



U.S. Department of Energy



Preclosure System Analyses and Quantification

Presented to:

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System Analysis

- **Seismic event sequence identification**
- **Consequence analysis and screening**
- **Seismic design bases assigned to SSCs**
- **Event sequence quantification**
- **Demonstration of compliance**



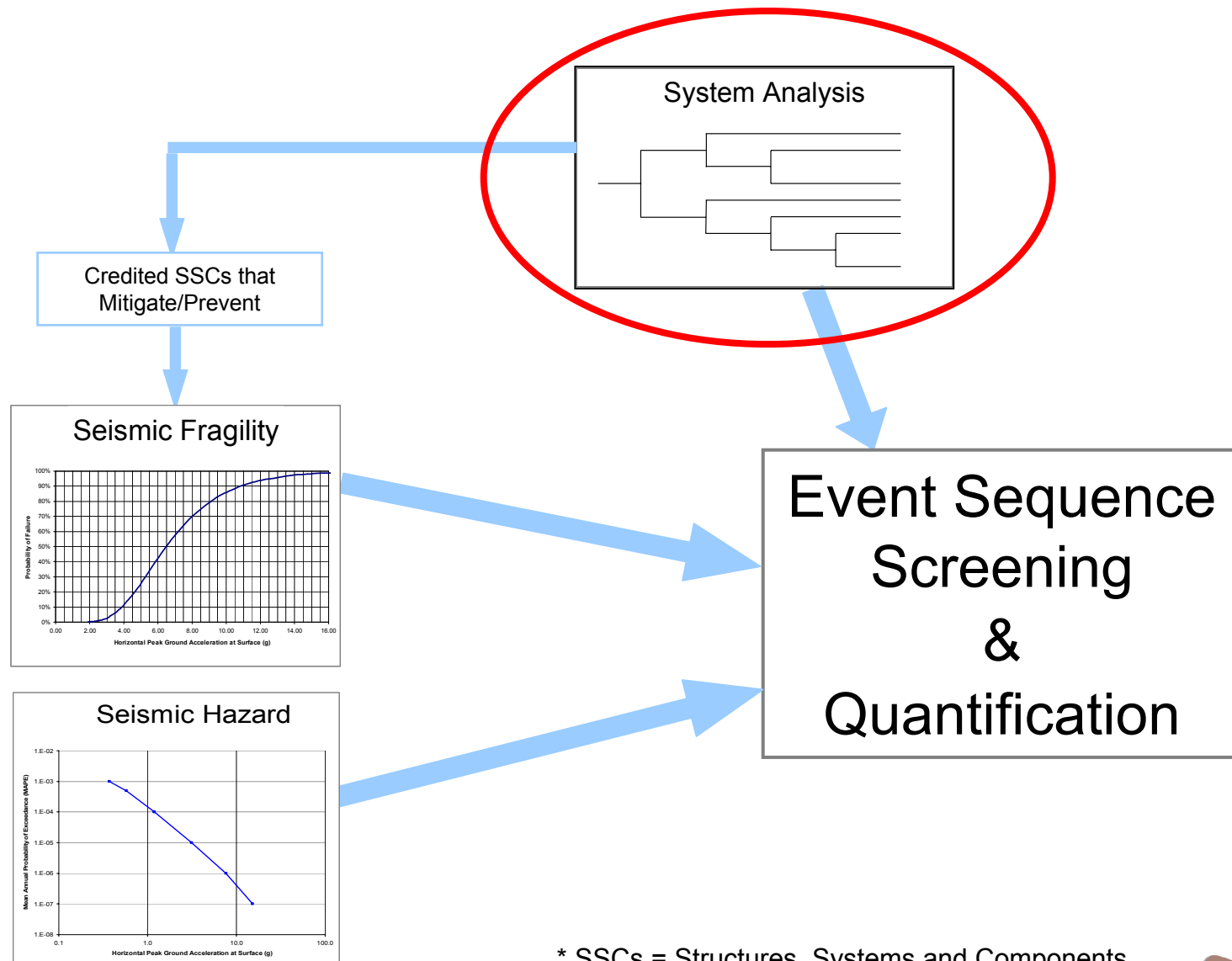
SSCs = Structures, Systems and Components

Department of Energy • Office of Civilian Radioactive Waste Management

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Schematic of Seismic Probability Analyses



* SSCs = Structures, Systems and Components



Seismic Event Sequence Identification

- **Identify scenarios for potential direct exposure or airborne releases**
 - Conduct systematic evaluation
 - Identify seismically-induced failure of SSCs that initiate or affect event sequences
 - Identify amount and type of material at risk
- **Typical seismically-initiated scenarios**
 - Building damage impacts waste form
 - Heavy object (e.g., crane) falling onto waste form
 - Crane drops waste form
 - Trolleys or transporters tip over with impact to waste form
 - Shield doors or shield windows fail
 - Ducts lose confinement



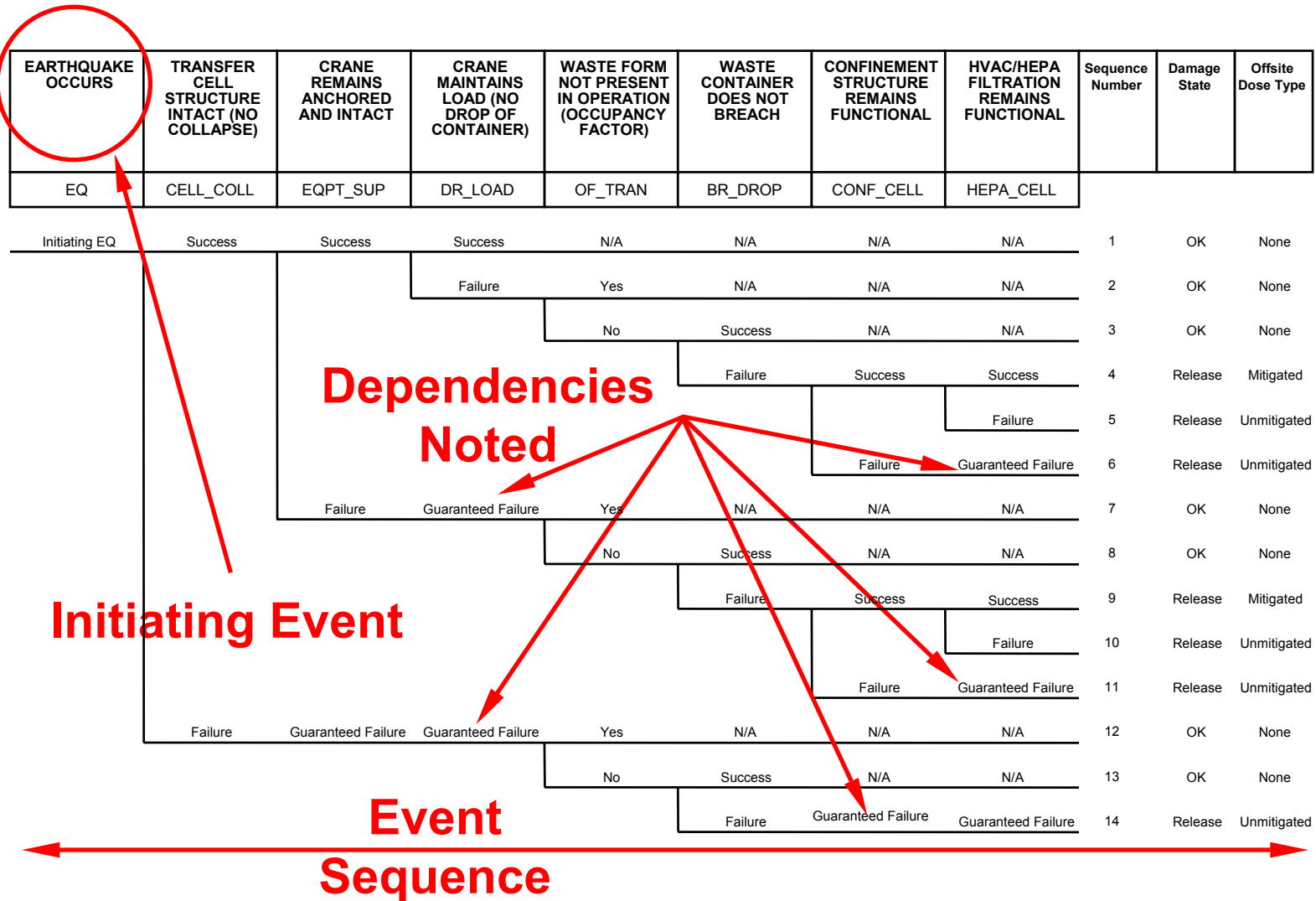
Seismic Event Sequence Identification

(Continued)

- **Identify non-seismic mechanisms or factors that affect potential radiation exposure or release**
- **Construct seismic event trees**
- **Apply screening doses to assign Design Basis Ground Motions (DBGM-1 or DBGM-2)**
- **Simplify event tree**



Example of Seismic Event Tree

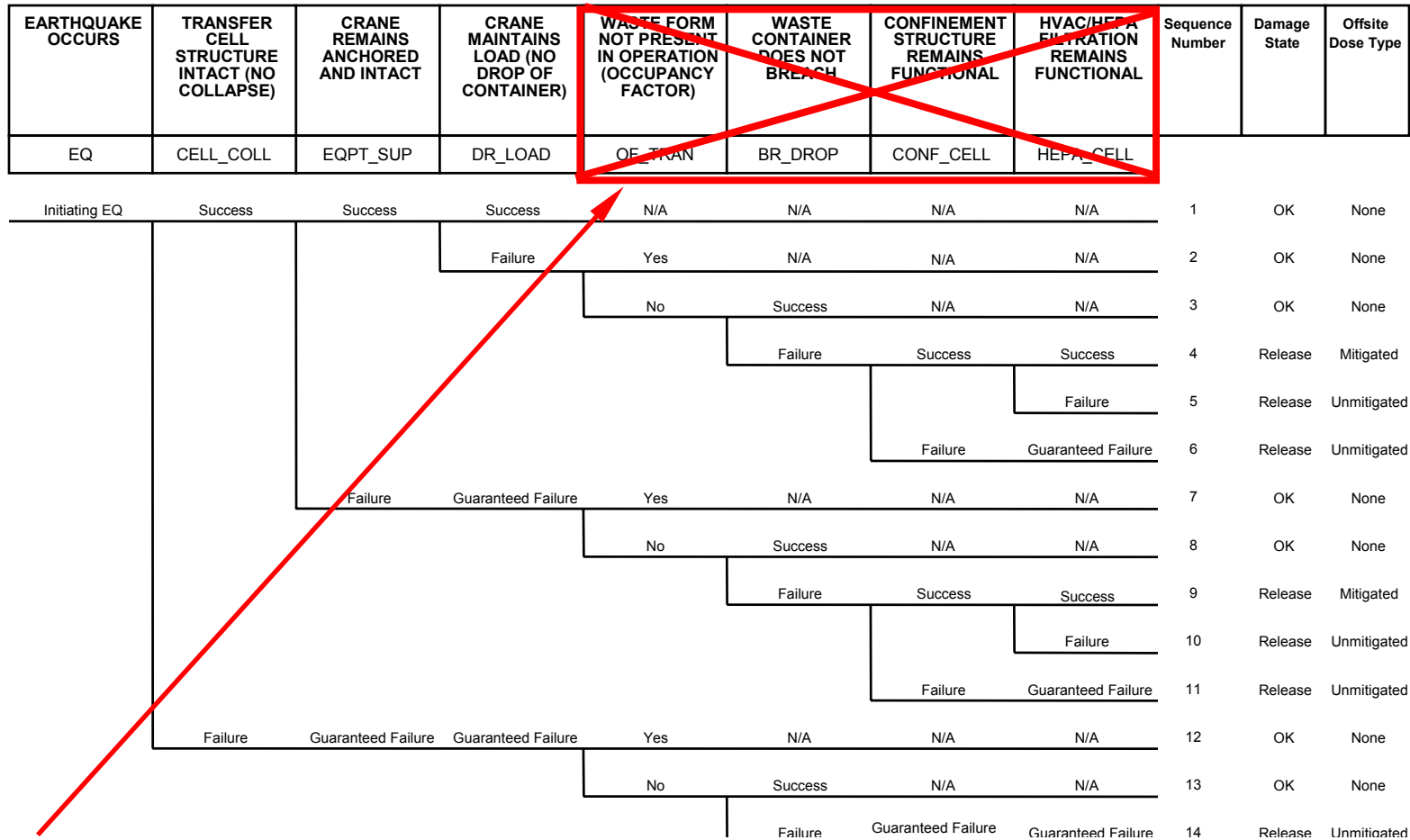


Simplifying Event Tree

- **Identify individual risk-significant SSCs**
- **Concentrate on preventing initiation of seismic event sequences**
- **No credit for active mitigation or confinement**
- **No credit for non-seismic factors that reduce likelihood of release scenario**



Simplifying Seismic Event Tree



Events not credited in simplification process.
Initially, conditional failure probability set equal to 1.0.



Simplified Tree

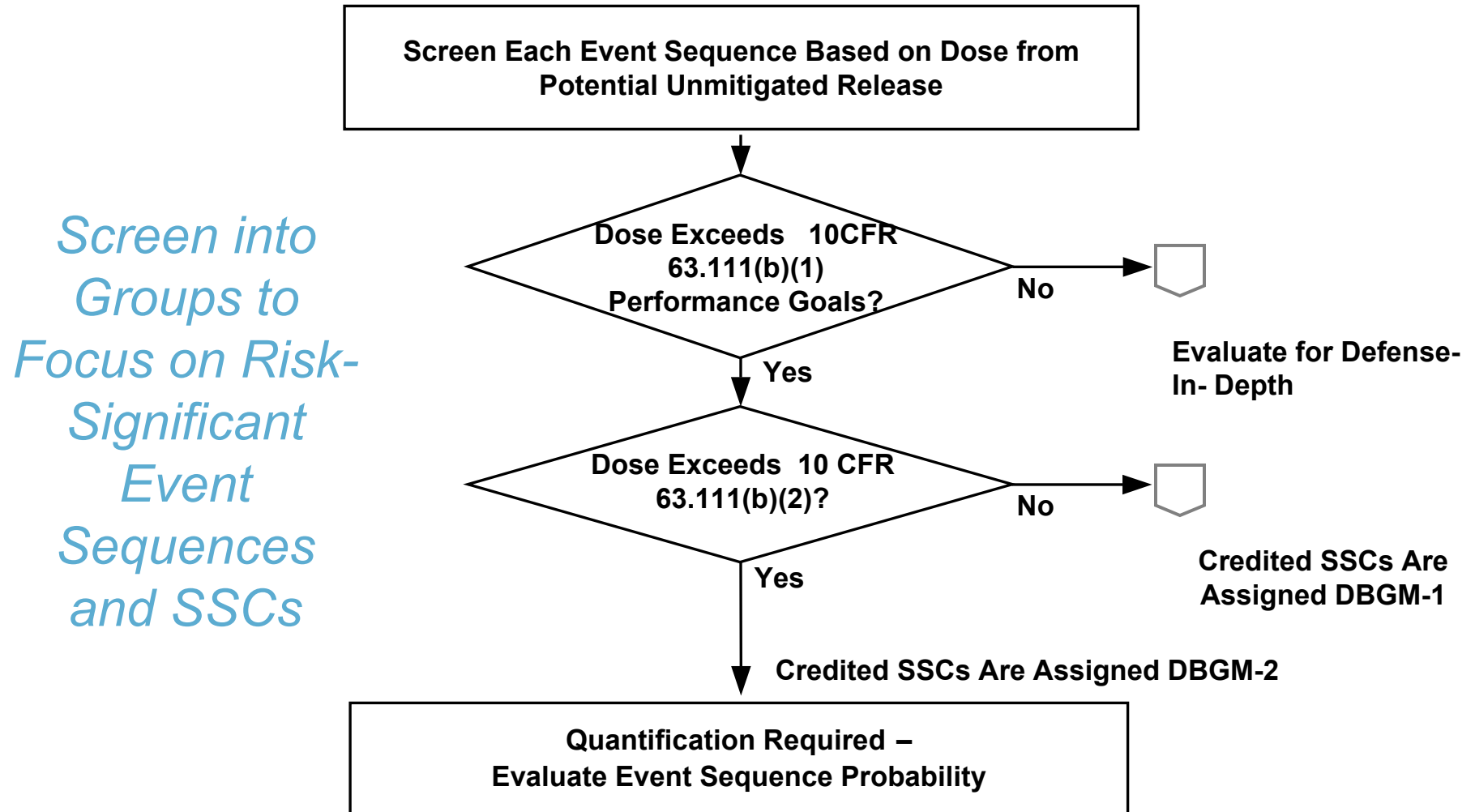
EARTHQUAKE OCCURS	TRANSFER CELL STRUCTURE INTACT (NO COLLAPSE)	CRANE REMAINS ANCHORED AND INTACT	CRANE MAINTAINS LOAD (NO DROP OF CONTAINER)	Sequence Number	Damage State	Offsite Dose Type
EQ	CELL_COLL	EQPT_SUP	DR_LOAD			
Initiating EQ	Success	Success	Success	1	OK	None
			Failure	2	Release	Unmitigated
		Failure	Guaranteed Failure	3	Release	Unmitigated
	Failure	Guaranteed Failure	Guaranteed Failure	4	Release	Unmitigated

SSC Safety Functions Credited in Preventing Event Sequence

Use unmitigated dose associated with material at risk



Screening and Assigning Design Bases



DBGM-1 = Design Basis Ground Motion #1 = 1×10^{-3} MAPE

DBGM-2 = Design Basis Ground Motion #2 = 5×10^{-4} MAPE

MAPE = Mean Annual Probability of Exceedance



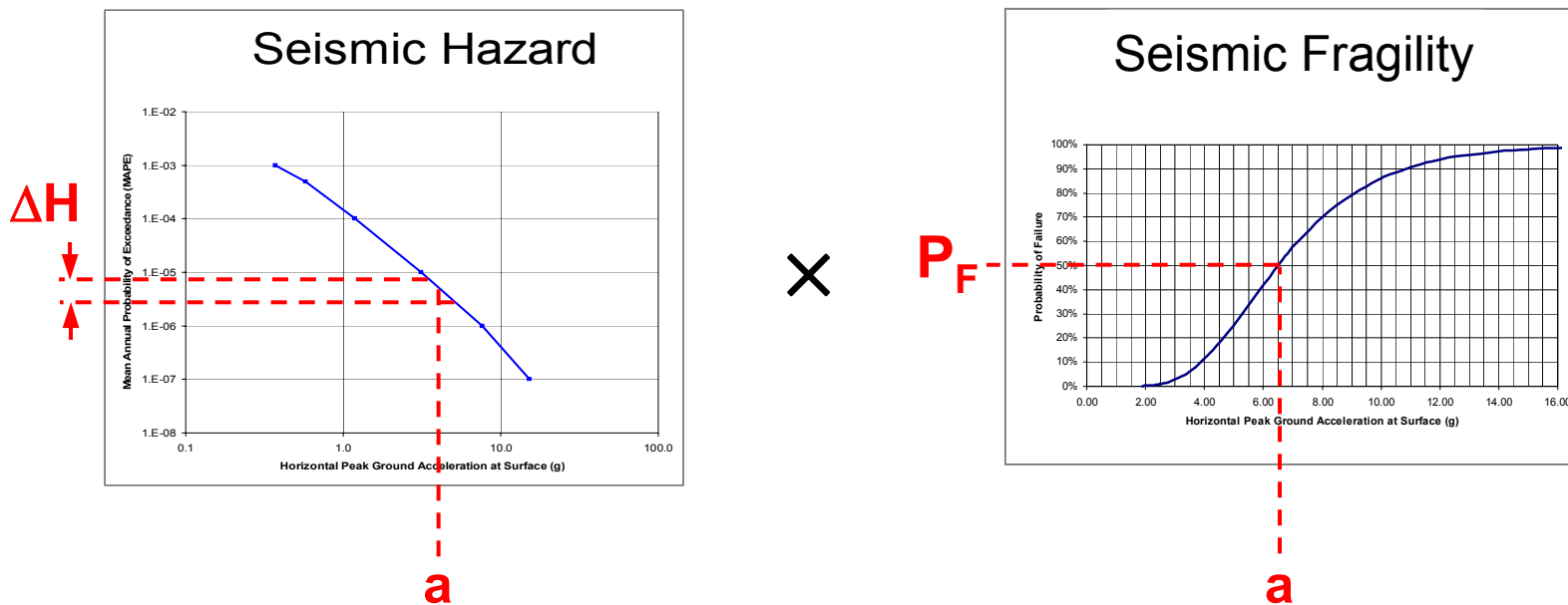
Seismic Event Sequence Quantification

- Apply to each event sequence where the dose consequence exceeds 10 CFR 63.111(b)(2)
- Obtain fragility for each SSC credited to prevent or mitigate a sequence; each SSC is
 - Classified as *Important to Safety*
 - Assigned DBGM-2 as seismic design basis
- Quantify the probability of the event sequence using probabilistic analysis including convolution integration of seismic hazard and fragility functions



Illustration of Convolution

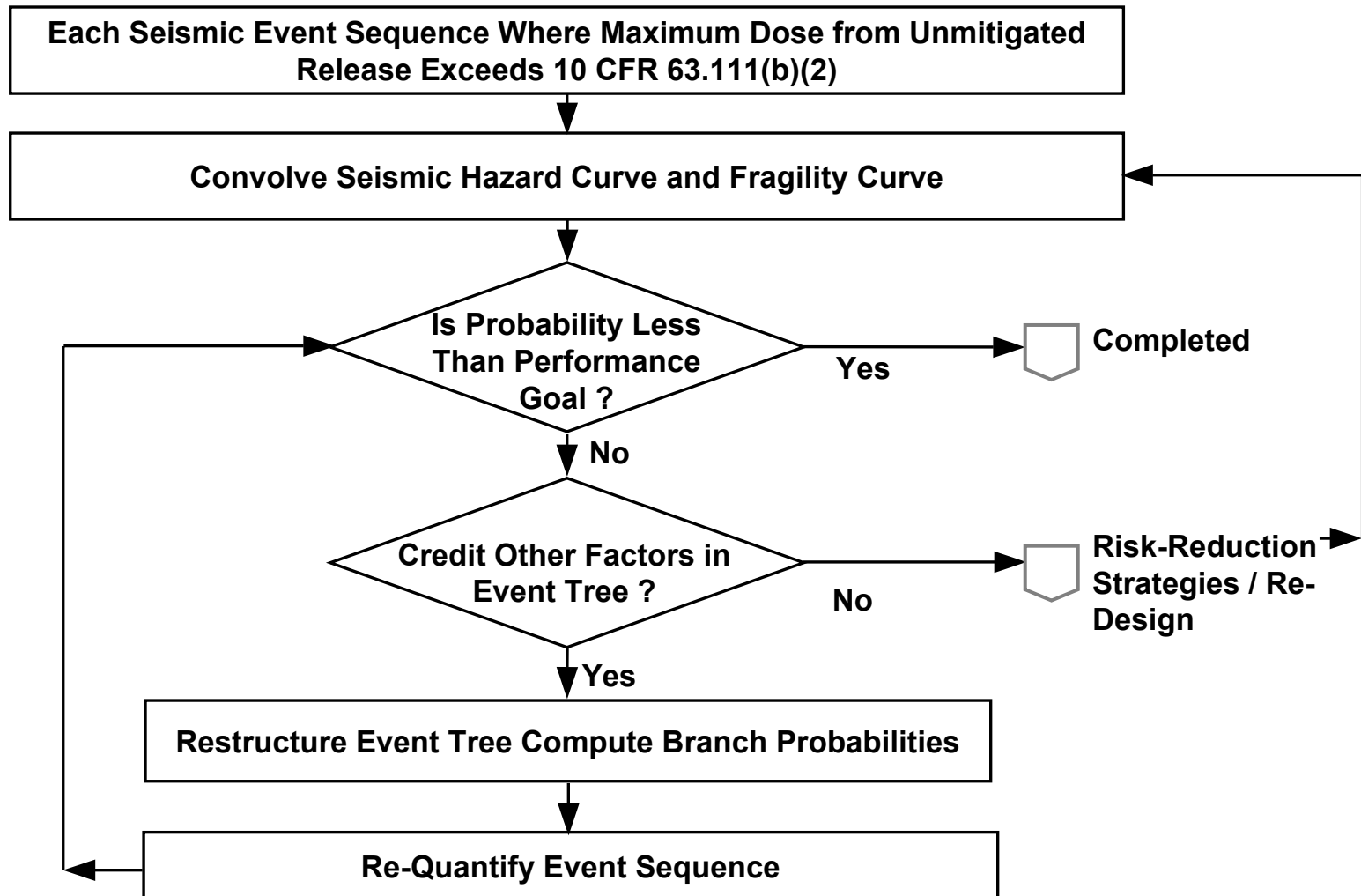
Example for seismic analyses – using numerical integration:



$$\sum \Delta H \times P_f = \text{Probability of Unacceptable Performance}$$



Quantification Process



Performance Goal = Less than 1 chance in 10,000 before permanent closure.



Results of Preclosure Seismic Analysis

- **Identification of credible potential seismically-initiated event sequences and associated consequences**
- **Assignment of DBGM-1 or DBGM-2 to ITS SSCs credited to prevent or mitigate event sequences, based on potential dose due to unmitigated release**
- **Quantification of event sequence probability to demonstrate compliance to 10 CFR 63.111(b)(2)**



ITS =Important to Safety

