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USGS
Earthquake Early Warning Coordinator

PNSN – ShakeAlert User Workshop
Sept. 15, 2016

http://shakealert.org

Lead Organizations

USGS
California OES
California Geological Survey
Caltech
UC Berkeley
University of Washington
University of Oregon
Moore Foundation
The Path to ShakeAlert

Development Phases:

I. 2006-2009 – R&D, network upgrades

II. 2009-2012 – operationalize, more upgrades

III. 2012-2015 – Demo to Production Prototype
   - PNW: Demo System - Live Feb. 2015

IV. 2016-2017 – continued improvement, testing
   - add PNW: WC Production Prototype, fall of 2016
   - Target station density in Metro L.A. and Bay Area
   - Pilot applications

V. 2018 – limited public roll-out

VI. ? - Full Public Operation (depends on funding)
Funding Outlook

• **Federal (USGS)**
  - FY14 $1.5 M
  - FY15 $6.5 M
  - FY16 $8.2 M
  - FY17 $8.2 M ($9.2M?) (CR likely)

• **California**
  - FY16/17 $10M
  - FY17/18 $10M?

• **Oregon**
  - 2015-16 ~$1M

• **Moore Foundation**
  - $10.1M

<table>
<thead>
<tr>
<th>Estimate from implementation plan</th>
<th>California</th>
<th>Pacific Northwest</th>
<th>West Coast Total</th>
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<tbody>
<tr>
<td>Construction</td>
<td>$23.1M</td>
<td>$15.2M</td>
<td>$38.3M</td>
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<tr>
<td>Annual Oper.</td>
<td>$11.4M</td>
<td>$4.7M</td>
<td>$16.1M</td>
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**ShakeAlert Funding History**

- Purple: CA
- Green: Redirect
- Red: Add-on
- Blue: Base

<table>
<thead>
<tr>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
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<tbody>
<tr>
<td>$20M</td>
<td>$18M</td>
<td>$16M</td>
<td>$14M</td>
<td>$12M</td>
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<tr>
<td>$10M</td>
<td>$8M</td>
<td>$6M</td>
<td>$4M</td>
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<tr>
<td>$0M</td>
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FY16 USGS Cooperative Agreements
(August ‘16 – July ‘17)

$1.5M in seismic station equipment via USGS contracts

$3.7M (FY16 funds)

- Improve networks (CISN, PNSN) for speed, density, robustness
- Operate the prototype production system in a mission critical mode
- Expand prototype production system to Pacific Northwest
- Improve and create new high-value algorithms (5 in pipeline)
- Encourage and support limited pilot use in fault tolerant applications

- Added University of Nevada, Reno (UNR)
  - Upgrade UNR-operated stations and telemetry in CA
- Added Central Washington University (CWU)
  - Develop improved RT GNSS processing for ShakeAlert
  - Satellite telemetry for GNSS stations in NW Washington
ShakeAlert: Major System Components

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

- ~760 stations contributing
- 1,675 stations needed
- Some still need upgrade
- Priority on metro areas
- Permits & NEPA/CEQA on public lands is challenging
ShakeAlert Testing
Real-time + >100 event test suite
Production Prototype V1.0

- PNW by year end
- Tuning for full west coast integration
- Testing & Certification
  - Now has PNW events
  - In the test queue
    - OnSite improvements
    - Elarms improvements
    - FinDer (finite fault)
    - 64-bit Linux
- Robust enough for pilots
Two End-User Categories

**People** (employees, public)
- Needs effective
  - Alert mass notification
  - Alert content, sounds
  - Messaging, “branding”
  - Ongoing education

**Things** (automated systems)
- Needs effective
  - Alert delivery
  - Pre-set, situation-specific decision logic, actuators
  - Private tech developers
ShakeAlert Data Products

Source parameter stream
- Latitude/longitude, depth
- Magnitude
- Origin time
- Finite fault – coming soon
- May update more than once per second
- User calculated MMI & time
- XML format

Intensity polygon stream
- In development
- Ground motion estimates (MMI)
  - “Strong shaking” (>II)
  - “Weak shaking” (>V)
- Simple polygons
- CAP format

\[\text{Intensity polygon stream} \quad \begin{cases} \text{In development} \\ \text{Ground motion estimates (MMI)} \\ \quad \begin{cases} \text{“Strong shaking” (>II)} \\ \text{“Weak shaking” (>V)} \end{cases} \\ \text{Simple polygons} \\ \text{CAP format} \end{cases} \]
Alerts are Not Simple

- Must be **fast** to be effective
- Large earthquake **fault ruptures**
  - are **long and complex**
  - **grow** over time (seconds to minutes)
- **Alert area** is **large, complex, growing**
- Effective alerts need
  - fast delivery
  - detailed alert areas (polygons)
  - frequent updates
- This is challenging for current alert delivery technology
Earthquake Alerts are Not Simple

• Current alerting systems assume a single alert in a simple pre-defined region or polygon
  • Example: tornados
  • Two levels: watch & warning

April 20, 2004 NWS Tornado Warnings for the Granville to Utica Tornadic Storm

County Based Warnings (2004)  Storm Based Warnings (Implemented 2007)

Northridge Earthquake
Mass Notification Technologies

- Internet
- IP push notifications
- IoT (e.g. NEST)
- Cellular Broadcast
- Radio and TV broadcast
- Digital radio
- Satellite
- Purpose build systems?
Limitations of Mass Alerts over Cellular

• ~10% of adults don’t have cell phones, not all areas covered

• Text messages (SMS)
  – flood cell carriers capacity, slow
  – text takes too long to read

• Apps & push notifications
  – flood cell carriers capacity, slow
  – non-uniform handling
  – low app retention, fees

• Cell broadcast (IPAWS/WEA)
  – faster, more efficient but still too slow
  – 90 character text message
  – all alerts sound the same
Cell Broadcast - Two-Step Alerts

First Message
- Fast (<3 seconds?) over control channel
- Little information (2 levels)
  - “Weak shaking expected”
  - “Strong shaking expected”
- Pre-programmed response on the phone

Second Message
- Slower (~10 seconds?)
- More information
- Short term: (1-2 years)
  - Text content only via WEA
  - 90 → 360 characters?
- Long term: >2 years
  - New message type
  - Info to calculate user-specific time and intensity in the phone
  - Receiver geolocation limitations

Japan ETWS based on 3GPP TR 23.828
ShakeAlert Communications, Education & Outreach (CEO)

- Joint CEO Working Group (CA, WA, OR, BC)
  - Coordinate CEO & pilot implementations
  - Social science R&D
  - Developing alert content
    - Messages (text, voice)
    - Sounds, signals, lights
  - Pre-event education and training
  - Integrate with other earthquake-related CEO
ShakeAlert Roll-out Plan

Steps

- **Pilots** - selected fault tolerant use
- **Automated Actions** - wider industrial use, transportation
- **Limited people alerts** - groups who can be trained
- **Expanded people alerts** in public venues (no advance training)
- **Geographically limited** public alerts (where network is dense)
- **Full public alerts** via all available pathways

- **Encourage responsible use of alerts**
- **Pace applications with system capabilities**
ShakeAlert Pilot Projects

Pilot Project Criteria

- No public alerting
- Actions only within pilot organizations
- Must be tolerant of errors
- No potential for injury, damage or loss
- Users must be trained
- Limited to areas with effective alerts
- Must be testable
- Must not duplicate other pilot projects
- Must commit organizational resources to complete and sustain the project
- Should be potential for broader application

Pilot Process

1. Develop pilot idea
2. Identify pilot user
3. Identify pilot partners
4. Discuss with local ShakeAlert POC
5. Fill out pilot application
6. Get project approval
7. Sign license agreements or TAA
8. Do the implementation
9. Evaluate success
<table>
<thead>
<tr>
<th>Sector</th>
<th>Current Betas</th>
<th>Current &amp; Likely Pilots</th>
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</thead>
<tbody>
<tr>
<td>Automated controls (commercial, home)</td>
<td>EWL, GSS</td>
<td>EWL, GSS, ArxPax</td>
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<tr>
<td>Education, schools</td>
<td>LAUSD, Redwood Empire, USC, Universities (UW, OU, UCB, Caltech)</td>
<td>LAUSD</td>
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<tr>
<td>Emergency Management</td>
<td>WA, OR, CA, BC plus many counties, cities</td>
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<tr>
<td>Entertainment Venues</td>
<td>NBC/Universal, Disney, Boyd Gaming, Dodgers</td>
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<tr>
<td>EOC management tools</td>
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<td>BofA</td>
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<td>Industrial / Commercial / Manufacturing</td>
<td>Boing, Intel, Paccar</td>
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<td>Information Technology (IT)</td>
<td>Microsoft, Intel, Google, Facebook</td>
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<td>Insurance</td>
<td>RESIG</td>
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<tr>
<td>Mass Media</td>
<td>RTNA, KTLA, KCBS, NBC/Universal, KABC, KNX, iHeart radio, KQED</td>
<td>iHeart</td>
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<td>Mass Notification (private)</td>
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<td>Everbridge</td>
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<td>March AFB, US Navy (NAS Whidbey Is.)</td>
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<td>Utility, water</td>
<td>LADWP, EBM, MWD, Seattle</td>
<td>RH2</td>
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Other Activities

- CalOES/CSSC/PEER benefits report
- GAO report - pending
- ExCom writing ShakeAlert research plan
- FCC rules changes to speed up IPAWS/WEA
- Work on permitting with USFS

- USGS testing low cost sensors in Chile
- EEW Feasibility studies
  - Hawai’i (Moore funded)
  - Alaska (Senate Request)
## Roll-out Plan Goals

### Steps

- **Pilots** - selected fault tolerant use
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### Goals

- Gain support, develop capability
- Encourage practical uses, public benefits, broader user base
- Test training and education strategies, public reaction
- Test alert effectiveness without training, public reaction
- Test general public training and reaction
- Develop large scale public education & multiple alert paths

- **Encourage responsible use of alerts**
- **Pace applications with system capabilities**
Challenges

- Full, ongoing funding
- Coordination among stakeholders
- Creating the system interface with business
- Station permits/NEPA
- Testing the system with big events
- User education
  - train for fast response
  - infrequent hazard
- Limits of mass notification technology