

## FAQ: ShakeAlert<sup>®</sup> Earthquake Early Warning System and Warning Times

The **ShakeAlert<sup>®</sup> Earthquake Early Warning system<sup>1</sup>**, operated by the U.S. Geological Survey (USGS), quickly detects significant earthquakes, estimates shaking, and issues ShakeAlert Messages to Technical Partners. Then, Technical Partners, which have entered into a license agreement with the USGS, use this information to deliver alerts that rapidly reach people and trigger automated actions to protect vital systems and infrastructure, potentially seconds before shaking arrives at their location.

### • Can ShakeAlert predict earthquakes?

In a word – **NO**. Although the ShakeAlert<sup>®</sup> system **cannot predict** when earthquakes will happen, **it can detect earthquake shaking very quickly after it begins**, potentially offering seconds of warning before shaking arrives at your location. You may receive an alert before, during, or after shaking arrives, depending on your distance from the earthquake epicenter and how you receive the alert.

### • How does earthquake detection happen?

During an earthquake, a rupturing fault produces fast-moving primary seismic waves (P-waves) and slower moving, but more damaging secondary waves (S-waves). P-waves travel nearly twice as fast as S-waves. The ShakeAlert seismic network, which currently includes more than 1,000 seismic sensors placed across the West Coast, **detects** the P-waves (first felt wave), and immediately transmits data to a ShakeAlert processing center. There, the location, estimated size, and estimated shaking of the quake are quickly determined. More sensors are being installed every year as the ShakeAlert system expands (about 1,700 total sensors are anticipated). Completion of the sensor network, updates to software, and technology upgrades to the ShakeAlert system will continue to improve.

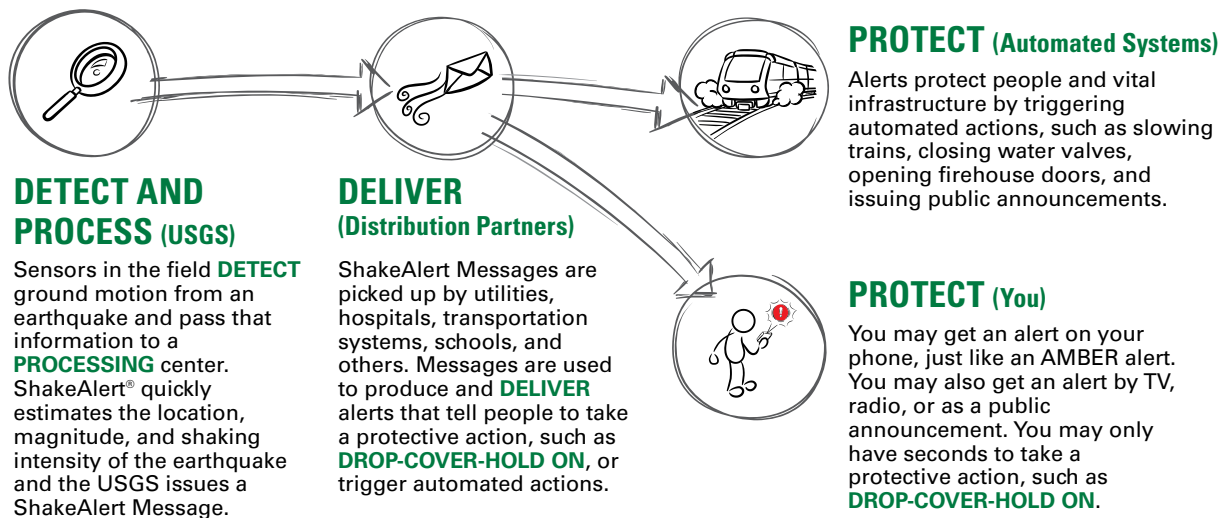
**Speed is of the essence for people and systems to get alerts before shaking arrives at their location. The amount of warning time depends on the proximity of seismic stations to the earthquake, the distance of a person or system from the epicenter, and how the alert is delivered.**

**As a result, individuals and other end-users, such as automated systems within key sectors (e.g., transportation, utility, healthcare, education, etc.), may receive an alert before, during, or after shaking arrives at their location.**

If the earthquake is large enough to meet USGS alerting thresholds, a ShakeAlert Message is issued by the USGS to Technical Partners, who **deliver** alerts that prompt people to take a protective action and/or trigger automated actions. The latter may include closing water valves, opening firehouse doors, and slowing trains, among other risk-mitigating measures. The objective is for alerts to be received *before* the more damaging S-waves arrive, so protective action can be taken by people and vital systems.

[Check out this video](#) that describes how ShakeAlert works.

<sup>1</sup> When referring to “system” vs “System,” lowercase “s” refers to the USGS part of the operation (sensors and processing centers), and uppercase “S” refers to the USGS part and the alert delivery Technical Partners (i.e., the entire System).



**If you feel shaking or get an alert, immediately DROP-COVER-HOLD ON.  
Do not wait, because seconds matter!**

## • What affects the amount of warning time someone receives?

ShakeAlert-powered alerts will provide varying amounts of warning time, depending on a person's distance from the epicenter and the alert delivery mechanism. For most earthquakes, there is a zone near the epicenter where there is no warning time before shaking is felt, because it takes a few seconds for the ShakeAlert system to detect the shaking and for the USGS to issue a ShakeAlert Message. These Messages are then picked up by ShakeAlert Technical Partners who deliver an alert to end-users. These end-users are people who receive alerts and organizations that implement ShakeAlert-powered automated actions.

The density of seismic sensors on the ground can also impact the processing speed of ShakeAlert Messages. Multiple seismic sensors need to detect shaking before an earthquake's location and magnitude are determined. If the nearest sensors are far away from the earthquake source, more time will elapse before ShakeAlert algorithms detect the earthquake. As more seismic sensors are installed, the average earthquake detection time will decrease, thus enabling faster alerts.

## • How do different types of earthquakes affect earthquake early warning?

There are several types of earthquakes that impact the West Coast of the United States. Each type presents a different scenario.

- 1. Shallow crustal fault earthquakes:** In California, these typically occur on strike-slip fault systems (e.g., the San Andreas Fault or the Hayward Fault). Crustal fault earthquakes also occur in the Pacific Northwest (e.g., the Seattle Fault or the Portland Hills Fault). While these earthquakes can vary in magnitude, even moderately sized crustal fault earthquakes can be damaging because they occur close to the surface.

**Strike-slip faults are vertical (or nearly vertical) fractures, where the two sides of the fault move laterally during an earthquake.**

**A subduction zone is where two tectonic plates come together, one subducting (diving) beneath the other. The plates are locked together, but periodically overcome the friction in a massive earthquake. Motion in the leading edge of the overlying plate can lift the ocean and produce a tsunami.**

2. **Intra-slab earthquakes:** These types of earthquakes occur deep within the subducted slab for northern California and the Pacific Northwest. The most recent intra-slab earthquake was the 2001 M6.8 Nisqually earthquake. Deep intra-slab earthquakes tend to produce moderate damage.
3. **Large, megathrust earthquakes:** These occur primarily offshore and can stretch from northern-most California to Washington along the Cascadia Subduction Zone. These earthquakes can take several minutes to grow and have the potential to cause major damage across the Cascadia region.

In northern California and the Pacific Northwest, most ShakeAlert-powered alerts will result from shallow crustal fault earthquakes and deep intra-slab earthquakes. In Southern California, most alerts will result from earthquakes that occur along the San Andreas Fault Zone.

## • How much alert time can be expected?

Studies of earthquake early warning methods in Washington, Oregon, and California have shown that alert times typically range from a **few seconds to tens of seconds** before shaking arrives. Sometimes, an alert may be received during shaking or after shaking is felt. For example, if the earthquake begins directly below you, seismic instruments may detect the earthquake around the same time as shaking reaches you, leaving you with little or no warning.

People and systems will receive different amounts of warning time for different earthquakes. Large earthquakes (M8-9) can rupture hundreds of kilometers along a major fault. Because this large earthquake rupture takes up to minutes to occur and produces shaking over a vast region, more warning time is possible for many end-users in these instances.

The longest warning times of 50–80 seconds are possible in northern California and the Pacific Northwest, but only for end-users located at considerable distance from the epicenter (and it's impossible to predict where the epicenter will be). Take protective action as soon as you feel shaking or get an alert.

## • What is the ShakeAlert warning strategy?

The ShakeAlert strategy is to provide Technical Partners with a data package (called a ShakeAlert Message) after shaking begins, so they can deliver alerts that warn people and systems that are likely to experience at least weak-to-moderate shaking. Alerting at low levels of expected shaking increases the chances of sufficient time for people to take protective action and automated actions to be triggered before strong shaking begins.

All earthquakes start small. When an earthquake begins, it is very difficult to determine if it will continue to grow. In terms of warning strategy, the choice is to:

1. **Issue alerts for weak shaking** and potentially provide long warning times, but risk sending alerts for the many events that do not ultimately produce damaging ground shaking; or
2. **Issue alerts only when ground shaking is expected to be damaging**, with the tradeoff that the alert will be sent much later, thus reducing the amount of time available to take protective action.

ShakeAlert Technical Partners can choose to set their own alerting thresholds higher than the USGS minimum; for example, they may set their alerting thresholds higher if their end-users prefer not to receive alerts for weak shaking.

## • What is the alert delivery time expected of ShakeAlert Technical Partners?



ShakeAlert Technical Partners are required to deliver alerts to their end-users, including the public and ShakeAlert-powered automated machine-to-machine actions, **in five seconds or less** after ShakeAlert Messages are generated by the USGS.

## • What are successful, false, missed, and inaccurate alerts? What is a late-alert zone?

### Successful Alerts

Most of the time, people will receive a **successful alert**. Exactly when they receive an alert will depend on several factors, including their distance from the earthquake and the alerting method by which they received the alert.



### False Alerts

In rare cases, people may receive a **false alert** when there was no earthquake at all. The USGS will inform ShakeAlert Technical Partners and you might receive an alert cancellation message.



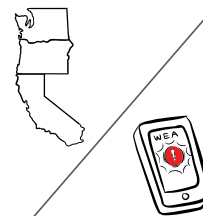
### Missed Alerts

Although also rare, it is possible for ShakeAlert to entirely miss an earthquake that has occurred. When this happens, ShakeAlert Technical Partners are unable to issue an alert. This is known as a **missed alert**.



### Inaccurate Alerts

Sometimes, the ShakeAlert system makes an error in estimating an earthquake's location or magnitude. This can result in alerts being delivered to an area that is too large or too small, or to the wrong area. This is known as an **inaccurate alert**. Some people may receive an alert but may not feel shaking; others may feel shaking but not receive an alert.



### What is a Late-Alert Zone?

Although the ShakeAlert system detects earthquakes within seconds, there is a region near the epicenter of most earthquakes called the **late-alert zone**, where alerts may not arrive before shaking begins.



### Alerting Take-Aways

ShakeAlert is continually improving. In addition to the cases above, it is still possible that people might feel a small earthquake and not get an alert, because ShakeAlert Messages are not produced for the smallest earthquakes.

It is also possible for problems to arise with the alert delivery service. Subscribing to multiple distribution services (e.g., multiple apps) can minimize the chances of this happening. It's better to receive multiple alerts for an earthquake than none at all.

USGS encourages people to take a protective action, such as **DROP, COVER, HOLD ON**, whenever they feel shaking or receive an alert. This is the case regardless of whether the alert turns out to be successful, false, missed, or inaccurate.



## • Will the ShakeAlert system issue follow-up messages after alerts are issued?

The ShakeAlert system is completely automated, but there is also a 24/7 ShakeAlert review team on duty to monitor all ShakeAlert Messages for accuracy. When necessary, the USGS will issue a Post-ShakeAlert Message Follow-up to Technical Partners. Technical Partners that deliver ShakeAlert-powered alerts to the public may provide their own report. The review will follow the initial ShakeAlert Message by 5-10 minutes under most circumstances. The purpose of the review is to provide closure. The review confirms that the ShakeAlert team is aware of what occurred by providing a few words on the quality of the ShakeAlert Message issued by the USGS.

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