ShakeAlert – Earthquake Early Warning

Doug Given
USGS, Pasadena
Earthquake Program,
Early Warning Coordinator

USGS Earthquake Hazard Responsibilities

• USGS has the lead federal responsibility to provide notification and warnings for earthquakes, volcanoes, and landslides. (Stafford Act, P.L. 92-288)

• Pre-earthquake products
  - for planning and preparation

• Post-earthquake products
  - for situational awareness

• Earthquake early warning is a developing capability to reduce earthquake losses
Time Scales of Quake Information

Hazard Assessment | Forecast | Prediction | Early Warning | Situation Assessment
--- | --- | --- | --- | ---
Long Term | Inter. Term | Short Term | | |
100's – 10's yrs | months - hours | | | Minutes – weeks after
years - months | | | | seconds

Earthquake
National Hazard Map

USGS National Seismic Hazard Map

Notable earthquakes in past decade

M5.2
M6.0
M5.4
M5.6
M6.5
M6.0
M6.6
M5.4
M7.2
M5.6
M5.2
M5.8
M4.9
M5.1
M7.9
M6.0
M7.2

National Hazard Map: a Tool for Performance-Based Seismic Design

Seismic element of NEHRP Provisions and Int'l Building Code are based on the USGS national seismic hazard map
Time Scales of Quake Information

- **Hazard Assessment**
  - Long Term
  - Inter. Term
  - Short Term

- **Forecast**
  - 100’s – 10’s yrs
  - years - months

- **Prediction**
  - months - hours

- **Early Warning**
  - minutes – weeks after

- **Situation Assessment**
  - Seconds

**Legend**
- Time Scales of Earthquake
- Prediction
- Early Warning
- Situation Assessment
ShakeMap
(ShakeCast)

DYFI?
Did You Feel It?

PAGER
Prompt Assessment of Global Earthquakes for Response

Post-Earthquake Information Timeline
(domestic earthquake)
USGS and its partners are developing an EEW system for the U.S.

ShakeAlert: Earthquake Early Warning

M 7.8 Scenario Fault Rupture

Rupture speed = 2 mi/sec
P-wave speed = 3.5 mi/sec
S-wave speed = 2 mi/sec
Two Types of EEW

- **On-site EEW**
  - Local sensor
  - Shorter warning time
  - S-P time
  - Simple, low cost
  - Less reliable

- **Network EEW**
  - Sensors near source
  - Longer warning time
  - S-wave travel time
  - More complex
  - More reliable

Summary of Estimated Warning Time
Earthquake Begins

M7.8 SoSAFZ Scenario

Stations Sense Shaking
Warning Issued

Strong Shaking Arrives – Palm Springs
Strong Shaking Arrives – San Bernardino

Strong Shaking Arrives – Orange Co.
Strong Shaking Arrives – Los Angeles

Who’s Doing EEW?

Richard Allan, UCB
Mexico City Early Warning System (SAS)

http://www.cires.org.mx/

Japanese EEW system

- Spent $500M on EEW after the M7.2 1995 Kobe earthquake killed 6,400
- Public warnings since Nov. 2007
Japan: Communicating the warning

- TV and radio announcements
  - 124 of 127 TV stations (98%)
  - 41 AM, 35 FM radio (75%)
- J-Alert messages
- 226 municipalities receive the warnings
- 102 announce them with public address systems
- Cell phones
  - 3 companies (Docomo, AU, Softbank)
  - 52 million can receive them (47%)
- Dedicated providers serve
  - power plants
  - factories
  - schools
  - hospitals
  - shopping malls

earthquake location and hazard
estimated shaking in your area

earthquake location and hazard
estimated shaking in your area
Tohoku M9.0 – EEW Alert

The good:
• Alert was sent in ~9 sec
• Millions of people got 5 – 40 sec warning

The not-so-good:
• JMA underestimated
  • magnitude (8.1)
  • intensity
  • area affected
  • missed aftershocks

EEW Development in the U.S.

USGS Funded Research & Development

Phase I (2007-2009) $750k
  • Develop and test three approaches (algorithms)
Phase II (2010-2012) $1.25M
  • Create demonstration system and partner with test users
Phase III (2012-2015) ??
  • Implementation

ARRA funding (2010-2011)
  • ~$20M to modernize stations nationally & speed up data
EEW Development in the U.S.

Moore Funded Research
2012-2014  $6M
• Continue research and development of algorithms
• Build prototype system
• Include Cascadia (U.W.)

Evolutionary Implementation
→ Research & Development
  → Demonstration
  → Prototype
  → Operation

What’s needed?

• Additional seismic sensors (leverage existing networks)
• Robust, resilient data communications
• Continued R&D – finite faults, GPS
• Staff and organization dedicated to EEW
• Standards & testing
• Multiple, robust notification methods
• Education and training

Estimated cost of a California system:
• $15-20M/yr for 5 years to build it
• $5-10M/yr to operate
Thank You

Doug Given

Earthquake Early Warning Coordinator,
USGS Earthquake Hazards Program

earthmagazine.org