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PLANNING, TRAINING, AND EXERCISING FOR EXTREME EVENTS ON THE RAILROAD

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Final Report | October 2025

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Frances L. Edwards https://orcid.org/0000-0002-0446-5556
Daniel C. Goodrich https://orcid.org/0000-0002-8123-6554

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College of Business
San José State University
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14. ABSTRACT
Scientists have noted that extreme weather events pose a multi-pronged threat to railroads, warning that without proactive adaptation, the industry will face degrading infrastructure, increased safety hazards, and sharply rising operational costs. Knowing how to manage emergencies generated by natural hazards like snow storms, hurricanes, and flooding is critical for safe operation of the railroads throughout the United States. The *Field Personnel Respond: Incident Command System (ICS) for Extreme Events on the Railroad* presents critical information on best practices and useful initiatives related to rail hazards associated with extreme weather in North America. This research builds on foundational Department of Transportation documents on the use of the Incident Command System (ICS) and, through a survey of past events and current practices, supports North America's railroads to prepare their personnel, equipment, and infrastructure for extreme weather hazards.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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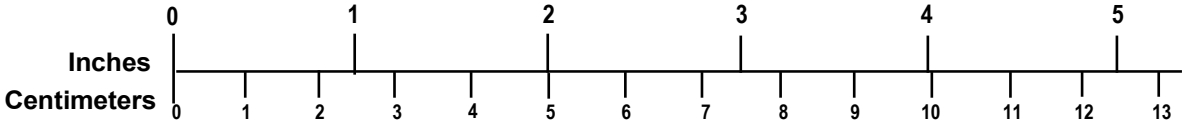
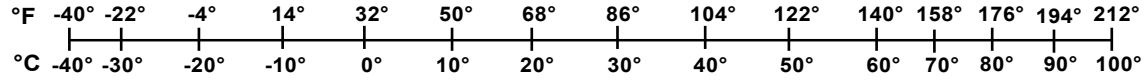
QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

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1. The Emergency Management Process

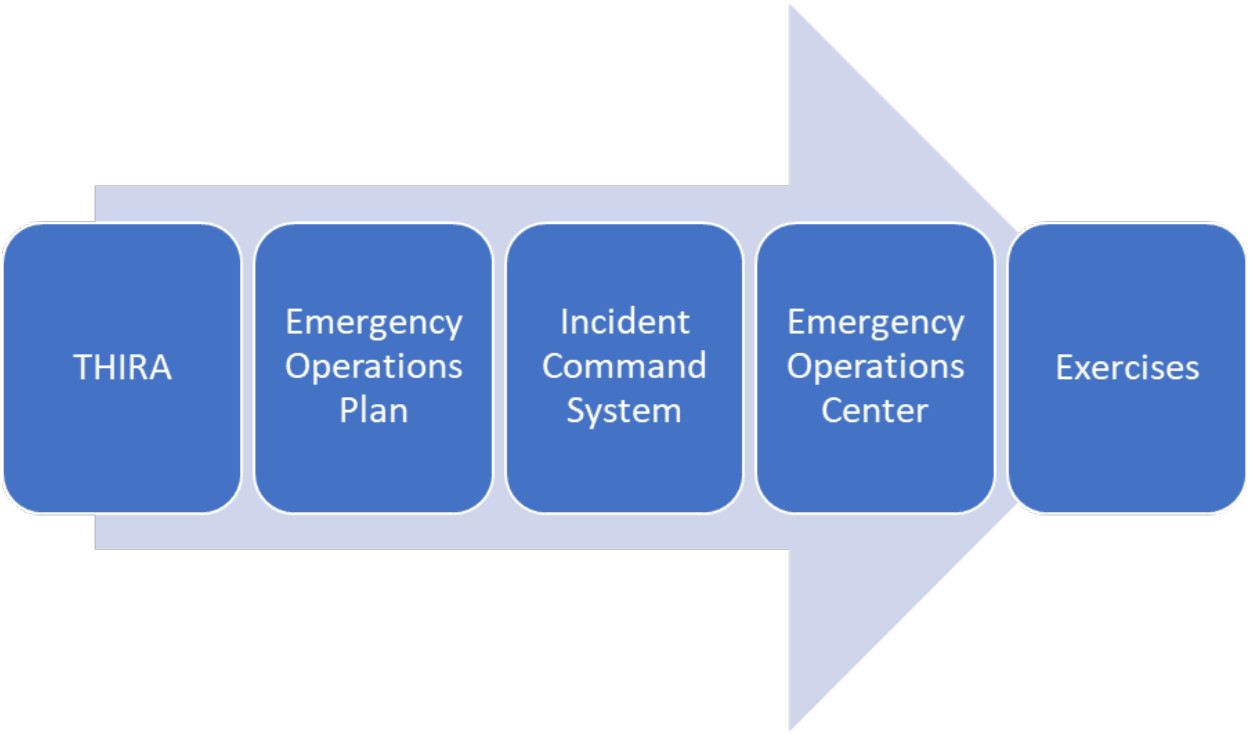

Figure 1. The Emergency Management Process

Emergency management is a process with five steps that build on each other, and lead to organizational preparedness for emergencies and extreme events. Knowing the threat and hazard inventory and risk assessment (THIRA) to the specific division of the railroad organization threat and leads to an emergency operations plan (EOP) that supports a successful response to known threats. The Incident Command System (ICS) is an organizational method used by first responders and public organizations for managing emergencies when multiple professions or multiple jurisdictions are involved. The railroad and first responders can work together more effectively when both are using ICS to coordinate their work. A "war room" or emergency operations center (EOC) that is organized on the ICS principles and prepared for the expected hazards will be more efficient than other systems at resolving emergencies and extreme events. Exercises of the plans, facilities, and training enable the railroad to determine whether the planning and preparation work has been adequate, and what improvements need to be made to the process. This introduction explains how the five sets of guides and supporting documents can be used to achieve a successful emergency management system on the railroad.

2. Changing Weather: Cause and Effect on the Railroad

Railroads have been responding to emergencies on the tracks for more than 150 years. They built snow sheds and raised track beds to avoid natural hazards, and more recently they have planned for hazardous materials accidents on the rail line[1]. Plans for responding to hazardous materials include the use of the Incident Command System (ICS) to coordinate with local fire departments, police departments, and specialized hazardous materials teams. Railroads also have "war rooms" (more commonly called emergency operations centers—EOCs), a term that dates from the early days of the railroad when military terminology was used for personnel and policies. In the "war room" or EOC, personnel marshal their resources and plan for a response to extreme events that impact their infrastructure. Hurricanes, floods, and wildland fires have all impacted railroad rights-of-way, requiring a self-supported response, and sometimes a multi-jurisdictional response.

Figure 2. Track Damage in Queens After Hurricane Sandy
Source: Metropolitan Transportation Authority

[1] The Pipeline and Hazardous Materials Safety Administration has published Transportation Rail Incident Preparedness & Response: High Hazard Flammable Trains (2018) that includes a discussion of using ICS for railroad events. TRANSCAER offers courses called Rail Incidents: Preparedness and Response for Emergency Managers, https://www.transcaer.com/training/training-events/or/rail-incidents-preparedness-and-response-emergency-managers/46812 including ICS on the railroad.

Recently, extreme weather patterns have shifted the location and intensity of disasters on the railroad. For many years railroads have heated track to the maximum expected temperature during track installation to ensure that hot weather-related track expansion will not damage the rails. High heating temperatures that were only used in the southwest deserts are now being used in the Great Plains and parts of the East Coast to avoid sun kinks, which are bends in the rails caused by heat that exceeds the temperature at which they were laid. This increased heat when laying track is now necessary in more northerly locations due to extreme weather.

Figure 3. Buckled Rail (Sun Kink) from Extreme Heat
Source: National Oceanic and Atmospheric Administration, 2017

After 150 years of service the Amtrak Northeast Corridor rail line is being relocated inland as it skirts Long Island Sound due to a rise in the water table related to sea level rise. The LOSSAN Corridor rail line used by freight and commuter trains is being moved inland in Orange County, California, because the rails that run close to the Pacific Ocean are being undermined by storm surge and sea level rise. Hurricane Helene left the coast and tracked up the Blue Ridge Mountains, doing significant damage in North Carolina and Tennessee, causing railroads to reconsider the materials used for road bed construction, such as concrete ties instead of wood.

The Federal Railroad Administration (FRA) has contracted with the partners in the Rail Resilience to Severe Weather: Training and Research Program (RR2SW) team to provide advice to the railroad industry on planning for future weather-related extreme events. In addition to technologies that might be applied and new understandings of costs, the team has also looked at how railroads might modify their current emergency management strategies to more effectively protect their property and the vital supply chains that depend on the railroad.

3. Threats and Hazards Inventory and Risk Analysis

More frequent and severe weather events highlight the need to reevaluate the natural, technological, and human-caused threats facing the built environment, with these conditions incorporated into emergency planning. The Threat and Hazard Inventory and Risk Assessment (THIRA) documents provide guidance on how a railroad might approach this activity using the THIRA methodology that was developed by the Federal Emergency Management Agency (FEMA). As private businesses, the railroads are not obligated to follow FEMA guidance, but this approach is cost-effective, and can be conducted by emergency management staff members rather than costly outside consultants.

The evaluation begins by creating segments to be studied, such as existing railroad divisions. The THIRA creates a catalog of hazards that exist in the division to be studied, using open-source materials like THIRA documents from cities and counties in the division and National Weather Service reports. Each threat is analyzed for the railroad's level of vulnerability to an event and the likelihood of its occurrence. Detailed information on creating the THIRA is available in the guide.

To help staff who are creating the THIRA better understand types of hazards, several video interviews with subject matter experts are also provided. There are question and answer interviews that focus on specific issues, and discussion-based videos that include wider conversations about issues related to railroad planning for extreme events.

4. Address the Problem: Creating an Emergency Operations Plan for Extreme Events

Once the THIRA has been completed, the information developed about types of hazards and their risks allows the organization to create an update to the existing emergency plan to address the changing or new potential events. The guide for updating an Emergency Operations Plan (EOP) offers step-by-step instruction for creating an emergency planning team, and a planning process to use, concluding with a strategy for an EOP update focused on extreme events.

One strategy suggested for the update is the creation of annexes to the plan with specific guidance for anticipated extreme events. A template for creating such an annex is provided, along with an example of such an annex.

Public safety personnel are required to use the National Incident Management System (NIMS) when they respond to emergencies that involve more than two jurisdictions or multiple professions. This response is based on ICS. Using ICS in the development of the EOP is discussed, along with suggestions for incorporating ICS into railroad operations.

A PowerPoint show with script (accessed through the Notes Pages function) is provided to allow an emergency management leader to introduce the planning team to the emergency planning concepts in the guide. This introduction will enable the team members to follow the guide more easily. Topics covered include risk assessment strategies that can be incorporated into the plan, steps in emergency planning, sections of the plan, and guidance for amending the existing plan to anticipate developing threats and hazards, and to incorporate ICS terminology to enhance cross-discipline emergency response.

Videos of interviews and discussions of elements useful for emergency planning are also provided, featuring subject matter experts.

5. Incident Command System and Extreme Weather on the Railroad

Having introduced the concepts of ICS in the planning guide, the ICS guide provides a comprehensive set of training materials for use with railroad personnel. The collection of materials for Rules Instructors to use begins with the presentation of critical information on best practices and useful initiatives related to rail hazards associated with extreme events in North America. This survey of past events and current practices is intended to help North America's railroads prepare their personnel, equipment, and infrastructure for extreme weather events. It shows how ICS for extreme weather events builds on the existing ICS guidance for hazardous materials events. This research builds on this existing training by adding the hazards caused by extreme weather to those that relate to safety and security, as well as preparedness and response strategies to cope with the hazards.

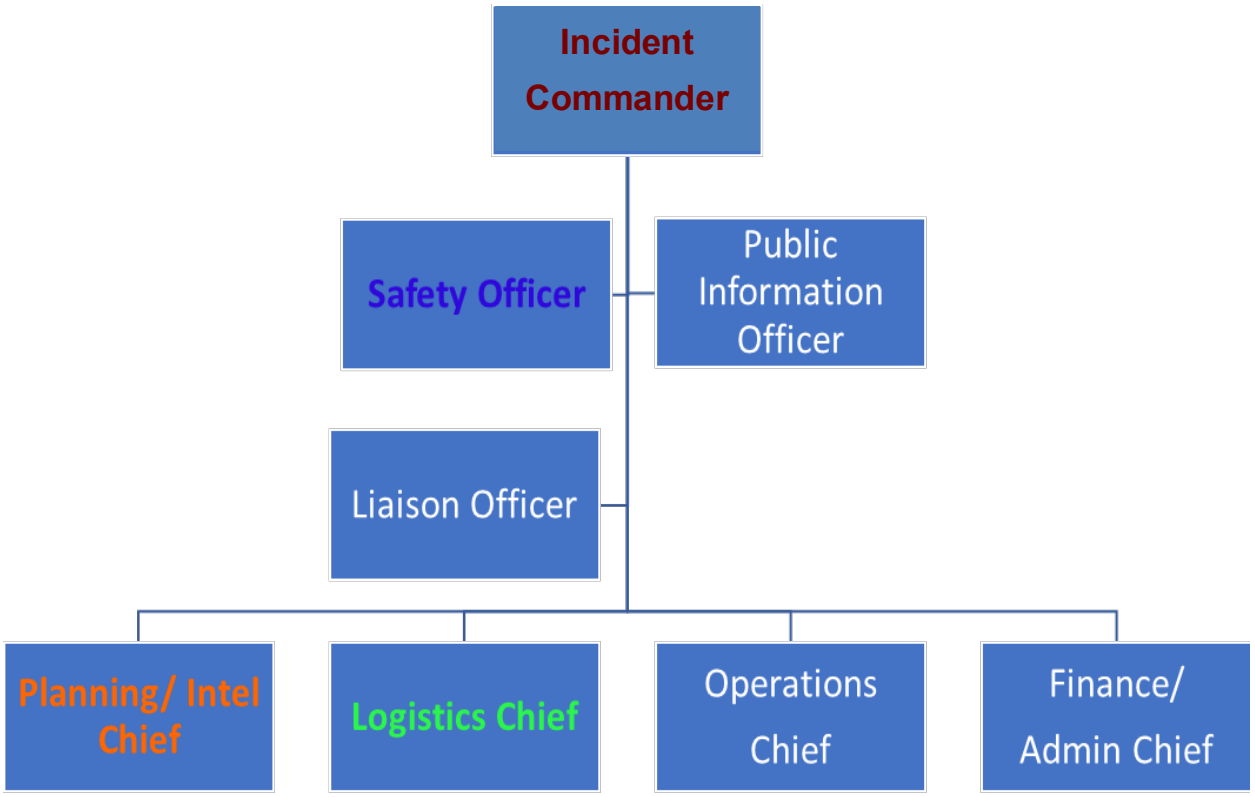

Figure 4. Incident Command System

Field Personnel Respond: Incident Command System (ICS) for Extreme Events on the Railroad provides information necessary for Rules Instructors to understand the impacts of extreme weather so that they can effectively deliver the ICS training to railroad personnel. After describing the impacts of various hazards on the railroad, the essay gives an overview of the roles in ICS that rail personnel might play.

Following this informational essay, there are ICS training guides and materials. The Rules Instructor's Guide Part 1 is a PowerPoint show and script that introduces ICS, the role of railroad personnel in emergency management, and the ICS training. The instruction uses railroad-specific training, with illustrations and examples drawn from real railroad events. It clearly details the specific ICS roles that railroad personnel might take during an extreme event.

Next an Acronym and Glossary list is provided. This document contains a complete and thorough glossary and explanation of acronyms used in the Planning, Training, and Exercising for Crisis Events on the Railroad and ICS documents and slides, including terms such as "action plan," "Multi-Agency Coordination System," "fusion center," and others. A Sources Consulted list contains a full list of all the resources used for all Incident Command System on the Railroad content.

The next segment provides some flyers that will help railroad personnel prepare for emergencies. These documents serve as guides to create comprehensive emergency kits. They provide overviews as well as details (e.g., how much water per person) for what items to include in a car or professional kit to help keep staff safe during an emergency. Such kits are critical for those responding during a disaster as part of an ICS system.

For most railroad personnel ICS will be a seldom-used skill that requires periodic refreshing. One form of refresher training is used during morning meetings when there are facilities to display a PowerPoint. Examples of such training topics are provided, with questions and answers available to the instructor. Example topics include safety in the ICS and collaboration with other organizations. These can be modified for the railroad organization to make the examples more specific. They can also be used as examples for the instructors to follow to create their own more appropriate refresher trainings.

Sometimes refresher training has to be delivered as a discussion without audio visual support, such as during "tailgate meetings" in the outdoors. The examples provided for discussion-only training include a scenario followed by questions to be asked of the students, with suggestions for student responses for the instructor. The goal is to get the students to think about how they would use ICS during a response.

Rules Instructor's Guide Part Two explains how to create supporting materials for ICS. This slide deck contains the second part of the instructor guide and script, focusing on building the ICS kit, including the supervisor's folder. The supervisor's folder contains the ICS forms used most often, the ICS Field Operations Guide (FOG) for detailed instructions, and the Quick Start Cards that provide detailed guidance for the first 15 minutes after arriving at an emergency. The first segment of the Guide Part Two explains how to create an inexpensive supervisor's folder and components that support field staff in carrying out their duties and documenting their actions on ICS forms. Step-by-step instructions for kit creation and illustrations of the activities are provided. A materials list is included that has suggestions for sources of the laminate material for the cards and sleeves for the ICS forms needed to create the folders. Commonly used ICS forms are provided for easy downloading.

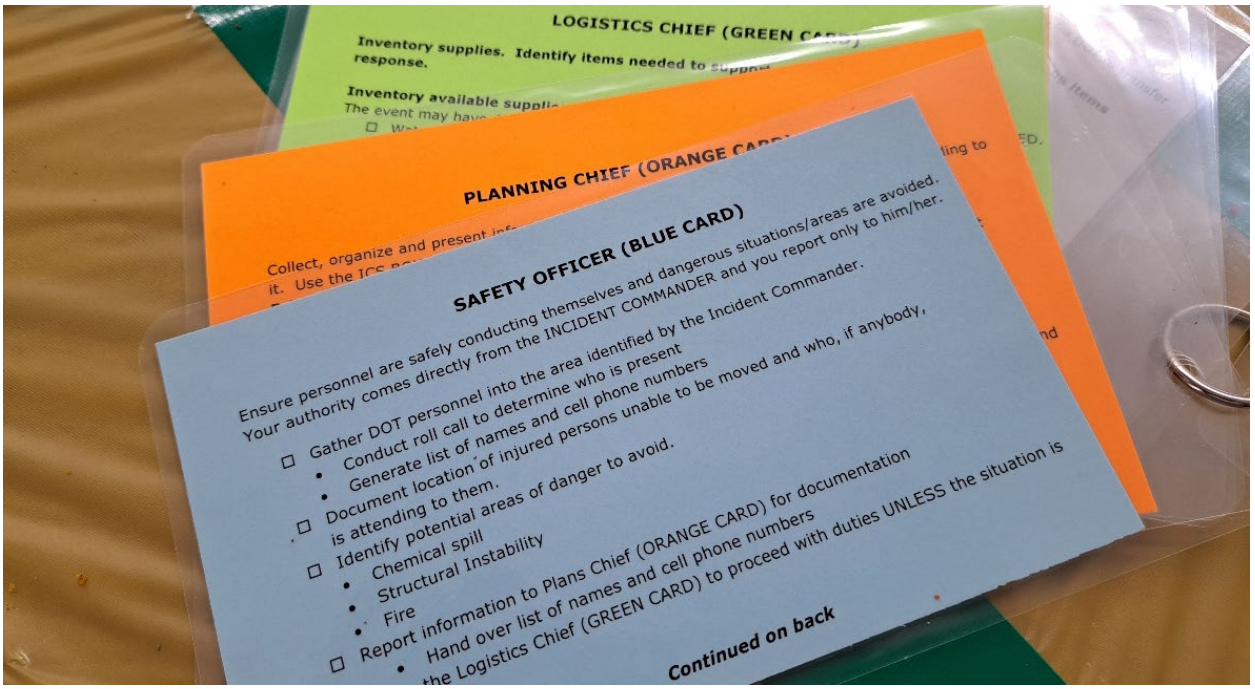

Figure 5. ICS Quick Start Cards
Source: F. Edwards

The Quick Start Cards document contains the Word versions to be used in the creation of the Quick Start Cards (also known as quick reference cards) that contain critical guidance for the first fifteen minutes after arriving at an emergency. The Word format enables the railroad staff to modify the cards for their specific organizational plans. Instructions for creating the Quick Start Cards sets can be found in the Instructor Guide Part Two.

Rules Instructor's Guide Part Three provides some specific guidance for potential instructors. It also mentions the need for refreshers for field staff, since ICS will be a seldom-used skill for most railroad personnel. It ends by reminding instructors that adults remember best what they see, hear, and do, making exercises an important part of long-term learning.

The Rules Instructor Information document includes a detailed guide to creating the items in the ICS kit. Videos of instructions are also provided through URLs. This document contains important information for instructors, including explanation and resources regarding quick start cards supplies and equipment, supervisor's folder materials and instructions for construction, directions for the supplies pack, and several other resources (e.g., images to guide construction of folder, and links to download the printable FEMA ICS Field Operations Guide).

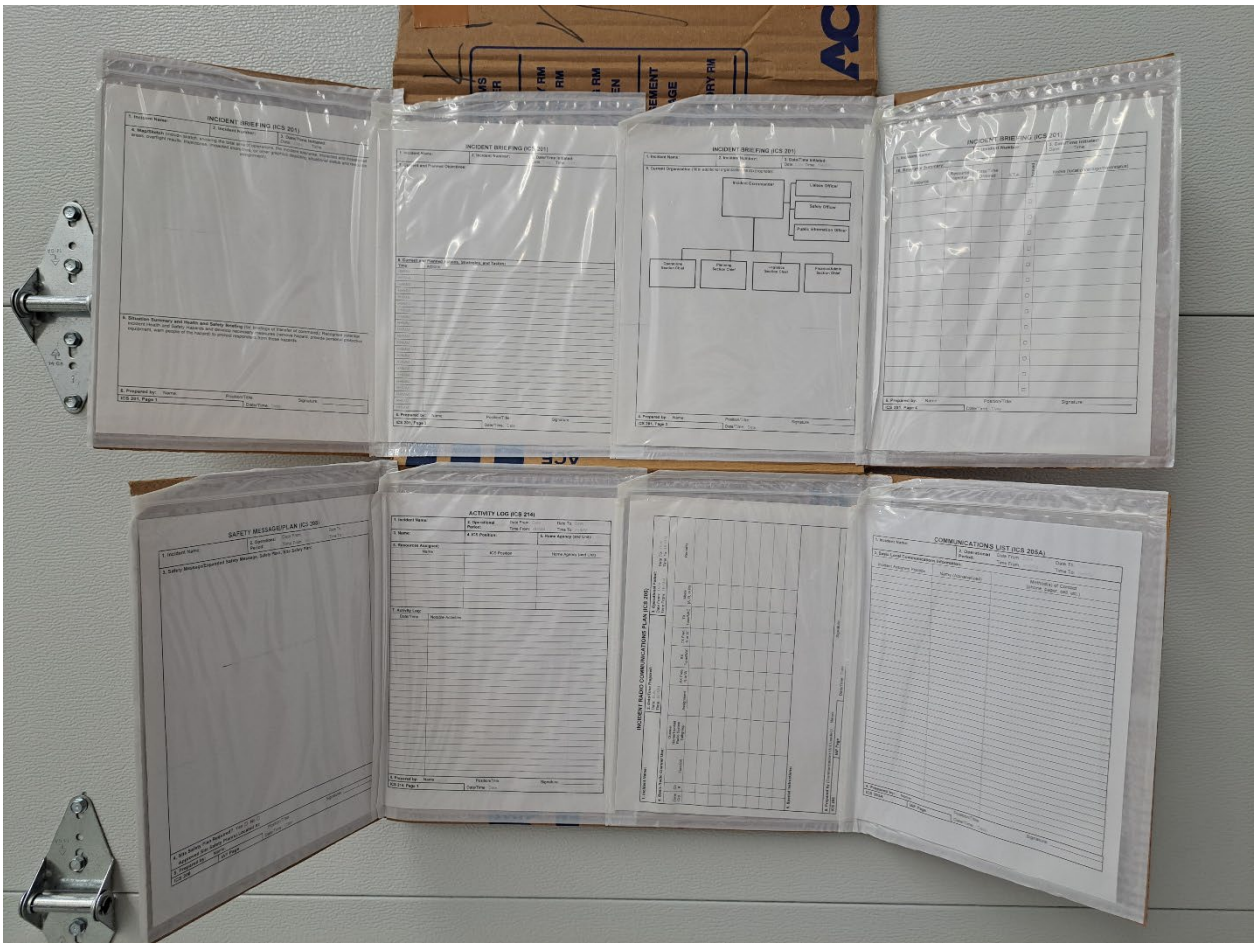

Figure 6. Supervisor's Folder Open with ICS Forms in Sleeves
Source: F. Edwards

Finally, an essay on adult learning is provided. This document offers guidance and resources on training adult learners to use the ICS for crisis events on the railroad, and tips for holding adult learner interest, such as including small vehicles and buildings on the sand table, and group participation in the training.

A second version of the instructional information is provided for students. It includes most of the instructional items in the Rules Instructor Guide selections, but not the detailed instructions for creating the supervisors' kits, or the guides for instructional activities. Instructors can manage the materials to include organization-specific elements as desired.

A third element is a set of videos by a subject matter expert that provides brief examples of ICS usage by Amtrak during real events.

6. Managerial Personnel Respond: Augment the Emergency Operations Center for Extreme Events

Preparing an EOC for the railroad—and preparing to join a regional response to wildfires, hurricanes, tornadoes, floods, and other extreme events—is good risk management. After creating a THIRA, then developing an EOP to guide the management of an extreme event, and training personnel on using ICS in the emergency response, the EOC should be reviewed to ensure that the personnel, supplies, and equipment are appropriate for the anticipated hazards.

Railroads have had "war rooms" for 150 years. This facility allows the leadership to gather to inventory resources and create response plans. More recently ICS has been incorporated into the "war room" when a hazardous materials response is underway. This guide introduces the reader to the concept of the "war room" as an EOC to be used for other types of emergencies, such as weather-related extreme events.

Figure 7. EOC by ICS Roles
Source: F. Edwards

It describes the way that normal emergencies are managed, then discusses the management of extreme events in the EOC, using ICS as an organizational mechanism. It then addresses the specific concerns of railroad emergency managers during extreme events.

Photos and examples of real events help illustrate the importance of preparing for emergency response. The guide describes some of the specific upgrades that may be needed to respond, such as geographical information systems (GIS) mapping and close coordination with local governments. The guide closes by describing the types of facilities that might be used as EOCs, from the boss's office to a specially built room. This section includes an overview of the EOC positions that are needed for each kind of facility. In the suggested structure they all align with

the ICS counterparts. Case studies include normal emergencies, as well as Hurricane Helene as an extreme event that destroyed hundreds of miles of rail.

In addition to the guide a PowerPoint show with script is provided. It serves as an introduction to the roles of EOCs and incident command posts (ICPs). It is illustrated with railroad EOC facilities and first responder ICPs. It briefly reviews ICS and the railroad, and the challenges of extreme events that require a reevaluation of current EOC designs. This lays the groundwork for fruitful discussions of developing new elements in the EOC for extreme event response.

Attached to the EOC homepage are videos where subject matter experts comment briefly on railroad war rooms and their roles.

7. Practice Responses to Extreme Events on the Railroad: Exercises of the Plans, Facilities, and Training

Once the plans have been made, the personnel trained and the EOC prepared, it is important to determine whether these steps have been effective. Exercises of the plans and facilities enable the railroad organization to assess the completeness of the plans, training, and facilities. The fifth set of materials in this series provides guidance for the development and conduct of discussion-based exercises.

Figure 8. Tabletop Exercise
Source: F. Edwards

The guide provides an overview of types of exercises and their benefits. It then gives detailed instructions for developing the discussion-based exercises that are part of the Homeland Security Exercise and Evaluation Program (HSEEP), as well as a facilitated exercise format that was developed by Dan Goodrich. It provides a discussion of exercise components and how to establish the exercise's purpose and goals.

The next section of the guide provides scenarios and case studies that can be used as the basis for an exercise. These can serve as direct guides, or as examples that the exercise designers can use to develop a scenario that is more appropriate to their organization's needs and circumstances. It is very important to have a realistic scenario as the basis for the exercise so the participants take the work seriously.

The next section is the exercise checklists. The checklists are designed using the project management system, which is familiar to many people working in construction and engineer roles. For each type of exercise there is a set of checklists starting with initiation, then planning, executing, controlling, and closing processes. These checklists are intended as a guide to the exercise development, and may be modified by each organization to meet its needs.

The first attachment is an example Master Sequence of Events List (MSEL) that can serve as a model for any type of discussion-based exercise. The exercise designers can adapt the MSEL format to the scenario that they have developed.

The second attachment is an example of a Learning Station Guide for the facilitators to follow when delivering the on-site orientation to the participants. Each learning station has respected professionals from within the organization who will teach critical information, then allow the group of participants to develop an appropriate plan of action for that learning station that is safe and effective. Discussion continues until the facilitator is satisfied with the response plan. Only then are participants allowed to enact the response plan.

Figure 9. Learning Station at a Facilitated Exercise: Hazmat and Explosives
Source: F. Edwards

The EOC website includes the exercise guide and downloadable versions of the checklists and the two attachments. Four instructional videos teach how to create a sand table exercise in steps. The first video is a wildland fire scenario narrated with photos to help participants envision the event. It can be used as the introduction to a sand table exercise, or as an example of how a scenario can be developed and delivered by the exercise director.

Next is a photo montage of a wildland fire scenario being set up on a model railroad platform for the sand table exercise. It shows the development of each element of the scenario, such as the forest, river, roads, and small vehicles. Next is a discussion about how a sand table exercise is developed, with details about developing the setup. Next there is an example of a sand table exercise of the ICS, with participants each holding an ICS role and discussing how their role would relate to the activities needed to resolve the scenario. This is followed by another version of an ICS exercise with each participant having the same role, and presenting their proposed actions from different perspectives.

Figure 10. Sand Table Setup
Source: F. Edwards

Finally, there is a video of some of the learning stations at a facilitated exercise to demonstrate how the instructors present critical information to the group of first responders who are learning about safe operation on the railroad.

Figure 11. Union Pacific Supervisor Explains the Electrical System of a Train to First Responders

Source: F. Edwards

The guide, checklists, and videos will prepare railroad emergency management staff to develop exercises that will enable railroad personnel to envision and act out how they will need to respond to a real extreme event. It would be beneficial to include first responders, utility representatives, and others who would interact with railroad personnel during emergencies. Meeting each other and jointly discussing the expected responses will help to reassure participants of their ability to work collaboratively, follow the emergency plans, use the provided facilities, and enact their training. It also offers the opportunity to critique the plans, facilities, and training in the after-action meeting, and to create an improvement matrix to address any deficiencies and provide a timeline for the needed changes.

Exercises provide the ability to tie together the planning and training that has been done, to assure that the railroad organization is ready for the next extreme event.

About the Authors

Frances L. Edwards, MUP, PhD, CEM

Frances L. Edwards, MUP, PhD, CEM, is the Deputy Director of the Mineta Transportation Institute's Allied Telesis National Transportation Security Center, Professor Emerita in the San José State University Political Science Department, and an instructor in the Master of Science in Transportation Management program at the SJSU Lucas College and Graduate School of Business.

Daniel C. Goodrich, MPA, CEM, MEP

Daniel C. Goodrich, MPA, CEM, MEP, is the Senior Transportation Security Scientist for the Mineta Transportation Institute and an instructor in the Master of Science in Transportation Management program at the SJSU Lucas College and Graduate School of Business