Attachment H – California Earthquake Early Warning System (CEEWS)

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, information 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, and production lines could be shut down 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 2013, the Working Group on California Earthquake Probabilities updated estimates of the likelihood that another major earthquake will occur in California in the coming years:

- Magnitude 6.7 Event Statewide (the magnitude of the 1994 Northridge earthquake): The 2015 update of the Uniform California Earthquake Rupture Forecast (UCERF 3*) estimates that the probability of at least one magnitude 6.7 earthquake somewhere in California within the next 30 years at more than 99 percent. The likelihood of an event of this size in southern California is estimated to be at 93 percent. The likelihood of an event of this size in northern California is estimated to be at 95 percent.

- Magnitude 7.5 Event Statewide: The 2015 update of the Uniform California Earthquake Rupture Forecast (UCERF 3*) estimates the probability of at least one magnitude 7.5 event [1]somewhere in California over the next 30 years at 48 percent. The 30 year likelihood of such an event in southern California is 36 percent. The 30 year likelihood of such an event in northern California is 28 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 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 affected region. This 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.

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* UCERF3 (http://www.WGCEP.org/ UCERF3), provides authoritative estimates of the magnitude, location, and likelihood of earthquake fault rupture throughout the state. Overall the results confirm previous findings, but model improvements that include multifault ruptures, have resulted some changes For example, compared to the previous forecast (UCERF2), the likelihood of moderate-sized earthquakes (magnitude 6.5 to 7.5) is lower, whereas that of larger events is higher.

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 no warning is available 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, 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, and
- End user education.

The planned system will use 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 broadcast radio and television 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.

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 warning products. This information will help emergency managers deploy resources to help protect lives and property, identify the areas hardest hit, and rapidly estimate the magnitude of the damage.

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
- Receiving support from 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.

How will the earthquake early warning system be managed?

In September 2016, Governor Jerry Brown signed Senate Bill 438 (Hill) into law. This bill established the California Earthquake Early Warning (CEEWS) Program and a CEEWS Advisory Board within the California Governor’s Office of Emergency Services.

Codified as Government Code Sections 8587.8 (amended), 8587.11 and 8587.12, SB 438, the legislation removed restrictions and contingencies regarding CEEWS funding and operation that existed in prior law. The new legislation requires Cal OES, in collaboration with the California Institute of Technology (Caltech), the California Geological Survey, the University of California, the United States Geological Survey (USGS), the Alfred E. Alquist Seismic Safety Commission, and other stakeholders, shall develop a comprehensive statewide earthquake early warning system in California. That activity will include:

1. Installation of field sensors,
2. Improvement of field telemetry,
3. Construction and testing of central processing and notification centers,
4. Establishment of warning notification distribution paths to the public, and
5. Integration of earthquake early warning education with general earthquake preparedness efforts.

The legislation also directs Cal OES to develop an approval mechanism to review appropriateness of, and compliance with, earthquake early warning standards as they are developed.

Earlier in 2016, Governor Brown directed $10 million to Cal OES in the 2016-17 state budget to further expand the state's earthquake early warning system.

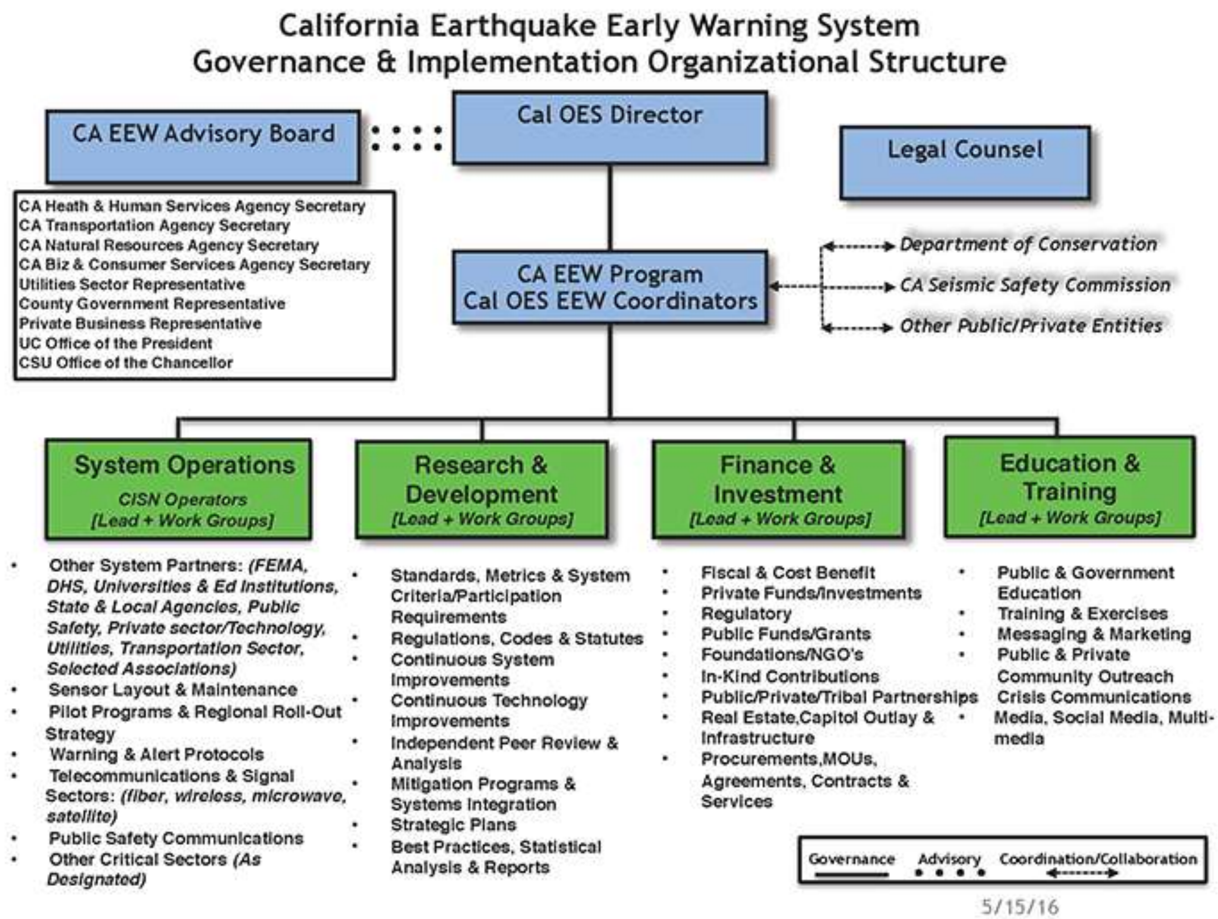

Figure 1 - CEEWS Organizational Structure

Cal OES is tasked with oversight of bringing the seismic early warning system online. In support of the CEEWS Advisory Committee four staff-level working groups will focus on:

1. System operations,
2. Research and development,
3. Finance and investment, and
4. Training and education.

How will the system be funded?

CEEWS has been allocated initial funding of $10 million for its first year of development. Long-term, sustainable funding will be needed for the system to become fully operational. The timeframe for implementing a comprehensive earthquake early warning system in California will depend on the available funding.

In order to sustain 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?

Earthquake early warning raises new requirements for rapid warning delivery that many existing warning systems are unable to meet. Cal OES and the USGS are working with warning system providers to accelerate their delivery of time-sensitive earthquake warnings. Both agencies also are conducting proof-of-concept trials and feasibility evaluations on a variety of new rapid warning delivery methods.

Speeding up warning delivery systems is not the only challenges that will need to be met before earthquake early warnings will be available directly to the public. Another 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. Furthermore, for early warning alerts to be most useful, people, companies, and institutions must plan beforehand what they will do when they receive the information.

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