13th National Conference on
EARTHQUAKE ENGINEERING
PORTLAND, OREGON | JULY 13-17, 2026
Resilience Through Community Engagement and Technology

Advancing Functional Recovery Performance Targets: Insights from Subject Matter Expert Workshop

L.A. Arendt[1], K.J. Johnson[2], S. Sattar[3], and M. Valley[4]

ABSTRACT

The Workshop on Functional Recovery Performance Targets was hosted by the National Institute of Standards and Technology (NIST) in October 2024 and organized by the Applied Technology Council (ATC). It brought together 48 interdisciplinary experts to assess and improve the Functional Recovery Goal Matrix (a table of functional recovery categories), which links target recovery times to societal functions and services. Functional recovery performance goals are being developed in response to a Congressional directive to strengthen post-earthquake resilience (see NIST SP 1254). The workshop enhances engineering approaches to recovery by including perspectives from housing, emergency management, lifelines, economics, and social sciences. Key findings from the workshop are summarized in this paper and include agreement on recovery priority for functions and services, future research needs, and data synthesis to recommend improvements to functional recovery goals.

Introduction

Congressional Mandate and Goal

The workshop builds on efforts related to the 2018 amendment to the Earthquake Hazards Reduction Act, which tasked NIST and FEMA with creating a roadmap to improve the built environment's post-earthquake functional recovery, defined as the ability to reoccupy and restore functions or services [1]. Functional recovery refers to designing a building or infrastructure system to resume basic intended functions or services within a specific timeframe. Building on previous work by NIST and others [2, 3, 4, 5], the functional recovery task committee (FRTC) of the NEHRP Provisions Update Committee produced a draft functional recovery goal matrix (FRGM) with five recovery categories and corresponding target recovery times (TRTs). However, there was widespread agreement that input beyond engineering was needed to refine the matrix. The workshop was organized to gather additional insights from practitioners, researchers, and decision-makers with extensive experience in community resilience, disaster recovery, lifeline systems, housing, urban planning, and public health to ensure that targeted timeframes align with community needs.

[1] Professor, Schneider School of Business & Economics, St. Norbert College, De Pere, WI 54115 (lucy.arendt@snc.edu)
[2] Social Scientist, National Institute of Standards and Technology (NIST), Gaithersburg, MD, 20899 (katherine.johnson@nist.gov)
[3] Group Leader, Earthquake Engineering Group, National Institute of Standards and Technology (NIST), Gaithersburg, MD, 20899 (siamak.sattar@nist.gov)
[4] Director of Projects, Applied Technology Council, Redwood City, CA, 94065 (mvalley@atcouncil.org)

Arendt LA, Johnson KJ, Sattar S, Valley M. Advancing Functional Recovery Performance Targets: Insights from Subject Matter Expert Workshop. *Proceedings of the 13th National Conference in Earthquake Engineering*, Earthquake Engineering Research Institute, Portland, OR. 2026.

Workshop Design and Data Collection Methodology

The workshop featured presentations to update participants on recent developments and activities, followed by breakout sessions to gather feedback. Five key topics were discussed: criteria and guiding principles for recovery prioritization, appropriate categories and times for recovery, assignment of essential functions and services, generalizability of the FRGM, and the identification of data and research gaps. Through facilitated discussions, structured handouts, and note-taking, workshop organizers documented findings summarized in a forthcoming NIST publication [6]. A key activity of the workshop was assessing the FRGM and developing recommendations for its refinement.

Session Details

Findings from Workshop Breakout Activities

The most important findings from each breakout session at the workshop are summarized:

- *Criteria/Guiding Principles for the FR Goals:* The top **five criteria for** prioritizing recovery time assignment were the availability of housing, access to physical and mental healthcare, access to utilities and lifelines, benefit to the entire community, and reduction of population displacement.
- *Appropriate Categories and Times for Recovery:* Participants agreed on **seven TRTs**: A: 0 hours (continuous functionality), B: 24 hours, C: 72 hours, D: 1 month, E: 3 months, F: 6 months, and Not Designed for Functional Recovery. Changes reflected participants' needs for more options than those proposed in the FRGM.
- *Assignment of Essential Functions and Services*: Participants **assigned 62 specific community functions/services,** including 10 types of housing, to the seven TRTs described above. Workshop organizers compiled these results and identified areas with high and low agreement across buildings and infrastructure. This leads to a recommended matrix highlighting items for future consideration in developing code language.
- *Generalizability of the FRGM:* Workshop participants evaluated how well the matrix applies to communities across the U.S. and agreed it is **generally applicable**, though local conditions, capacities, and vulnerabilities might need further consideration.
- *Data and Research:* **Critical gaps** include data on real-world recovery times, motivation and behavior related to reoccupancy decisions, metrics necessary to manage infrastructure interdependencies, data on individuals and groups overlooked by current recovery methods, and expanding interdisciplinary post-earthquake reconnaissance efforts.

Key Takeaways

- *Earlier Recovery for Critical Functions:* Items related to public safety and at-risk populations were prioritized earlier than those linked to quality-of-life or discretionary services. This may require expanding the definitions of the criticality of functions/services beyond those traditionally used for designing natural hazards. Additionally, most functions/services were scheduled within a 3-month timeframe, emphasizing the importance of functions/services that are not usually considered critical.
- *Clear Preference for Helping People Remain in Their Homes and Communities:* Most housing was prioritized for the 72-hour category, highlighting the important role these resources play for communities. This workshop data offers a new contribution to documented preferences for housing recovery by subject matter experts.
- *Missing Information:* Participants highlighted additional needs for: clear definitions and distinctions across categories to support the development of functional recovery performance targets; a better understanding of interdependencies that may affect recovery trajectories (e.g., utilities and transportation); and an assessment of budgetary, regulatory, and capacity constraints that could impact feasibility.

Recommendations for Matrix Revision

Space limitations prevent a full presentation of the revised matrix of recommendations resulting from the workshop activities and input from subject matter experts, which can be found in the workshop report [6]. However, a few items can be highlighted for future consideration by code language developers.

First, the workshop data offer a valuable resource for identifying areas with **high agreement** for the assignment of functions/services to revised TRT categories. Examples of items with high levels of agreement among the four groups include:

Examples with at least **75% agreement**:

- Category A (0 hours): emergency response/communication services, fire stations, and acute care hospitals.
- Category C (72 hours): multifamily and low-income housing.
- Not Defined for Functional Recovery Category: cultural and recreational facilities (e.g., nightclubs, museums).

Examples with at least **50% agreement:**

- Category B (24 hours): urgent care, emergency supply storage.
- Category C (72 hours): recovery-focused local government, single-family housing.
- Category D (1 month): hotels, social services & community centers.

Items with high agreement indicate shared views on the importance of these assets' basic intended functions. This data can serve as strong evidence for assigning that function or service to a specific TRT and for developing definitions and categorizations for that category, enabling the assignment of similar functions or services in the future.

Second, the workshop data serve as a valuable resource for identifying areas with **low agreement** on assigning functions or services to updated TRT categories. Some examples of items with low levels of agreement (assigned to three or more categories by four workshop groups) include: banking and finance, commercial employers, medical clinics, and veterinary clinics. Items with low agreement highlight the need for future research to better understand differences in opinion about their importance, order for recovery, or perceived feasibility of design for these assets to meet recovery goals.

And finally, workshop findings identify clearly where there may be significant **differences between the functional recovery provisions language** currently drafted (the FRGM) and assignments provided by subject matter experts adjacent to the engineering community. Functions/services for which there is a difference in assignment (almost all to an earlier TRT) include:

- Housing: foster care housing (72 hr to 0 hr), hotels (1 mo to 72 hr)
- Utilities Infrastructure: phone/cellular facilities (72 hr to 24 hr), internet infrastructure (72 hr to 24 hr)
- Government: recovery-focused local government (2 mo to 72 hr), routine local government services (6 mo to 72 hr)
- Education: post-secondary (i.e. college, university) (6 mo to 1 mo)
- Other: commercial (small business, retail) (72 hr/ 2 mo/6 mo to 1 mo), food and potable water services, both retail and wholesale (72 hr to 72 hr/1 mo split)

Future code/standards committees tasked with TRT assignment will want to evaluate reasons for discrepancies and consider how to enable TRT categories to best support societal recovery requirements.

Recommendations for Future Work

Workshop findings can inform the development of language in functional recovery performance standards and guidelines in future code cycles. Key activities could include considering revised placement of functions/services in the FRGM, collecting and analyzing feasibility attributes such as cost and design constraint data, involving new stakeholders in the development of design targets, and eventually expanding functional recovery targets to include existing structures. It will also be necessary to clarify the interdependencies that influence the performance of lifeline infrastructure systems. Support will likely be needed to build capacity at local and regional levels to carry out planning and implementation activities essential for applying functional recovery performance objectives effectively. Additionally, assistance will help communities tailor functional recovery performance to meet critical local contexts and needs.

Conclusion

The workshop enhances current practices for developing functional recovery categories and supports improved seismic risk reduction and resilience planning outcomes by incorporating expert insights beyond structural engineering. The recommendations offer practical guidance to advance recovery-based codes and standards. It helps the engineering community effectively prioritize societal needs by focusing on the functions and services provided by buildings and lifeline infrastructure systems. By collecting expert input on target recovery times and assessing the validity of recovery assignments across communities, the workshop can guide future updates to the NEHRP seismic provisions, ASCE 7, and the International Building Code to benefit the American public.

Acknowledgments

Additional members of the workshop organizing committee include Divya Chandrasekhar, Laurie Johnson, and Ryan Kersting, who provided invaluable support in developing, facilitating, and analyzing workshop activities. We sincerely thank the 48 workshop participants who contributed their time, expertise, and insights across multiple disciplines—such as structural engineering, public health, housing, infrastructure systems, emergency management, and social science. Their thoughtful engagement, collaborative spirit, and real-world perspectives were crucial in formulating recommendations for enhancing recovery-based design objectives. Lastly, we acknowledge the efforts of the NEHRP Provisions Update Committee in developing the original FRGM and Dustin Cook and Rebecca Laberenne for assisting with workshop execution.

References

[1] NIST-FEMA. (2021). Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time. (FEMA P-2090/NIST SP-1254). https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1254.pdf.

[2] Applied Technology Council. (2022). Proceedings of FEMA-Sponsored Workshop on Functional Recovery (ATC-58-7). Burlingame, CA: Applied Technology Council. https://www.atcouncil.org/docman/atc-publications/327-atc-58-7-fr-workshop-report-2022-2/file.

[3] NIST. (2021). NIST-FEMA Post-Earthquake Functional Recovery Workshop Report. (NIST SP 1269). https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1269.pdf.

[4] Sattar S, Cook D, & Johnson KJ. (2022). Preliminary recovery categories and times for a functional recovery framework. In Proceedings of the 12th National Conference on Earthquake Engineering, Salt Lake City, UT. https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=934248.

[5] Cook DT, Liel AB, Haselton CB, & Koliou M. (2022). A framework for operationalizing the assessment of postearthquake functional recovery of buildings. Earthquake Spectra, 38(3), 1972–2007. https://doi.org/10.1177/87552930221081538.

[6] NIST. (2025). Functional Recovery Performance Targets Workshop Report. (NIST SP 1341). https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1341.pdf.