California Earthquake Early Warning System

Frequently Asked Questions
(Sources: CalOES, CISN and USGS)

What is earthquake early warning?

Although no one can reliably predict earthquakes, the technology exists to rapidly detect seismic waves as an earthquake happens, calculate the maximum expected shaking, and send alerts to surrounding communities before damaging shaking arrives; this is Earthquake Early Warning.

Why do we need Earthquake Early Warning?

Timely warnings of an earthquake could provide seconds to nearly a minute to take protective action such as taking cover in safe locations, stopping elevators and opening doors at the nearest floor, or automatically stopping critical processes to mitigate damages or to enhance public safety.

Several countries, including Japan and Mexico, have existing earthquake early-warning systems. In Japan, **i**nformation is transmitted to the public through a variety of mechanisms, including television and radio broadcasts, computer pop-ups featuring real-time maps showing the location of the epicenter and radiating seismic waves and text-style messages accompanied by an audible alert sent to cell phone users.

What are the benefits of earthquake early warning?

Scientists cannot predict earthquakes, but rapid alerts sent to government officials, first responders and the public about a potentially damaging earthquake could reduce deaths, injuries and property losses.

Timely warnings that a major earthquake is occurring could provide a few seconds to up to two minutes depending on the size of the earthquake and your distance from the epicenter. That is enough time for students, commuters, workers and others to take protective action:

- **Public:** Allow citizens, including school children, to drop, cover, and hold on; turn off stoves, safely stop vehicles.

- **Medical Services:** Allow surgeons, dentists, and others to stop delicate procedures.

- **Emergency Services:** Open firehouse doors, allow personnel to prepare and prioritize response decisions.

- **Businesses and Construction:** Enable personnel to move to safe locations. Elevators could be programmed to stop and open their doors at the nearest floor when an earthquake warning is received could prevent occupants from being stranded. Sensitive equipment could be placed in a safe mode. Chemicals and other hazardous materials could be secured. Production lines could be shut to reduce damage.

- **Transportation:** Automatically trigger the slowing or stopping of trains to avoid derailing. Clear bridge traffic. Inbound aircraft could be automatically advised to divert to other airports.

- **Power Infrastructure:** Help electrical generation facilities to prepare for strong shaking and protect the grid.

What are the probabilities of an earthquake in California?

In 2008, the Working Group on California Earthquake Probabilities published the *Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2).* Within this document, scientists conclude it is certain that another major earthquake will occur in California in the coming years.

- **Magnitude 6.7 Event Statewide:** Scientists estimate that the probability of at least one magnitude 6.7 earthquakes somewhere in California within the next 30 years at more than 99 percent. The likelihood of such a quake in the Los Angeles region is estimated to be 67 percent. In the San Francisco Bay Area, the likelihood is estimated to be 63 percent.

- **Magnitude 7.5 Event Statewide:** Scientists also estimated the probability of a magnitude 7.5 quake somewhere in California over the next 30 years at 46 percent. The 30-year probability of a M7.0 earthquake in Southern California is 82 percent and the probability of a M7.5 earthquake is 37 percent. The 30-year probability of a M7.0 earthquake in Northern California at 68 percent and the probability of a M7.5 at 15 percent.

How does Earthquake Early Warning work?

The objective of earthquake early warning is to rapidly detect the initiation of an earthquake, estimate the level of ground shaking to be expected, and issue a warning before significant ground shaking starts. This can be done by detecting the first energy to radiate from an earthquake, the P-wave energy, which rarely causes damage. Using P-wave information, we first estimate the location and the magnitude of the earthquake. We use this to estimate the anticipated ground shaking across the region to be affected. The method can provide warning before the S-wave, which brings the strong shaking that usually causes most of the damage, arrives.

What determines warning time?

Earthquake early warning can provide seconds to minutes of warning before strong shaking arrives. The amount of warning time depends on the speed of the system and your distance from the event. The speed of the system relies on a dense network to ensure enough sensors are near all possible earthquake sources. A dense network especially helps reduce the "blind zone," within which warning is not possible because the earthquake source is too close for an alert to outpace the seismic waves. To maximize warning time, efforts will need to focus on minimizing delays in data processing and communication, and delivery of alerts.

What is needed for successful early warning?

The ability to send warning before shaking waves arrive depends on:

- A network of sensors that are densely spaced and close to faults
- Quick, robust telecommunication from sensors
- Computer algorithms for fast evaluation of earthquakes (location, magnitude, potential continued propagation)
- Quick reliable mass notifications
- End user education

What technologies already exist to support earthquake early warning?

California has the foundation for an early warning system through the California Integrated Seismic Network (CISN). CISN is a partnership among Cal OES, the California Geological Survey, the United States Geological Survey, the Caltech Seismological Laboratory and Berkeley Seismological Laboratory, with support from several contributing agencies and organizations. Using real-time information gathered by a network composed of nearly 1,000 seismic stations in Southern and Northern California, CISN provides real-time information to develop maps and other products to help emergency managers deploy resources to help protect lives and property in the areas hardest hit and rapidly determine the magnitude of the damage in order to qualify for federal assistance.

CISN is a partnership among:

- Cal OES
- California Geological Survey
- United States Geological Survey
- California Institute of Technology (Caltech) Seismological Laboratory
- UC Berkeley Seismological Laboratory; and
- Supported by several contributing agencies and organizations.

Another technology to be included in the strategy is the USGS "ShakeAlert" prototype Earthquake Early Warning System, which is currently being tested in California. ShakeAlert is built upon existing technology available through the CISN.

What efforts are underway to implement an earthquake early warning system?

In September 2013, Governor Jerry Brown signed Senate Bill 135 into law. This was a critical step forward in our efforts to provide Californians with enough warning that an earthquake capable of producing intense ground shaking has begun.

Codified as Government Code Section 8587.8, the legislation states that the Cal OES will, in collaboration with the California Institute of Technology (Caltech), the California Geological Survey (CGS), the University of California (UC Berkeley), the United States Geological Survey (USGS), the California Seismic Safety Commission, and other stakeholders, develop a comprehensive statewide earthquake early warning system in California through a public/private partnership.

A major feature of the legislation signed into law by Governor Brown was for California's system to be developed and implemented through a public/private partnership. To accomplish this, by 2016, California must also identify funding for a comprehensive statewide earthquake early warning system other than the State general fund.

Cal OES is tasked with oversight of bringing the seismic early warning system online.

What is the strategy for implementing the system in California?

The state is collaborating with a number of institutions, along with public agencies and the private sector, to assess current capabilities and resources to implement a system specific to California's unique needs.

An earthquake early warning system implementation plan is currently being developed that will describe the system requirements, minimum standards, management structure, cost estimates and funding sources, and public education guidelines. The implementation plan will constitute a detailed pathway to secure the goal of improving public safety and reducing the damage caused by large California earthquakes.

A series of committees are established to develop the plan. They include:

- A ***Steering Committee*** comprised of public and private stakeholders and subject matter experts to review and provide advice on the progress of the other project committees as they work toward meeting the objectives. The steering committee is comprised of the chairs of the five committees and chaired by an executive level member of Cal OES.

- A ***Stakeholder Liaison Group*** to inform and receive input on the development of the CEEWS external stakeholders and potential users of an earthquake early warning system during CEEWS development.

- A ***Funding Options Committee*** will identify costs and options for system funding that do not identify the state General Fund as one of those sources.

- A ***Standards Committee*** will ensure that the system operates in a timely, reliable and efficient manner.

- A ***Model Committee*** will develop a model that represents a public/private partnership that will operate in a cost effective and reliable manner. The Standards Committee and Model Committee are tasked with developing the system description for earthquake early warning in California.

- A ***Management Committee*** will formalize an organizational structure that incorporates existing roles and responsibilities for seismic monitoring in California.

- An ***Education and Training Committee*** will identify the components of a comprehensive training and education program that addresses the needs of all potential users of an earthquake early warning system.

What are the challenges of earthquake early warning?

The proposed system would allow earthquake monitoring equipment to analyze earthquakes as they occur and broadcast signals and warnings to people and equipment. Individuals will need the technology necessary to receive the signal, such access to Emergency Alert System messages or smart phone applications. Business and industry will need to invest in equipment to monitor, receive and control critical operations. A person's distance from the earthquake epicenter will affect how much time they will have to react and take protective actions. People living close to the epicenter might get little or no warning.

How will the system be funded?

Long-term, sustainable funding is needed for the system to become fully operational. The timeframe for implementing a comprehensive earthquake early warning system in California will depend on the discovery of an available funding source.

The United States Geological Survey estimates the cost to construct and operate a fully implemented system on the U.S. west coast at $16 million per year ($12 million per year for a California-only system).

In order to implement the system, a variety of funding alternatives will need to be evaluated including, the long-term viability of grant funding, how the system could benefit from subscription services, how to leverage bond funding, the consideration fees for service, and business and industry sponsorships.

How can I get Earthquake Early Warning alerts?

The public dissemination of earthquake early warning alerts is not part of the current project. There are two main reasons for this. The first is that there are many areas in California where

there are not enough seismic stations to recognize and characterize a newly starting earthquake so quickly that an early warning would be possible. The second reason is that for early warning alerts to be useful, people, companies and institutions must know beforehand what they will do when they receive the information. This is an outreach effort that has not yet been part of the project due to the limited funding currently available.

Eventually, earthquake early warning alerts will arrive by all means possible - through email, applets, radio, and television, and by computer-to-computer messages for automatic control of systems like trains and production facilities.

Where can I obtain more information on earthquake early warning?

www.cisn.org
www.shakealert.org

Summary

We believe a comprehensive earthquake early warning system will reduce the number of emergency services that need to be provided when disaster strikes. The system would be effective to mitigate the damage and losses to property. There is much support for a credible and well-funded earthquake early warning system from both government and the private sector.

California has the infrastructure and basic capabilities to support the development of an earthquake early warning system to enhance public safety in the event of a large earthquake. Such a system should build upon the existing earthquake monitoring framework, including CISN, ShakeMap, ShakeAlert prototype and other disaster assessment tools used by emergency managers.

At the same time, deployment of an earthquake early warning system presents challenges due to the state's vast number of fault zones and infrequent large events. In many areas there is limited sensor density. Other technological challenges include the possibility of missed events due to no receipt of data and false alarms that might lead to public notification when no earthquake has occurred.