

***A Framework for
Risk Assessment of
Infrastructure in a
Multi-Hazard Environment***

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Outline

- *Introduction and Motivation*
 - *The problem we are addressing*
 - *Multi-hazard environment*
- *Basic Framework for Assessment*
 - *Risk equation*
 - *Multi-hazard modeling issues*
 - *Simplified framework for assessment*
 - *Limitations and use of results*
- *Concluding Remarks*



The Problem

- *ASCE Report Card for America's Infrastructure (2005):*

"ASCE estimates that \$1.6 trillion is needed over a five-year period to bring the nation's infrastructure to a good condition."

- *Limited resources + competing priorities*
 - *What are the risks?*
 - *Which risks should be mitigated first?*
 - *Which mitigation options are best?*



Multi-Hazard Environment

- ***Hazards***
 - ***Natural and weather-related***
 - ***Accidental and service-related***
 - ***Intentional***
- ***Varying probabilities of occurrence***
- ***Varying consequences given occurrence***
- ***Varying design and assessment methods***



Multi-Hazard Environment

- ***Evaluation of Mitigation Options***
 - ***Ancillary benefits***
 - ***Increasing the risk for certain hazards***
- ***Risk Perception***
 - ***Outcome vs. occurrence likelihood***
 - ***Most recent hazardous event***
 - ***Social and political issues***
 - ***Influences funding decisions***
 - ***Not always rational***



Basic Risk Equation

$$P [B] = P [A] \times P [B | A]$$



In terms of Expected Values

$$E [B] = P [A] \times E [B | A]$$

Risk
(outcome B)

Occurrence
(probability
of event A)

Vulnerability
(outcome B
given event
A occurs)



Basic Risk Equation

- ***Quantifying Risk***
 - ***Rational basis for decisions***
 - ***Prioritization***
 - ***Cost-benefit comparisons***
- ***Decompose Risk Components***
 - ***Occurrence***
 - ***Hazard modeling (events and loads)***
 - ***Vulnerability***
 - ***Damage and loss modeling (consequences)***
 - ***Impact of mitigations***



Multi-Hazard Modeling

		Hazard Models	Damage Models	Loss Models
Natural Hazards	Wind	<ul style="list-style-type: none"> • Empirical data • Simulation • Accepted probabilities 	<ul style="list-style-type: none"> • Empirical data • Analytical data • Design methods • Published models 	<ul style="list-style-type: none"> • Empirical data • Analytical data • Published models
	Seismic			
	Flood			
	Snow			
Accidental Hazards	Fire	<ul style="list-style-type: none"> • Actuarial data • Simulation • Prevention 	<ul style="list-style-type: none"> • Actuarial data • Testing data • Analytical data 	<ul style="list-style-type: none"> • Actuarial data • Analytical data
	Fatigue			
	Corrosion			
	Impact			
Intentional Hazards	Sabotage	<ul style="list-style-type: none"> • Subjective • Human intent • Prevention 	<ul style="list-style-type: none"> • Limited data • Design methods • Many variables 	<ul style="list-style-type: none"> • Limited data • Many variables • Response
	Crime			
	Terrorism			

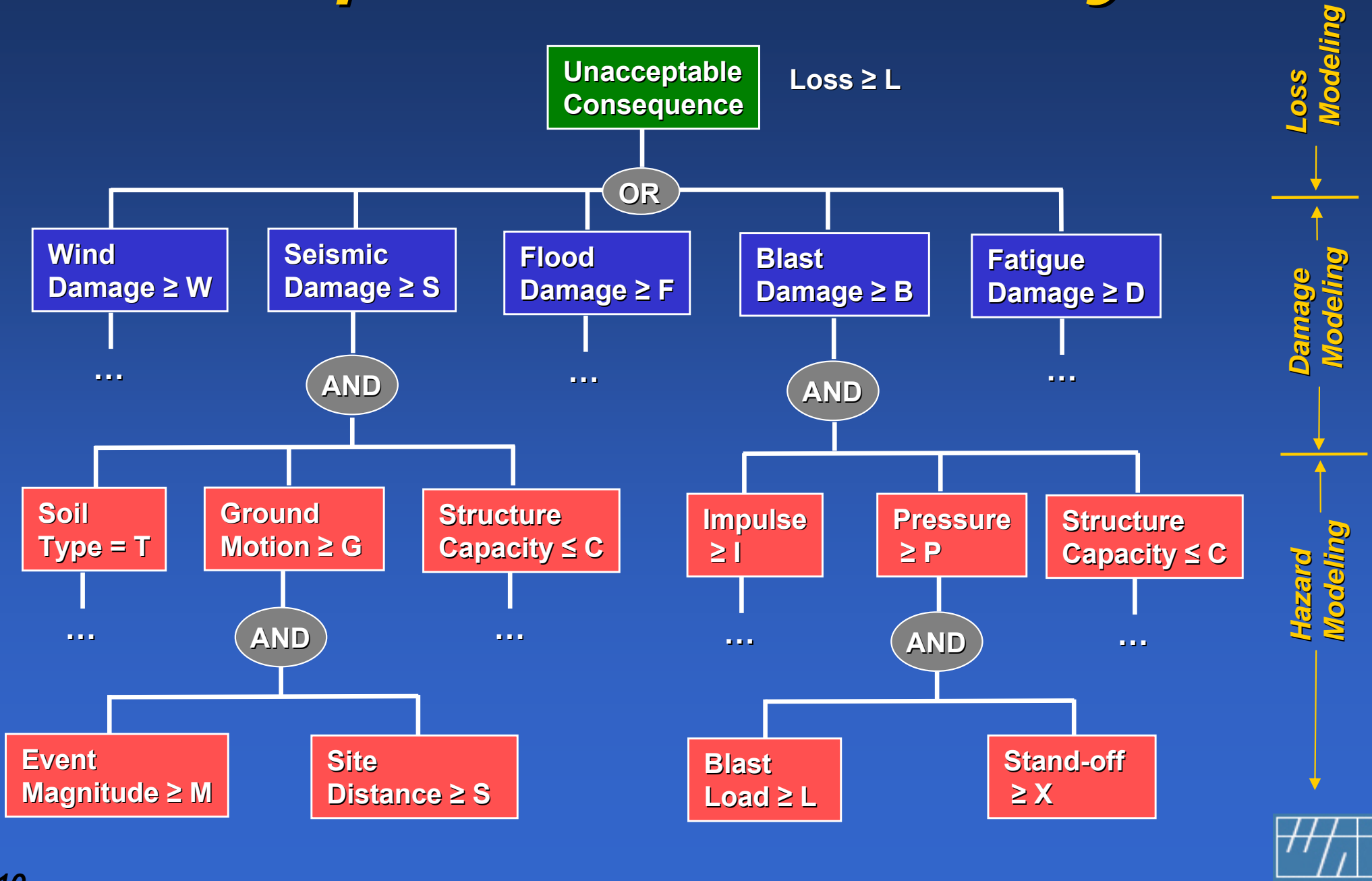


Framework for Assessment

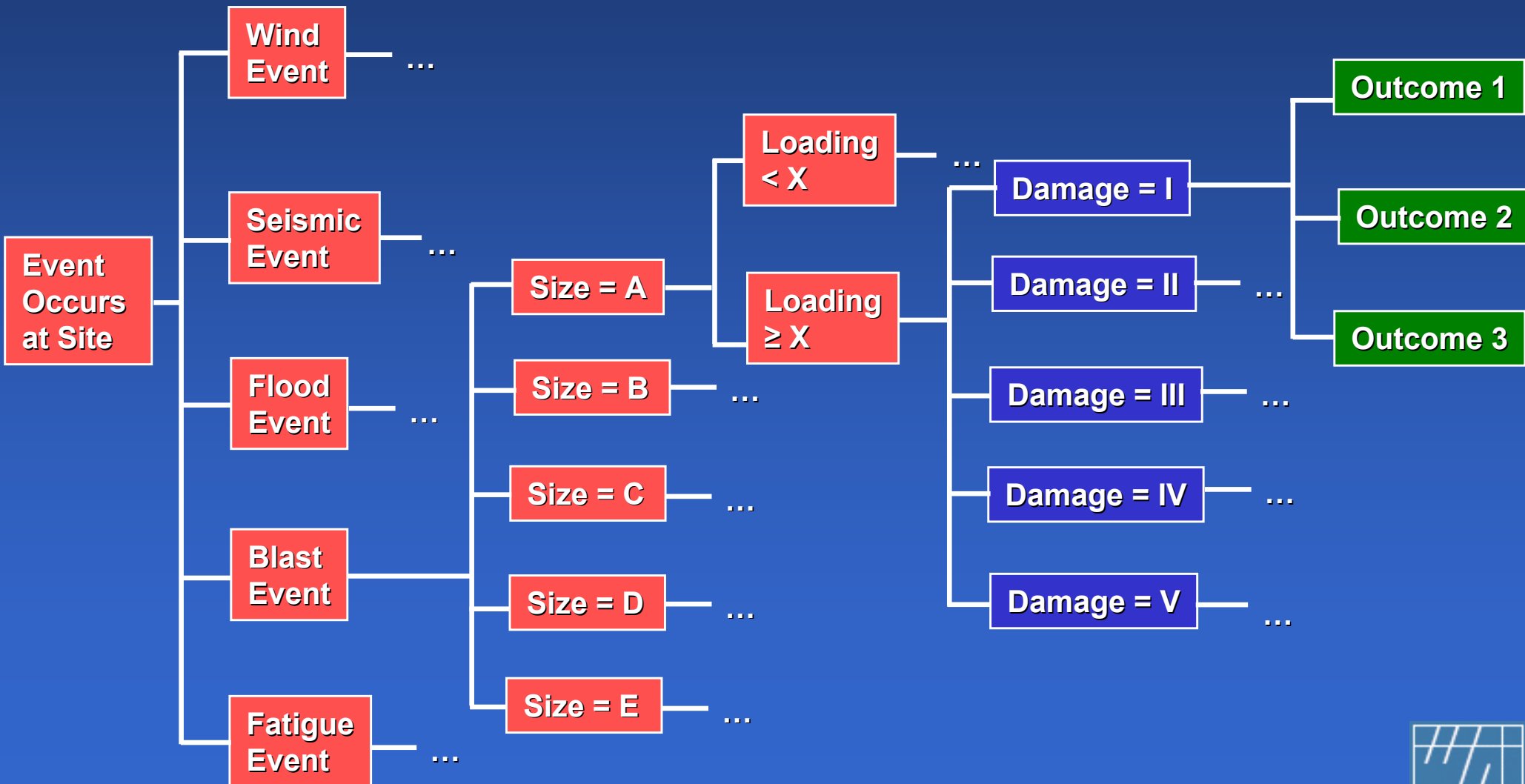
- ***Event and Fault Tree Approaches***
 - ***Quantified value of risk***
 - ***Clear contribution of risk components***
 - ***Track influence of assumptions***
 - ***Simplifications to make trees manageable***
 - ***Typically implement in software***



Example Fault Tree Analysis



Example Event Tree Analysis



Limitations on Results

- ***Risk assessment is a snapshot in time – many things change***
- ***Sensitivity of assumptions and simplifications***
- ***Understand the uncertainties***
- ***Combination of applicable models for various hazards***
- ***Use of subjective information***



Concluding Remarks

- *Quantifying multi-hazard risk*
 - *Decompose risk components*
 - *Rational basis for decisions*
 - *Prioritization*
 - *Costs and benefits of mitigations*
- *Understanding risk is the first step; need to act on that understanding*
 - *Funding issues*
 - *Liability issues*

