

# ***Functional Recovery of the Built Environment***

***Presenter: Siamak Sattar***

***Contributors: Dustin Cook; Jo Johnson, Juan Fung***

# Motivation

- What does the code promise?
  - Life safety is the primary objective
- Is Life Safety an acceptable target?
  - Buildings and Lifeline systems may experience extensive damage during an earthquake
  - Widespread damage can have severe social & economic impacts
- We need to do better!

2011 Tohoku



2014 Napa



2011 Christchurch

2011 Christchurch

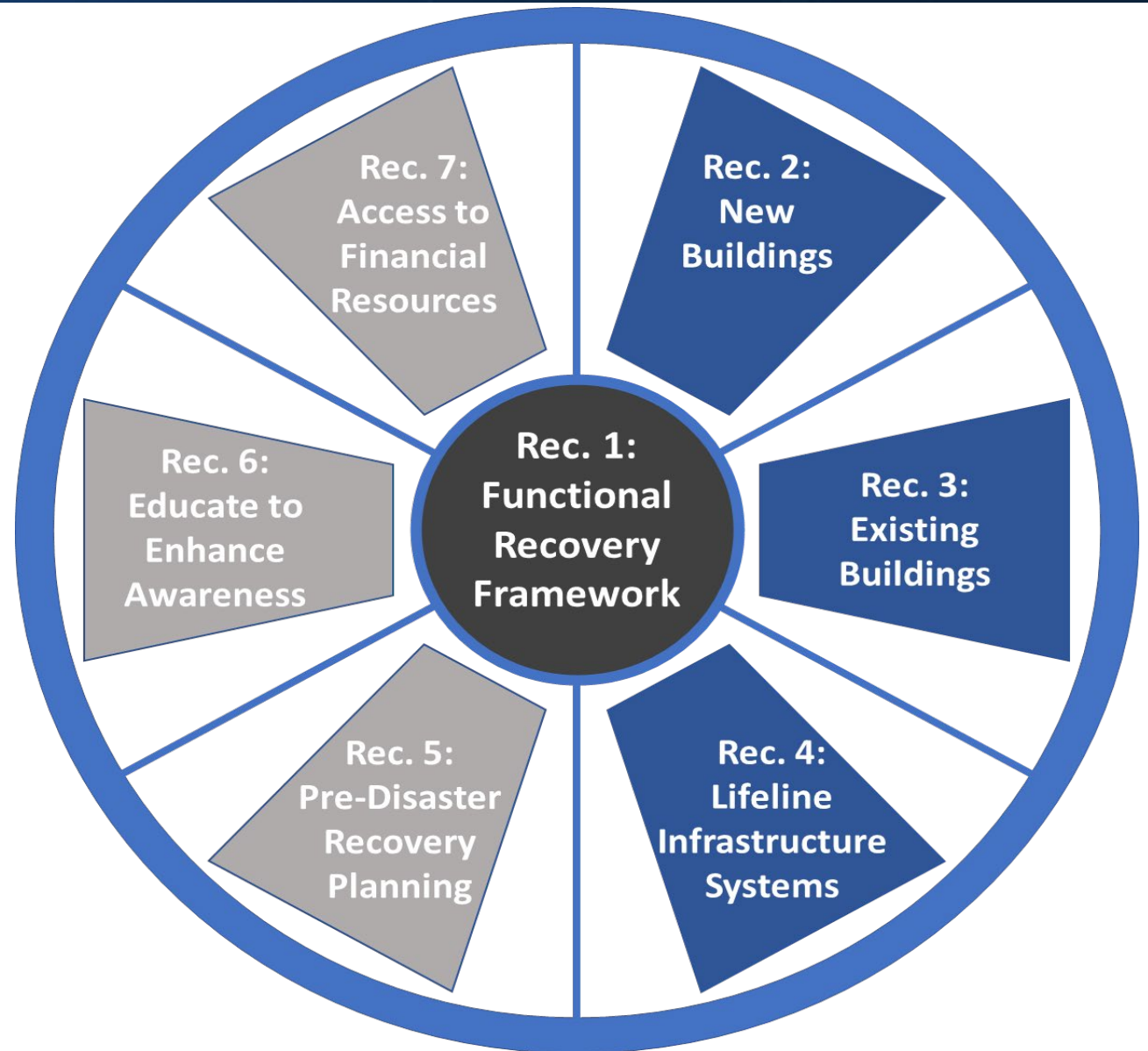


# Congressional Mandate



## Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time

FEMA P-2090 / NIST SP-1254 / January 2021



# After Development of the Report to Congress

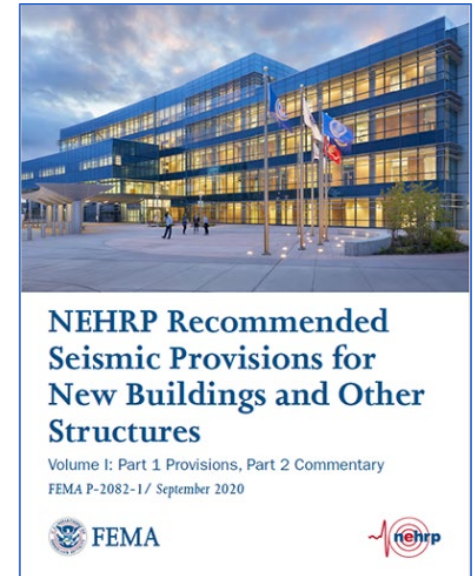
- Functional Recovery has become the premier emerging topic in the field of earthquake engineering!

**NIST** initiated the Functional Recovery project with a focus

on buildings, lifelines, social science, and economic evaluations (2021).

**Outside of NIST** many efforts

- PUC has identified FR as the largest effort in this cycle and formed FRTC to draft a chapter on FR building design (2022).



# Functional Recovery Framework:



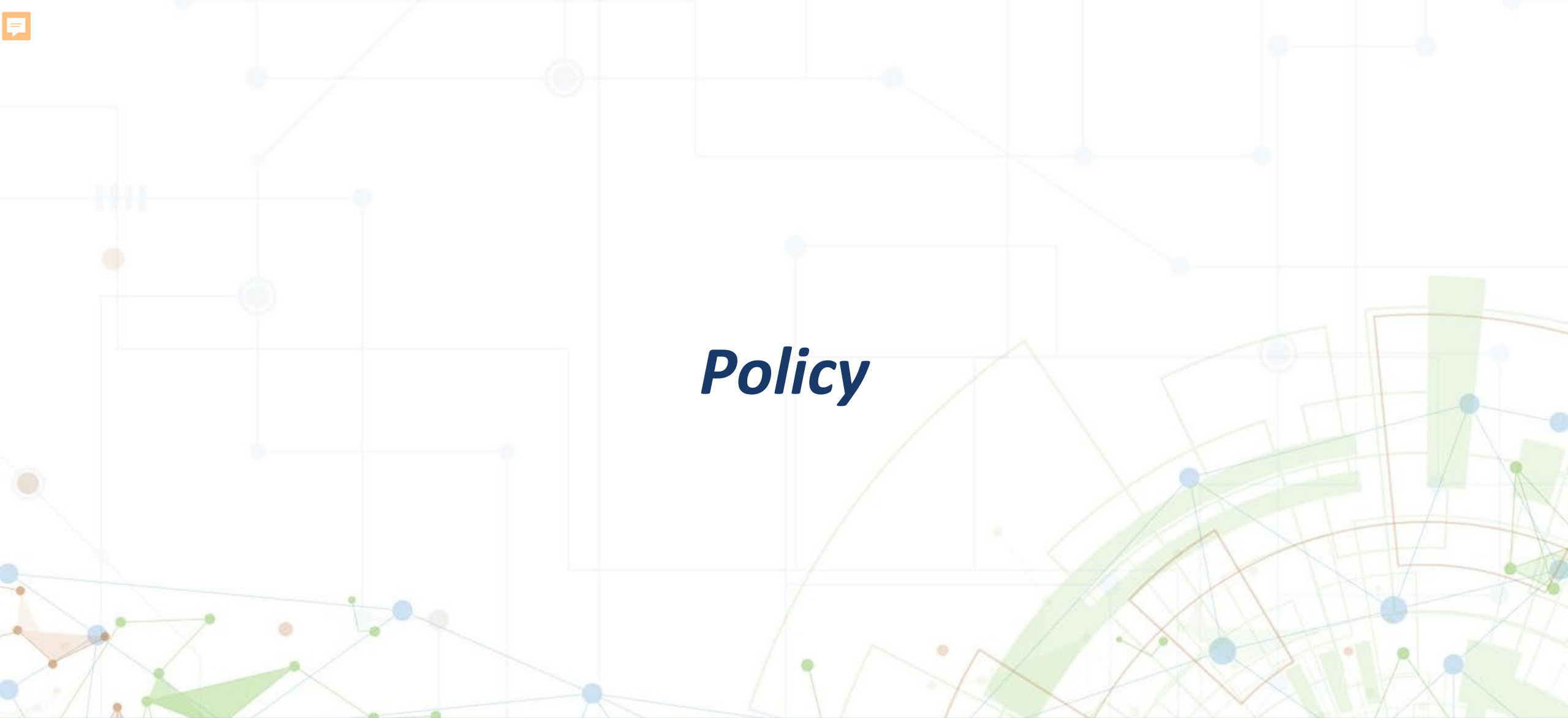
**Policy** ☐ what do we need and when?



**Engineering** ☐ how do we get it?



**Economic Evaluation** ☐ is it worth it?



# *Policy*



# Policy: What do we need, and when?

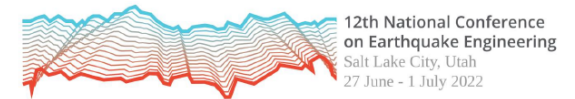
- Hosted five stakeholder workshops
- Explore **acceptable recovery times** for various components of the built environment
- Findings: participants described targets for recovery time categories fairly consistently
- Support FRTC efforts
- October 8-9, 2024 at the NIST with ~ 50 attendees

Table 2. Proposed Functional Recovery Categories and Target Recovery Times

Recovery Category	Recovery Phase	Community Functions or Services	Target Recovery Time	Example Buildings and Infrastructure Enabling Function or Service
A	Immediate	<ul style="list-style-type: none"> <li>Public Health and Safety</li> <li>Telecommunications and Cyber Infrastructure</li> <li>Healthcare (acute)</li> <li>Shelter</li> </ul>	0-24 hours	Cell Phone Towers; Emergency Operations Center; Fire Stations; Hospitals; Lifelines; Police Stations; Designated Shelters
B	Near Term	<ul style="list-style-type: none"> <li>Key Transportation Services</li> <li>Banking and Finance</li> <li>Energy and Electricity</li> <li>Food and Water Resources</li> <li>Healthcare (outpatient)</li> <li>Housing</li> </ul>	1-6 days	Critical Retail (Grocery Stores, Home Improvement); Nursing Homes; Outpatient Medical; Pharmacies; Residential Water; Transportation Nodes (roads, bridges, ports, runways)
C	Short Term	<ul style="list-style-type: none"> <li>Education</li> <li>Governance</li> <li>Housing</li> <li>Local Economy (jobs)</li> <li>Social Support</li> <li>Cultural Identity (religious)</li> </ul>	1-4 weeks	Courthouses; Daycares; Government Buildings; Lifeline Infrastructure that supports Short Term Functions; Major Regional Employers; Schools and Rec Centers; Single- and Multi-family Residential
D	Long Term	<ul style="list-style-type: none"> <li>Cultural Identity (landmark)</li> <li>Entertainment</li> <li>Recreation</li> </ul>	1 month+	Buildings not assigned to other categories; Historic Buildings; Landmarks; Museums; Night Clubs; Religious Centers; Stadiums; Restaurants; Other Commercial Buildings (small business, retail, etc.); Theaters; Country Clubs

Leslie Abrahams  
Lisa Van Pay  
Siamak Sattar  
Katherine Johnson  
Alexis McKittick  
Lauren Bartels  
L. Max Butcher  
Lara Rubinyi  
Michael Mahoney  
Jon Heintz  
Ryan Kersting  
Steven McCabe

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Hosted by the Earthquake Engineering Research Institute

Preliminary Recovery Categories and Times for a Functional Recovery Framework

S. Sattar<sup>1</sup>, D. Cook<sup>2</sup>, K. Johnson<sup>3</sup>

## ABSTRACT

To address the growing need for functional recovery design of U.S. built environment, a recent NIST and FEMA report recommends the development of a national function recovery framework serving as the minimum requirements to provide consistent performance targets and improve community resilience across the nation. Key to this framework is the identification and categorization of critical community services and functions, as well as acceptable post-earthquake downtimes for buildings and lifeline infrastructure systems that support those services. This paper reviews existing literature on recovery-based performance targets for the built environment and uses the data collected at five stakeholder workshops to propose preliminary recovery categories and times that can be employed in the development of a future functional recovery framework.



# *Engineering*



# Engineering: Design Requirements



## Goal

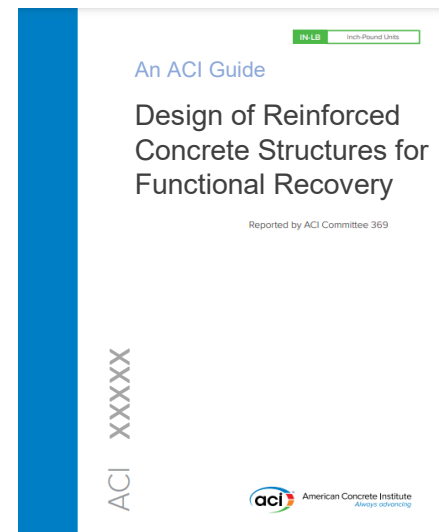
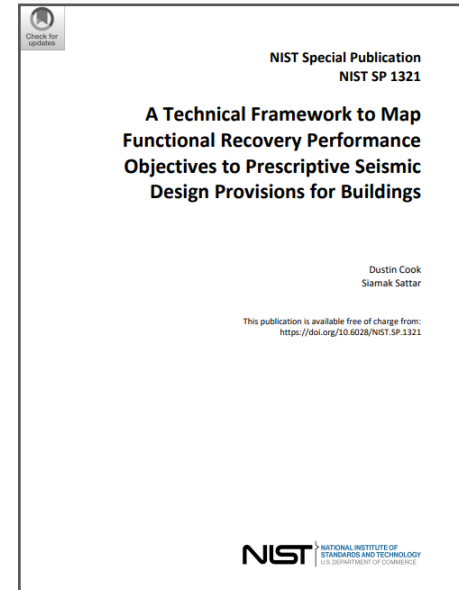
Develop design recommendation to achieve functional recovery objectives in buildings

### Study 1: Prescriptive Design

- A robust framework to map recovery time to design provisions
- Uses state-of-the-art recovery time estimation method; ML; includes structural and nonstructural systems

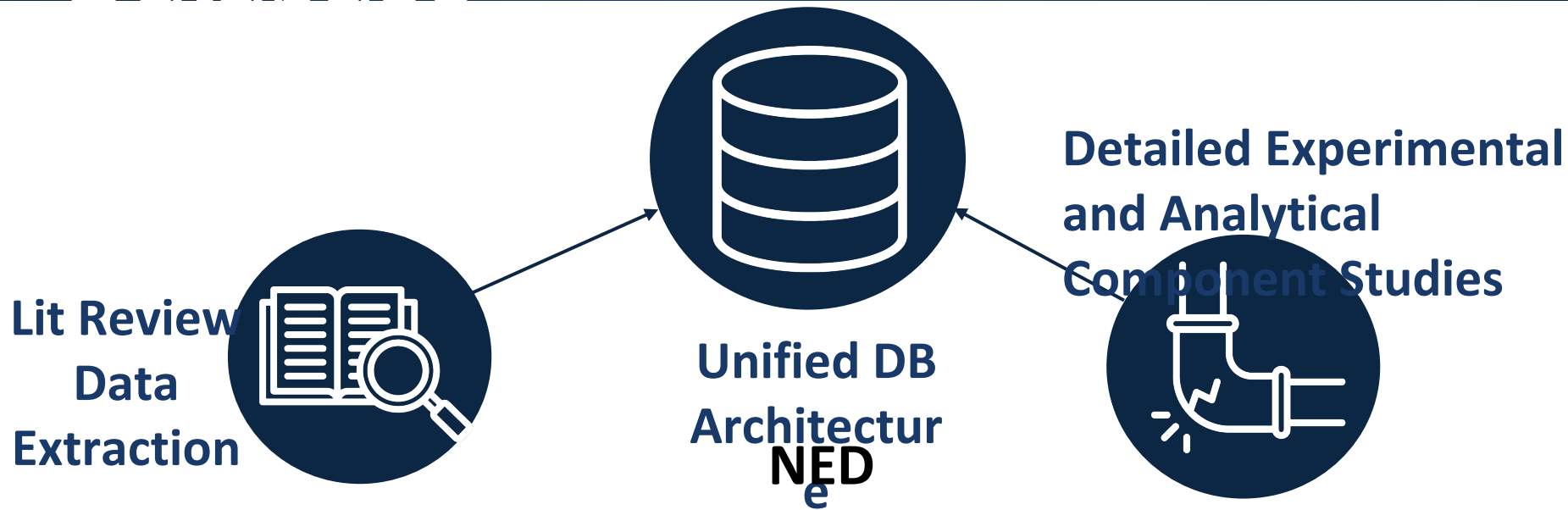
### Study 2: Performance-based Design

- Develop design requirements to mitigate structural damage that requires “safety-based repair”
- Fill a gap in the current PBSD Guides

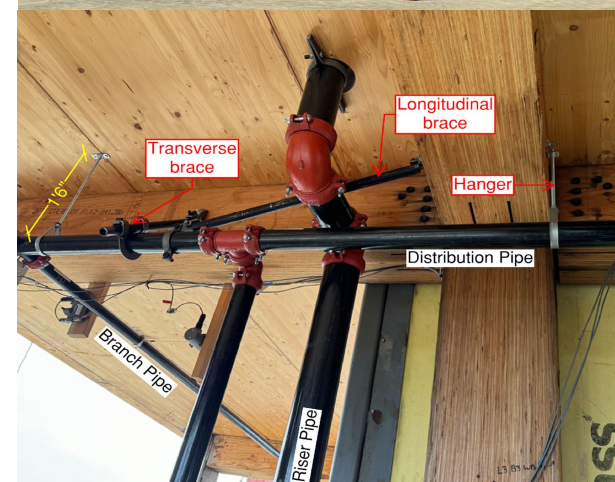
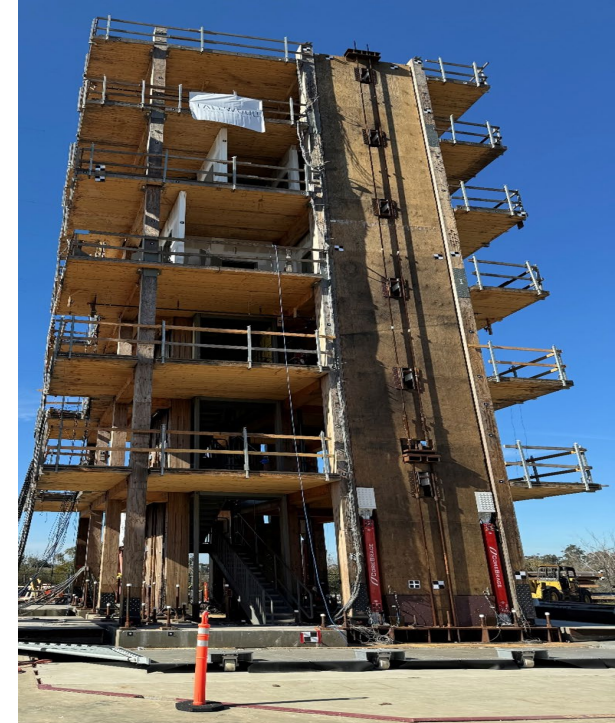
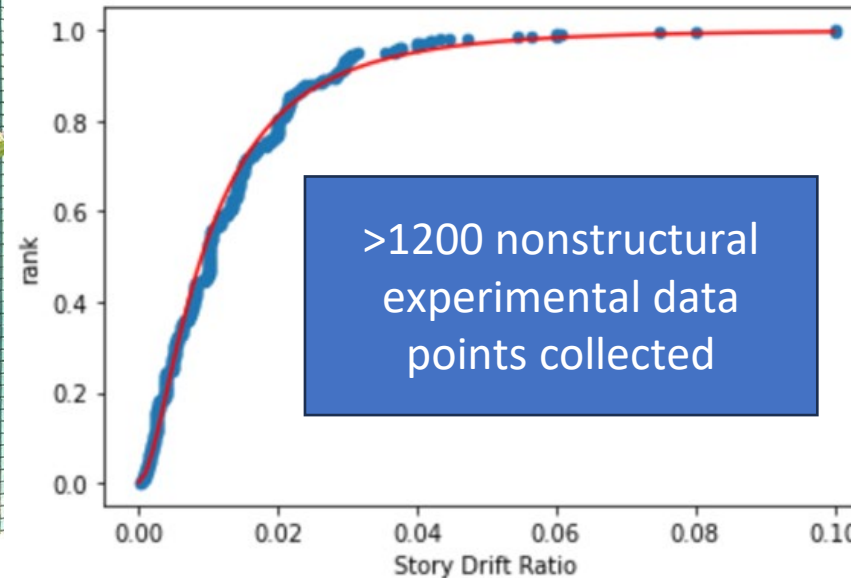


# Engineering: Nonstructural Element Database

NIST

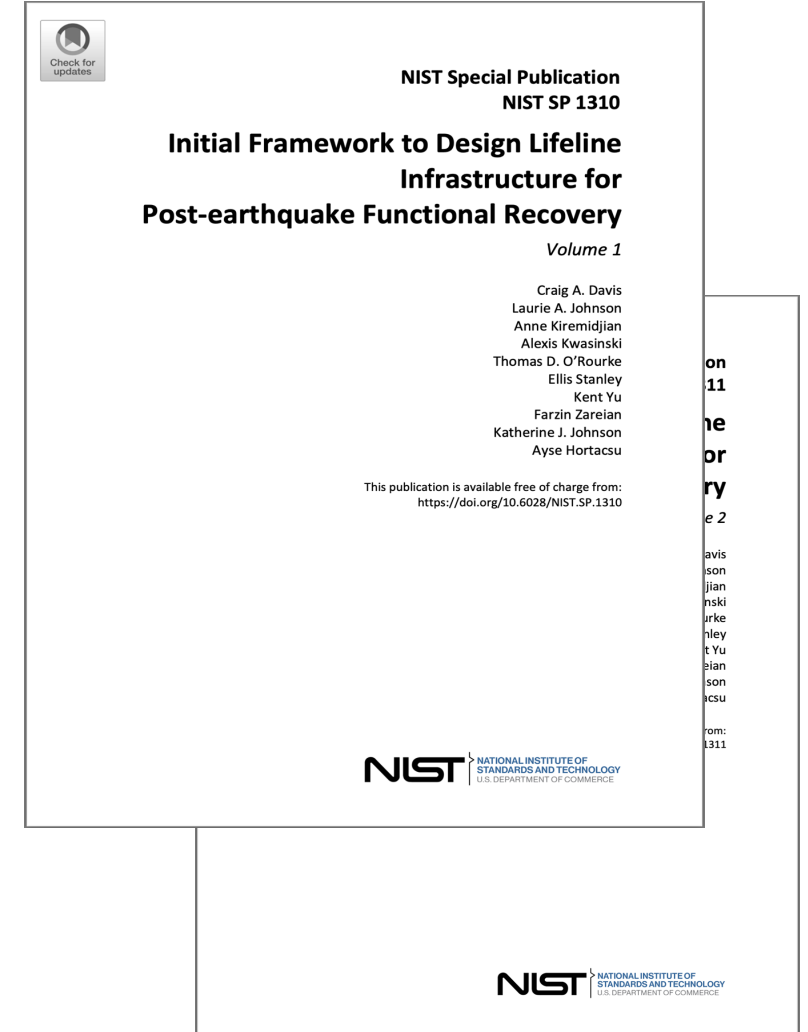


2014 Napa Earthquake



# Engineering: Lifelines

- 2-volume framework (NIST SP 1310 and 1311) for the application of functional recovery to lifelines systems (water, wastewater, and electric power)
- A multi-step process assists owners/operators in designing their physical and organizational systems for functional recovery performance
- Key objective: establish and meet recovery time objectives for basic service categories tailored to the critical needs of each lifeline





The background of the slide features a complex network of thin, light-colored lines connecting various nodes. Some nodes are represented by small circles in shades of blue, green, and orange. There are also larger, semi-transparent geometric shapes, including a prominent green curved band and several rectangular outlines in light green and brown, overlaid on the network. The overall aesthetic is technical and modern.

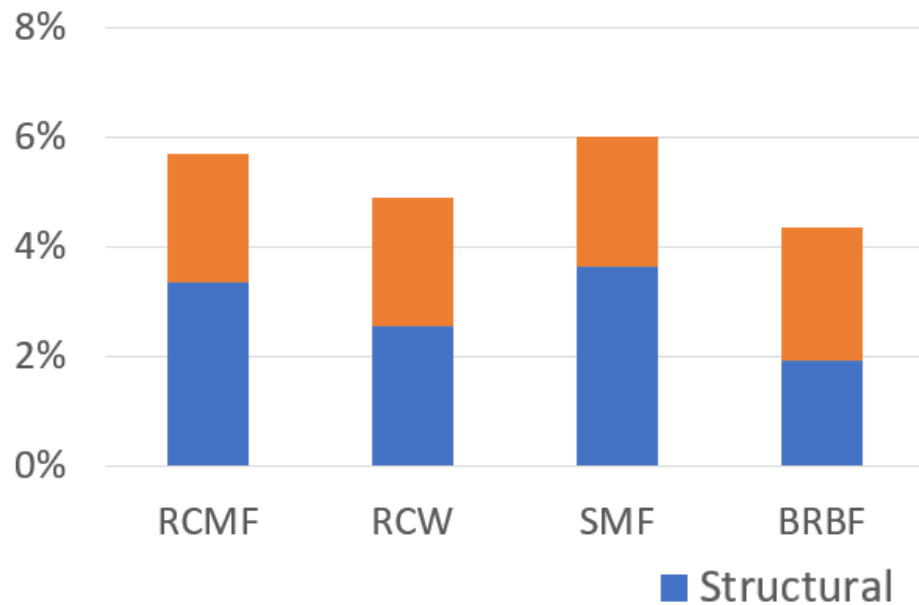
# ***Economic Evaluation***

# Economic Evaluation for Functional Recovery

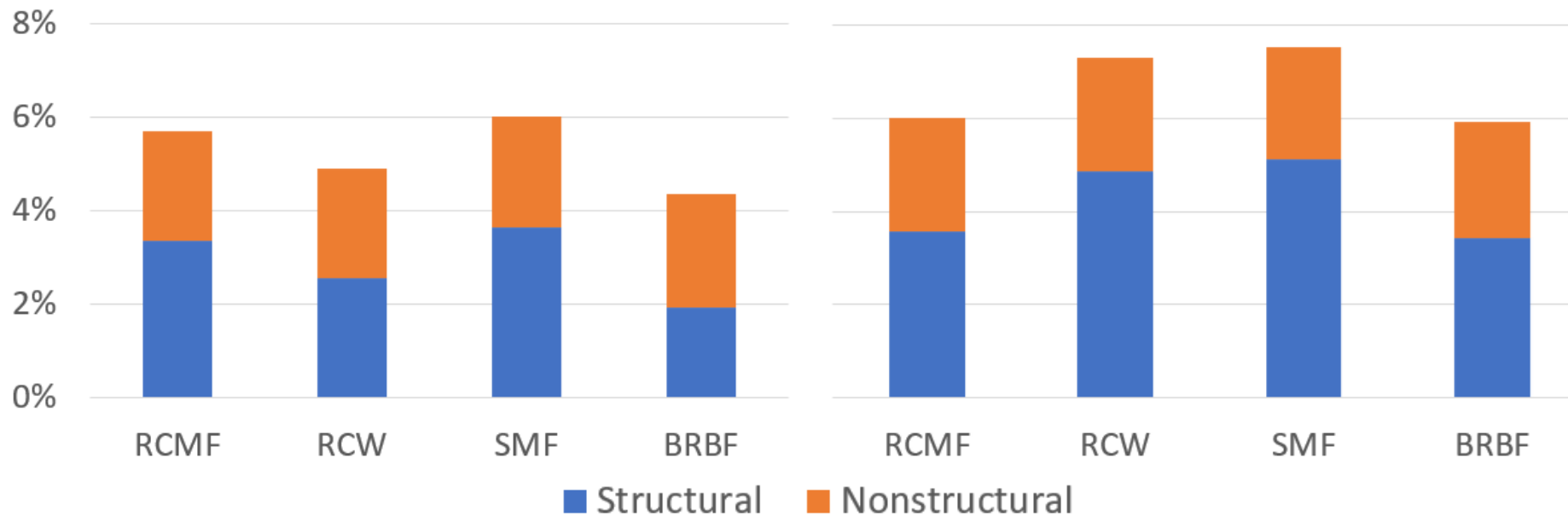


- 4 different structural systems; 4 different heights
- Construction costs increase ~4-8 % for above-code design

## 4 story



## 12 story



- Outcomes from this study provide key economic decision metrics for functional recovery design

NIST Special Publication 1277

**A Framework to Evaluate  
the Cost-Effectiveness of  
Recovery-Based Design**

Juan F. Fung  
Yating Zhang  
Katherine J. Johnson  
Dustin Cook  
Siamak Sattar

This publication is available free of charge from:  
<https://doi.org/10.6028/NIST.SP.1277>

**NIST**  
National Institute of  
Standards and Technology  
U.S. Department of Commerce

# Moving Forward

- Support codification of FR design
- Extend the BCA to the regional level
- Quantify the environmental impacts associated with designing “better” buildings
- Test and improve the lifeline framework for broad application to benefit the U.S. population
- Linking the building-level functional recovery design objectives to the community-level performance goals





Thank you!

# NIST Alternatives for Resilient Communities (NIST ARC)

An interactive tool for developing alternative sets of actions that meet community resilience and cost goals, given hazard and interdependency information, and socio-economic data.

Harrison, K, TI Faiz, Z Farahmandfar, S Crawford, and J. Loerzel. 2023. "NIST Alternatives for Resilient Communities (NIST ARC) Software Tool: Mathematical Programming Model." Technical Note (NIST TN) NIST TN 2239pt1. National Institute of Standards and Technology.

