ShakeAlert

West Coast Earthquake Early Warning - Brief History

Doug Given

USGS

Earthquake Early Warning Coordinator

PNSN
Pacific Northwest Seismic Network

PNSN Beta User Workshop
Feb. 17, 2015

Primary EEW Collaborators

- ***USGS***
  Given, D., Cochran, E., Oppenheimer, D.
- ***State of California (Cal OES, CGS)***
  Johnson, M., Parrish, J.
- ***Caltech***
  Heaton, T., Hauksson, E.
- ***UC Berkeley***
  Allen, R., Hellweg, P., Strauss, J.
- ***U. of Washington***
  Vidale, J., Bodin, P.
- ***Swiss Seismological Service, ETH***
  Clinton, J., Behr, Y.
- ***Moore Foundation***
  Chandler, V., Koch, N.

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science for a changing world
Earthquake Hazards Program

Brief History of EEW

- 1868 Hayward, M6.8 (30 killed)
  - Dr. J.D. Cooper suggests EEW system
- 1964 Niigata M7.6
  - Japan Railroad builds Shinkansen
  - Includes EEW for the system
- 1985 Mexico City M8.0 (~10,000 killed)
  - 1991 Mexico's EEW system goes live
- 1989 Loma Prieta M6.9 (57 killed)
  - USGS rapid-prototype EEW system
- 1995 Kobe M6.9 (6,400 killed)
  - 2007 JMA system (~$500M) goes live
- 2006 ShakeAlert development begins
  - 2012 Demonstration system live

The Path To Public EEW

Phased Approach

I. 2006-2009 – R & D phase

II. 2009-2012 – "show me" phase

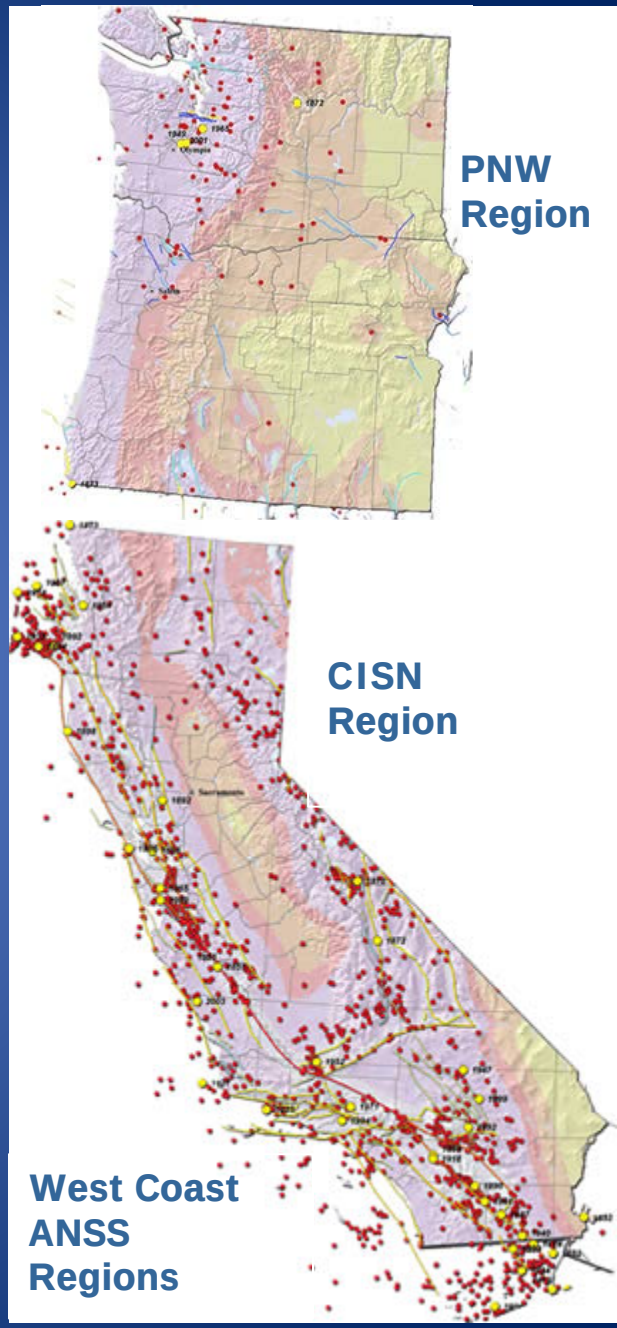
CA *Demo System Live 1/2012*

III. 2012-2015 – Production Prototype

– PNW beta

IV. 2015-2018 – Limited Rollout

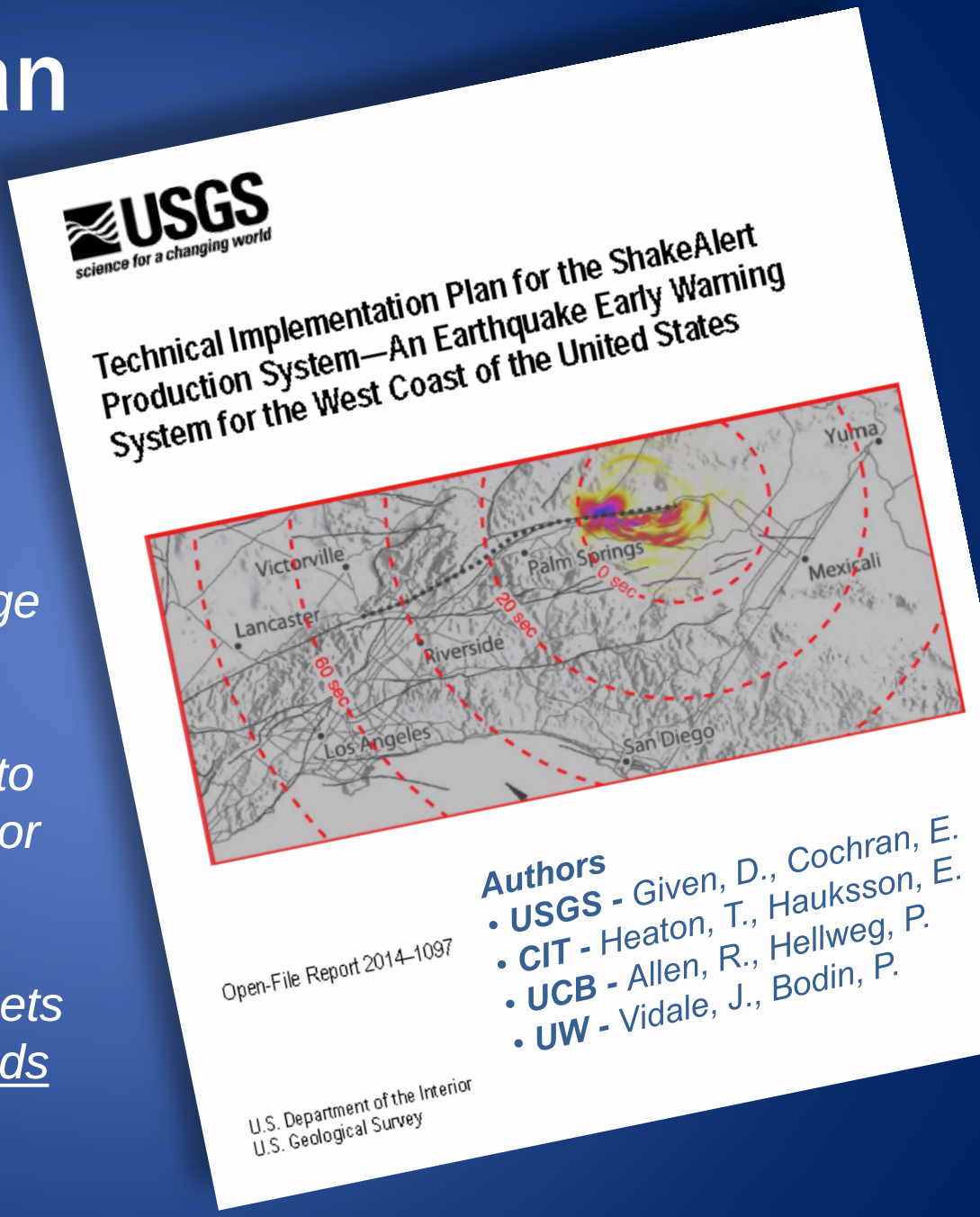
V. ? Full Public Operation



ShakeAlert Plan

USGS & ANSS partners will complete & operate a West Coast EEW system to…

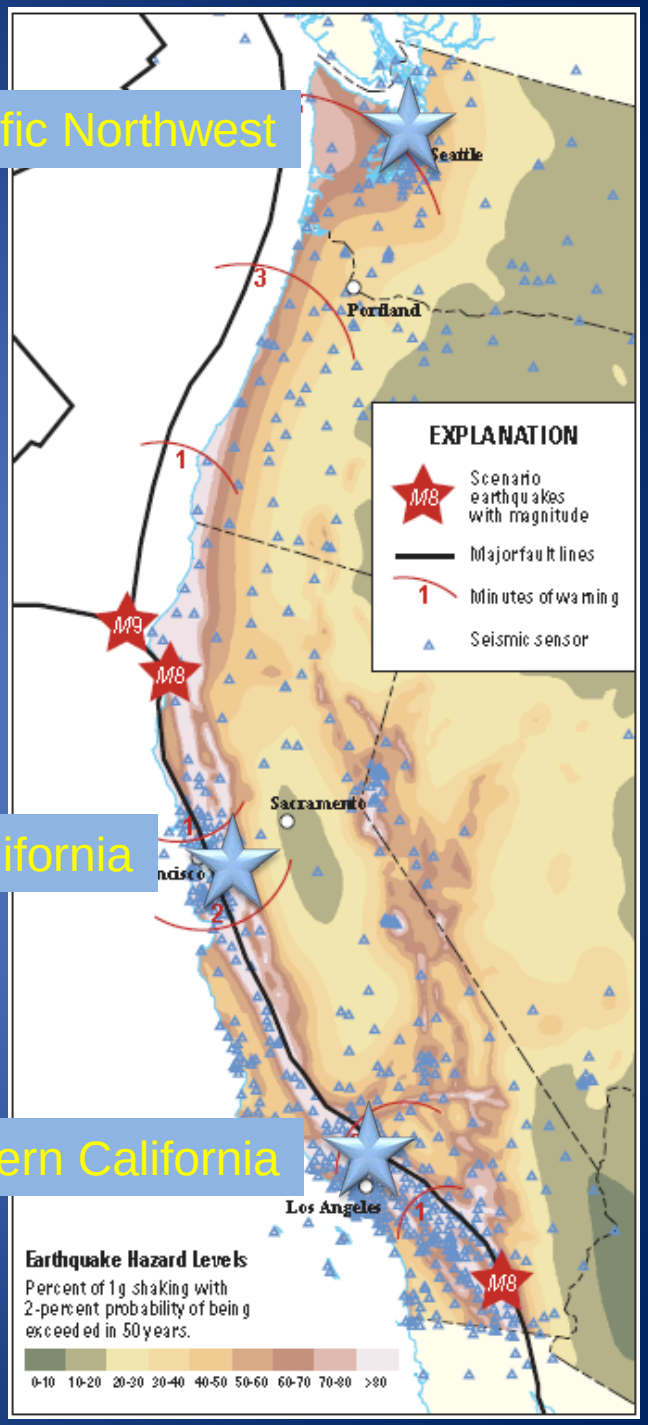
- *Issue public warnings for large earthquakes and…*
- *…send warning parameters to government and private sector users…*
- *…as soon as ShakeAlert meets quality and reliability standards on a region by region basis*



Open-File Report 2014-1097

West Coast System Architecture

- ShakeAlert is built on **ANSS** networks (CISN & PNSN)
- Leverages…
  - Stations
  - Telecommunications
  - Hardened centers
  - Software (EW, AQMS)
  - Expertise
  - Management structures
- *A new ANSS product*



Investments in ShakeAlert (Thru 2015)

(Over and above earthquake monitoring)

USGS Earthquake Program (2002-2015)

External coops R & D for EEW	
➢ Phase I & II (2002-2012)	$2,093,851
➢ Phase III (2012-2015)	$1,575,000
ARRA (2009-2011)	$4,426,110
➢ *- Network equipment upgrades*	
MultiHazards Project (2008-2014)	$2,342,150
EEW base (2015)	$1,500,000
TOTAL	**$11,937,111**

Moore Foundation R&D (2012-2015)

Caltech	$1,996,888
UC Berkeley	$2,040,889
Univ. of Washington	$1,848,351
USGS	$ 594,406
TOTAL	**$6,480,534**

Current Federal Funding

Base USGS budget for EEW	$1.5 million
FY15 congressional add on	$5.0 million
FY16 Pres. Budget request	*$3.5 million*
(would be added to base funding)	

City of Los Angeles – UASI funding

To Caltech FY 14 (SCSN) **$5,600,000**

- *125 new & upgraded SCSN stations*
- *41 RT-GPS stations*
- *System infrastructure upgrades*

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GORDON AND BETTY MOORE FOUNDATION

CITY OF LOS ANGELES FOUNDED 1781

Total = $ 29.0 million

Full West Coast Implementation

(estimate from implementation plan)

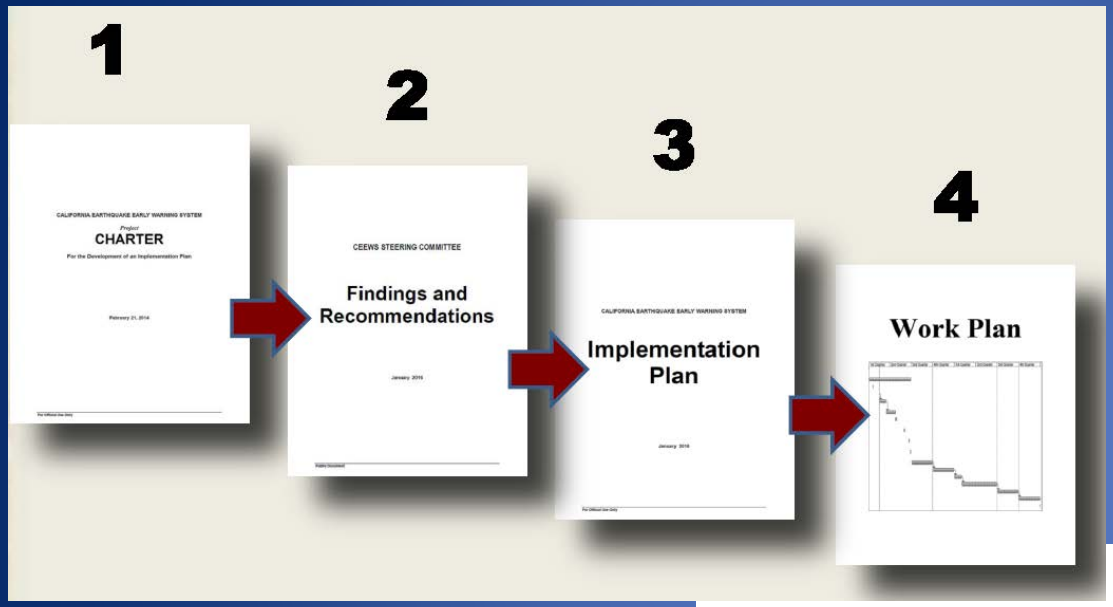
In addition to current network operational costs	California		Pacific Northwest		*West Coast Total*
Construction	$23.1M	+	$15.2M	=	*$38.3M*
Annual M&O	$11.4M	+	$4.7M	=	***$16.1M***

- Add and upgrade sensor networks
- Upgrade field telemetry
- Add infrastructure and personnel for:
  - maintenance and operation (RSNs)
  - testing and certification (centralized)
  - data stream and alert distribution
  - user education and training
- Continued R & D, encourage user applications, etc.

Sensor Networks → Field telemetry → Processing Alert Creation → Alert Delivery → User Actions

CEEWS: Cal OES – Planning Process

CA Code 8587.8: State Implementation Plan by 1/1/2016



Feb 2015
- Committee Reports

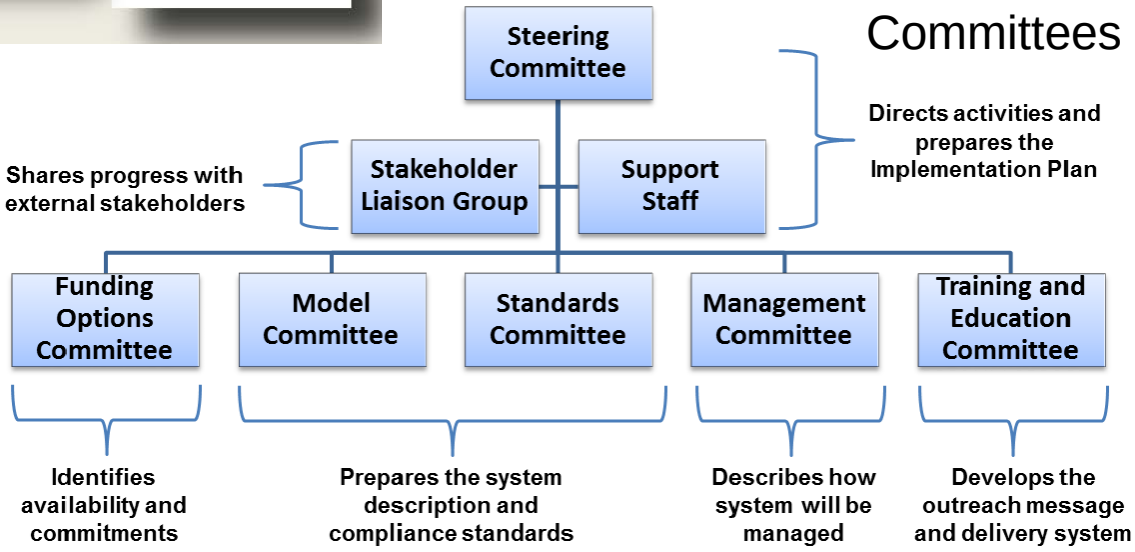
Jul 2015
- Findings and Recommendations

Sep 2015
- Draft Implementation Plan

Jan 2016
- Implementation Decisions Made

Cal OES
GOVERNOR'S OFFICE OF EMERGENCY SERVICES

Committees



Two User Categories

People (the public)

- Integrated education
- Need effective
  - Messaging, "branding"
  - Alert content, sounds
  - Ongoing education

Things (automated)

- Automated situation-aware decision-making
- Private partners will develop user-specific applications

Sensor Networks → Field telemetry → Processing Alert Creation → Alert Delivery → User Actions

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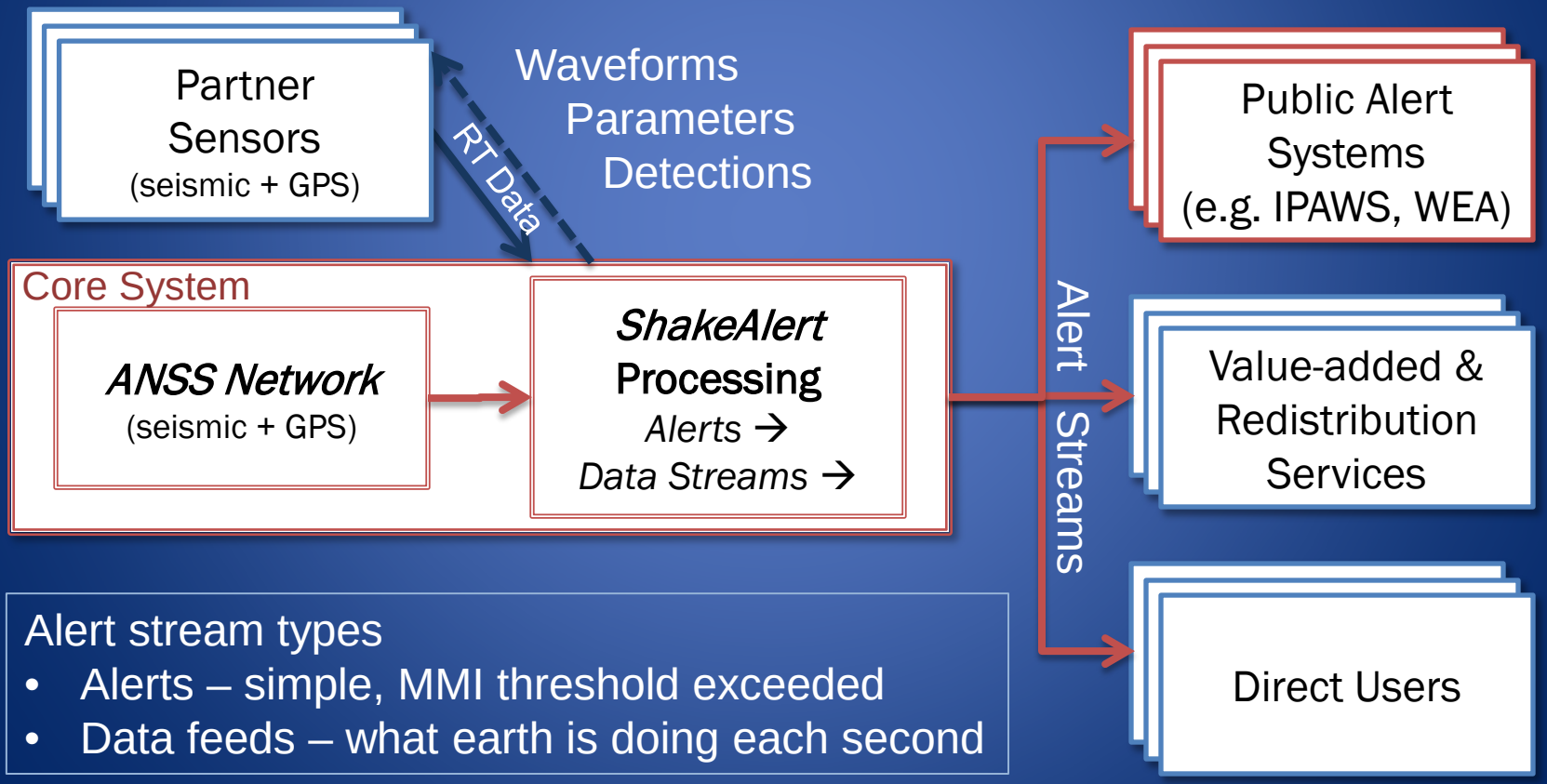
Public - Private Partnership Model

Red = ANSS Blue = partner



Alert stream types

- Alerts – simple, MMI threshold exceeded
- Data feeds – what earth is doing each second

ShakeAlert Beta Users - CA

- Amgen*
- Bay Area Rapid Transit (BART)
- Boyd Gaming , Las Vegas, NV*
- Cal OES, Warning Center
- Caltrans (8 traffic mgmt. centers)
- Caltech Safety/Security
- Disneyland*
- Google.org (crisis response)*
- Los Angeles City, EMD, Police, Fire
- Los Angeles Co. OEM, Sheriff, Fire
- Los Angeles Metro (rail)
- Los Angeles Unified School District
- Long Beach EOC, Fire, PD, Waste, Transportation, Airport
- Metrolink (dispatch)
- Metropolitan Water District
- Ontario City EOC
- Port of Long Beach
- Riverside County OEM/Fire
- San Bernardino OEC/Fire
- San Francisco DEM
- Southern California Edison*
- UC Berkeley OEP
- Universal Studios / NBC*
- US Digital Designs, Inc.*

- CRADA's with:
  - Global Security Systems*
  - Early Warning Labs*
  - More to come…

*** Private company**

Opportunities for Partnership

- Sensors & data
  - Buy & install sensors
  - Host ANSS sensors
  - Make EEW compliant devices
- Telemetry
  - Provide bandwidth
  - Host ANSS equipment
- Alert delivery
  - Integrate with mass notification systems
  - Integrate with apps
- Advocate for the system
- Become a beta tester
  - Prepare for implementation
- Implementation
  - Make, install, service receivers & actuators
  - Develop user-specific decision logic
  - Integrate EEW with current hazard education

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Thank You

http://shakealert.org

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Ground Motion Sensors

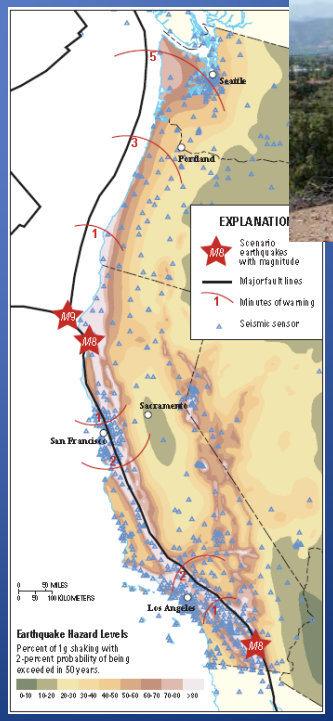
ANSS will:

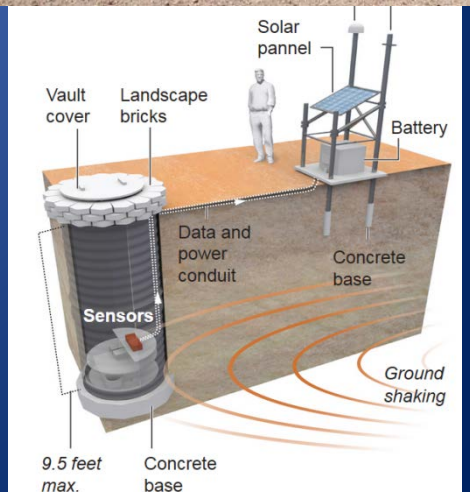
- Add & upgrade stations
  - Both seismic & RT-GPS
- Optimum spacing
  - 10km in urban areas
  - 20km in outlying areas

Partners can:

- Host ANSS sensors
- Install their own sensors
- Provide data communication

ShakeAlert Station Plan	CISN	PNSN	West Coast
	CA	WA,OR	
Total: contributing now	**400**	**224**	**624**
New and Upgraded stations			
Class A: Seismic equipment (ANSS station, BB+SM	125	66	191
Class B: Seismic equipment (Strong motion only)	314	210	524
Total: New and upgrade	**439**	**276**	**715**
Total: Add telemetry	**276**	**60**	**336**
Total: New, upgrade, add telemetry	**715**	**336**	**1,051**
Total EEW stations: current + planned	**1,115**	**560**	**1,675**
*GPS equipment (NetR9 w/ RTX & ant.)**	***150***	***156***	***306***





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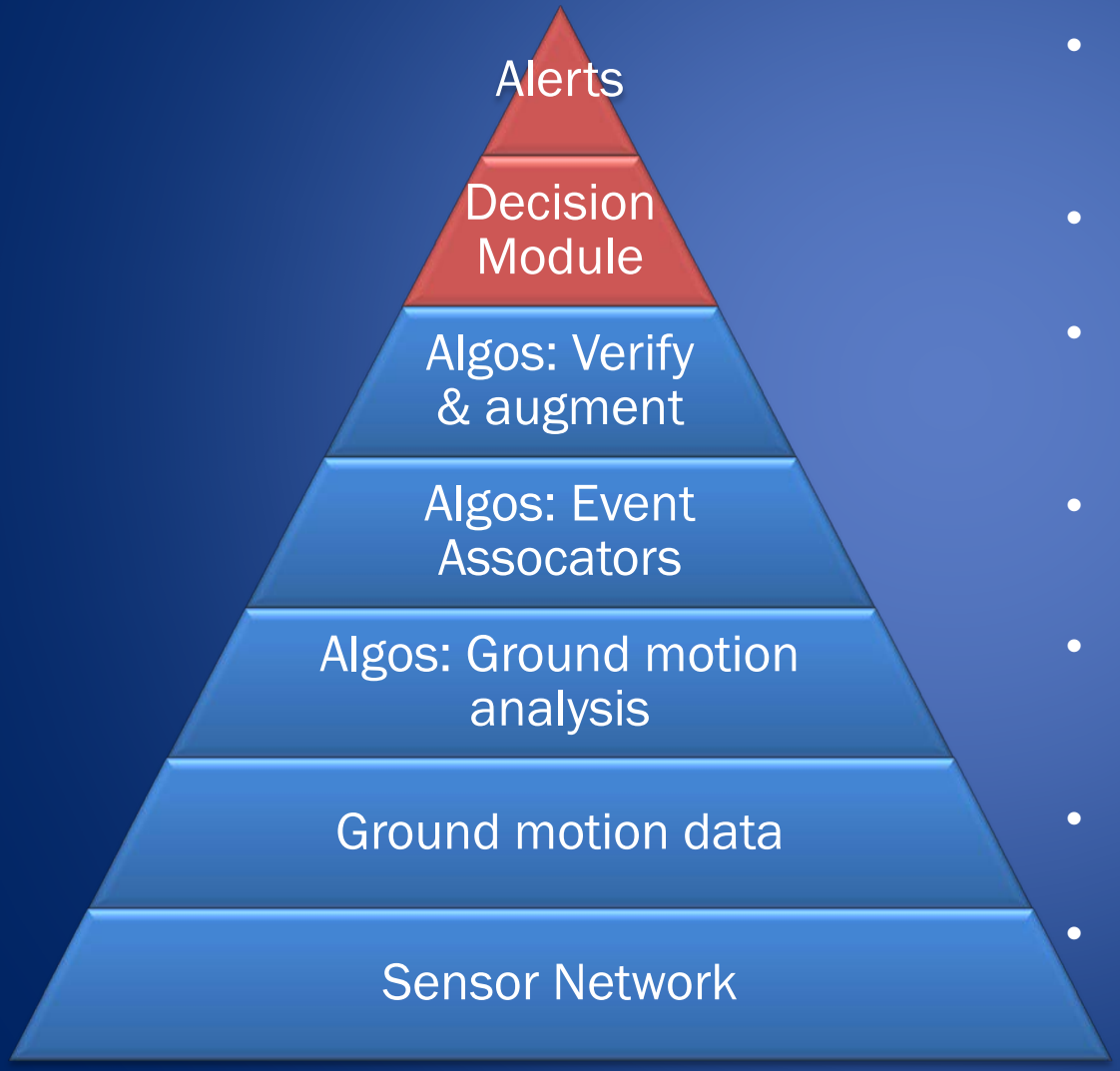

- Alerts and Data streams to public and end users
- DM reconciles various results
- Algorithms verify event detections and add additional information
- Associators detect events and estimate location, mag, likelihood
- Waveform scanners analyze data from channels or stations
- Raw ground motions from sensors
- Field sensors