frequencies or consequences, e.g.
    - In a Level 1 PSA, sequences that resulted in core damage from main shock should not be retained in aftershock analysis
    - In a Level 2 PSA, those sequences will have to be retained but still not double counted in CDF
  - Limit the number of aftershocks in the analysis (≤ 2)
  - Limit the time window for aftershocks to a few days after the mainshock (depending on the plant conditions)

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Declustering (WP 4)

- WP 4 is trying to improve the earthquake catalog through improved declustering of earthquakes close to each other in space or time
  - The objective is to provide seismic hazard analysts with guidance on how to perform declustering in a more rigorous manner
- The EAB recommends that the METIS team identifies a few experts on declustering techniques outside of the METIS project, and ask them to perform a peer review of the method(s) being advanced by the METIS team, so as to obtain the benefit of broader insights in this controversial area

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WP 6 - BDB and Fragility Analysis

- Nonlinearity of the soil and consequences for structural analyses
  - The EAB recommends that guidance is developed early in the METIS project concerning to what extent nonlinearities will be considered

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WP 7 - PSA Tools and Methodology

- Multiple IMs
  - The EAB recommends that an understanding is developed about to what extent the PSA tools are able to deal with multiple IMs

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METIS

Seismic Risk Assessment
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METIS EAB Review Meeting (1 December 2021)

Summary of actions following the questions and recommendations from EAB

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General Methodological Considerations

- Criteria should be specified for assessing whether a new methodology developed in METIS is better, more suitable and worth the additional effort under certain conditions
  - Improved representation of the physical system: Comparison to a reference solution, comparison to data
  - Industrial feasibility: computation time, modelling effort vs impact on risk quantification
- Preserve – at least in principle – the SSHAC philosophy
  - A Level 3 or 4 study is not feasable in the context of METIS, but it is recommended to apply the principles of Level 1 or 2

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Case Study

- Need to further define how to accommodate ZNPP with Italian site, (define reference earthquake, …, site conditions and embedment)

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Hazard Aspects

- Declustering techniques can have significant impact on hazard assessment and are controversial
- Need to be in agreement with approach for considering aftershocks
- Compare new approaches to literature, peer review
- Apply general framework/ideas of SSHAC procedure

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Illustration of the Risk Quantification Chain

- Develop a very simple example to illustrate the risk quantification analysis chain. There are 3 reasons:
  - To share current practice for seismic PSA in the METIS consortium: use of hazard ground motion, fragility (simple and detailed approaches), and risk quantification
  - To assess feasibility of considering 2 IMs in the seismic PSA analysis chain (impact on hazard, fragility, risk), approach needs to be compatible with standard 1 IM case
  - To develop/assess approach for the consideration of aftershocks (from a computational point of view)

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Organisation of EAB Activity

- Meetings
  - When the EAB participates remotely, organize the EAB review meeting 1-2 days after the plenary rather than directly after, to allow more time for deliberation
  - When most EAB members participate physically, organize the EAB review meeting at the end of day 2.
  - Next plenary and EAB#3: April 2022 (probably remotely)

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TECHNISCHE UNIVERSITÄT
KAISERSLAUTERN

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METIS

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2nd EAB Meeting (7 Jun. 2022)

Considerations and Recommendations based on the METIS 3rd Plenary Meeting

Presented at the METIS EAB Review Meeting,
24 June 2022

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WPs not Discussed in the EAB Meeting

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Choosing a Methodology

- (EAB1)The EAB recommends that the METIS partners consider the question, what criteria will determine that a proposed methodology is better and more suitable and worth the additional effort under certain conditions?
- (EAB2) This recommendation is still valid

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Case Study (WP 3)

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Case Study (WP 3)

- It was decided to chose the hybrid solution
  - (EAB1)The EAB recommends that the interface between the Italian site and the Ukrainian NPP should incorporate the following features:
    - Rock ground motion and soil behaviour from Italy
    - Buildings / structure, systems and components from ZNPP
  - (EAB2) The EAB recommendation has been followed.

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Case Study (WP 3) contd.

- Data for the Italian site
  - Data will be provided and site can be fully characterized
  - Site must not be mentioned explicitly
    - (EAB1) The EAB believes that his might cause some problems for data exchange / publication of METIS results. This issue requires careful guidance to all participants.

- (EAB2) The EAB recommendation above has been followed.

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Case Study and Aim of the METIS Project

- Depending on the aim of the METIS Project (purely methodological vs. methodological but with additional conclusions to be drawn), the plant might be "too weak" for the seismic hazard
- (EAB1) The EAB believes that the important parameter to select is the Reference Earthquake (RE) used to develop in-structure response spectra (ISRS)

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Intensity Measures (WP 4 & 5)

- Intensity measure (IM) need to be used so that they relate to functionality needs (fragilities) of SSCs
  - (EAB1) The EAB recommends the use of several IMs. This seem desirable from a scientific and engineering point of view
  - Consideration of several IMs (in a vectorial way) in the PSA model might be very difficult
    ⇒ (EAB1) The EAB believes that it is a reasonable exercise to explore the issue, but due to increased complexity may not be suitable for practical applications

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Intensity Measures (WP 4 & 5)

- (EAB1) The EAB recommends that the consequences of using several IMs should be explored first in a simplified exercise
- (EAB2) The recommendations is still valid.
  - Please explore and explain which IM is to be used and for which purpose.
  - As mentioned in the discussions three IM (PGA, Max_Sa, Average Sa) seem to be easiest to accommodate in fragility calculations

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Consideration of Aftershocks (WP 4 & 5)

- (EAB1) The EAB recommends to consider various effects of aftershocks
  - Fatigue-like effects due to repeated mechanical loading
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  - Different plant states (in the process of shutting down, hot shutdown, cold shutdown) with different SSCs needed to ensure safety
  - Temporal effects (time difference between mainshock and aftershock)
  - Realistic accounting for mitigation capabilities / accident management strategies
  - Damage to other SSCs due to different frequency content and duration

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Consideration of Aftershocks (WP 4 & 5)

- (EAB1) The EAB recommends that the consequences of considering aftershocks should be explored in a simplified exercise
- (EAB2) This EAB recommendation is still valid.
- Aditional Remarks
  - System model may be different for aftershocks
  - A qualitative investigation is needed (what can happen to the structure, which failure modes can be affected by structural response to the mail event)
  - What is the significance of the frequency shift due to cracking?
  - Fatigue is probably too demanding to be included

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Consideration of Aftershocks (WP 4 & 5) contd.

- (EAB1) Furthermore, the EAB recommends to
  - Be careful about double counting of frequencies or consequences, e.g.
    - In a Level 1 PSA, sequences that resulted in core damage from main shock should not be retained in aftershock analysis
    - In a Level 2 PSA, those sequences will have to be retained but still not double counted in CDF

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Consideration of Aftershocks (WP 4 & 5) contd.

- Limit the number of aftershocks in the analysis (≤ 2)
- Limit the time window for aftershocks to a few days after the mainshock (depending on the plant conditions)

►(EAB2) The EAB recommendations is still valid.

- EAB notes that only one aftershock is going to be considered

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Declustering (WP 4)

- WP 4 is trying to improve the earthquake catalog through improved declustering of earthquakes close to each other in space or time
  - The objective is to provide seismic hazard analysts with guidance on how to perform declustering in a more rigorous manner

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Declustering (WP 4)

- (EAB1) The EAB recommends that the METIS team identifies a few experts on declustering techniques outside of the METIS project, and ask them to perform a peer review of the method(s) being advanced by the METIS team, so as to obtain the benefit of broader insights in this controversial area
- (EAB2) This recommendation has been addressed. Two meeting with experts have taken place. However, findings are to be reported

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WP 6 - BDB and Fragility Analysis

- Nonlinearity of the soil and consequences for structural analyses
  - (EAB1) The EAB recommends that guidance is developed early in the METIS project concerning to what extent nonlinearities will be considered
  - (EAB2) This recommendation has been not addressed yet
- (EAB2) EAB remarks
  - The methodology to consider the SSI and to determine the ISRS needs to be explained in more detail. Also the clear definition of the interface to WP5 is necessary (double counting of uncertainties in near field).
  - The motivation and risks of using the surrogate models should be explained

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WP 7 - PSA Tools and Methodology

- Multiple IMs
  - (EAB1) The EAB recommends that an understanding is developed about to what extent the PSA tools are able to deal with multiple IMS
  - (EAB2) The problem of failure of identical components shall to be discussed. The easy-to-use methodology to define the correlation is to be specified.

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METIS

Seismic Risk Assessment
for Nuclear Safety

METIS EAB Review Meeting (24 June 2022)

Summary of actions following the questions and recommendations from EAB

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General Methodological Considerations

- Criteria should be specified for assessing whether a new methodology developed in METIS is better, more suitable and worth the additional effort under certain conditions
  - Improved representation of the physical system: Comparison to a reference solution, comparison to data
  - Industrial feasibility: computation time, modelling effort vs impact on risk quantification
- Preserve – at least in principle – the SSHAC philosophy
  - A Level 3 or 4 study is not feasable in the context of METIS, but it is recommended to apply the principles of Level 1 or 2

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Case Study

- Need to further define how to accommodate ZNPP with Italian site, (define reference earthquake, …, site conditions and embedment)

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Hazard Aspects

- Declustering techniques can have significant impact on hazard assessment and are controversial
- Need to be in agreement with approach for considering aftershocks
- Compare new approaches to literature, peer review
- Apply general framework/ideas of SSHAC procedure

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Illustration of the Risk Quantification Chain

- Develop a very simple example to illustrate the risk quantification analysis chain. There are 3 reasons:
  - To share current practice for seismic PSA in the METIS consortium: use of hazard ground motion, fragility (simple and detailed approaches), and risk quantification
  - To assess feasibility of considering 2 IMs in the seismic PSA analysis chain (impact on hazard, fragility, risk), approach needs to be compatible with standard 1 IM case
  - To develop/assess approach for the consideration of aftershocks (from a computational point of view)

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Additional Remarks

- It would be useful to establish a procedure to keep track of how the recommendation of EAB has been addressed.
- The access to Flexx-platform should be provided for EAB-members

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Organisation of EAB Activity

- Meetings
  - When the EAB participates remotely, organize the EAB review meeting 1-2 days after the plenary rather than directly after, to allow more time for deliberation
  - When most EAB members participate physically, organize the EAB review meeting at the end of day 2.
  - Next plenary and EAB#3: April 2022 (probably remotely)

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METIS

Seismic Risk Assessment
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Decisions from METIS EAB Review Meeting (24 June 2022)

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Decisions

- Follow up of EAB recommendations -> all WP leads

  - After each EAB recommendation meeting, WP leaders prepare a response to the question related to their WP

  - At each plenary, each WP prepares 1-2 slides explaining how they adressed the EAB recommendations

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Decisions

- EAB acces to METIS deliverables ->LGI

  - Send seperate message to EAB once and each time a deliverable has been validated on FLEXX (in addition to message send to FLEXX users), append report to message (EAB does not have acces to FLEXX)

  - Send an email to EAB with the already available technical reports from WP 3, WP4, WP5, WP6 and WP7

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Decisions

- Case study and accomodation of ZNPP to Italian site
  - A flow chart is required, in particular the strategy of WP6 to adress fragility assessment is needed –> WP6 & WP3
  - WP6 input on numerical simulation strategy for selected SSCs from tier 1 list required, strategy for fragility from tier 2 list to be developed -> WP6
  - ✓ It is expected that generic fragilities do not need modification when used with the different sites
- Comments
  - The design seems to be very robust, design PGA is 0.16g? (to be verified), it seems that plant has been revaluated for 0,3g in some locations, -> no majors problems when carrying ZNPP to the Italien site
  - ✓ The CDF will be increased (>10-6) but this might not be an issue for METIS case study purposes
  - What is the 10000 years return period of PGA for the site in Italy?

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THANK YOU

Reach out for more information!

Project coordinator: Irmela Zentner, EDF
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All project reports will be available for download on the METIS website: **www.metis-h2020.eu**

METIS

Seismic Risk Assessment
for Nuclear Safety

METIS EAB Review Meeting (5 December 2022)

Summary of actions following the questions and recommendations from EAB

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General Methodological Considerations

- Preserve – at least in principle – the SSHAC philosophy
  - A Level 3 or 4 study is not feasible in the context of METIS, but it is recommended to apply the principles of Level 1 or 2
  - The time dependencies between subprojects make it infeasible to carry out a hazard study according to the SSHAC methodology, even for level 1 or 2 only.
  - EAB suggest to write a short document explaining why the proposed simplified hazard model is appropriate for the purpose of the METIS project.
  - EAB also proposes to assess the impact that a more detailed hazard study would have on the final results of METIS.

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General Methodological Considerations

- EAB recommends to make clear which methods and developments are to be applied directly to the study and which will be part of recommendations for future studies

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Case Study

- Need to further define how to accommodate ZNPP with Italian site, (define reference earthquake, …, site conditions and embedment)

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Hazard Aspects

- Declustering techniques can have significant impact on hazard assessment and are controversial
- Need to be in agreement with approach for considering aftershocks
- Compare new approaches to literature, peer review
- Apply general framework/ideas of SSHAC procedure if possible.

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Aftershocks

- EAB supports the idea of a dedicated workshop on aftershocks. The following remarks should be considered:
  - An aftershock has no significance if the main event produces elastic response of the SSC
  - The main event considered should produce intermediate damage only.
  - The objective of the workshop should be to clarify, which aspects are to be considered and provide information to develop the corresponding guidelines.

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Correlation of Seismic Performance in Similar SSCs

- EAB recommends, that final guidance should emphasise using sensitivity studies to identify those few correlation issues that are important
- Related guidelines can be found in NUREG/CR-7237 "Correlation of Seismic Performance in Similar SSCs"

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WP6

- EAB recommends to ensure that the simplified surrogate models used in the project represent adequately the behavior of the considered structure
- EAB recommends to consider estimating the fragilities of a few components using SSI results directly. These results could then be compared with those obtained using the standard methodology including generation of FRS.
- In general, EAB recommends that results obtained using simplified methods should be compared with "exact" solution if possible. The "conservatism" of the applied methods should be quantified.
- EAB recommends to discuss the issue of double counting of uncertainties taking into account P. Renault's remark

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Illustration of the Risk Quantification Chain

- Develop a very simple example to illustrate the risk quantification analysis chain. There are 3 reasons:
  - To share current practice for seismic PSA in the METIS consortium: use of hazard ground motion, fragility (simple and detailed approaches), and risk quantification
  - To assess feasibility of considering 2 IMs in the seismic PSA analysis chain (impact on hazard, fragility, risk), approach needs to be compatible with standard 1 IM case
  - To develop/assess approach for the consideration of aftershocks (from a computational point of view)

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Additional Remarks

- It would be useful to establish a procedure to keep track of how the recommendation of EAB has been addressed.
- EAB acknowledges that the implementation of the previous recommendations has started well.
- The access to essential documents should be provided for EAB-members

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Organisation of EAB Activity

- Meetings
  - When the EAB participates remotely, organize the EAB review meeting 1-2 days after the plenary rather than directly after, to allow more time for deliberation
  - When most EAB members participate physically, organize the EAB review meeting at the end of day 2.
  - EAB proposes to give EAB members the opportunity to participate remotely in the technical sessions on day 2.

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Summary of actions from former EAB recommendations still to be adressed – summary from project coordinator

Actions following EAB recommendations

- WP 3 Case study
  - Define what criteria will determine that a proposed methodology is better and more suitable and worth the additional effort under certain conditions?
- WP 4/5/6/7 (all WPL) Intensity Measures
  - Analyse consequences of using several IMs should be explored first in a simplified exercise (lead WP6)
  - Develop understanding about to what extent the PSA tools are able to deal with multiple IMS (lead WP7)
- WP4 Declustering
  - Two meetings with experts have taken place. Findings are to be shared

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Actions following EAB recommendations

- WP 6 SSI and ISRS
  - The methodology to consider the SSI and to determine the ISRS needs to be explained in more detail. Also the clear definition of the interface to WP5 is necessary (double counting of uncertainties).
  - The feasibility and benefits of using the surrogate models for (in particular for complex structural models) should be clearly examined and shared
- WP5/6 Soil nonlinearities and consequence for SSI
  - Guidance concerning to what extent nonlinearities will be considered
  - ✓ Linear equivalent modelling strategies are adopted, guidance in upcoming report

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Actions following EAB recommendations

- WP4/5/6/7 Aftershocks
  - The EAB recommends that the consequences of considering aftershocks should be explored in a simplified exercise
  - Be careful about double counting of frequencies or consequences e.g.in a Level 1 PSA, sequences that resulted in core damage from main shock should not be retained in aftershock analysis (WP7)

- Workshop in February 9th & 14th, 2023 (two dates, teams)

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EAB recommendations follow-up

- Work package leaders (WPL)
  1. WP leaders prepare a response to the EAB question related to their WP
  2. Next Plenary: each WPL prepares few slides explaining how they adressed the EAB recommendations

- John Richards, EPRI, USA
- Tadeusz Szczesiak, ENSI, Switzerland
- Robert Budnitz, senior seismic risk expert, retired LBNL, USA
- Nilesh Chokshi, senior seismic risk expert, former USNRC, USA
- Paolo Conti, IAEA
- Gernot Thuma, ETSON
- Pekka Valikangas, STUK, Finland
- Abhinav Gupta, NCSU, USA

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METIS

Seismic Risk Assessment
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EAB Review Meeting
17 November 2023

Considerations and Recommendations based on the 6th METIS Plenary Meeting

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WP(s) not Discussed in the EAB Meeting

- WP 2 - Dissemination, Exploitation & Training

- Next METIS plenary meetings / final symposium
  - 5 - 6 June 2024 in Slovenia (Univ. Ljubljana)
  - 27 – 29 Nov. 2024 in Germany (TU Kaiserslautern)
  - 21 – 23 May 2025 in France (EDF, Paris Saclay)

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Comments and Recommendations by the EAB

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General Considerations (I)

- Many insights have been gained during the METIS project, but not all might be relevant for nuclear installations, in particular NPPs
  - (EAB1) The EAB recommends to keep the intended application to seismic safety analyses for nuclear installations in mind during the final stage of the project.

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General Considerations (II)

- The insights gained in the various work packages are definitely valuable in the respective fields, but in the end they should be usable in a combined way to allow for an effective seismic safety analysis for nuclear installations
  - (EAB2) Good coordination and communication between the individual work packages (upstream and downstream) should be maintained to ensure that every discipline provides the information to the others that is most relevant. Key assumptions and simplifications should also be identified.

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General Considerations (III)

- A lot of work has been done in the work packages and it is sometimes hard to keep track of all new developments.
  - (EAB3) In the final report, a short overview should be given for each work package
    - What has been done?
    - What is new compared to current practices?
    - What are the main insights?
    - What are the most important remaining methodology difficulties or major uncertainties?

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General Considerations (IV)

- A lot of people seem not to have heard of METIS
  - (EAB4) The EAB encourages the project leaders and the leaders of the work packages to advertise the work done by METIS in meetings, workshops, conferences, etc.
  - For this purpose it might be useful to prepare short and concise papers on the METIS project that will receive wide readership. (e.g. in Nuclear Engineering International)
    - One technical
    - One less technical

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METIS

Seismic Risk Assessment
for Nuclear Safety

EAB Review Meeting January 2024

Introduction from project coordinator:

Feedback on Considerations and Recommendations based on the 6th METIS Plenary Meeting

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Comments to Recommendations by the EAB

First of all thank you very much

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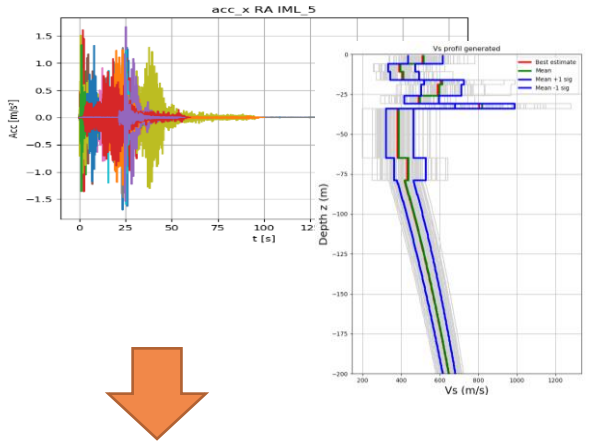
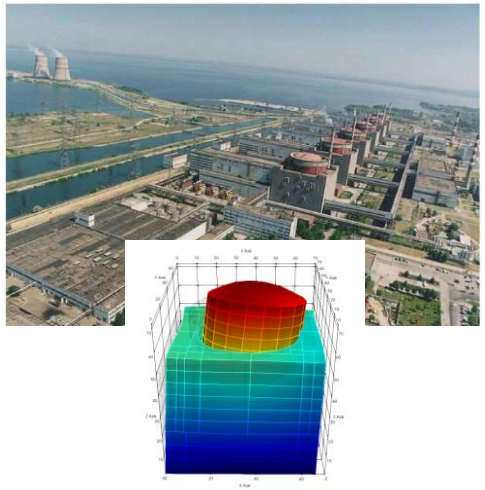
General Considerations (EAB1)

- (EAB1) The EAB recommends to keep the intended application to seismic safety analyses for nuclear installations in mind during the final stage of the project.

✓ Agreed, need to fully implemented METIS case study

- -> work with case study data, input, models and output





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General Considerations (EAB2)

- (EAB2) Good coordination and communication between the individual work packages (upstream and downstream) should be maintained to ensure that every discipline provides the information to the others that is most relevant. Key assumptions and simplifications should also be identified.

- Communication and data sharing actions planned in WP3 early 2024 related to case study data and applications

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General Considerations (EAB3)

(EAB3) In the final report, a short overview should be given for each work package

- What has been done?
- What is new compared to current practices?
- What are the main insights?
- Is it applicable in nuclear engineering industrial context?
- What are the most important remaining methodology difficulties or major uncertainties?

- Adress both PRA practitioners and decision makers in (separate?) documents, insights LWR – what is particular and what is applicable to new reactors?

✓ Keep in mind these questions for WP recommendations (each WP has recommendations deliverable) and final guidelines

✓ Peer review to be conducted 2024

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General Considerations (EAB4)

(EAB4) advertise the work done by METIS in meetings, workshops, conferences, etc., two papers technical and less technical to disseminate and promote

- Increased effort to promote METIS output and increase awareness
  - Scientific results papers -> advertise on Linkedin and METIS website
  - Special sessions in conferences -> WCEE, SMiRT 2024, 2025
  - Lessons-learned paper(s) for larger public in NED, METIS special edition in NED
  - …
- Professional networks

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METIS

Seismic Risk Assessment
for Nuclear Safety

EAB Review Meeting
6th June 2024

Considerations and Recommendations based on the 7th METIS Plenary Meeting

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WP(s) not Discussed in the EAB Meeting

- WP 2 - Dissemination, Exploitation & Training

- Next METIS plenary meetings / final symposium
  - 25 Nov. 2024 plenary meeting (Teams)
  - 21 – 23 May 2025 in France (EDF, Paris Saclay)

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Comments and Recommendations by the EAB

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EAB Comments from 6th Meeting (I)

- Many insights have been gained during the METIS project, but not all might be relevant for nuclear installations, in particular NPPs
  - (EAB1) The EAB recommends to keep the intended application to seismic safety analyses for nuclear installations in mind during the final stage of the project.

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EAB Comments from 6th Meeting (II)

- The insights gained in the various work packages are definitely valuable in the respective fields, but in the end they should be usable in a combined way to allow for an effective seismic safety analysis for nuclear installations
  - (EAB2) Good coordination and communication between the individual work packages (upstream and downstream) should be maintained to ensure that every discipline provides the information to the others that is most relevant. Key assumptions and simplifications should also be identified.

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EAB Comments from 6th Meeting (III)

- A lot of work has been done in the work packages and it is sometimes hard to keep track of all new developments.
  - (EAB3) In the final report, a short overview should be given for each work package
    - What has been done?
    - What is new compared to current practices?
    - What are the main insights?
    - What are the most important remaining methodology difficulties or major uncertainties?

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EAB Comments from 6th Meeting (IV)

- A lot of people seem not to have heard of METIS
  - (EAB4) The EAB encourages the project leaders and the leaders of the work packages to advertise the work done by METIS in meetings, workshops, conferences, etc.
  - For this purpose it might be useful to prepare short and concise papers on the METIS project that will receive wide readership. (e.g. in Nuclear Engineering International)
    - One technical
    - One less technical

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EAB Comments from 7th Meeting (I)

- Aftershocks (AS)
  - (EAB5) The EAB recommends to be aware of significance of general conclusions regarding AS. The EAB recommends to explain, how AS could be included in PRA and point out the technical aspects (e.g. different state of the NPP…). The application areas of the proposed procedures and the need for additional research should be mentioned.
  - AS should not be identified by METIS Project as requirement. The analysis methods can provide new insights but more research is needed to develop the methodology.
  - PSA tools can provide insights even if PSA quantification is not accomplished.

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EAB Comments from 7th Meeting (III)

- SSI, FRS and Fragilities
  - (EAB6) The EAB suggests that any method for SSI (Soil Structure interaction) or FRS (Floor Response Spectra) calculation which is consistent with probabilistic methodology can be used. Simplified methods can be useful but conservative methods should be used carefully to avoid distorting the risk insights.
  - The EAB recommends justification is required for applicability of Euro Code-Methods for FRS estimation for NPPs particularly when relevant SSI effects occur.
  - For the structures, fragilities should be estimated taking into account all relevant failure modes (e.g. geotechnical).

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EAB Comments from 7th Meeting (IV)

- Intensity Measures
  - (EAB7) The EAB is interested in final recommendation on intensity measures and associated explanations.

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EAB Comments from 7th Meeting (V)

- Final Meeting
  - (EAB8) The EAB recommends that the final report with reccomendations should be written and reviewed by EAB before the final meeting. A dedicated meeting with EAB and WP leaders should be organized prior to the May workshop.

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