ASCE 7-10, Chapter 21 Procedures for Determining Site-Specific, Risk-Targeted, Maximum Considered Earthquake (MCE_R) Response Spectra

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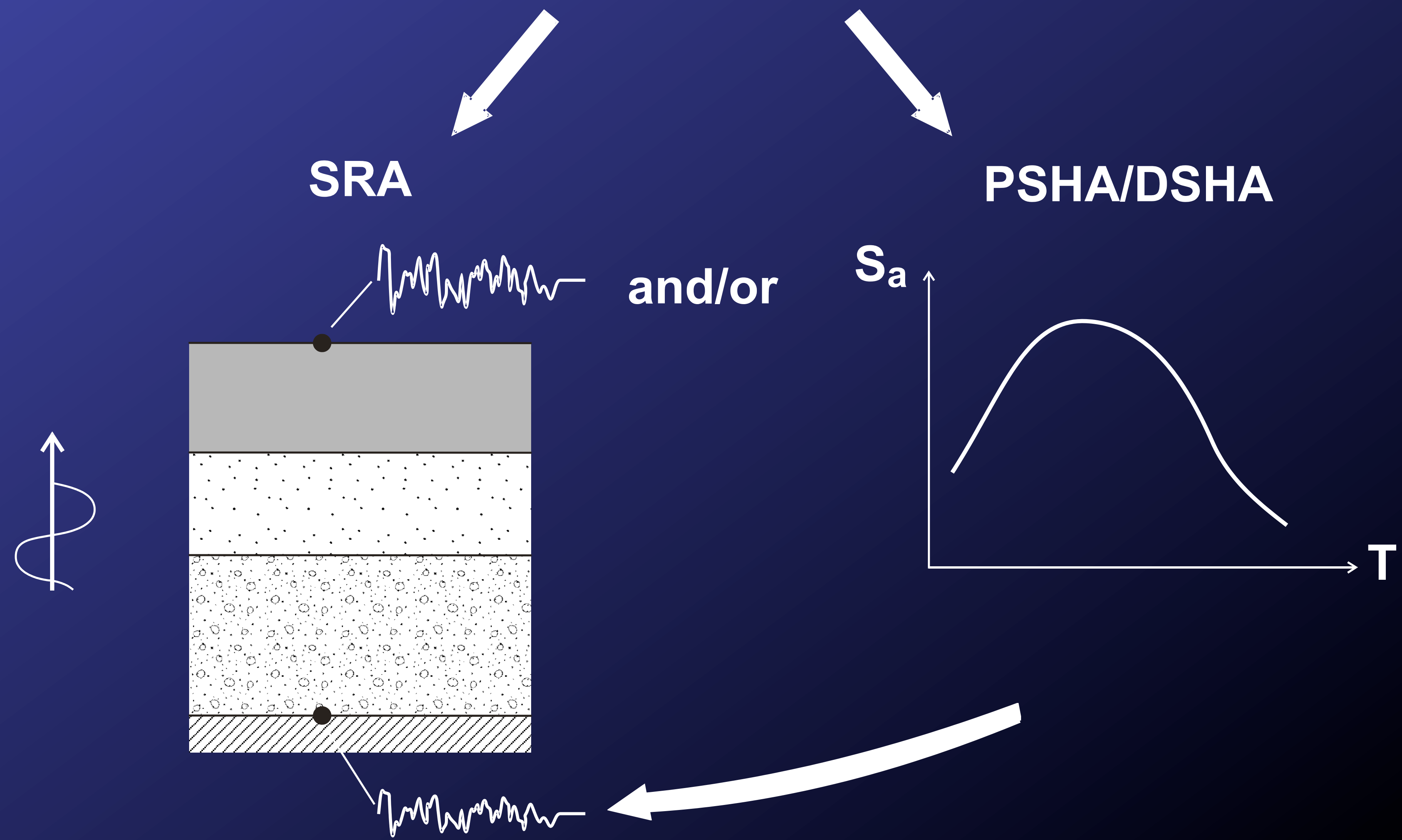
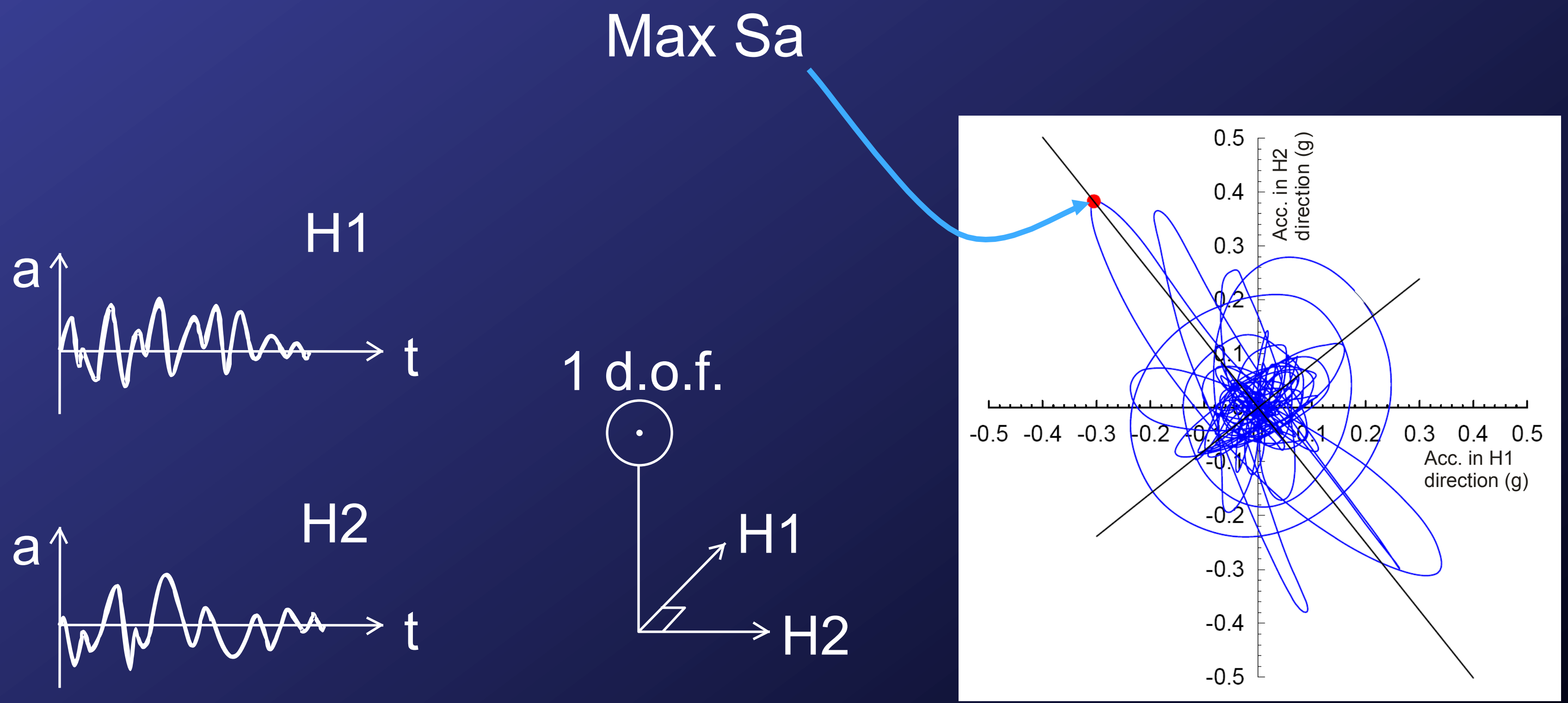
SCEC UGMS Committee Meeting
November 3, 2014

ASCE 7-10; Ch.21
Site-Specific Ground Motion



2008 USGS S_S and S_l Maps in ASCE 7-10



NGA West GMPEs Compute

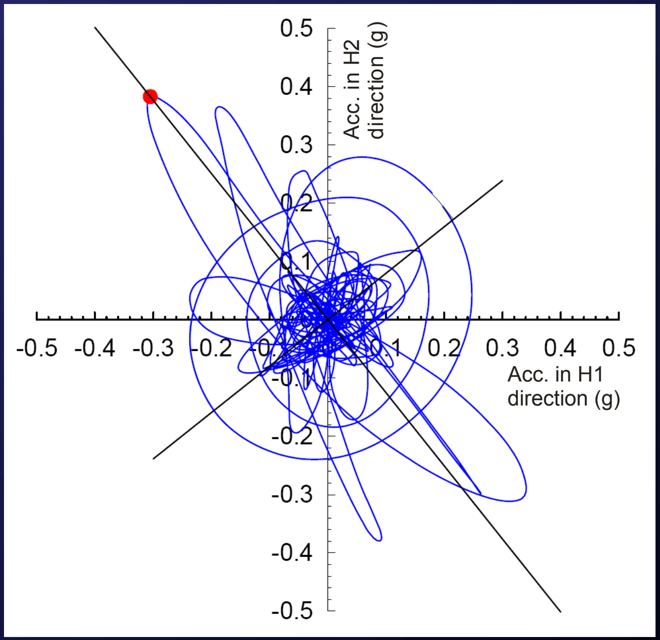
RotIM50 ~ Geometric Mean = $\sqrt{Sa_1 * Sa_2}$

Convert RotIM50 to RotD100 (i.e, max Sa)

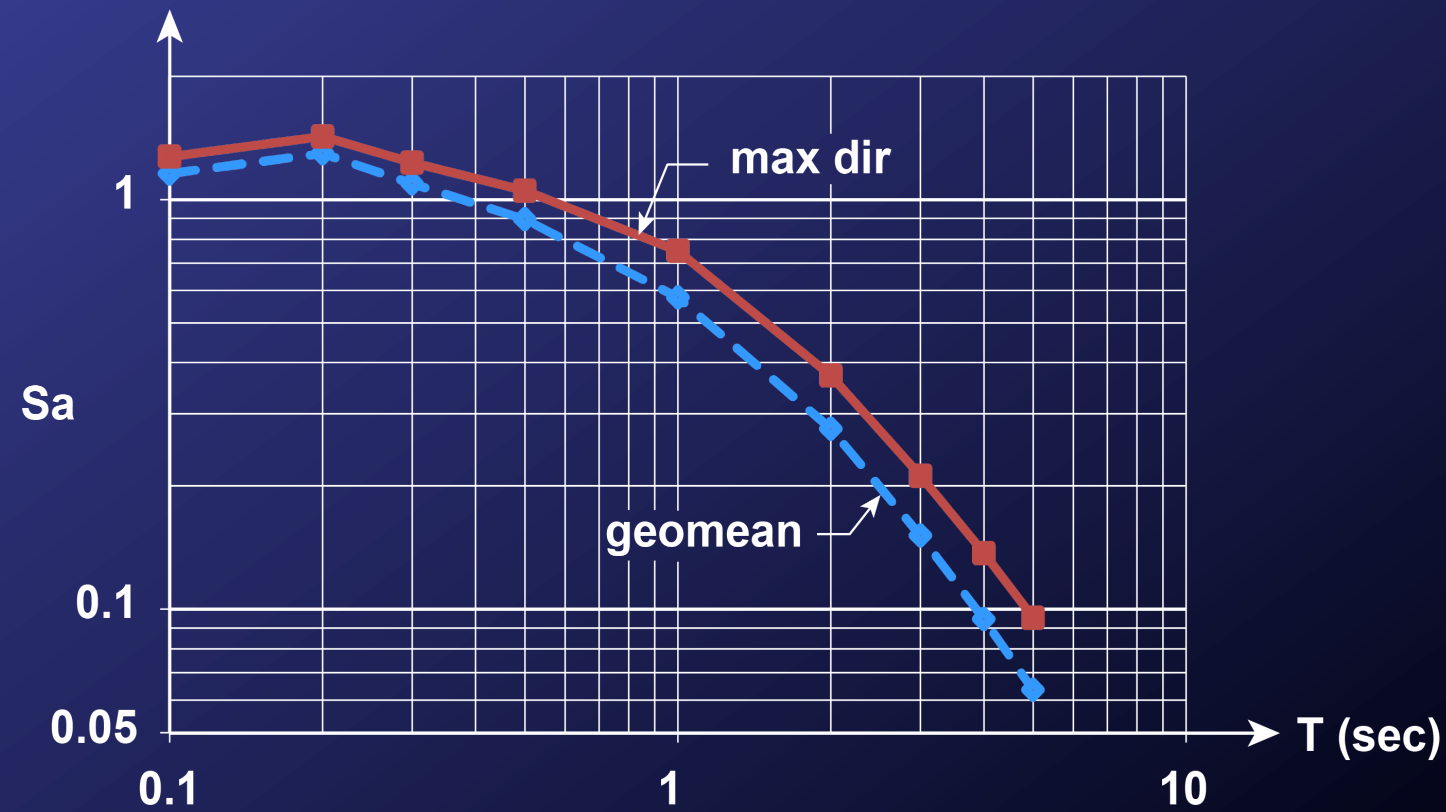
Used: Sashi & Baker (2013)

CyberShake Simulations

- Max Sa computed directly from simulated H1 & H2 time histories.



Adjustment of NGA West GMPEs from Geomean Sa to Max Direction Sa



Site-Specific Ground Motion Procedures in Ch. 21 of ASCE 7-10 ⟶ MCE_R

Sect. 21.2.1: Probabilistic MCE_R ⟶ S_a^{Prob}

Sect. 21.2.2: Deterministic MCE_R ⟶ S_a^{Det}

Sect. 21.2.3: Site-Specific MCE_R

$$S_{aM}(T) = \min[S_a^{Prob}(T), S_a^{Det}(T)]$$

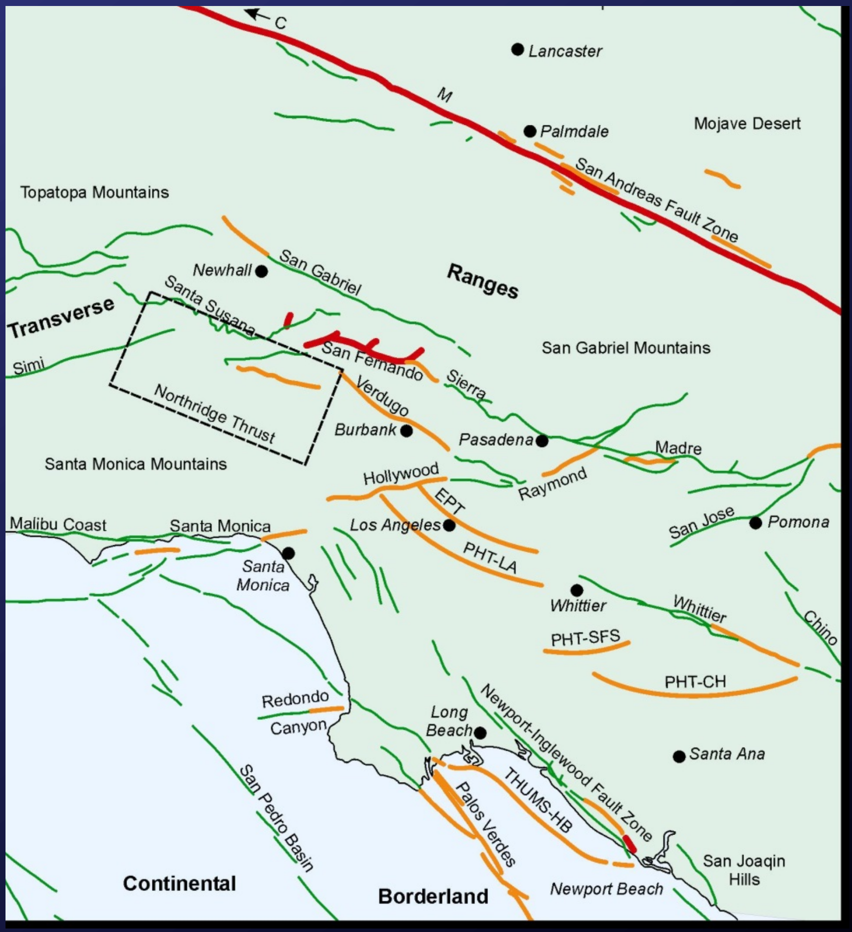
Probabilistic MCE_R

1. Characterize fault recurrence rate (SCEC UCERF2)

2. Perform PSHA with NGA GMPEs or CyberShake simulations

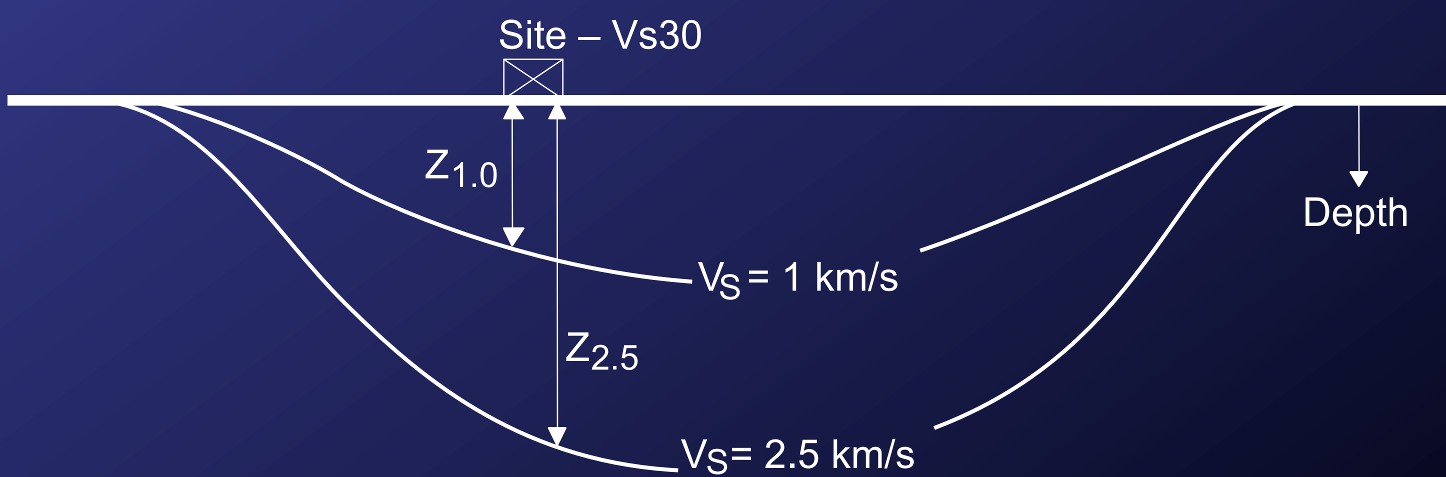
3. Compute seismic hazard curves for each T

(Ignore background seismicity)



2013 NGA Equations with Basin Depth Terms

- Abrahamson et al – Z1.0
- Boore et al – Z1.0
- Campbell & Bozorgnia – Z2.5
- Chiou & Youngs – Z1.0



Basin Profile

ASCE 7-10: Two Methods to convert seismic hazard curves to Probabilistic MCE_R

Method 2 (Exact) in Sect. 21.2.1.2

- Uses "Risk Integral" Equation
- Selected for NGA GMPEs & CyberShake

Probabilistic MCE_R

"Risk Integral"

$$P_f = \int_0^{\infty} P(a) \frac{dP_f(a)}{da} \, da$$

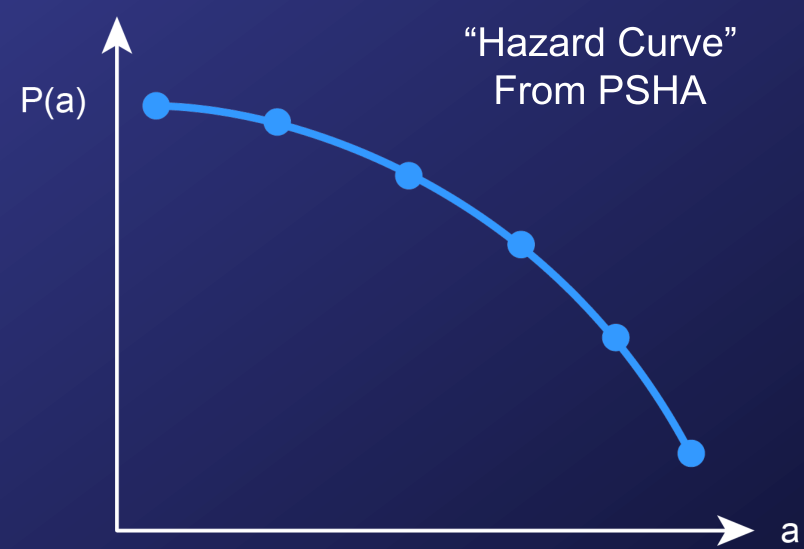
where

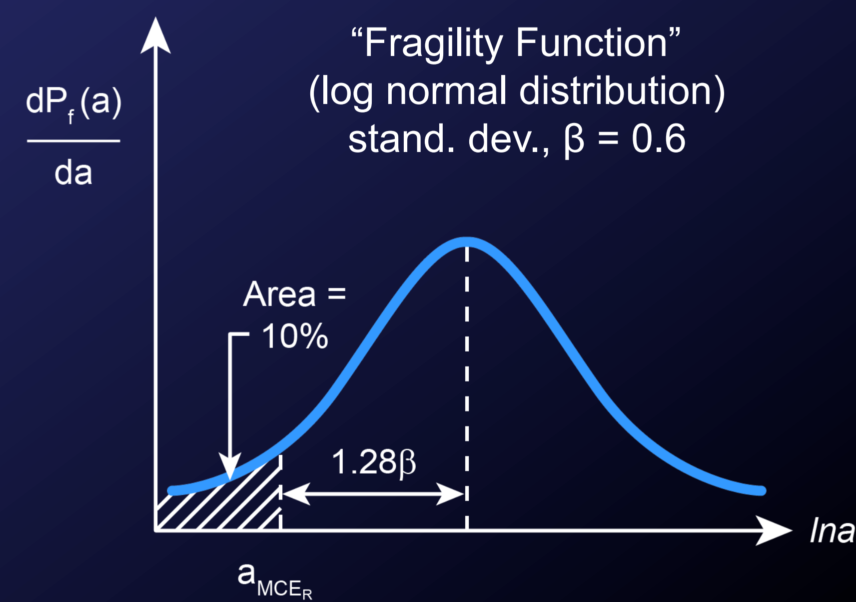
- P_f = 1% probability collapse in 50 yrs
- $P(a)$ = probability of exceeding spectral acceleration in 50 yrs
- $P_f(a)$ = probability of collapse given spectral acceleration

Probabilistic MCE_R

"Risk Integral"

$$P_f = \int_0^\infty P(a) \frac{dP_f(a)}{da} \, da$$

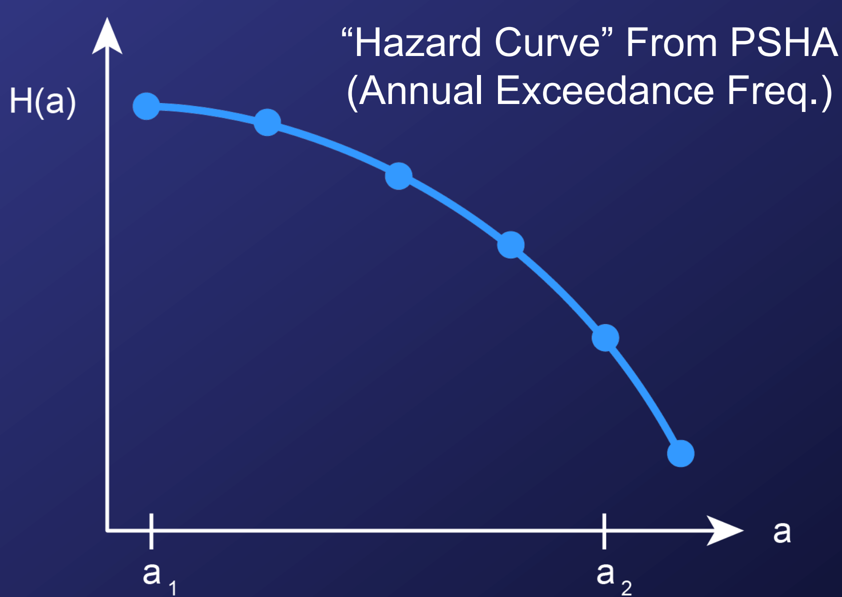


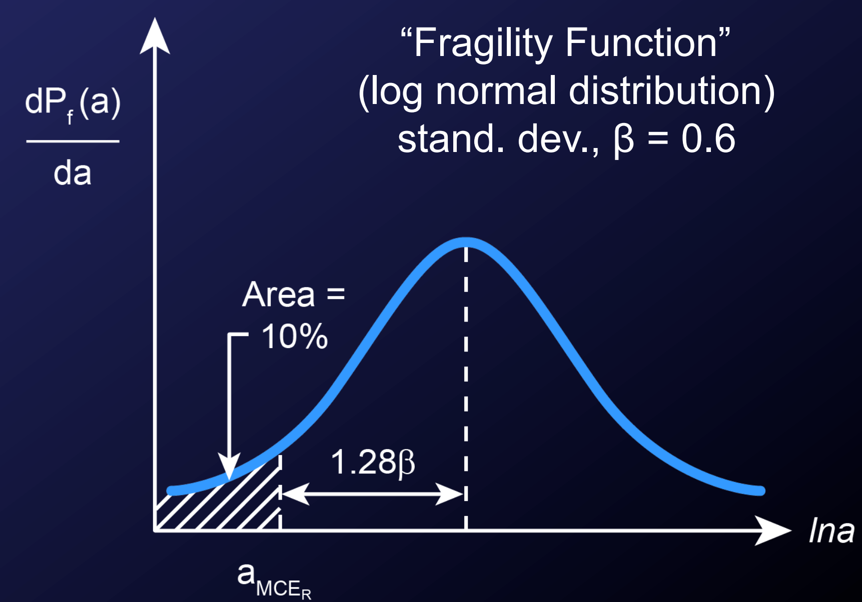


Probabilistic MCE_R (Actual Calc.)

"Risk Integral" becomes:

Annual Collapse Freq. → $H_f = \int_{a_1}^{a_2} H(a) \, \frac{dP_f(a)}{da} \, da$





Calculation of a_{MCE_R} is Iterative

- Assume a_{MCE_R} = 2475-yr a
- Compute H_f
- Adjust a_{MCE_R} ↑ or ↓
- Repeat until $H_f \approx 0.000201$

Deterministic MCE_R – from NGA GMPEs

1. **Identify Controlling Faults**

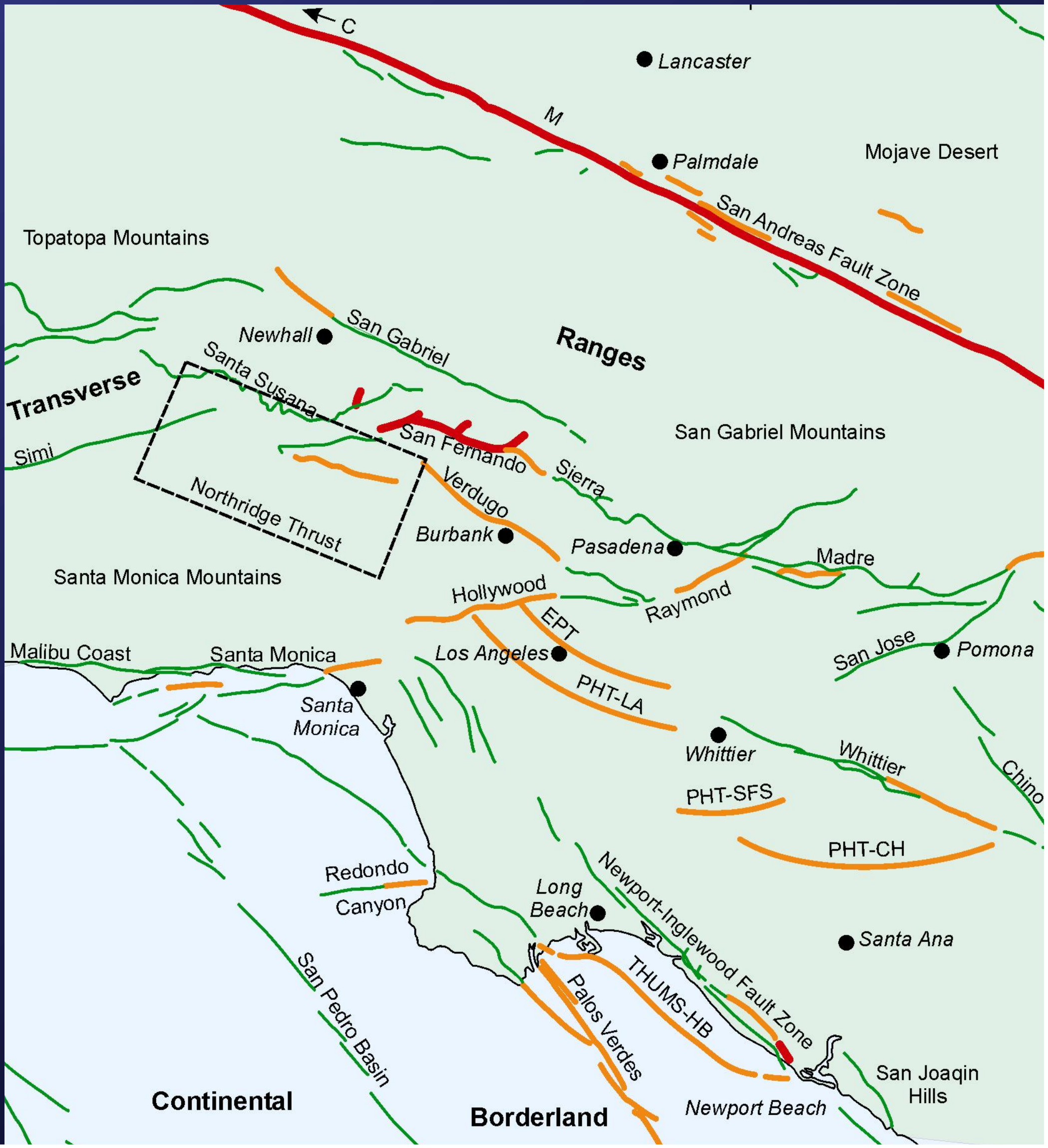
2. **Postulate M_{MAX} for each Fault**

3. **Use same GMPE's & weights in PSHA**

↓

84th Percentile $S_a(T)$

"median + 1σ"



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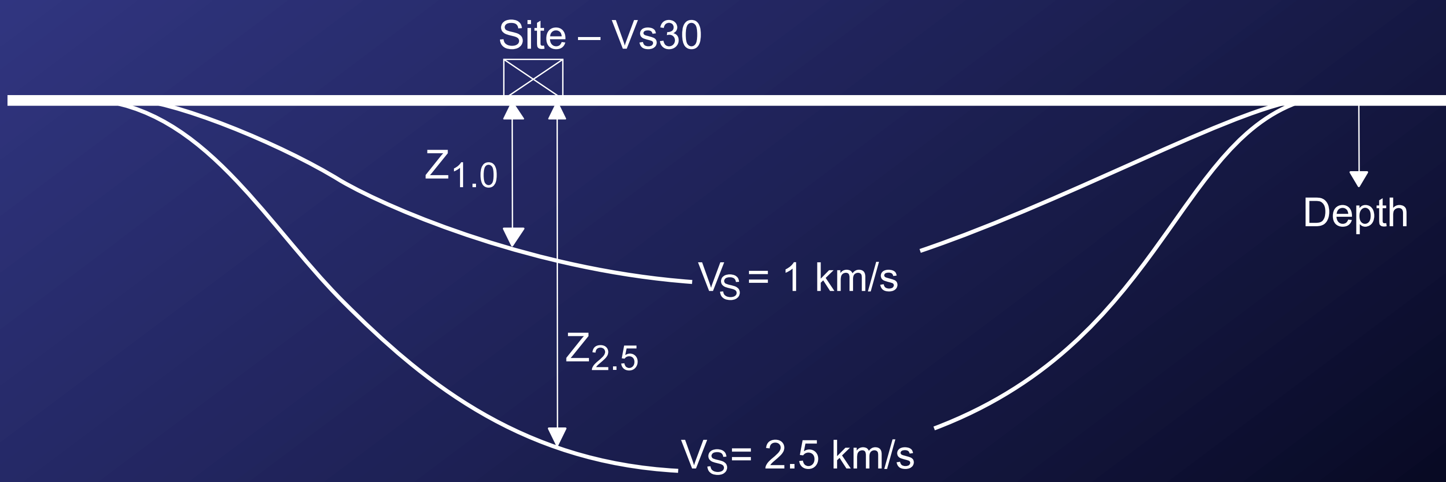


Basin Profile

Deterministic MCE_R – from CyberShake Simulations

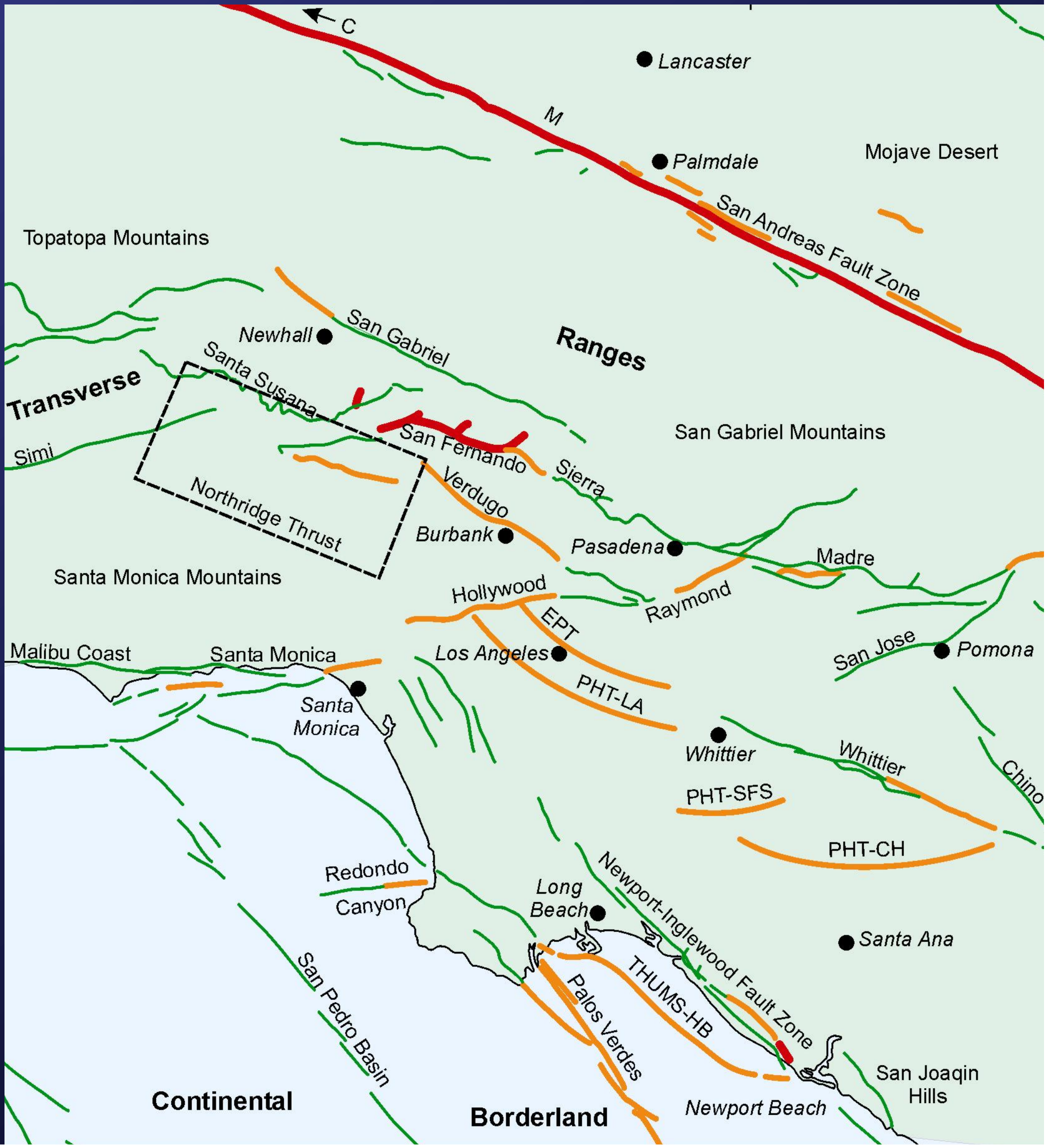
1. Select same USGS faults & M_{MAX}

2. Identify ruptures for M_{MAX} +/- 0.1 on each fault

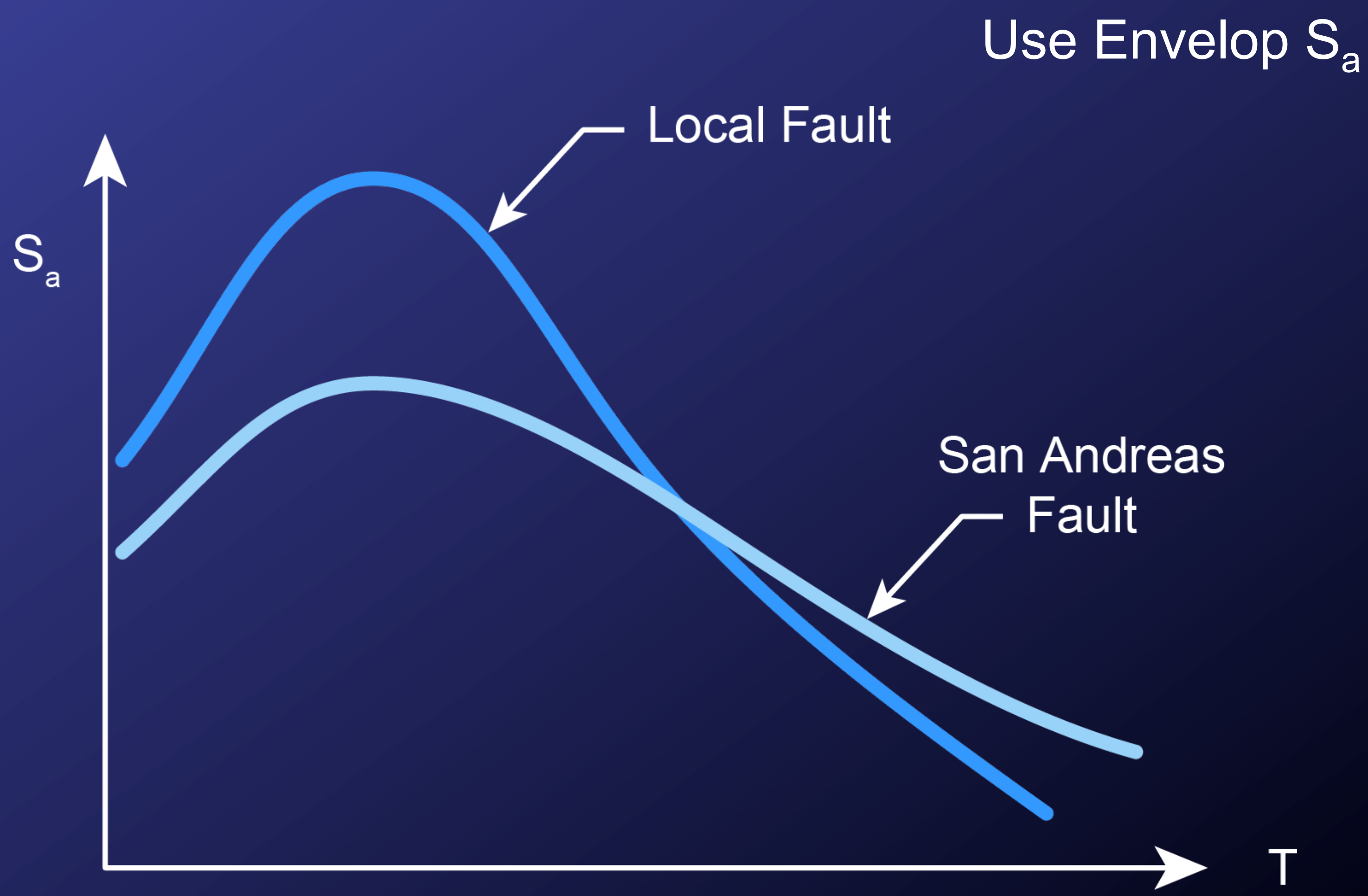
3. Compute Max Sa for each rupture

↓

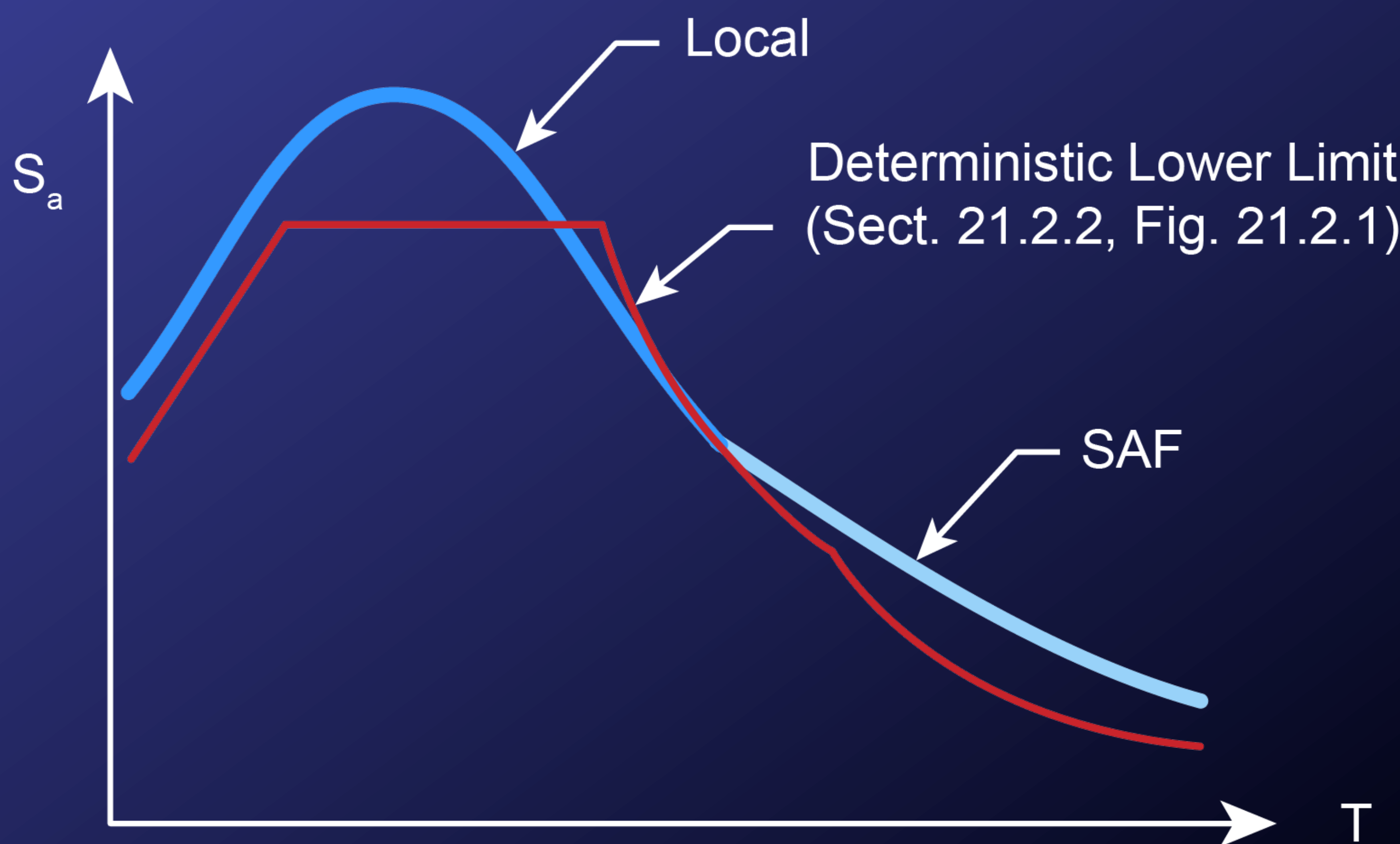
84th Percentile $S_a(T)$



Deterministic MCE_R – 84th Percentile S_a



Deterministic MCE_R



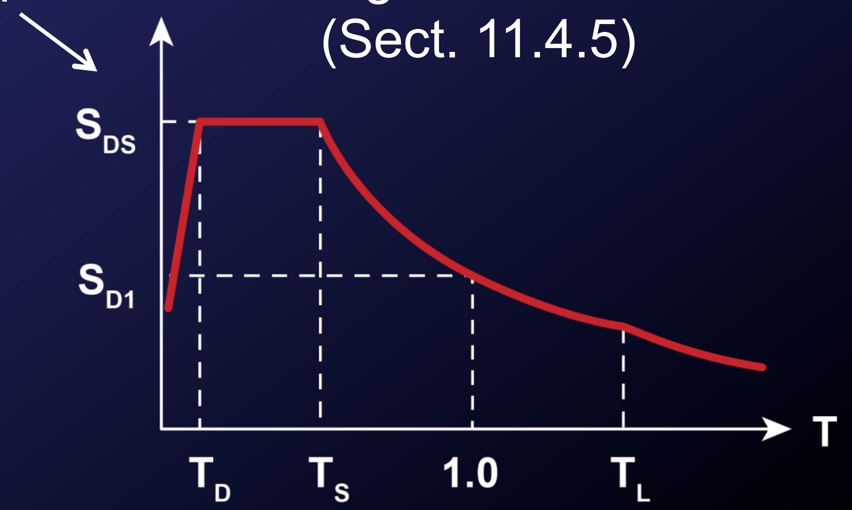
Site-Specific MCE_R S_{aM}

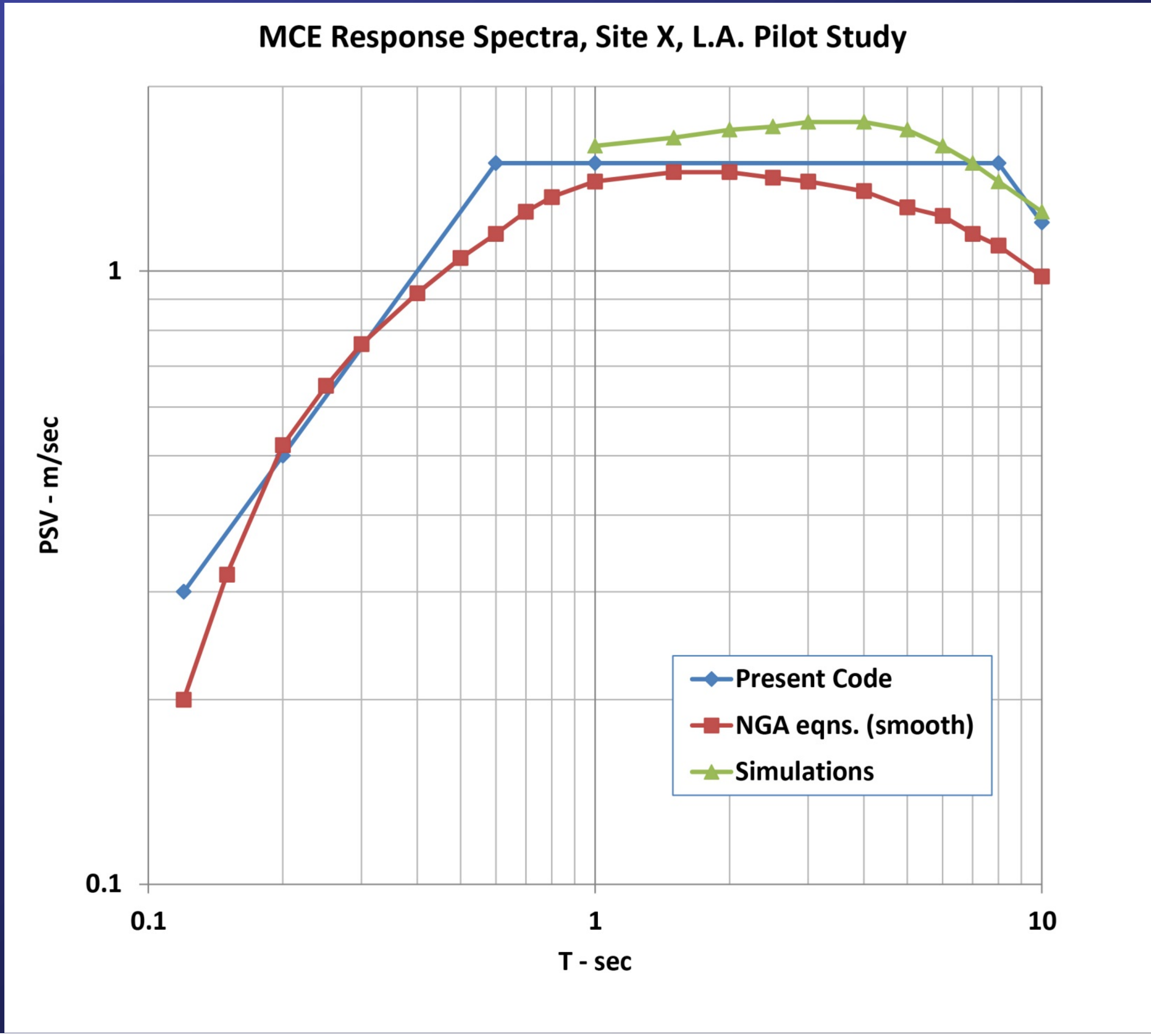
$$S_{aM} = \min[S_a^{Prob}(T), S_a^{Det}(T)]$$

Design Response Spectrum (Sect. 21.3)

$$S_a = \frac{2}{3} S_{aM} \geq 0.8 \times S_a$$

Figure 11.4-1
(Sect. 11.4.5)





MCE Response Spectra, Site X, L.A. Pilot Study
PSV - m/sec
1
0.1
0.1
1
10
T - sec
Present Code
NGA eqns. (smooth)
Simulations