Earthquake Early Warning System Notifications: *Leveraging the Power of the Commercial Cellular Network*

Panelists:

Mark Johnson

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Director, Core Network & Government/Regulatory Standards, AT&T

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Director of Engineering, Qualcomm

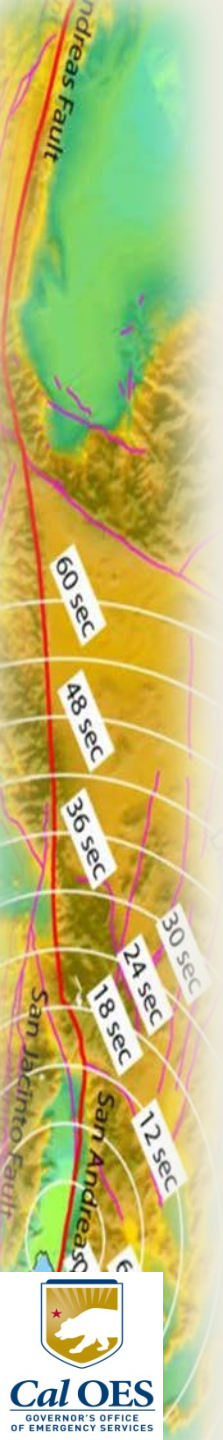
Moderator:

Steve Barclay

Director, Global Standards Development, ATIS

Agenda

- **California Earthquake Early Warning System**
  - Mark Johnson, California Governor's Office of Emergency Services
- **ATIS Feasibility Study for Earthquake Early Warning**
  - Brian Daly, AT&T
- **Earthquake Early Warning System: Technical Analysis**
  - Farrokh Khatibi, Qualcomm
- **Conclusions and Next Steps**
  - Brian Daly, AT&T
- **Questions & Answers**
  - Steve Barclay, ATIS



California Earthquake Early Warning System

(CEEWS)

MARK R. JOHNSON
Branch Chief
Earthquake and Tsunami Program
Governor's Office of Emergency Services

Background

SB135 (Padilla)
Government Code Section 8587.8

Our Task

- Develop a comprehensive statewide earthquake early warning system in California through a public private partnership
- Identify funding sources by January 1, 2016
- Must not specify the General Fund as a funding source
- Approved by Governor Brown September 24, 2013

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Current Legislation

SB494 (Hill)

As of July 14, 2015

The bill would:

- Create the California Earthquake Safety Fund
- Require appropriated funding to be used for:
  - Seismic safety
  - Earthquake-related programs
  - Earthquake early warning
- Authorize the fund to accept external funds (federal, local, bond funds and private sources)

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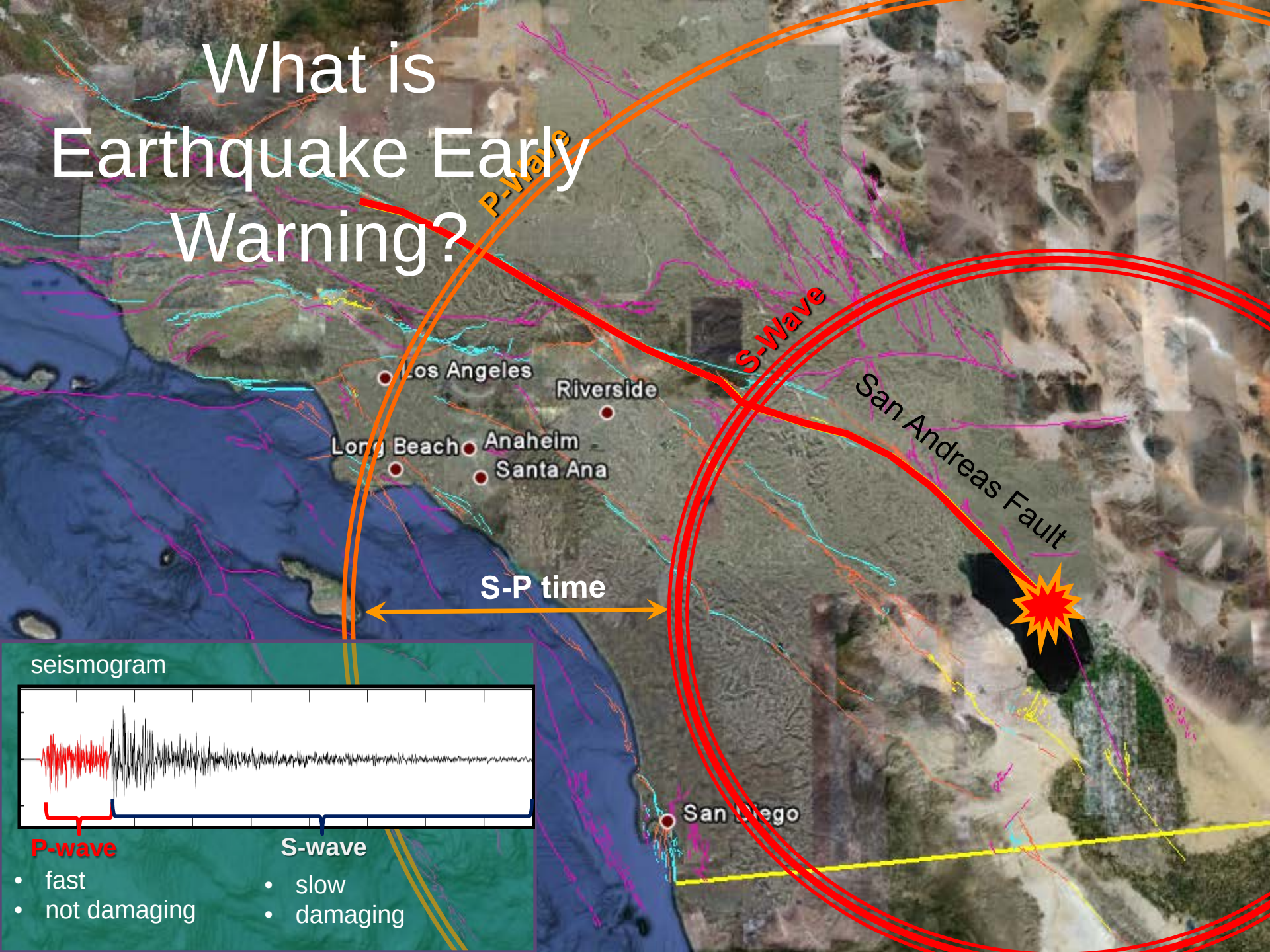
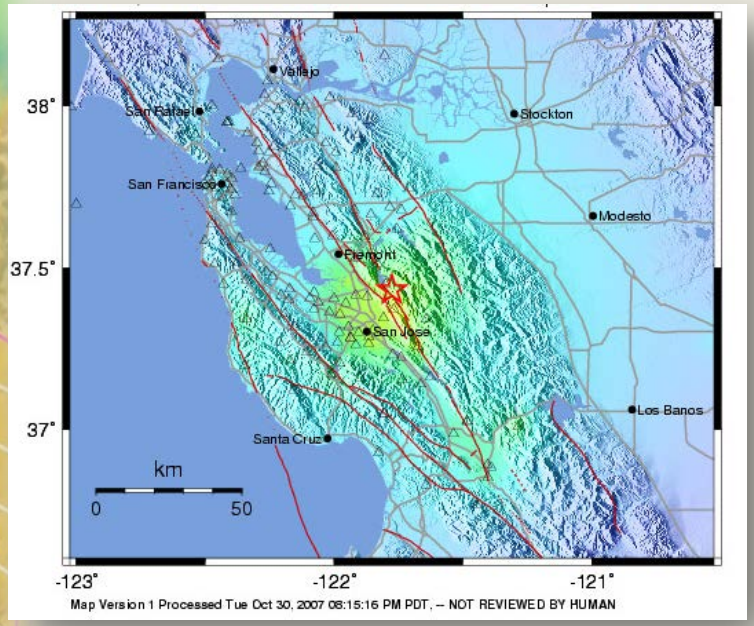
What is Earthquake Early Warning?

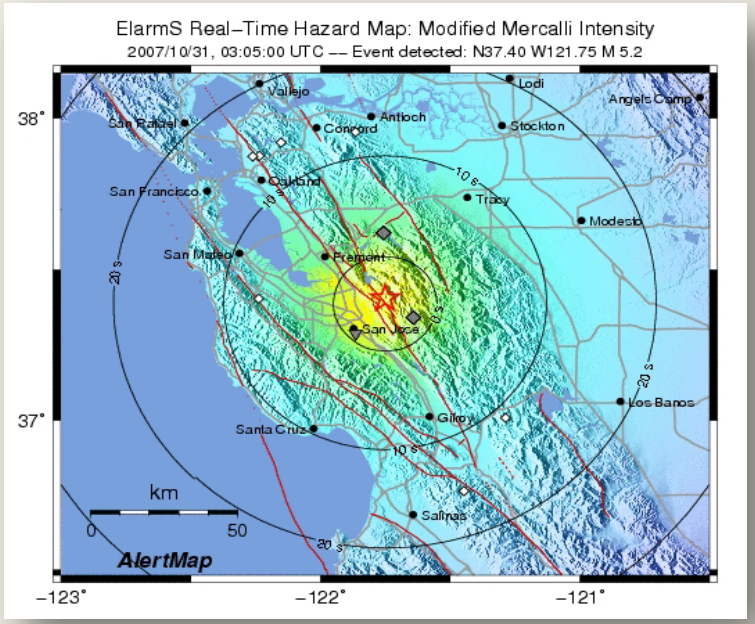


- fast
- not damaging

- slow
- damaging

Goal





Today:

ShakeMap in 5-10 minutes

- Location
- Magnitude
- Ground shaking

Goal:

Provide advance notification tens of seconds before shaking

- People move to safe zones
- Slow and stop trains (BART, Metrolink)
- Isolate hazards (equipment, chemicals)

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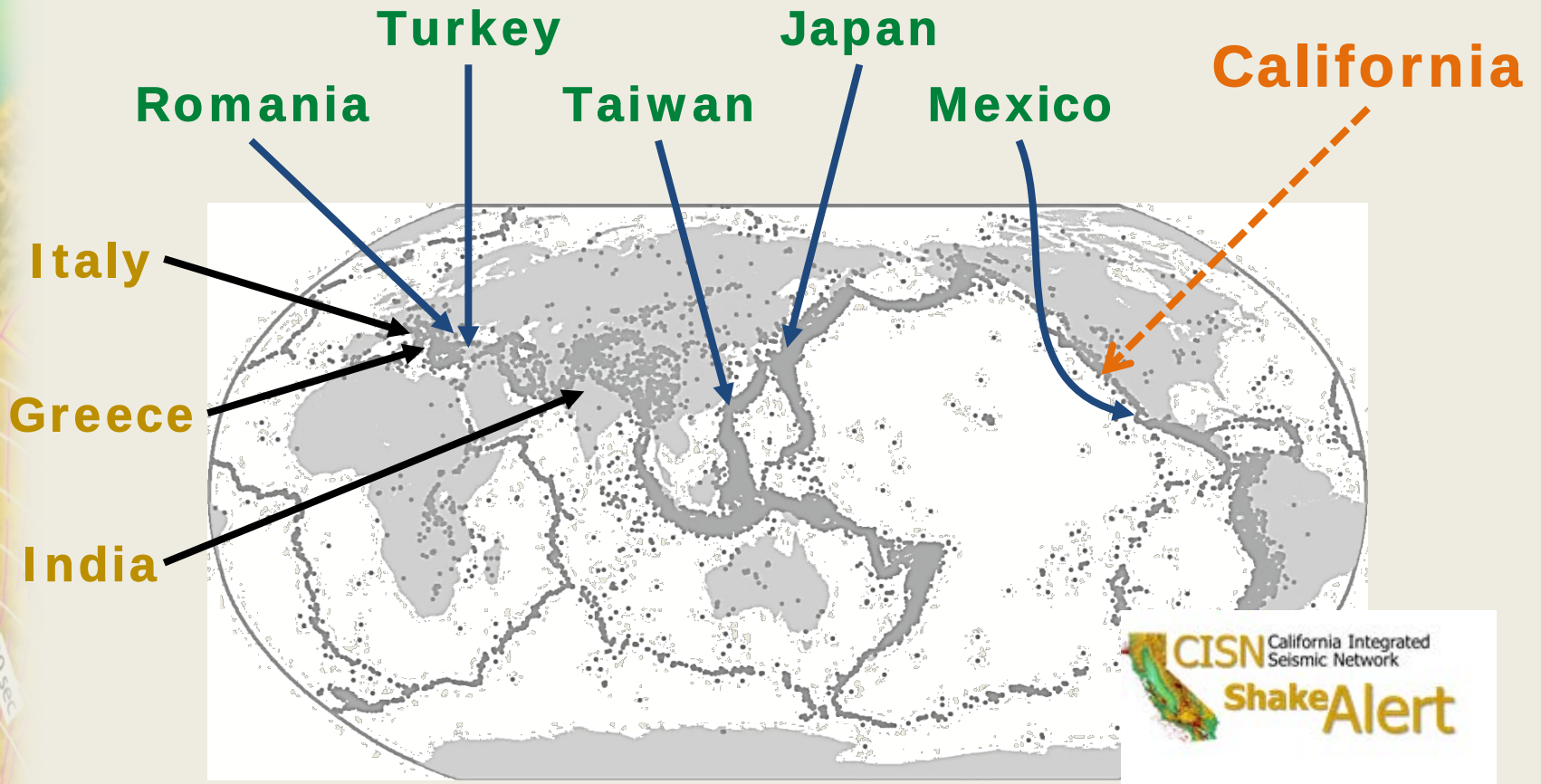
Where is Early Warning Used?



Systems under development

Operational Systems

Demonstration System

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General Benefits

- Supports hazard mitigation
- Promotes safer environments
- Investments can be cost effective
- Could result in lower insurance costs
- Individual efforts can contribute to a statewide system

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Examples of Specific Benefits

- ***General Public:*** Citizens, including school children, might have time to drop, cover, and hold on.
- ***Motorists:*** Motorists could be afforded a few seconds to safely stop vehicles.
- ***Businesses:*** Employees and customers can take actions to protect themselves.
- ***Construction:*** Construction workers could move to safer locations.
- ***Medical:*** Surgeons, dentists, and others could stop delicate procedures.
- ***Elevators:*** Could be programmed to stop and open doors at the nearest floor in order to prevent occupants from being stranded.
- ***Fire Stations:*** Doors could open before being damaged, delaying emergency response.
- ***Industry:*** Production lines could be shut to reduce damage. Sensitive equipment could be placed in a safe mode. Chemicals and other hazardous materials could be secured.
- ***Utilities:*** Electric generation facilities could prepare for strong shaking and protect the grid. Gas and water main controls can be automated.
- ***Transportation:*** Trains could be slowed or stopped to avoid derailing. Inbound aircraft could be automatically advised to divert to other airports.

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Limitations

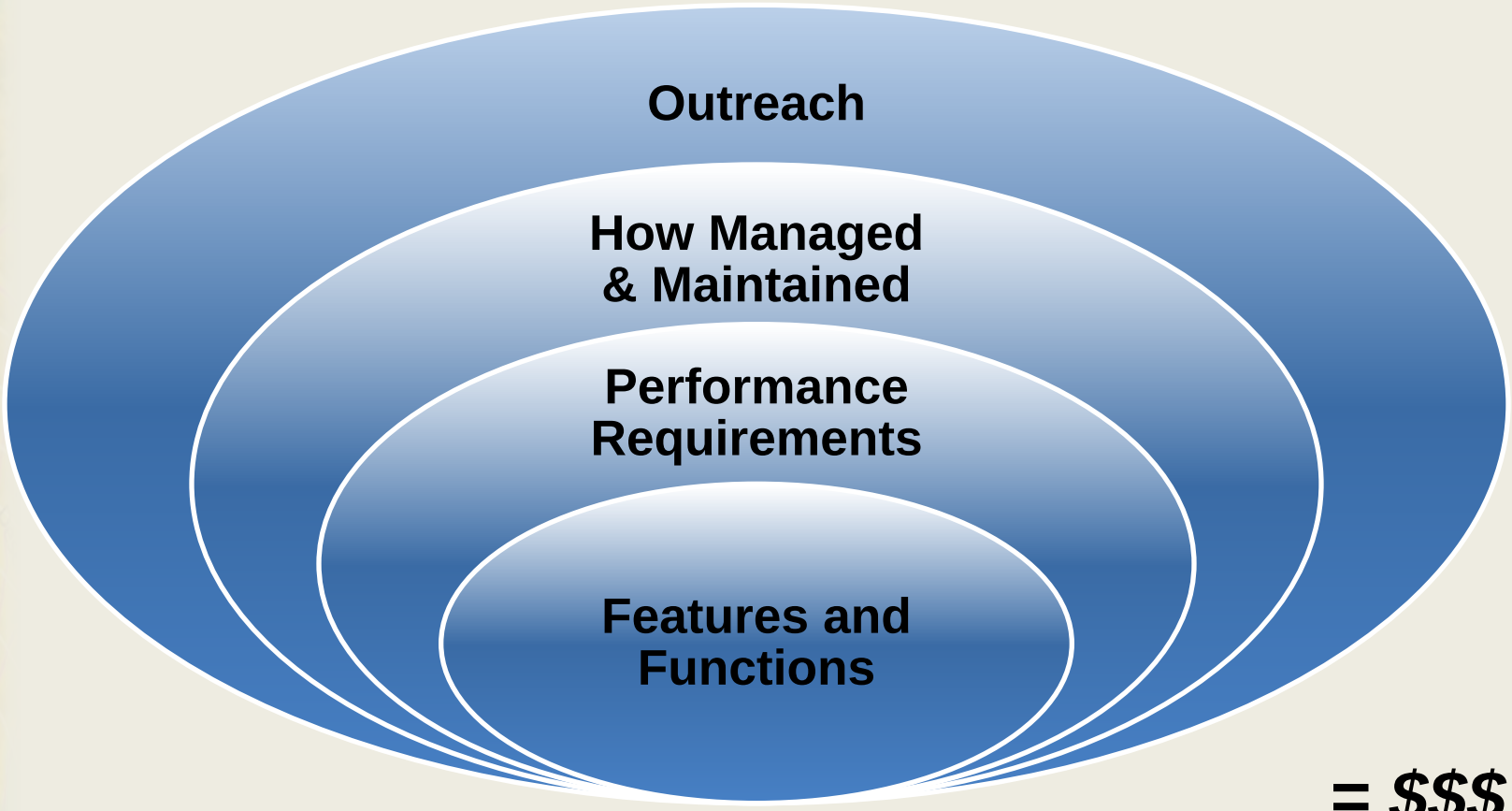
Early Warning will be challenging in California

- ***Variables:*** Many faults and infrequent large events.
- ***Blind Zones:*** Locations of limited sensor coverage.
- ***Missed Events:*** Due to no receipt of data.
- ***False Alarms:*** Negative reporting.
- ***Very Large Earthquakes:*** (>M8) Ruptures over a period of minutes rather than seconds. Early warning systems must send out alarms quickly, before the earthquake has fully ruptured.

Challenges

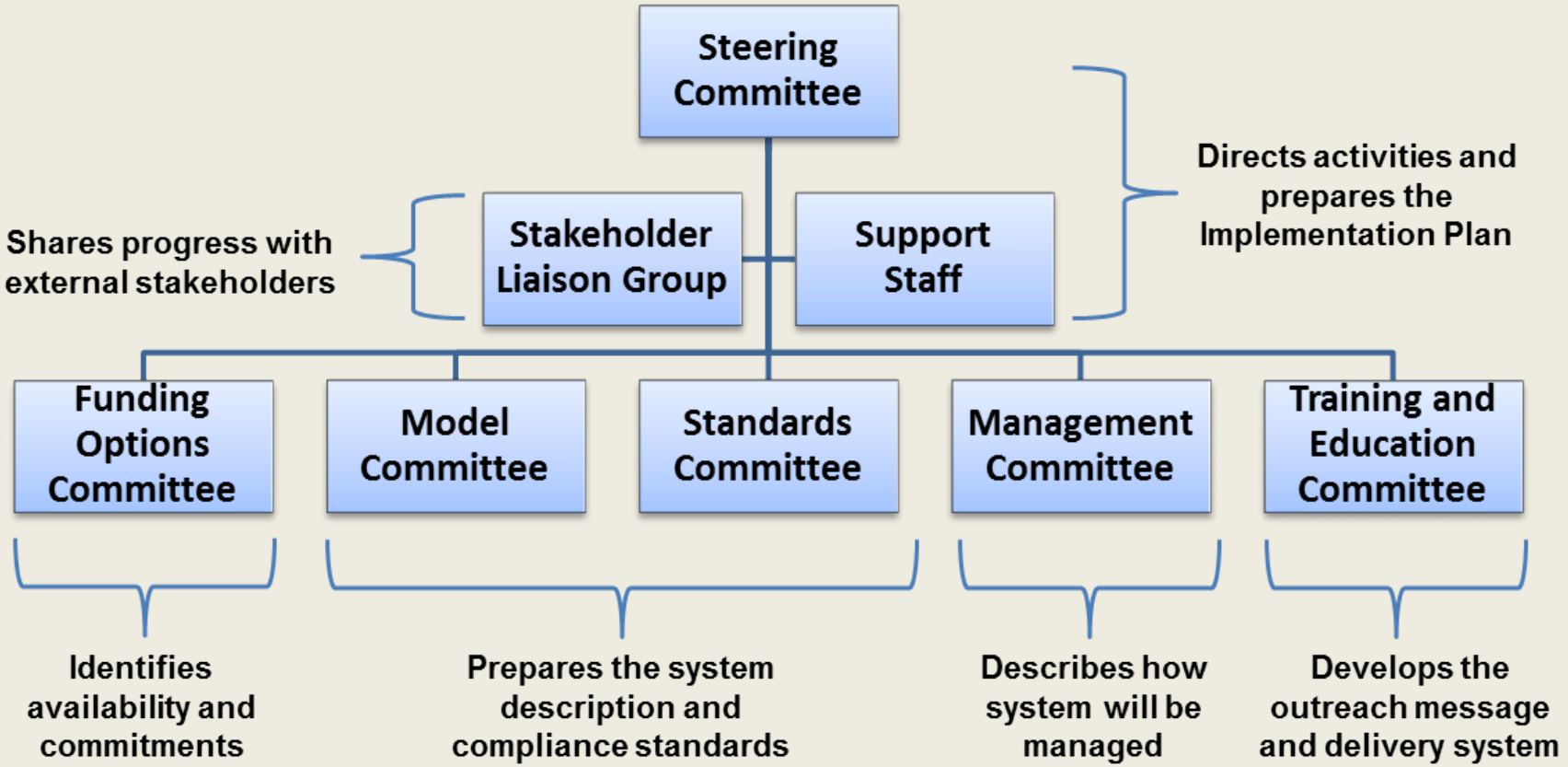
- ***Funding***
- ***Governance Authority*** for program administration
- ***Coverage*** with enhanced seismic sensors
- ***Coordination*** of multiple implementation plans
- Ensuring ***Reliable*** reporting
- ***Sustainment*** of operation and maintenance
- Public ***Education*** campaign

Project Scope



= $$$

CEEWS Steering Committee



Build Upon Existing System

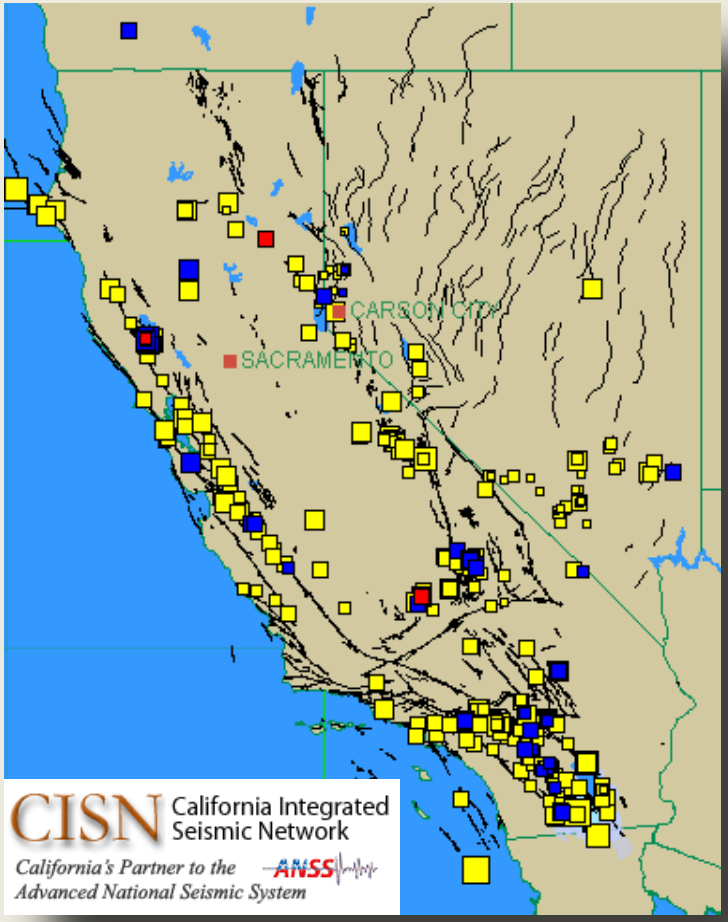
California Integrated Seismic Network

- ***Within Seconds:***

  Provides detection, magnitude, depth, location and time

- ***Within 15-30 Minutes:***

  Provides worldwide earthquake coverage from global partners

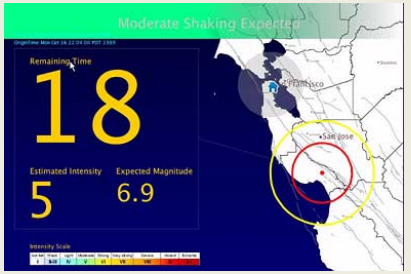


CGS USGS CalOES Caltech UC Berkeley

Build Upon ShakeAlert

CISN California Integrated Seismic Network

ShakeAlert



USGS science for a changing world

California Institute of Technology 1891

University of Washington 1861

ETH

SCEC an NSF+USGS center

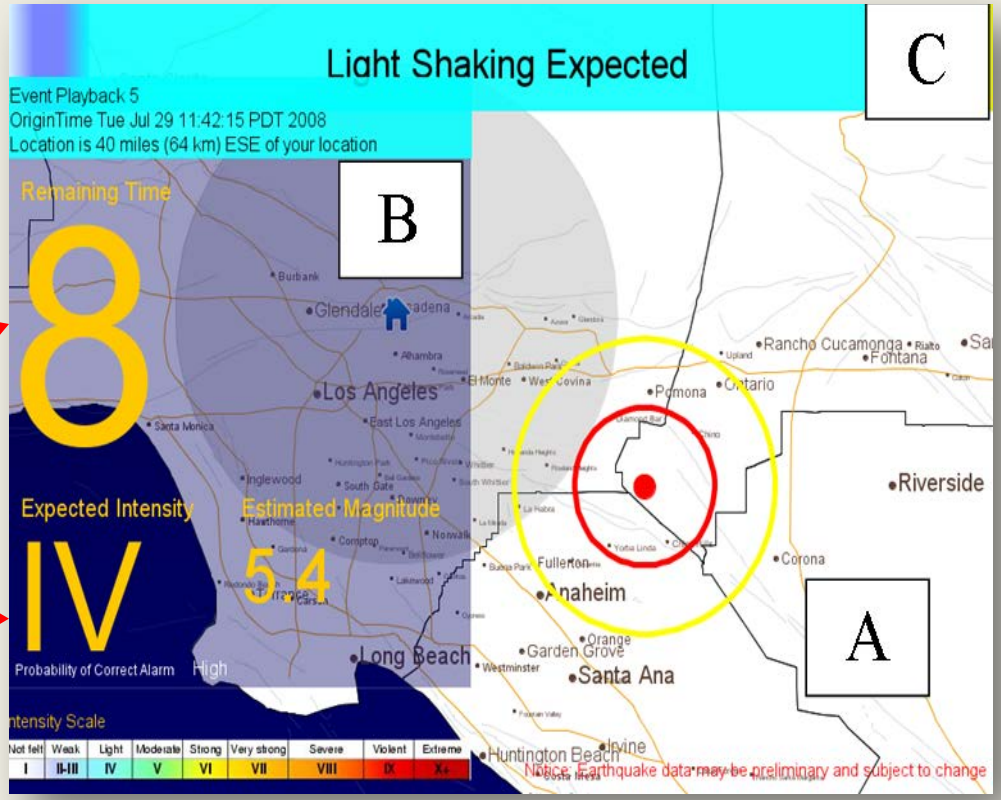
University of California Berkeley Seismological Laboratory

Gordon and Betty Moore Foundation

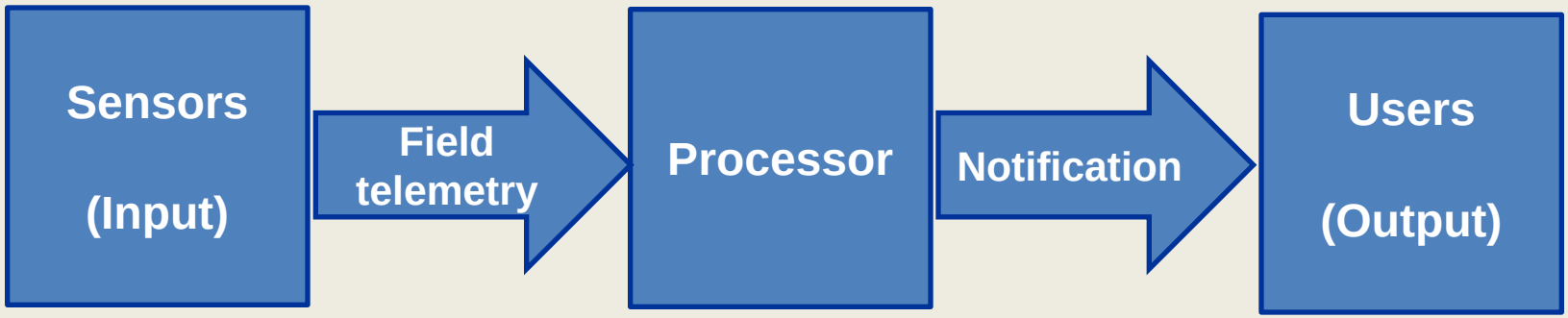
Cal OES Governor's Office of Emergency Services

ShakeAlert Prototype

- **Pops up when alert is received**
- **Calculates and displays:**
  - Countdown of remaining time until shaking starts
  - Expected local shaking intensity at user site
- **Stores alerts for replay**



System Description



Output Applications

- **Internet:** Via ***ShakeAlert*** and other applications
- **Public Alert System:** Message distributed to radio, television, EAS/IPAWS receivers
- **Wireless Telecommunications:** Message distributed to smart phone applications
- **Data Distribution:** To direct users and redistribution services

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Outreach and Education

Earthquake Early Warning: Dos & Don'ts

When Driving

- Don't slow down suddenly
- Turn on your hazard lights to alert other drivers, then slow down smoothly
- If you are still moving when you feel the earthquake, pull safely over to the left and stop

Remain calm, and secure your personal safety based on your surroundings!

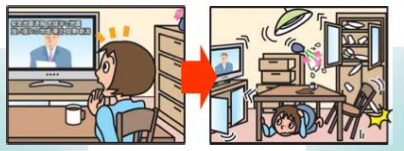
After seeing or hearing an Earthquake Early Warning, you have only a matter of seconds before strong tremors arrive. This means you need to act quickly to protect yourself.

Outdoors

- Look out for collapsing concrete-block walls
- Be careful of falling signs and broken glass
- Take shelter in a sturdy building if there is one close enough

At Home

- Protect your head and shelter under a table
- Don't rush outside
- Don't worry about turning off the gas in the kitchen



In Public Buildings

- Follow the attendant's instructions
- Remain calm
- Don't rush to the exit

On Buses or Trains

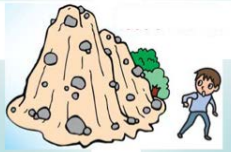
Hold on tight to a strap or a handrail

In Elevators

Stop the elevator at the nearest floor and get off immediately

Near Mountains/Cliffs

Watch out for rockfalls and landslides



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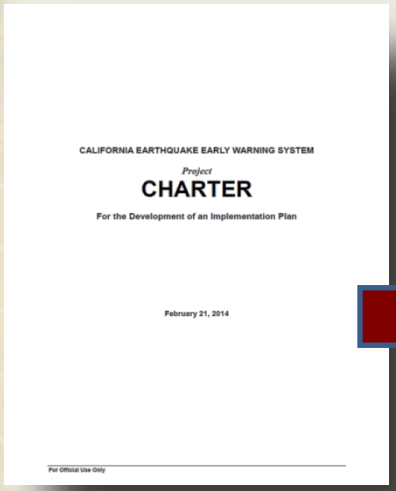
Cost Factors

1. Initial ***construction*** costs
2. New or upgraded ***seismic stations*** & GPS stations
3. Significant field ***telemetry*** upgrades
4. Annual ***operation*** and maintenance
5. ***Staffing*** for:
   - Implementation and testing
   - Operation and user outreach
   - Continued research and development

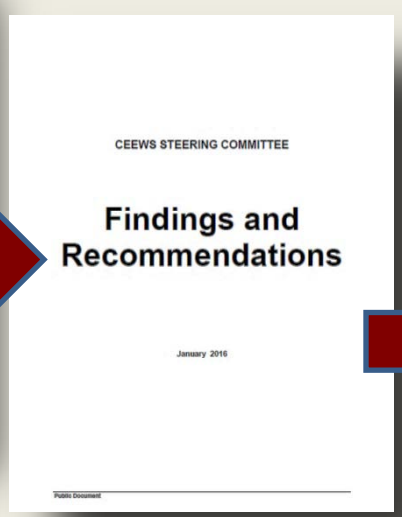
Development Phases

1



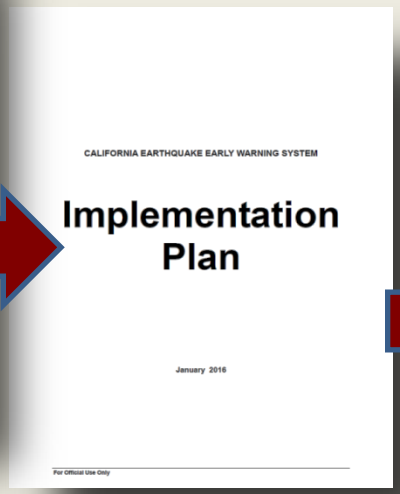
2014

2



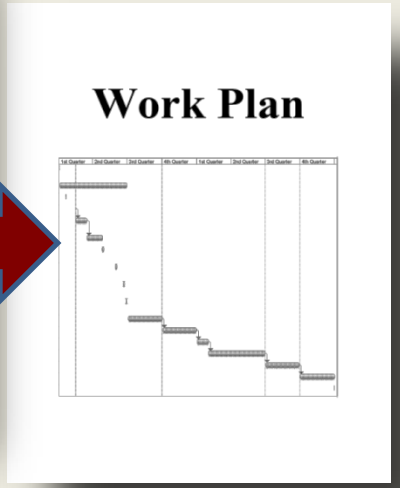
2015

3



2016

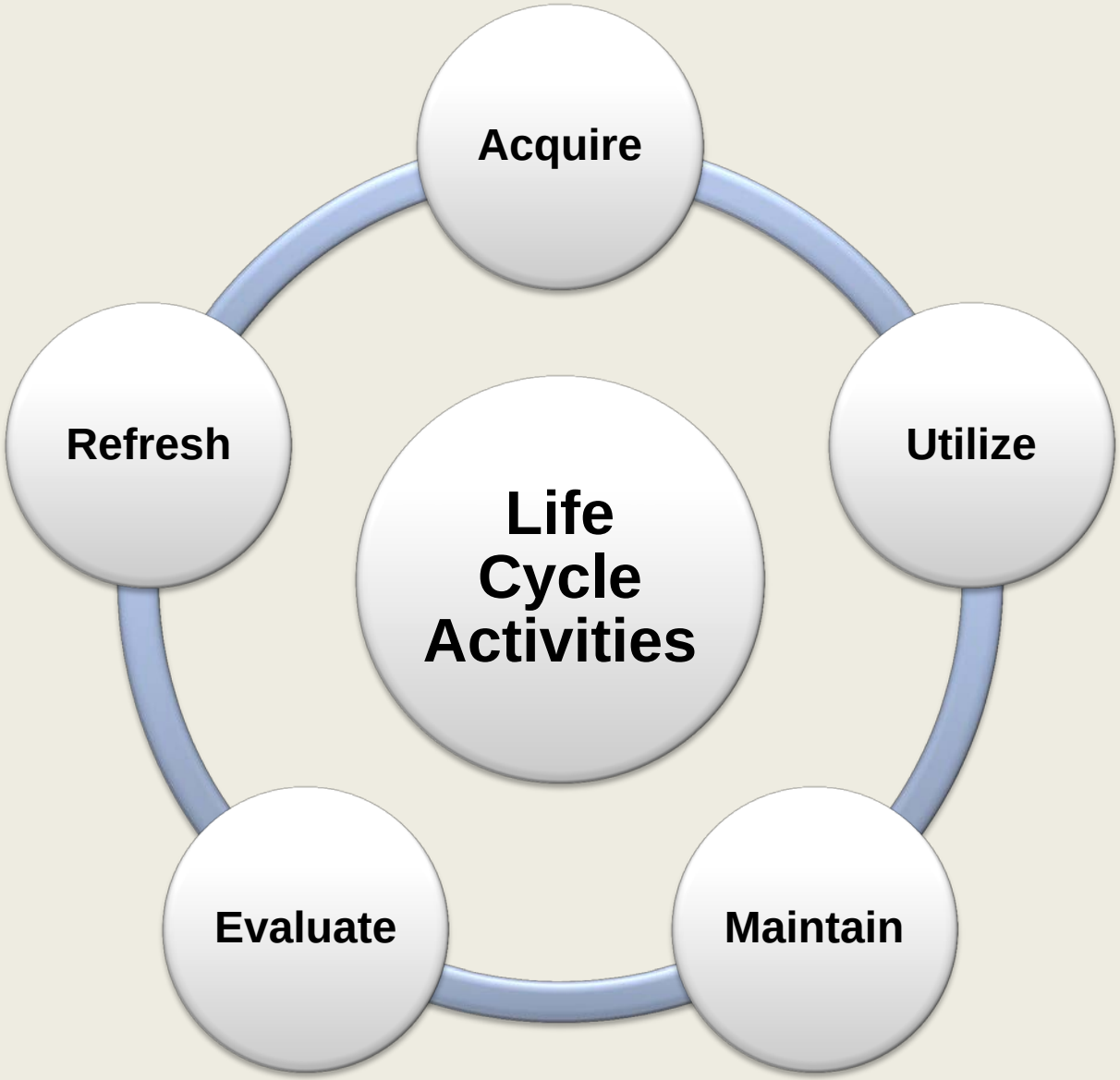
4



2016 +

Implementation Strategy

Implementation Concept



Next Steps

- ***Schedule workshops to develop the CEEWS Implementation Strategy***

1. CISN Partners
2. **Telecommunications** (Private Sector, ATIS, CPUC, CUEA, CISN Partners)
3. Utilities (Private Sector, CPUC, CUEA, CISN Partners)
4. Rail Transportation (HSR, BART, Metrolink, Commercial Carriers, CISN Partners)
5. Other Sectors

For more information:

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"Advance notification occurs with CEEWS"

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ATIS Feasibility Study for Earthquake Early Warning

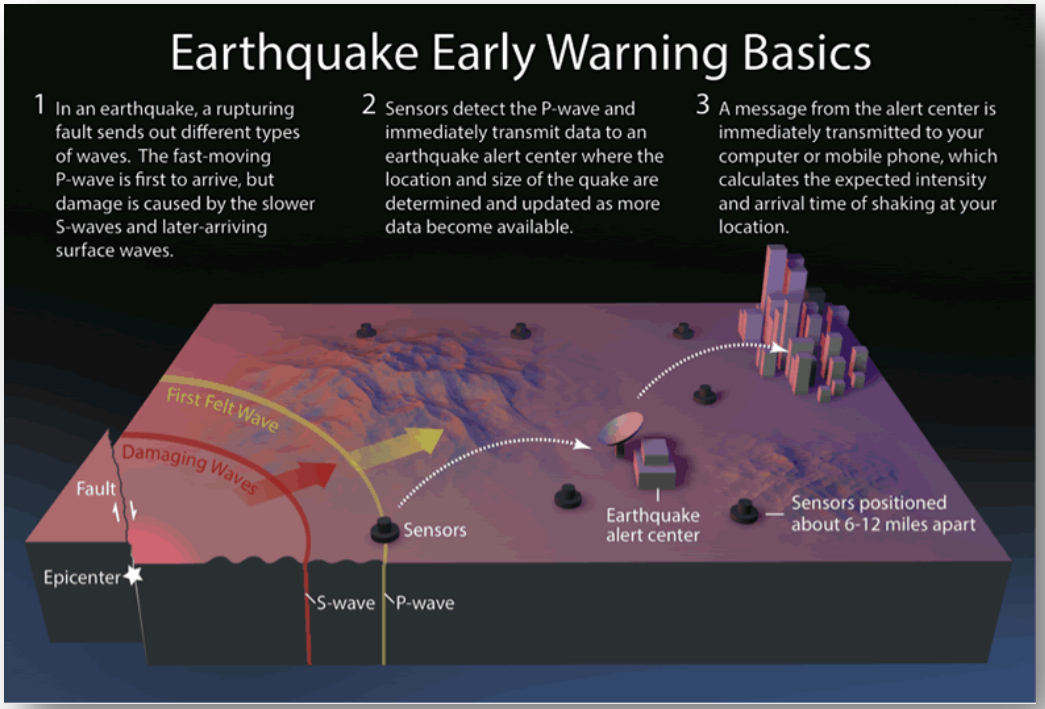
Brian Daly
Director, Core Network &
Government/Regulatory Standards
AT&T

Introduction & Definitions

- ATIS completed a feasibility study to evaluate techniques to distribute Earthquake Early Warning (EEW) notifications to the general public through cell phones via the cellular network as a way to complement the California Integrated Seismic Network (CISN)
- EEW Notification is the notification broadcast by the cellular network to cell phones in a specified geographic area following receipt of an indication from an Earthquake Warning Center that an EEW Notification should be broadcast
- An EEW Notification contains limited information
  - Indication of imminent danger using a standard display of a short earthquake warning message which is pre-configured in the cell phone

Earthquake Early Warning Principles

- Objective:
  - Rapidly detect the initiation of an earthquake
  - Estimate the level of ground shaking to be expected
  - Issue a warning before significant ground shaking begins

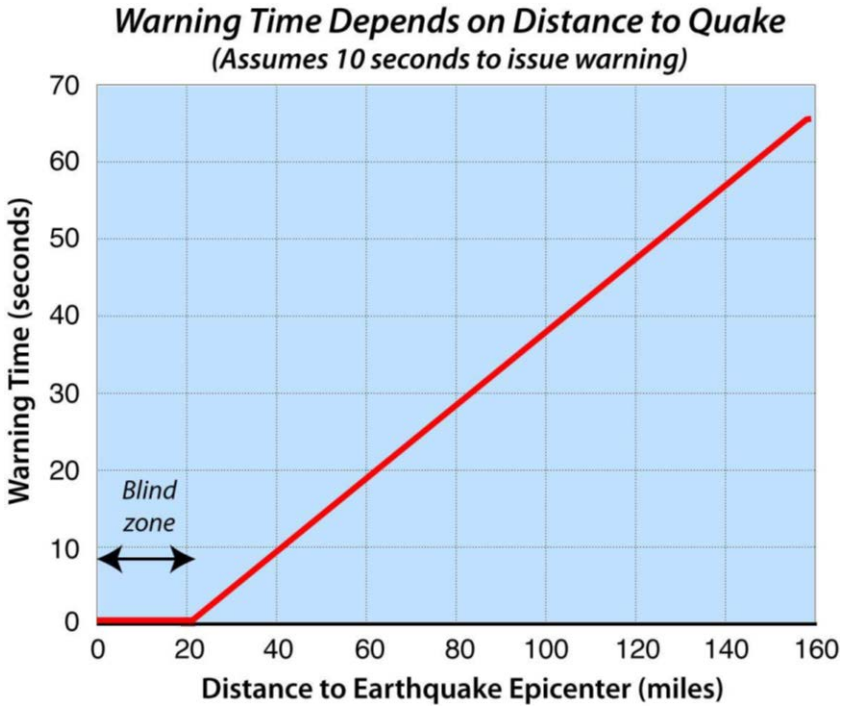


P-wave ~ 3.5 mi/sec (felt waves)
S-wave ~ 2.0 mi/sec (damaging waves)

EEW information is highly uncertain and provides only a limited amount of warning time

Earthquake Early Warning Principles

- Earthquake early warning is possible only when notifications can be sent through communication systems ahead of the seismic waves
- Shaking can take some seconds to minutes to travel from where the earthquake occurred to the alert area
- The farther a location is from the epicenter, the greater the possible amount of warning time
- To maximize warning time, the system must minimize delays in data processing, communication, and delivery of earthquake early warnings

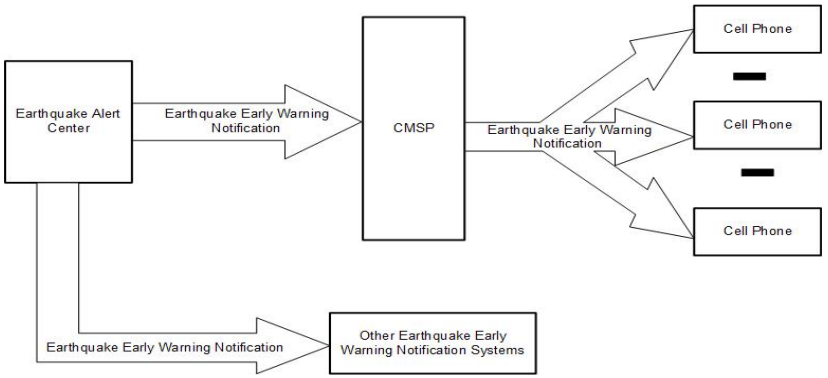


Basic Earthquake Early Warning System Model

- **Sensor Network**
  - A network of sensors that are densely spaced and close to faults
  - Sensors currently operated by the West Coast ANSS seismic networks are not sufficiently dense in all areas to accomplish EEW without unacceptable delays
- **Automated Decision Making Framework**
  - Quick and robust telecommunication from sensors to the Earthquake Warning Center
  - Computer algorithms to quickly estimate an earthquake's location, magnitude, and fault rupture length, and to map resulting intensity
- **Dissemination Channel**
  - Quick and reliable mass notifications
  - Earthquake early warning is possible only when EEW notifications can be sent through communication systems ahead of the seismic waves
- **Recipient**
  - End users educated what specific actions to take upon receipt of the alerts

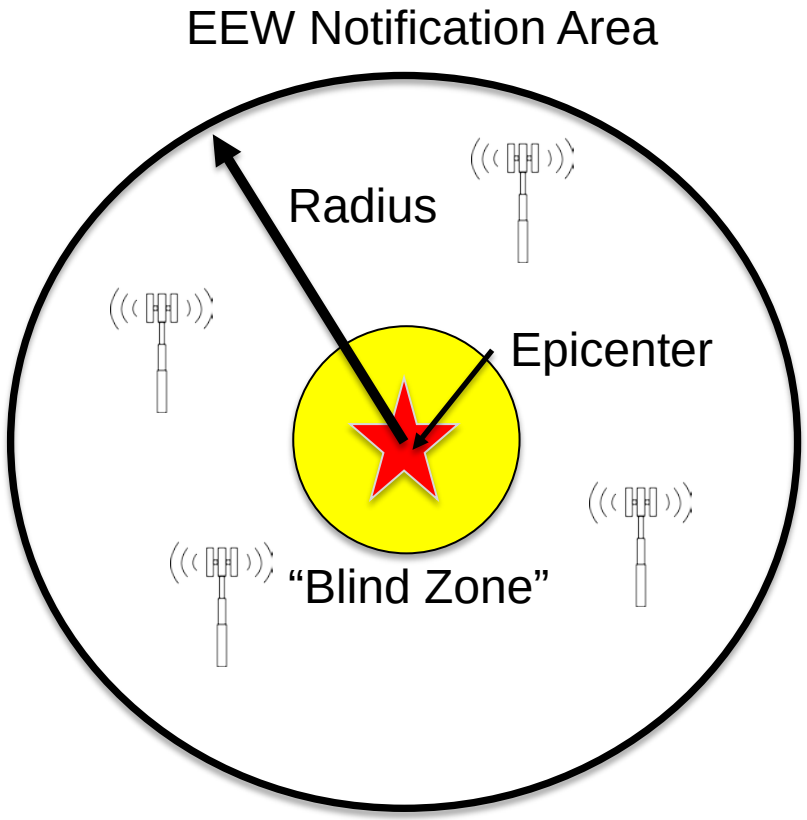
Assumptions

- EEW notification dissemination will be standardized for 4G LTE networks and received by new EEW-enabled cell phones with a valid cellular subscription
  - Existing cell phones will not be capable of receiving EEW notifications
  - Design and capabilities of 2G and 3G wireless networks do not provide the functionality required to support the dissemination of earthquake early notification message within the required short time interval
- Data and message formats will be standardized throughout the system
  - Especially the interface and protocol between the Automated Decision Making Framework/Earthquake Alert Center(s) and the cellular network infrastructure
- Because of the time-sensitive nature of EEW notifications, EEW-enabled cell phones will receive this notification as quickly as technically feasible
  - Given the nature of wireless networks and radio propagation, there is no guarantee that a cell phone will receive the EEW notification in a timely manner, and in some cases may not receive the EEW notification at all



Assumptions (continued)

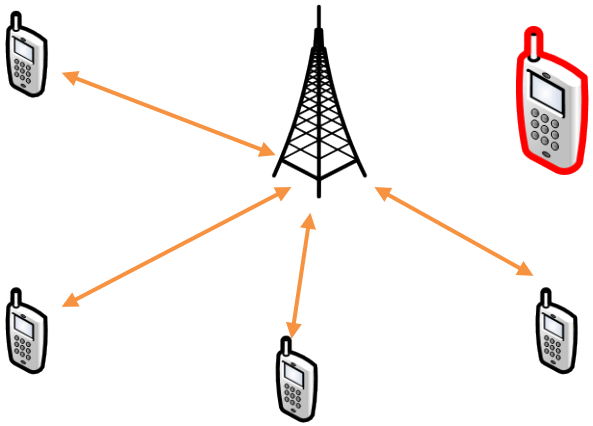
- It is assumed the earthquake early warning broadcast will typically occur within 20 seconds after the EEW notification from the Earthquake Alert Center is received by the cellular network
  - In order to meet these time-sensitive requirements, the proposed solution assumes the re-use of existing capabilities on the LTE broadcast channel
- EEW notification area is assumed to be a circle specified by the estimated surface location of the epicenter and an associated radius where the EEW notification should be broadcast
- Cellular networks will make the best approximation to map the EEW notification area to the associated set of cell sites which are to broadcast the EEW notification



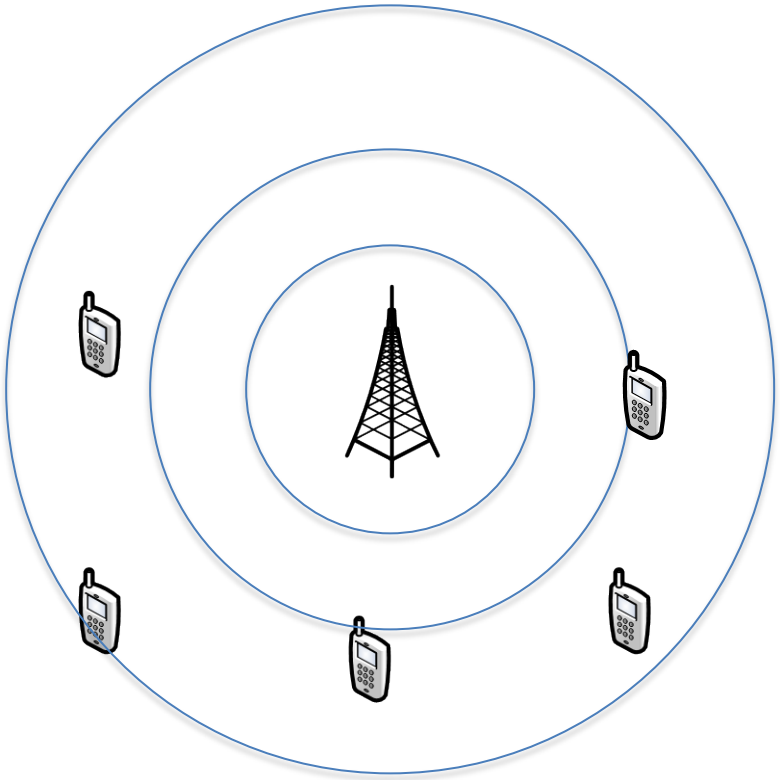
Earthquake Early Warning System: Technical Analysis

Farrokh Khatibi
Director of Engineering
Qualcomm

What is Cell Broadcast?



Point-to-Point (PtP) Communication



Cell Broadcast

Why not use PtP Communication for EEWS?

- PtP techniques (e.g., SMS, Over-the-Top (OTT) Smartphone Apps) all share a number of major issues that make them unacceptable for EEWS:
  - They are not designed for critical real-time authority-to-citizen emergency alerting.
  - They can experience significant delivery delays when attempting to deliver messages to a large number of recipients in a short period of time.
  - Messages are addressed to phone numbers and not to users within a specific alert area.

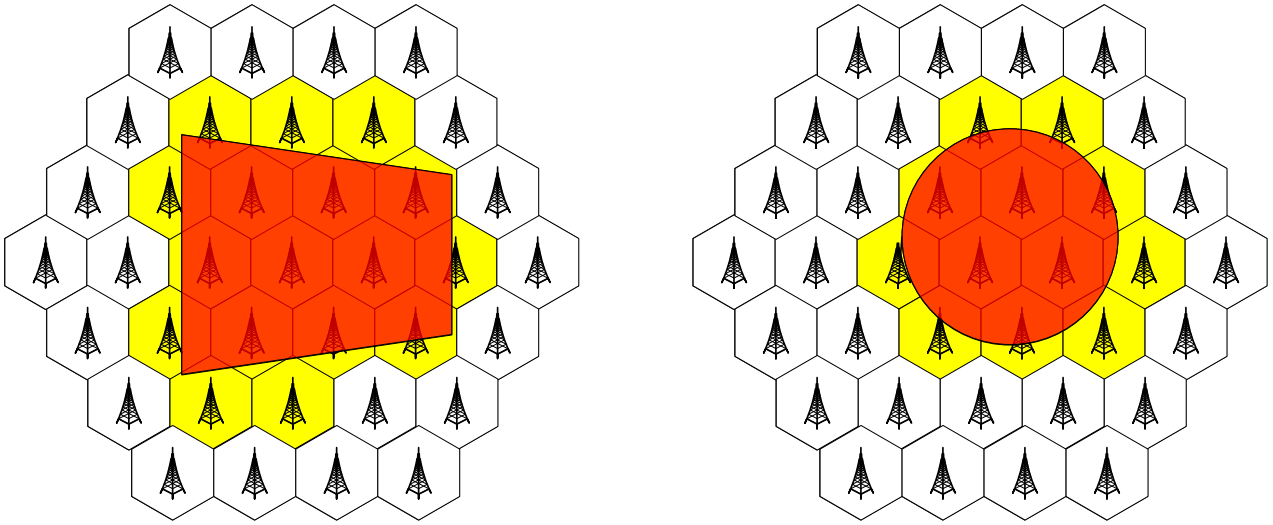
Why not use PtP Communication? (cont.)

- SMS does not have security protections and can be easily spoofed by individuals who wish to cause public disruption due to false earthquake alert messages.
- Smartphone subscribers must have a data services subscription with their wireless operator in order for the smartphone apps to receive alert notifications via the wireless operator's cellular network.
- Many more issues detailed in the feasibility study.

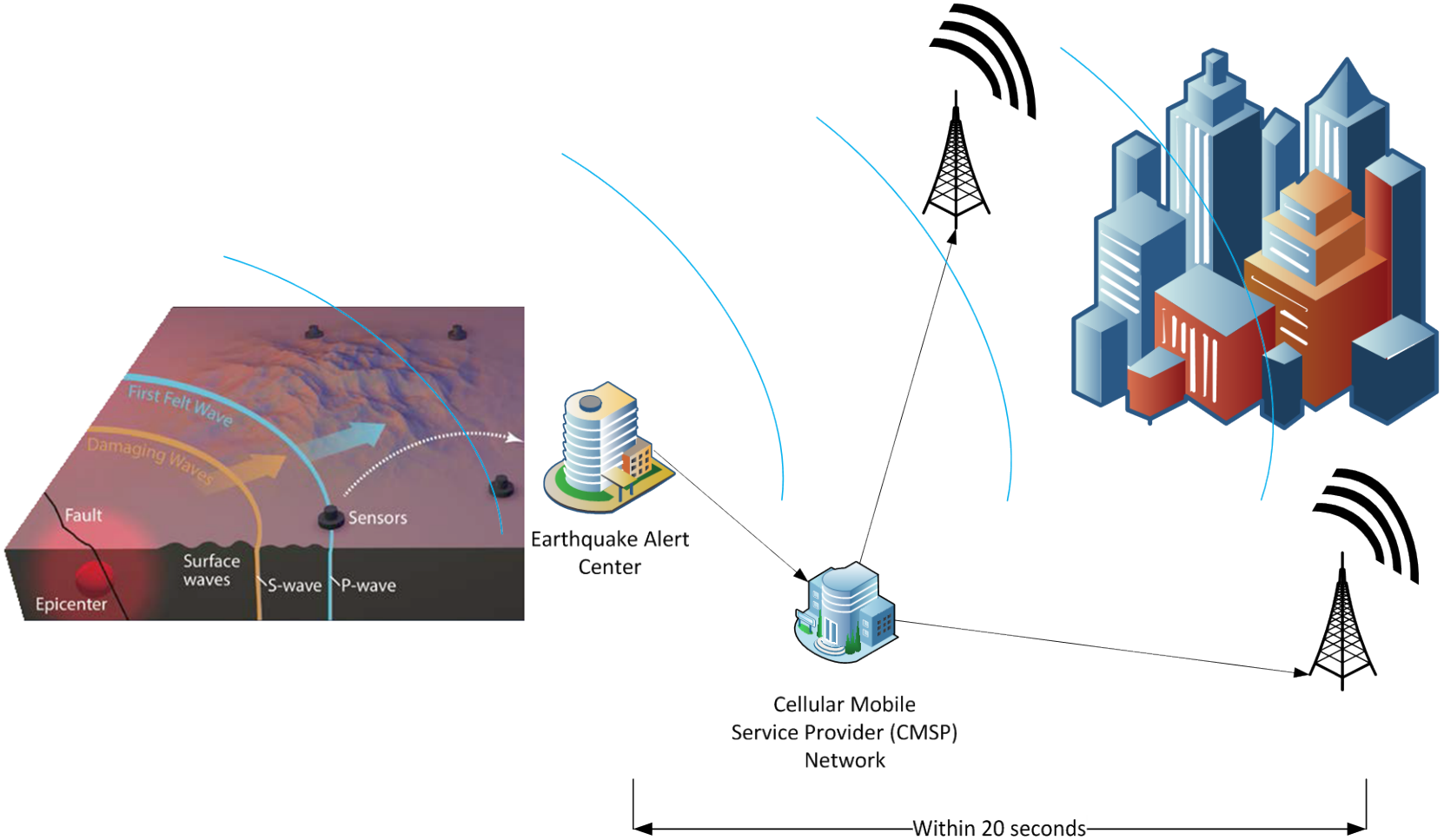
What is Geo-Targeting?

The Commercial Mobile Service Provider (CMSP) can broadcast to an alert area indicated by a polygon or a circle.

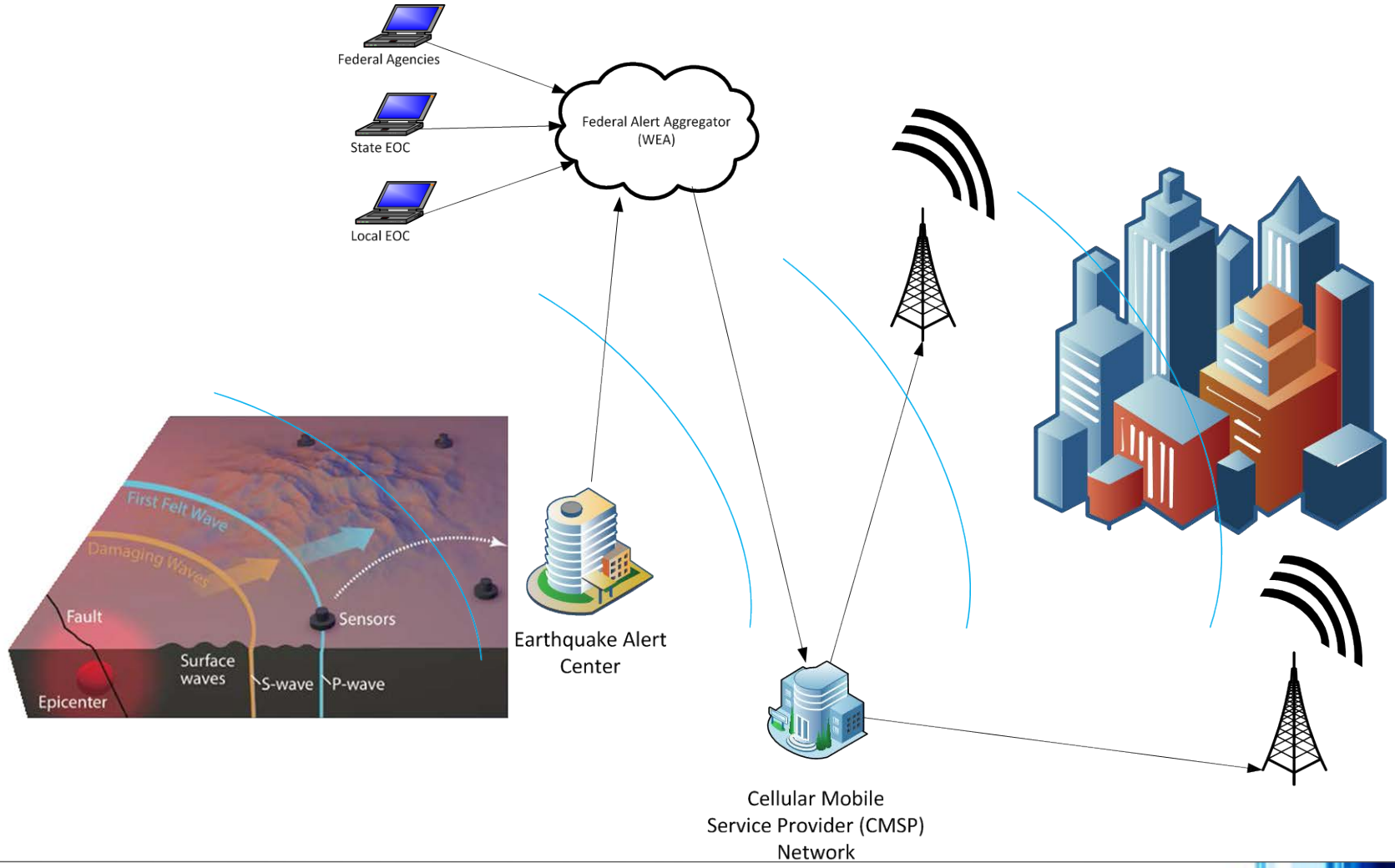
- Red polygon/circle is the alert area.
- Yellow cell sites are those providing coverage area for that alert.



Proposed Earthquake Early Warning System (EEWS)



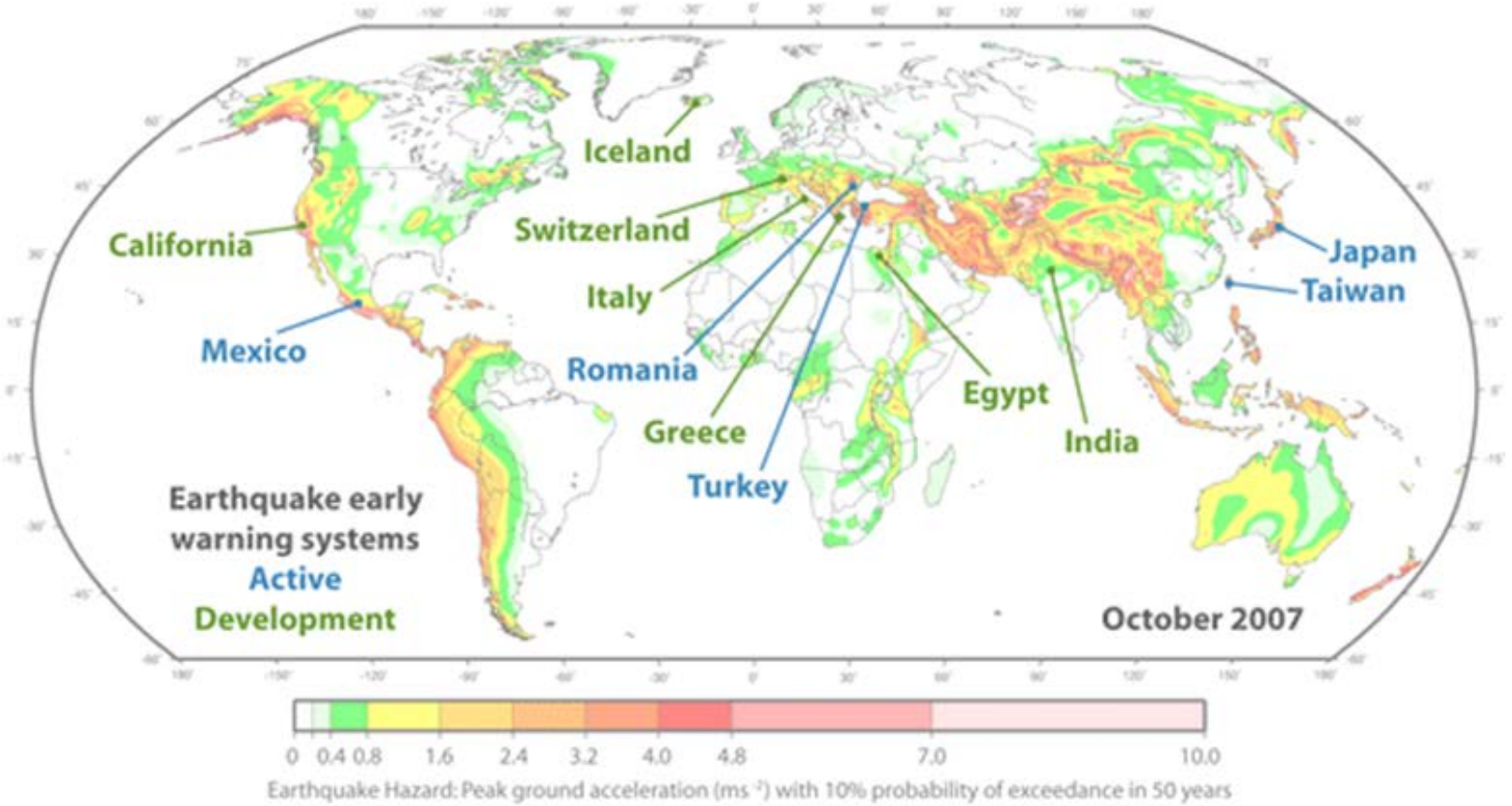
Why not use Wireless Emergency Alerts (WEA) System?



Why not use Wireless Emergency Alerts (WEA) System? (cont.)

- While WEA is designed to provide imminent threat alerts, it is neither designed for nor can be modified to handle time-sensitive alerts.
- WEA is appropriate for less-time sensitive alerts providing authorized alerting authorities a means to provide information to citizens, for example in the aftermath of an earthquake.

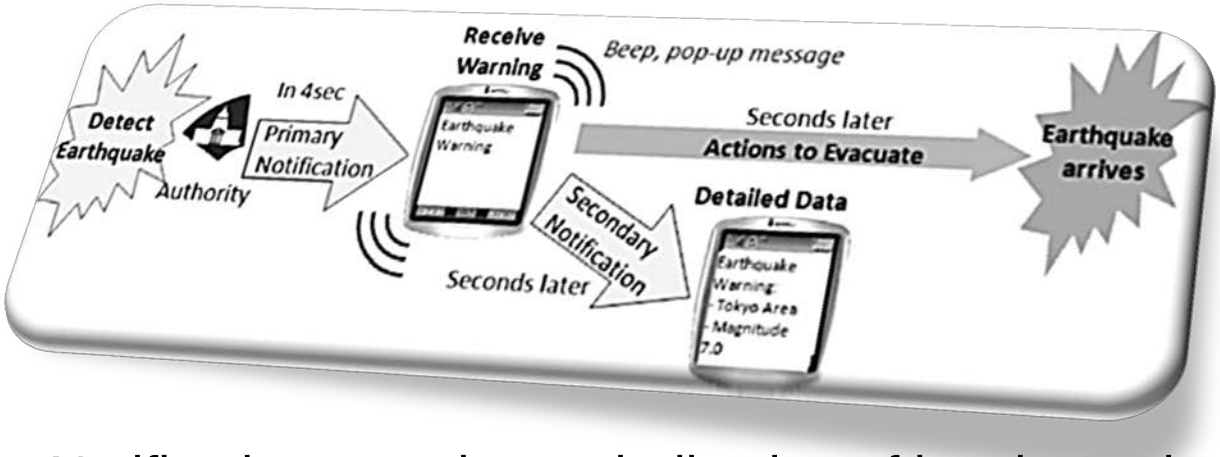
Earthquake Early Warning Around the World



Source: Earthquake Early Warning Around the World available at: http://seismo.berkeley.edu/research/early_warning.html

Japan's Earthquake and Tsunami Warning Service (ETWS)

At the time of this feasibility study, only Japan's EEW (known as ETWS) has an integrated capability to broadcast EEW notifications by cellular networks.



- Primary Notification contains an indication of imminent danger.
- Secondary Notification contains more detailed data in text format.

Conclusions and Next Steps

Brian Daly
Director, Core Network & Government/Regulatory Standards
AT&T

Conclusions

- ATIS determined that a cellular wireless broadcast EEW notification is a viable concept designed within the constraints and limitations of the cellular wireless networks.
- The ATIS study describes a proposed architecture for the EEW system for the distribution of time sensitive EEW notifications using capabilities in the LTE broadcast channel.
  - Broadcast has the potential to reach millions of users in seconds to minutes in an inherently geo-targeted fashion, whereas trying to reach the same number of users via traditional SMS or push data services (“apps”) would swamp the network, slowing the delivery of EEW notifications to a crawl.

Next Steps – Standards

- Upon agreement to proceed into the standardization phase by all stakeholders, new ATIS standards are needed to specify all the relevant interfaces and protocols for an end-to-end system.
  - Starting from the earthquake alert center all the way to broadcast to the cell phone that will notify the users of an imminent earthquake.
  - ATIS will standardize cellular network aspects of system security and engineering, alert messages and distribution, and overall system performance for the EEWS.
  - ATIS will collaborate in the development of standards for the maximum allowable telemetry latency and minimum quality of service for data sources so an end-to-end latency budget can be determined, as well as define the end-user perspective for EEWS.
- EEW standards for the U.S. will also be brought into the global 3GPP Public Warning System standards for global consistency and to facilitate EEW notifications for international roamers.

Next Steps – Timelines

- EEWS solution proposed by ATIS will take ~3-4 years to develop and deploy, starting with developing the new ATIS standards, updating cellular operators' networks, designing new cell phones that can receive EEW notifications, educating the public on the new service, begin introducing new cell phones that support EEW alerting, and deploying the interfaces to the earthquake alert center.
  - Close collaboration between USGS, CISN, ATIS, cellular network operators, and other relevant parties will be required to ensure a successful and timely standardization, planning, development, testing, and deployment of an EEW system.
  - This duration starts once the deployment plan and budget for the sensor network and automated decision making framework of the EEW system has been approved.
  - It will be ~5-7 years before a substantial number of cellular network users (e.g., > 25%) will have EEW capabilities in their devices.
- Global 3GPP standards impacts may increase the timeline to align with global standard release schedules.

How to Download the Feasibility Study

ATIS Feasibility Study for Earthquake Early Warning System
is available at:
www.atis.org/newsroom/EarthquakeFeasibilityStudy.pdf

Questions?

Thank you for attending
Earthquake Early Warning System Notifications
Webinar

All registered attendees will receive a follow up email containing links to a recording and the slides from this presentation.

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