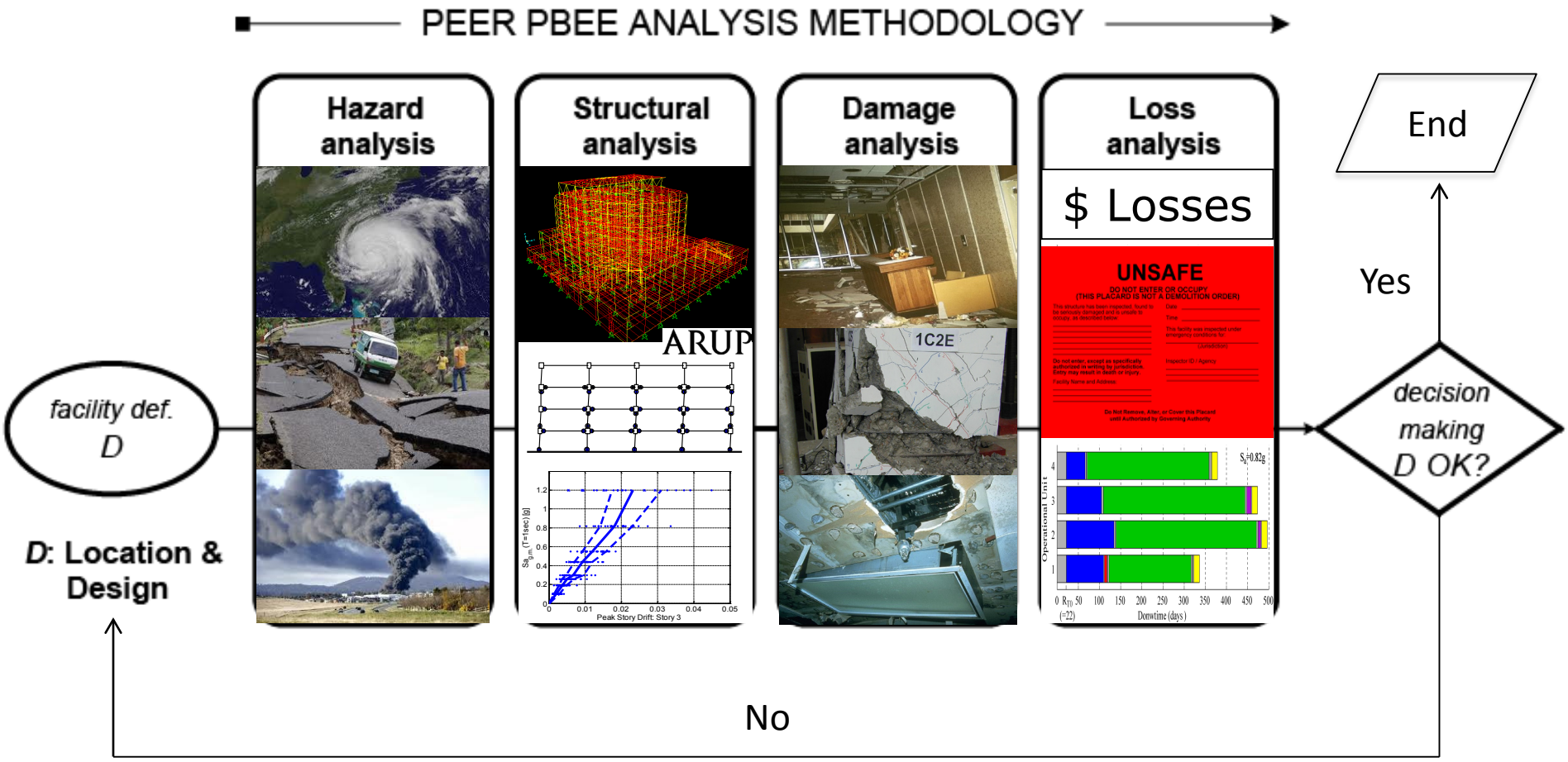
UTAH RESILIENCY WORKSHOP

Judith Mitrani-Reiser, Ph.D.

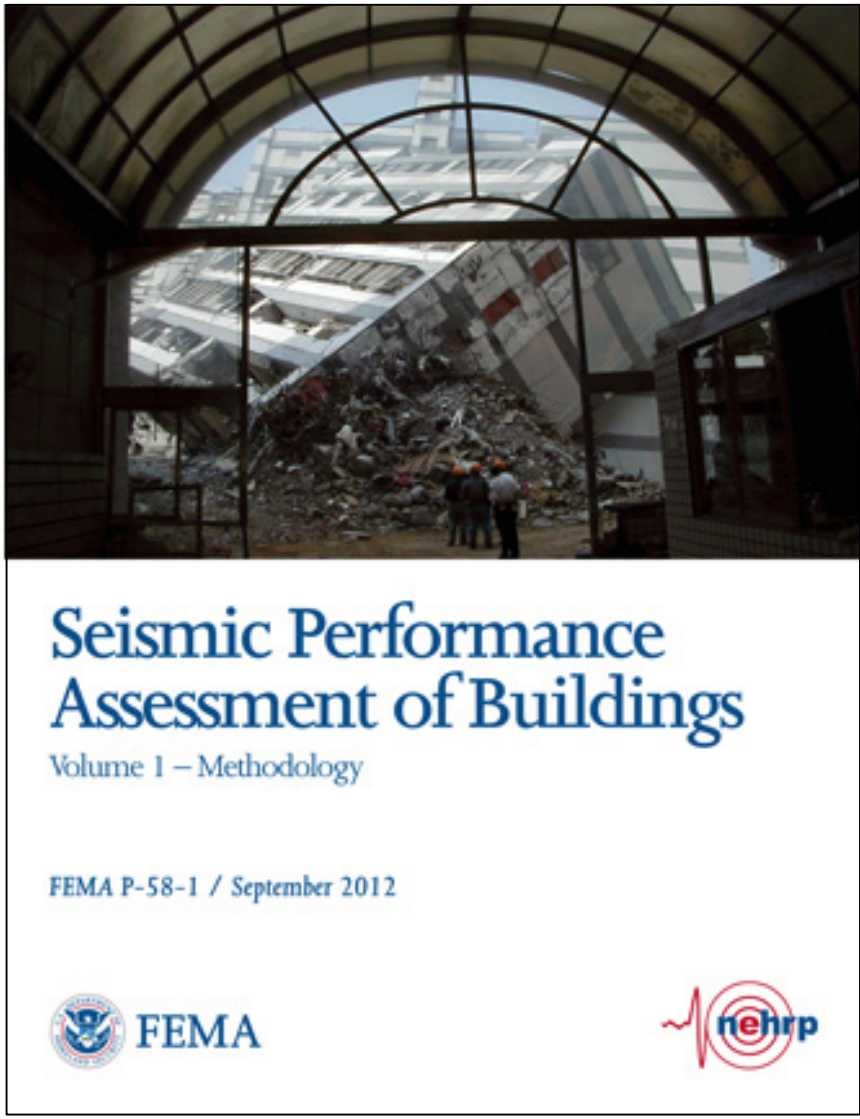
Performance-Based Design: Buildings



Performance-Based Design: Downtime in Buildings

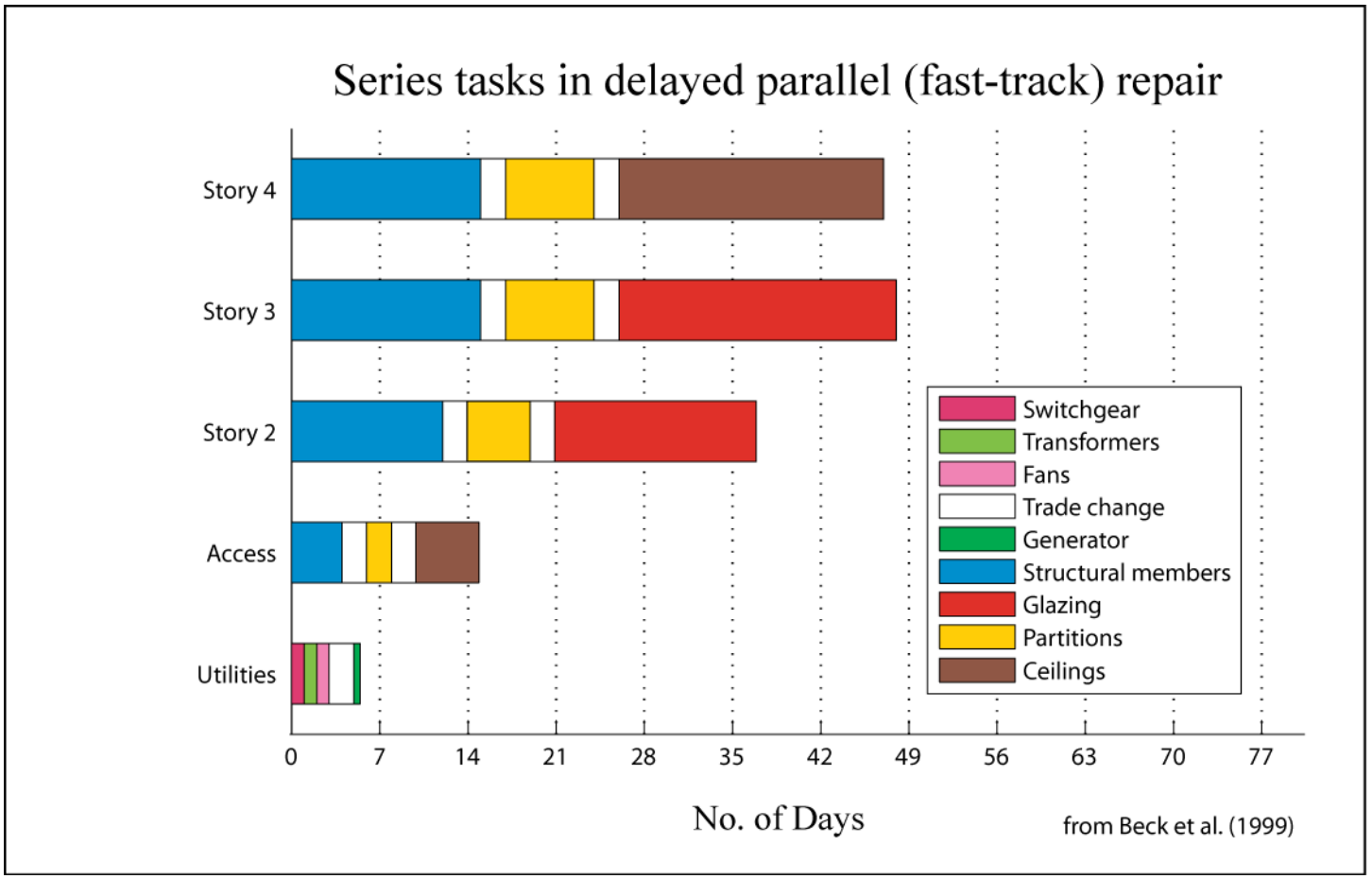
ATC-58 procedures (Mitrani-Reiser) provide the following measures of occupancy interruption:

- **The length of time necessary to conduct repairs,**
- **The need to procure items with long lead-times,**
- **The probability that the building will be placarded as unsafe for occupancy.**



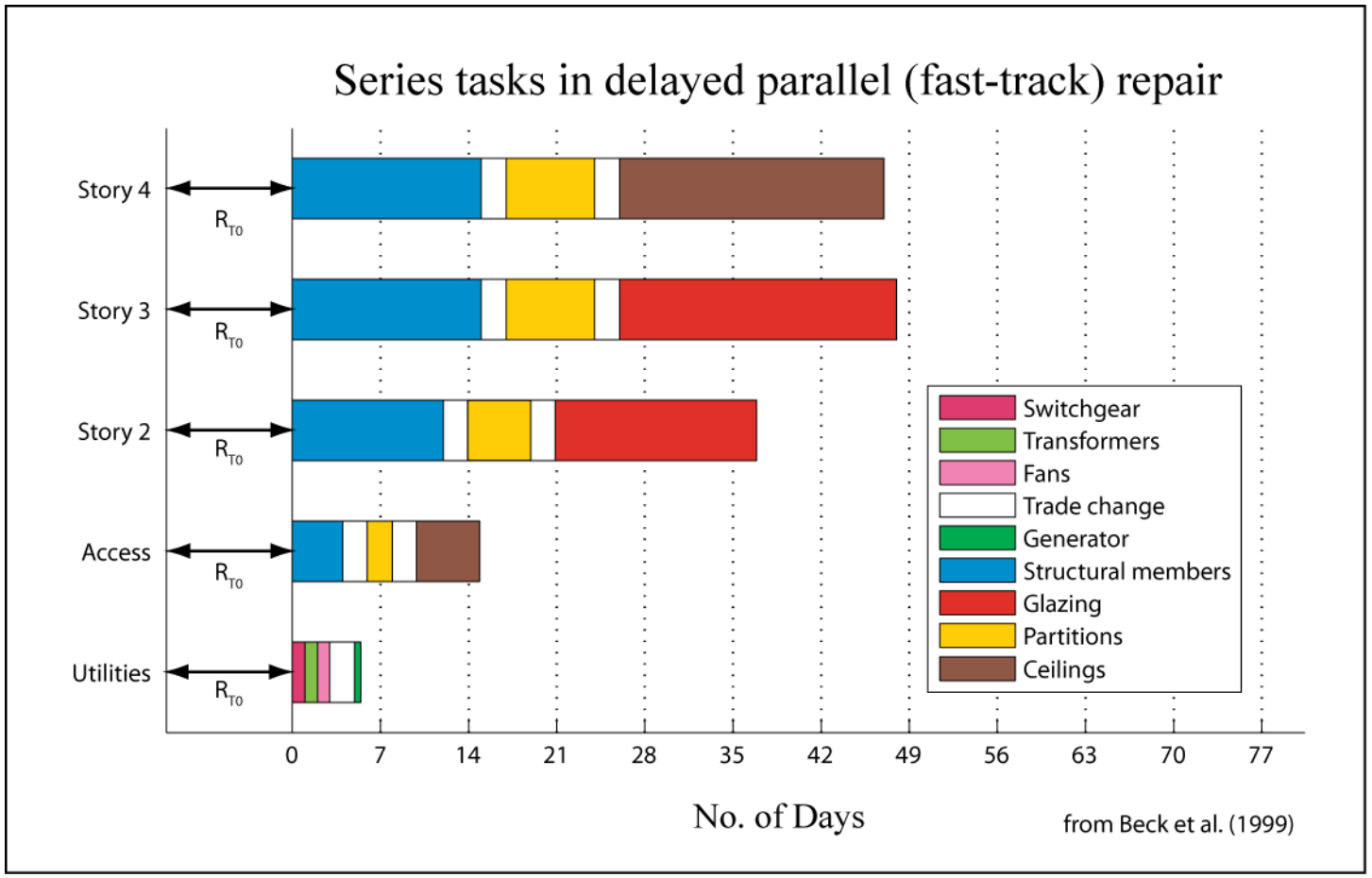
Performance-Based Design: Downtime in Buildings

Repair time is the time needed to repair the earthquake damage and return the building to its pre-earthquake condition.

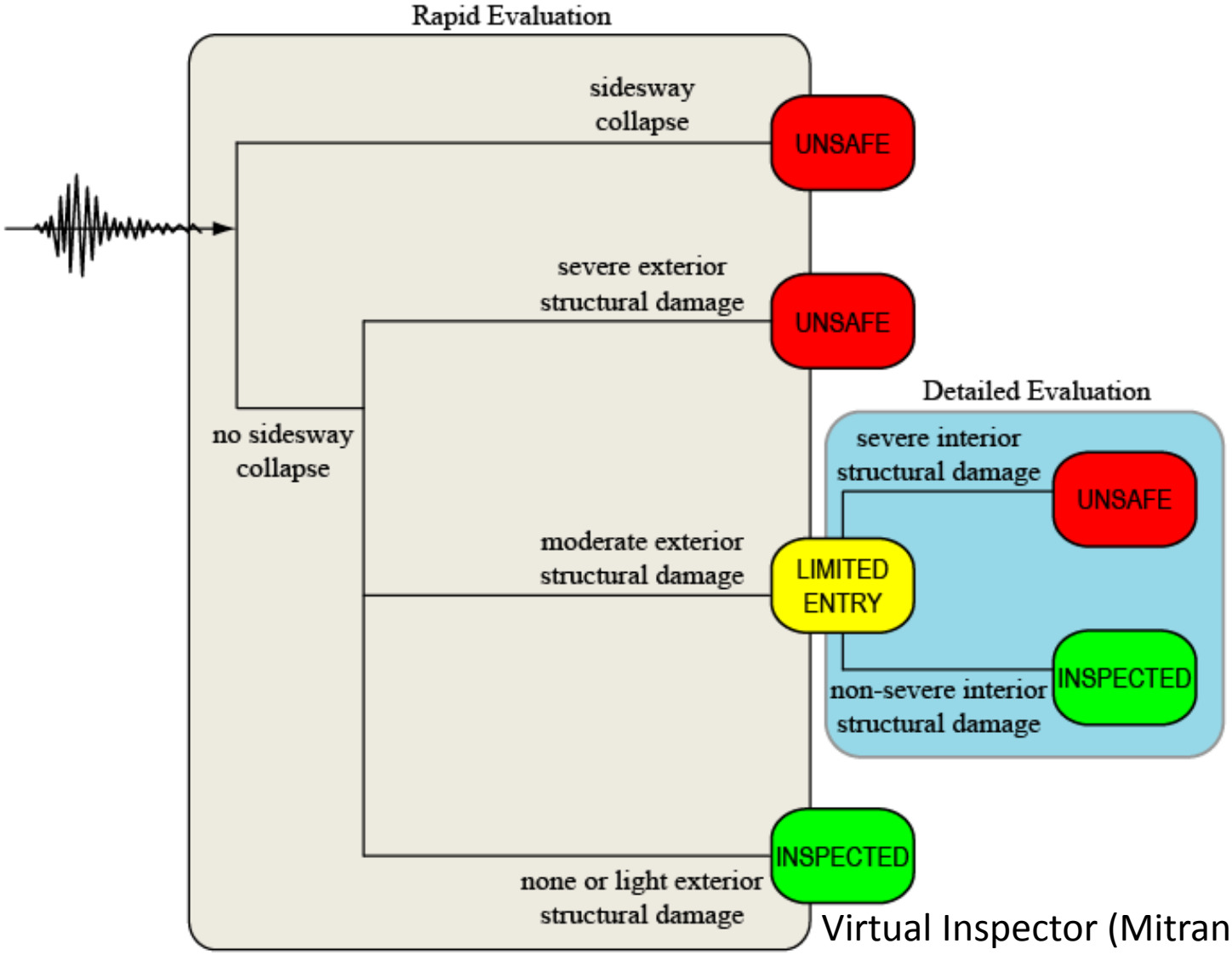


Performance-Based Design: Downtime in Buildings

Mobilization Time is the delay before construction begins needed to assess damage and inspect building, time to consult with professional engineers, time for bidding process, time for clean-up, time to acquire items with long lead times.

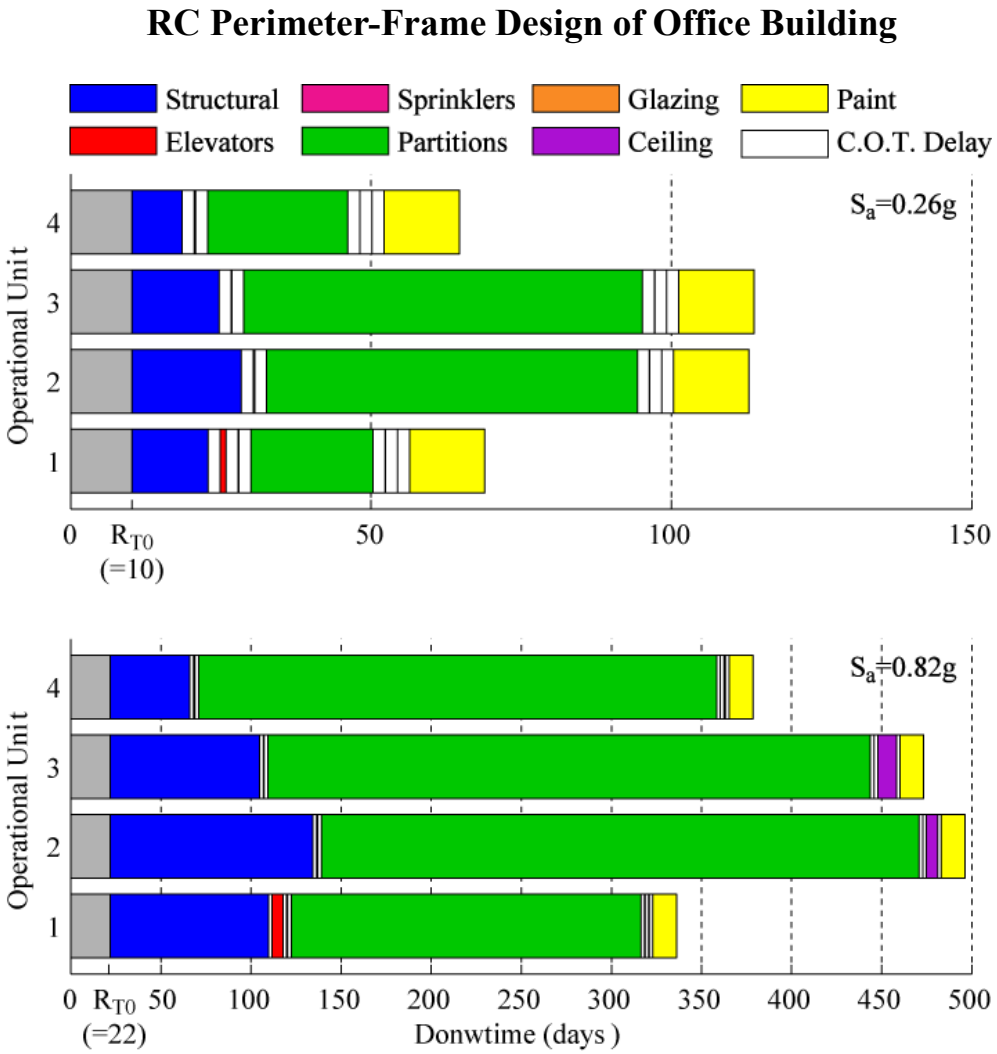


Performance-Based Design: Downtime in Buildings



Virtual Inspector (Mitrani-Reiser 2007)

Performance-Based Design: Downtime in Buildings



10%-in-5yr

DT ~ 4 months

2%-in-50yr

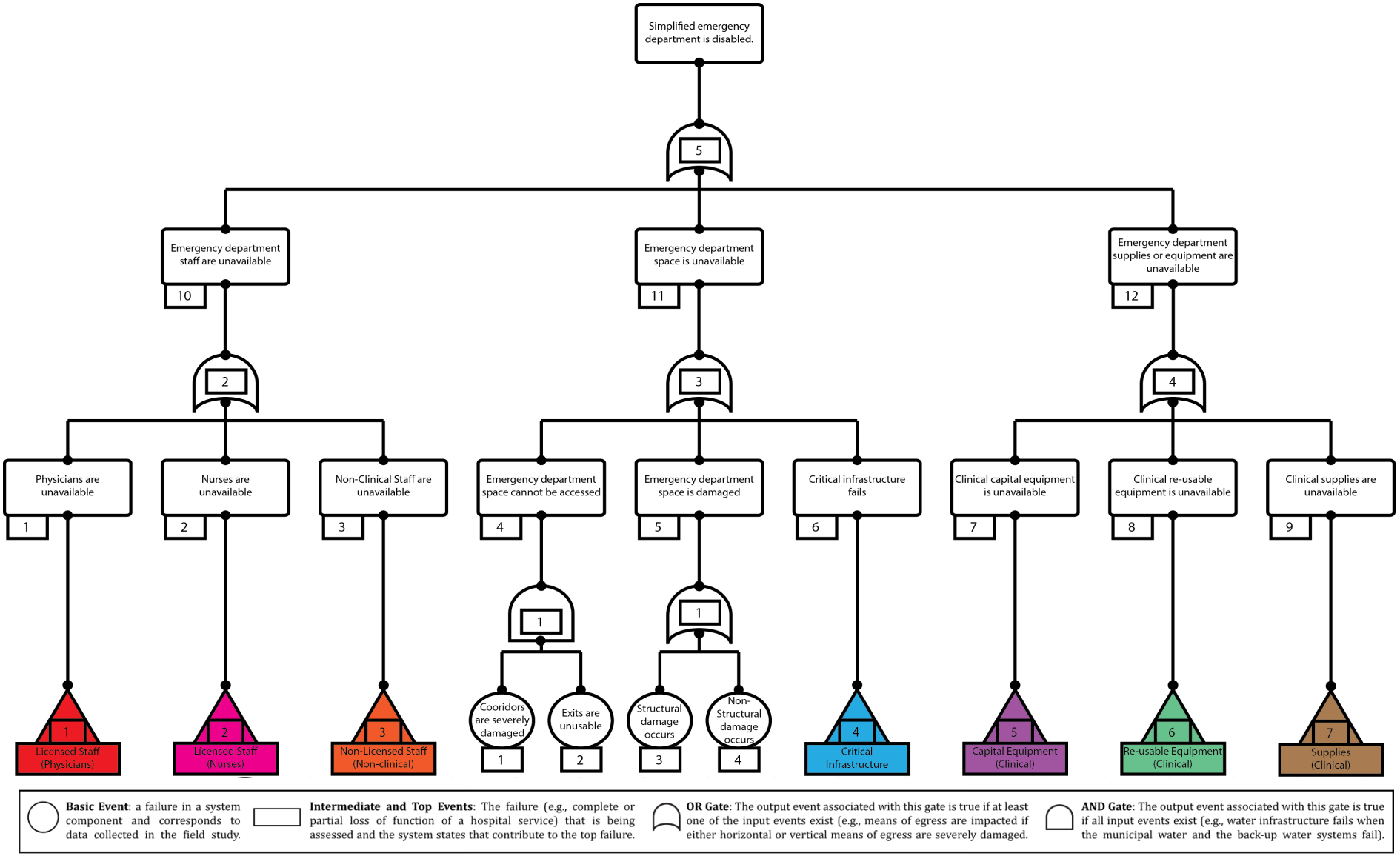
DT ~ 17 months

Performance-Based Design: Summary

For some building occupancies (i.e., hospitals), the above procedures will not suffice in capturing the loss of important services:

- **Need models that include infrastructure failures outside the building.**
- **Need occupancy-specific models that incorporate human infrastructure.**
- **Need systematic procedures for capturing building damage and loss of function over time in the field (eq reconnaissance).**

Building Impacts: beyond physical damage



Basic Event: a failure in a system component and corresponds to data collected in the field study.

Intermediate and Top Events: The failure (e.g., complete or partial loss of function of a hospital service) that is being assessed and the system states that contribute to the top failure.

OR Gate: The output event associated with this gate is true if at least one of the input events exist (e.g., means of egress are impacted if either horizontal or vertical means of egress are severely damaged.

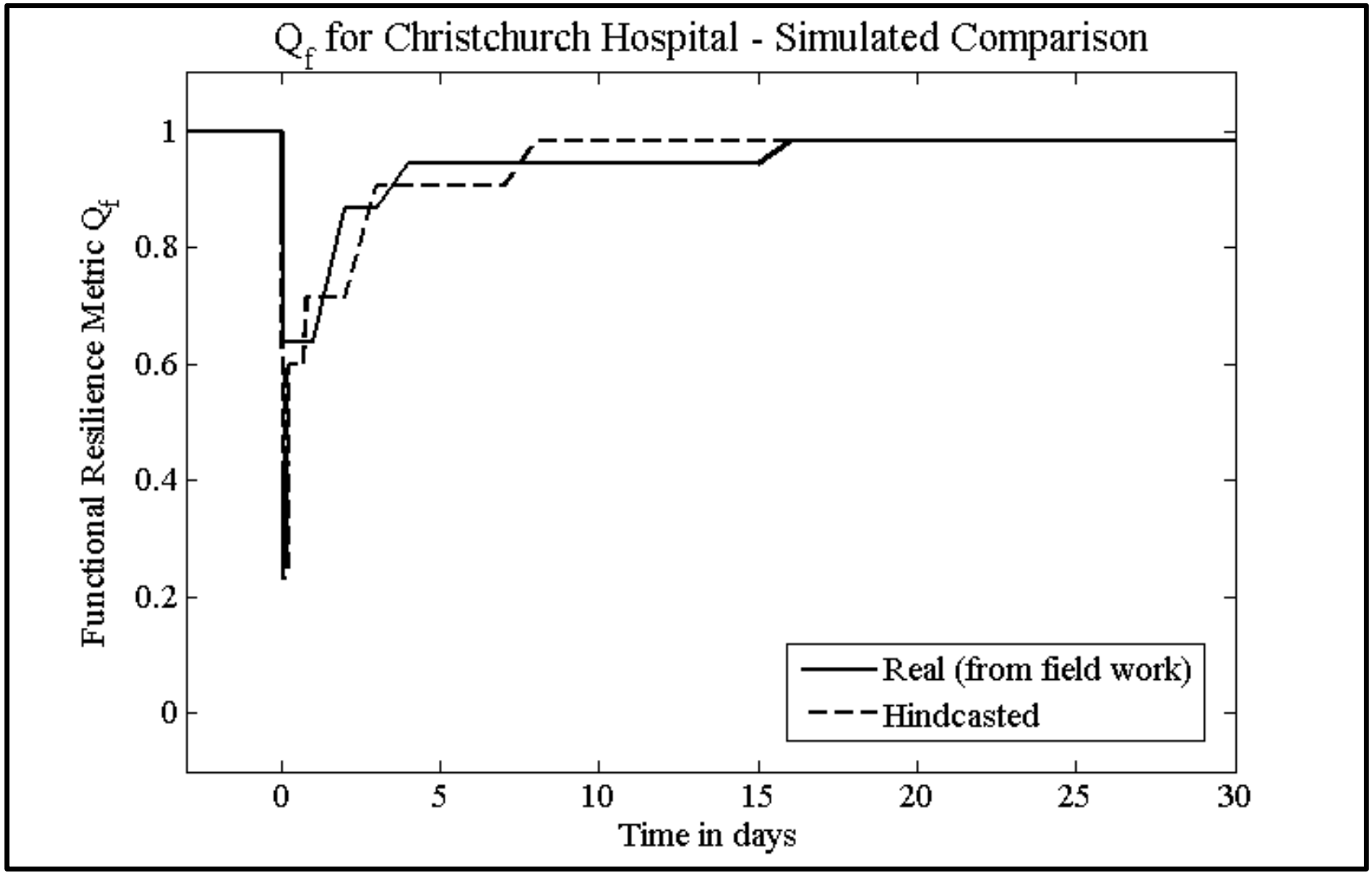
AND Gate: The output event associated with this gate is true if all input events exist (e.g., water infrastructure fails when the municipal water and the back-up water systems fail).

Resilience: functioning over time

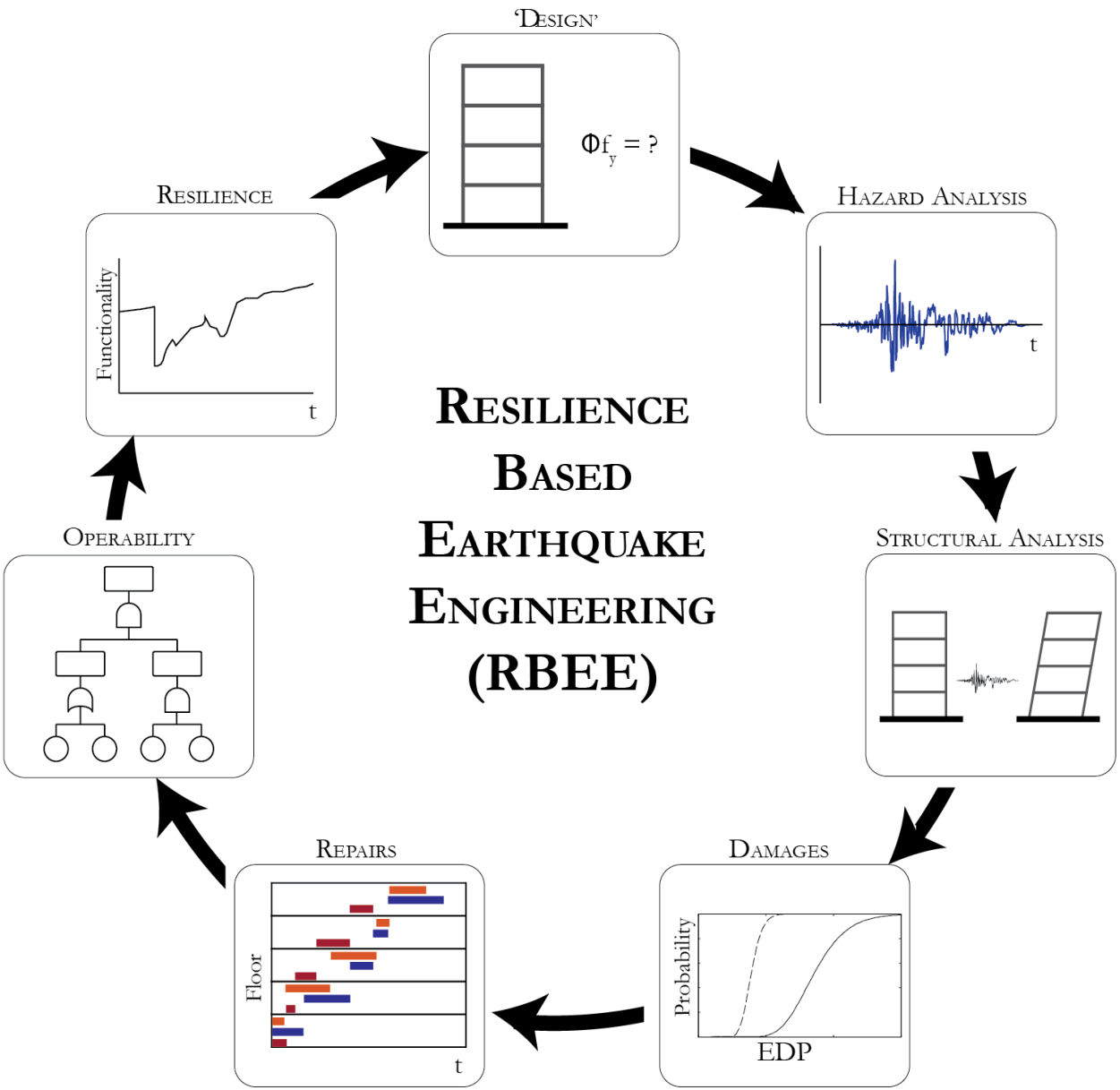
$$Q_f(t) = \frac{\sum_n w_i \left(1 - \left(1 - R_i(t)\right) L_i(t)\right)}{\sum_n w_i}$$

Variable	Definition
i	Total number of functions
w_i	Weight term, importance of the function
$L_i(t)$	Loss of function, range 0-1 (no loss to total loss)
$R_i(t)$	Redistribution of function, range 0-1 (no redistribution to complete redistribution)

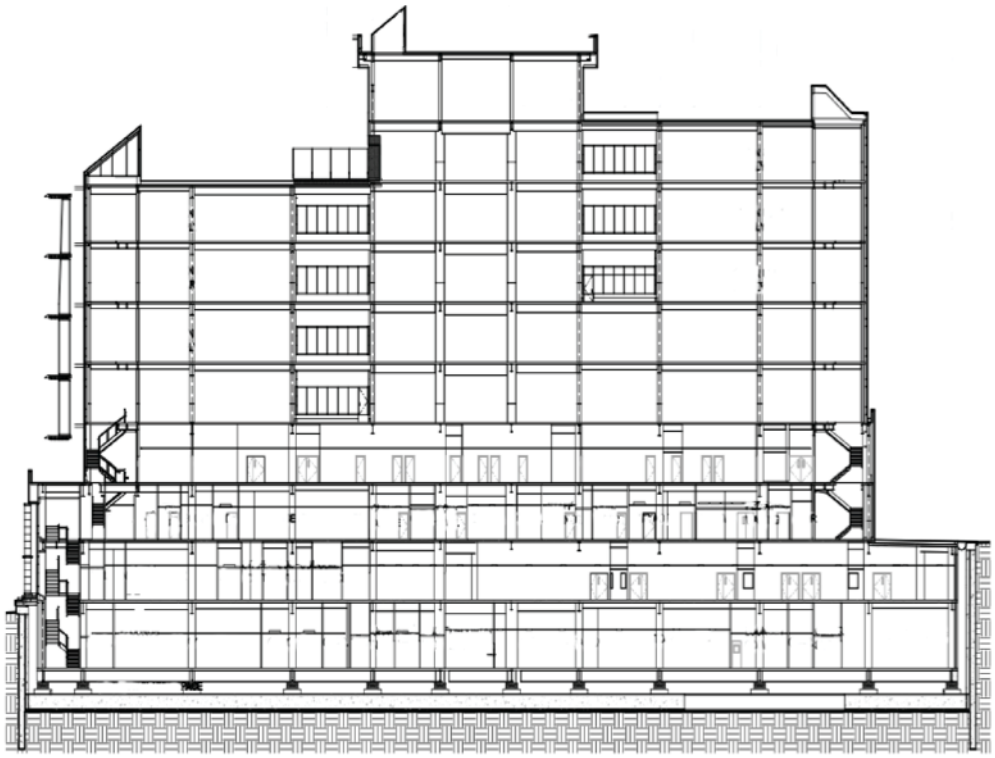
Resilience: functioning over time



Resilience-Based Design: Hospitals



Resilience-Based Design: Hospitals



Services by Floor

Mechanical Floor

Level 7: Medical/Surgical, Acute Care for Elderly
Palliative Care, Roof Garden

Level 6: Medical/Surgical

Level 5: Medical/Surgical Unit, Forensic Unit

Level 4: Step Down Medical/Surgical,
Step Down ICU, Dialysis

Level 3: Intensice Care Units (ICU)

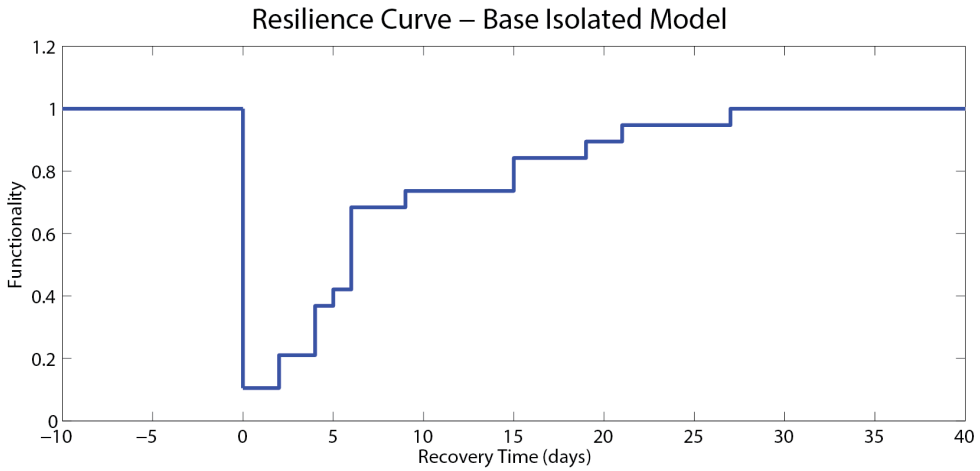
Level 2: Labor and Delivery, Postpartum, Pediatrics,
Neonatal Intensive Care

Level 1: Emergency Department and Trauma Center

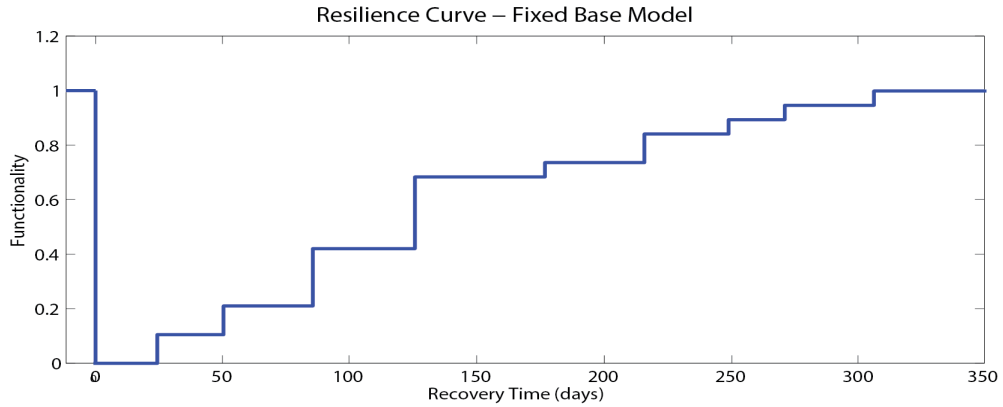
Basement 1: Operating Rooms, Pre-op, Post Op,
Endoscopy, Blood Bank

Basement 2: Dietary. Pharmacy, Cardiologloy,
Pulmonary, Diagnostic Imaging (Xray),
Sterile Processing

Resilience-Based Design: Hospitals



26 days until all hospital services are functional



~300 days until all hospital services are functional

Resilience-Based Design: Summary

The above procedures, while helpful for individual buildings (nodes), will not suffice in capturing disaster impacts on important community institutions:

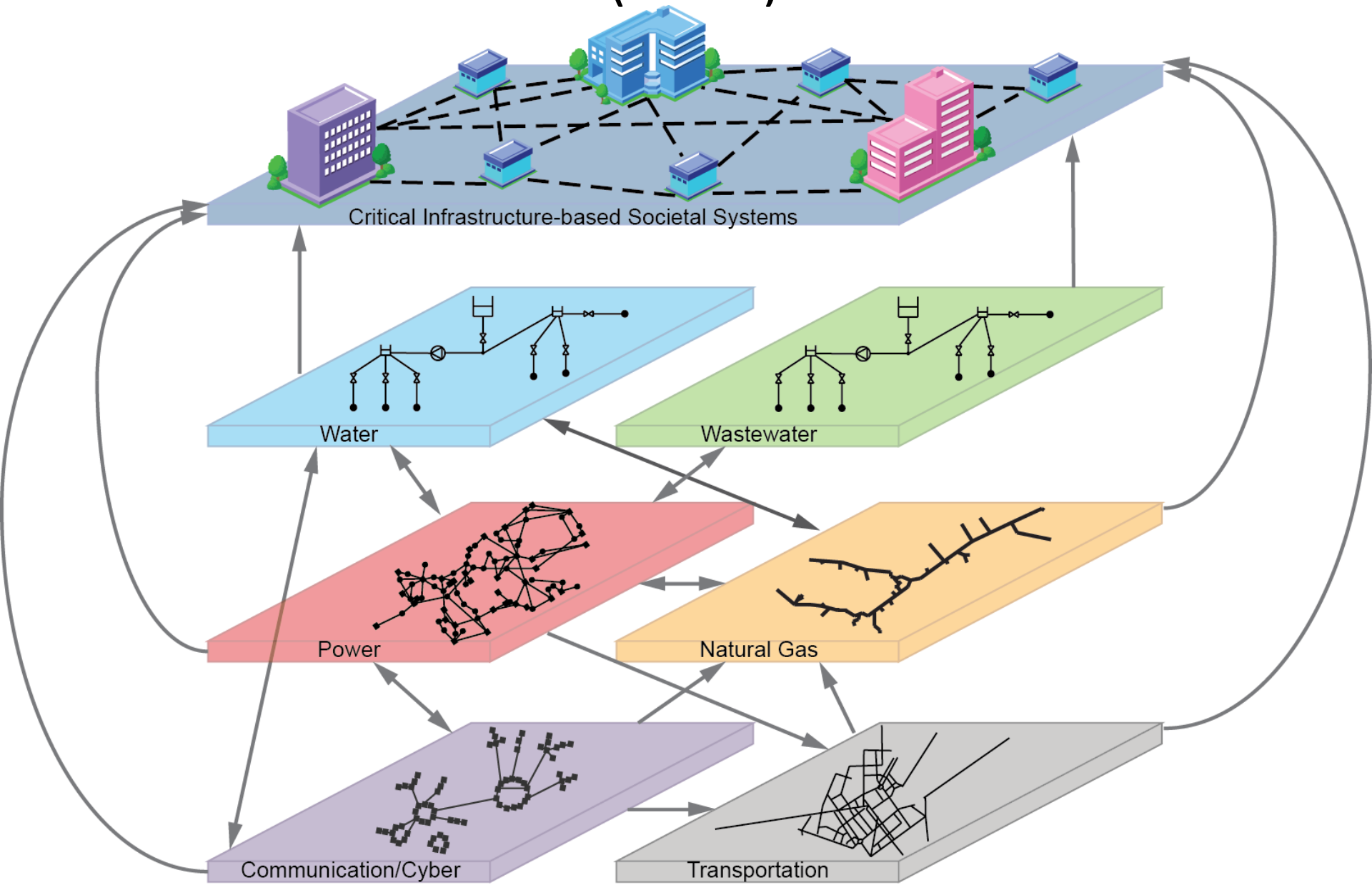
- **Need models that include interdependent critical lifelines and supply chains.**
- **Need to capture the 'networked' system of buildings that provides specific community services.**
- **Need performance metrics that are relevant to the entire system and to the stakeholders managing these institutions.**

Community Functioning Domains

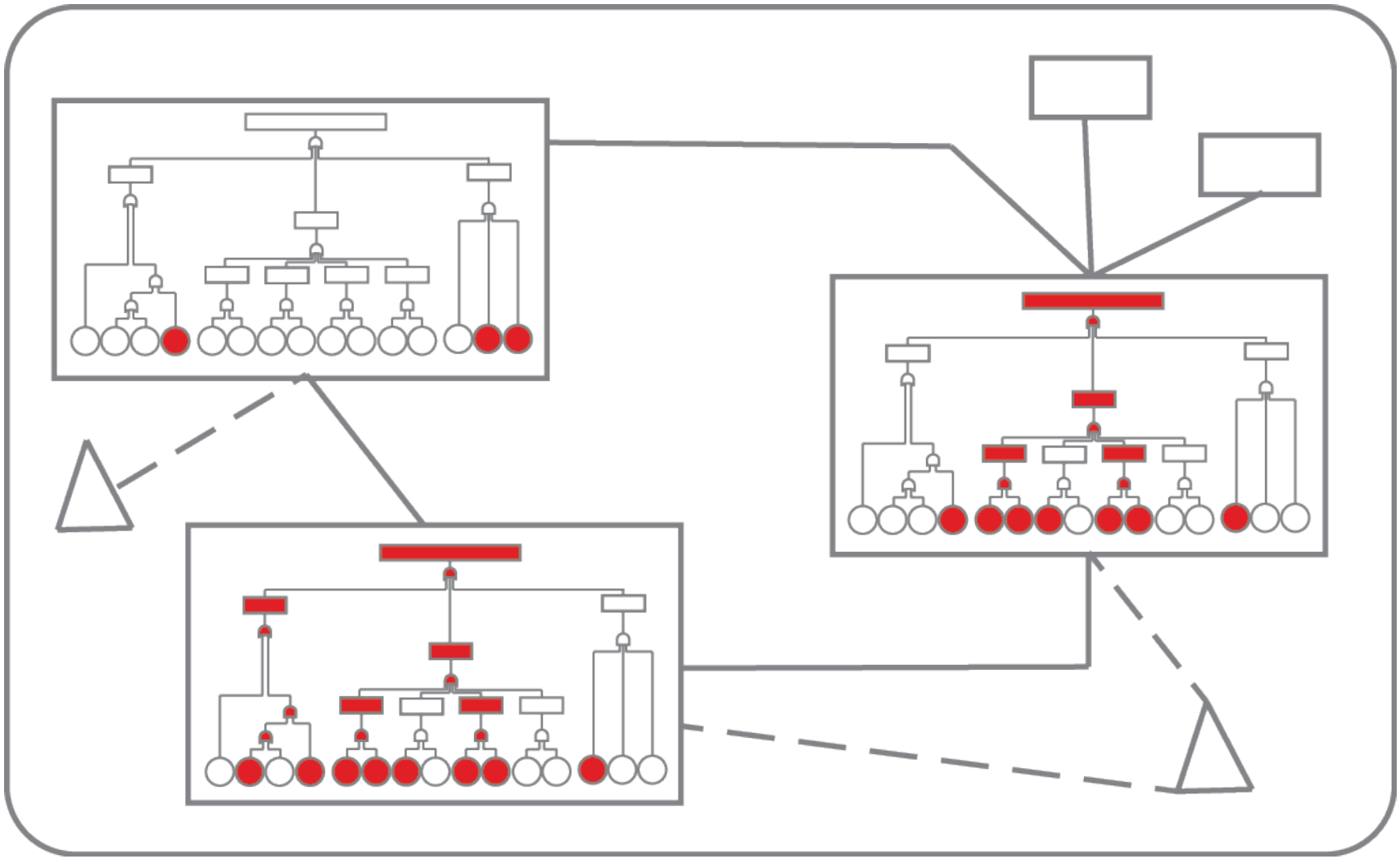
Disaster sociologists explain that not all community institutions mitigate disasters, and offer a short list of disaster-relevant institutions (Aguirre et al., 2005):

- Family
- Religion
- Politics
- Economy
- Medicine & Health
- Education
- Scientific Research
- Law & Courts
- Emergency Responders
- Communication
- Transportation
- Energy
- Food
- Water
- Entertainment
- Construction & Built Environment
- Land Use

Critical infrastructure-Based Societal Systems (CIbSS)



Resilience of the entire CIbSS

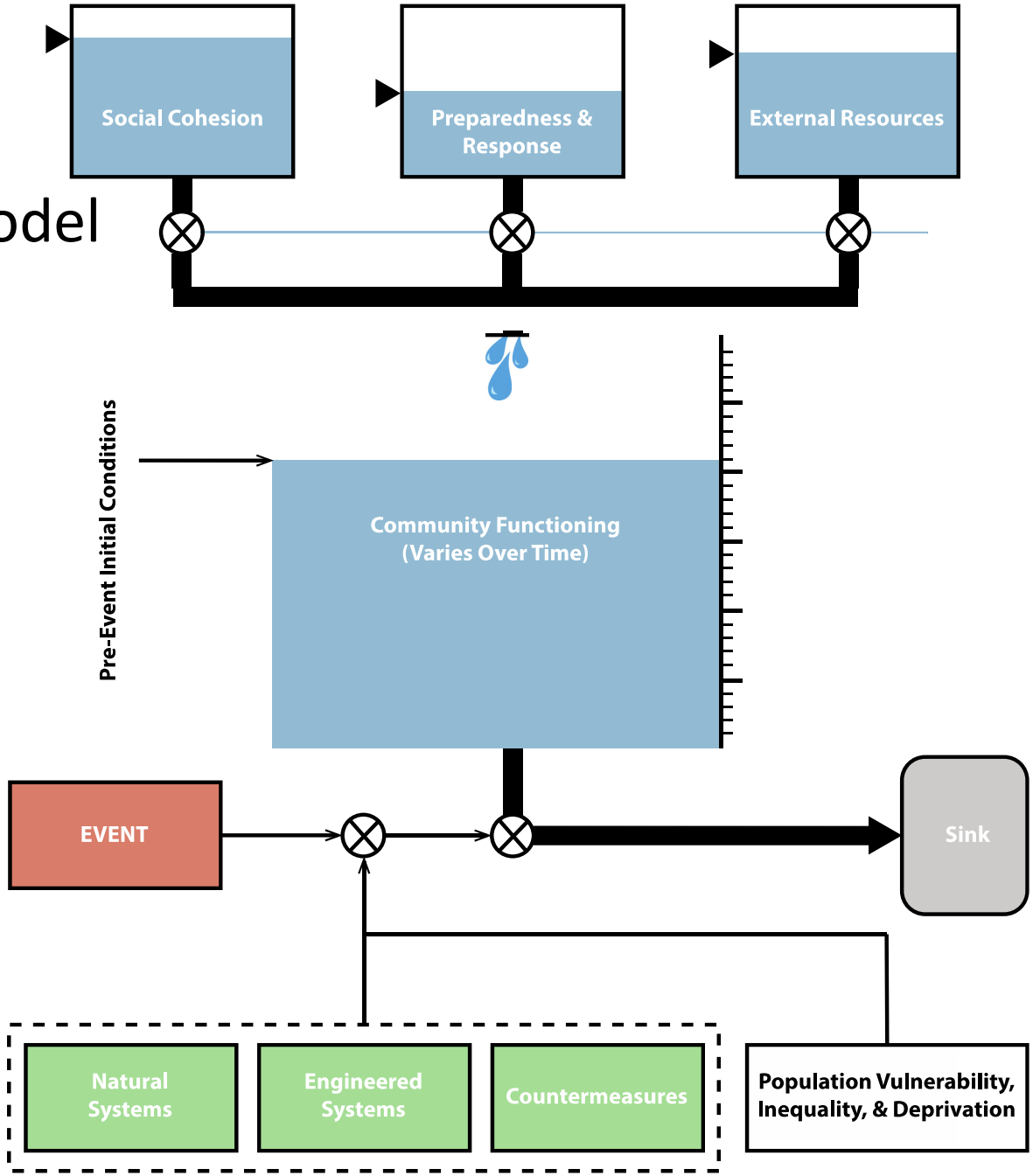


Community Functioning Summary

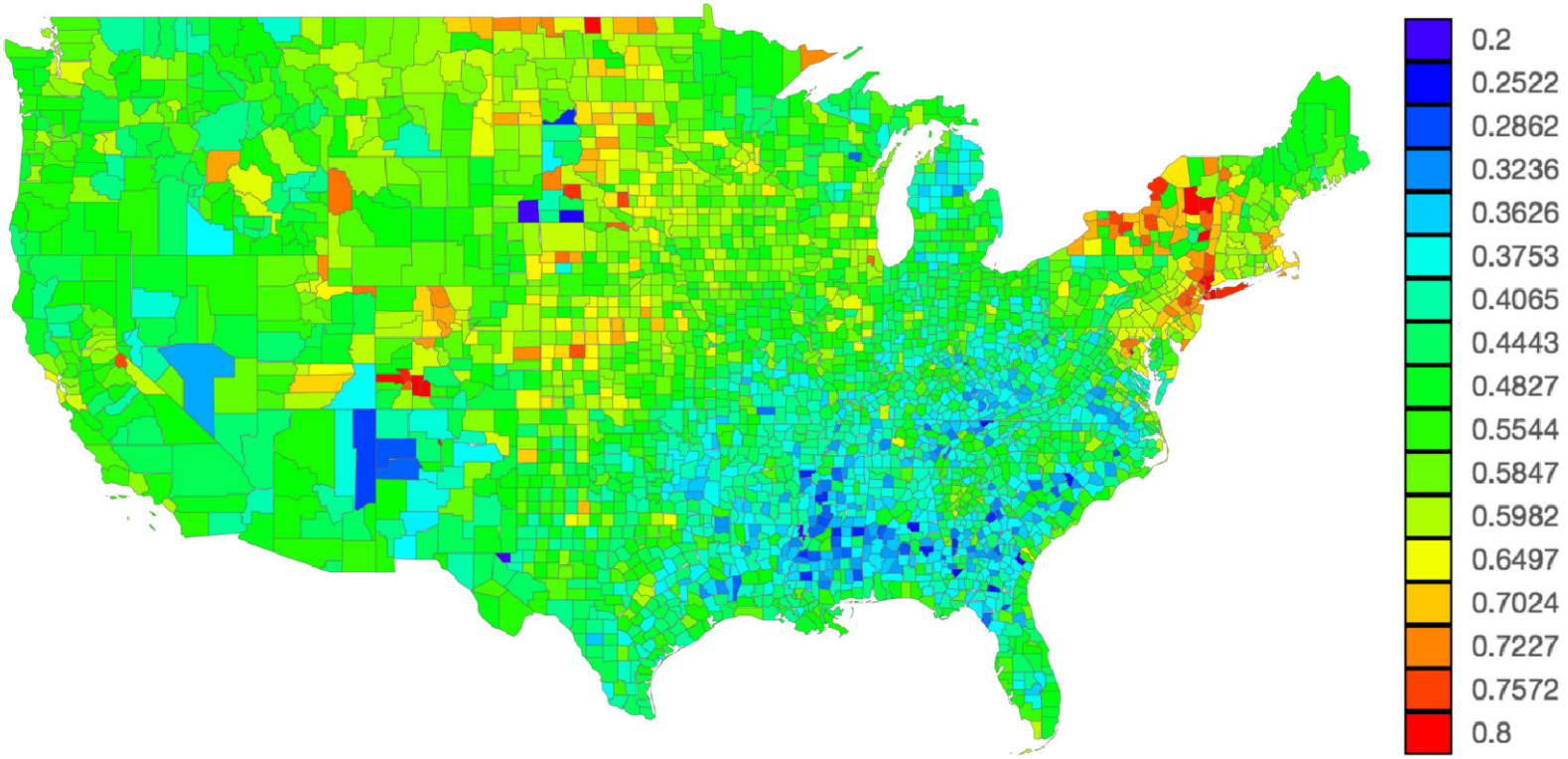
We're starting to scratch the surface of modeling the resilience of one CIbSS, but:

- **Need holistic approach to capture community functioning over time.**
- **Need models that interface multiple scales (building – institution – community).**
- **Need to effectively use data that is collected over a wide range of time scales (e.g., census, tax assessors, reconnaissance, etc.).**
- **Need models that capture the complex interactions of many community institutions.**

Community Functioning: CoPE-Well SD Model



Community Functioning: CoPE-Well SD Model



STIRM Research Summary

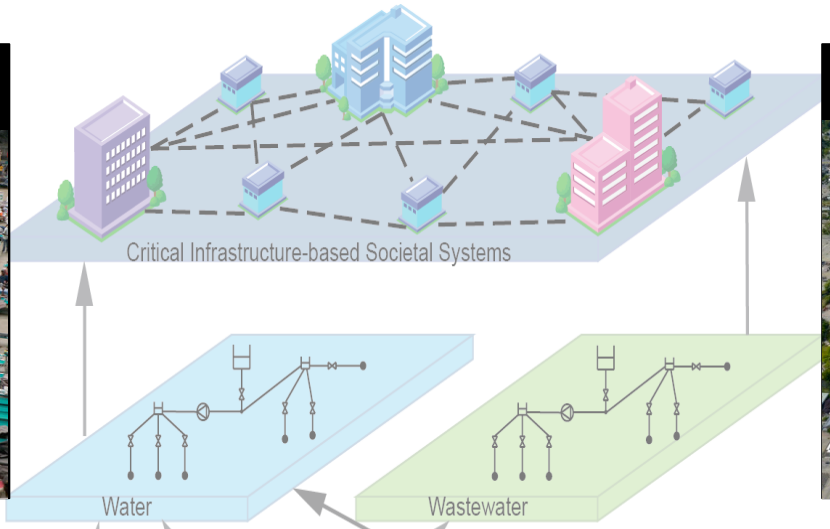
My research is focused on using engineering tools to answer important questions at the interface of physical and societal systems:

- **Adapting PBEE methods to other hazards (e.g., FPHLPM)**
- **Designing RBEE tools to assess functionality of infrastructure that's critical to communities**
- **Modeling human interaction with compromised infrastructure (building evacuations; patient transfers)**
- **Disaster field studies (acute and longitudinal)**
- **Creating tools that are useful to practitioners (e.g., States of Oregon, Utah, and California; Ministries/Departments of Health; USGS; Arup; CIGIDEN)**

STIRM Research Summary

Population Displacement

Photo: Andrea Booher/FEMA



Economic Security

Photo: Canterbury Earthquake Recovery Authority (CERA)

Food Security

Photo: Shamsuddin Ahmed/IRIN

Healthcare Delivery

Photo: Judith Mitrani-Reiser/JHU

S.T.I.R.M.

Sensor Technology and Infrastructure risk Mitigation

Acknowledgements