California Earthquake Early Warning System (CEEWS) Benefit-Cost Assessment

Presentation to the California Earthquake Early Warning Advisory Board

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California EEW BCA Project: Goals and Methods

What is the current state of EEW operations, use, benefits, and costs?

What opportunities exist to increase system reach and impacts?

- Stakeholder interviews
- Literature review/analysis
- Benefit-Cost Analysis (BCA)

EEW Developments Worldwide and in California

Seismic- and geodetic-based EEW systems in at least 23 nations:

- o 10 countries with operational public-alerting systems: Japan, Mexico, USA, China, India, Taiwan, Turkey, Canada, South Korea, Romania, Italy

- o 13 countries in development, testing, or restricted use

Figure Source: (McBride et. al., 2022)
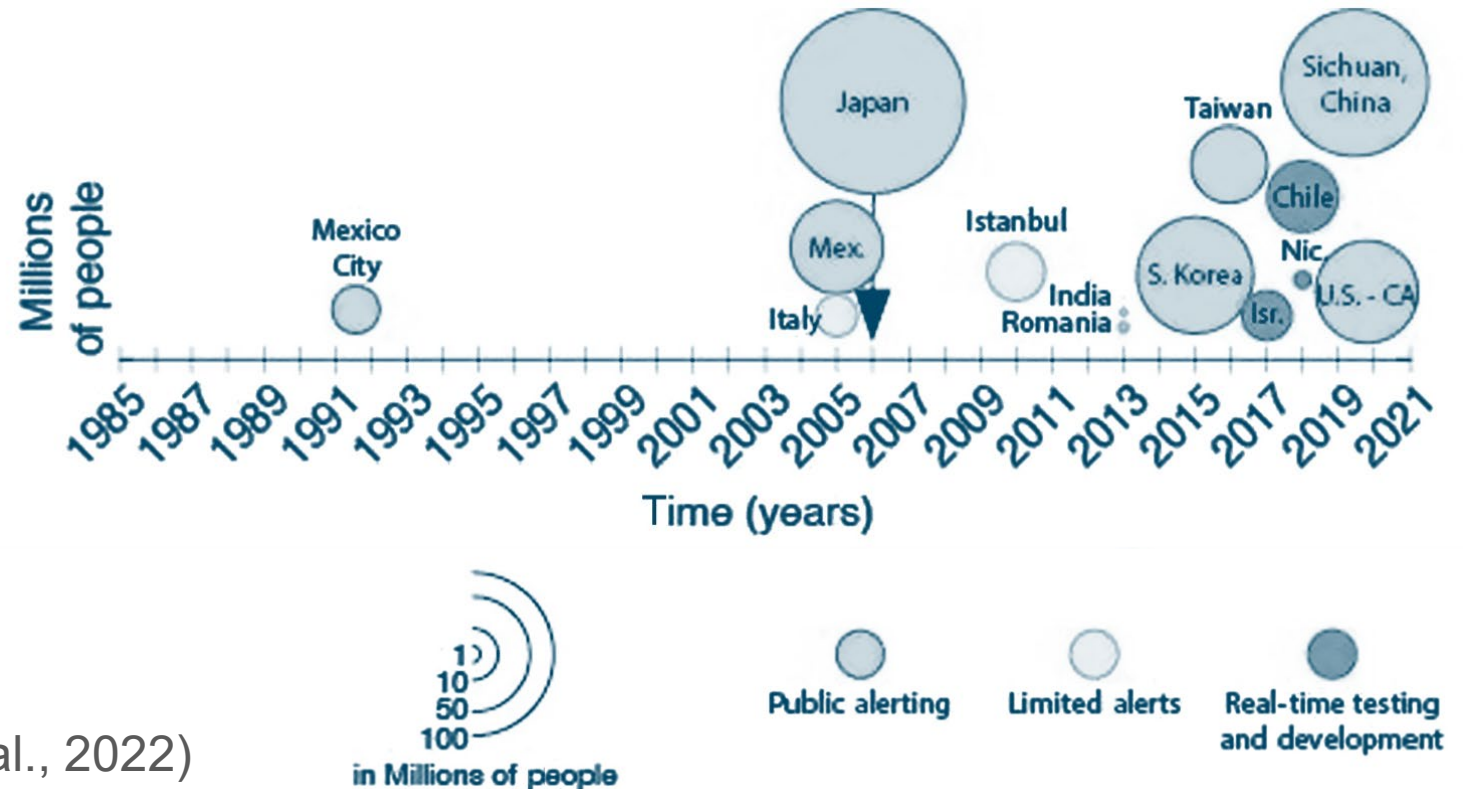
California's Strong Leadership:

CEEWS powered by ShakeAlert™

- Global leadership on earthquake detection and processing science / technology

- Early and sustained financial commitment

- Leveraged assets and partnerships

- Embedded in public safety / preparedness (e.g., Great ShakeOut)

- Dense instrumentation (90%+)

- Successful alert track record

- Vendor ecosystem

- Growing public interest and support

Qualitative Interview Coverage

- 17 stakeholder interviews: 22 people from 14 organizations, including 9 "License-to-Operate" (LtO) technical partners

Category	California	Other U.S. Regions	National	Global
Seismic network design and operation	√	√		
Real-time seismic data analysis / alerting	√	√	√	√
EEW program management	√		√	
EEW first-tier user / LtO / pilot partners	√	√		√
Automated EEW application users	√			
Human response EEW application users	√			
Emergency managers	√	√		
Social scientists		√	√	

LtO Types & Their Importance to Program Strategy

Personal Device Delivery	Specialized Vendor	Add-On Vendor	Institutional
Use telecom infrastructure to distribute EEW alerts to personal electronic devices	Specific EEW delivery solutions for public and private clients	Integrate EEW into broader multi-hazard notification platforms serving public and private clients	Directly use EEW to protect assets, operations, and persons on-site
Android/Google	Early Warning Labs	AlertFM	Allen Institute
MyShake / UC Berkeley Seismology Lab	Kinemetrics	Everbridge	BART
FEMA IPAWS / WEA*	RH2 Engineering	Genasys	Jet Propulsion Laboratory (JPL)
	SkyAlert	Valcom	JPL Deep Space Network
	Varius		MetroLink (SCRRA)

*FEMA IPAWS/WEA is not officially an LtO, but still a critical technical partner for alert delivery.

Quantitative BCA Use Case Coverage & Approach

Use Cases Considered
Personal Protective Action Alerts:
Smartphone Notifications
School Public Address Alerts
Automated Controls:
Mass Transit
High-Rise Elevators

We consistently apply conservative assumptions, rather than "best case" or "best guess"

- High confidence in using these numbers to set priorities and make decisions with trade-offs
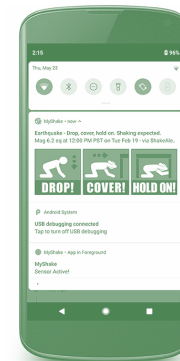
Use Case Findings: Success with Smartphones

California has widespread, fast, and reliable smartphone notifications with measurable injury avoidance benefits.

Benefits considered: Avoided physical injuries and PTSD

→ **Per earthquake, $574 benefit per person** *in locations with VI+ shaking that receives a warning of ≥10 sec*

Untapped Potential for School PA Alerts

High importance & low cost; small current benefits due to low coverage.

- <2% public school children
- High non-monetary barriers to adoption

→ **$272 benefit per student at a school** with VI+ shaking that receives ≥10 sec warning

(kids do DCHO better than adults)

Automated Mass Transit Control: Millions of Safer Rides Each Month

Successful implementation for both BART and Metrolink passenger trains.

- o Benefits considered: Avoided casualties and PTSD, car replacement

- o Benefits depend on train speed when alert is received, predicted shaking intensity, and distance to epicenter

Computation of Benefits for a Use Case & Region

dist

Point of interest i

Magnitude 7.0 on Hayward
(UCERF3 Rupture ID 102943)
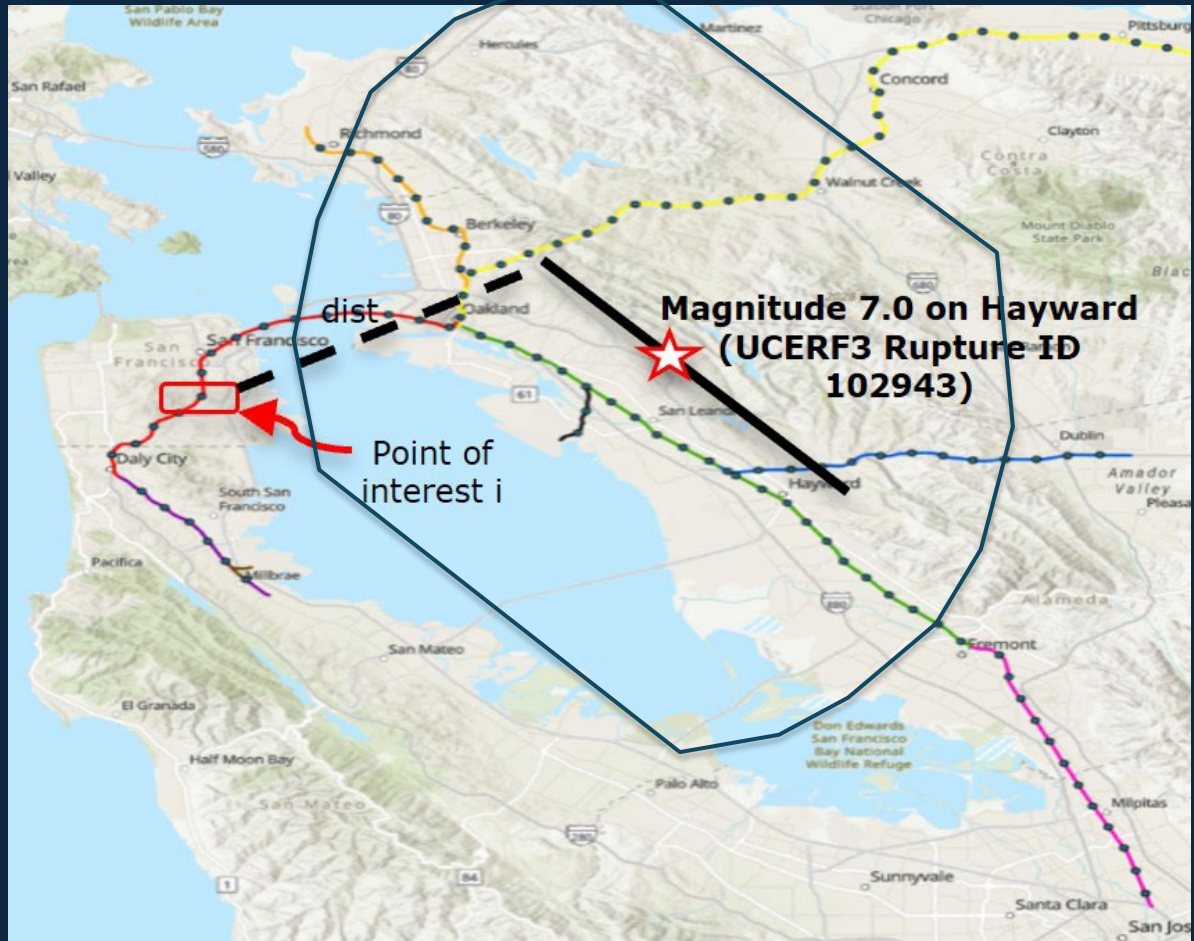
- Calculate distance and alert arrival time for 112 segments in BART network

- Use OpenSHA Intensity Measure tool to estimate benefits for <u>each relevant UCERF3 rupture*</u>

- Calculate the resulting expected EEW benefit for BART using the probability of occurrence of each earthquake

- Similar methodology for the other use cases, but with points of interest being buildings with people, children, or elevators
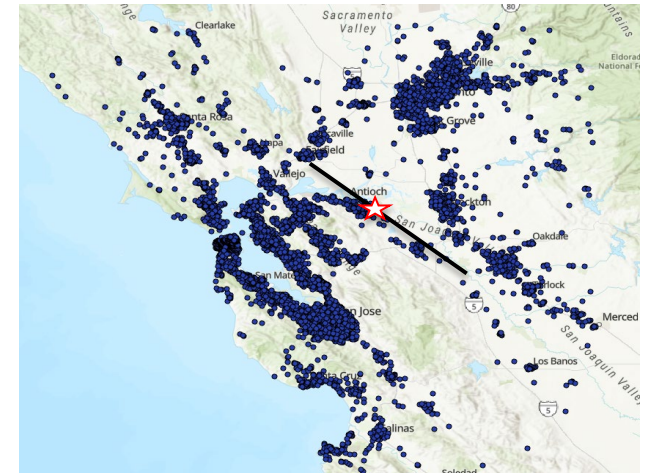
**Magnitude 7.0 on Hayward
(UCERF Rupture ID 102943)**

*Uniform California Earthquake Rupture Forecast, Version 3 (USGS, CGS, SCEC 2013)

Elevator Control Findings

Minimal uptake in this highly regulated, standards-driven market.

- Common in Japan but not elsewhere

- Benefits considered: injury via dehydration from entrapment due to power loss

- Lack of data to estimate additional indirect benefits

Bottom Line

1. CEEWS is a comparatively low-cost/high value public safety program that makes unique mitigation possible

    - Public's willingness to pay for EEW to exist implies benefits outweigh costs at least 20-to-1 annually

2. Program is positioned to grow its impacts significantly if fortified and focused on high-value initiatives

    o   Full report offers many insights/suggestions for CEEWS sustainability, strengthening, targeting, and expansion

Recognition and gratitude to all our research participants and colleagues–past, present, and future.

Your Questions / Discussion

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