**Title**
SEI0: CENS Seismic Research: Overview



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# CENS Seismic Research: Overview

## Objectives: Earth Science and Structural Engineering

One of the fundamental earth science questions facing seismology is under what circumstances small earthquakes develop into giant ones (e.g., the M=9.3 Sumatra earthquake last year). Recent developments in seismic source theory argue that seismicity can be described as a critical branching process whereby sub-events trigger other events, and that a mainshock is identified when the process cascades. In this model the mainshock is preceded by a foreshock sequence that could be used for short-term prediction, if recognizable as such, but what limits the size of the cascade is unknown. To test such models requires having multiple sensors spread across an earthquake zone so that the sub-events preceding the main shock are detected, and are separable from path effects such as scattering in geologic structures. Another issue facing seismologists is predicting the effects of seismic waves on the built environment. For example under what circumstances does geological structure focus seismic waves to cause concentrations of building damage, as happened in Santa Monica during the the Northridge earthquake (Fig. 1). When earthquake waves hit a building can we isolate where and when structural elements fail. The Seismology Application is using ENS technology to develop multi-scale dense networks of self-configuring seismometers and associated cyberinfrastructure to address these questions. Structural Health Monitoring (SHM) focuses on developing technologies and systems that assess integrity of structures. The objective is to assess structural performance during earthquakes using embedded networked sensing technology, and to design retrofitting or activators to reduce damage.

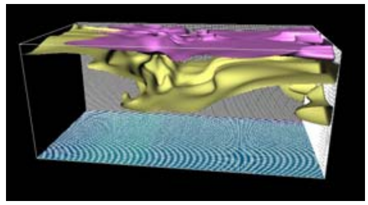


Fig. 1. Santa Monica Substructure from Seismic Tomography, North is to the left. Velocity surfaces delineate basin structures. Damaging seismic waves from the Northridge earthquake entered this structure from the north and were focused causing anomalous damage in Santa Monica

## Accomplishments: Improved resolution using wireless seismic networks

- Sixty working prototypes of the radio-linked (802.11) CENS data communications controller (CDCC) box have been designed and constructed. Software for networking, data routing, was designed and tested.
- Fifty nodes and ten repeaters are currently being installed across Mexico (Fig.2).
- Wireless mote network has been tested in buildings and compared with wired networking.
- Discovered that tomography using data from local networks can explain focusing of seismic waves that cause concentrated damage (Husker et al., 2005).
- Focusing fits the theory of diffraction catastrophes for cusps (Figs. 3).
- Modes of the Factor building change non-linearly with frequency as the amplitude of shaking increases (Kohler et al., 2005).
- Structural models of Factor building have been compared with seismograms from 72 node internal network.
- Equations of state were developed for the Earth's interior that fit seismic data and infinite pressure asymptote (Stacey and Davis, 2004).


Fig. 2. Line of radio linked (blue) and standard stand alone (red) seismometers spaced every 5 km to study wave-propagation and the subducting slab. This experiment will give the seismic community a strong understanding of the benefits of real-time analysis during temporary deployments.

Fig. 3a Focusing of seismic waves is described by diffraction catastrophe theory. Major diffraction catastrophes are illustrated here (from Berry 2002)

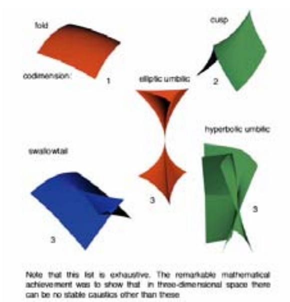
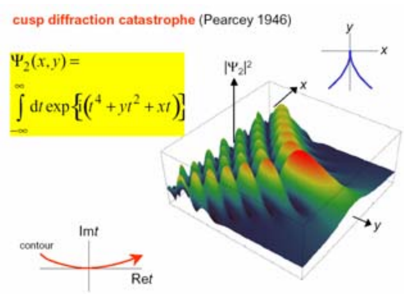



Fig. 3b Amplification of a three dimensional catastrophe (from Berry 2002). Seismic waves show a smeared pattern because they a re not monochromatic as in the diagram. Catastrophe theory provides a theoretical basis for describing focusing in natural systems.




## Future Goals: Increase sensitivity, dynamic range, resolution for science and engineering

LA-2005

1. Design and construct prototype a new CENS Digitizer and Data Communications Controller (CDDCC) that includes an internal low-power 24 bit digitizer and GPS/CENS timing and localization software. April-August 2005.
2. Construct a new 20 station strong/weak motion network for areal experiments. August 2005- April 2006 and perform field tests.
3. Construct a new 100 station strong/weak motion network for areal experiments. April 2006-April 2007. Field test.
4. Construct 1000 station strong/weak motion network areal experiments. April 2007-. Install on volcanoes, aftershock zones and basin edges to study source and path science.
5. Construct 100 station state of health building wireless network and Perform ambient/earthquake testing to characterize state of health of LA high rises and design activator strategies.

Mexico City-1985

Pino Suarez Towers Looking North

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