POLICY BRIEF

Institute of Transportation Studies | UNIVERSITY OF CALIFORNIA

When Seconds Count: Protecting Airports with Earthquake Early Warning Systems

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University of California, Berkeley

August 2026

Issue

Airports play a critical role in emergency response and disaster recovery, yet are highly vulnerable to earthquakes. Past earthquakes in California, including the 1989 Loma Prieta, 1994 Northridge, and 2014 South Napa events, caused infrastructure damage, power outages, and operational delays at airports, affecting both safety and mobility. As seismic risk remains high across the state, improving airport resilience is critical to maintaining transportation access and supporting emergency operations.

Earthquake Early Warning (EEW) systems offer a way to reduce these risks by providing seconds to tens of seconds of advance notice before strong shaking begins. While this technology has been around for several decades across the world, the development of the ShakeAlert system has brought it to the West Coast recently, giving airports in the region the chance to be early adopters of the technology in the United States. To better understand how EEW could be used in airport settings, we examined its operational applications, benefits, and implementation challenges across different types of airports.

Key Research Findings

EEW can support immediate protective actions that improve safety. Alerts can give airport staff and passengers time to take protective actions such as "Drop, Cover, Hold On", while also enabling air traffic control to warn pilots on final approach, pause aircraft ground movement, and other actions. Appropriate thresholds for responses based on earthquake shaking intensity can be based on individual airport needs, benefits, and costs.

Automated responses can reduce damage and improve speed recovery. EEW systems can be linked to automated actions such as initiating backup power, stopping elevators, opening fire station doors shutting off fuel and gas valves, stopping baggage systems, or opening doors to prevent jamming. These actions can help prevent potential flooding, fires, and physical damage, while allowing emergency responders to act more quickly after an earthquake.

EEW can be adapted to airports of different sizes and needs. Our findings show that EEW can work for both small regional airports (e.g., Palm Springs (PSP)) and large international hubs (e.g., Los Angeles (LAX)). Automated EEW responses can vary widely in implementation cost and logistical complexity depending on the system they are applied to. Actions can be as simple as turning off a valve to as complex as initiating coordinated electrical system back-ups across airport facilities. Smaller airports can focus on lower-cost actions that address their most critical vulnerabilities, while larger airports may need to coordinate EEW actions across multiple systems in the airport to protect infrastructure and support airport-wide operations.

Implementation will require system upgrades and integration across existing airport operations. Airports often operate with a mix of modern and legacy systems. Incorporating EEW into existing emergency management, communications, and operational control systems can be complex. Ensuring that EEW alerts seamlessly trigger automated responses may require hardware and software updates. Additionally, legacy infrastructure may need to be upgraded to support real-time data processing and secure communication.

EEW performance varies, requiring careful calibration and realistic expectations. While EEW systems offer valuable lead time, their performance has some limitations. In areas with sparse seismic sensor coverage, warning times may be reduced and the accuracy of magnitude or location estimates can be compromised. Airports located very close to potential fault lines might receive little to no warning in some cases. False alerts or misestimates of earthquake parameters can lead to either unnecessary disruptions or inadequate warning time. These risks can be reduced by using appropriate shaking intensity thresholds for different actions.

Upfront and ongoing costs may be a barrier, especially for smaller airports. Integrating alert mechanisms and automating infrastructure responses could require notable investment. Aside from hardware costs, there are recurring expenses associated with system upkeep, software updates, cybersecurity measures, and regular staff training to ensure proper use during emergencies. Balancing these costs with other operational priorities can be challenging.

Cybersecurity is essential to maintaining trust and system reliability. Because EEW systems may trigger automated operational responses, they must be protected from cyber threats. A compromised system could disable warnings or trigger false alerts, creating safety risks and undermining confidence in the system.

Clear standards and coordination are needed across agencies and jurisdictions. EEW systems must be compatible with Federal Aviation Administration regulations as well as local and state emergency management standards. Consistency in alert thresholds, communication protocols, and response actions will be important to ensure coordinated responses across airports and regions.

Training and coordination determine whether EEW is effective in practice. Successful implementation depends on how well airport management, air traffic controllers, emergency responders, and local authorities understand and act on alerts. Clear roles, established communication channels, and regular training are needed to ensure coordinated and timely responses during an event. Existing emergency response procedures may also need to be updated to support cross-departmental collaboration.

Policy Considerations

Our research suggests that EEW systems could play a valuable role in strengthening airport resilience, but their success will depend on thoughtful implementation.

In the short term, policymakers may consider advancing initial adoption of EEW through targeted funding strategies to help airports upgrade legacy systems and implement automated response mechanisms and provide for continuous maintenance, periodic upgrades, and cybersecurity enhancements. In addition, agencies may benefit from investing in regular training and preparedness drills for all stakeholders—from airport staff and air traffic controllers to emergency responders—and gather feedback from system users and stakeholders after drills or actual events to support continuous improvement. Specifically, the Governor's Office of Emergency Services should consider partnering with early adopters, providing technical and/or financial support while carefully documenting the implementation experience so that it can be shared with other airports.

In the medium to long term, agencies may also want to consider using knowledge gained from early adopters in supporting interoperability and standardization, ensuring EEW systems align with aviation and emergency management requirements across local, state, and federal levels.

More Information

This policy brief is drawn from the research project "Feasibility Study on the Implementation of Earthquake Early Warning in Airports". The project information can be found here: www.ucits.org/projects/2024-53. For more information, please contact Mark Hansen at mhansen@ce.berkeley.edu.

Research presented in this policy brief was made possible through the Resilient and Innovative Mobility Initiative (RIMI) led by the UC Institute of Transportation Studies (UC ITS). RIMI is supported by the State of California through a one-time allocation in the 2021 State Budget Act. The UC ITS created RIMI as a living laboratory – bringing together university experts, policymakers, public agencies, industry stakeholders, and community leaders – to inform the state transportation system's immediate COVID-19 response and recovery needs, while establishing a long-term vision and pathway for directing innovative mobility to develop sustainable and resilient transportation in California. Established by the California Legislature in 1947, the UC ITS has branches at UC Berkeley, UC Davis, UC Irvine, and UCLA.

Project ID UC-ITS-2024-53 | DOI: 10.7922/G2PZ576N