FUTURE DIRECTIONS FOR SEISMIC RISK MANAGEMENT FOR TRANSPORTATION NETWORKS

by

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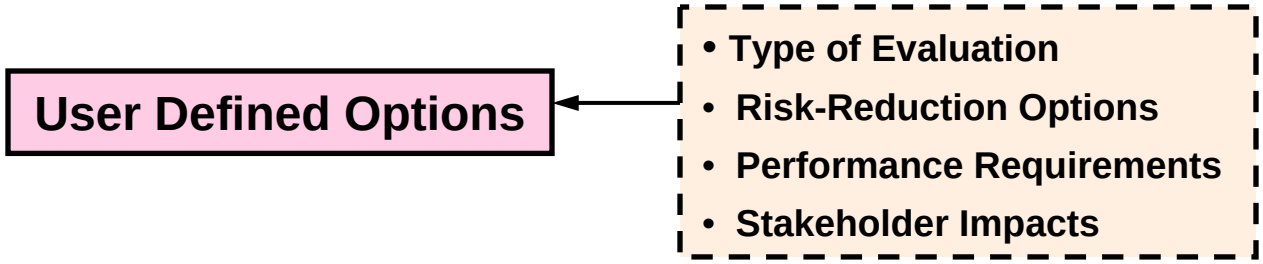
SCOPE

System Performance Evaluation Framework

- **Spatially Distributed Systems**
- **Uncertainties**

SYSTEM RISK EVALUATION FRAMEWORK



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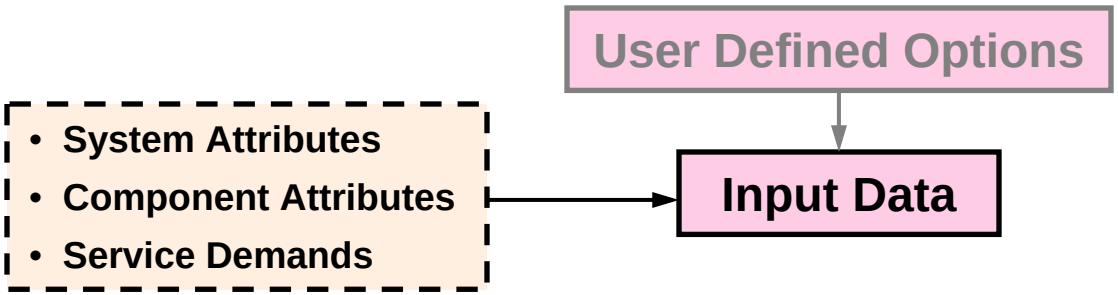

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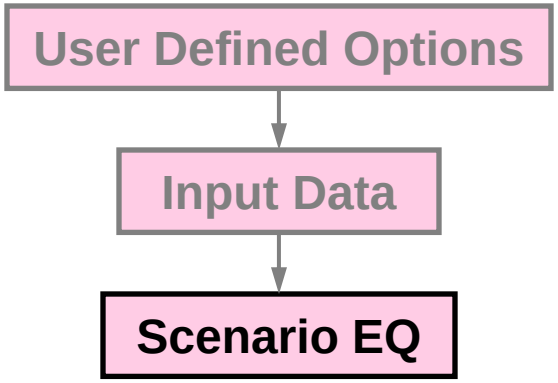

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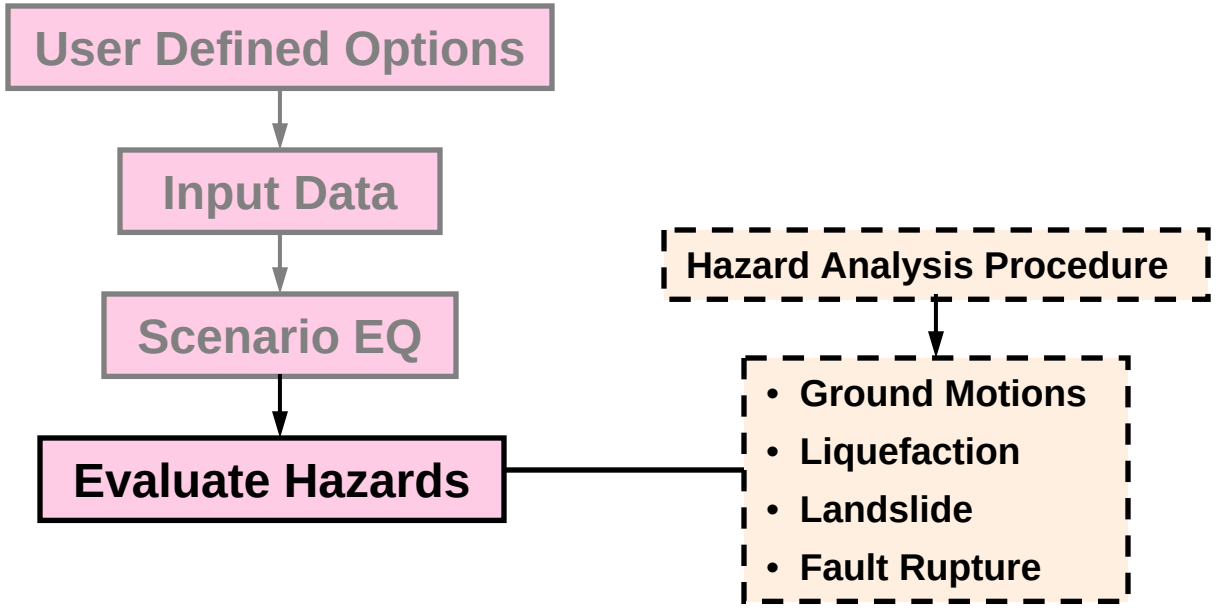

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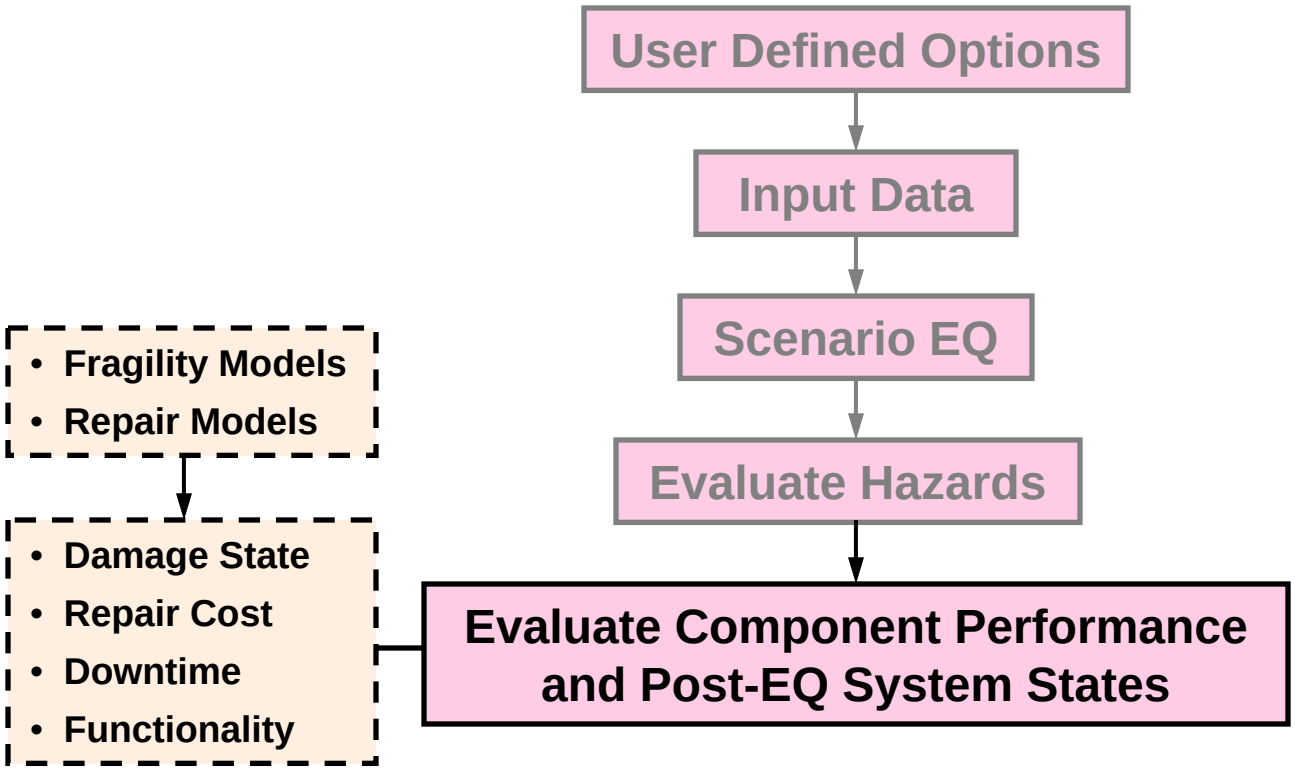

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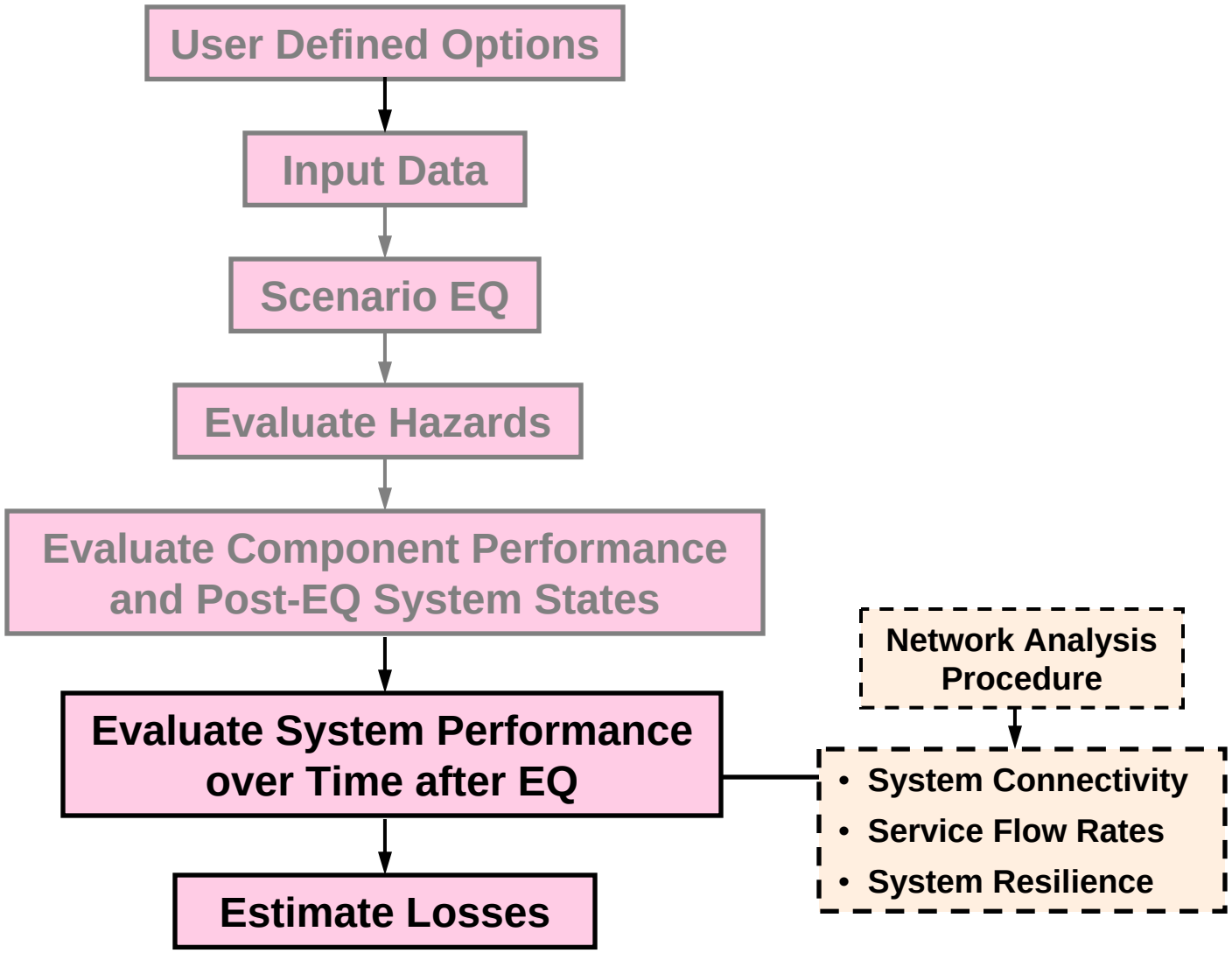

HIGHWAY SYSTEM SRA LOSS METRICS

- Traffic Flow Decreases
- Travel Time Delays
- Trip Demands
- Resiliency

→

- System Wide
- To/From Selected Locations
- Along Selected Routes

- Direct Economic Losses
  - Repair Costs
  - Due to Travel Time Delays and Trips Foregone

- Indirect Economic Losses
  - Regional / National

SCOPE

- **System Performance Evaluation Framework**
- **Spatially Distributed Systems**
- **Uncertainties**

SPATIALLY DISTRIBUTED HIGHWAY SYSTEM: Some Differences Relative to Single Site System

	Spatially Distributed Highway System	Single Site Systems
Seismic Hazards	**For Given Scenario EQ** • Compute Consistent Spatially Dispersed Hazards throughout System • Many Different Site Conditions	**Starting Point:** • Seismic Hazard Analysis • Compute One Set of Site-Specific Seismic Hazards • One Set of Site Conditions
Component Response	• Large Number/ Many Types of Components • Compute Consistent Spatially Dispersed Component Damage States • Possible Multiple Spatially Dispersed Post-EQ Repair Activities	• Smaller Number of Facilities • Compute One Set of Localized Damage States for a Few Facilities • Localized Repair Activities
System Response	• Spatially Dispersed: - Roadway Redundancies - Roadway Traffic Carrying Capacities - Damage Locations - Trip Demands - User Entry/Exit Locations	• Limited and Localized - Link Redundancies - Link Service Capacities - Damage Locations - Service Demands - User Entry/Exit Locations

SPATIALLY DISTRIBUTED HIGHWAY SYSTEM
Input Data

- **Because of Size and Spatial Extent of System**
  - **Significant Input Data Needed**

- **Highways and Bridges (FHWA Electronic Databases)**
  - **Highway Performance Monitoring System (HPMS)**
  - **National Highway Planning Network (NHPN)**
  - **National Bridge Inventory (NBI)**

- **Soil Conditions**
  - **NEHRP Classifications**
  - **Other Soils Data: From State DOT**

- **Trip Demands:**
  - **Trip Tables from Metropolitan Planning Organizations (MPOs)**

SCOPE

- **System Performance Evaluation Framework**
- **Spatially Distributed Systems**
- **Uncertainties**

UNCERTAINTIES IN SRA OF HIGHWAY SYSTEMS

- **Well Recognized Sources of Uncertainty**
  - **Earthquake Occurrences over Time**
  - **Seismic Hazard Estimation**
  - **Bridge Damage Estimation**

- **Other Important Uncertainties**
  - **Damage Repair Requirements**
  - **Traffic/Travel Impacts**
  - **Input Data Constraints**

UNCERTAINTIES IN SRA OF HIGHWAY SYSTEMS: Damage Repair Requirements

- **Repair Requirements**
  - **Costs**
  - **Mobilization Time**
  - **Rate of Repair**
  - **Functionality of Component during Repairs**

- **Depends on**
  - **Prior Post-EQ Experience**
  - **Availability of Repair Resources**
  - **Extent of Damage within Highway System**
  - **Accessibility of Damage**
  - **Extent of Damage to Other Elements of Built Infrastructure**

UNCERTAINTIES IN SRA OF HIGHWAY SYSTEMS: Traffic/Travel Impacts

- **Effects of Increased Traffic Congestion due to EQ Damage to System**
  - **Increase Travel Times**
  - **Reduce Trip Demands**

- **Assumptions in Analysis of Post-EQ Travel within Disrupted System**
  - **Traveler Route Choice**
  - **Relationship between Trip Demand and Travel Time**

- **Other Potential Impacts on Post-EQ Travel Not Considered**
  - **Damage to Other Elements of Built Infrastructure**

SPATIALLY DISTRIBUTED HIGHWAY SYSTEM: Some Input Data Constraints

- **Possible Errors/Gaps in Highway Data from HPMS and NHPN**
- **Bridges**
  - **NBI Database Insufficient for Seismic Performance Evaluation**
  - **Some State DOTs have Supplementary Data**
- **Soil Conditions for Assessment of Liquefaction, Landslide Hazards**
  - **Data may be Time Consuming to Obtain**

UNCERTAINTIES IN SRA OF HIGHWAY SYSTEM: Component Damage Estimation

- **Bridge Fragility Modeling**
  - **Large Numbers of Bridges**
  - **Insufficient Input Data on Bridge Attributes**
  - **Combined Effects of Ground Shaking and Permanent Ground Displacement**

- **Fragility Modeling for Other Components**
  - **Tunnels, Roadways, Approach Fills, Retaining Walls, Culverts**

- **Damage State Definitions**
  - **Need for Improved Basis for Estimating Repairs**
  - **HAZUS Damage States are Insufficient for this Purpose**