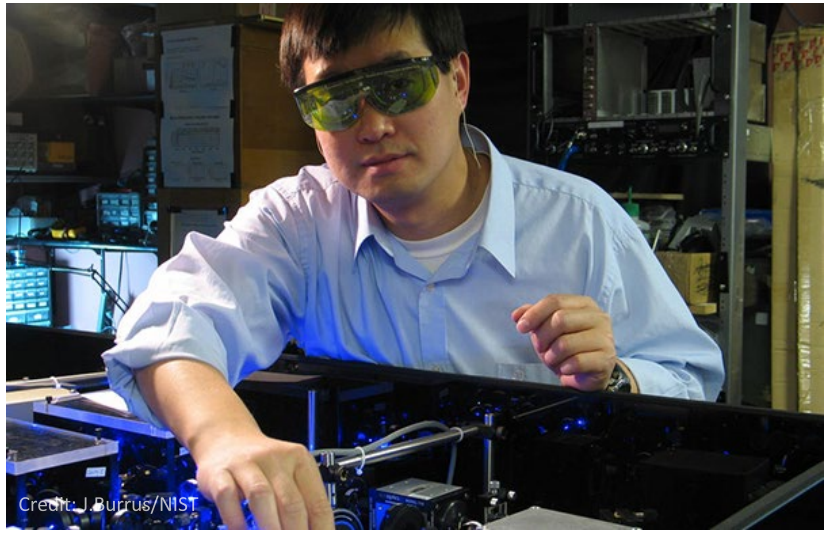
Infrastructure Resilience

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

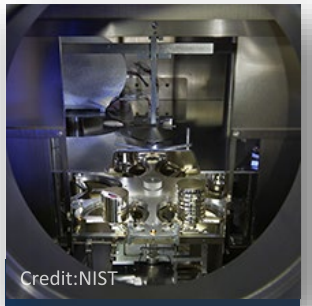
NIST Mission

To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life



NIST Laboratory Programs

Material Measurement Laboratory



Physical Measurement Laboratory

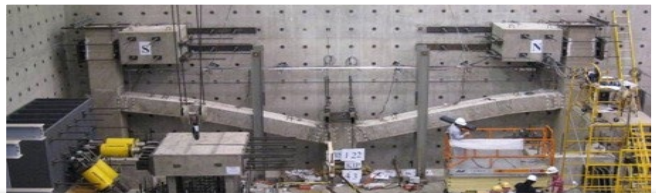
Engineering Laboratory

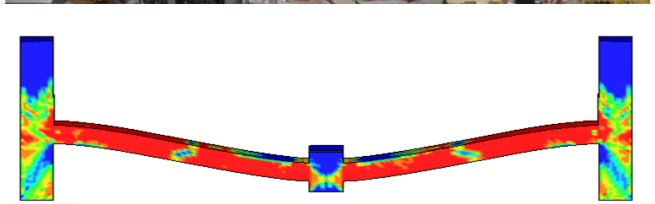
Information Technology Laboratory

Communication Technology Laboratory

NIST Center for Neutron Research

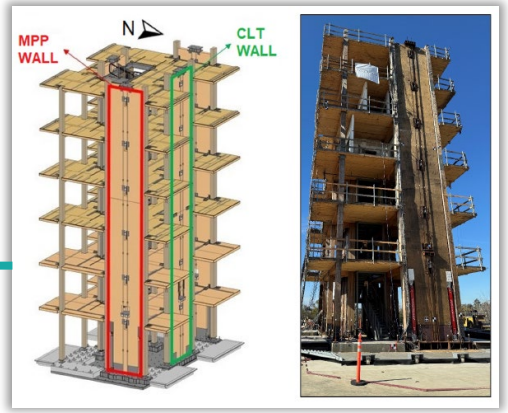
Disaster Resilience Goal

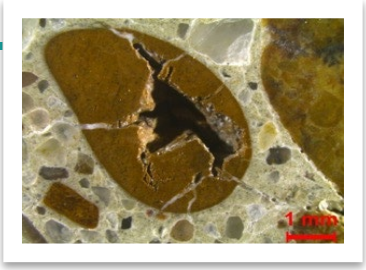




Materials and Structural Systems Division

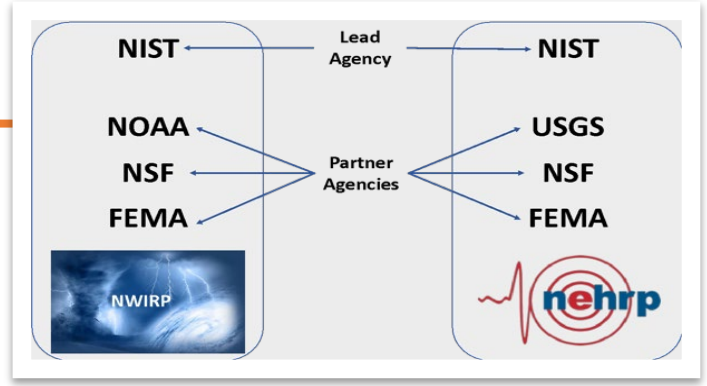
- Infrastructure Materials Science
- Structural Engineering
- Earthquake Engineering
- Community Resilience





Disaster Impact Reduction Office (DIRO)

- Field Studies NCST Investigations
- Interagency Leadership
- Extramural Programs



Resilience

Resilience is the ability to ***prepare for*** and ***adapt to*** changing conditions and to ***withstand*** and ***recover rapidly*** from disruptions. (NIST, NASEM)

Resilience is a comprehensive concept that:

- Recognizes that the built environment exists to serve social functions (e.g., healthcare)
- Includes prevention, protection, design, mitigation, response and recovery

Community Resilience

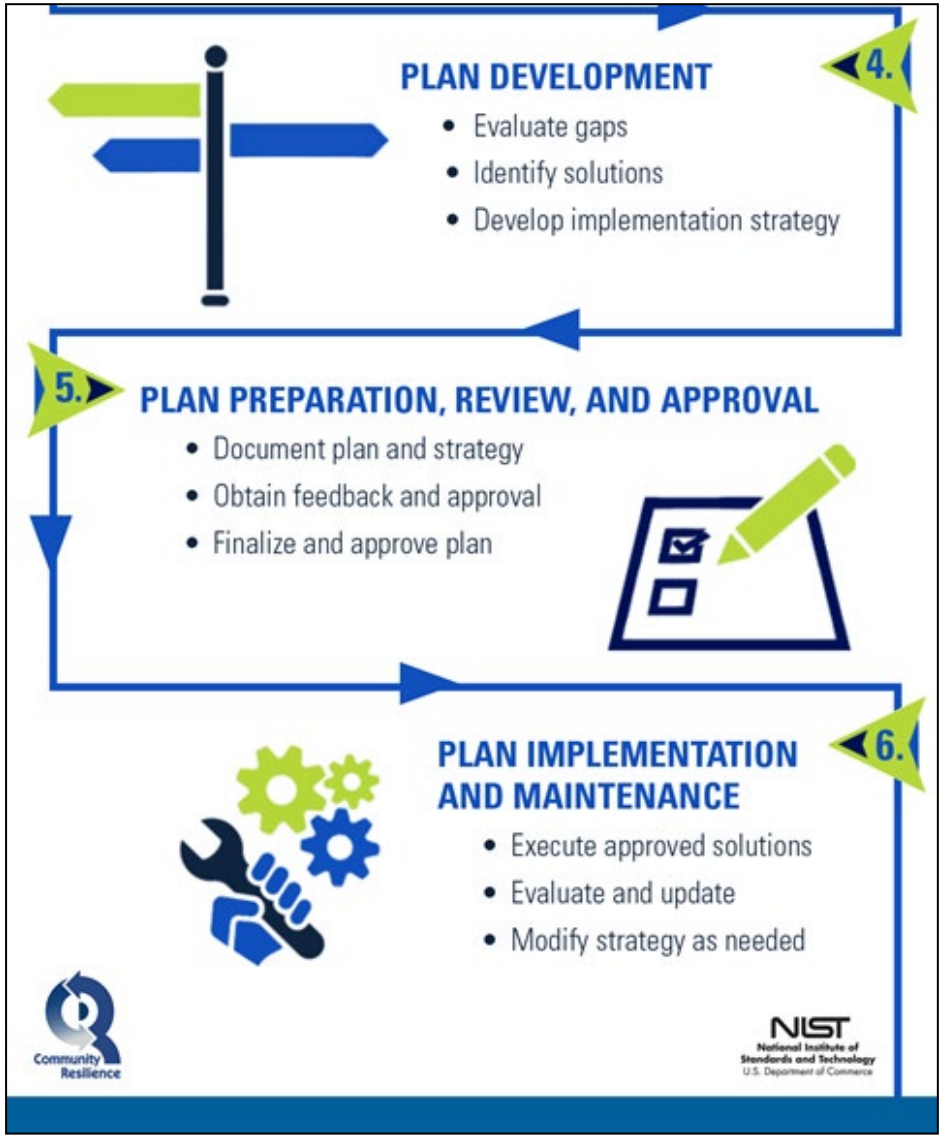
- **Communities** may be campuses, military bases, towns, counties… Any area under a governance structure.
- **Communities need to ensure:**
  - Critical functions are immediately available.
  - Housing, schools/daycare, and businesses are functional shortly after disruptive events.
  - Recovery is equitable across districts and demographics.
- **Social functions depend on the built environment:**
  - Housing comprises 70% of all buildings (with 80% single family homes and 15% multi-occupant).
  - Small businesses employ ~47 % of the population.
  - People cannot work if their children are not in school or daycare.

New Orleans Flooding in 2005 (FEMA)

Lumberton, NC Water Treatment Plant - Hurr. Matthew in 2016

Community Resilience Planning Guide

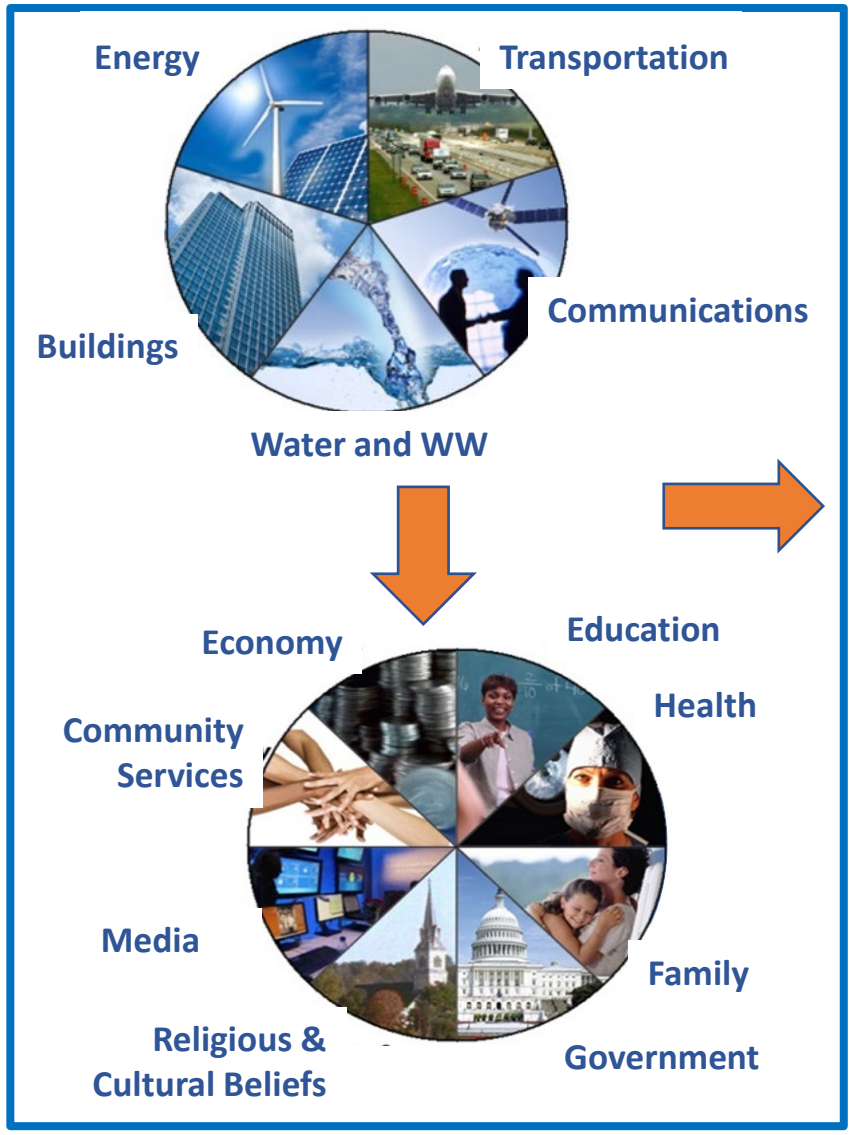
https://www.nist.gov/community-resilience/planning-guide



Linking Social and Built Systems

Built Environment

Population & Social Institutions



Social Impacts & Consequences

Individuals

- Loss of employment/income
- Loss of housing, food, clothing
- Reduced well-being/health

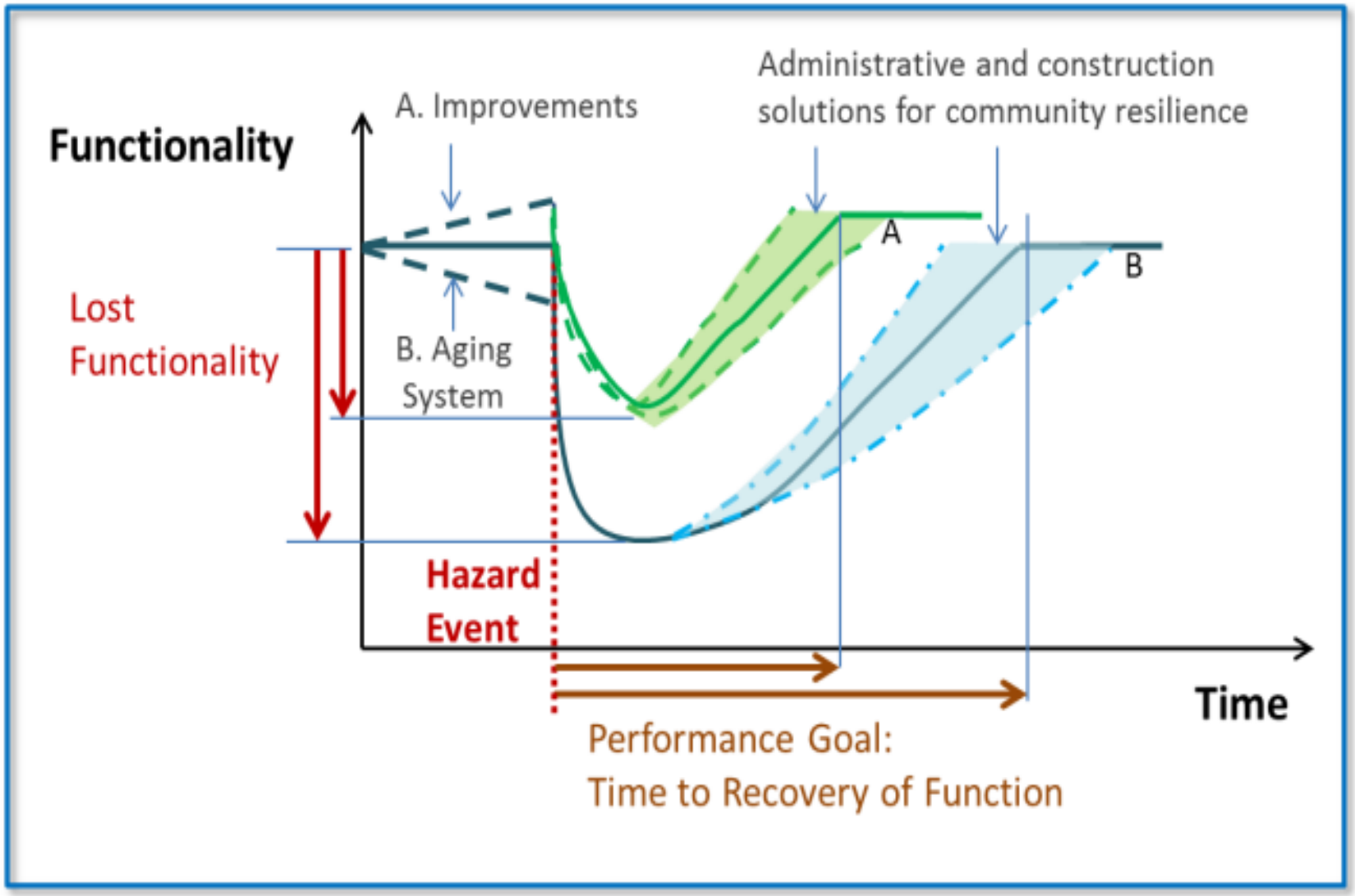
Businesses

- Loss of services, staff, customers, goods, revenue
- Closures

Community-level

- Disruption of essential services
- Disruption of social institutions
- Loss of tax revenue
- Loss of community members, identity, culture

Performance Goals - Recovery of Functionality



NIST SP-1190

Damage Levels provide initial conditions for recovery

Functionality measures how well a building or infrastructure system operates, delivers services, and meets its intended purpose.

Time to recovery of function is a measure of how long it takes before a building or infrastructure system is functioning after a hazard event.

FEMA P-2090/NIST SI

Prioritizing Resilience Projects

- Compare system damage/failure ***impacts*** on community (healthcare)
- Assess time to ***recovery of functions***
- ***Prioritize*** projects based on impacts and recovery time

Summary Performance Goals Matrix

Summary Resilience Table	Design Hazard Performance								
	Phase 1: Short-Term			Phase 2: Intermediate			Phase 3: Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Buildings	90%	←						X	→
Transportation		90%	X						
Energy		90%	X						
Water			90%		X				
Wastewater				90%	←			X	→
Communication	90%			X					

Desired Performance

Gap

Anticipated Performance

2011 Joplin Tornado – Medical Center

Event and Damage

Twelve impact related fatalities occurred in the hospital, four of which involved patients in intensive care units.

Building envelope failures led to many patients, visitors, and staff sheltering in internal hallways. They were hit with medical equipment, hospital furniture, ceiling tiles, broken glass, hailstones, and other windborne debris.

Due to the complete loss of power and the amount of damage and debris, the facility was evacuated.

Rebuilding

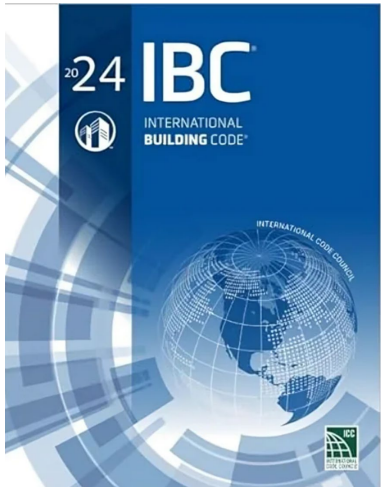
The new $465 million Mercy Hospital Joplin opened to patients in 2015 with:

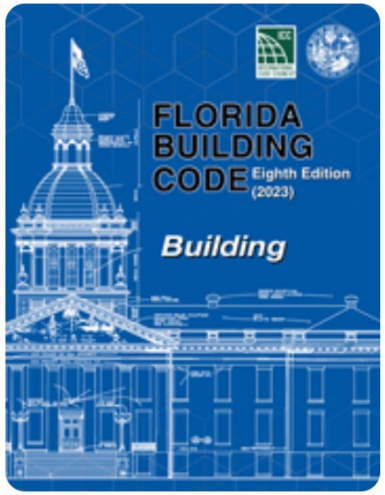
- Window system designed to withstand 250 mph winds
- Concrete roof
- Fortified "safe zones" on every floor
- Half-buried generators away from the main building

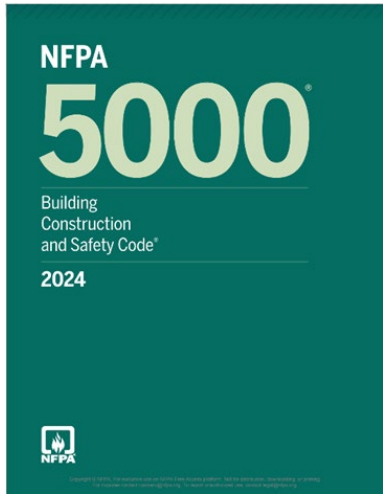
Typical Interior Damage to West Tower of St John Regional Medical Center (SJRMC)

Codes and Standards Impacts

- Building Code Adoptions of Tornado Hazard Maps and Loads (ASCE 7-22):
  - 2023 Florida Building Code
  - 2024 Houston, TX, Building Code
  - 2024 International Building Code
  - 2024 NFPA 5000







- Functional Recovery for Earthquake Events

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

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

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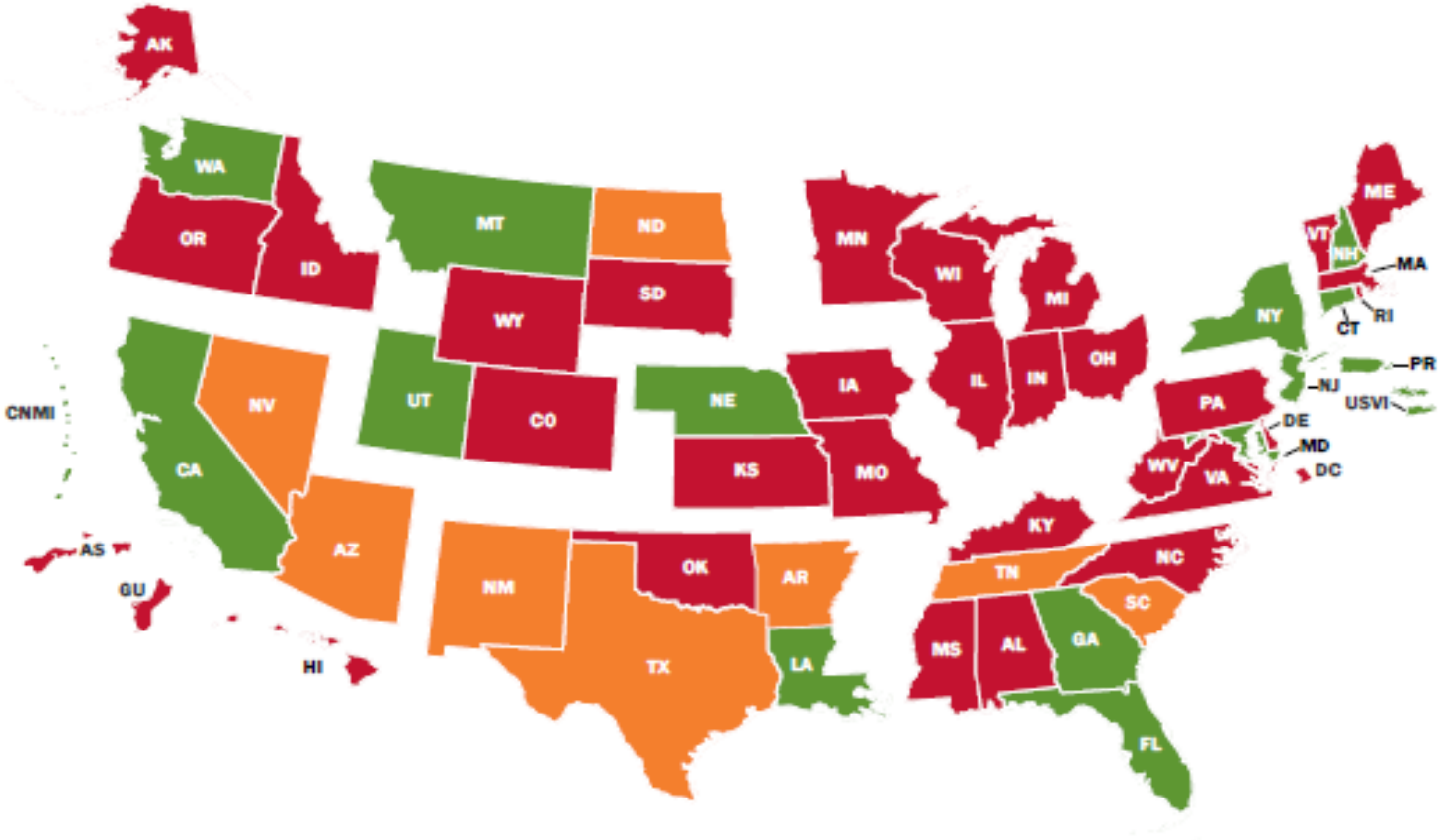
Building Codes and Standards



Higher Resistance (75.0% to 100% of tracked jurisdictions are resistant)
Moderate Resistance (25.0% to 74.9% of tracked jurisdictions are resistant)
Lower Resistance (0% to 24.9% of tracked jurisdictions are resistant)

Figure 2. Overview of BCAT Resistance Ranges Grouped by FEMA Region

https://www.fema.gov/sites/default/files/documents/fema_fy24-about-bcat-report.pdf

- Codes and standards provide minimum requirements for life safety and hazard events
- Model national codes must be locally adopted and enforced
- Future conditions are being addressed locally while national standards are being developed

Climate Collaborations

- Collaborations are fostering improved communication between climate scientists and designers
- ASCE and federal agencies are working on incorporating climate projections in building standards
- NIST is conducting research on community use of climate science
- NIST is developing a state-of-the-art assessment of current practice to inform a roadmap for future building codes

2023 NIST, NOAA, ASCE Community Climate Workshops

Sea Level Rise & Storm Surge
- New York City, NY
- South Florida
- San Francisco Bay, CA


Credit: Jerry Coli, Pixabay

Rain & Inland Urban Floods
- Philadelphia, PA
- Michigan
- Boulder, CO


Credit:12019, Pixabay

Wildfire & Urban Planning
- Austin, TX
- Ashland, OR
- CALFIRE, CA


Credit: sippakorn yamkasikorn, Pixabay

Thank You