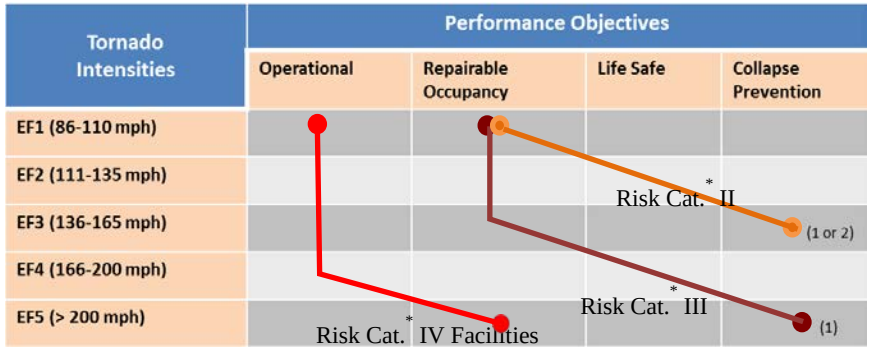
Recommendation	Interested Parties	Organization with Lead Responsibility for Implementation
Group 1: Tornado Hazard Characteristics and Associated Wind Field		
Recommendation 1: NIST recommends that a capacity be developed and deployed that can measure and characterize actual tornadic wind fields, including near–surface wind fields, for use in the engineering design of buildings and infrastructure. This would require enhancement and widespread deployment of cost-effective, advanced technologies, including weather radar.	Academia, DOE, FEMA, NOAA/NWS, NRC, NSF	NOAA
Recommendation 2: NIST recommends that information gathered and generated from tornado events (such as the Joplin tornado) should be stored in publicly available and easily accessible databases to aid in the improvement of tornado hazard characterization.	Academia, FEMA, NGA	NWS
Recommendation 3: NIST recommends that tornado hazard maps for use in the engineering design of buildings and infrastructure be developed considering spatially based estimates of the tornado hazard instead of point–based estimates.	ASCE, DOE, FEMA, ICC, NRC	NIST
Recommendation 4: NIST recommends that new damage indicators (DIs) be developed for the Enhanced Fujita tornado intensity scale to better distinguish between the most intense tornado events. Methodologies used in the development of new DIs and associated degrees of damage (DODs) should be, to the extent possible, scientific in nature and quantifiable. As new information becomes available, a committee comprised of public and private entities should be formed with the ability to propose, accept, and implement changes to the EF Scale. The improved EF Scale should be adopted by NWS.	Academia, ATC, FEMA, NRC, NSF, OSTP	NWS

Recommendation	Interested Parties	Organization with Lead Responsibility for Implementation
Group 2: Performance of Buildings, Shelters, Designated Safe Areas, and Lifelines		
Recommendation 5: NIST recommends that nationally accepted performance–based standards for the tornado–resistant design of buildings and infrastructure be developed and adopted in model codes and local regulations to enhance the resiliency of communities to tornado hazards. The standards should encompass tornado hazard characterization, performance objectives, and evaluation tools. The standards shall require that critical buildings and infrastructure such as hospitals and emergency operations centers be designed to remain operational in the event of a tornado. An example of a tornado performance objectives matrix for buildings of different risk categories is shown below:  (1) Hardened area, shelter–in–place. (2) Public shelter. * Risk Categories based on ASCE 7–10.	Academia, ATC, Design and construction industry (including ACI, AISC, AWS, NAHB, PCA, SDI, SJI, TMS), FEMA, ICC, NFPA	ASCE

Recommendation	Interested Parties	Organization with Lead Responsibility for Implementation
Recommendation 6: NIST recommends the development of risk–balanced, performance–based tornado design methodologies such that all building components and systems meet or exceed the same performance objectives when subjected to tornado hazards.	Academia, ASCE, ATC, Design and construction industry (including ACI, AISC, AWS, NAHB, PCA, SDI, SJI, TMS), ICC, NFPA	NIST, FEMA
Recommendation 7: NIST recommends that: (a) a tornado shelter standard specific for existing buildings be developed and referenced in model building codes; and (b) tornado shelters be installed in new and existing multi–family residential buildings, mercantile buildings, schools and buildings with assembly occupancies located in tornado hazard areas identified in the performance–based standards required by Recommendation 5.	Academia, FEMA, NAHB, NFPA, States and authorities having jurisdiction (AHJ) in tornado–prone areas	ICC
Recommendation 8: NIST recommends the development and implementation of uniform national guidelines that enable communities to create safe and effective public sheltering strategies. The guidelines should address planning for siting, designing, installing, and operating public tornado shelters within the community.	IAEM, IAFC, ICC, NAC, NCSL, NEMA, NFPA, NSF, NWS	FEMA
Recommendation 9: NIST recommends that uniform guidelines be developed and implemented nationwide for conducting assessment of tornado risk to buildings and designating best available tornado refuge areas as an interim measure within buildings until permanent measures fully consistent with Recommendations 5 and 7 are implemented.	Academia, DHS S&T, IAEM, IAFC, ICC, NAC, NCSL, NEMA, NFPA, States and AHJs in tornado–prone areas	FEMA
Recommendation 10: NIST recommends that aggregate used as surfacing for roof coverings and aggregate, gravel, or stone used as ballast be prohibited on buildings of any height located in a tornado–prone region.	ASCE, NFPA, SPRI, States and AHJs	ICC

Recommendation	Interested Parties	Organization with Lead Responsibility for Implementation
Recommendation 11: NIST recommends that enclosures of egress systems (elevators, exits, stairways) in critical facilities in tornado–prone areas be designed to maintain their functional integrity when subjected to tornado hazards.	BOMA	ICC, NFPA
Recommendation 12: NIST recommends that (a) tornado vulnerability assessment guidelines for critical facilities be developed and (b) owners and operators of existing critical facilities in tornado–prone areas perform tornado vulnerability assessments, which includes steps to protect the functionality of (1) backup power supplies, (2) vertical movement within the building (elevator equipment and shaft enclosures), and (3) means of egress illumination (battery–powered lighting in addition to backup power), in a tornado event.	BOMA, DHS IP, DHS S&T, IFMA, NFPA, States and AHJs	FEMA
Group 3: Pattern, Location, and Cause of Fatalities and Injuries, and Associated Performance of Emergency Communications Systems and Public Response		
Recommendation 13: NIST recommends the development of national codes and standards and uniform guidance for clear, consistent, recognizable, and accurate emergency communications, encompassing alerts and warnings, to enable safe, effective, and timely responses among individuals, organizations, and communities in the path of storms having the potential to create tornadoes. NIST also recommends that emergency managers, the NWS, and the media develop a joint plan and take steps to make sure that accurate and consistent emergency alert and warning information is communicated in a timely manner to enhance the situational awareness of community residents, visitors, and emergency responders affected by an event.	Academia, FEMA, IAEM, ICC, NEMA, and NWS	NFPA

Recommendation	Interested Parties	Organization with Lead Responsibility for Implementation
Recommendation 14: NIST recommends that the full range of current and next–generation emergency communication "push" technologies (e.g., GPS–based mobile alerts and warnings, reverse 9–1–1, outdoor siren systems with voice communication, NOAA weather radios) be deployed and utilized to maximize each individual's opportunity to receive emergency information and respond safely, effectively, and in a timely fashion.	Academia, DHS, FCC, IAFC, NEMA, NFPA, NWS	FEMA
Recommendation 15: NIST recommends research be conducted to identify the factors that will significantly enhance public perception of personal risk and promote rapid and effective public response during emergencies, including tornadoes.	Academia, DHS, ICC, NFPA, NWS	NSF, NIST
Recommendation 16: NIST recommends that technology be developed to provide tornado threat information to emergency managers, policy officials, and the media on a spatially resolved real–time basis to supplement the currently deployed official binary warn/no warn system.	FEMA, IAEM, Media industry, NEMA, NFPA	NOAA

Key: ACI, American Concrete Institute; AHJ, authority having jurisdiction; AISC, American Institute of Steel Construction; ASCE, American Society of Civil Engineers; ATC, Applied Technology Council; AWS, American Welding Society; BOMA, Building Owners and Managers Association International; DHS, U.S. Department of Homeland Security; DHS IP, DHS Office of Infrastructure Protection; DHS S&T, DHS Science and Technology Directorate; DOE, U.S. Department of Energy; FCC, Federal Communications Commission; FEMA, Federal Emergency Management Agency; IAFC, International Association of Fire Chiefs; IAEM, International Association of Emergency Managers; ICC, International Code Council; IFMA, International Facility Managers Association; NAC, National Association of Counties; NAHB, National Association of Homebuilders; NCSL, National Conference of State Legislators; NEMA, National Emergency Management Association; NFPA, National Fire Protection Association; NIST, National Institute of Standards and Technology; NOAA, National Oceanic and Atmospheric Administration; NRC, U.S. Nuclear Regulatory Commission; NSF, National Science Foundation; NWS, National Weather Service; PCA, Portland Cement Association; SDI, Steel Deck Institute; SJI, Steel Joist Institute; SPRI, Single Ply Roofing Industry; TMS, The Masonry Society.