PSA OF EXTERNAL EVENTS. SPANISH PRACTICE

José G. Sánchez Cabañero
jgsc@consultant.com

Trieste, October 13 of 2017

CONTENT

1. PREAMBLE AND IPEEE PROGRAMME
2. UE – ENSREG STRESS TEST
3. OVERVIEW ON PSHA AND UNCERTAINTY
4. CURRENT SPANISH PSHA APPROACH

1 PREAMBLE AND IPEEE PROGRAMME

PREAMBLE (1 of 2).

- ✓ The need of analysing the risks related to the existing NPPs comes from the fact that, the deterministic safety analysis and resulting design bases establish an upper limit to accidents considered in the plant design, and accidents occurred in certain plants have show the importance of considering accidents occurrence beyond design bases.
- ✓ In Spain, after finish the older plants re-evaluation by deterministic methods (USNRC, SEP and USI A-46), the CSN approved (June 1986) a PSA Integrated Program to be applied, step by step, to all Spanish NPPs and with increasing scope in every step.

1 | PREAMBLE AND IPEEE PROGRAMME

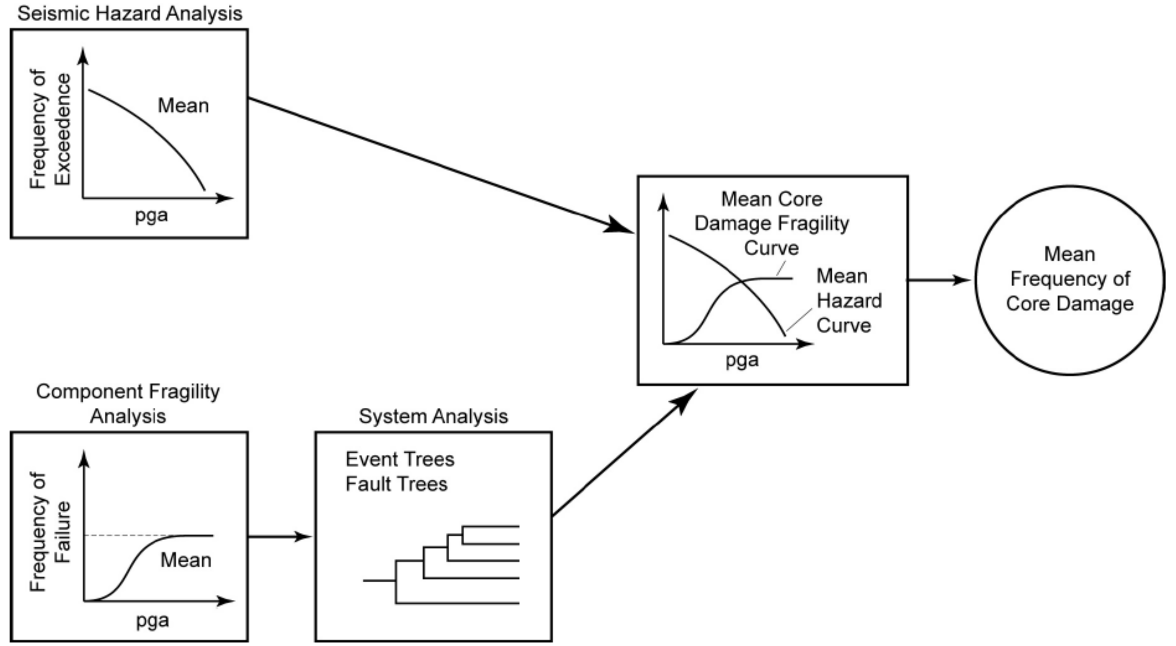
PREAMBLE (2 of 2).

✓ In this framework, consideration of External Events was required by the CSN to analyse in terms of likelihood the behaviour of the plants against events beyond design bases, identifying vulnerabilities and to correct those ones that supposed a reasonable cost. The USNRC practice for the IPEEE programme (NUREG-1407) was followed.

- For seismic hazards, methods of PRA and SMM (both, USNRC and EPRI approaches) were considered acceptable by CSN (NEA-CSNI-R(९९)-२८).
- For other external hazards, a simplified approach was applied to achieve similar target as a whole PSA, but considering conservative enveloping alternatives.

  The hazard value adopted for screening was 10^{-5} like exceedance probability per annum.

1 PREAMBLE AND IPEEE PROGRAMME



The box entitled "System Analysis" indicates event trees or fault trees, which are diagrams that illustrates the links between different structures, systems and components, and how the performance of one of these impacts on the next in the sequence. Although these visually have the appearance of logic-trees (see Section B.3.5) they are quite different in meaning and application.

Figure B-1. Risk-Assessment Methodology for Seismic Input (Kennedy, 1999).

1 PREAMBLE AND IPEEE PROGRAMME

HCLPF values for the mean seismic capacity, to reach shutdown by two independent paths and maintaining the plant 72 h in a safe condition.

SITE	DBE - SSE	SAFE SHUTDOWN SAFETY FUNCTION	CONTAINMENT ISOLATION AND INTEGRITY	SPENT FUEL POOL INTEGRITY (SFP)
	PGA	HCLPF VALUE OF PLANT SEISMC CAPACITY		
Trillo	0.12 g	0.20 g	0.30 g	0.24 g Temp. Stor. Bdg. 0.30g
Vandellós 2	0.20 g	0.30 g	0.30 g	0.30 g
Cofrentes	0.17 g	0.28 g	0.50 g	0.30 g
Ascó I-II	0.13 g	0.30 g	0.30 g	0.30 g
Almaraz I-II	0.10 g	0.21 g Unit I 0.24 g Unit II	0.30 g	0.30 g
Garoña	0.10 g	0.17 g	0.30 g	0.30 g

1 PREAMBLE AND IPEEE PROGRAMME

Exceedance Probability of the SSE Spectrum

	SSE – PGA	Mean	Median
	0,20g	૧,૩ x ૧૦-૪	1,0 x 10-4
	0,13g	2,8 x 10-4	2,4 x 10-4
	0,17g	૧,૧ x ૧૦-૪	૯,૧ x ૧૦-૫
	0,1g	૧,૨ x ૧૦-૪	૮,૬ x ૧૦-૫
	0,07g	૧,૪ x ૧૦-૪	૧,૧ x ૧૦-૪
	0,12g	5,9 x 10-5	૪,૫ x ૧૦-૫
	0,12g	૫,૦ x ૧૦-૫	૪,૨ x ૧૦-૫
	0,10g	૨,૬ x ૧૦-૫	2,2 x 10-5

1 PREAMBLE AND IPEEE PROGRAMME

Exceedance Probability of 0.3g N./CR-0098 median spectrum

	૫૦%	Mean	૮૫%	Ratio Mean/50%	Ratio ૮૫/૫૦%
	૫,૨ x ૧૦-૫	૬,૫ x ૧૦-૫	૧૦-૪	1,2	1,9
	9,7 x 10-5	1,13 x 10-4	1,7 x 10-4	1,2	1,7
	2,2 x 10-5	૩ x ૧૦-૫	૫,૩ x ૧૦-૫	1,4	2,4
	૬,૨ x ૧૦-૫	૮,૬ x ૧૦-૫	૧,૧ x ૧૦-૪	1,4	1,8
	૧,૧ x ૧૦-૫	૧,૬ x ૧૦-૫	2,7 x 10-5	1,4	2,4
	૫,૩ x ૧૦-૬	૬,૨ x ૧૦-૬	૯,૮ x ૧૦-૬	1,2	1,8
	૧,૬ x ૧૦-૫	1,9 x 10-5	૩,૬ x ૧૦-૫	1,2	2,3

1 PREAMBLE AND IPEEE PROGRAMME

Lessons learned:

- ✓ The need of improving the knowledge on seismic hazard in every nuclear site (to define and reduce the uncertainties) was confirmed.
- ✓ To attend this goal, outlines to R&D activities was developed by the CSN, and a total budget around 1.5 million € to promote derivate projects was dedicated. Main projects carried out were the following:

SHISTO2-SIGMA	Assessing the current/recent main stress field at the Iberian Peninsula
DAÑOS	Collecting a worldwide data base of accelerograms
DATACIÓN	Developing adequate methods to dating recent fault movements at Mediterranean environments
SEGMENTACIÓN	Researching techniques to justify fault segmentation
PRÍOR	Assessing main faults and seismotectonic features of the Iberian Peninsula
EXPEL	Developing a code to run the PSHA for the plants

2 UE – ENSREG STRESS TEST

- ✓ The CSN requires (since 1995) Spanish plants to do a Periodic Safety Review every ten years, to analyse new regulatory requirements and recent operational experience in/off Spain).
- ✓ After FK accident, all Spanish plants are complete the EU Stress Tests Specifications released by the ENSREG on the basis of a transparent and comprehensive risk assessment with the following targets:
  - Reassessment of the safety margins against extreme natural events challenging the plant safety functions and leading to a severe accident.
  - Evaluation of NPPs response when facing a set of extreme natural events beyond its design basis.
  - Verification of measures adopted for plant protection from initiating events, to avoid loss of safety function and reinforce SAM actions.

2 UE – ENSREG STRESS TEST

- ✓ The stress tests technical scope has been essentially a deterministic approach when analysing an extreme scenario, irrespective of its occurrence probability, and were considered:
  - Extreme external events for weather, flood and earthquake must be credible at the site;
  - Credible scenarios of combinations of External Events and failures must be considered too.
- ✓ In addition, the CSN was agree to introduce a programme to update the seismic characterisation of all sites of existing NPPs, and following the IAEA's most recent regulations.

SPAIN National Action Plan, Rev. 1, 2014 12 17, Attachment 2: Recommendations and Suggestions, Suggestion S1
http://www.ensreg.eu/sites/default/files/Spain%20-%20NAcP%20rev.1%202014.pdf

2 UE – ENSREG STRESS TEST

HEAVY RAIN.

✓ The PMP values (DBE) obtained from the time series of rain for each site was increased with a conservative margin to match with values with an exceedance frequency of 10^{-4}. Main improvements were:

- Drainage capability of sites has been increase by rebuilding the networks up to cover those values.
- Hydrostatic resistance of seals in galleries below grade level that connect buildings containing safety-related equipment has been improved.
- The water leak tightness of building gates has been reinforce.

2 UE – ENSREG STRESS TEST

RIVER SITES (1 of 2).

- ✓ Plant compliance with its current licensing basis (DBF) was checked; and sources of flooding and data updated.

  DBF is associated with a very low probability (10^{-5} by year) of being exceeded over the installation life.

  Consideration of severe weather conditions was added.

- ✓ Provisions to protect the plant against extreme floods as identification of SSCs safety related or developing monitoring programmes.

  As cliff edge value, grade level of each plant was considered.

- ✓ Flooding level to withstand without severe damage, duration of sustained maximum level, time between warning and flooding, plant weak points, and additional protective measures to be adopted in order to increase robustness of the plant were established.

2 UE – ENSREG STRESS TEST

RIVER SITES (2 of 2).

- ✓ The critical events for river sites came from rupturing of upstream dams. Two kinds of checking have been performed:
  - Sites with upstream dams, have carried out a structural analysis to verify if they would be capable of withstanding a similar earthquake as the plant DBE (SSE).
  - Specific analyses of dam break were performed to quantify the seismic capacity available for corresponding dams, in relation to seismic margin of each plant.
- ✓ Provisions to protect some sites like increase spillways capacity of dams located downstream are under analysis.

2 UE – ENSREG STRESS TEST

Resulting Flooding Margins

NPP	Grade Level	DBF level	Extreme Flooding Level (Dam break)
Trillo, Tajo river	832.00 m	725.57 m	726.85 m
Vandellós 2, Med. sea	24.30 m	Sea	5 m (not tsunami)
Cofrentes, Jucar river	372.00 m	367.41 m	363.49 m
Ascó I, II, Ebro river	50.00 m	47.70 m	49.85 m
Almaraz I ,II, Tajo river	257.50 m	256.53 m	255.40 m
Garoña, Ebro river	518.10 m	515.72 m	516.00 m

2 UE – ENSREG STRESS TEST

EARTHQUAKE.

- ✓ In addition to the UE stress test scope, an implementation of the necessary improvements to increase to 0.3 g the seismic capacity of equipment relating to the following also was required by the CSN:
  - a) The two “safe shutdown paths” defined in the IPEEE,
  - b) Containment integrity,
  - c) Mitigation of station blackout (SBO) situations, and
  - d) Severe accident management.
- ✓ In May 2015, the CSN releases a new technical Instruction (ITC) that require to licensees of all NPPs start a reassessment of the seismic risk of each site. This assessment need take into account geological and palaeoseismicity data to characterising relevant faults.

https://www.csn.es/csn/actas-del-pleno/2015/-/asset_publisher/ih4J8ik7P3I9/content/pleno-13-1

2 UE – ENSREG STRESS TEST

UPGRADING THE SPANISH PSHA:

A PSHA Level 2 (according the SSHAC nomenclature) was developed (July 2012) by using specific tools from a CSN project (OPPEL), with considering two alternative Iberian Peninsula zonation and adopting maximum magnitudes values from palaeoseismicity data known at that time.

Preliminary matching values with 10^{-4}/year, as mean probability of exceedance, show in most plant sites a discrete increasing above the DBE values and in one site the resulting value was significantly higher.

1 REGULATION AND SITE ASSESSMENT SCOPE

Degrees of SSHAC Issues and Levels of Study (Table 3.1 of the Nureg/Cr-6372)

Issue Degree	Decision Factors	Study Level
A Non-controversial; and/or Insignificant to hazard	Regulatory concern Resources available Public perception	1 *TI* evaluates/weights models based on literature review and experience; estimates community distribution
B Significant uncertainty and diversity; controversial; and complex		2 *TI* interacts with proponents and resource experts to identify issues and interpretations; estimates community distribution
C Highly contentious; significant to hazard; and highly complex		3 *TI* brings together proponents and resource experts for debate and interaction; *TI* focuses debate and evaluates alternative interpretations; estimates community distribution
		4 *TFI* organises panel of experts to interpret and evaluate; focuses discussions; avoids inappropiate behaviour on part of evaluators; draws picture of evaluator´s estimate of the community´s composite distribution; has ultimate responsibility for project

3 OVERVIEW ON PSHA AND UNCERTAINTY

PSHA – PROBABILISTIC SEISMIC HAZARD ANALYSIS

Main Reference: SSHAC Methodology.

- ✓ **USNRC NUREG/CR 6372,**

  Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts,

  Vols. 1 & 2, April 1997.

- ✓ **USNRC NUREG 2127,**

  Practical Implementation Guidelines for SSHAC Level 3 and 4 Hazard Studies,

  Rev. 1, April 2012.

3 OVERVIEW ON PSHA AND UNCERTAINTY

USNRC, NUREG/CR-6372:

"The most important and fundamental fact that must be understood about a SHA is that the objective of estimating annual frequencies of earthquake-caused ground motions can be attained only with significant uncertainty".

3 OVERVIEW ON PSHA AND UNCERTAINTY

SSHAC APPROACH (1 of 3).

Objective: To estimate the probability of exceeding specified seismic levels in a given time period at a specific site, by aggregating the scientific community opinion to include the state of the art and the full range of knowledge.

✓ The figure of merit is capturing the Center, Body and Range of technically defensible interpretations to characterise the uncertainties.

- Center: Best estimate/central value (median) of the distribution,
- Body: Shape of the distribution of interpretations that lie around the Center and capture the major portion of the distribution mass,
- Range: Distribution tails and the limiting credible values.

3 OVERVIEW ON PSHA AND UNCERTAINTY

SSHAC APPROACH (2 of 3).

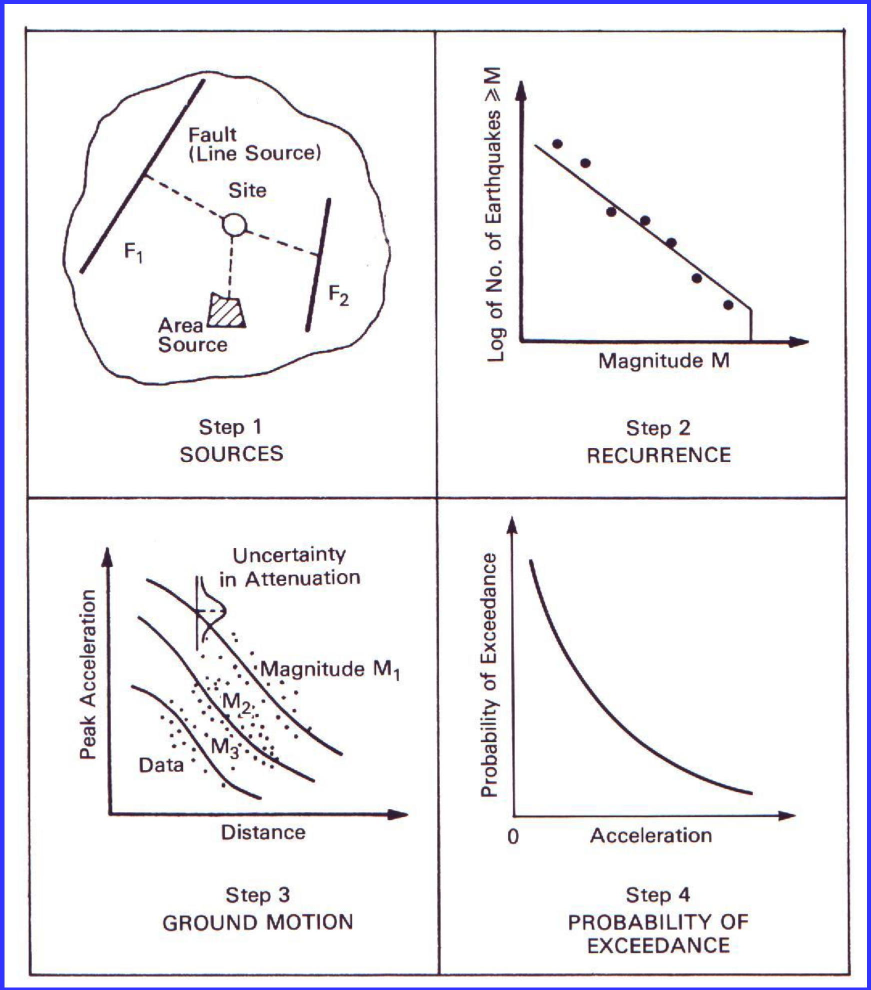
- ✓ Elicitation through some types of experts
- ✓ It is necessary to accept the reality:
  - Consensus among experts is not probable,
  - Don’t have only one correct interpretation, but it’s possible to reach a consensus over the range of all interpretations with technical and data support. Bayesian test,
  - Addressing uncertainties.
- ✓ Knowledge integration by a single entity: TI – TFI.
- ✓ Different (4) levels of analysis.

3 OVERVIEW ON PSHA AND UNCERTAINTY

SSHAC APPROACH (3 of 3).

- ✓ Large uncertainty in numerical results, reflect an approach to reality more realistic.
- ✓ Peer revision
- ✓ Previous methodologies limitations are based on:
  - The procedure used to eliciting expert opinion
  - The way of uncertainties treatment

3 OVERVIEW ON PSHA AND UNCERTAINTY



Main SHA Components:

- Seismic Sources Identification.
- Seismic Sources Characterization:
  - Maximum M_W / Seismicity Rate
- Ground Motion Attenuation.
- Site Effects.

Outputs:

⇨ Elastic Response Spectra and Time Histories on Free Field.

⇨ Hazard Curves for Ac., Vel., Displ.

⇨ Seismic Input on basement of nuclear structures (Site Effects).

4 CURRENT SPANISH PSHA APPROACH

CLASSES OF UNCERTAINTIES

✓ **EPISTEMIC** – Lack of Knowledge.

- The limited data are interpreted in a different way by the experts. this fact transfer large uncertainty to results,
- Will be standby at the time, and only will be reduce by using new and more refined models.

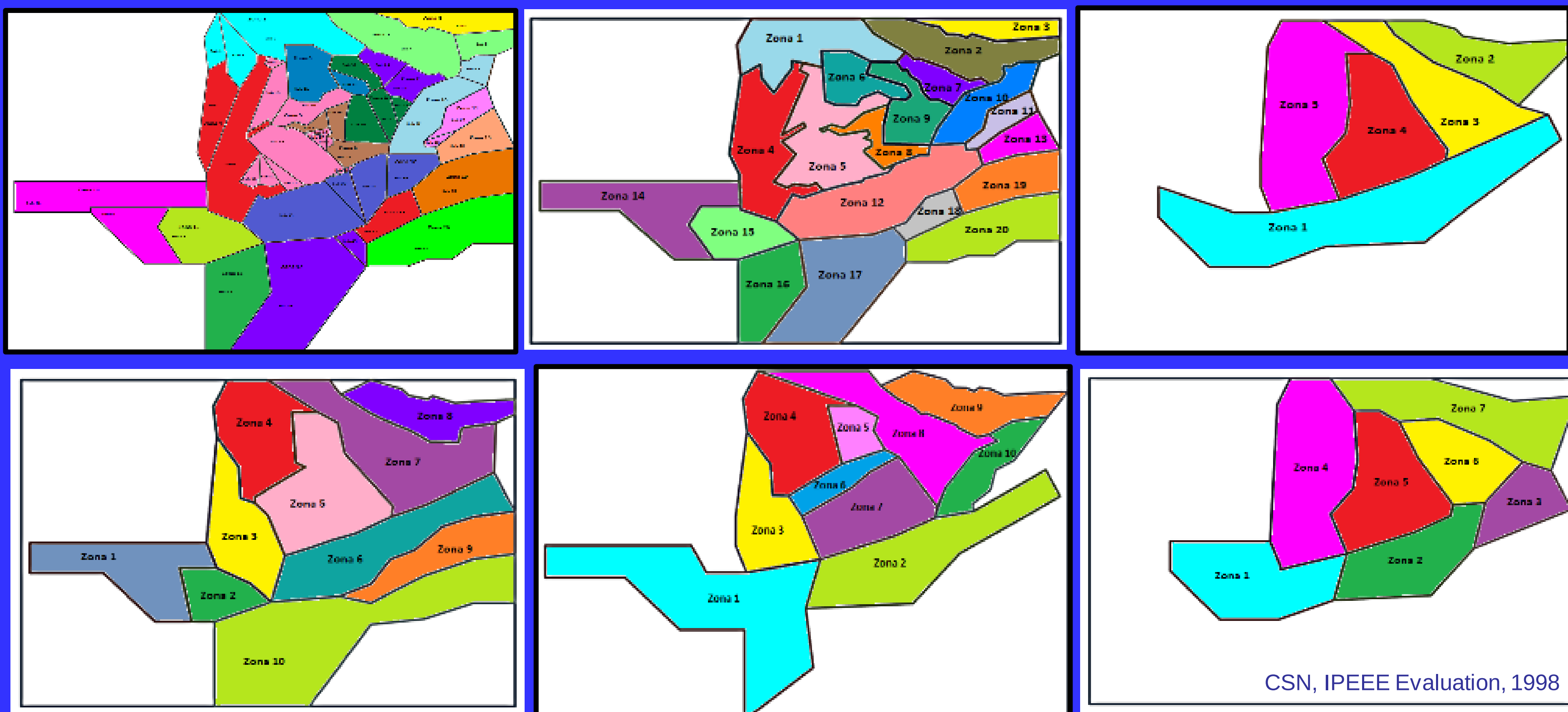
✓ **ALEATORY** – Weak Modelling.

- There are serious limitations on knowledge of earthquake mechanisms and his energy propagation,
- Will be reduce with the time on the basis of research and gathering of more data with better quality

4 CURRENT SPANISH PSHA APPROACH

EPISTEMIC

Seismic Sources Zonation from Different Experts

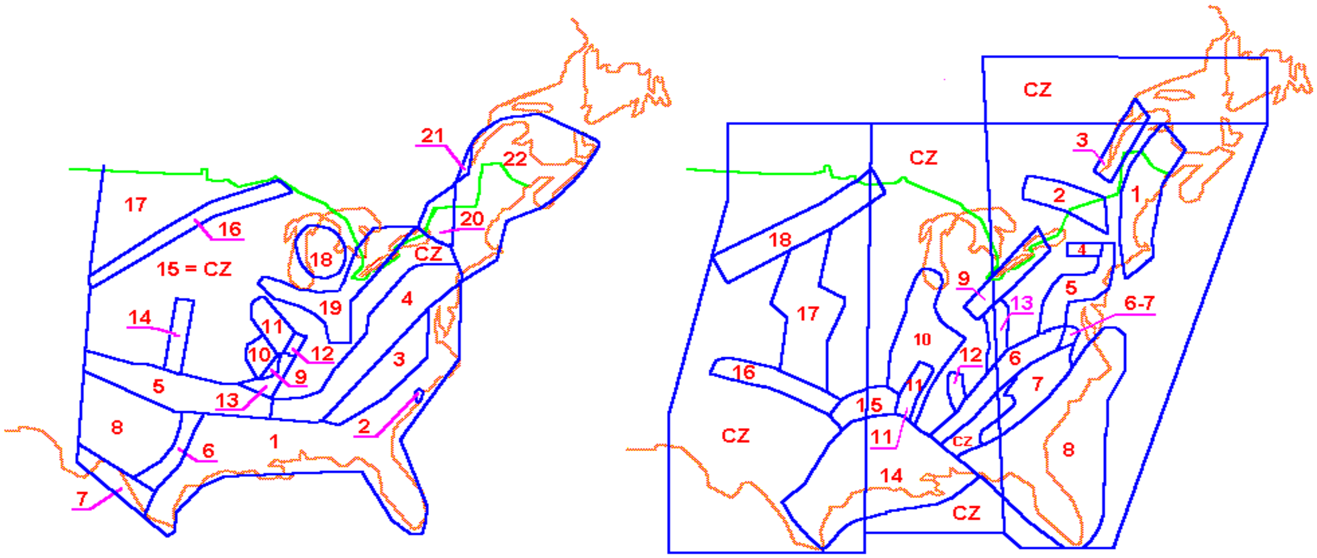


CSN, IPEEE Evaluation, 1998

4 CURRENT SPANISH PSHA APPROACH

EPISTEMIC

Seismic Sources Zonation from Different Experts

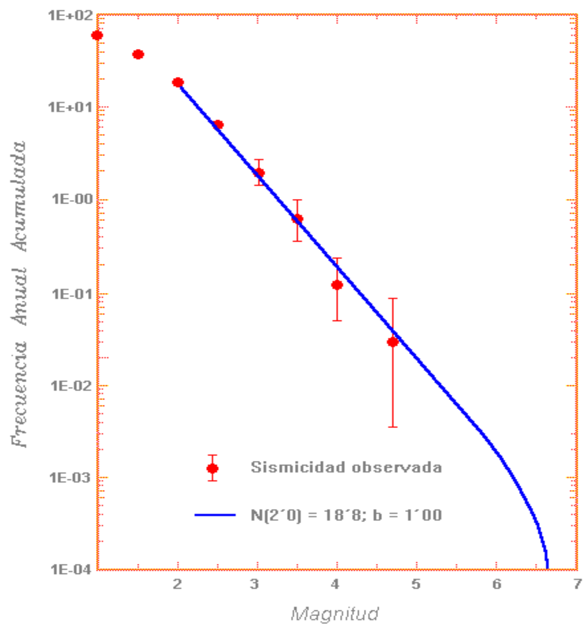


USNRC NUREG/CR-6372, April 1997

4 CURRENT SPANISH PSHA APPROACH

ALEATORY

Seismic Sources Characterization



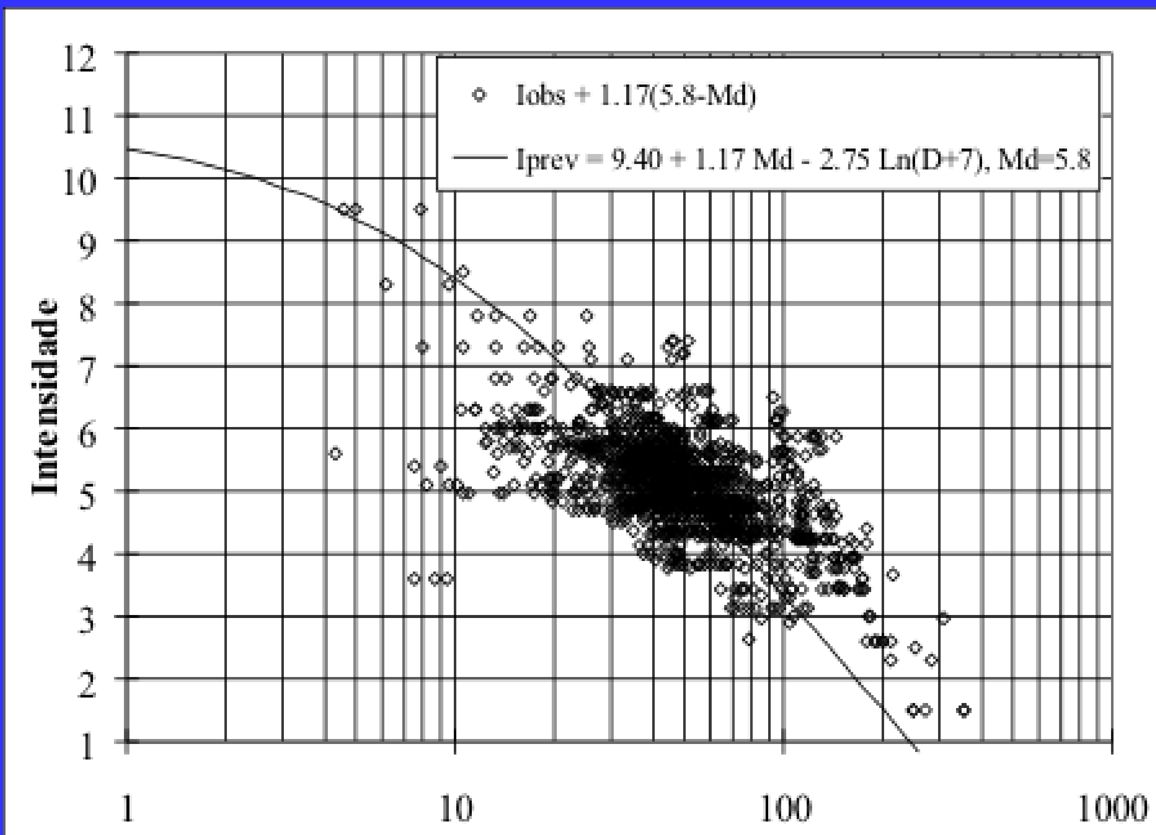
USNRC NUREG/CR-6372, April 1997

3 OVERVIEW ON PSHA AND UNCERTAINTY

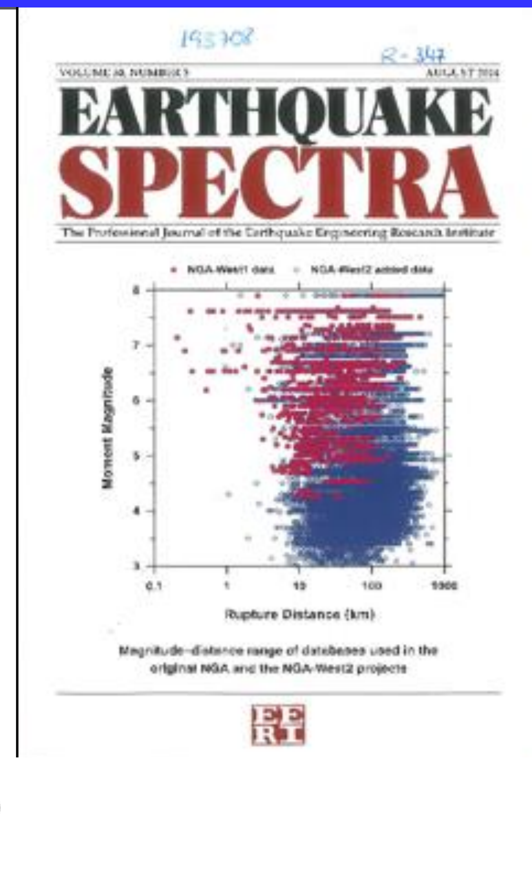
ALEATORY

Scatter in Açores Attenuation Data

West, NGA-Data Bases Red 03 / Blue 14



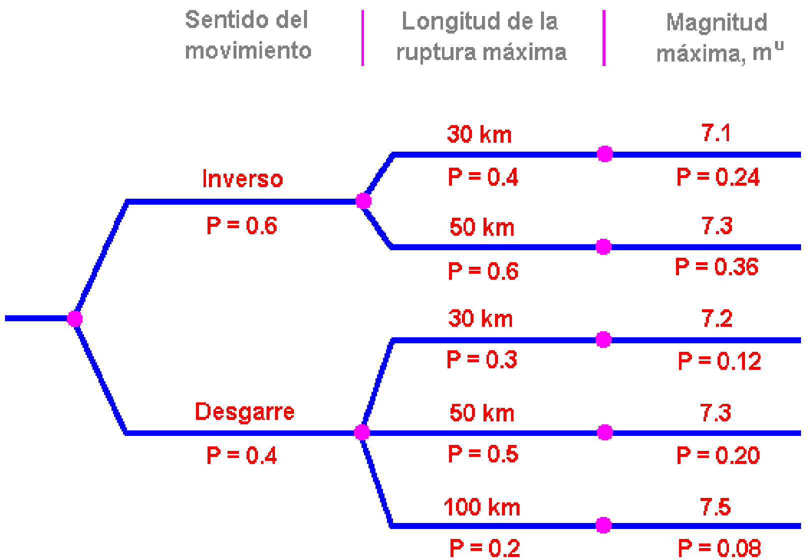
Paula et al, 1996)



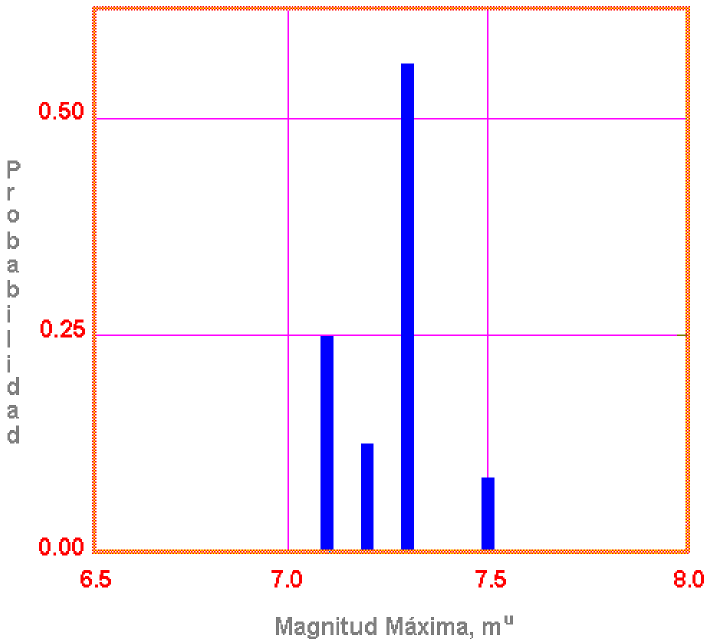
3 OVERVIEW ON PSHA AND UNCERTAINTY

ADDRESSING UNCERTAINTIES

Logic Three Procedure



a) Árbol Lógico para evaluar la Magnitud Máxima, m^u



b) Distribución discreta de la Magnitud Máxima, m^u

USNRC NUREG/CR-6372, april 1997

4 CURRENT SPANISH PSHA APPROACH

EFFECTS OF UNCERTAINTY ON PSHA OUTPUTS

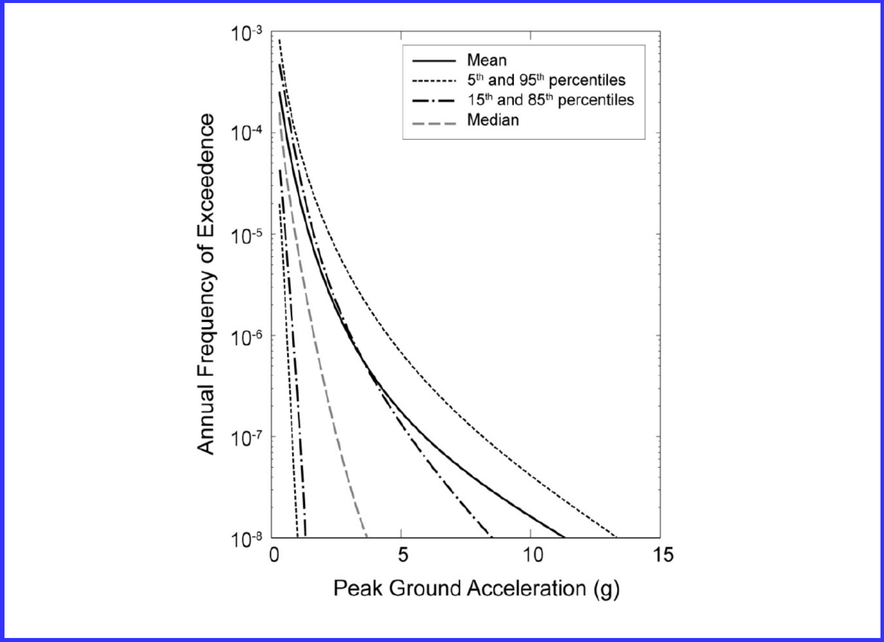
- ✓ Each combinations of branches leads a hazard curve, and the total weight of the path is the product of the individual branches weights.
- ✓ Aleatory influences the hazard curve shape, and Epistemic leads multiple hazard curves.

HAZARD CURVES

a) Mean/Median ratio*

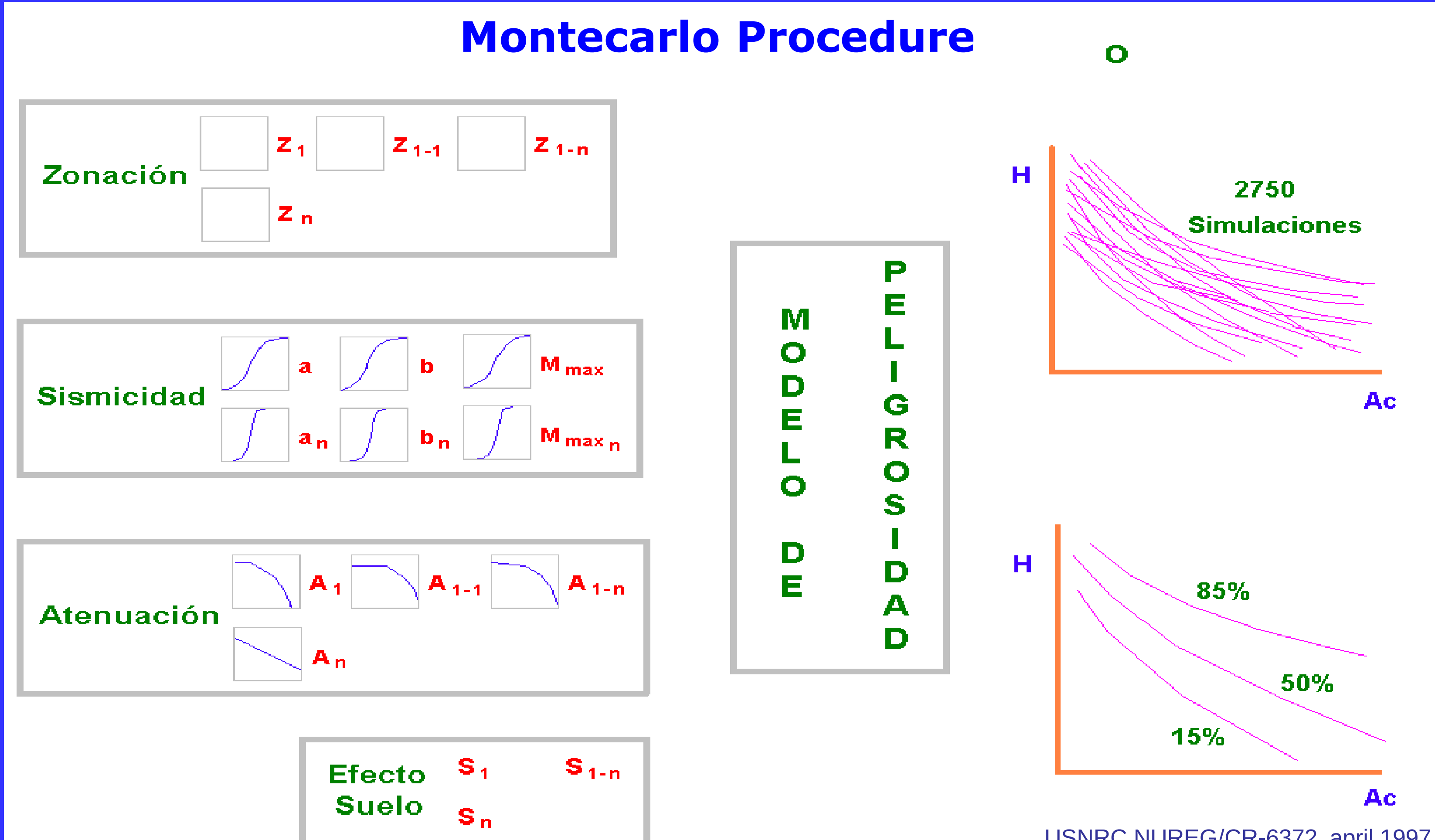
b) COV** = σ/mean

* Benreuter 1996.
** Cramer 2001.
Coefficient of Variation:
COV = 0, very good knowledge
COV = 1, very poor knowledge



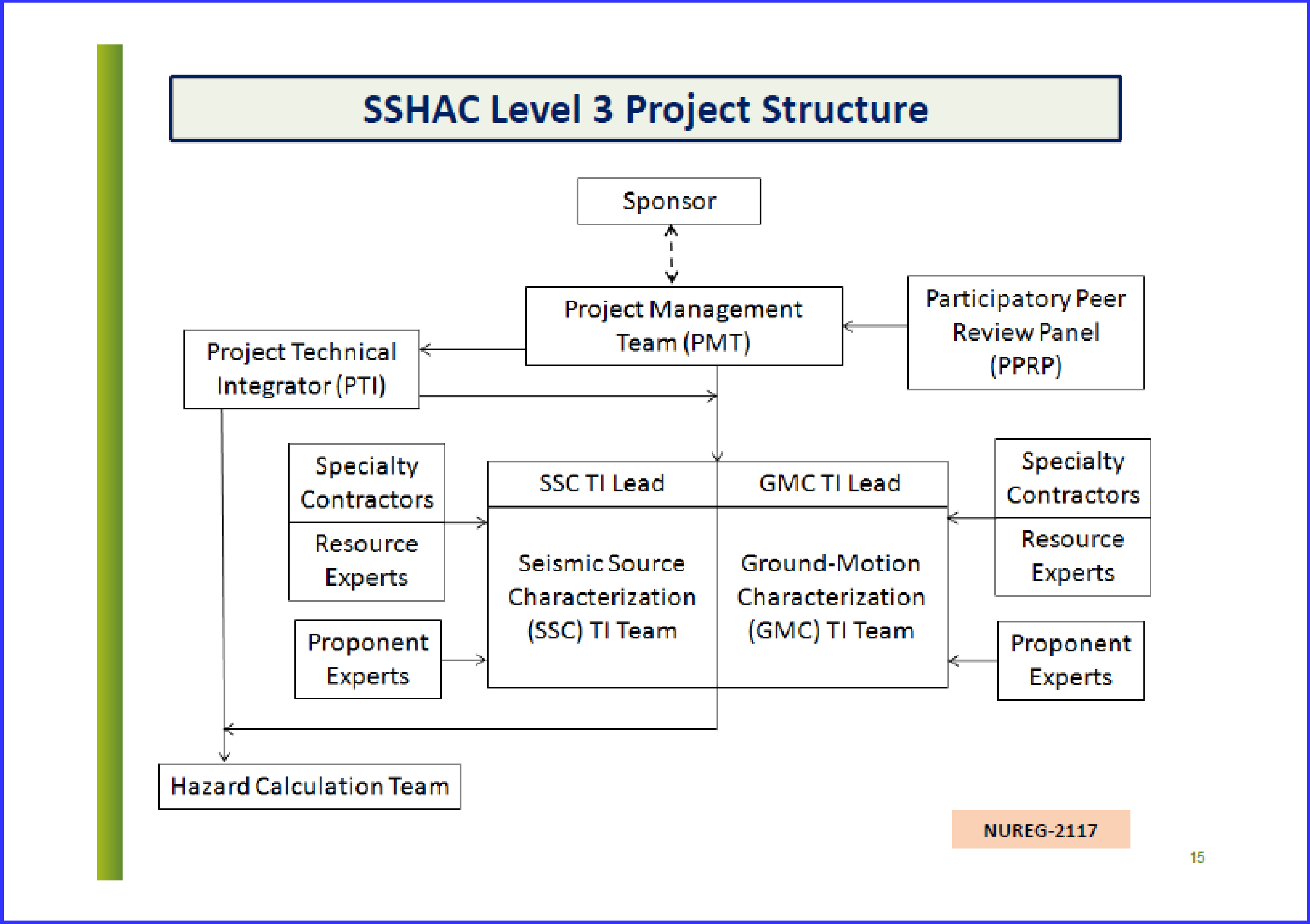
3 OVERVIEW ON PSHA AND UNCERTAINTY

ADDRESSING UNCERTAINTIES



USNRC NUREG/CR-6372, april 1997

3 OVERVIEW ON PSHA AND UNCERTAINTY



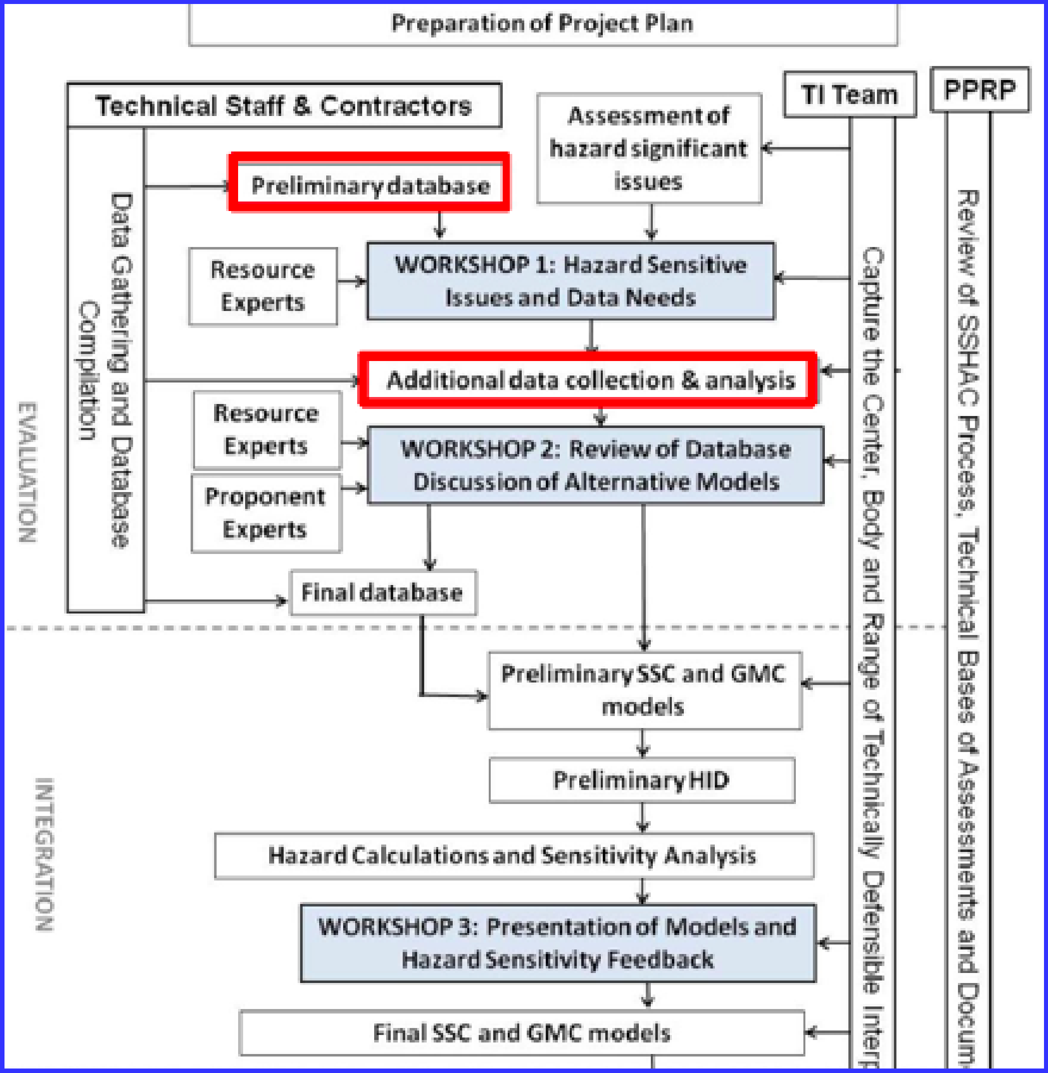
3 OVERVIEW ON PSHA AND UNCERTAINTY

Roles in a SSHAC Level 3 Process

TI Team

Role	Description
EVALUATOR EXPERT	Impartial and objective assessor of potentially applicable data, models, and methods
INTEGRATOR	Builds models that capture the CBR of the TDI
RESOURCE EXPERT	Has particular knowledge of a relevant data set, method or models
PROPONENT EXPERT	Advocates a particular hypothesis or technical position; will often promote a model that they have developed
SPECIALTY CONTRACTOR	Retrieves new data or undertakes new analyses to inform evaluators
PARTICIPATORY REVIEWER	Provides procedural and technical review; ensures capture of full range of views and robust technical justifications of logic-tree

3 OVERVIEW ON PSHA AND UNCERTAINTY



PRINCIPLE OF UNCERTAINTY

Yakov Y. Haimes, (1998):

- **To the extent that risk assessment is precise, it is not real.**

- **To the extent that risk assessment is real, it is not precise.**

4 CURRENT SPANISH PSHA APPROACH

ITC from the CSN to Updating Existing Seismic Hazard

✓ ITC scope (4 years) is divided in two sequential phases:

- Phase I: To collect a specific database of each site.

  (6) + 18 months

Breaking time for the CSN evaluation and endorsement: 3 months.

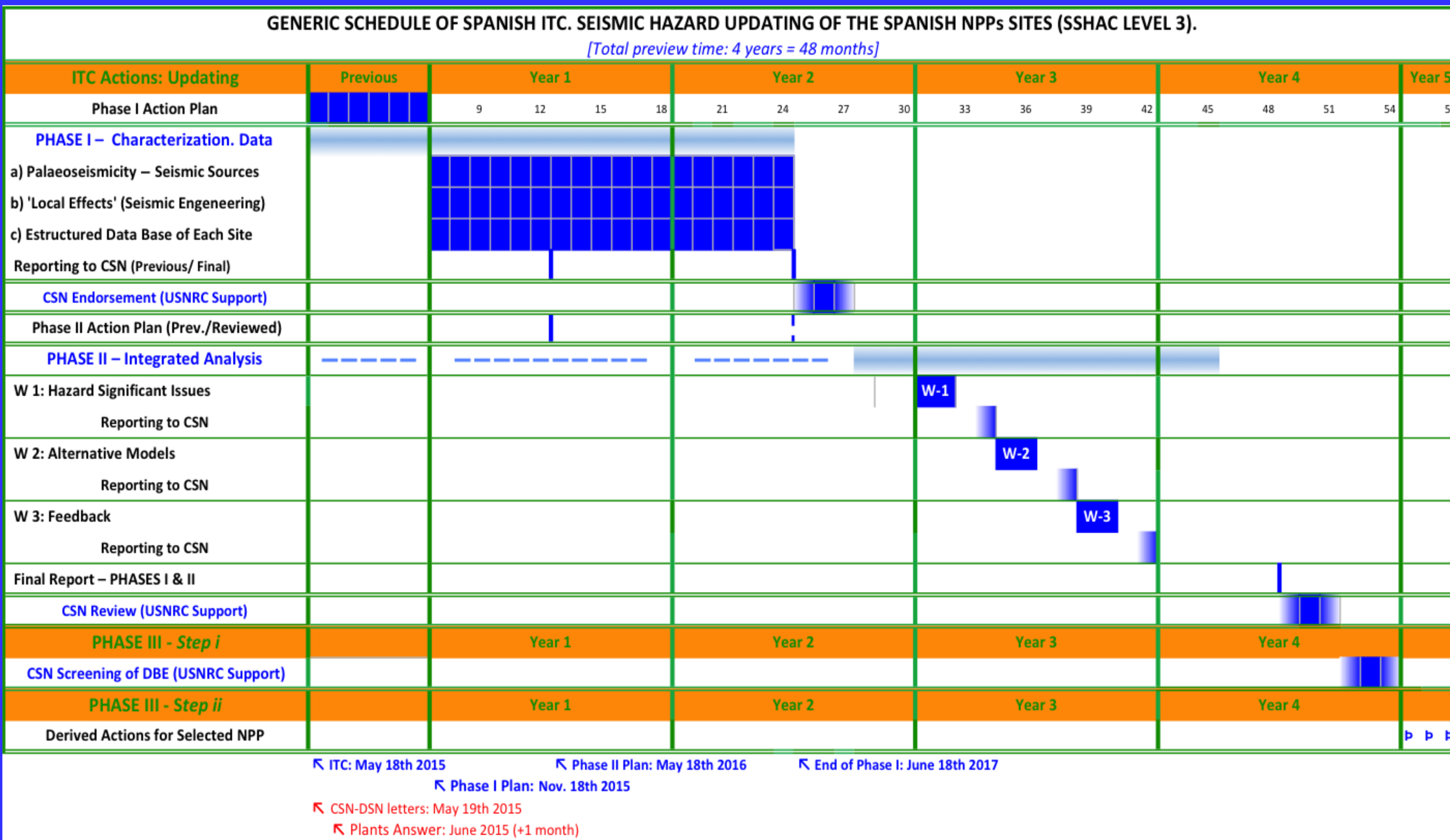
- Phase II: SSHAC, Level 3.

  (12 + 12) + 18 + 3 months

✓ In addition, a Phase III with two stages is expected after finishing previous phases for the CSN review of final reports of the plants and DBE screening to decide derived actions for selected plants.

✓ Plants are encouraged to jointly addressee the ITC resolution.

4 CURRENT SPANISH PSHA APPROACH



4 CURRENT SPANISH PSHA APPROACH

USNRC NUREG - 2117, Rev. 1 - SSHAC, Level 3

4.5.2 Collection of New Data

Early in the project during the data compilation stages, it may be possible to identify significant gaps in the available data that may significantly impact the hazard results. If project resources allow, focused new data collection efforts can be conducted within the timeframe of the SSHAC study to assist in the technical evaluations. Several past studies have benefited from such data collection efforts. For example, early in the Yucca Mountain PVHA-U study, the evaluator experts indicated that there existed significant uncertainty in the spatial distribution and ages of possible buried volcanic features in the site region. The evidence for the possible features at the time was primarily aeromagnetic and gravity data coupled with limited borehole data. The TFI team evaluated the information and concluded that the age and spatial distribution of these potential features could have a significant effect on the hazard results. A focused drilling and sampling program was developed and implemented with the intention of directly establishing the nature of the geophysical anomalies. The new data collection program occurred within the timeframe of the hazard study and provided a substantial reduction in the uncertainties in key model inputs.

Any new data collection activities should be identified early in the project, evaluated for their potential impact on the hazard results and associated uncertainties, and completed in a timely manner for use in the technical evaluations. Typically, this would mean that the activities should be completed prior to Workshop #3 on Feedback and certainly no later than the time that the models are finalized.

Page 67

The PTI/PTFI should take the responsibility for identifying any new data collection activities in consultation with the Project Manager, evaluator experts, and possibly the PPRP. Of course, the sponsor of the study ultimately makes the decision regarding whether or not such activities should be carried out because of the need for additional resources. If a decision is made to proceed, the PTI/PTFI and applicable TI/TFI Leads should assume responsibility for completing the studies in a timely manner and for overseeing the incorporation of the results into the project database.

- Early, during the data compilation stage, it may be possible to identify significant gaps in the available data that may significant impact the hazard results.
- If project resources allows, focused new data collection can be conducted.
- The sponsor of the study ultimately makes the decision regarding whether or not such activities should be carried out because of the need for additional resources.

The Fukushima Daiichi Accident, Vol. 2/5, Safety Assessment, IAEA, August 2015

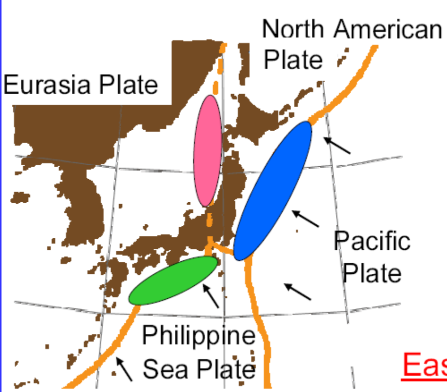
In general, 'back-checking' has been usually performed, instead of a comprehensive site reassessment or 'back-fitting'.

If was done 'back-checking' but not 'back-fitting' then the SAR (Safety Analysis Report) will remain written in accordance with existing regulation several decades ago.

4 CURRENT SPANISH PSHA APPROACH

Historic / Prehistoric (geologic) Data - GC2 (10CFR50)

… The design basis for the SSCs important to safety must contemplate the following aspects: 1) The most severe natural phenomena that have taken place at the site… and a sufficient margin shall be included in the design to account for the limitations in the historic data as regards precision, quantity and period of time to which the information corresponds…



Japan Trench

Keityou Sanriku, M_w=8.6, 1611

Meiji Sanriku, M_w=8.3, 1896

Showa Sanriku, M_w=8.4, 1933

Nankai Trough

Houei, M_w=8.8, 1707

Tounankai, M_w=8.4, 1944

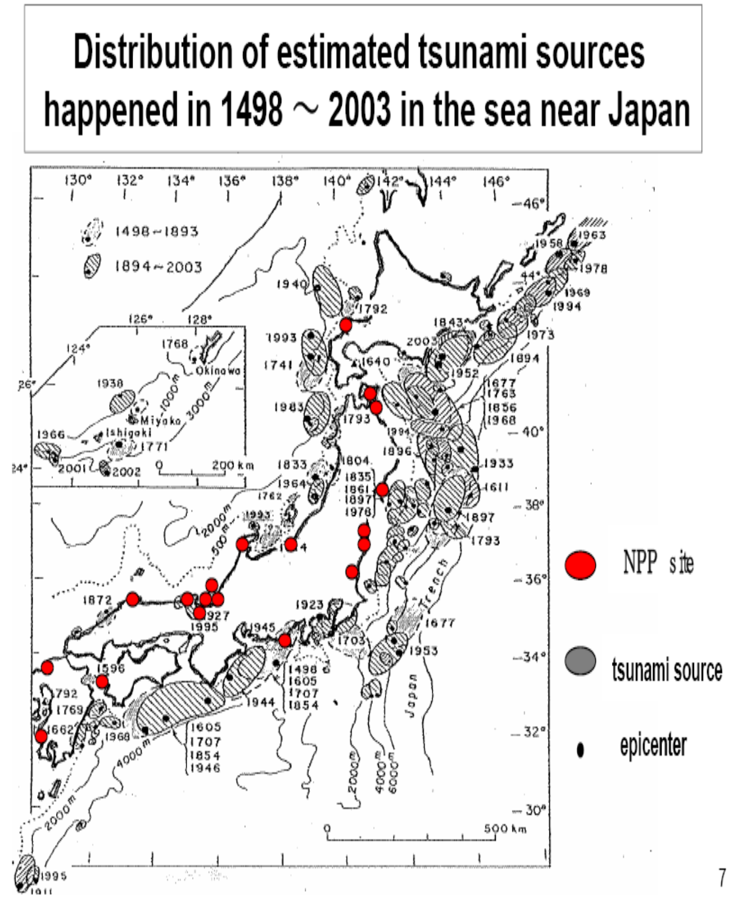
Nankai, M_w=8.5, 1946

Eastern Margin of the Japan Sea

Southwest Hokkaido, M_w=7.8, 1993

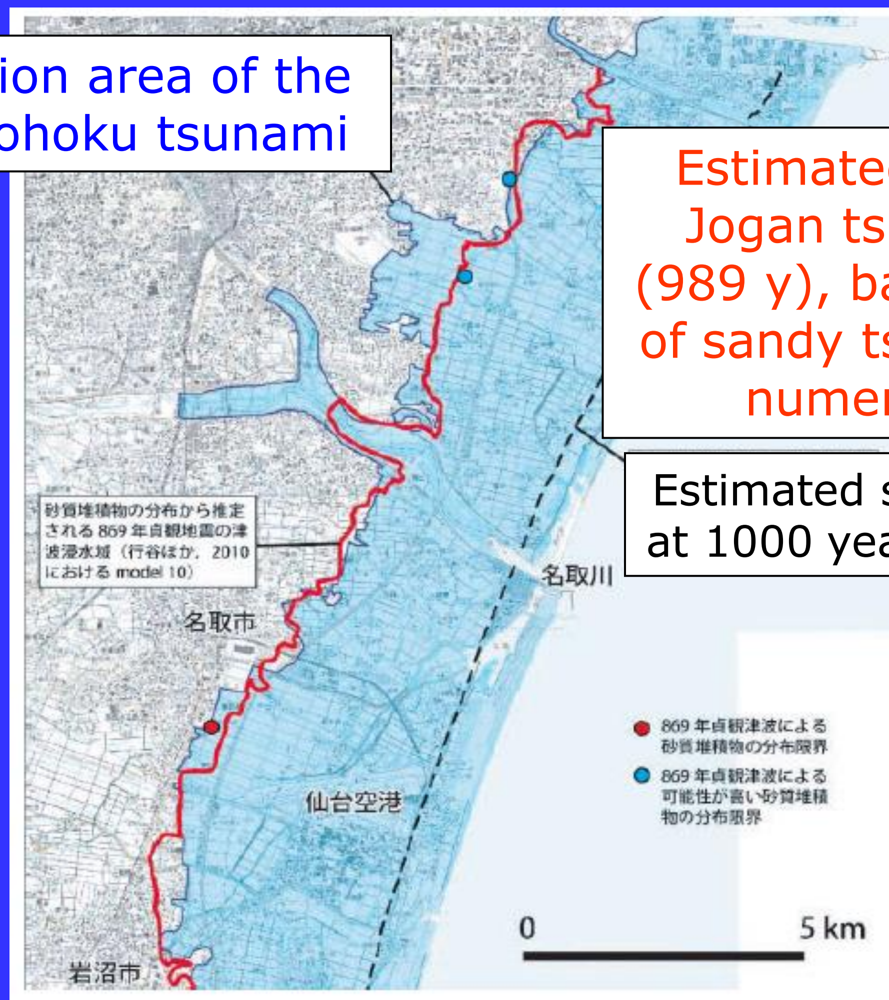
Nihonkai-Chubu, M_w=7.7, 1983

6



4 CURRENT SPANISH PSHA APPROACH

Inundation area of the 2011 Tohoku tsunami



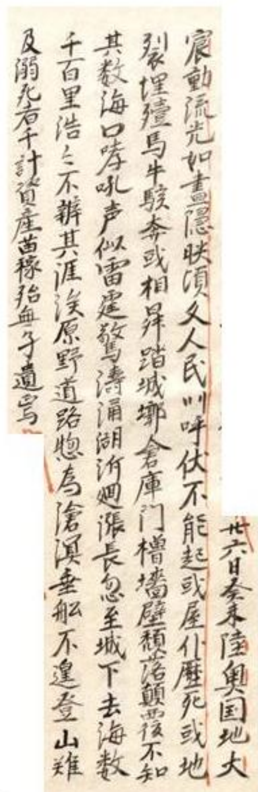
Estimated boundary of the Jogan tsunami inundation (989 y), based on distribution of sandy tsunami deposit and numerical simulation

Estimated shoreline at 1000 years before

From Shishikura, 2012

4 CURRENT SPANISH PSHA APPROACH

Record of May 26, 869



THE PAST IS THE KEY
FOR THE FUTURE

Source: 'Nihon Sandai-Jitsuroku'
(One of Six Official Chronologies of Ancient Japan)
Imperial Household Agency

Denis Flory (Deputy Director General, IAEA-NSS Dept. Head). After NCOE, 2007 (KK):

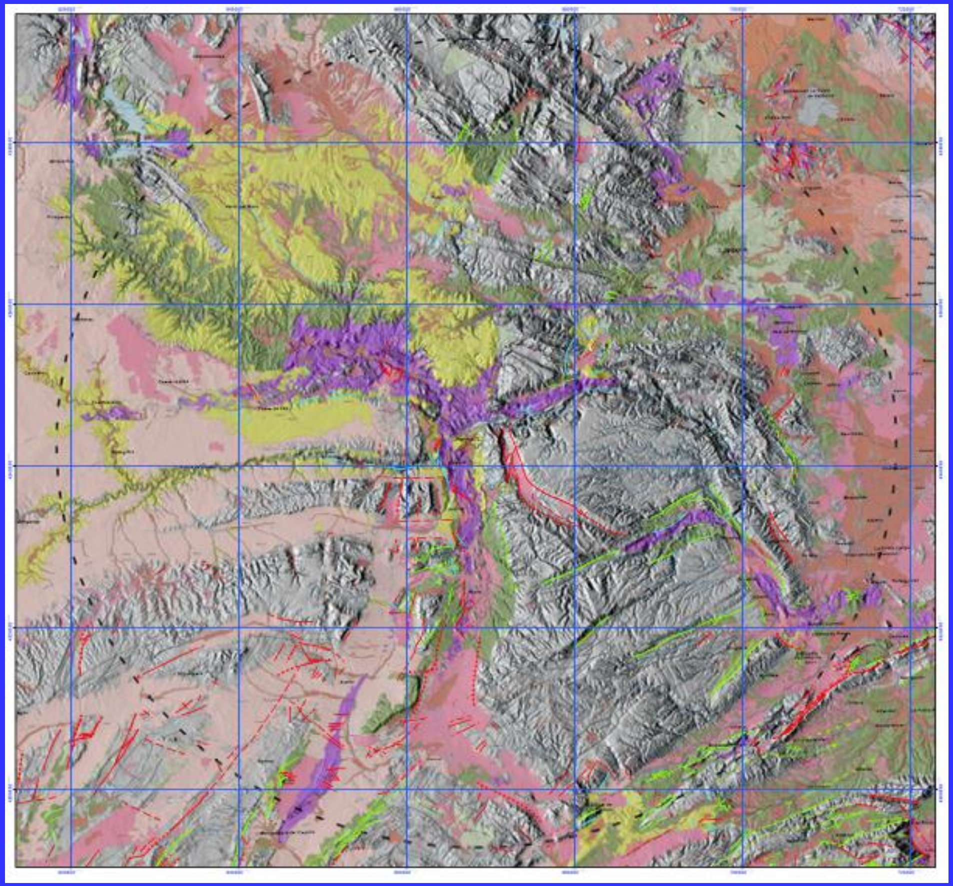
"The American philosopher Ralph Waldo Emerson said 'We learn Geology the morning after the earthquake'. It is an interesting notion from a philosopher, but no good philosophy for engineers, particularly when it involves nuclear safety."

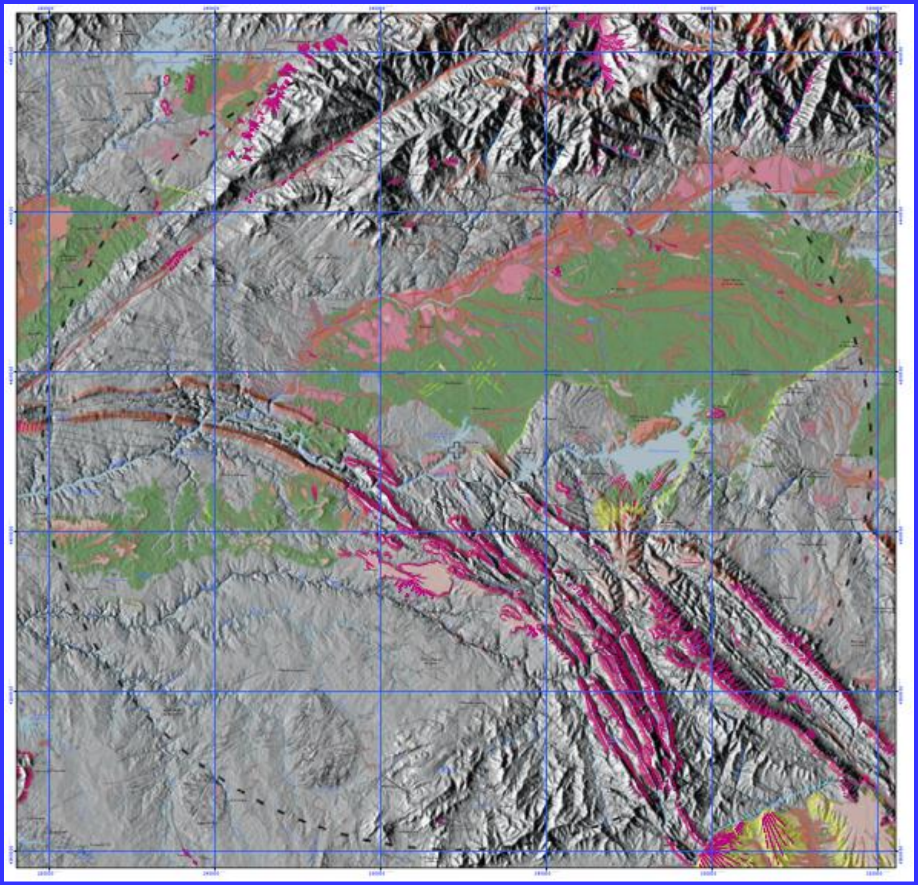
4 CURRENT SPANISH PSHA APPROACH

Seismic ITC - Phase I: Specific Database of each NPP site.

- ✓ Update seismotectonic around 50 km of the site, through field surveys and review of published data. The scope should include identification/characterization of potentially capable/seismogenic sources.
- ✓ If potentially capable/seismogenic sources are identified around 25 km of the site, these must be analyzed in detail according to a complementary specific plan.
- ✓ Update and complete initial geodinamic data of each plant site through needed field surveys to analyze the 'local effects'.
- ✓ Regulation:
  - Near Regional, Vicinity and Local scales (IAEA, SSG-9),
  - Site scale (USNRC RGs. 1.208; 1.132, Rev. 2; & 1.138, Rev. 3)

4 CURRENT SPANISH PSHA APPROACH





4 CURRENT SPANISH PSHA APPROACH

- ✓ According to the Gutenberg-Richter law, the causative faults of strong earthquakes will be delineated by the distribution of smaller events occurring along their traces. However, the surprise of strong earthquakes caused by faults not delineated by small events, shows that the historical record is insufficient to identify the "where” either both, areas with moderate / low seismicity rates and most active areas as Japan.

- ✓ The resolution of the "where", requires to identify active seismic sources during the prehistoric time, for which palaeoseismicity technics can be used as a tool to analyse surface effects (primary and secondary) that strong earthquakes print in the geological record and on the surface of the earth (seismic landscape).

4 CURRENT SPANISH PSHA APPROACH

Earthquake Environmental Effects (EEEs).

Any phenomena generated in the natural environment:

Primary effects:

Surface expression:

- Surface faulting
- Tectonic uplift / subsidence

Afectted area / Record Type:

- From local scale to > 50,0000 km^2
- Exceptional, Frequent, Characteristic

Secondary effects:

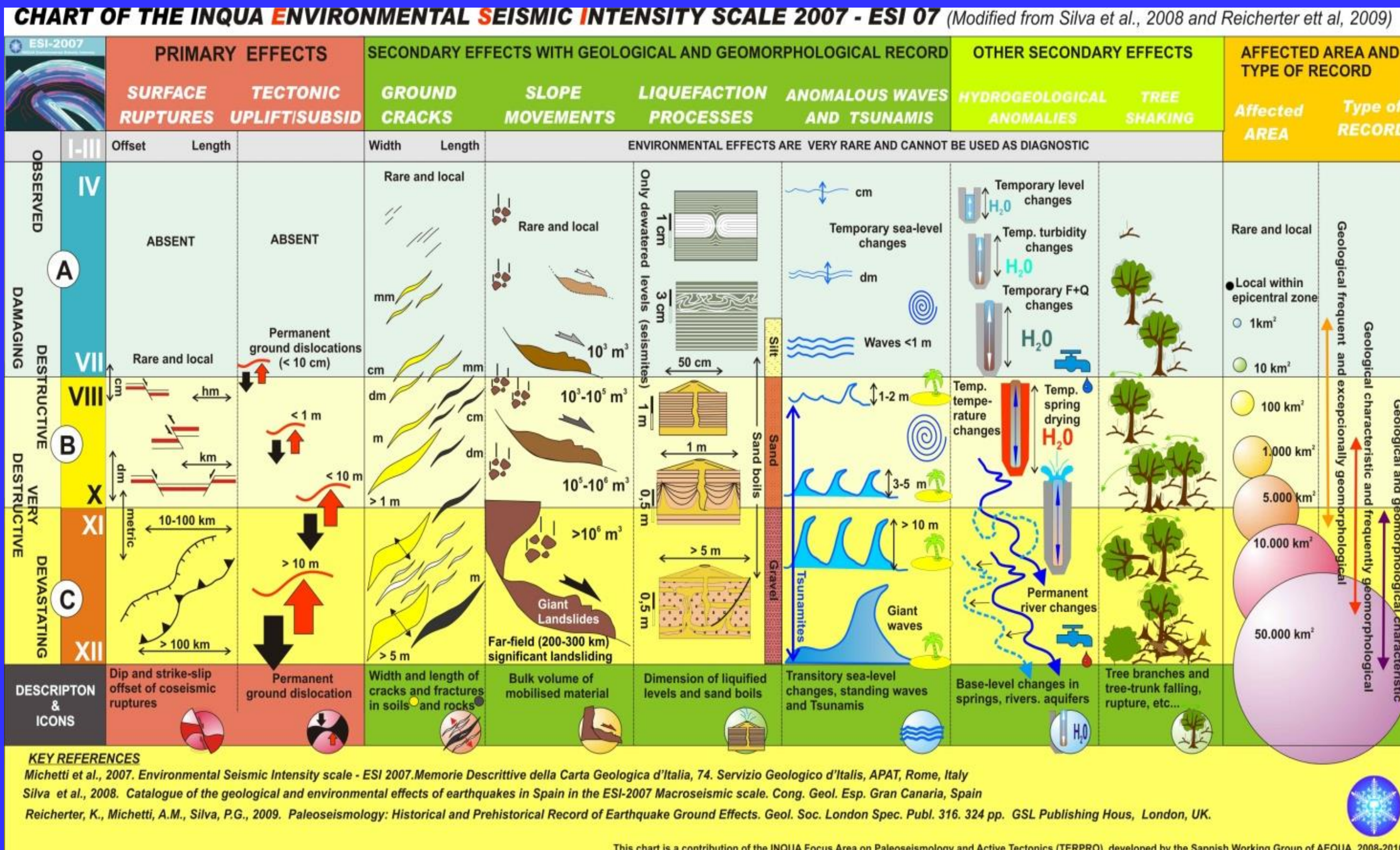
Geologic/Geomorphologic record:

- Slope movements
- Liquefaction processes
- Ground cracks
- Anomalous waves, tsunamis

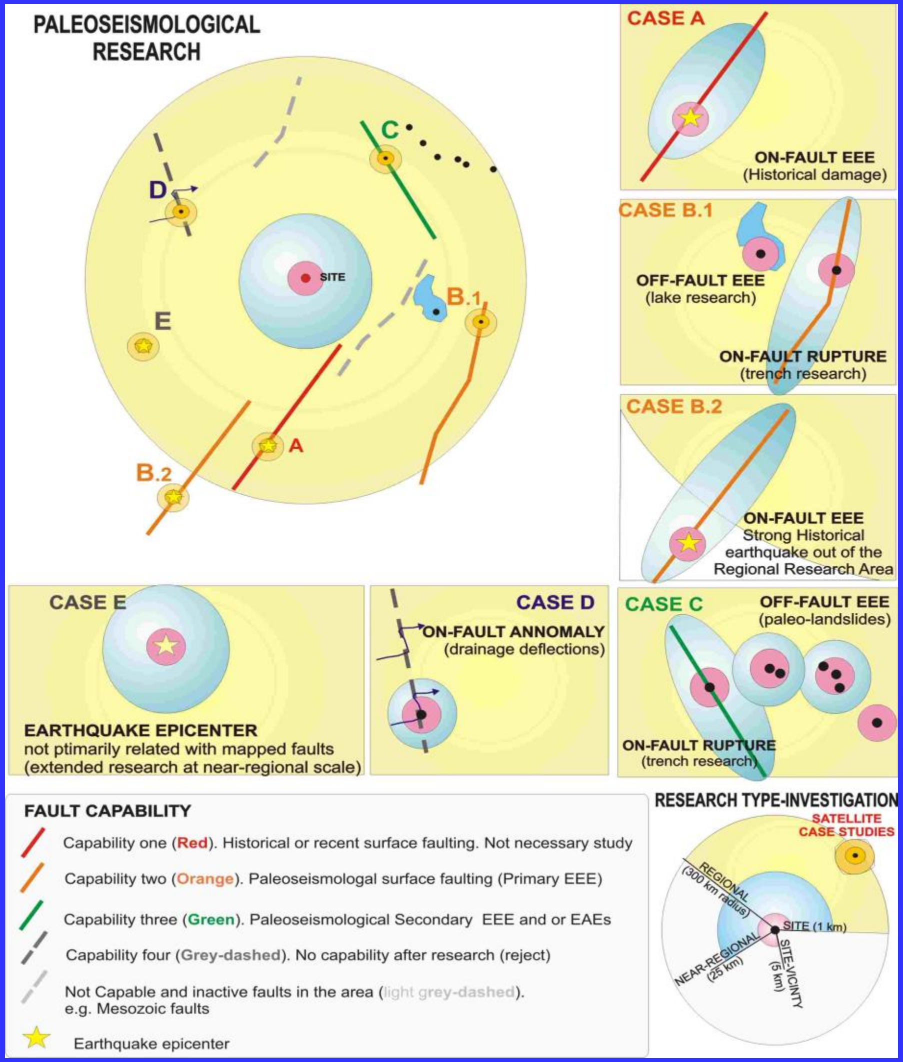
Others:

- Hydrogeological anomalies
- Tree shaking, jumping stones
- Dust clouds

4 CURRENT SPANISH PSHA APPROACH



4 CURRENT SPANISH PSHA APPROACH



4 CURRENT SPANISH PSHA APPROACH

Near Regional and Vicinity Investigations.

To be carefull with trenching Analysis

Poorly expressed faulting and actual termination of fault strands may occur on various types of faults and in various materials. Any apparent upward termination requires critical review and verification (Bonilla, 1990).

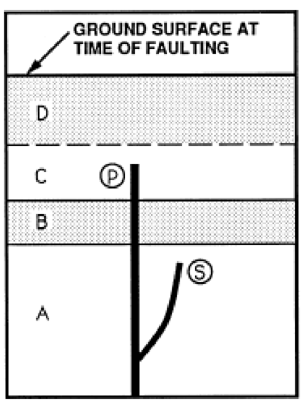


Figure 6. Diagram showing fault strands related to single strike-slip faulting event. A, B, C, D = unconsolidated sedimentary deposits; P, S = fault strands.

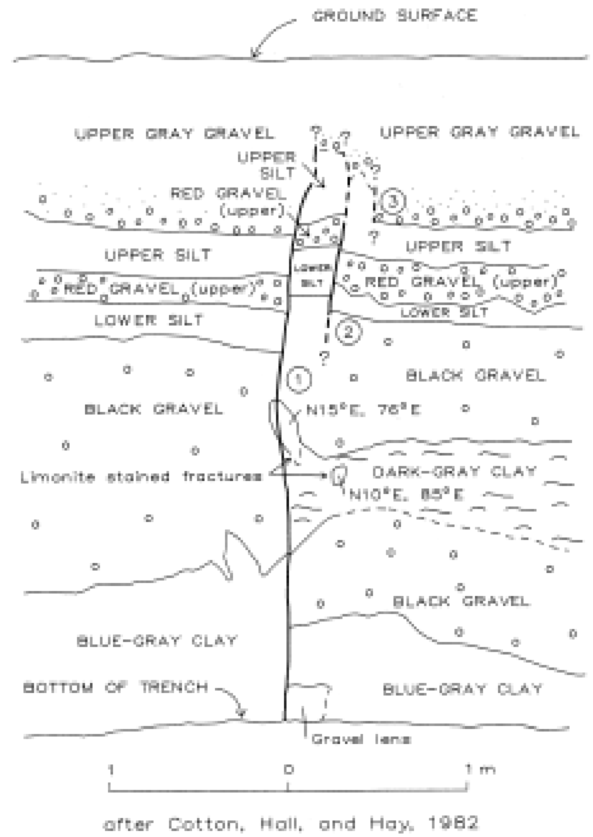
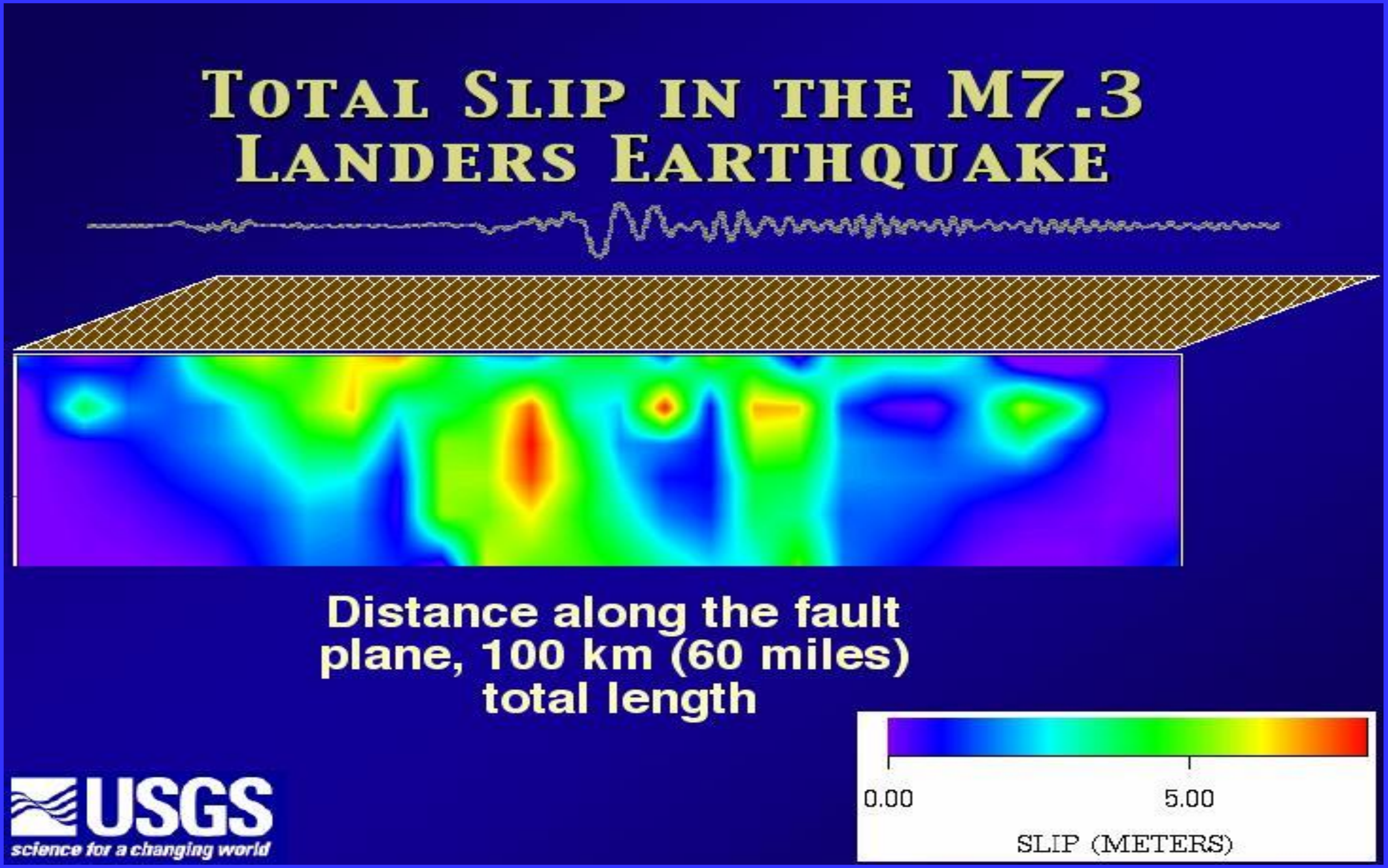


Figure 2. Log of trench on San Andreas fault at place where ground surface was ruptured by more than 4 m of strike- slip displacement in 1906. Fault strands visible in lower and middle parts of this trench and several parallel trenches were not traceable to ground surface. Modified from Cotton et al. (1982).

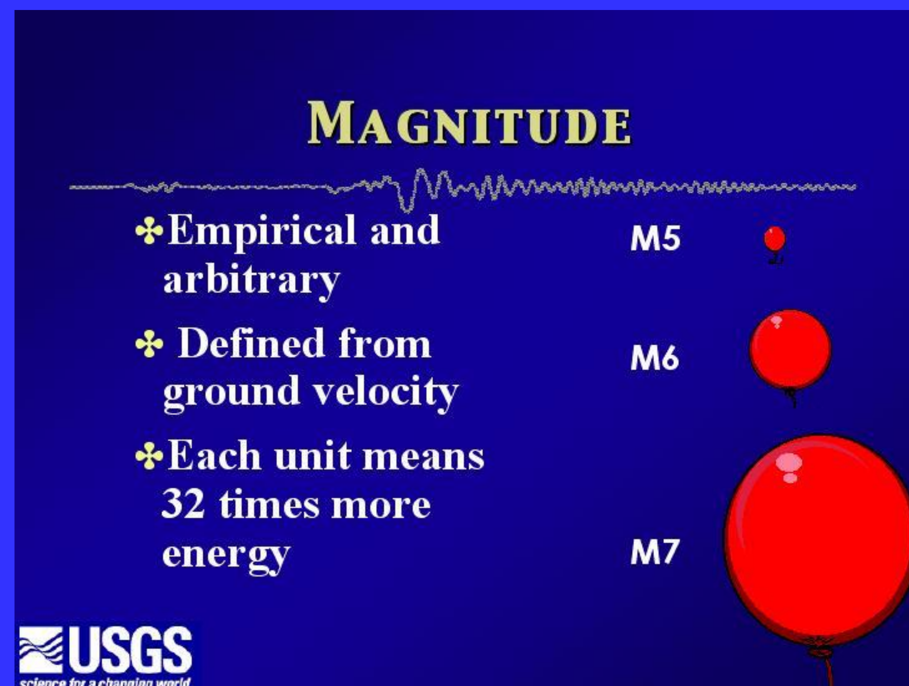
4 CURRENT SPANISH PSHA APPROACH



4 CURRENT SPANISH PSHA APPROACH

Earthquakes are generated by fault ruptures

July 21,1952 Tehachapi Earthquake M7.5



4 CURRENT SPANISH PSHA APPROACH

Seismic ITC - Phase II: SSHAC, Level 3

- ✓ Design a project to obtain seismic hazard curves for different frequencies of exceedance, at the base of foundation structures of the each site; using to do that a validated code which allows to incorporate the uncertainties inherent in this analysis.
- ✓ Addressing uncertainties treatment by following an appropriate integration of expert opinion.
- ✓ Regulation:
  - USNRC NUREG/CR – 6372,
  - NUREG - 2117, Rev. 1.

THANK YOU FOR YOUR ATTENTION !