

## ShakeAlert: Implementing Public Earthquake Early Warning for the U.S.

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The ShakeAlert Earthquake Early Warning (EEW) is a practical use of earthquake science that can reduce injuries, deaths, and property damage by giving people and systems up to a minute to take protective actions before the heaviest shaking arrives. The U.S. Geological Survey (USGS) and its many partners are working to implement ShakeAlert in the three states of the West Coast of the U.S., Washington, Oregon, and California. The partners include Caltech, UC Berkeley, the University of Washington, the University of Oregon, state emergency services organizations, private companies, and the Gordon and Betty Moore Foundation. ShakeAlert is built on the extensive monitoring infrastructure of the USGS Advanced National Seismic System.

The ShakeAlert demonstration system has successfully sent hundreds of test notifications to selected beta users in California since 2012 and began sending messages for Washington and Oregon in 2015. It has alerted on several significant earthquakes and has demonstrated its ability, in some cases, to send alerts less than 4 seconds after an earthquake begins.

On February 1, 2016 the USGS, along with its partners, rolled-out the next-generation ShakeAlert early warning test system in California. This next-generation "production prototype" does not support public warnings but will allow qualified early adopters to develop and deploy pilot implementations that take protective actions triggered by the ShakeAlert warnings in areas with sufficient station coverage.

To reach full public operation the system needs about 1,000 more sensors in California, Oregon and Washington, more reliable telecommunications paths, and a campaign to educate the public about earthquake early warning alerts and how to respond to them. Progress is being made in all these areas; however the project is not yet fully funded. The USGS ShakeAlert implementation plan estimates it will cost \$38.3 million in capital funding to complete the system on the West Coast to the point of issuing public alerts and \$16.1 million each year to operate and maintain it. This is in addition to current support for seismic networks from other sources.

Completion of the system to the point of public alerting will require a whole-community effort which is gaining momentum. The USGS budget is now \$8.2 million per year for the project. A recent White House summit focused attention on ShakeAlert and announced new commitments from a variety of stakeholders. There is a bill in the California legislature for \$23 million to build that state's part of the system and the state of Oregon, as well as various utilities, have funded stations. University partners and the USGS are implementing and testing new algorithms that will speed up and improve the system, incorporate high-precision real-time GPS data, and characterize evolving fault ruptures, including megathrusts, in real-time. Use of data from low-cost sensors and cell phones is also being explored. Private partners are co-developing commercial applications to receive and act on ShakeAlert notifications. The telecommunications industry is taking steps to develop the standards and technological enhancements needed to broadcast alerts to cell phones with minimum delay.

While significant progress is being made, a fully functional ShakeAlert system will require additional funding and further collaborative work before full West Coast public alerting will be possible.

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