SCEC–EarthScope Workshop Report

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Introduction

SCEC hosted a workshop, October 14-15, 2003 to explore potential interactions between the Center and EarthScope in southern California, and, in particular, how EarthScope can assist SCEC with its mission to gather and integrate various datasets into a comprehensive and predictive understanding of earthquake phenomena. Specific questions addressed by the attendees were:

a) What are the major scientific objectives for EarthScope in southern California as they relate to SCEC's mission?
b) What EarthScope data will be needed to reach these objectives?
c) What instrumental deployments are needed to acquire the necessary data?
d) How can the SCEC organization help the scientific community achieve these objectives?

The workshop began with a set of reports from the EarthScope facilities managers (S. Ingate, W. Ellsworth, and M. Jackson) that dealt with planning and staffing issues, instrumentation and siting, and major timelines. E. Hauksson reported on another SCEC workshop held a few weeks earlier that explored, among other things, future USArray and/or other EarthScope projects that may supplement existing California datasets to accelerate resolution of regional scientific problems. That workshop identified several scientific priorities including:

- Comparisons of California with the rest of western U.S.,
- High resolution studies of the earthquake source,
- High resolution studies of fault zones, and
- High-resolution studies of the crust and upper mantle.

These reports were followed by a series of short presentations dealing with ongoing and proposed projects in southern California. G. Fuis described the LARSE program and proposed follow-on transects; E. Cochran described proposed experiments to understand fault zone compliance by seismic probing of InSAR anomalies in the Mojave Shear Zone; P. Davis discussed the need to accelerate our understanding of the role of the lower crust and upper mantle in the tectonics of southern California, and reported on a passive OBS study of the Pacific-North American plate boundary that has been submitted to NSF-MG&G; Y-G. Li discussed the significance of fault-zone trapped wave studies; C. Nicholson reported on efforts to acquire a vast array of industry data on the California borderland, and its significance for investigating the structure and slip rates of active faults in the offshore coastal zone; and T. Henyey and T. Rockwell described an ambitious omnibus proposal to investigate the structure and evolution of the San Jacinto fault.

The workshop was organized into three disciplinary groups that generally for the purposes of breakouts – seismology, geodesy, and general/geology. The groups were chosen to reflect EarthScope as a scientific initiative with a special set of facilities. Each group met twice.

Participants were asked to address questions (a) to (d) above, and any other issues they felt were important. Following are the summaries from the breakouts.

General/Geology Breakout Group

- Add two boxes to SCEC Organization Chart (see figure):
  - EarthScope Working Group under Special Projects & Operations
  - Tectonophysics Focus Group under Focus Groups
- SCEC should take an active role in driving EarthScope science and outreach in southern California through community workshops to identify priority projects and targets.
- SCEC should consider funding pilot studies prior to major EarthScope projects.
- EarthScope/SCEC goals in southern California should go beyond simply earthquake hazard to include larger scale architecture of the plate boundary and its evolution over multiple time scales.
- Targeted EarthScope study areas should include integration of geology, geophysics, and geodesy.
- EarthScope/SCEC need to develop standardized IT toolsets for 3D integration of geology, geophysics, and geodesy that include interoperability between other tools such as ARC and EarthVision.
- Fault Systems Focus Group and other entities within SCEC should develop an ongoing dialogue with PBO Transform Region Siting Committee.
- Need for flexible array experiments to include telemetry for routine incorporation of data streams into network products.
- Borehole strainmeters and seismometers should be co-located for studying low magnitude events.
- Experiments to study the architecture and dynamics of the plate boundary in southern California at a variety of spatial and temporal scales should be an EarthScope priority.

Seismology Breakout Group

- Data needed by SCEC that EarthScope can provide:
  - Crust and upper mantle P and S wave velocities.
  - Crustal rheology and Q.
  - Occurrence of seismic reflection “bright spots” as evidence of fluids in the crust.
  - Seismic anisotropy in the lower crust and upper mantle.
  - Seismic structure of fault zones including depth extent, geometry, and physical properties (important faults include the San Jacinto fault, Eastern Mojave Shear Zone, Sierra Madre/Oakridge/San Cayetano fault system, and the San Andreas at Parkfield).
  - Near-field broad-band recordings of fault rupture.
  - Basin structures.

- Scientifically important targets:
  - Plate boundary – is it discrete of diffuse?
  - Mantle flow – does it exist in southern California?
  - Decollements – are they pervasive in southern California?
  - Moho relief – what is its pattern in southern California and relationship to the major faults and uplifts? Is there isostatic balance throughout the region?
  - Fault zone structure – at what depth are fault zone guided waves trapped?
  - Aftershock studies – what can they tell us about source physics?
  - Brittle-ductile transition – at what depth?

- Earthquake response:
  - Both short period and broad-band instruments from EarthScope pool should be available for responding to a major earthquake over the lifetime of EarthScope.
  - Deployments within 24 hours should be a target for studying temporal evolution of aftershocks and crustal relaxation, and capturing near-field ground motions from larger aftershocks.
  - Number of instruments and time allocated should be based on a formula that includes size of the event, focal mechanism, and location.
  - Instrumentation should include real time telemetry.

- Major experiments of high priority:
  - Southern California Imaging Project (SCIP) that includes three active/passive crustal transects across the Santa Susana, San Gabriel, and San Bernardino mountains to map crustal structure (sequel to LARSE).
  - Passive OBS deployments to study the crustal/upper mantle regional structure of the northern Continental Borderland.
  - High resolution active and passive deployments to study the physical properties of the San Jacinto fault, Eastern Mojave Shear Zone, and San Andreas at Parkfield.

Geodesy Breakout Group

- Science driven issues for PBO/SCIGN
  - Relationship between geodetic strain (10 yrs) and geologic strain (10^3 to 10^6 yrs).
  - Effects of earthquakes on strain and strain-rate fields.
  - Measuring vertical deformation rates in selected areas by integrating GPS and InSAR should be a priority .
  - Detection and classification of transients (both solid earth and non-solid earth).
  - Data rates must be adjusted for the different transients.

- Nature of transient signals
  - Post seismic deformation with durations ranging from months to years.
  - Periodic transients such as seen in the Pacific Northwest having a duration of ~10 days that occur on the order of every 14 months.
  - Creep on the central San Andreas with a duration of a few days.
  - Seismic surface waves with periods of seconds to minutes.
  - Atmospheric and ionospheric transients due to earthquakes.

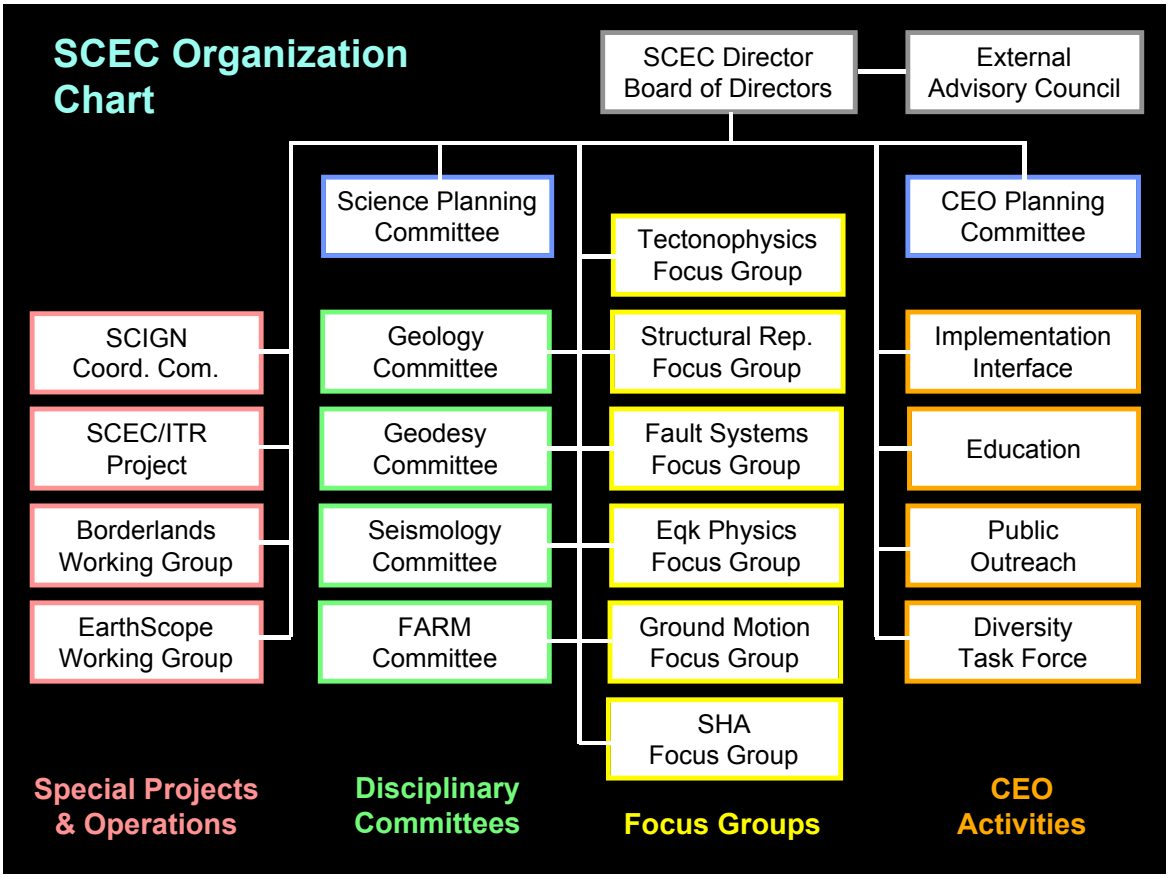
- Need to classify signals (each type of signal yields insights into rheology and dynamics that address the physics of deformational processes).

- System frequency bands
  - Nominal frequency bands of EarthScope systems:
    - Seismic: periods less than 1000 seconds.
    - Strainmeters: 1000 to 10,000 seconds.
    - GPS: daily and longer.
  - There should be sufficient overlap between bands so that the signal-to-noise ratio of each system in different frequency bands can be established.

- Data and products needed by SCEC from PBO/SCIGN
  - Raw data:
    - GPS: 15-sec sampling, 1 sample per sec when possible.
    - Strainmeters: 1 sample per sec.
  - Level 1: daily GPS position estimates; strain in strain units.
  - Level 2: velocity maps and strain rate maps.
  - Level 3: combined GPS + strainmeter analyses.

- Issues to be addressed
  - Merging of GPS, strainmeter, seismic and geologic data streams with seamless access to each type of data – an ideal role for SCEC.
  - SCEC/EarthScope development of parametric characterization of geodetic data streams (similar to phase picks, moment tensor solutions, catalogs, etc. for seismic data).
  - Establishment of EarthScope data products committee with SCEC representative.
  - Decomposition of data streams into components:
    - "Secular" motions for geologic comparison.
    - Earthquake transients.
    - Seasonal signals.
  - Study potential uses, and impact on archives, of high-rate (1 Hz) GPS data.
  - More thought needs to be given to strainmeter siting in southern California.
  - Earthquake response:
    - PBO not intended for immediate earthquake response, but a plan will need to be in place.
    - PBO portable GPS instruments ideal for studying transients after earthquakes and testing stress transfer models.
    - GPS results should be input into focal mechanism solutions.
  - A proposal should be made to co-locate strong motion instruments at GPS sites.
  - Consider using GPS to augment seismic early warning system.
  - CISN, ANSS, USArray, and PBO do not optimally address questions in earthquake source physics; this needs to be rectified; for example, accurate maps of coseismic slip distributions require high-resolution deformation fields.
  - Explore SCEC/EarthScope/NASA connections vis-à-vis PBO products.

- Proposals and studies with high priority for SCEC
  - Relationships between geologic and geodetic slip rates and earthquake history.
    - Pick four locations, 2 where geodetic rates faster and 2 where geologic rates faster.
    - Use community block models to isolate areas for study.
    - Refine error bars on all techniques.
  - SCEC geologists should guide PBO laser imaging and select areas for study in southern California, including pre-earthquake imaging of targeted active faults.
  - Integrate time series from seismic, strain and GPS on a variety of time scales.
  - Perform real time deconvolution of transients from merged time series.



SCEC/EarthScope Workshop – Agenda

Tuesday, October 14

Morning Session (Chair: Henyey)

9:30 Continental breakfast

10:00 Opening remarks (Henyey and Jordan)

10:30 Report on the SCEC/Caltech Seismology Workshop with discussion. Hauksson

11:00 Reports on EarthScope facilities activities, planning, staffing, timelines, instrumentation, deployment strategies, etc. (~20 minutes each) with discussion.

Ingate (USArray)
Jackson (PBO)
Ellsworth (SAFOD)

12:30 Lunch (to be provided)

Afternoon Session (Chair: Henyey)

1:30 Short project presentations (~ 20 minutes each) with discussion.

Gary Fuis
Elizabeth Cochran
Paul Davis
Yong-Gang Li
Craig Nicholson
Tom Henyey

3:30 Break

4:00 Breakout into three focus groups to identify the types of data, data derivatives, and final products needed by SCEC in pursuit of its mission, that EarthScope facilities can provide alone or in combination with other facilities/instrumentation:

Group 1) Geodesy (PBO)

Group 2) Broadband Seismology (USArray Bigfoot)

Group 3) High-Resolution Seismology (USArray Flexible)

Group 4) Geology

(Note: workshop participants will self organize into the various focus groups) Chairs to lead the discussions will be selected.

6:00 Break before dinner

6:30 Dinner (to be provided)

Wednesday, October 15

Morning Session (Chair: Henyey)

8:30 Continental breakfast

9:00 Reports from previous day's breakouts (~15 minutes each) with discussion.

10:30 Break

11:00 Breakouts organized along the lines of particular experiments or experimental approaches. Actual breakouts will be determined during the workshop based on earlier discussions. Each breakout should:

- Identify a set of EarthScope experiments (over 5-10 year timeframes) that could make a substantial impact on SCEC's mission in southern California,
- Determine the EarthScope facilities/instrumentation, with timelines, that will be necessary to carry out the experiments, and
- Explore the nature of an IT framework that would enhance the value of EarthScope data and their analyses.

Chairs to lead the discussions will be selected.

12:30 Lunch (to be provided)

Afternoon Session (Chair: Henyey)

1:30 Reports from morning breakouts (~15 minutes each) with discussion

2:30 General discussion regarding the role that SCEC might play (or how involved it should be) in organizing EarthScope science in southern California (or the southwest?) and what experiments would have the potential to significantly impact SCEC's mission as a regional earthquake center. To be led by a panel consisting of SCEC Director together with chairs of breakouts. (Henyey and McRaney to act as recorders)

3:30 Wrap up (Henyey)

4:00 Adjourn