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EERI Policy Position

A comprehensive Earthquake Early Warning (EEW) system should be developed and deployed in areas of high earthquake risk in the United States. EEW can save lives and reduce property damage but requires an urgent, substantial and long-term commitment and investment in the scientific basis, physical infrastructure, information technology, delivery systems and user training to support its widest possible beneficial and equitable use.

Background:

Earthquakes are a significant threat to the people, infrastructure and economy of the United States. About half of the US population lives in zones of moderate to high earthquake risk, from the West Coast, Alaska and Hawaii to the Midwest and East Coast. In our nation's history, quakes have resulted in loss of life, injury, property damage, and economic losses in the billions. Annual expected loss to the nation from building damage alone is estimated at $6.1 billion per year, on par with the level of losses from floods and hurricanes (FEMA, 2017).

More potentially devastating earthquakes will happen. For instance, it is almost guaranteed that there will be a severe earthquake somewhere in California within the next 30 years (Field et al., 2013). In an event of this scale in a large urban area, deaths may be in the thousands while economic losses will be hundreds of billions of dollars. For example, an analysis of a major Los Angeles region event estimates a total financial impact of about $213 billion with approximately 1,800 fatalities (Jones and Benthien, 2011). The potential also exists for catastrophic unpredictable consequences such as tsunami and nuclear reactor leaks as occurred in Japan in 2011.

Earthquake Early Warning (EEW) holds great promise to reduce the harm that future earthquakes will do in the US. EEW works by processing information from a network of ground movement sensors. With real-time analysis, EEW can provide seconds to tens of seconds of warning of incoming, potentially damaging shaking. Information communicated through an EEW system has the potential to protect lives, reduce damages, economic disruption and business downtime, and even lessen psychological trauma. This is true not just in one quake, but from every subsequent quake once the system is established, with the potential for greater warning effectiveness over time as technology and understanding advance.

Scientific understanding and technical capabilities exist to deliver useful Earthquake Early Warnings in the United States. A prototype version of an EEW system, known as ShakeAlert, has been in operation in California for years (USGS, 2019). Users such as the Bay Area Rapid Transit (BART) can use EEW information to slow trains in advance of the shaking to avoid injuries and damage. ShakeAlert is currently operational or in development for the three western states of California, Oregon, and Washington, in partnership with academic, philanthropic, state, and federal entities. Analysis is needed to determine where and how expansion of the system to other high earthquake risk areas and for wider purposes is feasible and cost-effective.

In order to make EEW as accurate and fast as possible and to spread its benefits to all high earthquake risk areas of the US, more seismic monitoring stations are needed. The Advanced National Seismic System, ANSS, is a well-developed network that currently operates over 3,000 stations. Still, ANSS does not yet cover all US areas with significant risks to the degree needed for EEW, and the quality of the information and speed of alerts increases with more sensors in the network. An assessment of critical needs and priorities for improving the system was completed in 2017 (USGS, 2017).

EEW system development requires coordination and leadership on a national scale, because earthquake risk is a national problem that needs a coherent, equitable response. Delivery technologies likely to be involved are primarily regulated at the federal scale. Warning information and messaging provided by EEW systems should be consistent and distributed as widely as possible. So far, other nations have led the way. EEW systems are operational in at least five countries: Japan, Mexico, Romania, Taiwan, and Turkey, and in development in several others such as Israel.

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Earthquake Early Warning system development should take place in an integrated manner with other national risk management and public communications efforts. There is high potential to incorporate earthquake warning and response information within existing and evolving multi-hazard communication and response frameworks. Plans exist to make both Integrated Public Alert and Warning (IPAWS) and Wireless Emergency Alert (WEA) systems and smart phone apps suitable for ShakeAlerts.

As for its uses and benefits, even seconds of warning can protect safety, property and societal functions in a wide variety of ways. A 2016 study commissioned by the California Office of Emergency Services and Seismic Safety Commission (CalOES et al., 2016) — with input from experts in eleven different sectors of the economy— identified 14 categories of potential uses including:

- Notification for Occupational Safety (e.g., stop work order, personnel movement to safer location)
- Mass notification for Public Safety in Specific Facilities (e.g., sports arena, hospital, school siren)
- Broadcast Notification for General Public Safety (e.g., smartphone alert, outdoor siren)
- Activation of Emergency Response Plans and Situational Assessment (e.g., improve speed and precision of predicted impacts, trouble spots and response needs)
- Large-Scale Utility Control (e.g., power down an electricity grid section)
- On-Site (Facility) Utility Control (e.g., generator plant power down, faster startup of back-up generators in hospitals)
- High-Speed Mass Vehicle Control (e.g., decrease train speed)
- Low-Speed Mass Vehicle Control (e.g., slow or re-route commuter transit)
- Independent Vehicle Control (e.g., driver alerts)
- Industrial Equipment, Asset Protection, and Process Control (e.g., assembly line slowdown, inventory lockdown)
- Industrial Chemical Control (e.g., valve shutoff)
- Commercial Equipment, Asset, and Process Control (e.g., slow amusement park ride, turn off gas in restaurants)
- Large-Scale Access Control (e.g., restrict bridge or airport traffic)
- On-Site Access Control (e.g., security doors, auto-open fire station doors)

Among the many potential EEW applications and benefit pathways, some are readily implement-able while others will require further behavioral research, industry collaboration, and/or technology development to be feasible and effective. Some have potential for automation while others will depend on human training and response. Ultimately, different regions and sectors of the nation's economy and infrastructure operators will be able to innovate to make concrete use of EEW information in different ways. Community leaders and stakeholders need a voice in how the system is developed and deployed.

Actions Needed

EERI advocates building on the US's current EEW capabilities to create a comprehensive, end-to-end system that integrates efforts at the federal, state and local level, across sectors, and among the many disciplines necessary to ensure an effective system. To achieve this, the following important and urgent steps need to be taken:

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1. **Increase investment in the scientific infrastructure for detection and analysis of ground movement.** EEW depends on there being numerous instruments in a region in order to detect the start of rupture and for interpreting the detected information. Instrument arrays and information transmission infrastructure need to be expanded to include all earthquake-vulnerable states (Given et al., 2018). The USGS and other agencies should be generously funded to aggressively deploy more monitoring instruments to create denser networks and develop the capability to process and interpret detected signals translate them into actionable information.

2. **Increase investment and coordination among the social- and operational- behavior, human-technology interaction, ergonomics, information technology, and engineering research to support creation of effective message formats, content, delivery modes and procedures.** Many possibilities exist for transmitting earthquake shaking information, each with their advantages and challenges. Many more EEW applications may yet be invented that we cannot now even imagine. Specific contexts and scenarios need to be studied in order to cultivate precise ways for EEW information to be communicated, to whom, why and how. This is important not just to maximize EEW benefits, but also to minimize potential concerns such as losses or injury due to false or misleading alarms, human or mechanical errors, and equitable access.

   There is potential to allow warning messages to be person- and situation- specific, literally tailored to a person's moment by moment location, surroundings, mobility and responsibilities. However, necessary understanding does not yet exist for this type of customization, such as knowledge of what is the best action to take and how to quickly communicate that action in the most comprehensible fashion. Study of EEW in past quakes, for instance during the Puebla Mexico earthquake in September 2017, shows that further research is needed on buildings, contents and industrial seismic hazards, and social, biological and behavioral factors that govern human response (Allen et al., 2018) Engineering and social science research should be generously funded in order to aggressively develop the knowledge and methods for effective warning messages.

3. **Build the communications infrastructure necessary to deliver fast, reliable EEW information.** Smartphone messages are one of the most promising communication modes, and could potentially be customized to the receiver's location, mobility and needs. However, cellular network industry-wide standards and cooperation will be essential to realization of public broadcast EEW (ATIS, 2015). The cellular industry should be strongly encouraged to pursue this capability as a public service, perhaps through mechanisms such as tax incentives for conducting relevant research and development. Public annunciators can be tailored to a structure's structural performance, room contents and exit locations. Sirens and broadcast messages reach more people – even though a very general message, such transmissions can still be enhanced with location- specific placarding. Another need is the development of transportation and industrial process- specific equipment, protocols, and procedures that will permit automated or manual safe slow- or shut- down or quick reconfiguration given a warning.

4. **Involve, educate and train users on what to do**. Knowing that earthquake shaking is about to occur is not enough – people need to know what to do and be prepared to act given only a few seconds to protect themselves and others. Further complicating this, the appropriate actions may depend on context—where a person is, what they are near, and what their capabilities and responsibilities are (GHI, 2015). User and use-specific public education campaigns, curriculums, training, practice drills and the like may need to be developed and regularly administered. This could be particularly valuable if adopted as part of the culture in public and private schools and other large businesses, agencies and organizations.

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5. **Lay an inclusive, clear, and durable foundation for the system in terms of governance, funding, policy and legal structure.** Beyond the initial cooperation and effort necessary to establish a national EEW system, it will also need to be maintained, refined and improved over time. Creation of a system may create new legal issues, insurance and risk exposure concerns, organizational arrangements and obligations, which should be addressed in legislation. Reauthorize and appropriately fund the National Earthquake Hazards Reduction Program (NHERP), given its potential to guide the kind of coordination needed for an effective, wide reaching EEW. Federal funding commitments are important in order to leverage the resources already devoted to EEW by states, universities and public and private partners.

6. **Encourage sustained scientific and international partnerships for shared learning.** As the US develops its EEW capabilities, it should strive to learn from the experiences and activities of other countries, as well as sharing what we're learning. The US. should work to expand global EEW capabilities through international partnerships (e.g., USAID, OFDA, USGS, the Peace Corps and other channels) in order to help the benefits of EEW extend to even more people and nations.

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Note: First Draft submitted 2 December 2015 by Charles Scawthorn, reviewed by ShakeAlert's Education, Training and Communications committee.