Buying time

West Coast warning system could offer crucial seconds when earthquakes hit

By Alexandra Witze

Students at Twin Lakes Elementary School in Federal Way, Wash., take shelter under tables in a 2012 earthquake drill. Millions of people took part in the "Great ShakeOut" to prepare for the possibility of real quakes in the future.

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At 2:46 p.m. on March 11, 2011, an earthquake-detection station on Japan's northeast coast began rocking back and forth, rattled by a powerful seismic wave racing from deep offshore. Just 5.4 seconds later, the Japan Meteorological Agency issued a notice that a magnitude 4.3 quake had begun.

As the seconds ticked by, however, and more stations picked up the rippling wave, the tremor started looking bigger. Three seconds after the first notice came an official warning: A quake of at least magnitude 7.2 was on its way. That's a big tremor, even for earthquake-prone Japan. The city of Sendai needed to act quickly.

Televisions, radios and cellphones blared alerts. Trains screeched to a halt. Assembly-line robots froze in place and schoolchildren dived under desks. Fifteen seconds later, the biggest earthquake in Japanese history rocked Sendai — a monstrous magnitude 9.0 accompanied by a tsunami that disastrously flooded two nuclear power plants in nearby Fukushima.

Earthquakes are impossible to predict. But in the last few years, officials in various countries have started alerting the public once a quake is under way. Seismic sensors and communications networks have improved to the point that electronic alerts can race ahead of seismic waves. Such notifications give a few crucial seconds during which emergency managers can secure natural gas lines, factory workers can shut down hazardous equipment and surgeons can withdraw their scalpels from patients. In Sendai, those 15 seconds of advance notice may have saved many lives, making the catastrophic Tohoku earthquake at least a little less devastating.

Many other countries have seismic early warning systems. Japan's nationwide system has been in place since 2007. Mexico City gets public alerts when a big quake begins. Even Romania uses a small network of seismometers to alert nuclear reactor workers when the ground is about to shake.

The United States has no public warning system for incoming quakes — yet. Officials are seriously talking about launching a full-fledged early warning system for the quake-prone West Coast. In September, California Gov. Jerry Brown signed legislation that requires the state to figure out how to fund an earthquake early warning system by 2016. Lawmakers have yet to pony up the money, but even so "we are the closest we've ever been," says Richard Allen, a seismologist at the University of California, Berkeley.

California is close to taking action, in part, because of innovations that are improving the accuracy of warnings. In the last few years, earthquake specialists have begun incorporating real-time data from global positioning system stations, which measure how the ground moves. Traditional earthquake-monitoring systems rely on seismo meters, which measure the energy of seismic waves passing through the ground, but do not do a good job measuring big shifts from big quakes. Adding the GPS data produces a better estimate of exactly how a big earthquake propagates across hundreds of kilometers, and therefore what kind of hazard it may pose to people. During the Tohoku quake, for instance, the Japanese early warning system relied mostly on seismometer data, and thus underestimated the strength of shaking very far from where the quake began. The system didn't accurately warn people in Tokyo, 300 kilometers from Sendai, of their vulnerability.

New discoveries have essentially solved that problem. "We have the technology, we have the science, we have networks that can communicate quickly enough to provide warning," says Allen, who directs the Berkeley Seismological Laboratory. "It doesn't make any sense to wait for the next big earthquake. We should go ahead and do it."

Call to action

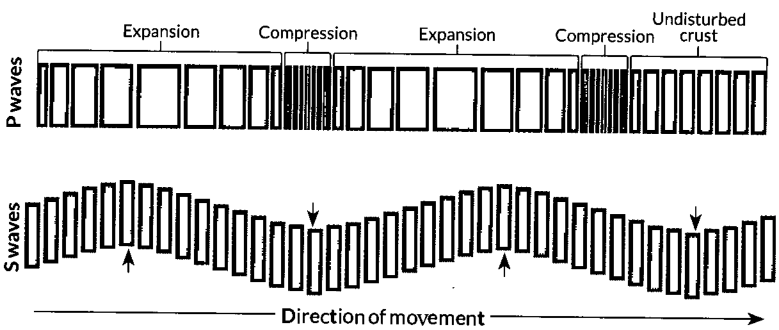
The idea of earthquake early warning is far from new. In 1868, a San Francisco physician proposed setting up an alarm bell in the city, strung by telegraph wires to some sort of faraway mechanical device that would generate an electric current if the ground started shaking. "This bell should be very large, of peculiar sound, and known to everybody as the earthquake bell," J.D. Cooper wrote in the *San Francisco Daily Bulletin*.

Turning the earthquake bell into reality took more than a century. After the 1989 Loma Prieta earthquake rocked the San Francisco Bay Area, the U.S. Geological Survey rigged a warning system to help protect workers who were trying to restore collapsed portions of an interstate in Oakland. USGS researchers peppered the area around the quake's epicenter with seismometers. When an aftershock hit, the stations automatically radioed a warning to the workers in Oakland, about 80 kilometers away. "It was a temporary system, but it worked," says Allen. In one case, it provided workers a warning as long as 20 seconds.

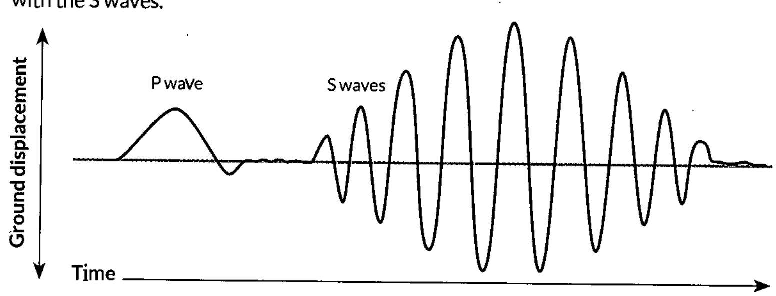
It took more than two decades for the next big advance. In 2011, the USGS and university partners debuted ShakeAlert, a prototype warning system that uses data from about 400 seismic monitoring stations across California. When an earthquake starts, the computer screen of a ShakeAlert user flashes a bright blue-and-yellow warning box. Numbers begin counting down to when ground shaking will begin at the user's location and how strong it will be. A blaring

Follow the wave Earthquake early warning systems rely on the fact that quakes produce several types of seismic waves. The first to arrive are P, or primary, waves and after that come S, or secondary, waves.

P waves travel as a series of contractions and expansions through Earth's crust, while S waves travel by shearing material at right angles to their direction of movement.



P waves travel roughly twice as fast as S waves, so they appear first on a seismograph. They serve as the initial warning to brace for the larger ground shaking that will arrive with the S waves.



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