



# **NRC Seismic Margin Methodology with Enhancements**

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# Outline of Presentation

- History of SMA
- SMA Concepts
- NRC SMA Methodology
- Additional Enhancements
- Broader Technical Issues



# History of SMA

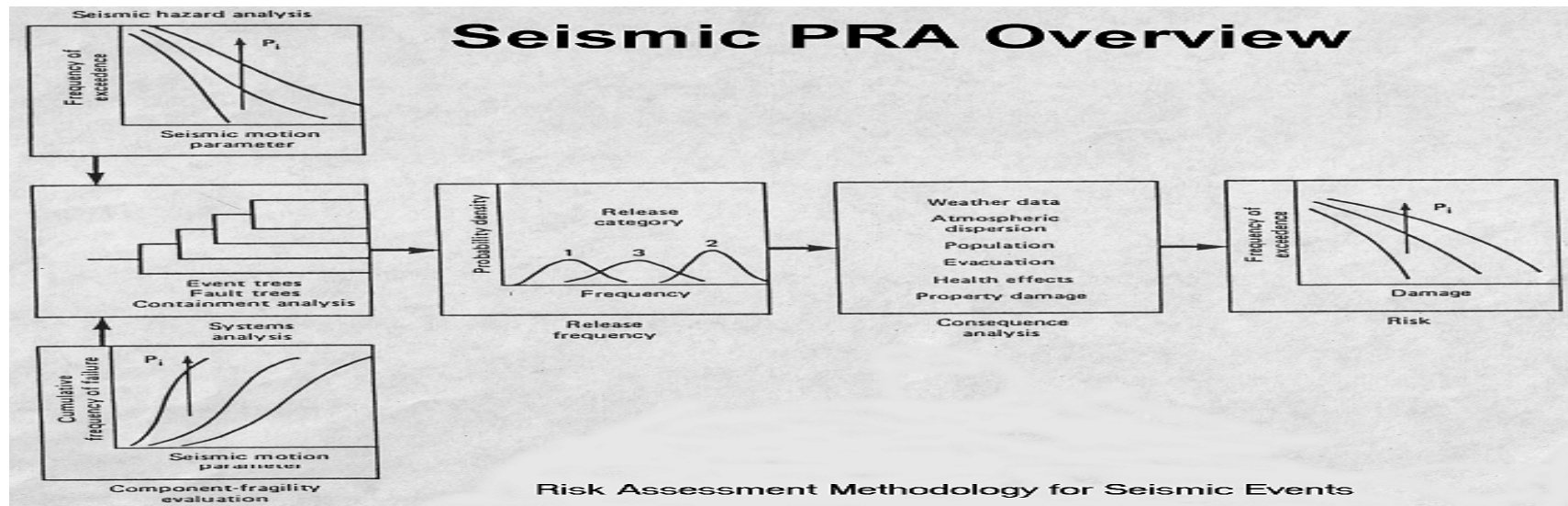
- Seismic Safety Margin Research Program in early eighties
- NRC formed an expert panel to address the question of seismic margin
- NRC expert panel addressed easier task
  - review the plant against a specific earthquake level (i.e., SME) and determine whether plant has a high confidence of low probability of failure for SME
  - if less than SME, then calculate the plant “high-confidence low probability of failure (HCLPF)” capacity
- Fragility Analysis (FA) and Conservative Deterministic Failure Margin (CDFM) methodologies



## History of SMA (cont.)

- NRC expert panel (NRC Methodology)– NUREG/CR-4334
- Maine Yankee plant trial review using NRC method– NUREG/CR- 4826
- EPRI Methodology - EPRI NP-6041
- Catawba trial review using EPRI method – EPRI NP-6359
- EPRI NP-6041, Revision 1
- IPEEE guidance document, NUREG 1407
- IPEEE Insights – NUREG - 1742
- ASME/ANS Standard (Including Augmented SMA)

# Seismic Margin Concepts



## SYSTEM MODELING

Abbreviated system models for dominant initiators

## Seismic Margin Overview

### IDENTIFICATION OF SSCs

System and Walk downs

### SCREENING OF SSCs

Eq. exp., PRAs, Tests

### CAPACITY OF COMPONENTS

Deterministic Fragility method

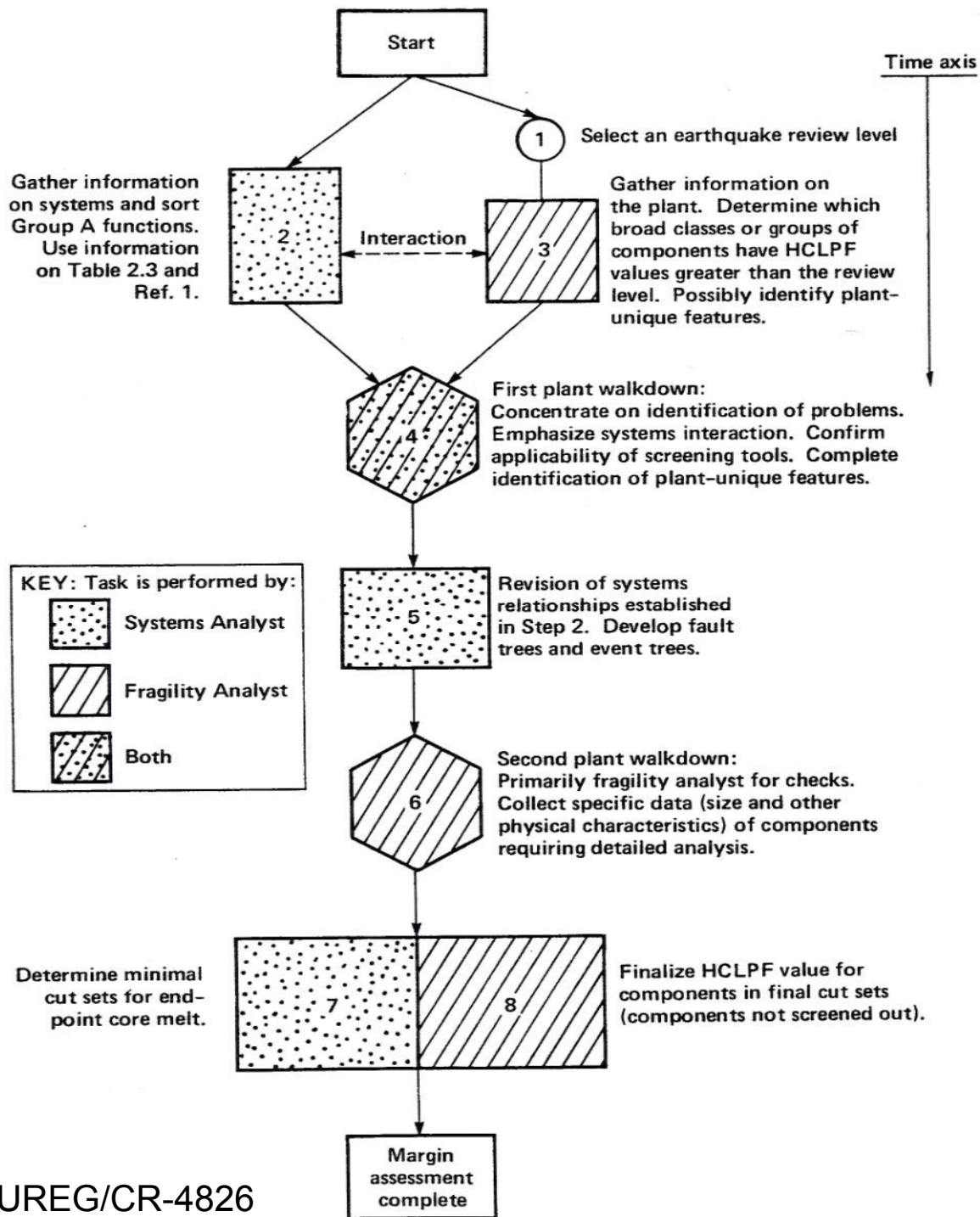
### EARTHQUAKE (GROUND) MOTION

One fixed level (RLE)  
> Design Basis

### RESULTS

Plant capacity statement

# NRC SMA





# Example of Evaluated Functions for PWRs

TABLE 2-3a

**FUNCTIONS REQUIRING DETAILED EVALUATIONS IN SEISMIC MARGIN REVIEWS FOR PWRs**  
(Taken from Ref. 1, Table 4.13)

Function	Screening Requirement	Remarks
<hr/>		
<u>Initiators:</u>		F= Assume Failure
Offsite Power	F	
RCS Integrity (LOCA)	X	
Containment Integrity	X	
 <u>Functional Group A:</u>		
Reactor Subcriticality	X	X = Margin evaluation for all potential failure modes is required.
Normal Shutdown	F	
Emerg. Core Cooling (Early)	X	
 <u>Functional Group NOT-A:</u>		
Emerg. Core Cooling (Late)	A	A= Assume failure if core melt occurs resulting from failure of Functional Group A, assume successful if functional Group A is successful in preventing core melt. Conditional on plant walkdown not finding any extremely gross plant-specific differences.
Containment Heat Removal	A	
Cont. Overpress. Prot. (Early)	A	
Cont. Overpress. Prot. (Late)	A	

From NUREG/CR-4826

From NUREG/CR-4826





# Example of Evaluated Functions for BWRs

TABLE 2-3b

FUNCTIONS REQUIRING DETAILED EVALUATIONS IN SEISMIC MARGIN REVIEWS FOR BWRs

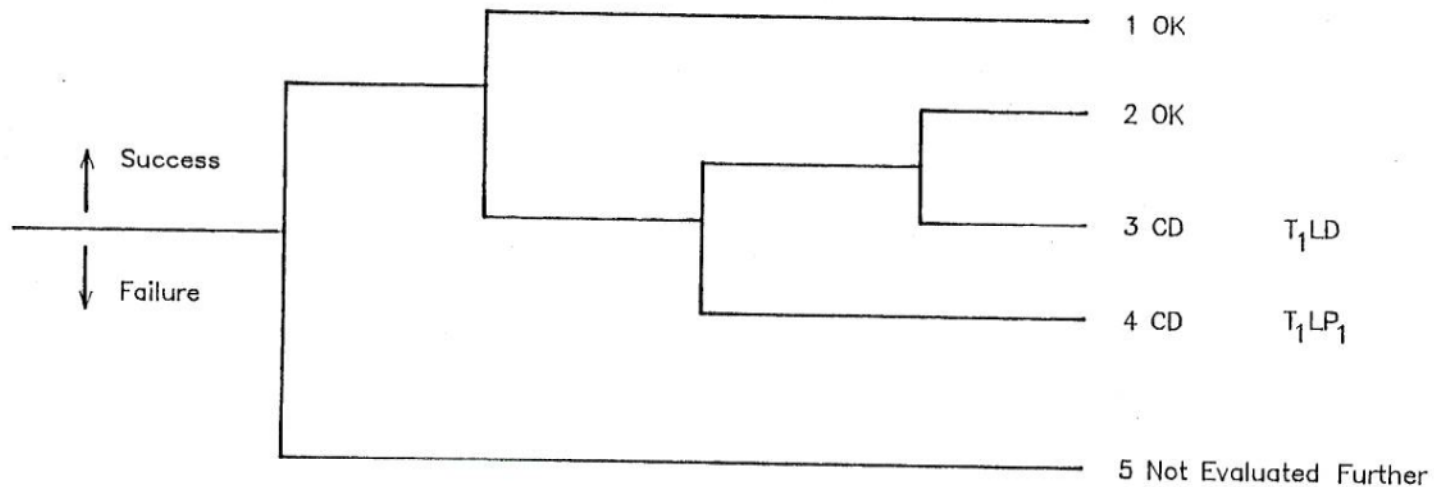
Function	Screening Requirement	Remarks
<u>Initiators:</u>		F= Assume Failure
Offsite Power	F	
RCS Integrity (LOCA)	X	
Containment Integrity	X	
<u>Functional Group A:</u>		
Reactor Subcriticality	X	X = Margin evaluation for all potential failure modes is required.
Normal Shutdown	F	
Emerg. Core Cooling (Early)	X	
Emerg. Core Cooling (Late)	X	
Containment Heat Removal	X	
Cont. Overpress. Prot. (Early)	X	
Cont. Overpress. Prot. (Late)	X	

From NUREG/CR-4826



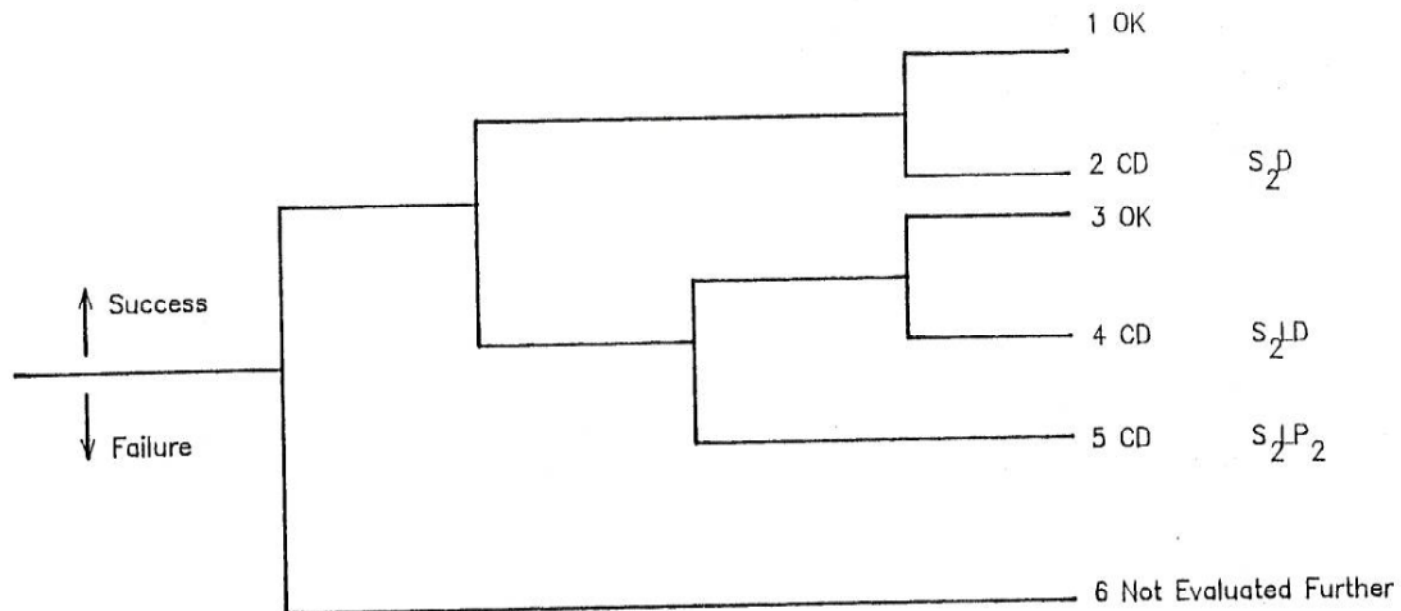
# Loop Initiated Transient

Seismic LOOP $T_1$	Reactor Subcritical C	AFW/EFW L	Feed & Bleed Actions $P_1$	HPSI/R D	Status	Sequence
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# Small LOCA

Seismic, LOOP LOCA $S_2$	Reactor Subcritical C	AFW/EFW L	Feed & Bleed Actions $P_2$	HPSI/R D	Status	Sequence
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## Example of Plant Level HCLPFs

Case	Description	HCLPF Capacity (g)
1	Small LOCA - Independent Seismic Failures	0.21
2	Small LOCA - Dependent Seismic Failures	0.21
3	No LOCA - Independent Seismic Failures with Nonseismic Failures	$\geq 0.30$
4	No LOCA - Independent Seismic Failures without Nonseismic Failures	$\geq 0.30$
5	Core Damage - Split Fraction	<div> <math>p = 0.01</math>  <math>p = 0.10</math>  <math>p = 0.50</math> </div> <div> <math>\geq 0.30</math>  0.28  0.23 </div>
6	Small LOCA - RWST Reduced Fluid Level	0.26



# Enhancements

- Full Scope from NUREG-1407
  - Walkdowns using EPRI-6041
  - Relay Chatter evaluations
  - Address soil induced failures
  - 72 hours mission time
- Non-seismic failures and human performance expected fully integrated in logic models



## Enhancements (cont.)

- HCLPF Calculations
  - Fragility method
  - Conservative Deterministic Failure Margin (CDFM)
- Applicable requirements on Part 5 and Part 10 of ASME/ANS Standard



# Broader Technical Issues

- High frequency evaluations
- System functions to accommodate extended mission time
- Need for development of additional guidance