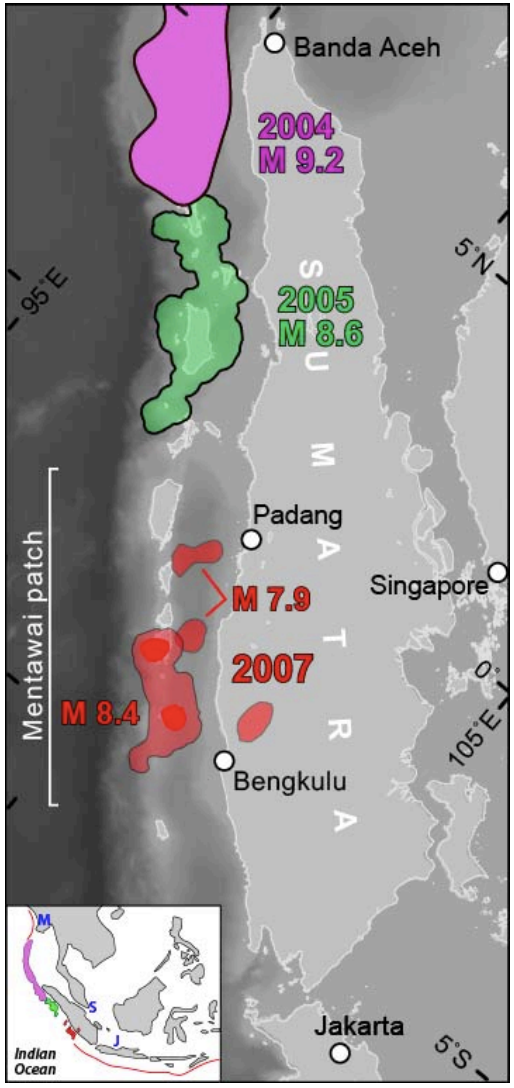
Research needs and opportunities for Performance-Based Tsunami Engineering

Greg Deierlein

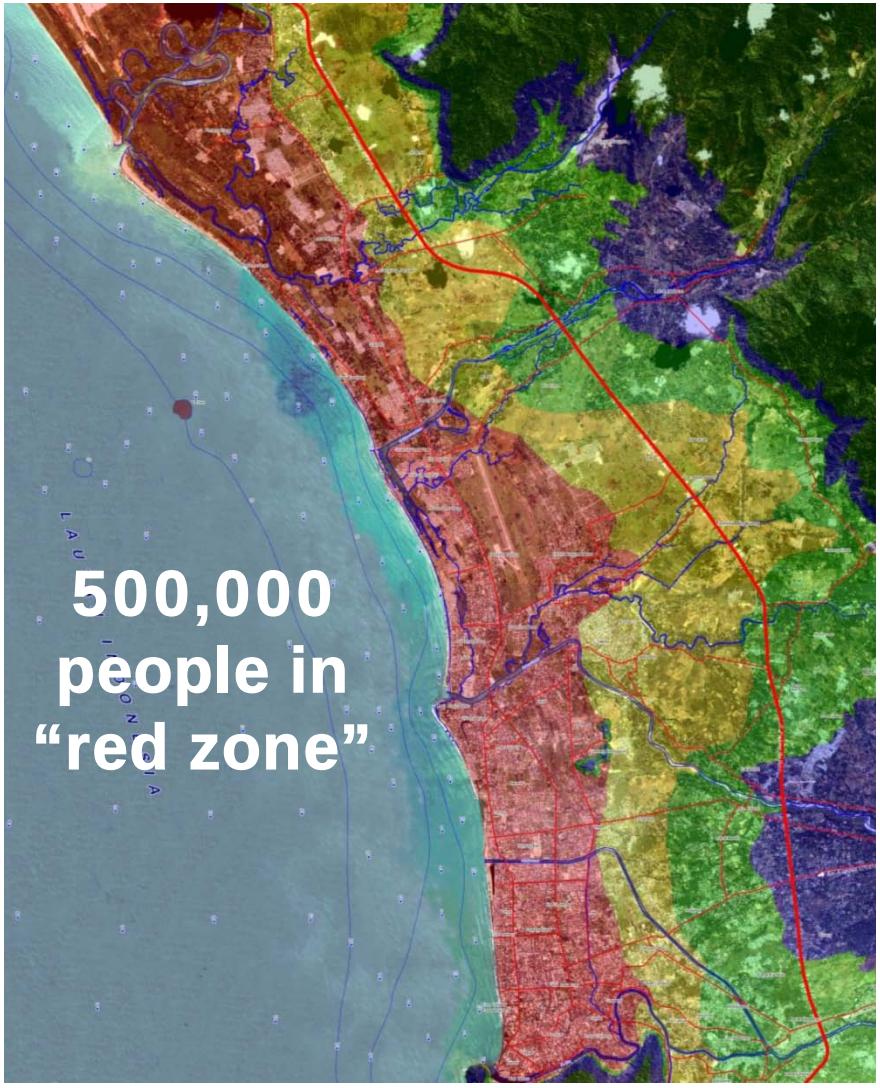
Stanford University

PEER Annual Meeting – October 1, 2011

What peeked my interest ...



Sunda trench fault



Padang, Indonesia

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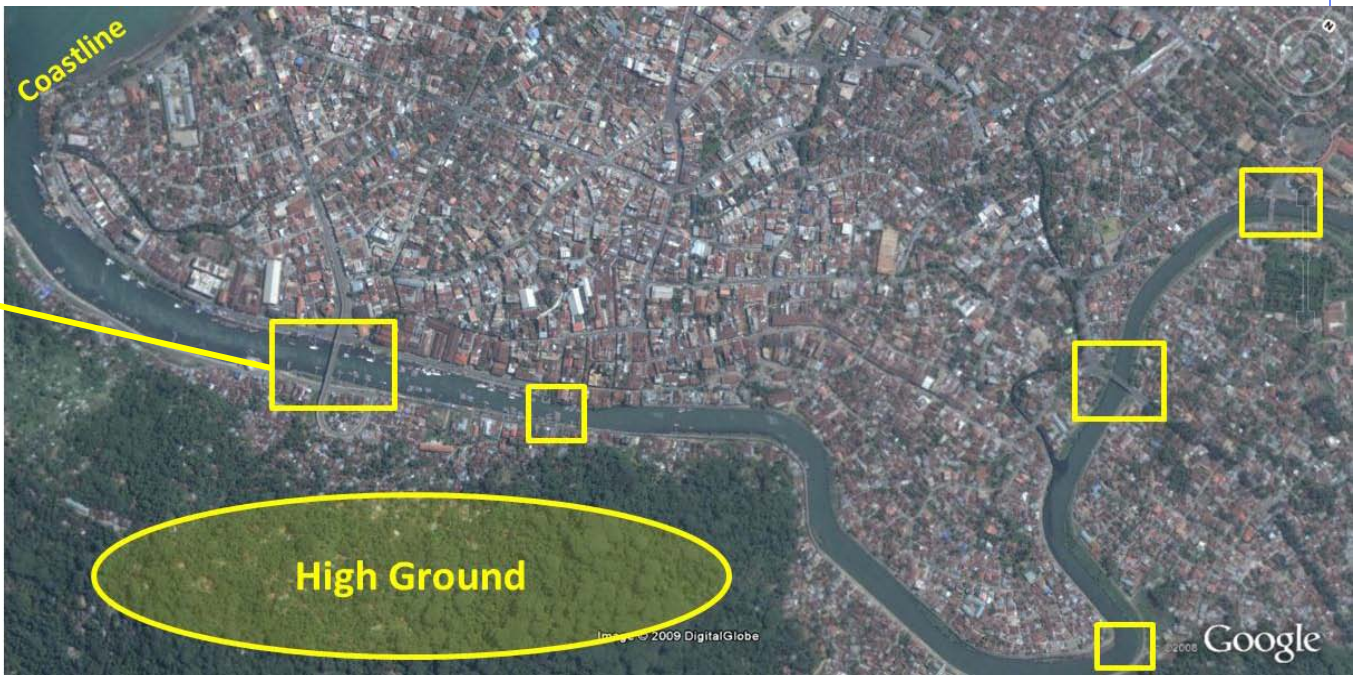
Horizontal & Vertical Evacuation



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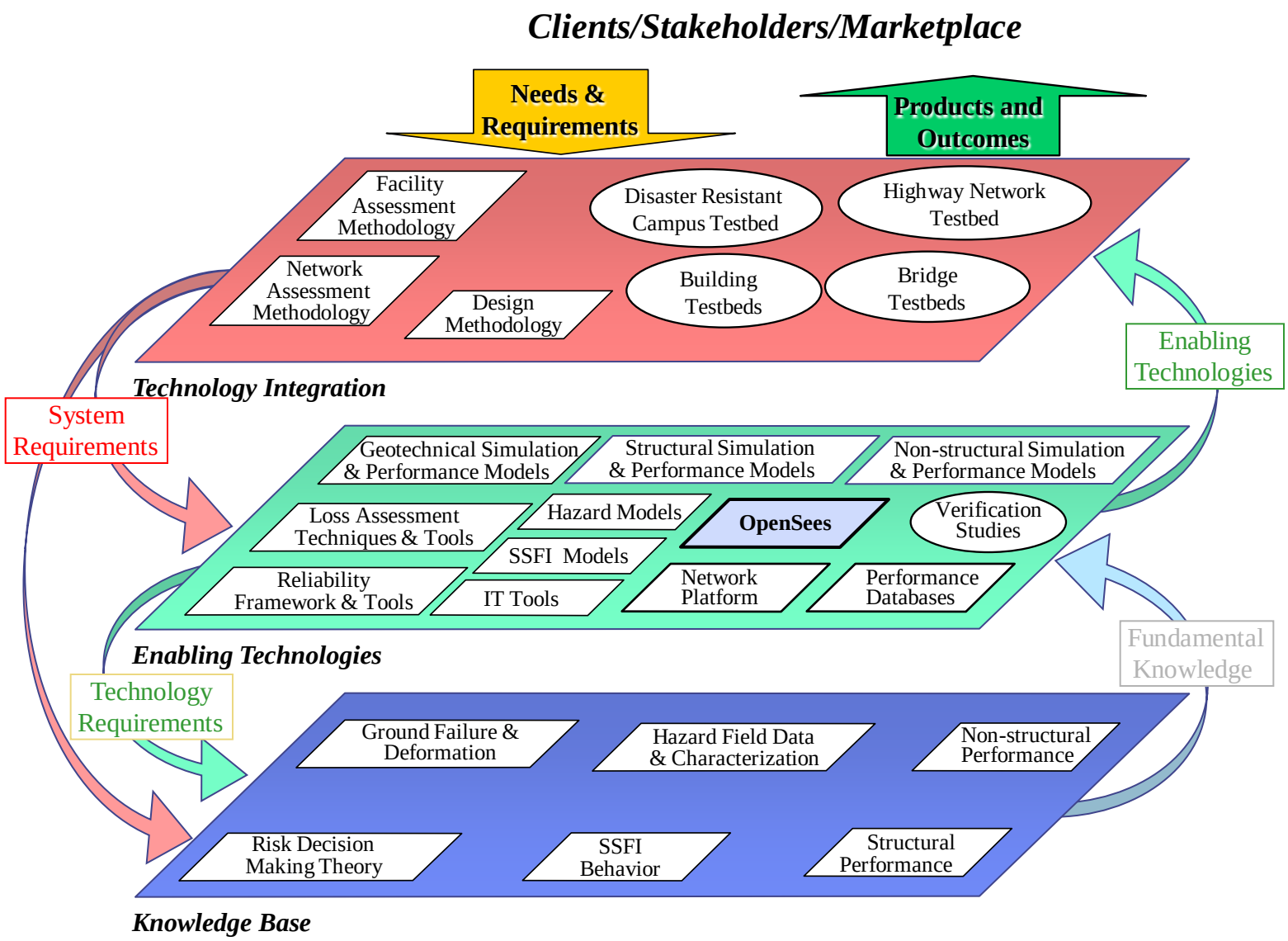
Systems-Level Research

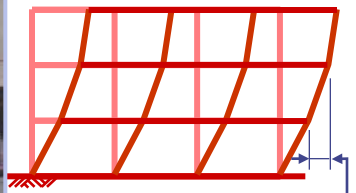


Performance-Based Framework

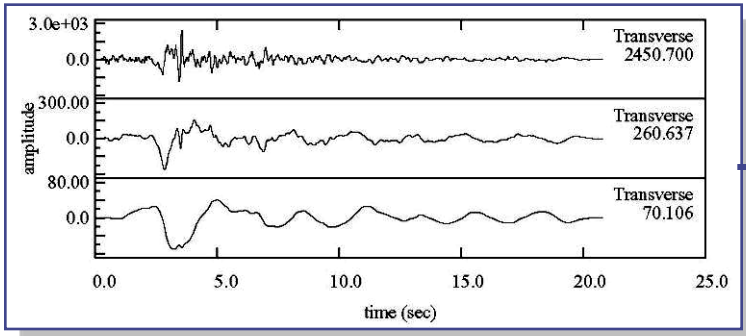
- Collapse & Casualties
- Direct Financial Loss
- Downtime

Decision Variable

Damage Measure



Engineering Demand Parameter



Intensity Measure

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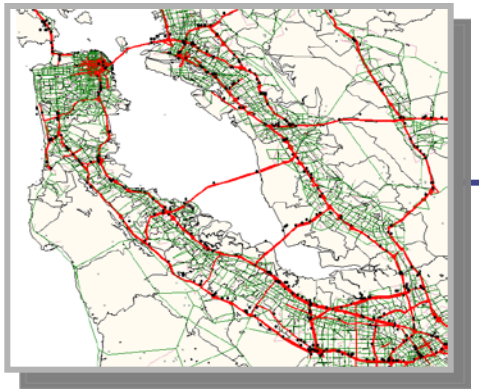
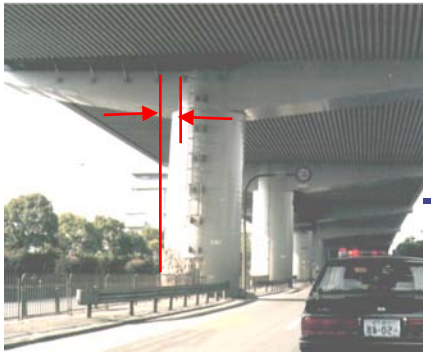
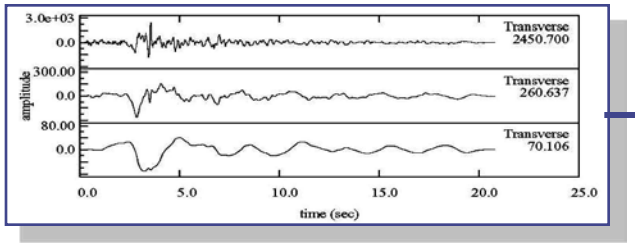
Bridge and Transportation Systems







Decision Variable (DV)

Damage Measure (DM)

Engineering Demand Parameter (EDP)

Intensity Measure

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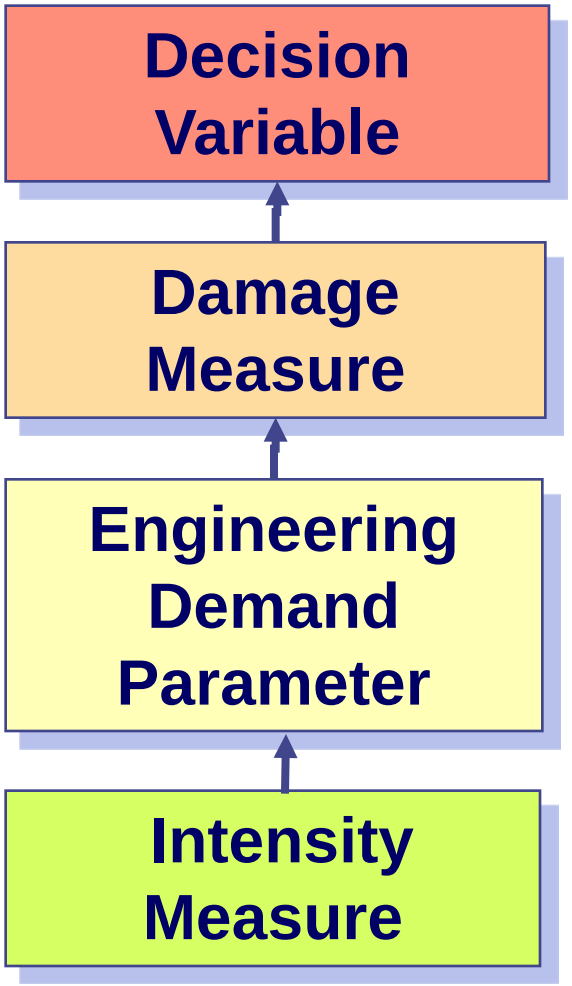
Performance Assessment Components



Relating Performance to Risk Decision Making

Quantifying Damage Measures

Simulation of System Response

Earthquake Hazard Characterization

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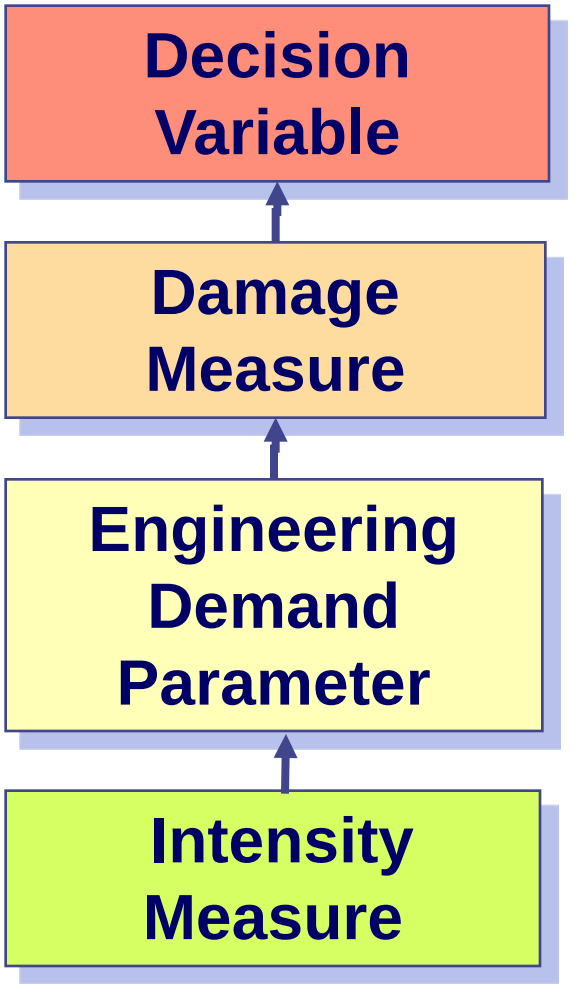
Performance Assessment Components



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Tsunami Hazard Characterization

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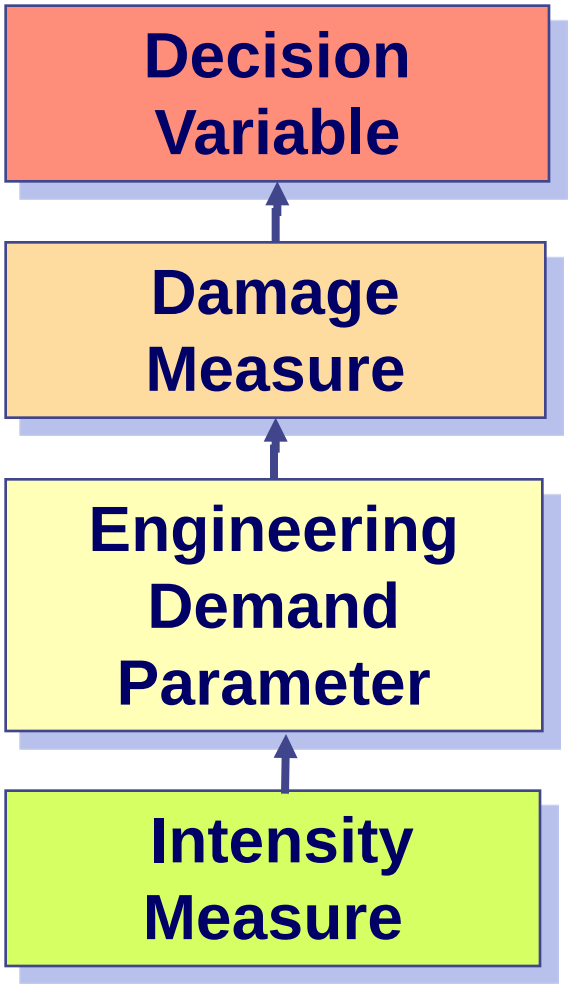
Performance Assessment Components



DV: $ loss, functionality, downtime, casualties

DM: physical condition & consequences/ramifications

EDP: Drift Ratio (peak, residual), Floor Acceleration, Local Indices (Θ_p, strain, ...)

IM: *Sa(T_1),* multiple *Sa's,* epsilon, *$Sd_{inelastic}$,* duration

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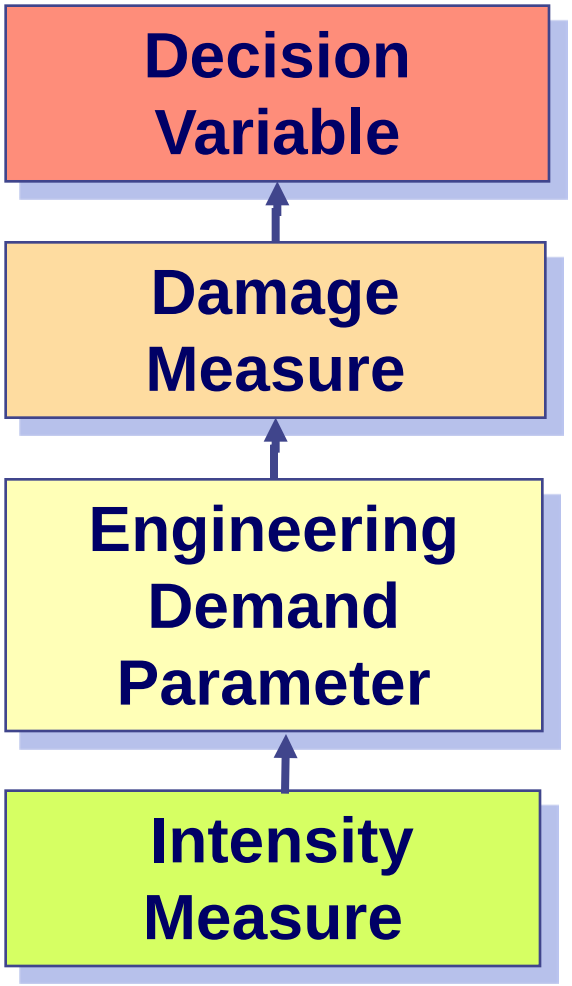
Performance Assessment Components



DV: $ loss, functionality, downtime, casualties

DM: physical condition & consequences/ramifications

EDP: facility deformations, scour, evacuation response time, ???

IM: inundation, wave height, ???

PBEE – Probability Framework Equation

$$\nu(DV) = \iiint G\langle DV \mid DM \rangle \mid dG\langle DM \mid EDP \rangle \mid dG\langle EDP \mid IM \rangle \mid d\lambda(IM)$$

Impact | **Performance (Loss) Models and Simulation** | **Hazard**

IM – Intensity Measure

EDP – Engineering Demand Parameter

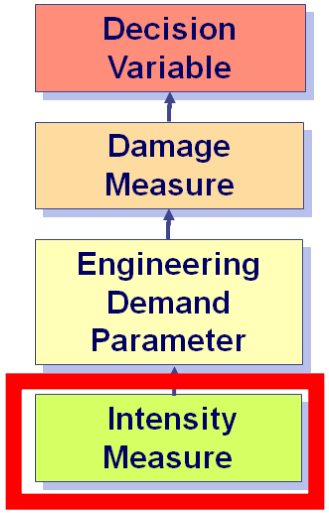
DM – Damage Measure

DV – Decision Variable

ν(DV) – Probabilistic Description of Decision Variable

(e.g., Mean Annual Probability $ Loss > 50% Replacement Cost)

Tsunami Intensity Measures (IM)



- Waveheight
- Inundation
- Flow depth - D
- Flow velocity – V (maybe at minimum flow depth)
- Momentum, momentum flux
- Drawdown, duration
- Vorticity
- Combinations of the above?

REF: PTHA study by Hong Kie Thio, URS Corp.

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Probabilistic Tsunami Hazard in CA

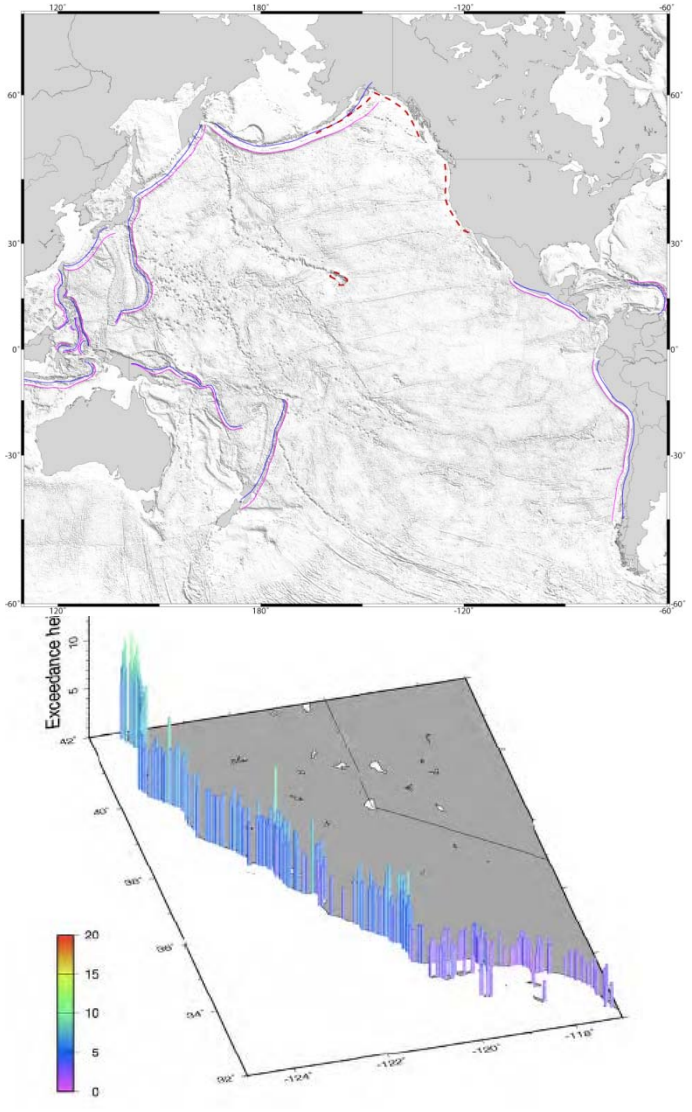
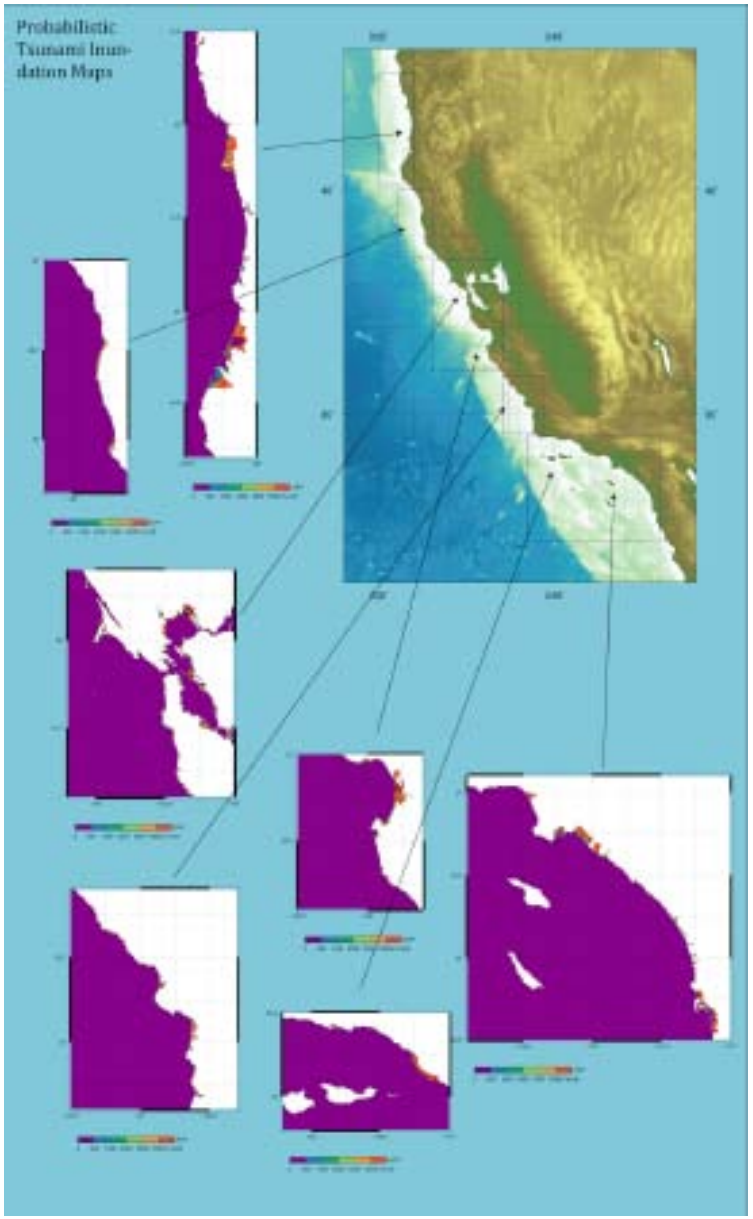


Fig. 8.4 Offshore exceedance waveheight for a 2500 yr return period.



REF: H.K. Thio, P. Somerville, & J. Polet

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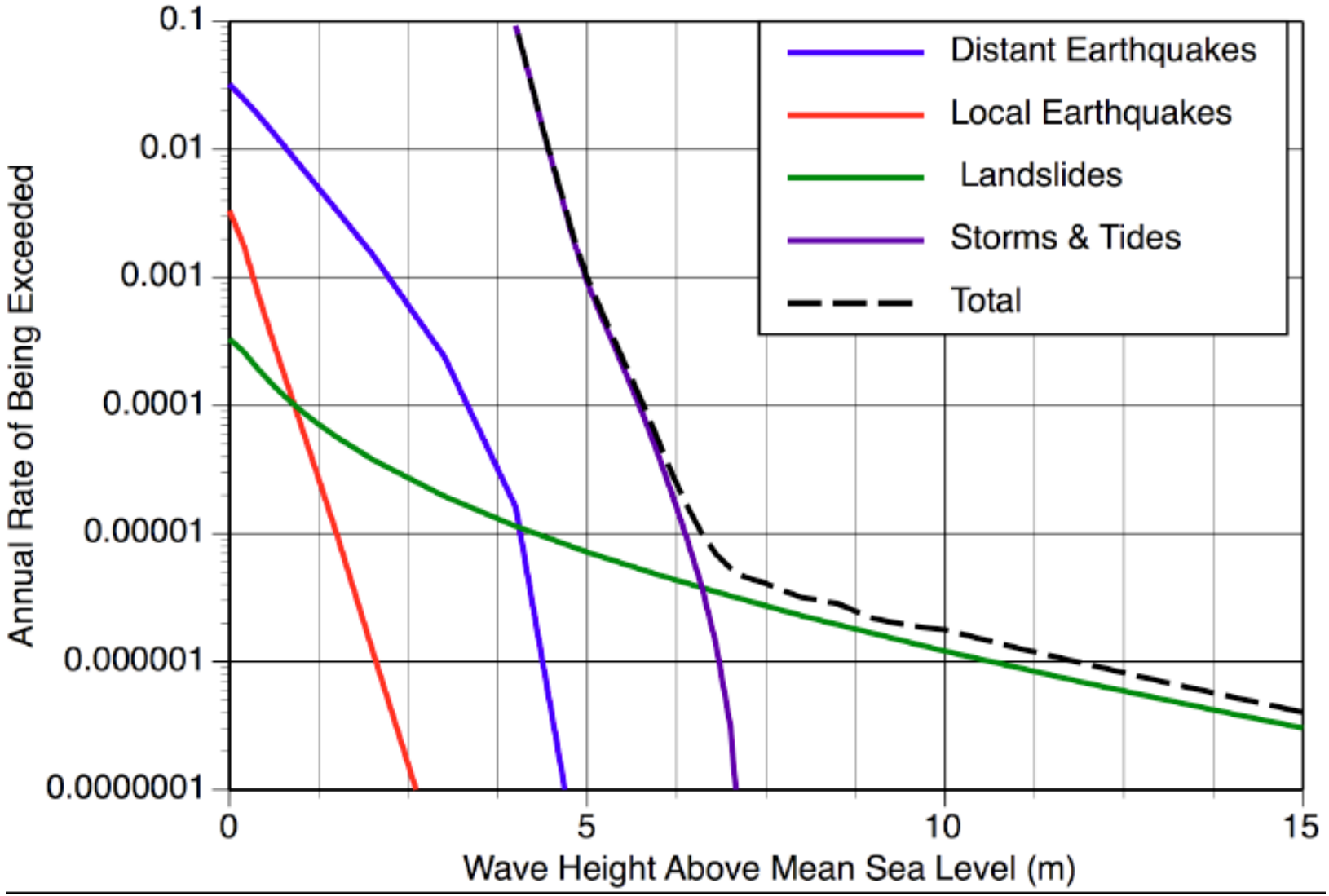
Probabilistic Tsunami Hazard in CA



REF: S. Nishenko, PG&E

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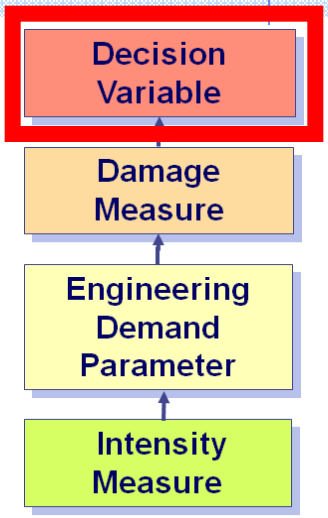
Life Safety Risk Mitigation



- Land Use Planning
- Horizontal Evacuation
  - planning & training (routes, signage, etc.)
  - early warning & evacuation management
- Vertical Evacuation Structures
  - suitability – location, capacity, height, strength
  - cost-effective meantime usage
  - acceptance and utilization
- Cascading Risks
  - hazardous materials & facilities (e.g., nuclear, chemical)
  - critical facilities & lifelines

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Society & Stakeholder Interests

commercial ports

communities

special facilities

Session Agenda

Overview Presentations (9:00 to 10:30 AM)

1. Introduction and Overview (Greg Deierlein)
2. Tsunami – General Issues (Harry Yeh, OSU)
3. Coastal Effects and Modeling (Patrick Lynnett, USC)
4. Tsunami Flow Sensing and Measurement (Alex Bayen, UCB)
5. Engineered Structures and Facilities (Ian Robertson, UofH)
6. Tsunami Early Warning and Evacuation (Vasily Titov, NOAA)
7. Tsunami Risk and Loss Modeling (Keith Porter, UC Boulder)
8. Industry Perspectives (Norm Abrahamson and others)

Discussion (10:45 to 11:30 AM)

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Things to be thinking about ...

- Is the IM-EDP-DM-DV framework amenable to *PBTE*?
- If so, what are the appropriate parameters to quantify performance framework metrics?
- Who are important stakeholders for tsunami risks, and what are their main concerns
  - *commercial ports*
  - *municipal harbors and coastal regions*
  - *important facilities (nuclear, navy/DOD, other)*
- What are the big knowledge gaps and research questions in applying *PBTE*?
  - *risk management --- PTHA to engineering to decision making*
- Research strategies and next steps ...

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