ShakeAlert™

STEM Connections to the ShakeAlert Earthquake Early Warning System

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NGSS: MS-ESS3-2, MS-PS4-2, MS-PS4-3, 4-ESS3-2, HS-PS4
Scientific & Engineering Practices: Obtaining, Evaluating, & Communicating Information
Crosscutting Concepts: Cause and Effect
Disciplinary Core Ideas: Earth and Human Activity

Background

Earthquakes pose a serious risk to our Nation - 77% percent of that risk, or an average annual loss of $4.1 billion, is concentrated on the West Coast in California, Oregon, and Washington (Federal Emergency Management Agency, 2008). Growing urbanization and increasing reliance on complex infrastructure for power, water, telecommunication, and transportation magnify that risk.

More than 143 million people in the United States are exposed to potentially damaging shaking from earthquakes. Fifty million of those people are in California, Oregon, and Washington. Earthquake shaking can affect West Coast residents at any time. Although scientists cannot predict exactly when, where, and how big an earthquake will be, earthquake early warning science, engineering, and technology detects significant earthquakes so quickly that an alert can reach many people before shaking arrives. The USGS has been developing the ShakeAlert Earthquake Early Warning System for the West Coast since 2006, jointly with partners from state governments, universities, and private foundations.

The annual ShakeOut drill teaches us what to do to protect ourselves if there is an earthquake, but what would happen if people and automated systems had seconds to tens of seconds alert before strong shaking arrives?

The ShakeAlert System can identify and characterize an earthquake and provide alerts to be distributed to people and infrastructure several seconds after the earthquake begins. The ShakeAlert System is currently in its Pilot Implementation Phase where **ShakeAlerts** are being tested in various environments such as transportation, schools, hospitals, and utilities. This has motivated the development and testing of new software, novel engineering solutions, and ways to improve human safety. ShakeAlert is an innovative technology that will improve over time and will complement existing tools that contribute to risk reduction.

Overview

The same questions being asked of potential ShakeAlert pilot testers across California, Oregon, and Washington will challenge students in this workshop - to think critically, ask questions, consider problems, and explore solutions. How can hospitals, airports, amusement park rides, and other categories of infrastructure utilize this information technology resource? Students explore the next steps science, engineering, and technology can play to improve safety for individuals as well as infrastructure. The example used in this activity will be from California.

ShakeAlert Classroom Activity

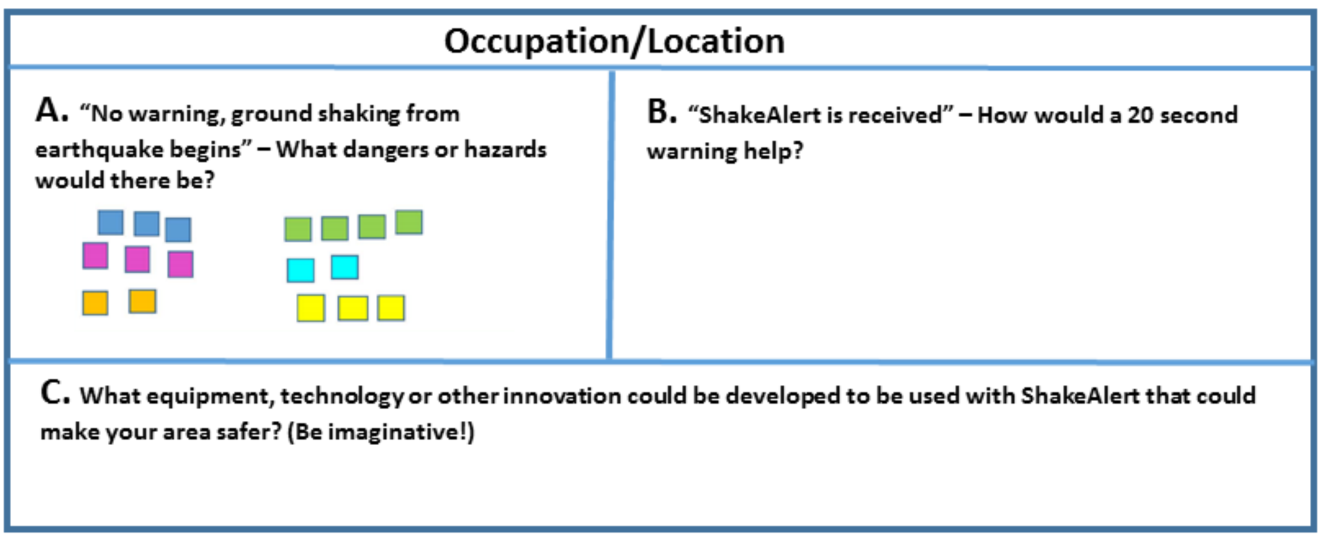
Materials

Sticky Note Pads (can divide single pad into multiple bundles)
Markers
Occupation/location Cards (see appendix)
Prepared Wall Sheets (see appendix)
Wall tape
One Flash light
Earthquake Shaking Potential Map, CGS Map Sheet 48
USGS ShakeAlert Fact Sheet (https://pubs.er.usgs.gov/publication/fs20143083)

Part A - Inquiry

1. Provide each student with a colored sticky note pad, marker, and an occupation/location card. Ask each student to imagine their self as the person and at the place described on the card. Use the sticky notes to record each of their answers to the question on their card.

2. Have students find their corresponding occupation/location wall sheet and post their responses to the question (in section A). Ask students to each post responses in a horizontal row across the wall sheet. Allow students time to compare responses. Have students return to their seats.



Part B - ShakeAlert Science

1. Detecting Earthquakes, Introduction to ShakeAlert –
Play **IRIS/USGS ShakeAlert** video
(stop video at 1 min, 30 seconds).
http://www.iris.edu/hq/inclass/animation/shakealert_earthquake_early_warning_system

Group questions for quick review and discussion of video content:
-What types of waves are used for earthquake early warning? [S & P]
-Which wave is faster? [P waves]
-Which wave is more damaging? [S waves]
-Once the earthquake wave is detected by the seismometers close to the earthquake, information is sent at the speed of light to a computer system that determines what? [Arrival times and level of shaking for different regions.]

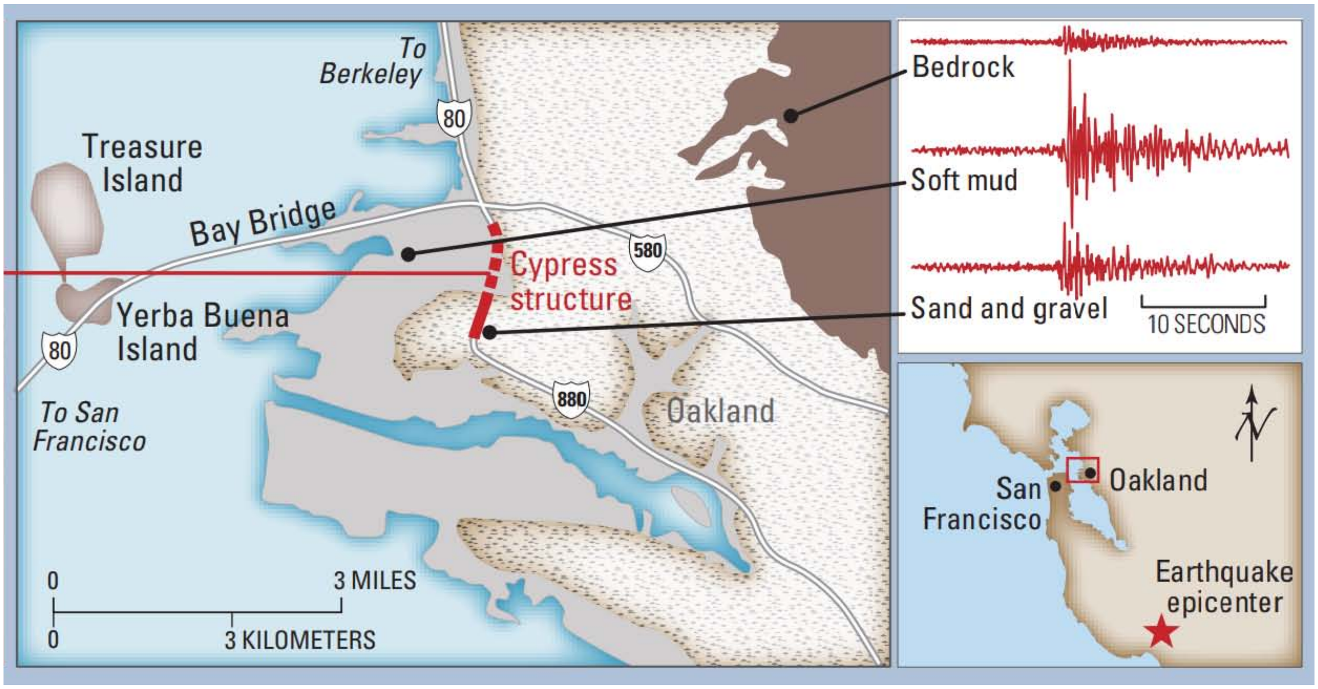
2. S and P human wave participation –
Play **IRIS Video "Modeling Seismic Waves"**
(stop video at 2 min, 27 sec)
(https://www.iris.edu/hq/inclass/video/human_wave_modeling_seismic_waves_in_the_classroom)

One way that earthquakes release energy is in the form of seismic waves (e.g. P and S waves). ShakeAlert uses information from P and S waves and other details such as local ground conditions to determine where and what intensity shaking may occur at a particular location. How are P and S waves different in how they move through the Earth? Students will physically form a line and are instructed how to propagate P and S waves. After practicing a few times, measure the time for each wave to travel down the line of students.

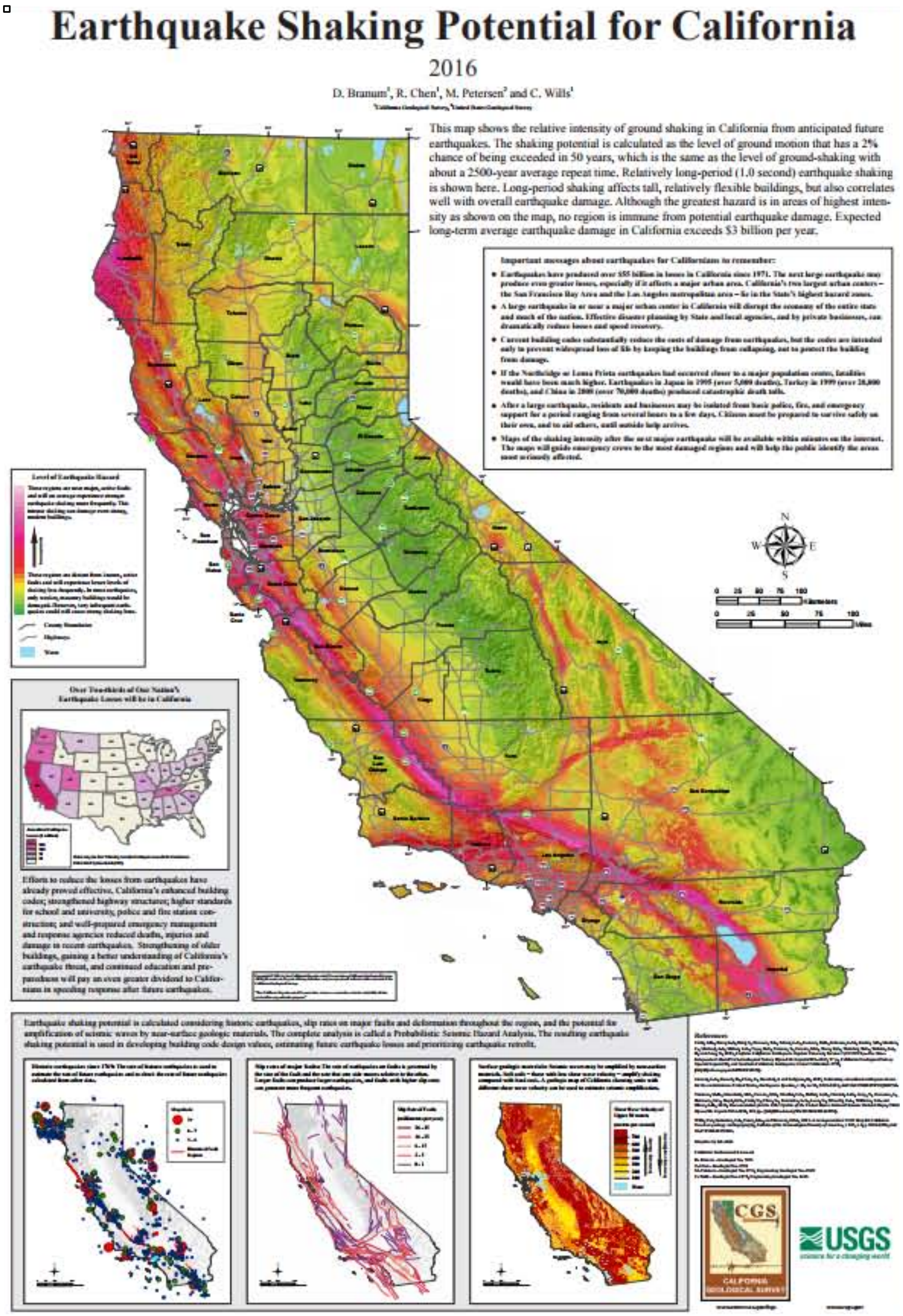
Discuss the difference in travel times and the path the wave energy takes. Use a flashlight to emphasis how much faster light is than both the S and P waves, as it travels through air. Discuss how the technological use of fiber optics and other communication technologies such as microwave are crucial for the rapid dissemination of ShakeAlerts. (~15 minutes)

3. Video/discussion on difference between Intensity and Magnitude –
Play **IRIS/USGS "Earthquake Intensity"** video
Pause video to emphasis key points and/or to provide clarity where needed.
(http://www.iris.edu/hq/inclass/animation/earthquake_intensity)

4. Rock type and soils affect ground shaking intensity.
Look at USGS figure from the 1989 Loma Prieta earthquake to see where areas underlain by mud and loose materials shook harder and caused damage where the Cypress freeway structure in Oakland was underlain by soft mud. https://pubs.usgs.gov/fs/2014/3092/pdf/fs2014-3092.pdf



Using the CGS/USGS "Earthquake Shaking Potential Map for California" explain the relationship of earthquake source areas and surface materials (rock and soil) to ground shaking potential (ftp://ftp.conservation.ca.gov/pub/dmg/pubs/ms/048/MS_048_revised_2016.pdf)



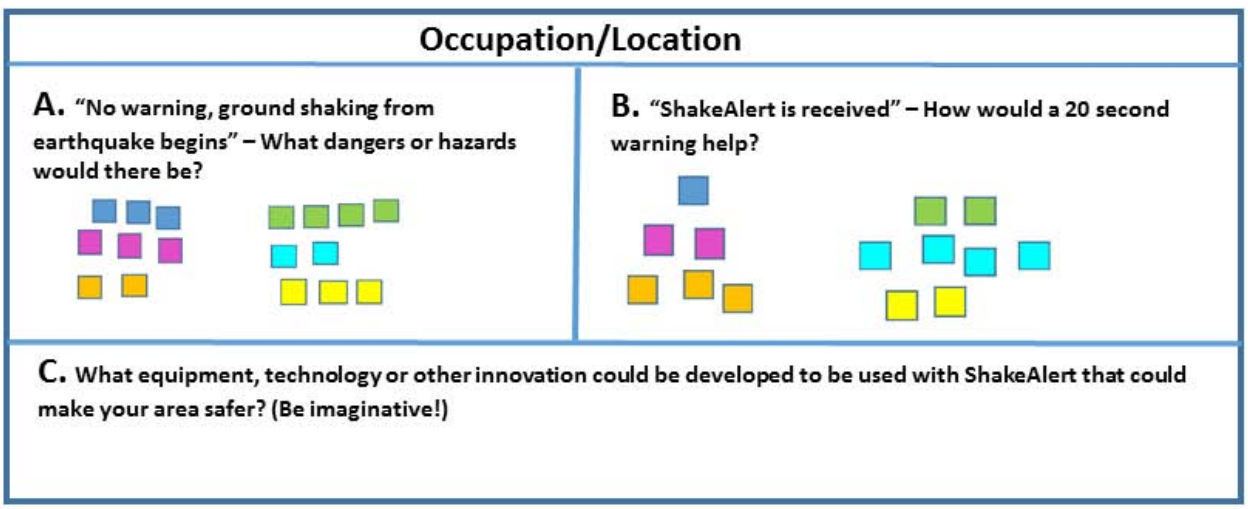
5. Play **IRIS/USGS ShakeAlert** video (again).
Pausing where needed to emphasis key points.

Stop at 2 min, 07 seconds
http://www.iris.edu/hq/inclass/animation/shakealert_earthquake_early_warning_system
-Does ShakeAlert predict when or where earthquakes will occur? **No.**
-How much alert does someone near the epicenter get? Potentially none, the alert may be late because of the time it takes to detect and characterize the earthquake and generate the ShakeAlert. This will take about 5 seconds. After the ShakeAlert is generated by the USGS it is up to alert distributors to get ShakeAlerts to cell phones, TVs, etc. Rapid delivery of ShakeAlerts is still a technological challenge.

- How much more alert time does someone in the next city or county get, hours or seconds? Potentially seconds.

Part C - Problem Solving

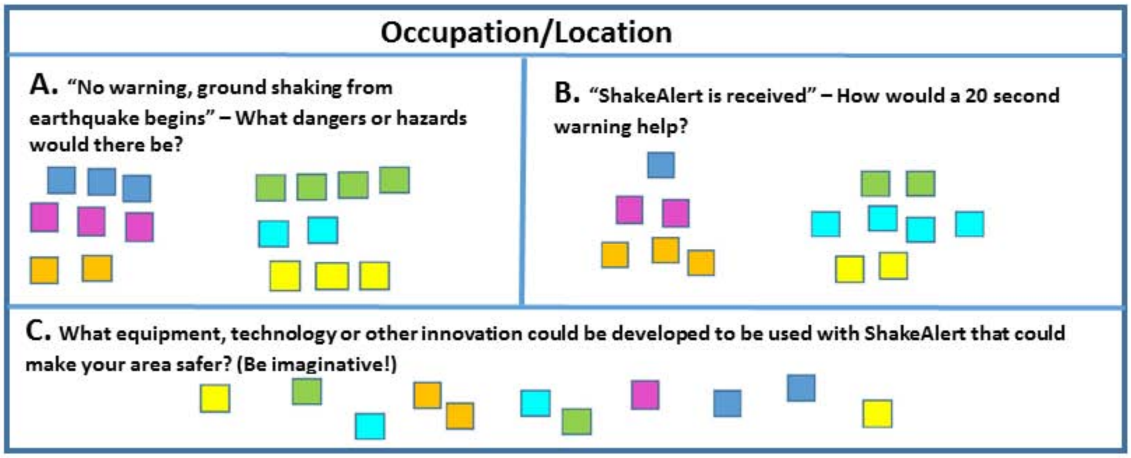
1. Instruct students that they will be using their Occupation/Location again. Tell the students that they will receive an earthquake warning message that a strong earthquake will arrive in 20 seconds. With the occupation and workplace location they have, how will the warning help? Have students jot short answers on their sticky notes, and return to their wall sheet and post their responses (in section B).



2. Have students remain in their group and share their responses with each other. Post any new ideas the group generates.

3. Ask students to think about how a ShakeAlert would be delivered to them?
As a group, ask them to brainstorm and post current or new technology and/or engineering that might be needed to make their occupation and work place safer (in section C).

4. Have each group summarize their findings to the rest of the class.



Part - D Group Discussion

Discussion questions:

1. What is the role of science in earthquake early warning?
2. How does technology support earthquake early warning?
3. Will there be unique engineering needs?
4. How will warning be broadcast in a variety of settings?
5. What types of machinery could be shut down or slowed to prepare for shaking?
6. How should the public be prepared for earthquake warning messages?
7. What technology will be needed to rapidly get the warning message out?
8. How might an earthquake early warning help firefighters?
9. What technology or engineering would be needed to prepare your school to receive ShakeAlerts?

Appendix

Examples of Occupation/Locations

Ride operator at amusement park
Dentist starting a root canal on patient
Surgeon doing surgery in Operating Room
Window washer at the top of a tall building
Warehouse worker operating a forklift at Home Depot
Chemistry teacher in lab with chemicals
Power plant operator monitoring gauges
Factory worker using automated machinery
Site manager of an oil refinery
Light rail or train engineer driving a train
Chef in a kitchen with sharp knives and gas stove
LASIK surgeon about to start surgery
Crane operator at a port
Air traffic controller at airport
Train engineer on train with toxic cargo
Kindergarten teacher with 35 kids/classroom
Fire fighter with fire trucks parked inside garage
Employees in tall building's elevator
News reporter in studio during live recording
Gas utility operator responsible for high pressure pipelines
School bus driver in bus with 50 kids
Emergency manager at Emergency Operation Center
Senior engineer at a water district pipeline control center
Gas company manager at pipeline control center
Lineman for electrical company working on a high power transmission line
Museum science educator in planetarium with 35 kids
After school care provider with 40 kids out on playground
State Park naturalist at Park Visitor Center
Zookeeper that cares for large dangerous animals
Aquarium employee leading a tour of very young students
Outdoor science camp instructor with 60 kids and 10 parents

Occupation/Location

You are at work and suddenly a strong earthquake starts shaking. What dangers or hazards would there be? Write answers on sticky notes.

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