

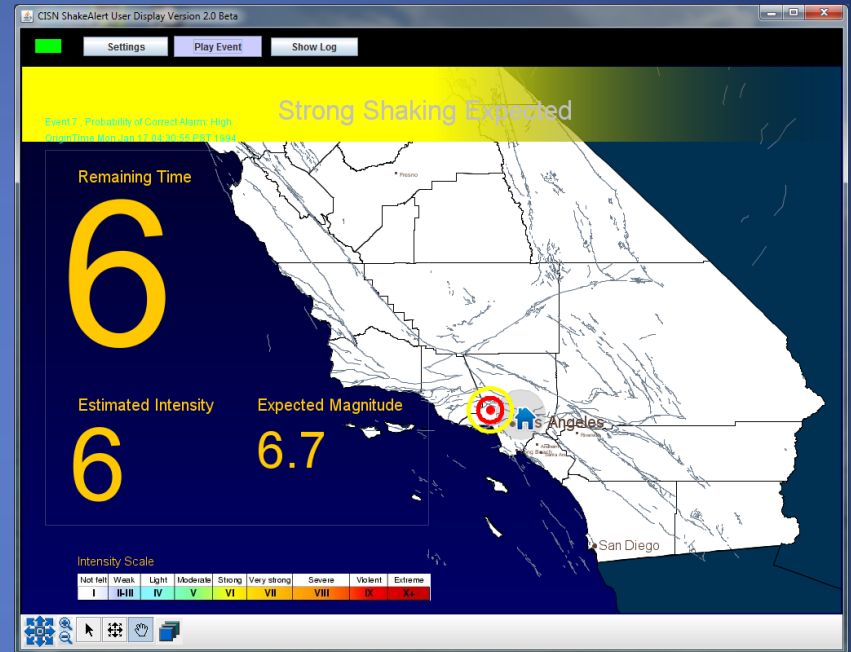
# Earthquake Early Warning

*Where we are and where we are going*

**Doug Given**

**USGS**

*National Earthquake  
Early Warning Coordinator*



# Earthquake Hazard Responsibilities

- USGS Mission: reduce losses due to geological hazards
- USGS has the lead federal responsibility to provide notification and warnings for earthquakes, volcanoes, and landslides. (Stafford Act, P.L. 92-288)
- Earthquake early warning is one of many USGS products to reduce earthquake losses



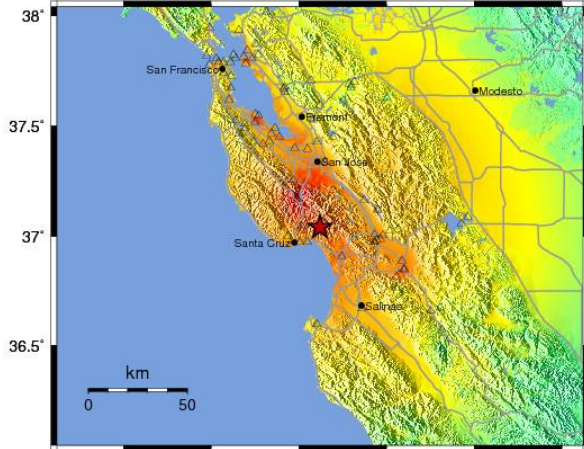
# ShakeMap (ShakeCast)

# DYFI? Did You Feel It?

# PAGER

## Prompt Assessment of Global Earthquakes for Response

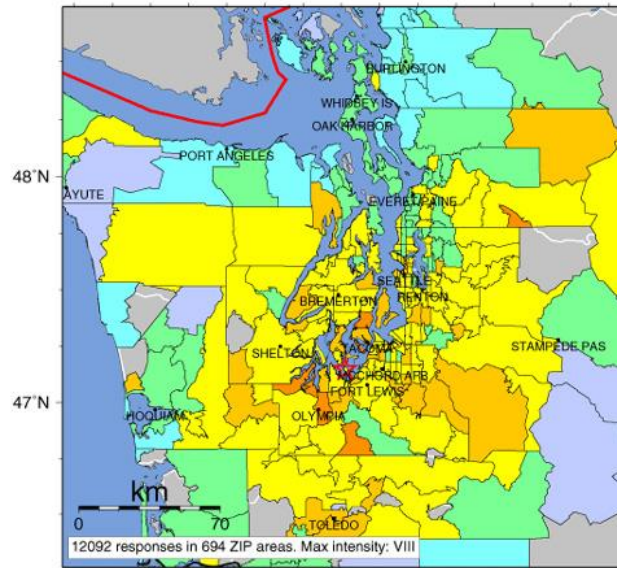
CISN ShakeMap for Loma Prieta Earthquake  
Tue Oct 17, 1989 05:04:00 PM PDT M 6.9 N37.04 W121.88 Depth: 18.0km ID:Loma\_Prieta



Map Version 3 Processed Fri Oct 13, 2006 10:12:35 AM PDT, - NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy	Very Heavy
PEAK ACC. (%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL. (cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

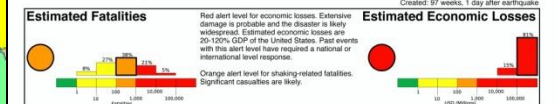
Community Internet Intensity Map (10 miles NNE of Lacey, Washington)  
ID:2261854 10:54:33 PST FEB 28 2001 Mag=6.8 Latitude=N47.15 Longitude=W122.73



12092 responses in 694 ZIP areas. Max intensity: VIII  
Map last updated on Thu Mar 29 11:46:03 2001

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

**USGS** Earthquake Shaking **Red Alert**  
Origin Time: Thu 2008-11-13 10:00:00 UTC (03:00:00 local)  
Location: 33.35°N 115.71°W Depth: 7 km



**Estimated Population Exposed to Earthquake Shaking**

ESTIMATED POPULATION EXPOSURE (x 1000)	I	II-III	IV	V	VI	VII	VIII	IX	X+
ESTIMATED MODIFIED PEAKAL INTENSITY	127k	3,394k	5,292k	3,292k	3,699k	4,754k	2,958k	1,902k	
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy



PAGER content is automatically generated, and does not consider secondary hazards in loss calculations. Limitations of input data, shaking estimates, and loss models may add uncertainty.  
http://earthquake.usgs.gov/pager

Event ID: usShakeOut2\_all

# ENS, Twitter (TED)

USGSSted  
TED USGSSted

USGSSted Strong earthquake, KURIL ISLANDS, Nov-19 22:05 UTC, 0 quake-tweets/min, on.doi.gov/1Z6SAN

USGSSted Powerful earthquake, OFF E. COAST OF N. ISLAND, N.Z., Nov-18 07:51 UTC, 0 quake-tweets/min, on.doi.gov/UC22dt

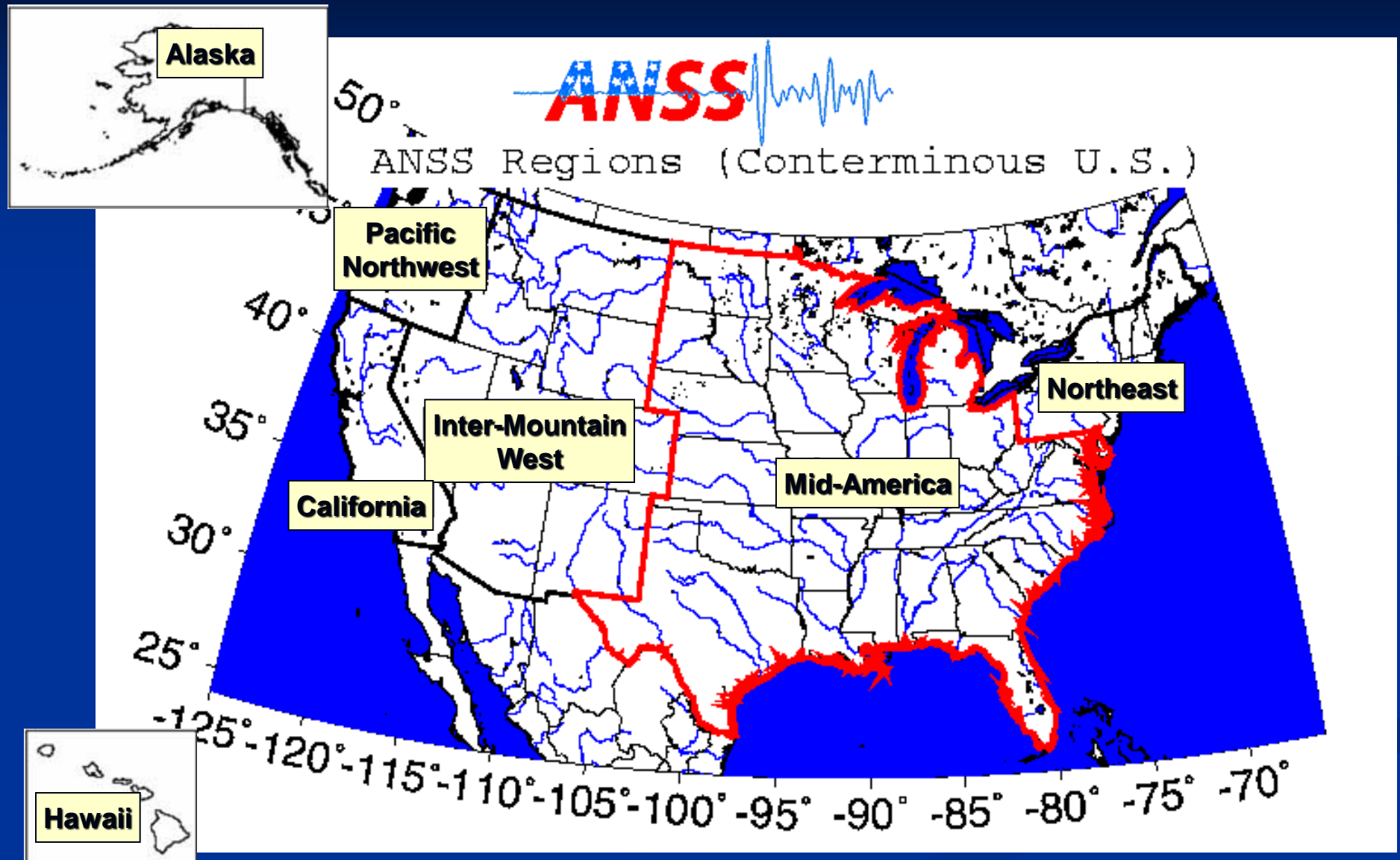
USGSSted Strong earthquake, OFF E. COAST OF N. ISLAND, N.Z., Nov-18 04:34 UTC, 0 quake-tweets/min, on.doi.gov/w1xaEz

USGSSted Strong earthquake, OFF COAST OF ECUADOR, Nov-17 01:57 UTC, 76 quake-

Join the conversation

<http://earthquake.usgs.gov>

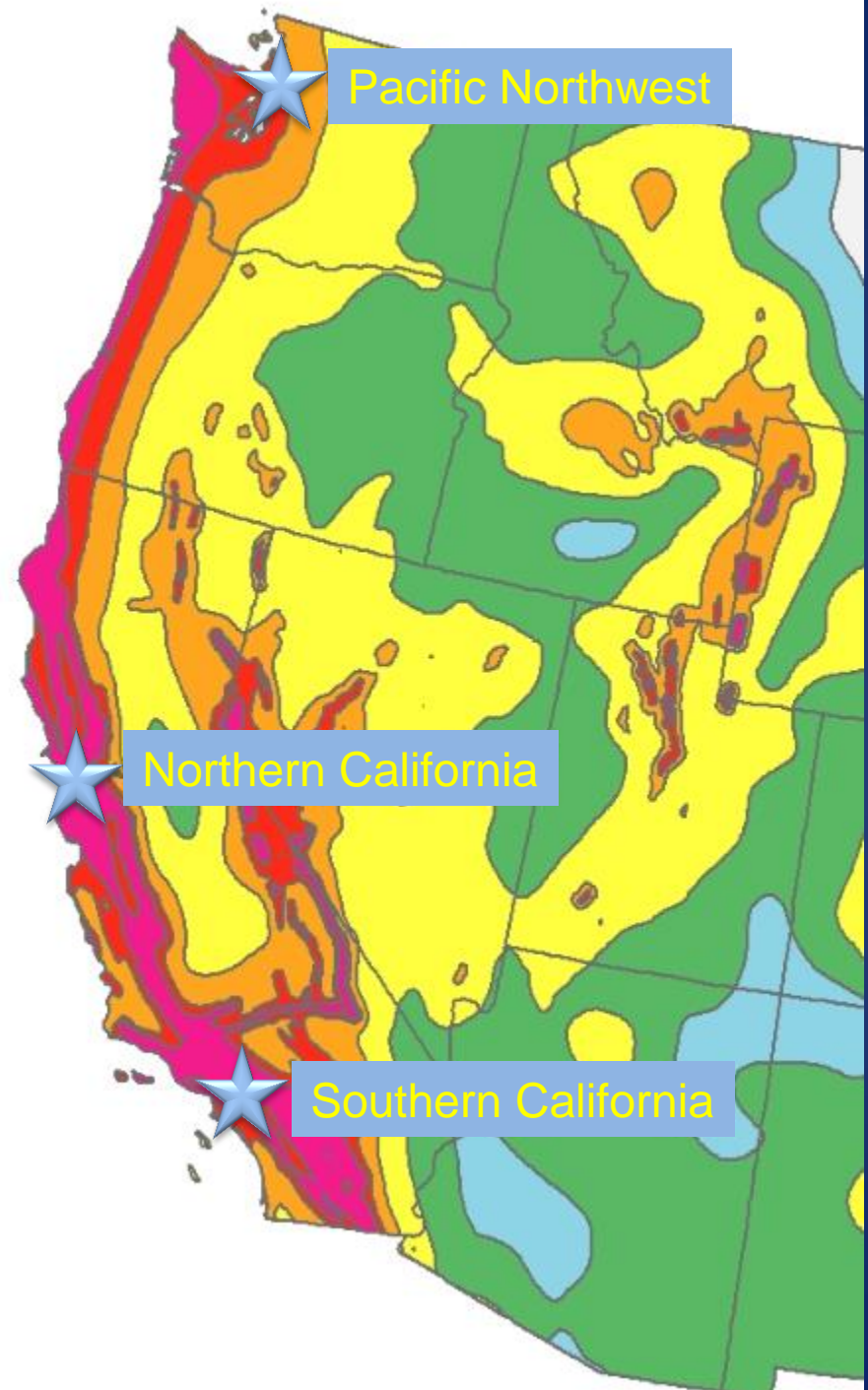
# Advanced National Seismic System





# West Coast Centers

- *EEW is a natural extension of ANSS core capabilities*
- *Leverage...*
  - *Technical*
  - *Management*
  - *Community engagement*



# Commitment to EEW

*“The USGS has directly funded research and development toward earthquake ‘early warning’ since 2006 with **the goal of creating an operational warning capability in the highest-risk regions of the United States.**” – Dr. Marcia McNutt, Director USGS*

## USGS



- External grants R & D for EEW
  - Phase I & II (2002-2012) \$2,093,851
  - Phase III (2012-2015, 1<sup>st</sup> yr only) \$ 450,000
- ARRA California (2009-2011) \$4,426,110
  - Network equipment upgrades
- MultiHazards Project (2008-2012) \$1,618,150
  - San Andreas sensors, digital upgrades, production computers, personnel

**TOTAL**

**\$8,588,111**

## Moore Foundation (2012-2015)



- Caltech \$1,996,888
- UC Berkeley \$2,040,889
- Univ. of Washington \$1,848,351
- USGS \$ 594,406

**TOTAL**

**\$6,480,534**

# ShakeAlert Current Test Users

## Status today:

Demonstration system

## Next three years:

Demonstration → Prototype

Made possible by partnerships  
public-private-foundation



## Receiving alerts today:

- >50 scientists
- CalEMA
- Google.org
- BART
- LA Metro
- Metrolink
- Amgen
- So Cal Edison
- SF DEM
- L.A. City
- L.A. County
- UC Berkeley OEP
- more...



# Phase III Goals

**Goal 1:** Transfer algorithms to AQMS operational environment to create a prototype production system and operate the system.

**Goal 2:** Continue to support and enhance the existing *demonstration* system.

**Goal 3:** Evaluate system performance on a region-by-region basis. Identify causes of strong/weak performance and feedback to algorithm developers.

**Goal 4:** Continue to interact with users in collaboration with the USGS.

**Goal 5:** Develop an implementation plan with the USGS.



# Cost of Full Implementation (Estimated)

	California	Pacific Northwest	West Coast (CA+PNW)
<b>One-Time Construction costs</b>	<b>\$23,165,072</b>	<b>\$15,146,920</b>	<b>\$38,311,992</b>
<b>Annual Operation and Maintenance</b>	<b>\$11,888,128</b>	<b>\$4,607,909</b>	<b>\$16,496,037</b>

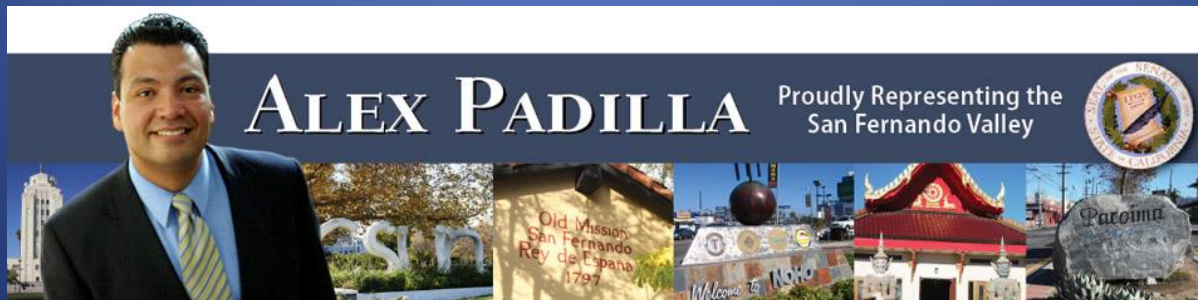
## Includes:

- Bringing ANSS network staffing up to robust levels
- New personnel for EEW implementation, operation, and user outreach
- 700 new or upgrades seismic stations & 300 GPS stations
- Significant field telemetry upgrades

# California SB 135 on EEW

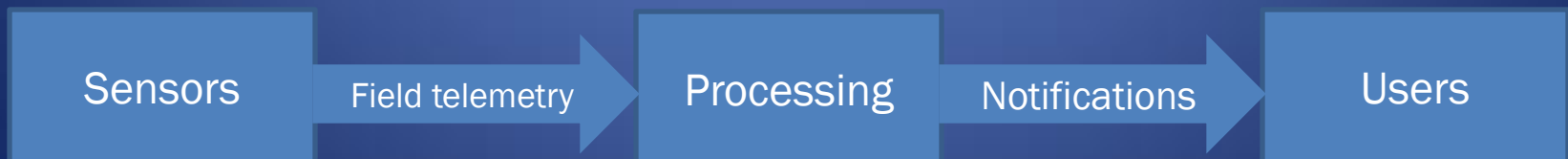
Introduced January 28, 2013

“The Office of Emergency Services, in collaboration with the California Institute of Technology (Caltech), the California Geological Survey, the University of California Berkeley, the United States Geological Survey, and others, **shall develop a comprehensive statewide earthquake early warning system in California.**“



# Progress on EEW

- Dense sensors
- Robust telemetry
- Fast algorithms
  - Large magnitudes
  - Estimation of “finite fault” slip amount & extent
  - Reliable ground motion estimates
- Fast mass notification
- End user education
- *Installing/upgrading sensors*
- *Redesigning telemetry*
- *R & D continues*
  - *GPS techniques*
  - *Fin-Der*  
*(finite fault detector)*
  - *Amplification & response modeling*
- *IPAWS / CMAS alert authority*
- *Beta user outreach, social science, web sites*



# Recent EEW Developments

- BART went “live” 8/12 with PGA approach to EEW (feed from BSL)
- Production system being set up in CISN
- ShakeAlert installed at PNSN
- Web sites set up: [shakealert.org](http://shakealert.org) & [earthquake.usgs.gov/research/earlywarning](http://earthquake.usgs.gov/research/earlywarning)
- Completed 1st draft of implementation plan with budget
- Los Angeles area UASI funding for new & upgraded station
- Partners developing strategy for congressional support
- Social science testing of CMAS messages for EEW and OEF



# Strategy for EEW

- Continue development of EEW algorithms
- Build the EEW production system using existing assets and funding
- Document requirements and cost for a fully operational west coast system
- Seek federal, state & local funding for full EEW system
- Pursue other funding opportunities as they arise (e.g. ARRA, UASI)



# Summary

- USGS and ANSS partners are committed to building and operating EEW for highest risk areas
- ShakeAlert is sending test EEW notifications today in California
- Work has begun on the “production” system
- Significant progress is being made in all parts of the system despite limited resources
- Partners are working to build support at all levels of government and in the private sector