

Southern California Earthquake Center
2002 Annual Report
NSF Cooperative Agreement EAR-0106924 and USGS
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I. Introduction

The Southern California Earthquake Center (SCEC) is a regionally focused organization with a tripartite mission to

- gather new information about earthquakes in Southern California,
- integrate knowledge into a comprehensive and predictive understanding of earthquake phenomena, and
- communicate this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.

SCEC was founded in 1991 as a Science and Technology Center (STC) of the National Science Foundation (NSF), receiving primary funding from NSF's Earth Science Division and the United States Geological Survey (USGS). SCEC graduated from the STC Program after a full 11-year run (SCEC1). It was reauthorized as a free-standing center on February 1, 2002 (SCEC2) with first-year base funding of \$2.5 million from NSF and \$1.1 million from USGS. In addition, the Center was awarded major grants from NSF's Information Technology Research (ITR) Program (\$10 million for 5 years, beginning October 1, 2001) and its National Science, Technology, Engineering, and Mathematics Digital Library (NSDL) program (\$650K for 2 years, beginning August 1, 2001).

This report summarizes the Center's activities during the first year of SCEC2. The report is organized into the following sections:

- I. Introduction
- II. Planning, Organization, and Management of the Center
- III. Research Accomplishments
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II. Planning, Organization, and Management of the Center

The transition from SCEC1 to SCEC2 involved considerable planning and restructuring. A five-year planning document, *The SCEC Strategic Plan 2002-2007*, was submitted to the sponsoring agencies in October, 2001. This plan articulates the Center's long-term research goals, which are reproduced here in Appendix A. The current organization chart of the Center is presented in Figure II.1.

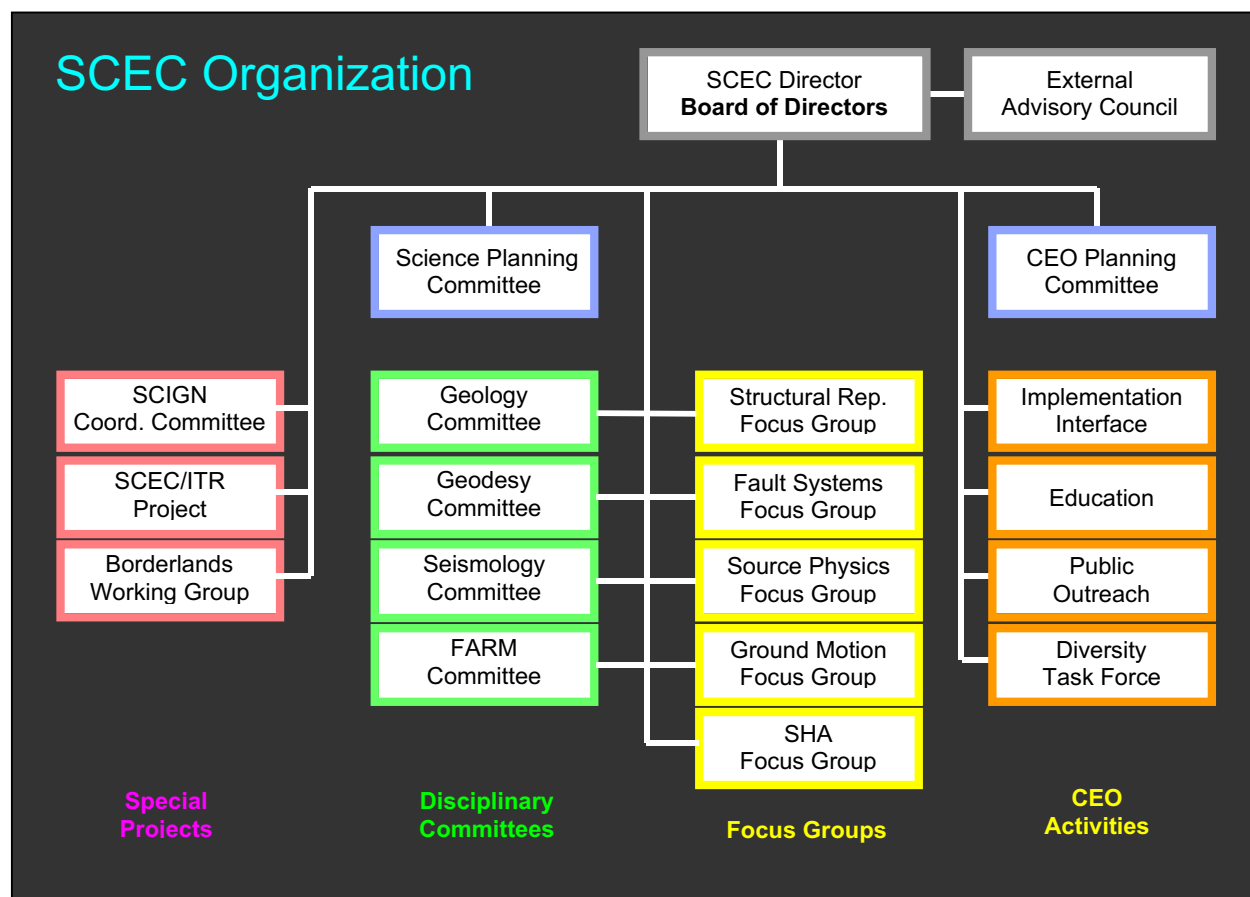


Figure II.1. Organization chart of the Southern California Earthquake Center

Board of Directors

SCEC remains an institution-based center, governed by a Board of Directors that represent its members. The institutional membership has now expanded to 14 core institutions and 27 participating institutions. The new SCEC By-Laws (Appendix B) specify that each core institution shall appoint one board member and that two at-large members shall be elected from the participating institutions. The new Board of Directors thus has 16 voting members and 3 *ex-officio* members (Table II.1). Mr. John McRaney continues is Executive Secretary to the Board.

At its first meeting on March 6, 2002, the Board elected Greg Beroza as its vice-chair and appointed an Executive Committee comprising T. Jordan, G. Beroza, D. Burbank, L. Jones, and B. Minster. The Board also approved the appointments of T. Jordan as Center Director, T. Henyey as Deputy Director, J. McRaney as Associate Director for Administration, and M. Benthien as Associate Director for CEO. This management team is assisted by a very capable

Table II.1. SCEC Board of Directors

Institutional and At-Large Representatives

Thomas H Jordan* (Chair)	University of Southern California
Gregory C. Beroza* (Vice-Chair)	Stanford University
James N. Brune	University of Nevada Reno
Douglas Burbank*	University of California Santa Barbara
Steven M. Day	San Diego State University
James Dieterich	USGS-Menlo Park
Lisa Grant (At-Large)	University of California Irvine
Thomas Heaton	California Institute of Technology
Thomas A. Herring	Massachusetts Institute of Technology
David D. Jackson	University of California Los Angeles
Lucile Jones*	USGS-Pasadena
J. Bernard Minster*	University of California San Diego
James Rice	Harvard University
Bruce Shaw	Columbia University
Terry Tullis (At-Large)	Brown University
Robert Wesson	USGS-Golden

Ex-Officio Members

Tom Henyey (Deputy Director)
 John McRaney* (Executive Secretary)
 Mark Benthien (Associate Director, CEO)

* Executive Committee members

staff, which includes Bob DeGroot, Sally Henyey, John Marquis, Michelle Smith, and Shelly Werner.

External Advisory Council

As in the past, the Center benefits from an external Advisory Council, which is charged with developing an overview of SCEC operations and giving advice to the Director and the Board. Professor Robert Smith (University of Utah), who chaired the last SCEC1 Advisory Council, has agreed to continue as chair of the new SCEC2 Advisory Council. Its current membership and first report are given in Section VI.

Organization of Research

A central organization within the new SCEC is the Science Planning Committee, which has the responsibility for formulating the Center's science plan, conducting proposal reviews, and recommending projects to the Board for SCEC funding. The Planning Committee is chaired by Deputy Director Tom Henyey and its membership includes the chairs of the major SCEC working groups. There are three types of working groups—disciplinary committees, focus groups, and special project groups. The Center is fortunate that some of its most energetic and accomplished colleagues have agreed to participate as group leaders (Table II.2).

The Center sustains disciplinary science through standing committees in *seismology*, *geodesy*, *geology*, and *fault and rock mechanics*. These committees are responsible for planning and coordinating disciplinary activities relevant to the SCEC science plan, and they make recommendations to the Science Planning Committee regarding the support of disciplinary infrastructure. Interdisciplinary research is organized into five science focus areas: *structural representation*, *fault systems*, *earthquake source physics*, *ground motion*, and *seismic hazard analysis*. The focus groups are the crucibles for the interdisciplinary synthesis that lies at the core of SCEC's mission.

In addition to the disciplinary committees and focus groups, SCEC manages several special research projects, including the Southern California Integrated GPS Network (SCIGN), the

Table II.2. Leadership of the SCEC Working Groups

Disciplinary Committees

Seismology:	John Vidale (chair)* Peter Shearer (co-chair)
Geodesy:	Duncan Agnew (chair)* Mark Simons (co-chair)
Geology:	Tom Rockwell (chair)* Doug Burbank (co-chair)
Fault & Rock Mechanics:	Terry Tullis (chair)* Jim Dieterich (co-chair)

Focus Groups

Structural Representation:	John Shaw (leader)* Rob Clayton (co-leader)
Fault Systems:	Brad Hager (leader)* Charles Sammis (co-leader)
Earthquake Source Physics:	Ruth Harris (leader)* Greg Beroza (co-leader)
Ground Motions:	Ralph Archuleta (leader)* Steve Day (co-leader)
Seismic Hazard Analysis:	Ned Field (leader)* John Anderson (co-leader)

Special Project Groups

Implementation Interface:	Paul Somerville (leader)* Rob Wesson (co-leader)
SCIGN Steering Committee:	Ken Hudnut (chair)*
SCEC/ITR Project:	Bernard Minster (liaison)*
Borderland Working Group:	Monica Kohler (chair)* Craig Nicholson (co-chair)

* Science Planning Committee members

Borderland Working Group, and the SCEC Information Technology Research (SCEC/ITR) Project. Each of these groups is represented on the Science Planning Committee by its chair, with the exception of the SCEC/ITR Project, which is represented by Bernard Minster, a Co-P.I. of the project (the P.I. is the Center Director, Tom Jordan).

During the transition process, SCEC reaffirmed its commitment as the parent organization for the Southern California Integrated GPS Network (SCIGN), which has now achieved its design goal of 250 continuously monitoring GPS stations. The challenge for the near future will be to coordinate future SCIGN developments with those of the Plate Boundary Observatory (PBO) of the EarthScope Project.

The Borderland Working Group, approved by the Board at its meeting in late June, represents a new initiative. SCEC researchers have a long-standing interest in California Borderland, and the enthusiasm for coordinated studies of the offshore tectonic activity and seismic hazards has been increasing. This working group, which nucleated at a SCEC-sponsored workshop in March, has produced a white paper that outlines the scientific opportunities priorities.

The goal of the SCEC/ITR Project is to develop an advanced information infrastructure for system-level earthquake science in Southern California. Partners in this SCEC-led collaboration include the San Diego Supercomputer Center (SDSC), the Information Sciences Institute (ISI), the Incorporated Research Institutions for Seismology (IRIS), and the USGS. In many respects, the SCEC/ITR Project presents a microcosm of the IT infrastructures now being contemplated in the context of EarthScope and other large-scale science initiatives, so the opportunities and pitfalls in this area need to be carefully assessed. The SCEC/ITR annual report will be submitted as a separate document.

The long-term goals and short-term objectives laid out in the SCEC Strategic Plan provided the basis for the SCEC Program Announcements, which are issued annually in October. This proposal process is the primary mechanism through which SCEC recruits scientists to participate in its research collaborations. The response to the first-year Program Announcement was overwhelming: the community submitted 167 proposals for 134 projects, requesting over \$6,100K in total funding. The amount available for these projects was \$2,640K; i.e., total base funding from the NSF and USGS minus \$960K for core operations (meetings, CEO, and management). The Planning Committee reviewed all of the proposals and formulated a detailed plan for project funding. In March, the Board acted on the Planning Committee recommendations, approving 72 science projects totaling \$1,955K and 17 infrastructure proposals totaling \$685K. Section III outlines the progress achieved during the first year of these research efforts.

SCEC is coordinating its research program with the USGS through a Joint Planning Committee (JPC). For example, the USGS members of the JPC attended the proposal review meeting of the SCEC Planning Committee as non-voting participants.

Communication, Education, and Outreach

SCEC is committed to applying the basic research in earthquake science to the practical problems of reducing earthquake losses. To accomplish this aspect of its mission, SCEC maintains a vigorous Communication, Education, and Outreach (CEO) Program that receives 10% of its base funding plus other funds from special projects, such as the Electronic Encyclopedia of Earthquakes. CEO activities are managed by the Associate Director for CEO,

Mark Benthien. The programmatic elements include structured activities in education and public outreach and two new structures: an *Implementation Interface*, designed to foster two-way communication and knowledge transfer between SCEC scientists and partners from other communities—in particular, earthquake engineering, risk analysis, and emergency management, and a *Diversity Task Force*, responsible for furthering the goal of gender and ethnic diversity in earthquake science. A report on the first-year CEO activities is given in Section IV.

III. Research Accomplishments

This section summarizes some of the main research accomplishments and research-related activities organized by the disciplinary committees, focus groups, and special project working groups.

Disciplinary Activities

During this past year, the disciplinary committees were charged with reviewing infrastructure elements in their disciplines that have been previously supported by SCEC and to assess how SCEC resources should be allocated to the disciplinary infrastructure in the future. The chairs and co-chairs of the disciplinary committees also participated in developing the program announcements and in the proposal review process to insure that the disciplinary elements of SCEC research remain strong. In the following reports, the emphasis is on the infrastructure issues. Discipline-oriented research is also well represented in the focus-group reports that follow.

Seismology. In 2002, SCEC has supported a four activities to maintain and improve seismic infrastructure. Three projects are managed by the UCSB, and the largest is run from Caltech.

Portable Broadband Instrument Center. The SCEC portable instrument program at UCSB, managed by Jamie Steidl, provides a valuable resource for focused experiments in southern California, and it has contributed to a number of important results, including analyses of fault-zone guided waves, aftershock seismicity studies, and detailed images of crustal velocity structure derived from the LARSE refraction profiles. These experiments promote student involvement and can be conducted with greater flexibility and shorter lead times than is possible through the IRIS PASSCAL program.

In the past year, SCEC support for the PBIC covered maintenance of instrumentation (including DAS firmware upgrades, battery maintenance, and sensor calibrations) and continued support of the following five ongoing research projects. 1) Santa Barbara Array: Ralph Archuleta, UCSB; 2) Northern Baja experiment: Steve Day, SDSU; 3) Millikan Shaking: Javier Favella, Caltech; 4) Santa Cruz Cliff Shaking: Peter Adams, UCSC; and 5) Portable Borehole Experiment: Jamie Steidl, UCSB. The PBIC is currently seeking future funding opportunities to upgrade the existing instrument pool with new data-logger and telemetry technology. This upgrade would enable the portable instrument pool to be deployed and integrated into local regional networks. These upgrades would facilitate routine data processing and archival, as well as provide real-time access to data from individual PBIC projects and major earthquake

deployments. An NSF MRI consortia pre-proposal is currently under review by the UCSB administration and will be submitted for the January 23, 2003, deadline if cost sharing is approved by UCSB and other SCEC core institutions.

Borehole Instrumentation Program. Borehole seismic instruments, installed by Jamie Steidl at UCSB, have advantages over surface installations owing to their generally lower noise levels and ability to record signals below highly attenuating near-surface layers. They provide valuable constraints on seismic structure and earthquake source processes, as well as motions for nonlinear soil behavior during strong shaking. Boreholes are expensive, however, and the seismic community cannot afford to drill many new holes. Hence, the SCEC borehole instrument program is taking advantage of the opportunities provided when pre-existing boreholes become available for research purposes.

This year, three borehole installations were completed: two in the San Fernando Valley, and one in the Imperial Valley. All three of these sites are now part of the USGS National Strong Motion Program (NSMP) permanent array of strong-motion stations. In cooperation with SCEC, the ROSRINE and USGS site characterization programs provided cased boreholes; the USGS provided the surface instrumentation for all three of the sites; and CISN is providing the frame relay link for two of the sites to bring the data into Caltech in real-time. Through such cooperation SCEC continues to leverage its investment in borehole infrastructure and research.

Strong Motion Database. The SCEC strong motion database (SMDDB) had evolved into the COSMOS (Consortium of Organizations for Strong-Motion Observation Systems) Virtual Data Center (VDC) (<http://db.cosmos-eq.org>). As such, it has continued to expand and refine its database and the website through which the strong-motion data are accessible to the scientific and engineering community. In late August, 2002, the NSF Directorate of Engineering, Civil and Mechanical Systems, Geotechnical and GeoHazards Systems Program funded the VDC to support and expand the web-deployed database over a three-year period 9/1/2002–8/31/2005.

VDC enhancements during the past year are shown in the following table:

Available Data	10/1/2001	10/1/2002
Earthquakes	199	317
Stations	1744	2284
Acceleration Time Histories	11,537	15,403

The database was given a considerable boost with the addition of two large data sets in the last year: the reprocessed data (by California Geological Society, formerly CDMG) for the September 20, 1999, M 7.6 Chi Chi, Taiwan, earthquake added 408 stations; and a new data set from New Zealand added 98 earthquakes recorded from 1966 to 1999 as well as 230 new stations. Data were added from California earthquakes: October 31, 2001, Anza; May 14, 2002 Gilroy; June 17, 2002 Bayview, and the Feb 22, 2002 California-Baja earthquakes (with 73, 24, 3 and 9 stations reporting, respectively). From Alaska, the February 6, 2002 earthquake and aftershock were added (9 and 12 stations reporting, respectively). Five magnitude 5 or greater earthquakes in Japan from December 2001-September 2002 were also incorporated. The remaining increases are from older earthquakes and stations in Turkey, El Salvador and California, which were included as the data became available. The database just added 17

recordings from the November 3, 2002 M 7.9 Denali earthquake that are not represented in the table.

The VDC averages 4000 web hits per month from users from more than 60 countries. There is a significant number of users with ".edu" addresses suggesting that the VDC has an impact on the education of young scientists and engineers. The average number of web pages accessed per month is ~2000, which seems too large for simply research by those in the ".edu" community.

The SMDB/VDC has become what SCEC originally intended: an up-to-date infrastructure program that serves the broadest community with the data most useful to the needs of the user.

Southern California Earthquake Data Center (SCEDC). The USGS/Caltech/SCEC data center for SCSN/Trinet/Terrascope, overseen by Rob Clayton, plays a key part of seismic network operations and facilitates both routine and innovative analyses of seismic data. It has continued to maintain and update the primary online, near "real-time" searchable archive of seismological data for Southern California. Recent software development of STP (Seismic Transfer Program) allows users to preview waveforms on a PC before downloading using internet seismogram visualization software. STP provides data in a variety of formats, including mSEED for seismologists and now COSMOS-V0 format for engineers. The CUSP data sets from 1981 to 2000 have been converted from a VAX system into the modern archival format. The parametric data has been loaded into the SCEDC Oracle database for a continuous catalog from 1981 to present; the 1981-present waveform data has been converted to mSEED format. The Data Center executed a successful pilot-test of archiving waveform data on mirrored network appliances and has begun regular archiving onto RAID magnetic disks with Linux operating systems. The initial motivation for this change in archival hardware was to reduce storage cost, but it also has the advantage of nearly eliminating the time latency associated with retrieving data from a robotic system. EQuest, an interface to provide compiled, prepackaged waveform data sets for magnitude 5.0 and greater local earthquakes in Southern California stored at the SCEDC has been updated and enhanced. For a significant event, processes have been developed to automate the packaging of waveforms for the event into a single, downloadable product.

SCEC has traditionally provided a significant amount of support for the data center, but the funding during the first year of SCEC2 was cut to only \$150K (out of an operating budget of about \$500K). The Seismology Committee concluded that continuing support at this or higher levels will be vital to ensuring that SCEDC continues to service the SCEC community.

Geodesy. The SCEC geodesy program continued to produce data, and analyses, of great interest to the understanding of earthquake physics in Southern California. The program rests on a substantial base of data-collection and analysis efforts which have given southern California the longest and spatially densest set of crustal deformation measurements anywhere in the world outside Japan. Thus has been possible only through SCEC's willingness to support long-term and collaborative efforts of a type very difficult to fund as part of conventional research proposals.

The past year has brought a number of new developments in SCEC-sponsored geodetic measurements and data interpretation (though the latter is more a part of the interdisciplinary Fault Systems focus). Only a few of these are highlight in this report.

- This year brought a large number of analyses of the Hector Mine earthquake, many done by SCEC scientists, and published as part of a special volume of *BSSA*. These studies made use of InSAR and GPS data, the former made available through the WinSAR archive, and the

latter largely collected and analyzed with SCEC support. The amount and variety of data make this one of the best-recorded earthquakes ever, geodetically speaking, and perhaps for some time to come.

- One result not included in this volume, but funded by SCEC, was published in September 2002 (Fialko et al., 2002). This paper explained a puzzling feature observed in InSAR measurements of the coseismic displacement field from the Hector Mine earthquake: in addition to the slip on the causative faults, other faults in the area showed small offsets, in some cases in a direction opposite to that seen in their long-term geologic motion. These offsets appear to have been caused by enhancement of the elastic response caused by a lower shear modulus parallel to the fault zone over widths of a kilometer—a result that is obviously important to understanding the mechanics of faults.
- Version 3.0.1 of the SCEC Crustal Motion Model is about to be released. This will contain the velocities of 780 points throughout Southern California, over twice as many as were in the previous release, with notable increases of spatial density in Los Angeles, much of the Mojave Desert area, and San Diego County. Figure III.1 shows the velocities away from the main part of the plate boundary, on the east side referred to the North American plate and on the west, for clarity, to San Nicholas Island (on each side we also show one velocity with respect to the other side). So presented, one striking aspect of the field is its rotational symmetry: there are small velocity gradients to the SW and NE, and large ones (little change right up to the plate boundary) to the NW and SE.

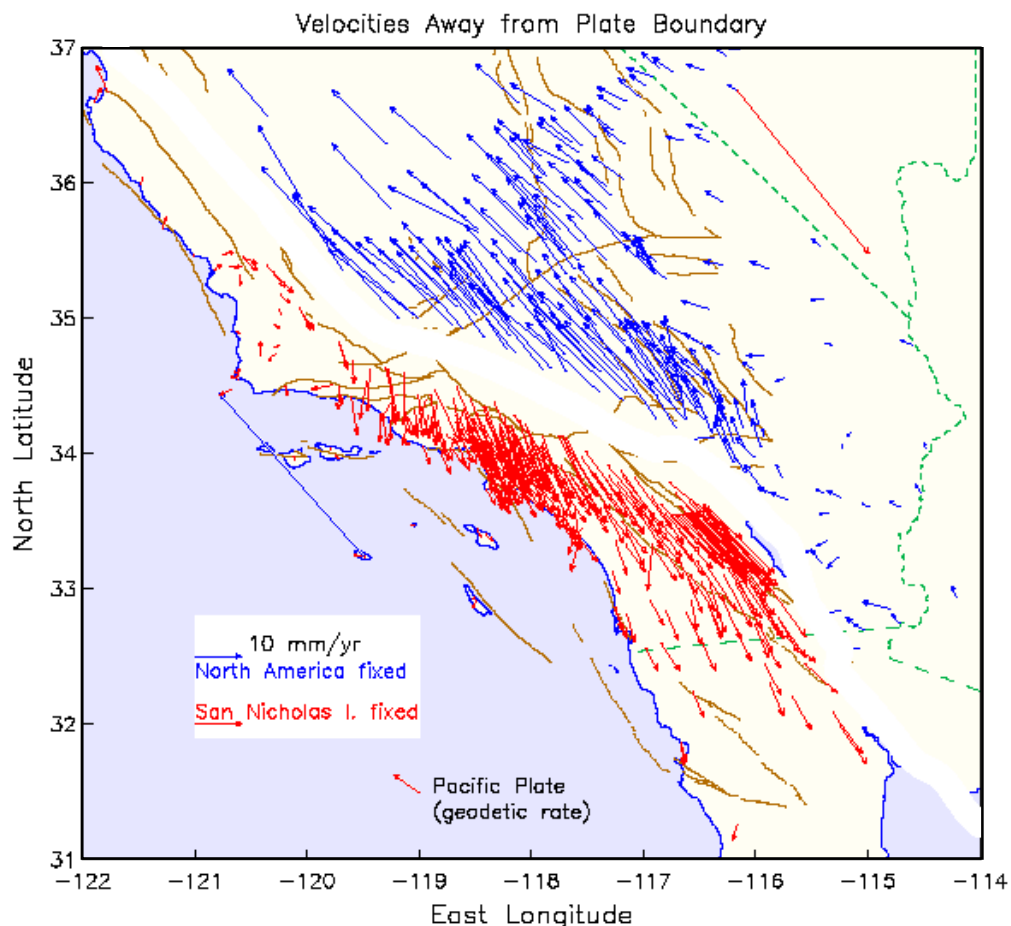


Figure III.1. Community Crustal Motion Model, Version 3.0.1.

- The SCIGN project completed construction and moved to an operational status. Time series of data are now available from all three of the analysis centers (see <http://www.scign.org>). An analysis of these series, by Nikolaidis (2002), suggests systematic postseismic motions after the Landers and Hector Mine earthquakes, and was able to produce reliable vertical rates for a number of SCIGN sites--adding an important third dimension to geodetic measurements.
- Also completed as part of SCIGN was the long-base laser strainmeter in Glendale (see <http://jacinto.ucsd.edu/gvs>) which is producing high-resolution measurements of deformation to complement those made using GPS. This combination of measurements makes SCIGN a paradigm for the coming Plate Boundary Observatory, in which many SCEC scientists expect to be involved.

Scripps Orbit and Permanent Array Center (SOPAC). This center maintains the largest and most comprehensive archive of continuous GPS data, metadata, and data products serving 1-1.5 million data files per month to 2000-3000 users around the world. All data operations at SOPAC are controlled by an Oracle 8.1 RDBMS, which is continually improved and expanded to ensure data completeness, reliability, accuracy, and accessibility. SCEC investigators benefit most directly from SOPAC's contributions and responsibilities to the SCIGN project. Specifically, SOPAC maintains and downloads 20% of the SCIGN stations, is the central archive for all SCIGN data and metadata, and analyzes daily all SCIGN data to produce position time series. SOPAC maintains an active and heavily used home page (<http://sopac.ucsd.edu>) with a variety of Web-based tool, as well as an ftp server (<ftp://garner.ucsd.edu>). SOPAC analysis of SCIGN data is critical for anchoring the analysis of historical and new field GPS (campaign) data and has been the cornerstone of the SCEC Crustal Motion Model, Version 3. SOPAC also participates in the SCIGN Analysis Committee, an effort that has gone a long way to reconcile site position differences between the independent SOPAC and JPL analyses. The SOPAC director is a member of the SCIGN Executive Committee and Coordinating Board. SCEC investigators also benefit from other SOPAC activities such as precise orbit generation for the IGS, the leading role SOPAC plays in UNAVCO's GPS Seamless Archive (GSAC) effort, and SOPAC's analysis of all continuous GPS data in the region covered by the PBO, including a reanalysis of all data up to the present in ITRF2000. The California Spatial Reference Center (CSRC) an important community outreach effort also leverages SOPAC's infrastructure. CSRC projects such as upgrading SCIGN sites to high-rate (1 Hz), low-latency (1-2 seconds) operations also directly benefit SCEC investigators.

WInSAR. Over the past year SCEC funds have been used to begin a series of improvements in the WInSAR archiving system. In particular, SCEC and additional NSF funds have been combined to develop identical RAID storage systems that will reside at Caltech and Stanford (UCSD already has such a system). These RAID servers will also serve as stand alone web servers for WInSAR. This system will be a considerable upgrade from the slow and volume limited existing tape system (which is being decommissioned). In addition, the consortium has begun to design improved web based user interfaces for both data ordering and data downloading. These software development activities are critical for efficient functioning of the WInSAR system as the amount of data fluxed through the system increases. In particular, the consortium is looking to the future when the ENVISAT and ALOS data streams become active.

Geology. Geology infrastructure support in 2002 falls generally into three areas: 1) radiometric dating for all SCEC geology projects; 2) development of hyperspectral scanning as an archival tool for paleoseismology; and 3) development of the Southern California fault activity database.

Radiometric Dating. There are several primary reasons SCEC has chosen to consolidate the dating budget into a single effort. These are: 1) economy of scale; 2) better science; 3) more rapid turn-around; and 4) the dollars go to where they are most needed. A common aspect to any proposal that requests radiometric dates before the fieldwork is actually done is that the PI doesn't know how many samples will actually need to be run. Money is requested for how many the PI's would like to have or think they will need. That is normal and expected. In SCEC, we can be more efficient and fund the individual projects. Then, after the initiation of fieldwork, we decide where the resources are best used. Additionally, because of the close collaboration between LLNL, Seitz and the PI's conducting fieldwork, it is possible to acquire C-14 results within two weeks, while the investigations are underway. By getting a suite of preliminary dates, we can test the overall age of the stratigraphic section and then focus on those parts of the section where age data are most needed or problematic. In the end, we get better results for fewer dollars.

In 2002, the bulk of the dating is divided between paleoseismic efforts on the San Andreas, San Jacinto, Mojave and other Southern California faults. The Hog Lake site on the San Jacinto fault yielded better than expected samples for dating, resulting in a higher demand for C-14 analysis. The end result will be one of the longest and most precise records of past earthquakes for any site in southern California. The San Andreas studies also required substantial chronologic support. In contrast, the Mojave efforts are slow to develop because SCEC funding wasn't received until the hot summer months and the field effort is only now getting underway in November. Consequently, it is likely that most of the Mojave dating will come out of the 2003 budget and the dates that were earmarked for those studies in 2002 will be used instead on the San Jacinto and San Andreas sites.

There was also a component for cosmogenic dating. We are finally getting the final surface exposure dates for the paleoseismic work completed after the Hector Mine earthquake. In addition, through this collaboration, Ryerson joined with Rockwell to sample and date offset alluvial fans near Anza to provide a high-resolution slip rate that will greatly complement the SCEC effort at Hog Lake.

Hyperspectral Scanning. There is an effort to develop new methodologies for both aiding in the recognition of paleoseismic events in trench stratigraphy, providing independent evidence of unit correlations, and facilitating the archiving of paleoseismic data. Through a joint effort between UCSD and SDSU, strata offset by the San Jacinto fault at Hog Lake were collected and scanned with a hyperspectral scanner at JPL. Over 2000 spectra were collected and are currently being analyzed. The intent is to determine the best spectra to use to distinguish stratigraphic units and their composition and mineralogy, ultimately to develop new instrumentation for geologic analyses.

Southern California Fault Activity Database (SCFAD). This activity has evolved into a key component in SCEC's Fault Information System (FIS), an on-line umbrella for fault related data, models and other products within SCEC's collaboratory. The need for a fault activity database is great and long-standing. For nearly a decade, the California Geological Survey (CGS), SCEC,

and the United States Geological Survey (USGS) have put considerable shared resources into synopsizing and assessing what has been published about hazardous faults, then making the data accessible over the internet. Several complementary databases now exist, with different focuses and users, in various stages of completion. The SCFAD began as a compilation of observational, chiefly paleoseismic studies, but now incorporates data from many sources, including the other databases, in a format most conducive to research. When fault databases were first planned, the full power of today's internet was not yet recognized, and databases were envisioned as the Web equivalents of review papers. Reading an overview summation of a fault remains important to many users, but more is now possible. This year, the SCFAD data model was revamped to allow complex queries that may be interactive or automated. SCFAD data will soon be obtainable "live," by automated processes as well as by human users. Further, SCFAD output is being encoded in XML, to enable data interchange irrespective of computer software or platform. Content changes have been made as well. New data fields in the SCFAD include the fault names and ID numbers used by other databases. All of these changes have been made to ensure maximum usefulness to the research community.

Fault and Rock Mechanics. The disciplinary committee for Fault and Rock Mechanics (FARM) is a new component of SCEC, and as such there was little funding in this area prior to 2002 and thus little to report as yet. The grants awarded for 2002 are not yet complete and annual reports have not yet been submitted by individual PIs, so it seems more appropriate to describe FARM activities in general and the plans for the future than to focus on any particular preliminary result. During 2002 there has been considerable activity and FARM is now an active component of the SCEC program. The FARM community held a very successful workshop for the two days prior to the annual meeting in September, 2002, and a summary of this workshop and some of its suggested directions are of interest. Many of these have been incorporated in the RFP for 2003 SCEC proposals.

The report of the workshop is included elsewhere in this Annual Report, so only a brief overall summary of it is given here, with more focus on the consensus outstanding problems. The workshop brought together for the first time under the auspices of SCEC a group of scientists working primarily in Fault and Rock Mechanics. The purpose was to begin to define collaborative efforts that can be undertaken by these and other workers to attain the short term objectives and long term goals of SCEC. Attendees at the workshop were primarily drawn from scientists working on FARM, but members from other groups actively participated, especially those the discipline of Seismology and in the Earthquake Source Physics Focus Area.

Out of this workshop emerged a list of important issues for SCEC to work on from the perspective of FARM. Most of these fall into the Earthquake source Physics Focus Area. A more complete list of these is included in the final report of the FARM workshop, but some of the most important include the following: 1) Determine sliding resistance on faults during large earthquakes in order to make dynamic models of earthquake rupture that are more realistic than those currently used. This would allow the rupture models used to calculate wave propagation and ground motions from scenario earthquakes to be based on physically consistent dynamic models rather than somewhat arbitrary kinematic models as is now generally the case. Coseismic sliding resistance needs to be determined by new and difficult-to-conduct high-slip-speed laboratory experiments and theoretical models, as well as by inversion of strong motion seismic observations guided by insight from laboratory and theoretical results. 2) Determine what the character of near-fault damage, seen in exhumed ancient fault zones and in geophysical data on

active faults, can tell us about the constitutive properties and processes that occur during coseismic slip. 3) Determine the behavior of geometrically complex faults and networks of faults and the interactions between faults in such systems. This includes the role of normal stress and normal-stress memory as well as shear localization and damage, both in quasi-static and dynamic situations. 4) Determine the role played by fluids, including the spatial and temporal variation of pore pressure and its role in dynamic rupture and the nature of interseismic chemical healing. 5) Determine the nature of damage produced by fault propagation and slip, for example how much is due to dynamic vs. quasi-static effects, and what can be inferred from observations of exhumed faults, experiments on confined ruptures, and theoretical modeling.

Focus Group Activities

Within the new SCEC structure, the focus groups are responsible for coordinating interdisciplinary activities in five major areas of research: *structural representation*, *fault systems*, *earthquake source physics*, *ground motion*, and *seismic hazard analysis*.. The following reports summarize some of the activities in each of these areas.

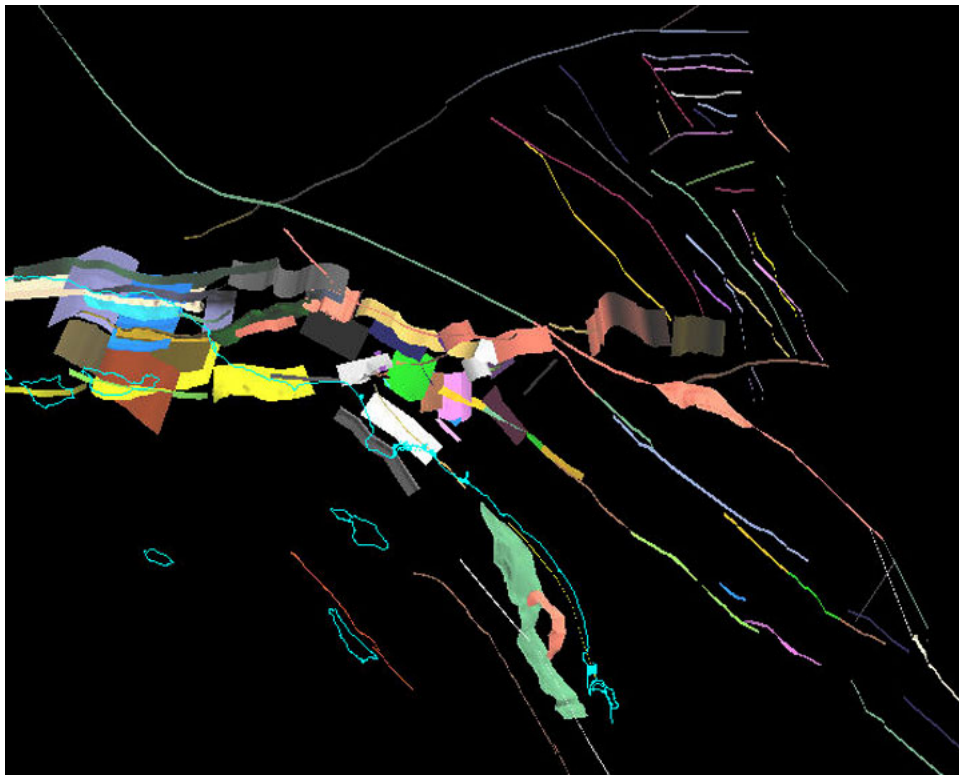


Figure III.2. Perspective view of the current Community Fault Model (CFM-A) for Southern California (A. Plesch and J. Shaw, 2002).

Structural Representation. In 2002, activities in the Unified Structural Representation (USR) Focus Area centered on developing a new Community Fault Model (CFM) and improving the existing Community Velocity Model (CVM) for southern California. The Community Fault Model (Figure III.2) is an object-oriented, 3-D representation of active faults intended for use in fault systems studies, strong ground motion modeling, and seismic hazards assessment. The

model's inventory and design specifications were established by a SCEC working group, which includes representatives from the US and California Geological Surveys. The model consists of triangulated surface representations (T-surfs) of major faults, distinguishing between interpolated and extrapolated fault patches and providing alternative representations for the most contentious sources. Versions of the model will represent a list of preferred fault representations that are extracted from a database being constructed with *Postgresql*. Using a *MapServer* web interface,

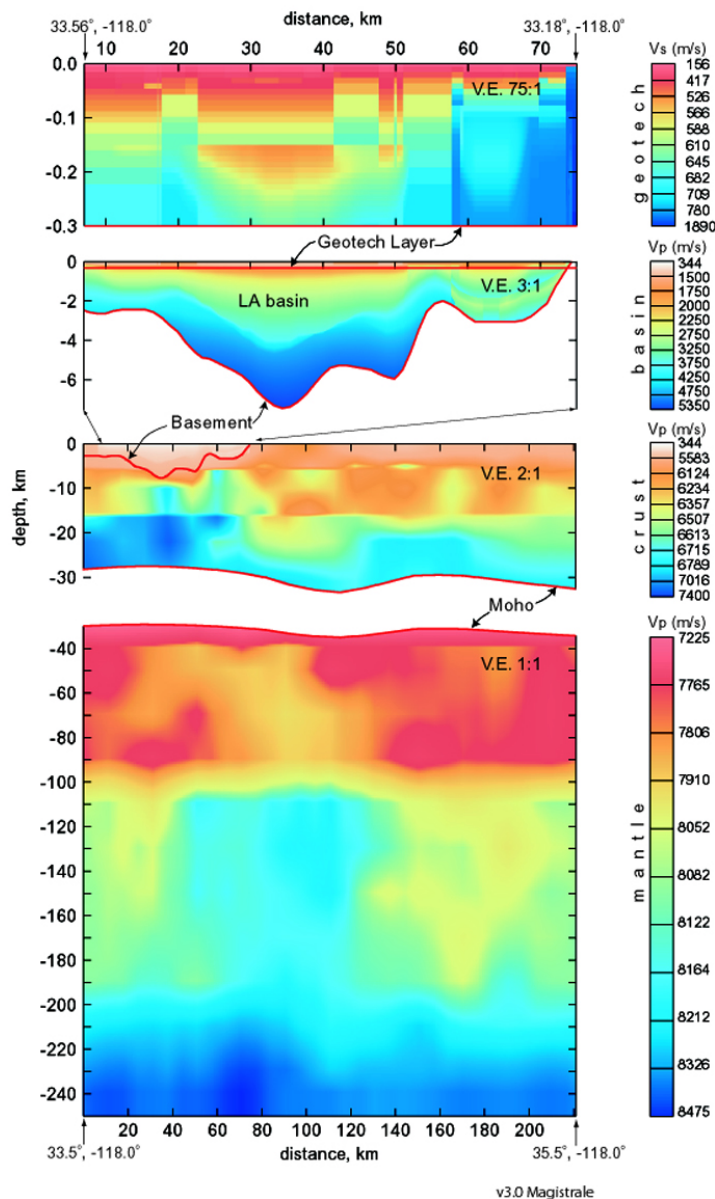


Figure III.3. Cross section through Version 3 of the Community Velocity Model (H. Magistrale, 2002).

users will be able to access the versioned models, as well as build their own fault models by selecting alternative representations using search criteria such as fault type and slip rate. A beta version of the fault model is currently available for review (<http://structure.harvard.edu/cfma/>), and the online database and Version 1 are slated for release in January, 2003.

Interaction between the USR and Fault Systems Focus Areas also established the need for a Community Block Model (CBM). The CBM will be used to mechanically model fault systems behavior using strain rates recorded by GPS, seismicity, and paleoseismology. The CBM is based on the fault representations contained in CFM, but consists of blocks or volumes that are fully encompassed by extrapolated fault surfaces and topography. In 2002, a prototype CBM was developed for the northern Los Angeles basin (Figure III.5). Alternative approaches to meshing the prototype model are currently being evaluated and simple solvers will be tested, providing a basis to design and implement a CBM for all of southern California.

Version 3 of the Community Velocity Model (CVM) was completed (Figure III.3) and made available in 2002. Updates to the new model include topography, in the form of a 30-m DEM, an improved representation of the San Bernardino basin, and a revised density description. The velocity model is currently being used for several applications in SCEC, including earthquake relocation and numerical simulation of seismic wave propagation for the prediction of hazardous ground shaking.

USR activities are driven by the production of these community models, which in turn support the work of a large number of scientists. In 2002, the CFM effort involved geologic and seismologic research to better define the geometry of several major faults in southern California, the development of new geomorphologic and paleoseismologic techniques for constraining slip rates on blind-thrust faults, and the testing of modeling and observational methods for distinguishing between alternative fault representations. The CVM effort supported activities in waveform modeling and tomography to investigate the crustal structure in southern California, including the development of new methods for testing and calibrating the model.

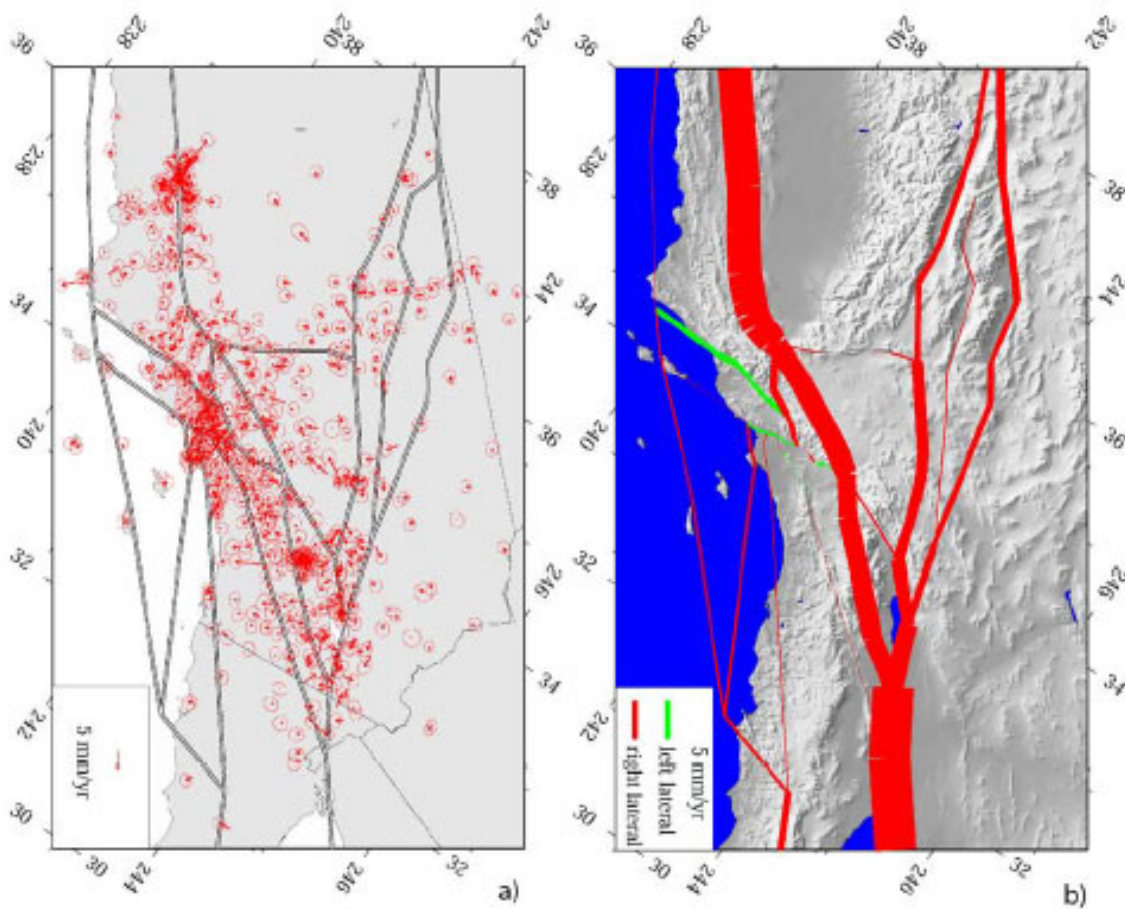


Figure III.4. a) Residual (observed-model) velocities with 50% confidence ellipses and fault system geometry, and b) inferred strike-slip rates for a fault-systems model that relates geodetic velocities to fault slip rates, including the effects of elastic strain accumulation and block rotation.

Fault Systems. Understanding fault system behavior in southern California requires consideration of observations of crustal displacements obtained via several approaches over a wide range of spatial and temporal scales: Geologic estimates of slip rates on faults on ~100 – 100,000 yr timescales; geodetic measurements of crustal deformation over time scales of 1 – 10 yrs; and coseismic displacements result from the partial release of the accumulated elastic component of the strain. Relating geodetic velocities to geologic slip rates on faults and to seismic hazard is one example of model based inference that requires a continuum mechanics model. Another example is relating secular loading rates and coseismic strain redistribution in the fault system to characteristics of the earthquake catalogue. Thus much of the research of the Fault Systems Group revolves around using and improving models of stress and strain evolution through the southern California fault system.

Part of this year's effort involved using "heritage" continuum mechanics models that have relatively simple geometries and rheologies to investigate the evolution of stress, strain, and/or seismicity. For example, the MIT group has used the SCEC Crustal Motion Model to infer the slip rates on the major faults in the system. They extended the classic Savage and Burford model of strain accumulation and release in an elastic halfspace to include the effects of a system of multiple intersecting faults of finite length and varying strikes and dips. Each model fault segment makes up part of the boundary between two adjacent blocks. The model implicitly

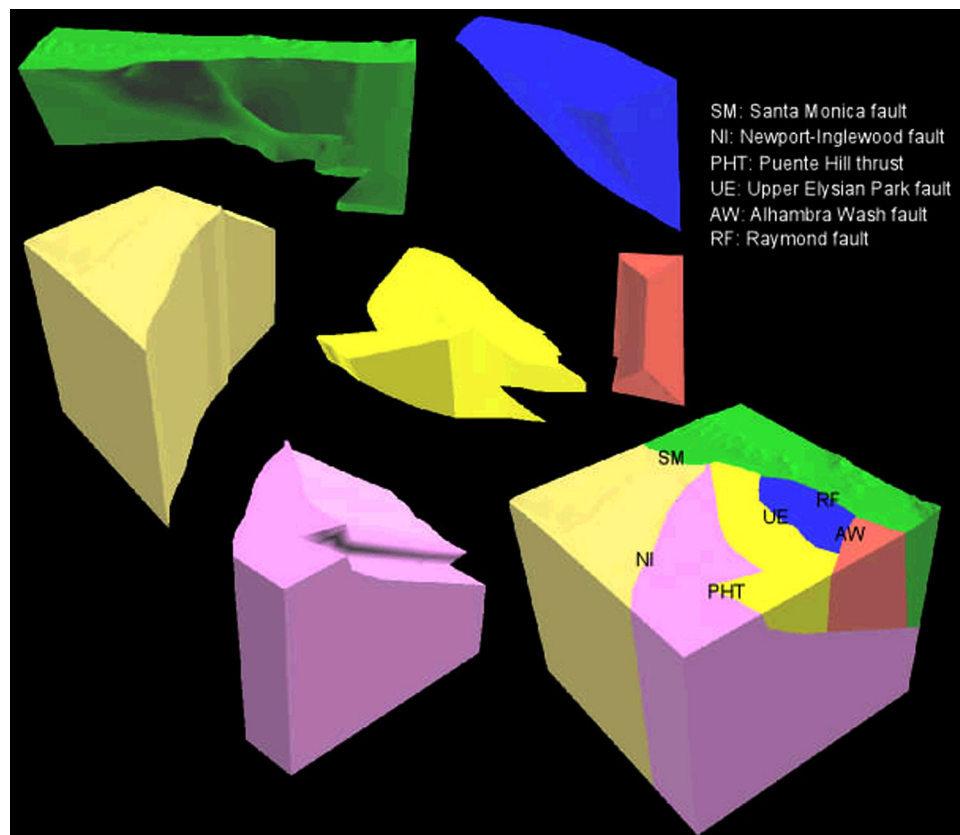


Figure III.5. Perspective view of the prototype Community Block Model (CBM), developed for use by the Fault Systems Focus Group for finite-element modeling of deformations. Separate fault blocks are shown in the upper left, and the composite block model is shown in the lower right. (A. Plesch and J. Shaw, 2002).

enforces a path integral constraint on both the geodetic and the geologic velocity fields, ensuring that the relative velocity between any two points is not a function of the path connecting them. Block boundaries are defined by faults with slip rate components determined in an internally consistent manner by the projection of the relative block velocity vector onto the fault plane. Figure III.4 shows results for their preferred (15-block) model of Southern California, including the residual velocities (observed – model), along with error ellipses, and predicted rates of strike-slip motion on selected faults. The residual velocities are generally small. In the immediate vicinity of Los Angeles the faults from the Cucamonga to the San Cayetano fault accommodate the majority of the shortening in the Transverse ranges ($5\text{--}8 \pm 2$ mm/yr of dip slip). With the exception of the Cucamonga fault, the same set of faults also has about 5 mm/yr of left lateral motion. The strand of faults (Raymond Hills to the Santa Monica Mountains fault) to the south shows < 3 mm/yr motion.

Models like this can be used in areas of simple geology (e.g., Owens Valley) to compare geologic and geodetic rate estimates and to investigate the effects of gross fault system morphology on the evolution of seismicity. Ultimately, however, more realistic descriptions of both of the fault geometry and the rheology of the crust are required. Finite element modeling will be an increasingly important component of fault systems studies, and efficient mesh generation is an important consideration. If a physical domain can be decomposed into closed subvolumes (“blocks”), mesh generation can be handled by existing software. The Fault Systems Group is involved in a collaborative effort with the Unified Structural Representation Group to develop such a description, called the Community Block Model (CBM). This year, the Harvard group, with input from the MIT group, began this process, developing the μ CBM, a block description of a subregion of the Los Angeles basin (Figure III.5).

Earthquake Source Physics (ESP). The goal of the Earthquake Source Physics focus group is to understand the physics of earthquake rupture nucleation, propagation, and termination and the resulting generation of strong ground motion.

Since ESP is a subject with a tremendous potential for breakthrough data and ideas, and the range (but not number) of FY02 proposed projects was quite broad, in FY02 SCEC funded research into a diverse subset of ESP-related topics. In the future, as promising distinct avenues appear, ESP will narrow its focus. Some other differences from FY02 to subsequent years funding will involve the addition of geological observations to this group and the moving of more routine data processing, such as earthquake locations to the Seismology Discipline committee.

ESP problems are tackled from the observation and simulation perspectives. In FY02, observations included microseismicity studies of detailed fault geometry and fault zone processes, a geodetically-based stress-triggering study that inferred the nature of materials surrounding some active faults, and development of techniques to infer the slip distributions and mechanisms of moderate and large southern California earthquakes. Simulations included evaluating the impacts of fault geometry, strength heterogeneity, and fault rheology on earthquake rupture propagation and the resulting strong ground motion, and solving the related inverse problem.

In the next few paragraphs we highlight some of the new discoveries of FY02 from the ESP Focus Group.

- On the fault-zone geometry front, using relocated microseismicity, PI Shearer modeled the deep geometry of the Imperial fault, which last produced large earthquakes in 1979 and 1940. He found that there may be 3 active strands at depth, below the single strand observed at the earth's surface. Using a similar methodology, but investigating a slightly different topic that relates to both fault geometry and source processes, Co-PI's Beroza and Vidale used Trinet waveform data to image a sequence of previously un-noticed foreshocks to the 1999 Hector Mine earthquake. They located the foreshocks on the same plane as the mainshock and found that they spread out over the same plane as the time of the mainshock approached.

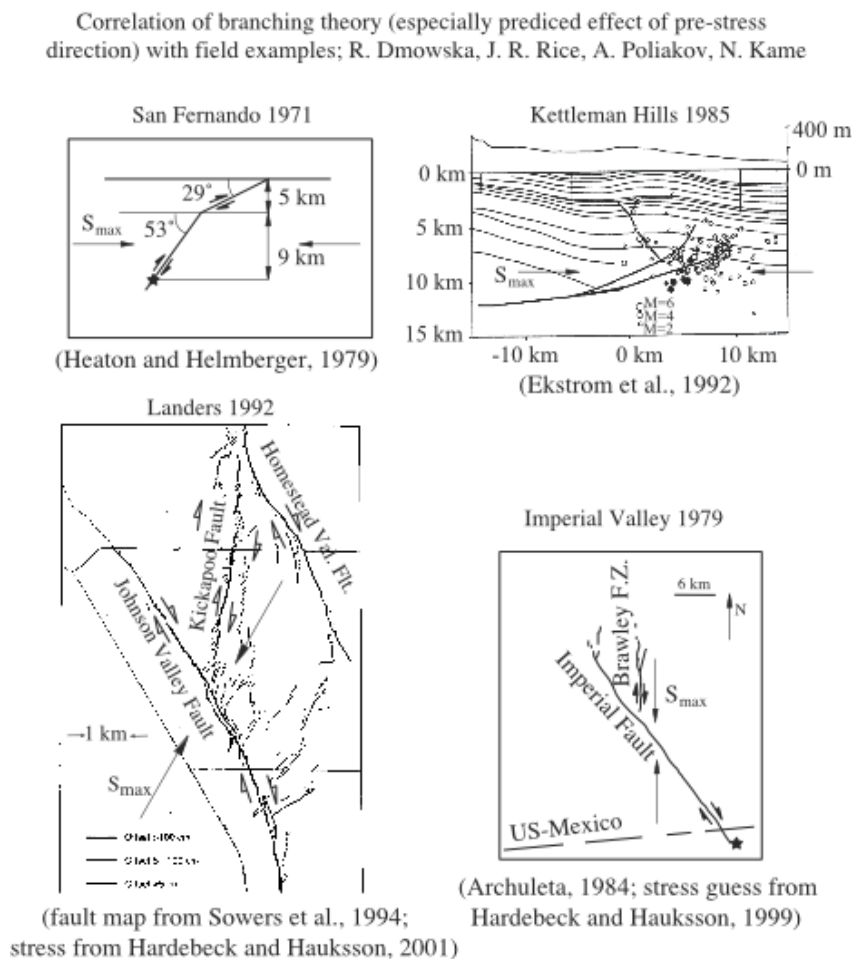
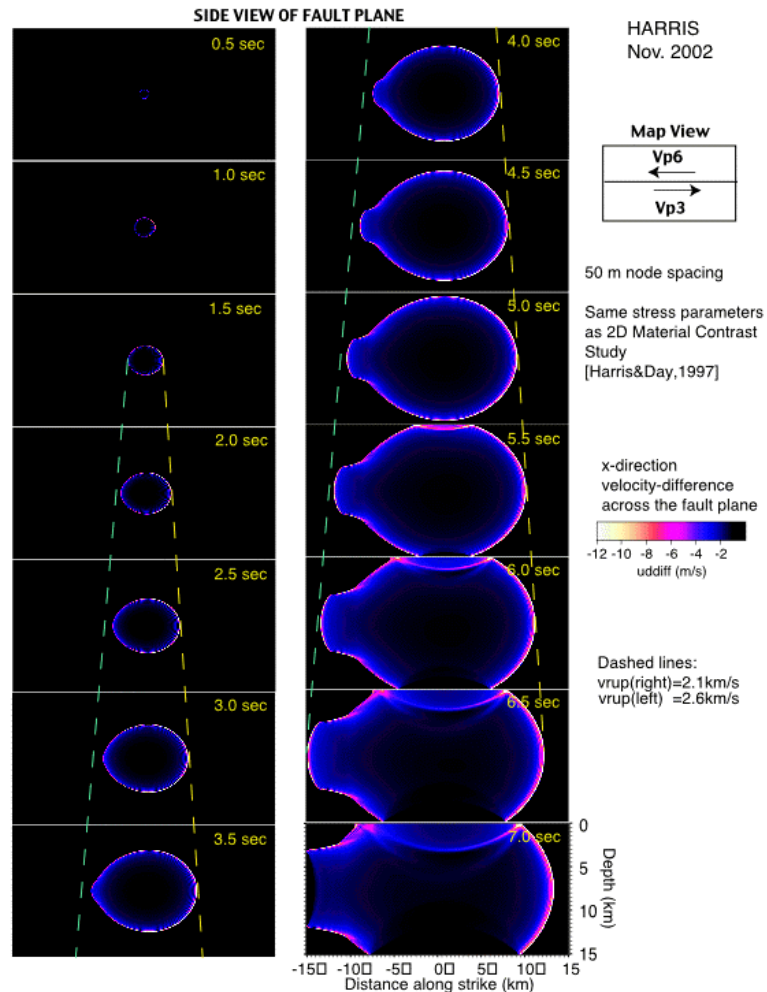


Figure III.6. PI Rice is examining what happens when a rupture encounters a bend in a fault. Theoretical modeling explains the observations of real earthquake behavior shown above.

- On the numerical simulations front, PI Rice is investigating the effect of an earthquake rupture encountering a fault bend, and PI's Day/Harris are investigating the effect of material contrast in the rocks surrounding a fault on the progress of an earthquake rupture. Rice finds that ruptures encountering a bend will continue or stop depending on the angle of the fault with respect to the background stress, and the velocity of the rupture as it enters the bend region (Figure III.6). In some situations the rupture will be able to propagate simultaneously on both branches of a bend, but this is not very likely. The Day/Harris study examines if the 2D findings of material contrasts can be extrapolated to the "real world", which is 3D. Preliminary Harris/Day 3D simulations using node spacing that is fairly coarse

(50m, for computational efficiency), show similar behavior in 3D as was observed in 2D. This result includes bilateral rupture propagation for bilateral nucleation, that the rupture velocities in each direction depend on the material contrast, and that the amplitude of the slip-velocity is slightly lower in one direction. Day/Harris studies also analytically explain the effect of a viscosity parameter in the finite-difference numerical simulations. This parameter allows for standard modeling of material contrasts in a numerical simulation without need to resort to exotic friction laws to obtain regularized behavior (Figure III.7).

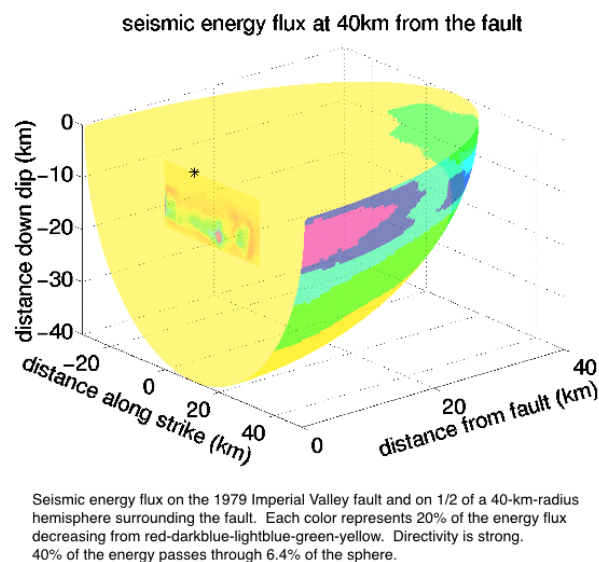
Figure III.7. PI's Day/Harris are examining the 3D effect of a material contrast on spontaneous rupture propagation.



- In FY02 ESP investigators studied parameters of currently hypothesized friction laws during dynamic rupture. PI Olsen examined if the slip-weakening distance, a parameter in the slip-weakening friction law could be inferred from strong motion data. PI Olsen also initiated inversions for choosing among the myriad of spontaneous rupture parameters using models of the 1992 Landers earthquake. On a related topic, PI Tullis examined the fracture energy constraints of various friction laws, as they relate to conditions of laboratory experiments on rock samples. They found that some forms (e.g., slowness-based) of the empirically-derived friction laws produce more realistic energy estimates than other forms (e.g., slip-based).

- In spontaneous rupture (dynamic rupture) models of earthquakes, and stress triggering studies in general, material homogeneity is often assumed, for simplicity. This is especially true for static stress-change calculations. However, PI Fialko found that this is not what should always be assumed. Examining geodetic measurements of the eastern Mojave shear zone around the time of the 1999 Hector Mine earthquake, Fialko inferred material heterogeneity in the fault zone region of a few neighboring faults, with kilometer-wide zones of reduced elastic moduli.

Figure III.8. PI Archuleta produced a dynamic rupture model (rectangular fault) of the Imperial Valley earthquake and the resulting energy flux. Strong directivity is evident.



- Similar to the material heterogeneity inferred for the near-fault region, the stress state on faults also appears to be heterogeneous rather than homogeneous. Using a spontaneous rupture model constrained by kinematic solutions for the 1979 Imperial Valley earthquake, PI Archuleta was able to show that much of the fault plane was an energy sink rather than an energy source, and that most of the seismic energy radiated by the Imperial Valley earthquake passed through a very narrow region surrounding the source. This result is significant for those trying to understand the directivity effects of earthquakes, and resulting damage (Figure III.8).

Ground Motions. The basic objective is to produce realistic time histories of ground motion that take into account wave propagation in the three dimensional structure of the crust, both linear and nonlinear site effects and physics based models of earthquake scenarios. In concert with PEER we have continued a close collaboration of five SCEC research groups who have been working to validate that the 3D numerical codes (finite difference and finite element) are modeling wave propagation in a 3D velocity earth structure. These codes are being extended to account for anelastic properties that can seriously affect the amplitudes of waves in sedimentary structures (Olsen et al., 2002). For example, Figure III.9a compares a finite element prediction (FE) for a layer-over-halfspace problem with an exact reference solution (FK). In this case, the FE solution used a commonly-used damping formulation in which damping is proportional to the mass matrix. The FE solution departs substantially (underdamping at high frequency, overdamping at low frequency) from the exact solution with frequency-independent anelastic

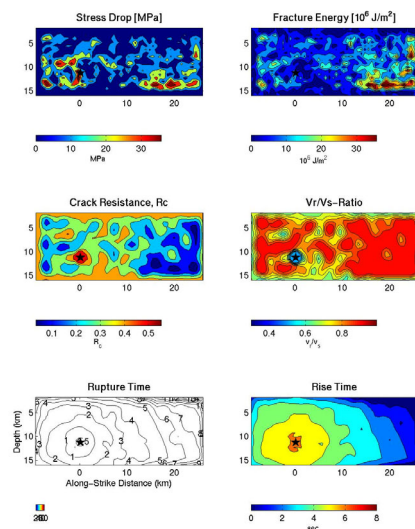


Figure III.9a. Example representing the pseudo-dynamic procedure. The starting point is a slip realization generated as a spatial random field (Mai and Beroza, 2002). The corresponding stress drop distribution is computed using the method of Andrews (1981)

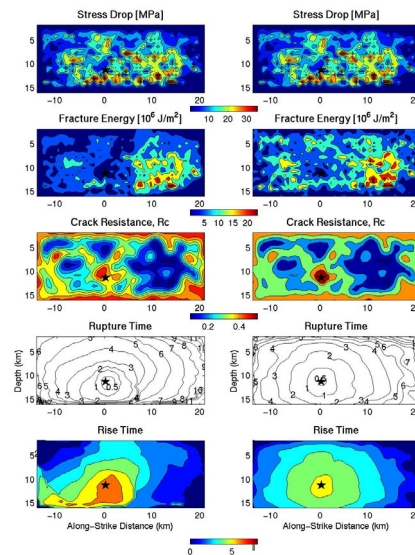


Figure III.9b. Comparison between a fully dynamic rupture model (left) and a corresponding pseudo-dynamic source model (right)

attenuation. Figure II.9.b shows a similar comparison, but in this case the numerical solution is from a finite difference (FD) method that uses coarse-grained memory variables to represent attenuation (Graves and Day, 2002). The more complete attenuation representation has brought the numerical solution into very close agreement with the reference solution, with no significant impact on computational load.

These numerical methods are being extended to include comparisons for realistic faulting models such as the 1994 Northridge earthquake. In these comparisons the kinematic faulting is embedded within the 3D SCEC structure of the San Fernando Valley. As an example of these comparisons, the three components of particle velocity at two stations are computed using two different codes with the same earth structure and faulting model. While the resulting ground motions are in close agreement, especially for station HSL, the ground motions are not identical. However, these comparisons demonstrate that the 3D numerical methods are converging in their ability to accurately propagate anelastic waves in a 3D medium and in their ability to simulate the kinematic faulting process. The faulting process is critical to ground motion because these codes, or ones like them, will be used to compute suites of ground motion time histories from earthquake scenarios for which we have no data.

As we plan for the future research on earthquake scenarios, we have to consider how SCEC researchers are going to characterize the source. With the help of SCEC funding Guatteri, Beroza and Mai have been developing a pseudo-dynamic source model, which is a physically consistent kinematic model in which the relevant source parameters (slip, rupture velocity and slip rise time) are specified in a manner consistent with spontaneous dynamic rupture results.

This approach is developed by investigating the relationship between kinematic and dynamic source parameters for a set of dynamic rupture models representing M7 strike-slip earthquakes. The starting point of our source characterization for a given earthquake magnitude is given by the spatial distribution of slip generated using a spatial random field model. Although the spatial slip distribution can be characterized based on slip models for past earthquakes, the characterization of the temporal slip evolution is limited by the lack of resolution of temporal slip behavior, such as rupture velocity and slip rise time, from the analysis of ground motion data. The fundamental idea of our approach is that dynamic rupture modeling can provide constraints on the temporal slip evolution, given a spatial slip realization. The pseudo-dynamic

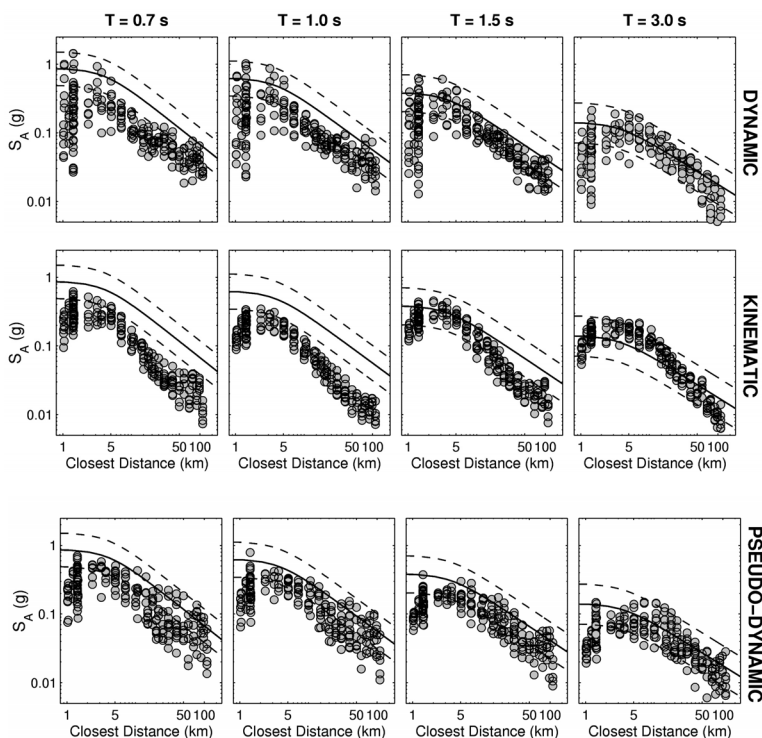


Figure III.10. Comparison of simulated (circles) and empirical average horizontal spectral acceleration attenuation (solid line) of Abrahamson and Silva (1997) for a M 7 strike-slip earthquake.

approach allows us to avoid the computational demands of generating fully dynamic rupture models at the short spatial scales required for modeling high-frequency ground motion (Figure III.10). It also forces us to develop physical intuition into how source parameters are related in dynamic rupture models.

We calculated ground motions from our set of pseudo-dynamic models at the same observer locations used in Guatteri et al. (2002) (their Figure 1). We used a quasi-dynamic slip-velocity function parameterization (Archuleta and Hartzell, 1981) approximated in the frequency domain using superimposed exponentials (O'Connell and Ake, 1995). Figure III.10 shows the simulated response spectra accelerations at different periods from the pseudo-dynamic models (bottom row), for kinematic models having the same spatial slip distribution but homogeneous temporal slip parameters (middle row), and for the fully dynamic models (top row). The pseudo-dynamic simulations are consistent with the empirical relationship by Abrahamson and Silva (1997) and with the ground motion simulations from the corresponding dynamic models.

Seismic Hazard Analysis. The SCEC goal is to improve seismic hazard analysis (SHA) by enabling the application of physics-based, system-level models of earthquake phenomena. These include the various earthquake-rupture forecasts being developed by the working group for the development of Regional Earthquake Likelihood Models (RELM; <http://www.relm.org>), which constitutes the lead activity of the SHA focus group. A longer-term goal is to replace the empirical ground-motion models presently applied in SHA with the full waveform modeling capabilities being developed in the Ground-Motions and Earthquake Source Physics focus groups. Working with the Implementation Interface, we also plan to develop and incorporate new intensity measures that predict damage measures with greater certainty, and to support the engineering community's transition to performance-based design.

Because there is no consensus on how to forecasts earthquakes, the RELM working-group members are developing a variety of alternative models (competing hypotheses). Some of the more physics-based models are being developed with the Fault-Systems focus group. Our goals are to formally test each model against existing and future geophysical data and to evaluate each model in terms of the hazard implications. This will help define existing uncertainties in seismic hazard analysis, identify the research topics needed to reduce these uncertainties, and identify which models are exportable to other regions where the options are fewer.

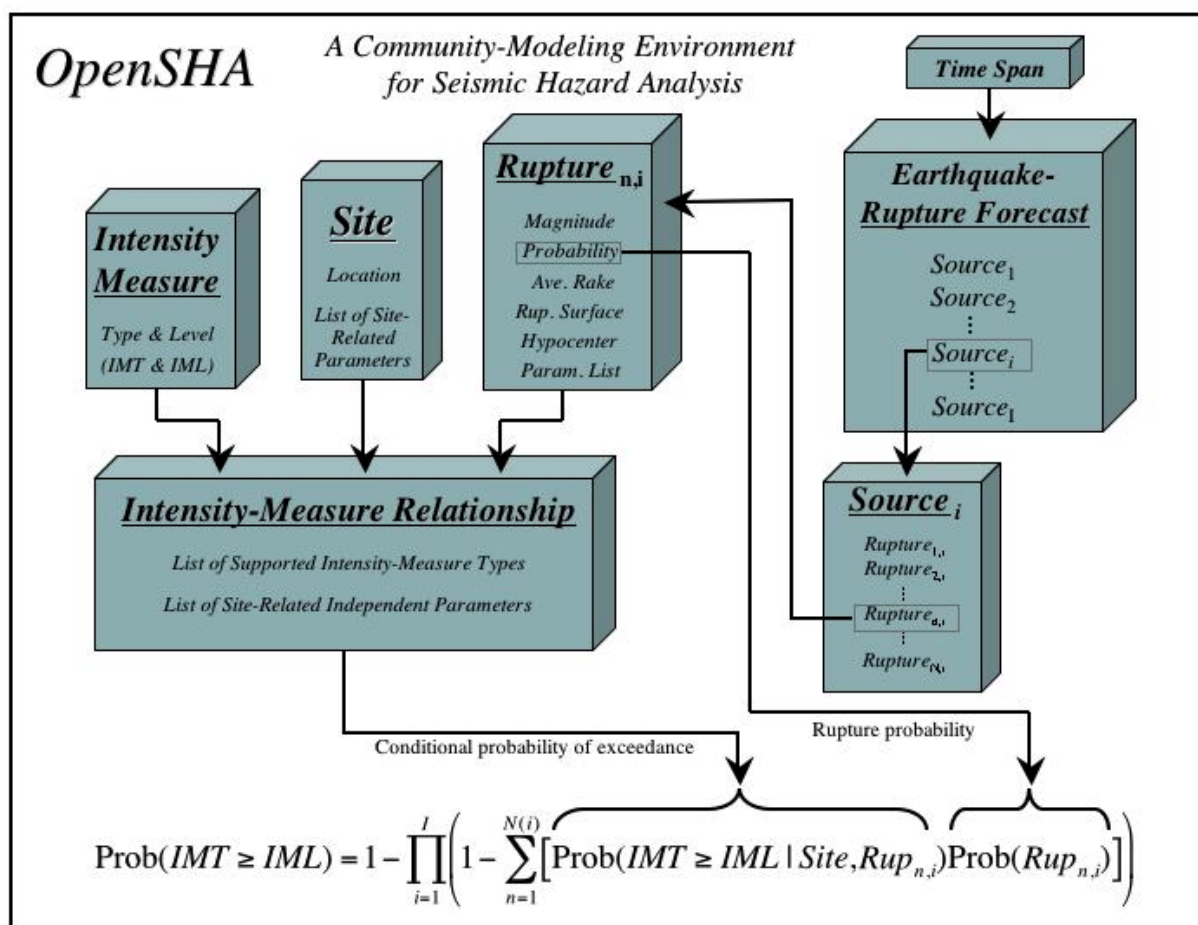


Figure III.11. Structure of the OpenSHA environment.

The RELM effort, which began under SCEC1, has depended on developing of a variety of “community” databases. These include an earthquake catalog, a fault activity database, the quantification of alternative fault-system geometries for southern California, and GPS strain estimates for the purpose of earthquake forecasting. Establishing standardized, shared data resources is important not only to avoid effort duplication, but to also minimize differences in model inputs so we can better understand why outputs (forecasts) are different.

Developing these data resources has been a multi-year effort, and has depended on collaboration with other groups in SCEC. In the mean time modelers have been conducting basic research to support their models, as well as developing prototypes and fine-tuning their forecast methodologies. We are now at the point where we can begin implementing the various models over the next year.

Accounting for multiple hypotheses (e.g., alternative RELM forecasts) does not present a conceptual challenge to SHA (in fact, it is demanded by a proper implementation). Multiple models do, however, present a practical challenge in that there has been no SHA code that could handle the wide variety currently under development (especially the more physics-based models). This led us to initiate new a Java SHA code development, with the goal that any forecast model could be analyzed without having to rewrite existing code. This has since grown into the OpenSHA infrastructure (see <http://www.OpenSHA.org>), where the goal is to allow *any* arbitrarily complex (e.g., physics based) SHA component to plug in for analysis without having to change what’s being plugged into (see Figure III.11). These other components might include ground-motion estimates from full, 3D waveform modeling, or a new type of intensity measure found by engineers to predict damage measures with greater certainty.

Finally, we hope to use the ITR collaboration to enable the various SHA components to be geographically distributed and electronically accessible at run-time (thereby minimizing overhead associated with data and model maintenance). We also hope reduce the time needed to execute hazard calculations by utilizing GRID computing technologies, which will greatly enhance our ability to explore the practical implications of each model. Finally, we plan to make all of this web-enabled to provide easy access for both scientists and the user community.

Special Projects

Southern California Integrated GPS Network (SCIGN). Southern California now benefits from a state-of-the-art geodetic array for monitoring earthquake-related crustal deformation. SCEC supports operations of this array, including the acquisition and open distribution of these data and derived data products in support of the SCEC science goals and mission. The Southern California Integrated GPS Network (SCIGN), an array of 250 continuously operating GPS stations and one long-baseline laser strainmeter, tracks regional strain with unprecedented precision. Scientists of organizations participating in SCEC designed and manage SCIGN; SCEC also played a vital coordinating role in making SCIGN possible.

The array is now operational and is already providing horizontal station velocities good to within <1 mm per year for nearly all stations. For many stations, already several years' data have been collected; these stations and data from them become increasingly valuable through time for sites that provide clean data. Approximately 200 stations are performing at a level of precision that exceeds original expectations. The SCIGN Analysis Committee reported in Sept. 2002 that the level of agreement between precise solutions by JPL and SOPAC is now at better than ppb in baseline length. This indicates that, for most SCIGN stations, the investment of human and

financial resources in careful site selection, as well as in equipment, site construction, and data processing developments seem to have paid off. In contrast, some 35 have been shown to have moderate to large seasonal variations, some of which clearly correlate to hydro-geological effects that are non-tectonic. Several papers have been published on these effects, and ways in which to identify and possibly correct for them.

This new network provides data with which to improve seismic hazard assessments, through the innovation of new methods as part of the SCEC seismic hazard analysis efforts. SCIGN will also enable us to quickly measure the larger displacements that occur during and immediately after future earthquakes. Recently, all three operational groups have made their complete time series available, and these are now linked from the main SCIGN web page at <http://www.scign.org/>. Already, over 60 scientific articles have been published that used SCIGN data either directly or indirectly. Among these are a wide variety of contributions to earthquake research including all aspects of co-seismic, post-seismic and inter-seismic crustal deformation and their interpretation, as well as continental plate boundary tectonics, and many technical aspects of GPS array technology development.

SCEC/ITR Project. SCEC, in collaboration with SDSC, ISI, IRIS, and the USGS, has received a five-year grant from NSF's Information Technology Research (ITR) Program and Geosciences Directorate to build a new information infrastructure for earthquake science. Project goals have been formulated in terms of four "computational pathways" related to seismic hazard analysis (SHA). Pathway 1 involves the construction of an open-source, object-oriented, and web-enabled framework for SHA computations that can incorporate a variety of earthquake forecast models, intensity-measure relationships, and site-response models. Pathway 2 aims to utilize the predictive power of wavefield simulation in constructing intensity-measure relationships. Pathway 3 will incorporate fault-system models into time-dependent earthquake forecasts. Pathway 4 concerns the assimilation of various types of data into the unified structural representation of Southern California required by the other pathways. The overall goal is to create a SCEC "community modeling environment" or collaboratory that will comprise the curated (on-line, documented, maintained) resources needed by researchers to develop and use all four of these computational pathways.

The short-term objectives of the project have been focused on Pathways 1 and 2. Specific activities include (1) the development and verification of the computational modules, (2) the standardization of data structures and interfaces needed for syntactic interoperability, (3) the development of object classes, control vocabularies, and ontologies for knowledge management and semantic interoperability, (4) the construction SCEC computational and data grid testbeds, and (5) the development of user interfaces for knowledge-acquisition, code execution, and visualization. The first-year project report will be submitted as a separate document.

Workshops

Seven workshops on a variety of topics central to the SCEC research program were convened during the past year. Brief reports on each are given below.

Community Fault Model Workshop, February 22-23, 2002. The Workshop, organized by John Shaw and held at the SCEC facilities at USC, was used to coordinate the assembly of a community-based, coarse resolution fault model (CFM-A) of southern California for use in fault

systems analysis, the community velocity model (CVM), and earthquake hazards assessment. The model inventory and design specifications were established at the Workshop by the CFM Working Group, which included representatives from the model's planned users (e.g., RELM project), from related database efforts (e.g., CDMG, SCFAD), and SCEC's IT program.

The California Geological Society's fault database was selected as a starting point for the inventory of CFM. The fault set was broken into six geographic sub-divisions, and discussion leaders summarized the current state of knowledge of faults in each area. This discussion yielded specific recommendation about fault nomenclature, segmentation, orientation, and depth, as well as a list of primary references for each fault that were subsequently used to build a 3-D representation in CFM. A beta version of CFM-A was presented at the 2002 SCEC Annual Meeting, and an evaluation version of the model is currently available online (<http://structure.harvard.edu/cfma/>).

Borderland Initiative Workshop, March 8-10, 2002. The SCEC Borderland Initiative, organized by Monica Kohler, held its first workshop at the Wrigley Marine Institute in Two Harbors on Catalina Island, California. The workshop was well attended by about 40 scientists representing a large number of academic institutions, the USGS, and two consulting firms. The workshop's objectives were to:

- Plan strategies for interdisciplinary investigations of offshore fault and structural systems in coordination with the USGS marine program, cross-division NSF programs, and other oceanographic activities.
- Determine long-term and short-term scientific and experimentation goals for SCEC-related Borderland research.
- Understand what research efforts have already been carried out or are currently underway.
- Determine the quantity and quality of geophysical data (e.g., reflection, multibeam, core, well log, aeromagnetic, gravity) currently available.
- Develop support among and include the expertise of potential collaborating institutions and individuals.
- Examine the need for new or proprietary data in the context of offshore Community fault and velocity models.
- Examine research activities complementary to EarthScope/USArray's first transportable array installation in Southern California.
-

Workshop organizers issued a call for statements of interest that were to define major scientific issues, available data and current data collection efforts, prioritized lists of short-term and long-term objectives, and permanent instrumentation needs. The contributions were assembled into a draft white paper and distributed at the workshop to serve as a basis for discussions and breakout groups. The following action items resulted from the workshop: 1) submit letters of support to the SCEC BoD requesting establishment of a Borderland Working Group, and letters in support of partnership to NSF MARGINS, USGS CMG, NOAA, and

MMS, 2) construct a SCEC Borderland Initiative white paper based on workshop discussions and statements, 3) propose a special Borderland Science Session at the next SCEC Annual meeting, 4) adopt a Borderland proposal submission model whereby the BoD decides whether or not to formally endorse new Borderland science proposals to external funding agencies, and 5) begin Borderland research proposal submissions to NSF and NOAA, in addition to other relevant agencies.

ACES Workshop, May 5-10, 2002. During the week of May 5-10, 2002, a U.S. organizing committee led by Andrea Donnellan, hosted the Third International Workshop of the ACES (APEC Cooperation for Earthquake Simulations) at the Maui Prince Hotel in Maui, Hawaii. The workshop consisted of 5 days of technical discussions with no parallel sessions. The sessions focused on microscopic simulations, scaling physics, macro-scale simulations on both earthquake generation and cycles and dynamic rupture and wave propagation, computational environment and algorithms, data assimilation and understanding, and model applications. A reviewed abstract proceedings volume will go to press in December on the talks presented at the workshop. 47 journal articles have been submitted for a special volume in PAGEOPH. These papers are currently in the peer-review process and we plan to go to press in March of 2003.

ACES aims to develop realistic supercomputer simulation models for the complete earthquake generation process, thus providing a "virtual laboratory" to probe earthquake behavior. This capability will provide a powerful means to study the earthquake cycle, and hence, offers a new opportunity to gain an understanding of the earthquake nucleation process and precursory phenomena. The project represents a grand scientific challenge because of the complexity of phenomena and range of scales from microscopic to global involved in the earthquake generation process. It is a coordinated international effort linking complementary nationally based programs, centers and research teams.

Finite Element Modeling Workshop, June 4-5, 2002. The Crustal Deformation Modeling subset of the Fault Systems Working Group held a workshop at Caltech in June to begin development of community Finite Element Modeling (FEM) software. The workshop was organized by Mark Simon (Caltech) and Brad Hager (MIT), and 36 scientists from 12 universities, NSF, the USGS, JPL, LANL, and GSC participated. Workshop goals were to survey what software is currently available, to define the computational challenges, and to map out a strategy for making rapid progress. FEM software can be divided into three parts: meshing, assembly of equations, and equation solving. The Workshop investigated existing codes in order to determine the relative strengths and weaknesses of academic and commercial packages. Before the Workshop, benchmark problems were designed to test the accuracy and efficiency of the solvers; follow on benchmarks were designed at the workshop to test the meshers. The results of this investigation (see also <http://bowie.mit.edu/fe>) are:

- *Assemblers/solvers:* No software package known to Workshop participants has all of the components that will be eventually required, including efficient meshing, realistic rheologies, iterative solution of equations on distributed memory computers, and open source. All of these components are implemented in at least one available code, so all components could be evaluated. Benchmark comparisons were useful, demonstrating that parallel iterative solutions are both fast and accurate, but also revealing differences in physics among codes

and disagreements in calculated responses that are not yet fully understood. Benchmark studies are continuing to validate codes and to assess cost vs. accuracy for various meshes.

- *Meshing:* The SCEC USR group is generating descriptions of fault geometries using triangular surfaces. A high priority emerging from the Workshop is the capability of converting the discontinuous fault segments making up CFM-A into closed surfaces bounding blocks (the Community Block Model, CBM). The most straightforward interface between USR and FEM would be achieved using tetrahedral elements; investigating the speed and accuracy of unstructured tetrahedral meshes is therefore a high priority for benchmarking studies. Given limited resources and ongoing developments by other groups, the highest priority is to develop a realistic mesh describing the fault system of southern California. We are aware of no other effort to grid such a large region with such realism.

San Andreas Workshop, September 4-6, 2002. A workshop was held in early September, prior to the annual SCEC meeting, to decide the course of action on future paleoseismic work on the San Andreas fault in southern California. Seitz and Rockwell organized and orchestrated this meeting, which was held in Wrightwood on the San Andreas Fault. Two fieldtrips were also conducted during this meeting – one to the Wrightwood paleoseismic site and one to Hog Lake on the San Jacinto fault.

Nearly 30 SCEC scientists attended the workshop, during which time was divided between a few, select presentations and discussions on the direction of future work and priorities. Among the identified priorities are: 1) the need for new, high-resolution slip rates at a number of sites along the central and southern sections of the San Andreas fault, as well as new high-resolution rates on the San Jacinto and Elsinore faults; 2) high-resolution slip per event sites at several localities, especially near some of the existing well-resolved paleoseismic sites; 3) 2-3 sites where we can develop very long earthquake records, new high-resolution paleoseismic sites in the Mojave segment of the SAF and the northern SJF. It was concluded that a serious effort to achieve these goals will require serious funding that is beyond the scope and facility of SCEC, and it was decided that an effort would be mounted for a NSF CD initiative.

Towards that end, immediate priorities were discussed that would lead to a much stronger NSF proposal. These included: 1) clarification of correlation issues at Pallet Creek by re-dating of that section; 2) establishment of slip per event information at Devore, near where the earthquake chronology is well-established; 3) finding of a good site in the northern Mojave to establish a high-resolution event chronology; and 4) further work on the Indio segment, possibly at Salt Creek, to qualify what is possible in the southernmost part of the fault zone. It was felt that with some new preliminary information on these and possibly other sites, that a much stronger CD proposal effort could be mounted. The main focus of funding for the NSF effort should be to fully fund and army of students to work with more senior PI's on the San Andreas system.

Fault and Rock Mechanics (FARM) Workshop, September 7-8, 2002. This workshop was organized by Terry Tullis (Brown University), Chris Marone (Penn State University), and Jim Dieterich (USGS, Menlo Park) to bring together for the first time under the auspices of SCEC a group of scientists working primarily in the discipline of Fault and Rock Mechanics (FARM). The purpose was to begin to define collaborative efforts that can be undertaken by these and other workers to attain the short term objectives and long term goals of SCEC. Attendees at the workshop were primarily drawn from scientists working on fault and rock mechanics, but the

workshop drew members from other disciplinary groups, primarily seismology and earthquake source physics. The convenors invited the chairs and some of the co-chairs of all the disciplinary committees and focus groups. Although not all of these attended, there was a good representation from a variety of perspectives.

The meeting was held on Saturday and Sunday, September 7-8, 2002 just before the SCEC annual meeting and at the same site in Oxnard, California. This enabled most of the workshop participants to attend the SCEC meeting which helped introduce the FARM community to SCEC and saved travel costs and time. The meeting was organized so that there would be as much time for discussion as for speakers and this proved a very successful format. The participants were enthusiastic about the quality of the discussions and the usefulness of the workshop. A list of the most important issues for this community to focus on in the context of the SCEC program was prepared at the end of the workshop, and this was taken into account in preparation of the 2003 RFP for SCEC.

Workshop on Generation of Synthetic Strong Ground Motions, November 7-8, 2002. A workshop in Reno, Nevada, was organized by John Anderson, Yuehua Zeng, Ralph Archuleta, Steve Day and attended by at least 25 scientists. The workshop resulted in a very good sharing of ideas, and discussion of issues, related to generation of broadband synthetic seismograms.

One of the major purposes of the workshop was to come to some consensus on the methods to compare two seismograms. This was not entirely successful. A proposal by John Anderson at the end of the meeting seemed to be reasonably well received and may be considered worthy of additional investigation. That is to identify a matrix of parameters (e.g. peak acceleration, peak velocity, Fourier spectra, response spectra, cumulative squared acceleration, cross-correlation, etc.) for the accelerogram with different pass-band filters. The similarity of each of these quantities would be scored from 0 to 1. The grand score would be the sum of the scores on each of the individual parameters, normalized to a perfect score of 10. This method needs more study, to identify the list of parameters such that the score correlated with the visual impression of the similarity of the records.

Perhaps one of the most unexpected developments of the workshop resulted from the occurrence of the M7.9 earthquake in Alaska on Nov. 3. The participants learned a strong motion record was recovered at about 3 km from the fault, although nobody had seen the records. Both Yuehua Zeng and Robert Graves presented blind predictions for the ground motions at that site. The predictions are posted on the UNR web site (www.seismo.unr.edu/blind).

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IV. Communication, Education, and Outreach Activities

SCEC is a community of over 500 scientists, students, and staff from 39 academic institutions across the United States, in partnership with more than 50 other science, engineering, education, and government organizations worldwide. To develop applications of the knowledge and scientific products developed by this community, SCEC maintains a *Communication, Education, and Outreach* (CEO) program with four long-term goals:

- Coordinate productive interactions among a diverse community of SCEC scientists and with partners in science, engineering, risk management, government, business, and education.
- Increase earthquake knowledge and science literacy at all educational levels, including students and the general public.
- Improve earthquake hazard and risk assessments
- Promote earthquake preparedness, mitigation, and planning for response and recovery.

Short-term objectives are outlined below. Many of these objectives present opportunities for members of the SCEC community to become involved in CEO activities. These objectives set the programmatic milestones for the Center's internal assessments, guide the development of research results needed for effective education and outreach, and identify priorities for information technology and other resources.

Management Objectives

- M1. Develop CEO five-year strategic plan
- M2. Establish additional collaborations with partner organizations and pursue funding opportunities
- M3. Represent the SCEC Community in partner organizations, science, engineering and education conferences, etc.

CEO Focus Area Objectives

SCEC Community Development and Resources (activities and resources for SCEC scientists and students)

- SC1. Increase diversity of SCEC leadership, scientists, and students
- SC2. Facilitate communication within the SCEC Community
- SC3. Increase utilization of products from individual research projects

Education (programs and resources for students, educators, and learners of all ages)

- E1. Develop innovative earth-science education resources
- E2. Interest, involve and retain students in earthquake science
- E3. Offer effective professional development for K-12 educators

Public Outreach (activities and products for media reporters and writers, civic groups and the general public)

- P1. Provide useful general earthquake information
- P2. Develop information for the Spanish-speaking community
- P3. Facilitate effective media relations
- P4. Promote SCEC activities

Implementation Interface (activities with engineers and other scientists, practicing professionals, risk managers, and government officials.

- I1. Engage in collaborations with earthquake engineering researchers and practitioners
- I2. Develop useful products and activities for practicing professionals
- I3. Support improved hazard and risk assessment by local government and private industry
- I4. Promote effective mitigation techniques and seismic policies

SCEC CEO Team

Mark Benthien, associate director for CEO

John Marquis, digital products developer

Ryan Nambu, webmaster

Glenn Song, web assistant

Jasten Wine, database developer

Bob de Groot, education specialist

Ilene Cooper, education assistant

Paul Somerville, Implementation Interface project manager

Eric Runnerstrom, resource application specialist

Jason Masters, HAZUS specialist and administrative assistant

The following sections include highlights of SCEC's 2002 CEO program.

Management

C02001: Recruit CEO Advisory Panel. To expand participation by partners and recipients of SCEC CEO activities, a small advisory panel will be recruited for each focus area to help review progress and provide suggestions for opportunities that might otherwise be unknown. Recruitment will begin in early 2003.

C02002/C02003: Develop strategic plan. Continue development of long-term strategic plan, with a focus on evaluation strategies. The CEO advisory panel will be instrumental in providing guidance for evaluation priorities. Careful assessment must be conducted at every stage of program development in order to ensure that the program can be responsive to audience needs and effective in achieving its goals:

1. Stakeholder needs assessment will determine a base level of knowledge among various audiences and identify specific needs to be addressed. This information will be gathered through document reviews and interviews with representatives of the key targets audience groups.

2. Evaluation design will consider the types of evaluation methodologies and logic models SCEC CEO will employ, based on decisions of what should be evaluated (quality and/or quantity of products? Usefulness of services? Cost-effectiveness?) and why the evaluation is needed (improve the discipline of E&O? Accountability to agency management and stakeholders? Improve service delivery and program effectiveness?)
3. Performance measurement of product development and implementation will involve collecting accountability information for stakeholders, tracking intended and unintended outcomes of the program, and providing information vital to program improvement in order to achieve pre-established goals. This information can be useful for management of activities, resources, and partnerships.
4. Programmatic assessment of the overall success in achieving SCEC's stated goals and identification of what was successful, what failed, and why. This step is broader than performance measurement as it addresses the long-term, overall affect of the CEO program as a whole, and has implications for other large-scale E&O programs.

C02004/C02027: Northridge Ten-year anniversary. SCEC is coordinating efforts to develop a set of activities to mark the ten-year anniversary of the Northridge earthquake in 2004. The activities will be coordinated and developed around a consistent theme and will commence on January 17, 2004 and continue throughout the year. The plan is to include seminars, workshops, field trips, and earthquake-related annual conferences, public awareness campaigns at multiple levels including mitigation awareness, and involvement of policy makers.

C02006-C02010: Represent SCEC as Member of

- EarthScope E&O Committee
- Western States Seismic Policy Council
- Earthquake Information Providers (EqIP) group (Benthien is Chair)
- Earthquakes and Mega Cities Initiative (Los Angeles representative)
- California Post-Earthquake Technical Information Clearinghouse
- Southern California HAZUS Users Group (Benthien is project lead)
- EERI Southern California Chapter
- EERI Mitigation Center So. Cal. Planning Committee
- Emergency Survival Program Coordinating Council

SCEC Community Development and Resources

C02012: SCEC Diversity Issues and Possible Activities for a Diversity Task Force. The participants in SCEC represent a diverse array of ethnicities and a mix of genders. Nonetheless within this array there are perceived to be certain issues related to diversity. Among these perceptions are:

- The leadership of SCEC, including the Officers and the Board, is dominantly white and male.
- The Planning Committee will have quite significant power in SCEC II and serves as a stepping-stone to leadership. It would be desirable for the planning committee to be significantly diverse.
- Although many women and minority students are involved in intern and other programs at the undergraduate level, successively smaller numbers of women and minorities are involved at the graduate student, post doctoral, junior faculty and senior faculty levels.
- The current situation is not unique to SCEC, but reflects historical trends in the earth and physical science communities.
-

Possible Activities: An important first step in planning for the diversity effort at SCEC is to decide at what scale to address these perceived issues and to scope the effort. There seem to be several classes of activities that could be undertaken to address the concerns listed above. It would seem appropriate for the Board to consider which of the following classes of activities it wishes to pursue, and then to assign the responsibility for developing the activities to either a Diversity Task Force, or to specific individuals:

- Goal Setting—Does the SCEC Board want to establish a written statement of diversity goals? The goals could be cast in several ways. The goals need not necessarily be numerical, but rather could be aimed at processes.
- Analysis of statistics of past activities and maintenance of statistics on future activities—What are the actual statistics on interns, graduate students, postdocs, P.I.'s, project awards, etc.? How have these statistics changed with time? Considerable care must be taken in analyzing these statistics because the rules at some institutions (e.g. Harvard) require that a P.I. be a faculty member. This requirement may conceal a greater diversity than may be at first apparent.
- Establishing policy guidelines for the selection of individuals for "stepping stone" opportunities—SCEC could develop a policy of announcing the availability of opportunities for roles within SCEC leading to increased responsibility and/or visibility. Such opportunities might include speakers at the annual meeting, workshops and retreats, and committee assignments. By asking for volunteers and nominees for these opportunities, SCEC leadership could assure that qualified, interested individuals are not being overlooked.
- Sounding board—There may be significant diversity-related perceptions within the SCEC community that are not currently obvious to the leadership. Actions aimed at elucidating these might include the appointment of one or more diversity contacts who could serve as informal counselors, and/or holding an evening session at the annual meeting where diversity issues could be aired.
- Mentoring program—SCEC could develop a mentoring program. The program could be developed at a variety of scales, but perhaps the most critical need might be at the graduate student, post doc and junior faculty levels. The program could try to match volunteer senior faculty/researchers with younger individuals who request a mentor.

- Placement assistance—SCEC could develop a program aimed at assisting graduate students and postdocs find successor positions.
- Enhanced intern and community-based programs for involving undergraduates—SCEC I was active in involving women and minority students through internships and other activities. These programs could be continued and enhanced.
- Benchmarking—SCEC could undertake to learn what activities other large science and/or NSF-funded centers and consortia have done to achieve diversity goals and consider adoption of the most successful and appropriate of these.
- Multi-year plan—The SCEC Board could ask an individual or the Diversity Task Force to propose a 2 to 5 year plan for developing the activities the Board considers most appropriate.
- Seeking Support for Diversity Activities—SCEC could investigate additional opportunities for supporting diversity-related activities from NSF-education or other sources.
- Periodic self-analysis and reflection—The SCEC Board could hold a discussion, perhaps on an annual basis, of how SCEC is doing on diversity issues, perhaps receiving a report from the Diversity Task Force, if one is established.

C02013-C02016: SCEC Community Information System (SCECCIS). SCEC CEO has developed a new online database system, using technology developed as part of the Electronic Encyclopedia of Earthquakes project. This system was first implemented to facilitate registration for the 2002 SCEC Annual Meeting, but will soon be expanded to generate a web page for each SCEC scientist that will provide access to their past and current SCEC-funded projects, published research, outreach activities, etc. This system will also allow SCEC CEO to better track research projects with potential CEO applications. Contact information will be accessible by members of the SCEC community after signing in with a password.

Education Activities

C02017/C02054: Electronic Encyclopedia of Earthquake (E3). This project between SCEC, the Consortia of Universities for Research in Earthquake Engineering (CUREE) and the Incorporated Research Institutions for Seismology (IRIS), will synthesize a large and varied amount of data and information and provide broad access via the Internet in the context of the NSF-funded Digital Library for Earth System Education (DLESE). The project is supported with multi-year funding from the NSF National SMET Digital Library initiative. Subject matter will feature information and resources for over 500 Earth science and engineering topics, and provide connections to curricular materials useful for teaching Earth Science, engineering, physics and mathematics. The collection supports high-quality K-12 and undergraduate education by providing educators and students with the tools and resources for instruction and research. A very sophisticated information system for building and displaying the E3 collection and web pages has been developed and the content collection process is underway by ten faculty-student teams (four CUREE teams, two IRIS teams, and four SCEC teams.) SCEC teams are led by Sally McGill, Sue Owen, Gerry Simila, and Jan Vermilye. In addition to the main E3 website, a project led by Rob Mellors will provide access to



E3 content from the California Seismic Safety Commission website. (<http://www.scec.org/e3> login: e3, password: eee)

C02017: SCEC's Regional Seismicity and Geodesy Online Education Modules. These interactive online learning resources are based on seismic data from the SCEC data center, and geodetic data from the Southern California Integrated GPS Network (SCIGN). The modules are used by high school and undergraduate students and teachers, and will be integrated with the Electronic Encyclopedia of Earthquakes) (<http://www.scecdc.scec.org/Module> and <http://scign.jpl.nasa.gov/learn>)

C02019: Seismic Sleuths Revision. SCEC is revising the AGU/FEMA Seismic *Sleuths* middle school earthquake curriculum to reflect advances in science and technology since the last update in 1995. The objectives are to promote and improve natural hazard education for students; to foster preparedness for natural hazards through empowerment and encouraging personal responsibility; to provide an updated and redesigned learning tool that can be easily integrated into a curriculum based on national standards; and to provide constant updates in science content, pedagogy, and resource information through an interactive website. Each unit has been streamlined and can stand-alone in print or on the Internet in order to be used in a variety of environments. In addition, a television special (*Earthquakes: Seismic Sleuths*) based on the series has been created and aired worldwide, made possible by funding from the California Department of Insurance, the Institute for Business and Home Safety, and SCEC. The hour-long video was first broadcast on “Assignment Discovery” in spring, 2001. The video can be used by teachers as an excellent advance organizer, or viewed by interested citizens who want to learn more about earthquakes, the destruction they can cause, the scientists and engineers who study them, and what they can do to prepare. (<http://school.discovery.com/lessonplans/programs/earthquakes-gettingready/q.html>)



C02020: ShakeZone. In partnership with the Riverside County Children's Museum (“KidZone”), the CUREE-Caltech Woodframe Project and UC Riverside, SCEC created an educational, family-oriented exhibit on earthquakes (“ShakeZone”) that opened in January, 2002. The mission of the exhibit is to reach the local community, particularly the 20,000 elementary school children who visit KidZone each year, with positive messages about studying the Earth and preparing for earthquakes. The exhibit presents information about science, engineering, safety and mitigation. A shake table, an interactive computer display, and wall displays teach the visitors about the tools and techniques of earth scientists, engineers and emergency services personnel. (<http://www.kidzone.org>)



C02021: Summer Internship Program. To provide hands-on experiences in the earth sciences, provide insights into career opportunities, and interest underrepresented undergraduate students in Earth science-related careers, SCEC has supported 92 students to date (including 45 women and 19 minority students) to work alongside 50 SCEC scientists over the past 7 years. In summer 2002 SCEC supported 16 undergraduate students (8 IT interns at USC, 6 E3 interns, 1 HAZUS intern, and 1 research intern) 7 masters students (4 IT interns and 3 E3 interns). An additional 4 undergraduates were supported by SCEC scientists and participated in SCEC summer student activities. To begin the summer, the interns attended a Communication Workshop held jointly with interns from the Pacific Earthquake Engineering Research Center (PEER). Students participated in a three-day field trip to stops along the San Andreas and San Jacinto faults, Pinon Flat, the San Diego Super Computing Center, Scripps Inst. of Oceanography, and USC's Information Sciences Institute. Finally, students present posters at the SCEC annual meeting. (<http://www.scec.org/internships>)



C02022: SCEC Student Network. A new activity for 2002/2003, this network will involve students at SCEC institutions (and elsewhere) in SCEC activities (research, seminars, workshops, annual meeting), provide educational and career resources, and encourage continuation into graduate school. The network will eventually be expanded to include high schools students through mentoring by SCEC undergraduate and graduate students.

C02023: IRIS/USGS/SCEC Teacher Workshops. CEO offers 2-3 teacher education workshops each year in partnership with the U.S. Geological Survey (USGS) Pasadena Outreach and Education office. The workshops provide a direct connection between scientists and developers of earthquake education resources and those who use these resources in the classroom. Many of the materials for the workshops are provided by the Incorporated Research Institutions for Seismology (IRIS). SCEC is also coordinating a college instructor version of the workshop in southern California, based on a program also designed by IRIS.



Public Outreach Activities

C02018/C02032/C02033: SCEC Webservice and SCEC News. SCEC's webservice presents the research of SCEC scientists, provides links to SCEC institutions, research facilities, and databases, and serves as a resource for earthquake information, educational products, and links to other earthquake organizations. In 2000 SCEC introduced SCEC News to provide a source of information in all matters relevant to the SCEC community – to disseminate news, announcements, earthquake information, and in-depth coverage of earthquake research, in a timely manner via the World Wide Web. Since its inception in March 2000, over



1500 people have subscribed to e-mailed news "bytes" which announce new articles. (<http://www.scec.org>)

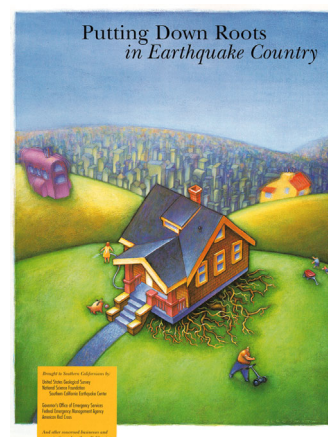
C02009: EqIP. CEO participates in the EqIP (Earthquake Information Providers) group, which connects information specialists from most earthquake-related organizations. EqIP's mission is to facilitate and improve access to earthquake information through collaboration, minimize duplication of effort by sharing information through individual personal contact, joint activities and projects, group annual meetings and biennial forums, and electronic communication. SCEC's former CEO director was among the founding group members and managed the initial development of EqIP's website which provides a database of descriptions of over 250 organizations with links to their websites. SCEC's current director for CEO is now the Chair of this group. (www.eqnet.org)

C02025: Wallace Creek Interpretive Trail. In partnership with The Bureau of Land Management (BLM), SCEC designed an interpretive trail along a particularly spectacular and accessible 2 km long stretch of the San Andreas Fault near Wallace Creek. Wallace Creek is located on the Carrizo Plain, a 3-4 hour drive north from Los Angeles. The trail opened in January 2001. The area is replete with the classic landforms produced by strike-slip faults: shutter ridges, sag ponds, simple offset stream channels, mole tracks and scarps. SCEC created the infrastructure and interpretive materials (durable signage, brochure content, and a website with additional information and directions to the trail). BLM has agreed to maintain the site and print the brochure into the foreseeable future.



C02026: SCEC Publication Distribution. Copies of SCEC's field trip guides, technical reports (Phase I & II reprints, Liquefaction and Landslide Mitigation Guidelines reports, etc.), and *Putting Down Roots in Earthquake Country* general public handbook (see below) are widely distributed at workshops, earthquake preparedness fairs, and through the SCEC website. (<http://www.scec.org/resources/catalog>)

C02026/C02028: Putting Down Roots in Earthquake Country. To answer the growing concern regarding the implications of the Northridge earthquake and other recent seismic events in southern California, the U.S. Geological Survey and SCEC developed a graphically illustrated, 32-page color handbook on earthquake science, mitigation and preparedness. Lucy Jones (USGS) wrote the handbook, and Jill Andrews (SCEC) managed the production and distribution of over 1.5 million copies. Its message is consistent and encouraging: earthquakes are inevitable, but they are understandable, and damage and serious injury are preventable. The content has also been developed into a web page (<http://www.scec.org/education/public/roots/eqcountry.html>). This publication was the basis for a Nevada version, and an update is in progress.



C02030/C02031/C02034: Media Relations. SCEC has successfully engaged local, regional and national media organizations (print, radio and television) to jointly educate and inform the public about earthquake-related issues. The goal has been to communicate clear, consistent messages to the public—both to educate and inform and to minimize misunderstandings or the perpetuation of myths. SCEC CEO encourages scientists who are interested in conducting interviews with media reporters and writers to take advantage of short courses designed and taught by public information professionals.

C02034/C02037: SCEC Re-Dedication Ceremony: This event was held in April 2002 at the University of Southern California (USC). Tom Henyey (SCEC, USC) introduced Dean Joseph Aoun (USC), Jim Whitcomb (NSF), John Filson (USGS), James Davis (California State Geologist), and Ed Bortugno (California Office of Emergency Services, OES) who gave invited comments. Tom Jordan (SCEC, USC) then presented SCEC 1 highlights and the plan for “SCEC 2.” Next Lucy Jones (USGS) discussed the importance of earthquake science in reducing earthquake risk. Finally, Ellis Stanley (Manager, City of Los Angeles Emergency Preparedness Department) described the role of earthquake science in emergency management. Following the presentations, a lunch reception was held during which attendees viewed displays and toured the newly retrofitted and significantly expanded headquarters for SCEC. Over 80 people attended the event, which received news coverage via local television, radio, and newspapers.

Implementation Interface Activities

Implementation Interface Research Partnerships:

The development of new knowledge about earthquakes and their effects is an important role of SCEC, but not its only role. Because earthquakes have major impacts on society, SCEC must also transfer knowledge about earthquakes and their effects for use in earthquake risk mitigation. This includes the transfer of knowledge to organizations involved in earthquake engineering research, and organizations that have special responsibilities for earthquake safety. The high-end information that these users need must contain the most current and highly evolved knowledge about earthquakes and their effects.

The purpose of Implementation Interface research partnerships are to implement SCEC research in earthquake engineering research and practice through information transfer and collaborative research. Table IV.1, from the 2003 SCEC Program Announcement, lists the collaborative research projects that have been developed during the past year between SCEC investigators and investigators from organizations that are involved in earthquake engineering research or practice.

Table IV.1. SCEC Implementation Interface Research Partnerships -Current and Planned Projects with PEER and PEER-Lifelines

THEME	PROJECT	SCEC / OTHER ORGANIZATION INVESTIGATORS	SPONSORS
Ground Motion Prediction using Rupture Dynamics	Pseudo-Dynamic Modeling Project	Beroza, Guatteri	PEER-Lifelines, SCEC
Ground Motion Simulation Code Validation	3D Basin Code Validation Project	Day, Bielak, Dreger, Graves, Larsen, Olsen, Pitarka	PEER-Lifelines (admin through SCEC); SCEC (recent co-fund)
	Foamquake Data Interp. Project: Phase 1: Modeling of directivity Phase 2: Validation of source inversion procedures	/ Day, Graves, Pitarka, Silva, Zeng	PEER-Lifelines, admin through SCEC
Probabilistic Seismic Hazard Analysis	Object Oriented PSHA Framework Project (Open-PSHA)	Field /	SCEC
	PSHA Code Validation Project	/ Wong et al., Field to use results to validate Open-PSHA	PEER-Lifelines
	Surface Faulting Hazard	/ Schwartz, Petersen; Wills; Rockwell (Adv)	PEER-Lifelines
	Vector-Valued Hazard Project	Somerville / Cornell	SCEC, PEER
Ground Motion Time Histories	Time Histories for PEER Performance Based Earthquake Engineering Testbeds	Somerville	PEER, SCEC
Ground Motion Prediction Model	Next Generation Attenuation Ground Motion Model	/ Power, Chiou, Abrahamson	PEER-Lifelines

This year, these collaborative projects have mostly involved the PEER Program and the PEER-Lifelines Program. Extensive work has also been done to expand the number of organizations with which SCEC is engaged in collaborative work. The breadth of the proposed collaborations is reflected in the potential new projects listed in Table IV.2, which is from the 2003 SCEC Program Announcement. These potential projects were identified through extensive communications with representatives of the potential co-sponsoring organizations.

Table IV.2. SCEC Implementation Interface Research Partnerships –Potential Future Projects

THEME	PROJECT	POTENTIAL CO-SPONSORS
Ground Motion Time Histories	Provide spatial wavefield and distributed input ground motions for bridges	PEER
	Provide ground motion time histories for use in earthquake engineering testing facilities and simulation software	NEES
	Validation of simulated ground motions for performance assessment of buildings and bridges, including site effects	PEER
Information Technology	Exchange information on information technologies	NEES
	Simulation and visualization of earthquake hazards, ground motions, geotechnical/structural response and damage	PEER
Ground Motion Response	Improved regional site response factors from detailed surface geology and from geotechnical borehole data bases (follow through on SCEC Phase III)	CGS, PEER-Lifelines
	Seismic velocity profiles from microtremor arrays for deep Vs profiles to complement SASW testing	PEER-Lifelines
	Mapping of basin edge effects using geological data consistent with engineering model from the “Basins” project (see Table 1)	CGS, PEER-Lifelines (future)
Relationship Between Ground Motion Characteristics and Building Response	Identify damaging characteristics of ground motions e.g. through PEER PBEE Testbeds, and mapping of associated hazard intensity measures	PEER
	How ground motions enter lowrise buildings	PEER
Societal Implications of Earthquake Hazard	Risk and implications of earthquake hazards on distributed lifeline systems and regional economies	PEER, PEER-Lifelines

Further expansion of Implementation Interface research partnerships is planned for the coming year. Interfacing with agencies of the California State Government, which is a particularly important focus of the SCEC Implementation Interface, has already begun.

Development and coordination of research partnerships between SCEC and organizations involved in earthquake engineering research requires familiarity with the research objectives, programs and activities of those organizations. P. Somerville, Implementation Interface project manager, spends a considerable amount of time attending meetings and workshops to maintain this knowledge. Table IV.3 lists the meetings that Somerville attended during October-November 2002 alone. These meetings involve a broad spectrum of organizations involved in research to which SCEC is contributing or can potentially contribute.

Table IV.3. October – November Meeting Schedule

Oct 10.	California Seismic Safety Commission – Research Workshop, Long Beach
Oct 15.	California Seismic Safety Commission (SSC), Sacramento
Oct 15.	California Geological Survey (CGS), Sacramento
Oct 15.	California Earthquake Authority (CEA), Sacramento
Oct. 16.	Presentation to Department of Water and Power, Los Angeles “Ground motions – what the engineer needs to know”
Oct. 21-22.	NSF US-Japan Workshop on Urban Earthquake Hazard Mitigation, Kyoto
Oct 24-25	PEER-Lifelines Kickoff Meeting on Next Generation Attenuation Model, Richmond
Oct 30.	Building Seismic Safety Council. Technical Subcommittee TS1 Meeting, (NEHRP Code Provisions update), Oakland
Oct 31.	PEER-Lifelines / CGS Design Ground Motion Library Meeting, Oakland
Nov. 7-8.	SCEC Strong Motion Simulation Workshop, Reno
Nov. 7-8.	PEER Testbeds Meeting, Oakland

Descriptions of specific projects during 2002:

C02039: SCEC/PEER Interface - PEER PBEE Methodology Testbed Program. The PEER Testbeds are real facilities to which PEER performance based earthquake engineering assessment (PBEE) and design methodologies are being applied. The primary focus of the testbed program is to assess the applicability of the methodologies and to foster their refinement. The testbeds will serve supplementary purposes such as focusing and integrating the research, promoting multidisciplinary research interactions, emphasizing systems level research, and involving interested earthquake professionals and decision makers. The testbed program includes the following four individual structure testbeds: a Van Nuys hotel, damaged by both the 1971 San Fernando and 1994 Northridge earthquakes; a new laboratory building at UC Berkeley; the Humboldt Bay Bridge, an older bridge which has been retrofitted by Caltrans; and a new bridge on Interstate 888 in Oakland. Paul Somerville provided ground motion time histories for these four testbed structures under a contract from PEER, and in a SCEC project is interacting with the teams of researchers for all four testbeds to make sure that the time histories are properly interfaced with the geotechnical and structural engineering analyses.

C02041: SCEC/PEER Interface - 3D Basin Ground Motion Modeling Project. An ongoing program of calibration of 3D basin modeling codes is being funded by the PEER Lifelines Program and recently by SCEC. To date, the program has focused on validation of five different computer codes. Under the leadership of Steve Day at SDSU, this program has been very successful, to the point where all significant differences in the results of five different codes have

been wrung out by a series of carefully designed tests. The next steps, which are under way, are to test the codes against recorded data of the 1994 Northridge and other recent earthquakes, and to use the codes in the calculation of the ground motions of important earthquake scenarios.

C02042: SCEC/PEER/PEER Lifelines Interface -Framework for Object-Oriented Seismic Hazard Analysis. Allin Cornell (Stanford), who is involved in the PEER Core Program, and Norm Abrahamson (Pacific Gas & Electric), who is involved in the PEER Lifelines Program, are providing review and guidance of the Framework for Object-Oriented Seismic Hazard Analysis that is being developed by Ned Field (USGS Pasadena). A review meeting, attended by these three individuals together with Tom Jordan (USC and SCEC Director) and Paul Somerville, was held at USGS on June 17 to discuss issues related to the development of the Framework. The Framework will provide an important vehicle for the experimental use of RELM hazard models and the SCEC Community Models. Earthquake source and ground motion models that are developed for the user community will need to undergo rigorous review before being made available for use.

C02039/C02043: SCEC/PEER Interface - Probabilistic Vector-Valued Ground Motion Hazard. Allin Cornell (funded by PEER) and Paul Somerville (funded by SCEC) are participating in the development and use of a vector-valued representation of seismic hazard for use in the prediction of building response. The vectors will initially consist of spectral acceleration at two or more periods, with a plan to eventually use the peak velocity and period of the near-fault rupture directivity pulse. The use of vector-valued hazard is expected to improve the accuracy and the efficiency of prediction of building response. The project will be performed within the context of the PEER PBE Methodology Testbed Program, specifically, the Van Nuys hotel testbed. In this program, ground motions are being specified using the conventional scalar-valued hazard approach. The goal of the collaborative project is to concurrently test the application of vector-valued hazard to this project, and compare its efficacy with that of the standard scalar-valued hazard approach.

Other Implementation Interface Activities:

C02045: Landslide Report and Workshops. In August 1998, a group of geotechnical engineers and engineering geologists with academic, practicing, and regulatory backgrounds was assembled to form a committee (chaired by Thomas Blake) to develop specific slope stability analysis implementation procedures to aid local southern California city and county agencies in their compliance with review requirements of the State's Seismic Hazard Mapping Act. The work of that committee resulted in the development of a relatively detailed set of procedures for analyzing and mitigating landslide hazards in California (edited by T. Blake, R. Hollingsworth, and J. Stewart), which was recently published and is available on the SCEC web site (<http://www.scec.org/resources/catalog/hazardmitigation.html>). In June 2002, over 200 geotechnical engineers, practicing geologists, government regulators and others attended a two-day SCEC workshop that explained the Landslide document. Because of the outstanding response to the sold-out workshop, a second workshop will be held in Los Angeles for those who were unable to attend the first. The course materials (now available for order) include extensive printed materials including all PowerPoint presentations, and two CDs with software tools and

PDF files of all presentations and printed materials. As a bonus, the CD includes PDF files of the presentations given at the 1999 SCEC Liquefaction workshop and both the Landslide and Liquefaction Procedures documents.



C02049: HAZUS. CEO is coordinating the development and activities of the Southern California HAZUS Users Group (SoCalHUG) with the Federal Emergency Management Agency (FEMA) and the California Office of Emergency Services (OES). HAZUS is FEMA's earthquake loss estimation software program. SoCalHUG brings together current and potential HAZUS users from industry, government, universities, and other organizations to (a) train GIS professionals in HAZUS earthquake loss estimation software, (b) improve earthquake databases and inventories, and (c) develop and exercise emergency management protocol. SCEC is also considering how it can improve the data and models that HAZUS uses in its calculations. SCEC CEO has organized three general meetings of the user group and in July 2001, a HAZUS training was held at California State University Fullerton for 23 Geographic Information System professionals employed by local governments, utilities, universities, and corporations. Funding for the training was provided by FEMA in response to a proposal by the SCEC and the OES. SCEC is also promoting the improvement of USGS ShakeMap (to include results of SCEC Research) for use in HAZUS scenarios.

C02050: Effective Risk Mitigation for SCEC Target Audiences. Lisa Grant and Eric Runnerstrom are researching local mitigation practices in Orange County to assess how SCEC research has been implemented in the past, and identify what seismic risk communication activities may be most effective. The following is their annual report for 2002:

Purpose of the project

Scientific research in support of mitigation can reduce vulnerability to seismic hazards (Committee on the Science of Earthquakes, 2002). The Southern California Earthquake Center (SCEC) is positioned to advance knowledge transfer and risk communication about seismic hazard. To strengthen risk communication between SCEC and target audiences, such as local governments, it is necessary to establish a baseline understanding of current efforts and their effectiveness at risk communication and risk mitigation.

Summary of project

We are designing and conducting a study of the type and level of earthquake hazard mitigation efforts employed in selected Orange County communities. Results will provide an overview of local mitigation practices and identify areas where seismic risk communication activities may be most effective. The study is focused on evaluating the effectiveness of previous SCEC activities and products in communicating seismic risk. We are currently studying cities in Orange County, but the study is designed so that it can be replicated in other areas with minor modification.

Methodological Approach

We are surveying the use of SCEC products by local jurisdictions in Orange County by compiling data from city documents and conducting informational interviews with representatives of 27 of 34 Orange County cities. Orange County is well suited for this study because it contains diverse sociologic, geologic, and seismic conditions, which may influence other cities' use of SCEC products. Orange County ranks second in California counties ordered by total population or population density. Approximately 40% of the housing stock was built before 1970, which is prior to substantial upgrades in seismic building practices. Using the HAZUS methodology, the CDMG estimated that Orange County's expected annualized total loss due to earthquake activity is among the highest in the state.

Evidence of Progress

We have established a framework for understanding local mitigation practices and assessing whether or not they were influenced by SCEC products. The framework was developed following a review of refereed literature on risk communication. To date, we have conducted interviews with representatives from twenty-seven cities and compiled data from Safety Elements and their associated geotechnical background reports. Some of this data is summarized in Table IV.4. We have also corresponded with officials from CGS (Calif. Geological Survey, formerly CDMG) to inquire about relevant unpublished studies or surveys in their archives. We presented our preliminary findings at the 2002 SCEC Annual Meeting, and discussed our methodological approach with representatives from FEMA, state geological surveys, practicing professionals and researchers at the Western States Seismic Policy Council 2002 meeting last month.

Preliminary Findings

Our preliminary observations reveal substantial variation in the treatment of seismic hazard assessment, planning, and mitigation among Orange County cities. *Approximately half of Orange County cities' safety elements are based on seismic hazard assessments that do not consider research newer than 1997. These cities have not fully utilized many of SCEC's products to date, but they may be the best targets for future seismic risk communication and mitigation efforts. Based on CA Governor's Office of Planning and Research recommendations, we expect approximately half of Orange County cities will be addressing seismic safety issues within the next few years.* Safety element revisions represent windows of opportunity for promoting effective mitigation techniques and seismic policies to city officials and general public.

Table IV.4. Status of Safety Elements for Orange County's Thirty-Four Cities, August 2002

Year of incorporation	City	Population (2000)	Date of adoption for current Safety Element	Status for adopting an updated Safety Element
1876	Anaheim	328,000	1984	in revision; planned adoption in mid-2003
1886	Santa Ana	338,000	2002	not on agenda
1888	Orange	130,000	1989	revision scheduled for 2003
1904	Fullerton	127,000	1997	not on agenda
1905	Newport Beach	69,000	1975	in revision; planned adoption in 2004
1909	Huntington Beach	190,000	1996	not on agenda
1915	Seal Beach	24,000	1998	not on agenda
1917	Brea	35,000	1986	in revision; planned adoption in 2003
1925	La Habra	59,000	1990	not on agenda
1926	Placentia	46,000	1975	in revision; planned adoption in 2004
1927	Laguna Beach	23,000	1995	response pending
1927	Tustin	67,000	2001	not on agenda
1928	San Clemente	50,000	1993	not on agenda
1953	Costa Mesa	109,000	2002	not on agenda
1955	La Palma	15,000	1998	not on agenda
1956	Cypress	46,000	1993	revision scheduled for 2003
1956	Garden Grove	166,000	1995	response pending
1956	Stanton	37,000	1992	response pending
1957	Fountain Valley	55,000	1995	response pending
1957	Westminster	88,000	1996	not on agenda
1960	Los Alamitos	11,000	1999	not on agenda
1961	San Juan Capistrano	34,000	1999	not on agenda
1962	Villa Park	6,000	1991	response pending
1963	Buena Park	79,000	1994	not on agenda
1967	Yorba Linda	59,000	1993	not on agenda
1971	Irvine	142,000	1999	not on agenda
1988	Mission Viejo	93,000	1990	in review; planned adoption in early 2003
1989	Dana Point	35,000	1995	response pending
1989	Laguna Niguel	61,000	1992	response pending
1991	Laguna Hills	31,000	1994	not on agenda
1991	Lake Forest	59,000	2000	not on agenda
1999	Laguna Woods	17,000	2001	in review; planned adoption in 2003
2000	Rancho Sta. Margarita	47,000	2002	in review; planned adoption in late 2002
2001	Aliso Viejo	40,000	in revision	response pending

Looking ahead

New opportunities to establish linkages between seismic hazards and other natural hazards may emerge due to the requirements of FEMA's new Pre-Disaster Mitigation Program. On average, cities are unaware of documentation that outlines the ways SCEC can improve hazard and risk assessment by local government. In some circumstances, SCEC products and research are nested within other resources that are non-exclusive to SCEC (e.g., HAZUS). Consequently, some substantial SCEC contributions are not easily recognized by end-users. For the cities that are using SCEC for seismic hazard mitigation, we expect that the types of products and extent of usage will be better understood following our analysis of geotechnical background reports to safety elements. To date, our review of refereed literature suggests that this methodology will contribute to a better understanding of risk communication between a scientific center and non-technical government decision-makers.

V. Director's Management Report

In the past year, we have completed the transition from SCEC1 to SCEC 2. A number of factors contributed to a successful transition: hard work on the part of many individuals who wrote proposal drafts and science plans *ad nauseum*; the enlightened attitudes on the part of SCEC's principal supporting agencies, the NSF and USGS; the enthusiastic support of its many organizational partners—CGS, OES, LAEDP, SSB, CUREE, IRIS, UNAVCO, SSA, IEEE, PEER, MCEER, MAE, GEM, ACES,... (this list continues); and the substantial resources contributed in dollars and in kind by the participating research institutions, which span academia, government and private industry.

Of course, the success of SCEC1 was the real key. Early in the transition, many of us became convinced that the Center would indeed continue, simply because almost everyone inside and outside of SCEC realized the tremendous value of a scientific community practiced and adept at collaboration in the study of earthquakes. Over the last decade, this field has become a system-level science requiring interdisciplinary synthesis to improve its predictive tools. By virtue of its scientific diversity and previous accomplishments, the SCEC community is recognized to be structurally capable of achieving this synthesis. Moreover, SCEC remains deeply committed to its tripartite mission of gathering all kinds of data about earthquakes in Southern California, integrating this information into a more comprehensive, physics-based understanding of earthquake phenomena, and communicating our understanding as useful knowledge to end-users, which include the 20 million people that happen to live in the SCEC's sometimes shaky "natural laboratory." The SCEC community is engaged in basic research with a practical purpose, and this purpose guides us in developing a scientific consensus about what we know, what we don't know, and what we might be able to learn by focusing our collaborative energy and common resources. The old saw applies: if SCEC didn't exist, it would have to be invented.

One of the products of our transition activities was the *SCEC Strategic Plan for 2002-2007*, which was submitted to the NSF and USGS in October of last year. The long-term goals articulated in this report are reproduced in Appendix A.

Overall Status of the Collaboration

SCEC is an unusual center in the sense that it manages an open collaboration with a constantly changing mix of institutions and investigators. All indicators suggest that the collaboration is healthy and has been getting more vibrant during the first year of SCEC2.

- The SCEC Annual Meeting has become a major convention for earthquake science, and the attendance is growing. This year, 330 people registered for the SCEC Annual Meeting, held on September 7-11 in Oxnard, California, compared to only 180 at the same location and timeframe the year before. Feedback from the attendees was very positive with comments like “best SCEC meeting ever!”
- Official collaborations with other organizations are expanding at a rapid rate. Part of our new structure is an “implementation interface,” configured and funded to encourage collaborations between SCEC and other communities, especially the NSF-funded earthquake engineering research centers. As a result of this activity, a number of new collaborations with the Pacific Earthquake Engineering Research (PEER) Center have been initiated (see Section IV). We have also been funded to collaborate with the Consortium of Universities for Research in Earthquake Engineering (CUREE) and the Incorporated Research Institutions for Seismology (IRIS) to develop an Electronic Encyclopedia of Earthquakes (the E-Cube Project), and with IRIS, the USGS, and two IT organizations, the San Diego Super computer Center (SDSC) and the Information Sciences Institute (ISI), to develop a new information infrastructure for earthquake science.
- SCEC has taken a lead in applying advanced information technology to Earth science problems. SCEC organized the EarthScope Computer Science and Information Technology Workshop in Utah on March 25-27, 2002, and it is collaborating with other IT projects (e.g., the GEON Project) in the EarthScope IT Forum. The SCEC Director is also serving as Vice-Chair of a cyberinfrastructure working group organized by the Geosciences Directorate.
- Several organizations previously unaffiliated with SCEC have applied to become participating institutions, and two participating organizations have been exploring the possibility of becoming core institutions.
- SCEC is expanding its interactions with foreign earthquake scientists and research organizations through the APEC Cooperative for Earthquake Simulation (ACES) and the United States Japan Natural Resources Committee (UJNR).

Subaward Process

The SCEC proposal and subaward funding process is critical to its mission, because it provides the mechanism to recruit and sustain the participation of scientists, students, and other technical experts in SCEC research collaborations. This process has been reconfigured in several ways to improve its effectiveness (see Section VIII for a detailed description). Proposal evaluations are done by a broad-based leadership group that includes the 24 chairs and co-chairs of the various working groups (Table II.2), plus the Center Director and Deputy Director. The review process and the formulation of a program plan are accomplished through a Planning Committee comprising the group chairs and the Deputy Director.

A major difference with SCEC1 is that the SCEC2 Planning Committee (which replaced the SCEC1 Steering Committee) is decoupled from the Board of Directors. This configuration allows the Board to provide more independent oversight of the entire subaward process. In

addition, we have improved communication with the USGS through a Joint Planning Committee, which helps to coordinate the research programs of the two organizations (see Section II).

SCEC Facilities at USC

The University of Southern California has recently renovated the first floor of North Science Hall to provide improved facilities for SCEC scientists, students, and staff, including a media center, conference room, advanced IT facilities, laboratories, and the SCEC2 administrative center. This investment of more than \$8 million in institutional funds has more than tripled the space available for SCEC Headquarters and operations at USC. Additional space will be made available to SCEC on the second floor in Phase II of the renovation project.

Management Challenges

Although the SCEC transition is now complete, the organization continues to face challenges that require will require attention by the community and its management. Here are a few issues of particular concern, phrased as questions for the future:

- In its current formulation, the SCEC Strategic Plan casts a very wide net around the earthquake problem. Should we retain this generality or focus ourselves on more specific objectives?
- SCEC's base funding is about 25% lower than it was at its peak in 1999, while the size of its community has grown substantially. What are the best strategies to increase our research funding?
- In particular, where we will find the resources to pursue new major initiatives, such as those that are being formulated for high-priority targets like the southern San Andreas fault and the California Borderland, and in exciting research areas like fault and rock mechanics?
- How should SCEC activities be coordinated with EarthScope activities? What SCEC initiatives should be put forward under the banner of EarthScope?

VI. Advisory Council Report

The membership of the SCEC External Advisory Council is listed in Table VI.1. Professor Robert Smith, who chaired the Advisory Council for the last two years of SCEC1, chairs the SCEC2 committee. The Advisory Council convened at the SCEC Annual Meeting in September, and their report is reproduced verbatim below.

Table VI.1. SCEC Advisory Council for 2002

Robert SMITH (Chair), University of Utah, Department of Geology and Geophysics,
Salt Lake City, UT 84112-1183

Jeff FREYMUELLER, University of Alaska, Geophysical Institute, P.O. Box 757320,
Fairbanks, AK 99775-7320

Raul MADARIAGA, Laboratoire de Geologie, Ecole Normale Supérieure, 24 Rue Lhomond,
Cedex 05, 75231 Paris, FRANCE

Jack MOEHLE, Pacific Earthquake Eng. Research Center, 1301 S. 46th St., Bldg. 451,
Richmond, CA 94804-4698

Farzad NAEIM, John A. Martin & Associates, 1212 S. Flower St., Los Angeles, CA 90015

Garry ROGERS, Geological Survey of Canada, Box 6000, Sidney, V8L 4B2, BC, Canada

Chris ROJAHN, Applied Technology Council, 555 Twin Dolphin Dr., Ste. 550,
Redwood City, CA 94065

Haresh SHAH, RMS, Inc., 149 Commonwealth Dr., Menlo Park, CA 94025

Ellis STANLEY, City of Los Angeles, Emergency Preparedness Department, 200 N. Main Street,
Room 1500, Los Angeles, CA 90012

Susan TUBBESING, EERI, 499 14th St., Suite 320, Oakland, CA 94612-1902

SCEC Advisory Committee Report, SCEC Annual Meeting of 9-11, September 2002, Oxnard, California

Members present:

Robert B. Smith, Chair, University of Utah
Jeff Freymueller, University of Alaska
Raul Madariaga, L'Ecole normale supérieure, Paris
Jack Moehle, Pacific Earthquake Eng. Research Center, University of California, Berkeley.
Gary Rogers, Geological Survey of Canada
Chris Rojahn, Applied Technology Council
Ellis Stanley, City of Los Angeles, Emergency Preparedness Department
Susan Tubbesing, EERI

Our advisory comments are in response to the following: 1) AC member participation in the 2002 Annual SCEC meetings, 2) from the Advisory Committee meetings with the SCEC management group, and 3) from our overall perspectives of SCEC's progress.

First, we compliment the new SCEC management team for the planning efforts and implementation of their new operational plans. The Advisory Committee appreciated the planning presentations and responses to our queries during the annual meeting.

It is our judgment that the inaugural year of SCEC2, has focused on implementation of disciplinary and working groups goals. In addition the organization is notably broader as the result of incorporating additional core institutions and additional USGS personnel. The new participants afford more opportunities for research and outreach.

We also note the important ties that SCEC is making to PEER, as well as with other engineering organizations. We especially remark on the participation of the City of Los Angeles, Emergency Preparedness Department including the appointment of a member of that office on the SCEC Advisory Council. This provides a direct link to emergency users of this large municipality.

A significant SCEC goal has been to place more effort on statewide partnering with other risk management organizations. These include such agencies as the California Seismic Safety Commission, the California Integrated Seismic Network, private engineering companies, the California Geological Survey (CGS), USGS, and PEER.

We note a general perception that SCEC is a *de facto* national center for earthquake science and enjoys a respected global reputation in this field. This position implies high expectations in earthquake science and hazard research as well as for the timely distribution of its research products through printed and web-accessible information.

A. SCEC Management

SCEC has reorganized into disciplinary, topical and expert working groups. The former addresses specific research goals elaborated in the new Strategic Plan and the latter implements those tasks needed to address issues across a wide range of scientists and engineers. This matrix management scheme assures that each of the disciplinary goals is addressed by the wide variety of researchers, from science and engineering to outreach and education.

However, we caution that such a matrix management scheme can be inherently difficult to manage because of the broad expertise of its members. It will require careful attention to accomplish such goals.

We note that the SCEC “legacy” document remains as an outstanding product that needs to be completed and published as soon as possible. SCEC management should plan on having this information posted not only as a printed document, but available on the web with links to its referenced data.

B. SCEC Proposal Reviews

There was a cautionary consideration regarding the SCEC internal proposal review process, not only from the necessity of fairness, but to insure that the programmatic goals of the organization are met.

While the AC does not participate in the SCEC review process, the council received assurances that the proposal review process integrated independent assessments across the

working disciplines as well as within the working groups. The reviews were followed by appraisals of the SCEC Director and Executive Director before final decisions was made.

We suggest that the review process be elaborated in more detail to SCEC investigators and to the funding agencies to assure the perception that the review process is independent and that it ensure that SCEC goals are met.

C. Budget

We note the large decrease in the overall SCEC funding, following the completion of its transition from the NSF Science and Technology Center decade support. This, in addition to the expanding number of SCEC participants, places additional stress on its resources.

The stated “open-policy” by Tom Jordan for the grant process led some AC members to ask whether SCEC was indeed focused on its programmatic needs versus a volunteered proposal submission policy. Concern was expressed that the proposals may be driving the program, rather than the other way around, thus slowing progress towards or diverting focus away from SCEC’s strategic goals.

In the current budget regime, the SCEC average grant of ~ \$26k is considered only enough to support graduate student research. This small amount concerned the AC because if the grants are not monitored carefully the small grants could lead to heterogeneity of topics not fully addressing the goals of the organization.

We caution that under such funding pressure, SCEC must not lose sight of its programmatic goals.

D. Outreach and Education

The Outreach and Educational philosophy have continued successfully into the new SCEC management scheme. This task was enhanced to include an engineering component as a means to communicate more effectively with an important segment of the community through workshops, publications, etc.

We have already noted that closer ties to the Los Angeles Emergency Preparedness Department, will enhance the application of SCEC’s end products that provide timely and useful information for earthquake risk mitigation.

E. Diversity

As a leading national organization, it is implicit that that SCEC2 management develops, announces, and implements a diversity plan that is broadened and emphasized in the new SCEC organization.

F. Partnering

We iterate the long-term efforts for partnering of SCEC with other agencies and groups to enhance the breadth of its outreach as well as for developing additional funding possibilities.

VII. Financial Report

Table VII.1 gives the breakdown of the SCEC 2002 budget by major categories. The list of individual projects supported by SCEC in 2002 can be found on the website <http://www.scec.org/research/2002research/index.html>.

Table VII.1 2002 Budget Breakdown by Major Categories

Total Funding (NSF and USGS):	\$3,600,000
Budgets for Infrastructure:	\$ 960,000
Management	280,000
CEO Program	360,000
Annual, AC, Board, and PC Meetings	150,000
Information Architect	170,000
Budgets for Disciplinary Activities:	\$ 685,000
Geodesy	170,000
Geology	190,000
Information Technology	80,000
Seismology	245,000
Budgets of Focus Groups (including workshops):	\$1,955,000
Earthquake Source Physics	309,000
Fault Systems	681,500
Ground Motions	275,500
Seismic Hazard Analysis	143,000
Structural Representation	546,000

VIII. Report on Subawards and Monitoring

The process to determine funding for 2002 began with discussions at the SCEC annual meeting in Oxnard in September, 2001. An RFP was issued in late October, 2001 and 140 proposals were submitted in late December, 2001. Proposals were then sorted and sent out for review in mid-January, 2002. Each proposal was independently reviewed by the Center Director Tom Jordan, the Deputy Director Tom Henyey, by the chair and co-chair of the relevant focus group, and by the chair and co-chair of the relevant disciplinary committee. Reviewers had to recuse themselves where conflicts of interest existed. Every proposal had from 4 to 6 reviews. Reviews were sent to John McRaney, SCEC Associate Director for Administration, who collated and tabulated them. The SCEC Planning Committee (chaired by Tom Henyey) met on February 20-21 and spent 20+ hours over two days discussing every proposal. The PC assigned a rating from 1-5 (1 being highest) to each proposal and recommended a funding level. Proposals were rated based on quality of science and the proposed research plan, their relevance to the SCEC 2002 science goals, and the amount of money available for the overall program.

The recommendations of the PC were reviewed by the SCEC board at a meeting on March 6-7, 2002. The board voted 13-1 to accept the recommendations of the PC, pending a final review of the program by the Center Director. Jordan completed his review of the program on March 20, making changes totaling about 2% of the budget recommended by the PC. The board was given two days to comment on the final plan of Jordan.

SCEC funding for 2002 is \$3.6M. The board approved \$280K for administration; \$360K for the communications, education, and outreach program; \$150K for workshops and meetings; and \$170K for the information technology program. The administration and CEO budgets were cut 20% from the proposed levels in the SCEC2 proposal; the workshop budget was cut 25%; and the IT program budget was cut 58%. A proposed visitors program was eliminated for 2002.

The Center Director gave the PC target budgets of \$740K for infrastructure (\$1.22M requested) and \$1.9M for science (\$4.53M requested). The final plan approved by Jordan and the board provides \$685K for infrastructure and \$1.955M for science.

Following this action, individual PI's were notified of the decision on their proposals. Successful applicants submit formal requests for funding to SCEC. After all PI's at a core or participating institution submit their individual proposals, the proposals are scanned and the institution's request is submitted electronically to NSF/USGS for approval to issue a subcontract. Once that approval is received, the formal subcontract is issued to each institution to fund the individual investigators and projects.

Scientific oversight of each project is the responsibility of the Center Director, Deputy Director, and focus/disciplinary group leaders. Fiscal oversight of each project is the responsibility of the Associate Director for Administration. Regular oversight reports go to the SCEC Board. Any unusual problems are brought to the attention of agency personnel.

Subcontracts issued in 2002 are shown in the table below for both the USGS and NSF components of SCEC funding.

Table VIII.1 SCEC Subcontracts for 2002

USGS Funds

Caltech	150,000 Data Center Only
ABS Consulting	25,000
Boston U	20,000
Stanford	67,975
LLNL	66,000
SDSU	56,000
WLA	30,000
Oregon	14,000
Oregon State	25,000
UCI	28,000
Utah State	24,881
URS	110,000
Harvard	158,000

NSF Funds

MIT	110,000
SDSU	195,500
CMU	17,500
Colorado	15,000
LDEO	30,000
UNR	103,000
Brown	24,000
CWU	25,000
UCSD	242,000
Caltech	117,000 Science only
U Mass	20,000
UCSC	25,000
UCD	33,000
New Mexico	20,000
UCB	60,000
UCLA	137,000
UCSB	347,500

IX. Demographics of SCEC Participants

Center Database of SCEC Participants in 2002

	Administration/ Technical	Faculty Researcher	Graduate Student	Non-faculty Researcher	Undergraduate Student
Race					
Asian	7	12	16	8	2
Black	1	0	0	1	0
White	39	118	67	157	14
Native American	0	0	4	0	0
Ethnicity					
Latino	1	4	5	2	2
Not Latino	34	112	45	138	8
No information	11	13	30	23	4
Withheld	1	0	3	3	1
Gender					
Female	19	18	33	46	6
Male	27	111	50	120	9
Withheld	1	0	0	0	0
Citizenship					
US	37	106	39	124	10
Other	5	4	23	16	1
No information	5	5	20	10	3
Resident	0	14	0	16	0
Withheld	0	0	1	0	1
Disability Status					
None	36	112	36	131	9
No information	11	15	46	31	6
Hearing	0	1	0	0	0
Visual	0	0	1	2	0
Mobility	0	1	0	2	0

X. Report on International Contacts and Visits

1. SCEC Advisory Council. We have two international members of our Advisory Council. They are Raul Madariaga of Ecole Normale Supérieure, Paris and Garry Rogers of Geological Survey of Canada, Sydney.

2. ACES (APEC Cooperative for Earthquake Simulation). SCEC and JPL are the U.S. organizations participating in ACES. Information on ACES can be found at <http://www.quakes.uq.edu.au/ACES/>. Andrea Donnellan of SCEC/JPL is the U.S. delegate to the ACES International Science Board and John McRaney of SCEC is the secretary general. SCEC hosted the ACES biennial meeting in May, 2002 in Maui, Hawaii. There were 50 U.S. and 55 international participants (15 from Australia, 10 from China, 1 from New Zealand, 2 from Mexico, 2 from Germany, and 25 from Japan).

3. ETH/Zurich. Stefan Wiemar, Martin Mai, and Matt Gerstenberger of ETH are participants in the SCEC/RELM project. ETH pays the salaries of the participants and SCEC pays their travel to meetings in the U.S.

4. UJNR (U.S./Japan Natural Resources Council). This biennial meeting was held in November, 2002 in Honshu, Japan. The meeting focused on the earthquake source and seismic events associated with volcanoes. SCEC academic scientists participating included Kim Olsen, Jeanne Hardebeck, Mark Simons, and David Bowman. There were also 10 SCEC/USGS participants and 40 participants from Japan.

5. SCIGN. The SCIGN network has stations in Baja California and on Isla Guadalupe. Scientists from CICESE in Ensenada, Mexico participate in the SCIGN program.

6. SCEC Borderland Working Group. SCEC is developing plans to study the active tectonics of the California Borderland. Scientists from CICESE in Ensenada, Mexico are participating in this effort as the area of interest includes both U.S. and Mexican waters.

7. SCEC Annual Meeting. The SCEC annual meeting is attracting more international participants each year. There were participants in the 2002 annual meeting from China, Japan, India, Mexico, Canada, France, Spain, Switzerland, Germany, Russia, and New Zealand.

8. Visit by Chinese Seismological Bureau. In April 2002, 25 representatives of the Chinese Seismological Bureau visited SCEC. Tom Jordan gave an overview presentation about SCEC, and Mark Benthien described CEO activities. The group was very interested in examples of educational materials developed or used by SCEC, and took away many copies of such materials. This was the first use of the new SCEC media center for a presentation to a large group.

9. Third International Workshop on Earthquakes and Megacities, Shanghai, China, October, 2002. Mark Benthien attended this workshop which focused on local initiatives for reducing vulnerability of large urban areas and the relationship of these initiatives to sustainable development for megacities. SCEC was represented in order to establish and build partnerships among the countries represented, especially those within the EMI “Americas Cluster” which

include Mexico, Ecuador, Chile, and the U.S. Ellis Stanley, the City of Los Angeles Emergency Preparedness Manager and a member of the SCEC AC has participated in EMI since its inception and invited SCEC to participate in order to further develop the SCEC/Los Angeles partnership in the context of being an international example of academic/public partnership.

XI. Publications

Note: Publication numbers listed here are continued from the SCEC list that was initiated in 1991. This list includes only published papers and does not include papers in press or in review.

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Appendices

Appendix A. Long-Term Research Goals

This section outlines the SCEC science priorities for the five-year period from February 1, 2002, to January 31, 2007, as stated in *The SCEC Strategic Plan 2002-2007* (October, 2002). Additional material on the science and management plans for the Center can be found in the SCEC proposal to the NSF and USGS (<http://www.scec.org/SCEC>).

Long-term research goals have been formulated in six problem areas: plate-boundary tectonics, fault systems, fault-zone processes, rupture dynamics, wave propagation, and seismic hazard analysis. These goals delineate the general areas of research where substantial progress is expected during the next five years, and they provide the scientific context for the short-term objectives outlined in Section VI.B.

Plate-Boundary Tectonics

Goal: To determine how the relative motion between the Pacific and North American plates is distributed across Southern California, how this deformation is controlled by lithospheric architecture and rheology, and how it is changing as the plate-boundary system evolves.

Key Questions:

- How does the complex system of faults in Southern California accommodate the overall plate motion? To what extent does distributed deformation (folds, pressure-solution compaction, and motions on joints, fractures and small faults) play a role within the seismogenic layer of the crust?
- What lateral tractions drive the fault system? What are the directions and magnitudes of the basal tractions? How do these stresses compare with the stresses due to topography and variations in rock density? Do they vary through time?
- What rheologies govern deformation in the lower crust and mantle? Is deformation beneath the seismogenic zone localized on discrete surfaces or distributed over broad regions? How are these deformations related to those within the seismogenic zone?
- What is the deep structure of fault zones? Are major strike-slip faults such as the SAF truncated by décollements or do they continue through the crust? Do they offset the Moho? Are active thrust faults best described by thick-skin or thin-skin geometries?
- How is the fault system in Southern California evolving over geologic time, what factors are controlling the evolution, and what influence do these changes have on the patterns of seismicity?

Fault Systems

Goal: To understand the kinematics and dynamics of the plate-boundary fault system on interseismic time scales, and to apply this understanding in constructing probabilities of earthquake occurrence in Southern California, including time-dependent earthquake forecasting.

Key Questions:

- What are the limits of earthquake predictability, and how are they set by fault-system dynamics?
- How does inelastic deformation affect strain accumulation and release through the earthquake cycle? Does inelastic deformation accumulated over repeated earthquake cycles give rise to landforms and geologic structures that can be used to constrain deformation rates and structural geometries on time intervals of thousands to hundreds of thousands of years?
- Are there patterns in the regional seismicity related to the past or future occurrence of large earthquakes? For example, are major ruptures on the SAF preceded by enhanced activity on secondary faults, temporal changes in b-values, or local quiescence? Can the seismicity cycles associated with large earthquakes be described in terms of repeated approaches to, and retreats from, a regional “critical point” of the fault system?
- What are the statistics that describe seismic clustering in time and space, and what underlying dynamics control this episodic behavior? Is clustering observed in some fault systems due to repeated ruptures on an individual fault segment, or to rupture overlap from multiple segments? Is clustering on an individual fault related to regional clustering encompassing many faults?
- What systematic differences in fault strength and behavior are attributable to the age and maturity of the fault zone, lithology of the wall rock, sense of slip, heat flow, and variation of physical properties with depth? Is the mature SAF a weak fault? If so, why? How are the details of fault-zone physics such as “critical slip distance” expressed at the system level?
- To what extent do fault-zone complexities, such as bends, changes in strength, and other quenched heterogeneities control the nucleation and termination of large earthquakes and their predictability? How repeatable are large earthquakes from event to event, both in terms of location and slip distribution? How applicable are the “characteristic-earthquake” and “slip-patch” models in describing the frequency of large events? How important are dynamic cascades in determining this frequency? Do these cascades depend on the state of stress, as well as the configuration of fault segments?
- How does the fault system respond to the abrupt stress changes caused by earthquakes? To what extent do the stress changes from a large earthquake advance or retard large earthquakes on adjacent faults? How does stress transfer vary with time? Does a more realistic lower-crustal rheology affect the spatial and temporal evolution of seismicity?
- What controls the amplitude and time constants of the post-seismic response, including aftershock sequences and transient aseismic deformations? In particular, how important are induction of self-driven accelerating creep, fault-healing effects, poroelastic effects, and coupling of the seismogenic layer to viscoelastic flow at depth?

Fault-Zone Processes

Goal: To understand the internal structure of fault zones and the microscale processes that determine their rheologies in order to formulate more realistic macroscopic representations of fault-strength variations and the dynamic response of fault segments and fault networks.

Key Questions:

- Which small-scale processes—pore-water pressurization and flow, thermal effects, geochemical alteration of minerals, solution transport effects, contact creep, microcracking and rock damage, gouge comminution and wear—are important in describing the earthquake cycle of nucleation, dynamic rupture, and post-seismic healing?

- What fault-zone properties and processes determine velocity-weakening vs. velocity-strengthening behavior? How do these properties and processes vary with temperature, pressure, and composition? How do significant changes in normal stress modify constitutive behavior?
- How does fault strength drop as slip increases immediately prior to and just after the initiation of dynamic fault rupture? Are dilatancy and fluid-flow effects important during nucleation?
- What is the explanation of the discrepancy between the small values of the critical slip distance found in the laboratory (< 100 microns) and the large values (> 100 millimeters) inferred from the fracture energies of large earthquakes? What is the nature of near-fault damage and how can its effect on fault-zone rheology be parameterized?
- How does fault-zone rheology depend on microscale roughness, mesoscale offsets and bends, variations in the thickness and rheology of the gouge zone, and variations in porosity and fluid pressures? Can the effects of these or other physical heterogeneities on fault friction be parameterized in phenomenological laws based on rate and state variables?
- How does fault friction vary as the slip velocities increase to values as large as 1 m/s ? How much is frictional weakening enhanced during high-speed slip by thermal softening at asperity contacts and by local melting?
- How do faults heal? Is the dependence of large-scale fault healing on time logarithmic, as observed in the laboratory? What small-scale processes govern the healing rate, and how do they depend on temperature, stress, mineralogy, and pore-fluid chemistry?

Rupture Dynamics

Goal: To understand the physics of rupture nucleation, propagation, and arrest in realistic fault systems, and the generation of strong ground motions by earthquakes.

Key Questions:

- What is the magnitude of the stress needed to initiate fault rupture? Are crustal faults “brittle” in the sense that ruptures require high stress concentrations to nucleate, but, once started, large ruptures reduce the stress to low residual levels?
- How do earthquakes nucleate? What is the role of foreshocks in this process? What features characterize the early post-instability phase?
- How can data on fault friction from laboratory experiments be reconciled with the earthquake energy budget observed from seismic radiation and near-fault heat flow? What is explanation of short apparent slip duration?
- How much inelastic work is done outside a highly localized fault-zone core during rupture? Is the porosity of the fault zone increased by rock damage due to the passage of the rupture-tip stress concentration? What is the role of aqueous fluids in dynamic weakening and slip stabilization?
- Do minor faults bordering a main fault become involved in producing unsteady rupture propagation and, potentially, in arresting the rupture? Is rupture branching an important process in controlling earthquake size and dynamic complexity?
- Are strong, local variations in normal stress generated by rapid sliding on nonplanar surfaces or material contrasts across these surfaces? If so, how do they affect the energy balance during rupture?
- What produces the slip heterogeneity observed in the analysis of near-field strong motion data? Does it arise from variations in mechanical properties (quenched heterogeneity) or stress fluctuations left in the wake of prior events (dynamic heterogeneity)?

- Under what conditions will ruptures jump damaged zones between major fault strands? Why do many ruptures terminate at releasing step-overs? How does the current state of stress along a fault segment affect the likelihood of ruptures cascading from one segment to the next?
- What are physical mechanisms for the near-field and far-field dynamical triggering of seismicity by large earthquakes?

Ground Motion

Goal: To understand seismic ground motion in urbanized Southern California well enough to predict the ground motions from specified sources at frequencies up to at least 1 Hz, and to formulate useful, consistent, stochastic models of ground motions up to at least 10 Hz.

Key Questions:

- How are the major variations in seismic wave speeds in Southern California related to geologic structures? How are these structures best parameterized for the purposes of wavefield modeling?
- What are the contrasts in shear-wave speed across major faults in Southern California? Are the implied variations in shear modulus significant for dynamic rupture modeling? Do these contrasts extend into the lower crust and upper mantle?
- How are variations in the attenuation parameters related to wave-speed heterogeneities? Is there a significant dependence of the attenuation parameters on crustal composition or on frequency? How much of the apparent attenuation is due to scattering?
- What are the differences in near-fault ground motions from reverse, strike-slip, and normal faulting? In thrust faulting, how does energy trapped between the fault plane and free surface of the hanging-wall block amplify strong ground motions?
- How does the structure of sedimentary basins affect the amplitude and duration of ground shaking? How much of the amplification pattern in a basin is dependent on the location of the earthquake source? Can the structure of sedimentary basins be determined in sufficient detail to usefully predict the pattern of ground shaking for future large earthquakes?
- Is the ability to model recorded seismograms limited mainly by heterogeneity in source excitation, focusing by geologic structure, or wavefield scattering?
- What role do small-scale heterogeneities and irregular interfaces play in wave propagation at high frequencies? How do they depend on depth, geological formation, and tectonic structure? How important is multiple scattering in the low-velocity, uppermost layers? Can stochastic parameterizations be used to improve wavefield predictions?

Seismic Hazard Analysis

Goal: To incorporate time dependence into the framework of seismic hazard analysis in two ways: (a) through the use of rupture dynamics and wave propagation in realistic geological structures, to predict ground-motion time histories for anticipated earthquakes, and (b) through the use of fault-system analysis, to forecast the time-dependent perturbations to average earthquake probabilities in Southern California.

Key Questions:

- What factors limit fault-rupture propagation? How valid are the cascade and characteristic-earthquake models? What magnitude distribution is appropriate for Southern California?

- How can geodetic (GPS and InSAR) measurements of deformation be used to constrain short- and long-term seismicity rates for use in seismic hazard assessment? How can geologic and paleoseismic data on faults be used to determine earthquake recurrence rates?
- What temporal models and distributions of recurrence intervals pertain to faults in Southern California? Under what circumstances are large events Poissonian in time? Can PSHA be improved by incorporating non-Poissonian distributions?
- Can physics-based scenario simulations produce more accurate estimates of ground-motion parameters than standard attenuation relationships? Can these simulations be used to reduce the high residual variance in these relationships ?
- What is the nature of near-fault ground motion? How do fault ruptures generate long-period directivity pulses? How do near-fault effects differ between reverse and strike-slip faulting? Can these effects be predicted?
- What are the earthquake source and strong ground motion characteristics of large earthquakes (magnitudes larger than 7.5), for which there are few strong motion recordings? Can the shaking from large earthquakes be inferred from smaller events?
- How does the nonlinear seismic response of soils depend on medium properties, amplitude, and frequency?

Appendix B. SCEC By-Laws

The by-laws given here were approved by the SCEC Board of Directors at its March 6, 2002, meeting.

By-Laws of the Southern California Earthquake Center (SCEC) Effective February 1, 2002

PREAMBLE

The By-Laws of the Southern California Earthquake Center (SCEC) are adopted by the Board of Directors for the purpose of conducting SCEC business in a collegial manner. They should not be construed as overriding the standard responsibilities and prerogatives of Principal Investigators or their respective institutions. However, situations and issues may arise from time to time for which resolution through standard procedures cannot be achieved. Consequently, should the Center Director and the Board of Directors not be able to reach agreement on any given issue, the Center Director, as Principal Investigator on all Center grants/contracts, will ultimately retain full authority to make and implement decisions on Center programs and policies. These by-laws supercede those adopted by SCEC upon its founding on February 1, 1991 and revised in February, 1996.

ARTICLE I

Name

Section 1. The name of the Center is the Southern California Earthquake Center.

ARTICLE II

Member Institutions

Section 1. Core Institutions. The following named institutions shall be Core Institutions:

- * California Institute of Technology
- * Columbia University

Harvard University
Massachusetts Institute of Technology
San Diego State University
Stanford University
United States Geological Survey, Golden
United States Geological Survey, Menlo Park
* United States Geological Survey, Pasadena
* University of California, Los Angeles
* University of California, San Diego
* University of California, Santa Barbara
University of Nevada, Reno
* University of Southern California

* The *founding* Core Institutions of SCEC.

Section 2. Obligations and Responsibilities of Core Institutions. SCEC Core Institutions are designated academic and Government research organizations with major research programs in earthquake science. Each Core Institution is expected to contribute a significant level of effort (both in personnel and activities) to SCEC programs, including the Communications, Education and Outreach Program. Core Institutions are obligated to contribute a yearly minimum of \$35K of institutional resources as matching funds to Center activities. Each core institution shall appoint an *Institutional Director* to the SCEC Board of Directors, who shall represent the appropriate Dean, Office Chief, or higher officer as described in Article III.

Section 3. Addition of Core Institutions. Additional institutions that meet the requirements specified in Article I, Section 2 may become Core Institutions by a two-thirds affirmative vote of the entire Board of Directors.

Section 4. Removal of Core Institutions. Any Core Institution may resign as a Core Institution at any time by giving written notice from the appropriate Dean, Office Chief, or higher officer to the Center Director. Such resignation shall take effect at the time of receipt of the notice, or at any later time specified therein. Any Core Institution may be removed by affirmative vote of $N-1$ Directors, where N is the total number of Directors. Any Core Institution that fails to provide a qualified Institutional Director for a period exceeding one year shall be removed as a Core Institution.

Section 5. Participating Institutions. In addition to Core Institutions, SCEC membership shall be open to *Participating Institutions*. Eligible institutions shall include any organization (including profit, not-for-profit, domestic, or foreign) involved in a Center-related research,

education, or outreach activity. Participating Institutions do not necessarily receive direct support from the Center. Each Participating Institution shall appoint a qualified *Institutional Liaison* to facilitate communication with the Center. The interests of Participating Institutions shall be represented on the Board of Directors by two Directors At-Large, elected as specified in Article III, Section IV.

Section 6. Election of Participating Institutions. Election to the status of Participating Institution requires a majority affirmative vote of the entire Board of Directors.

Section 7. Removal of Participating Institutions. Any Participating Institution may resign at any time by giving written notice to the Center Director. Such resignation shall take effect at the time of receipt of the notice, or at any later time specified therein. The status of Participating Institution may be withdrawn by a two-thirds affirmative vote of the entire Board of Directors. Any Participating Institution that fails to provide a qualified Institutional Liaison for a period exceeding one year shall be removed as a Core Institution.

Section 8. Current roster of Core and Participating Institutions. The current list of Core and Participating Institutions shall be public and maintained in an accessible location, such as the Center web site.

ARTICLE III

Board of Directors

Section 1. Powers. The management of the affairs of the Center is vested in the Board of Directors. The Board of Directors shall have power to authorize action on behalf of the Center, make such rules or regulations for its management, create such additional offices or special committees, and select, employ or remove such of its officers, agents or employees as it shall deem best.

Section 2. Composition. The Board of Directors shall be composed of Institutional Directors from each of the Core Institutions and two Directors At-Large.

Section 3. Appointment of Core Institution Directors. The *Institutional Director* from each academic Core Institution shall be appointed by the appropriate Dean, or higher level officer, in a letter to the Center Director. The Institutional Director from the U.S. Geological Survey offices shall be appointed by the appropriate USGS official in a letter to the Center Director.

Section 4. Appointment of Directors At-Large. Two *Directors At-Large* shall be elected for two-year terms from a slate of three or more nominees proposed by a Nominating Committee of the Participating Institutions. The Nominating Committee will be appointed by the Center Director.

Section 5. Term of Office, Core Directors. Each Institutional Director of the Board of Directors shall continue in office until a successor is appointed; or until he or she dies, resigns or is replaced by the relevant officer of the Core Institution as specified in Article III Section 7; or until his or her institution is removed from the list of Core Institutions.

Section 6. Term of Office, Directors At-Large. Each Director At-Large shall serve a term of two years and may be reelected for up to two additional terms. The term of a Director At-Large may be terminated by a vote of $N-1$ of the entire board, where N is the total number of Directors.

Section 7. Resignation, Core Directors. Any Institutional Director may resign at any time by giving written notice to the Chairman of the Board of Directors and the appropriate academic dean or USGS official. Such resignation shall take effect at the time of receipt of the notice, or at any later time specified therein. Upon resignation of an Institutional Director, the Core Institution shall appoint a new Institutional Director within 30 days, or resign as a Core Institution.

Section 8. Resignation, Core Directors. Any Director At-Large may resign at any time by giving written notice to the Chairman of the Board of Directors. Such resignation shall take effect at the time of receipt of the notice, or at any later time specified therein. Upon resignation of an Director At-Large, the Board of Directors shall elect a new Director At-Large within 30 days.

Section 9. Alternate Members. Any Core Institution Director may appoint for a specified time interval, not to exceed one year, an Alternate Member from the same Core Institution to replace Core Institution Director in all of the activities during that interval. Such appointments must be transmitted in writing to the Center Director before taking effect.

Section 9. Salary Compensation. There shall be no salary compensation from Center funds for Institutional Directors and Directors-At-Large. The Center Director and/or Deputy Director may receive salary compensation from Center funds at a level approved by the Board and commensurate with administrative activities carried out on behalf of the Center.

ARTICLE IV

Meetings of the Board of Directors

Section 1. Annual Meeting. The Board of Directors shall hold at least one annual Board meeting at a time convenient for all members of the Board for the purpose of conducting center business.

Section 2. Special Meetings. Special meetings of the Board of Directors may be called by the Chair or Vice-Chair of the Board at any time.

Section 3. Place of Meetings. The Center Director shall designate the place of the annual Board meeting or any special meeting, which may be either within or without the State of California and which shall be specified in the notice of meeting or waiver of notice thereof.

Section 4. Notice of Meetings. Notice of such meeting of the Board of Directors shall be given to each Director by the Executive Secretary, or by an officer directed by the Chairman of the Board of Directors to give such notice by delivering to him or her personally, or by first-class mail or e-mail addressed to him or her at the address of his or her member institution, a written or printed notice not less than ten nor more than sixty days before the date fixed for the meeting. Notice of any meeting need not be given to any Director, however, who submits a signed waiver of notice, whether before or after the meeting. The attendance of any Director at a meeting without protesting the lack of notice thereof prior to the conclusion of the meeting, shall constitute a waiver of notice by him or her. When a meeting is adjourned to another place or time, it shall not be necessary to give any notice of the adjourned meeting if the time and place to which the meeting is adjourned are announced at the meeting at which the adjournment is taken.

Section 5. Quorum. Except as may be otherwise expressly required by law or these By-Laws, at all meetings of the Board of Directors or of any committee thereof, a majority of the Directors or members of such committee then serving in such position shall constitute a quorum. If a quorum is not present, a majority of the Directors present may adjourn the meeting without notice other than by announcement at said meeting, until a quorum is present. At any duly adjourned meeting at which a quorum is present, any business may be transacted which might have been transacted at the meeting as originally called.

Section 6. Executive Sessions. The Board of Directors may, at the direction of the Chairman of the Board of Directors, meet in executive session. At such executive session, the meeting will be open only to Directors, the Executive Secretary, and other persons specifically invited by the Chairman of the Board of Directors.

Section 7. Voting. Each Director shall be entitled to one vote. Except as otherwise expressly required by law, or these By-Laws, all matters shall be decided by the affirmative vote of a majority of the entire Board of Directors membership, if a quorum is then present. All votes shall be by voice vote, unless two members request a secret ballot. Votes pertaining to elections are governed by Article VII.

Section 8. Action Without a Meeting. Any action required or permitted to be taken by the Board of Directors or any committee thereof, may be taken without a meeting if all members of the Board of Directors consent in writing or by e-mail to the adoption of a resolution authorizing the action. The resolution and the written consents thereof shall be filed with the minutes of the proceedings of the Board of Directors or the committee.

Section 9. Participation by Telephone or Televideo Conference. In any meeting of the Board of Directors or any committee thereof, any one or more Directors or members of any such committee may participate by means of a telephone or televideo conference allowing all persons participating in the meeting to hear and/or see each other at the same time. Participation by such means shall constitute presence in person at a meeting.

ARTICLE V

Officers

Section 1. Officers and Qualifications. The officers of the Center shall consist of a Center Director, a Deputy Director, an Executive Secretary, and other such officers as the Board of Directors may from time to time establish, deem qualified and appoint.

Section 2. Center Director. The *Center Director* is the Chief Executive Officer of the Center and Chairman of the Board of Directors. It shall be his or her duty, insofar as the facilities and funds furnished to him or her by the Center permit, to see that the orders and votes of the Board of Directors and the purposes of the Center are carried out. He/she must be a full-time faculty member at one of the Center's Core Institutions, and shall be the Principal Investigator on all proposals submitted by the Center to external agencies. He/she shall be the board member for his/her home institution. The Center Director is the Center's official liaison to the rest of the world and, specifically, to the funding agencies. The Center Director will be the principal person for dealing with questions and concerns raised by members of the Center or from the outside. As Chairman of the Board of Directors, he/she shall call and preside at all meetings of the Board of Directors. He/she shall perform other such duties and exercise other such powers as shall from

time to time be assigned by the Board of Directors. The Chairman shall have final authority for the science program, budget and financial obligations of the Center. The Chairman may appoint advisory committees or panels to assist in carrying out the business of the Center. The Center Director oversees, in consultation with the Board, the implementation of the Science Plan for the Center and will maintain day-to-day oversight of the science activities. Chairs of standing committees of the Board will report to the Chairman of the Board.

Section 4. Deputy Director. The *Deputy Director* of the Center will assist the Center Director in all his/her duties. He/she shall be nominated by the Center Director and elected by the entire Board of Directors. He/she shall serve as a non-voting *ex-officio* member of the Board of Directors. The Deputy Director will chair the Planning Committee described in Article VI, Section 4. He/she will oversee the CEO program, and will serve as liaison with SCEC partners.

Section 5. Vice-Chair of the Board of Directors. The Board of Directors will elect a *Vice-Chair* from among its members. He/she shall serve as chair of the Board of Directors in the absence of the Center Director.

Section 6. Associate Director for Administration and Executive Secretary to the Board. The *Associate Director for Administration* is the senior staff person to the Board of Directors, the Center Director, and the Deputy Director. He/she shall be nominated by the Center Director and confirmed by a vote of the Board of Directors. He/she reports to the Director and is Executive Secretary to the Board. The Executive Secretary shall give notice of meetings of the Board of Directors, shall record all actions taken at such meetings and shall perform such other duties as shall from time to time be assigned by the Board of Directors.

Section 7. Associate Director for Communication, Education and Outreach. The Center Director shall nominate an *Associate Director for Communications, Education, and Outreach* (CEO). The nominee will be confirmed by a vote of the Board of Directors. The Associate Director for CEO shall oversee the Center programs in communications, education, and knowledge transfer. He/she shall be a non-voting *ex-officio* member of the Board of Directors.

Section 8. Other Associate Directors. Other Associate Directors may be established through nomination by the Center Director for specific activities of the Center and approval by the Board.

Section 9. Resignation of Officers. Any officer may resign at any time by giving written notice to the Center Director, or the Executive Secretary of the Board of Directors. Such resignation shall take effect at the time of receipt of the notice, or at any later time specified therein.

Section 10. Vacancies of Officers. Any vacancy in any office may be filled for the unexpired portion of the term of such office by the Center Director with approval of the Board of Directors.

Section 11. Removal of Officers. Any officer may be removed at any time either with or without cause by affirmative vote of $N-1$ Directors, where N is the total number of Directors. Removal of the Center Director also requires the consent of funding agencies.

ARTICLE VI

Committees and Advisory Council

Section 1. Establishment of Committees of the Board of Directors. Committees of the Board of Directors may be established for specified terms. Actions by the Board of Directors to create Committees shall specify the scope of Committee activity. Committee members shall be appointed by the Chairman of the Board of Directors. Committee chairs shall be appointed by the Chairman of the Board of Directors from among members of the Center. Committees may not set policy nor take binding action nor publish documents without the consent of the Board of Directors. Committees may not create or appoint Subcommittees without consent of the Board of Directors.

Section 2. Executive Committee of the Board of Directors. The Board of Directors shall establish an *Executive Committee* to take care of the day-to-day business of the Center. The powers of the Executive Committee shall be established by a two-thirds affirmative vote of the entire Board. All actions taken by the Executive Committee must be reported to the full Board with ten business days. The Executive Committee shall consist of the Chairman and Vice Chairman of the Board and three other Board members elected for staggered three-year, renewable terms. The Executive Committee shall hold a business meeting, either in person or by electronic means at least once per quarter. The Executive Secretary of the Board shall serve as Secretary of the Executive Committee, and shall be responsible for transmitting minutes and actions of the Executive Committee to the entire Board.

Section 3. Standing Committees. The Board of Directors may designate one or more *Standing Committees* for each major scientific, educational or research program of the Center. Members of each such committee shall have only the lawful powers specifically delegated to it by the Board. Each such committee shall serve at the pleasure of the Board. Members of a Standing Committee are not required to hold a Director or officer position within the Center. Standing Committees shall prepare plans for the appropriate scientific, educational, or research programs

of the Center. These plans shall be modified as appropriate and approved by the Center Director with the advice and counsel of the Board of Directors.

Section 4. Planning Committee. A *Planning Committee* shall be appointed by the Center Director with approval of the Board of Directors. The Planning Committee shall be responsible for conducting the annual proposal review process and constructing annual and long-term science and budget plans for consideration by the Board of Directors. It shall be chaired by the Deputy Director, and its membership shall be constituted to provide a balanced representation of the various disciplines and focus areas of the Center. Planning Committee meetings will be called by the Deputy Director.

Section 5. Advisory Council. The Board of Directors will establish an *Advisory Council* to serve as an experienced advisory body to the Board. The members of the Council shall serve for three-year rotating renewable terms (by thirds). The chair of the Advisory Council shall be appointed for a three-year term by the Center Director in consultation with the Board and may be reappointed for two additional terms. The size and responsibilities of the Council shall be determined by the Board of Directors to reflect current needs of the Center.

ARTICLE VII

Election Procedures

Section 1. Procedure. Officers may be elected by the Board of Directors at any meeting, in accordance with the procedures established in this Article.

Section 2. Election. Election shall be by written ballot, which may be cast in person by a Director at the meeting, or may be submitted by mail, facsimile, or e-mail if received by the Executive Secretary before the meeting. The Executive Secretary will treat all electronic ballots as secret ballots. Election shall be valid if ballots are received from two-thirds of the membership of the entire Board of Directors in accordance with this Article, even if a quorum is not present for the purpose of conducting other business.

Section 3. Method of Voting. In the election of officers, a valid ballot shall contain at most one vote for each office; election shall be decided in favor of the nominee receiving a majority of votes.

Section 4. Counting of Ballots. Ballots shall be counted by the Executive Secretary and the Chairman and Vice-Chairman of the Board of Directors, unless they have cause for recusal.

ARTICLE VIII

Amendments

Section 1. Amendment. All By-Laws of the Center shall be subject to amendment or repeal by the affirmative vote of two-thirds of the entire Board of Directors at any annual or special meeting, provided the notice or waiver of notice of said meeting shall have specified the proposed actions to amend or repeal the By-Laws.

Appendix C. 2003 Program Announcement

I. INTRODUCTION

On February 1, 2002, the Southern California Earthquake Center (SCEC) changed from an entity within the NSF/STC program to a free-standing center, funded by NSF/EAR and the U. S. Geological Survey. This document solicits proposals from individuals and groups to participate in the second year of the program.

II. GUIDELINES FOR PROPOSAL SUBMISSION

A. Due Date: November 12, 2002, 5:00 pm PST. Late proposals will not be accepted.

B. Delivery Instructions. Proposals should be submitted as PDF documents via the SCEC Proposal web site at <http://www.scec.org/proposals>. Submission procedures will be found at this web site.

C. Formatting Instructions.

- **Cover Page:** Should begin with the words “2003 SCEC Proposal,” the project title, Principal Investigator, institution, proposal category (from types listed in Section IV), and the disciplinary committee(s) and focus group(s) that should consider your proposal. Indicate if the proposal should also be identified with one or more of the SCEC special projects (SCIGN, Borderland, and IT) or advanced Implementation Interface projects (see Section VII.B for examples). Collaborative proposals involving multiple investigators and/or institutions should list all principal investigators. Proposals do not need to be formally signed by institutional representatives, and should be for one year, with a start date of February 1, 2003.
- **Technical Description:** Describe in **five pages of text or less (including figures)** the technical details of the project and how it relates to the short-term objectives outlined in the SCEC Science Plan (Section VI.B).
- **Budget Page:** Budgets and budget explanations should be constructed using NSF categories. Under guidelines of the SCEC Cooperative Agreements and A-21 regulations, secretarial support and office supplies are not allowable as direct expenses.
- **Current Support:** Statements of current support, following NSF guidelines, should be included for each Principal Investigator.

- 2002 Annual Report: Scientists funded by SCEC in 2002 must attach a report of their progress to the 2003 proposals. 2003 proposals lacking 2002 reports (albeit an abbreviated funding year) will **not** be reviewed nor will they be considered for 2003 funding. Reports should be up to five pages of text and figures.

D. Investigator Responsibilities. Investigators are expected to interact with other SCEC scientists on a regular basis (e.g., by attending workshops and working group meetings), and contribute data, analysis results, and/or models to the appropriate SCEC data center or database (e.g., FAD, CFMA, SCEDC, etc.). Publications must include a publication number available from the SCEC website. By submitting a proposal, investigators are agreeing to these conditions.

E. Eligibility. Proposals can be submitted by eligible Principal Investigators from:

- U.S. academic institutions
- Private corporations

F. Collaboration. Collaborative proposals with investigators from the USGS are encouraged; USGS employees should submit their requests for support through USGS channels. Collaborative proposals involving multiple investigators and/or institutions are strongly encouraged; these can be submitted with the same text, but with different institutional budgets if more than one institution is involved.

G. Award Procedures. All awards will be funded by subcontract from the University of Southern California. The Southern California Earthquake Center is funded by the National Science Foundation and the U. S. Geological Survey.

III. SCEC ORGANIZATION

A. Mission and Science Goal. SCEC is a multidisciplinary, regionally focused organization with a mission to:

- gather new information about earthquakes in Southern California;
- integrate this information into a comprehensive and predictive understanding of earthquake phenomena; and
- communicate this understanding to end-users and the general public in order to increase earthquake awareness, reduce economic losses, and save lives.

SCEC's primary science goal is to develop a comprehensive, physics-based understanding of earthquake phenomena in Southern California through integrative, multidisciplinary studies of plate-boundary tectonics, active fault systems, fault-zone processes, dynamics of fault ruptures, ground motions, and seismic hazard analysis. The long-term science goals are summarized in Section VI.A.

B. Disciplinary Activities. The Center sustains disciplinary science through standing committees in *seismology*, *geodesy*, *geology*, and *fault and rock mechanics*. These committees will be responsible for planning and coordinating disciplinary activities relevant to the SCEC science plan, and they will make recommendations to the SCEC Planning Committee regarding support of disciplinary research and infrastructure. High-priority disciplinary activities are summarized in Section VI.A.

C. Interdisciplinary Focus Areas. Interdisciplinary research is organized into five science focus areas: 1) *unified structural representation*, 2) *fault systems*, 3) *earthquake source physics*, 4) *ground motion*, and 5) *seismic hazard analysis*. In addition, interdisciplinary research in risk assessment and mitigation will be the subject for collaborative activities between SCEC scientists and partners from other communities – earthquake engineering, risk analysis, and emergency management. High-priority activities are listed for each of these interdisciplinary focus areas in Section VI.B.

D. Special Projects. SCEC encourages and supports several special projects including the Southern California Integrated GPS network (SCIGN), the Southern California Continental Borderland initiative, and the development of an advanced IT infrastructure for system-level earthquake science in Southern California. High-priority activities are listed for each of these interdisciplinary focus areas in Section VI.C.

E. Communication, Education, and Outreach. SCEC maintains a strong Communication, Education, and Outreach (CEO) program with four principal goals: 1) coordinate productive interactions among SCEC scientists and with partners in science, engineering, risk management, government, business, and education; 2) increase earthquake knowledge and science literacy at all educational levels; 3) improve earthquake hazard and risk assessments; 4) promote earthquake preparedness, mitigation, and planning for response and recovery. Opportunities for participating in the CEO program are described in Section VII. Current activities are described online at <http://www.scec.org/ceo>.

IV. PROPOSAL CATEGORIES

A. Data Gathering and Products. SCEC coordinates a multidisciplinary and multi-institutional study of earthquakes in Southern California, which requires data and derived

products pertinent to the region. Proposals in this category should address the collection, archiving and distribution of data, including the production of SCEC community models that are on-line, maintained, and documented resources for making data and data products available to the scientific community.

B. Integration and Theory. SCEC supports and coordinates interpretive and theoretical investigations on earthquake problems related to the Center's mission. Proposals in this category should be for the integration of data or data products from Category A, or for general or theoretical studies.

Proposals in Categories A and B should address one or more of the goals in Section VI, and may include a brief description (<200 words) as to how the proposed research and/or its results might be used in an educational or outreach mode (see section VII).

C. Workshops. SCEC participants who wish to host a workshop between February 2003, and February 2004, should submit a proposal for the workshop in response to this RFP.

Workshops in the following topics are particularly relevant:

- Organizing collaborative research efforts for the five-year SCEC program (2002-2007). In particular, interactive workshops that engage more than one focus and/or disciplinary group are strongly encouraged.
- Engaging earthquake engineers and other end-user groups in SCEC-sponsored research that addresses earthquake hazards.
- Participating in national initiatives such as EarthScope.

D. Communication, Education, and Outreach. SCEC has developed a long-range CEO plan, and opportunities for participation are listed in Section VII. Investigators who are interested in participating in this program should contact Mark Benthien (213-740-0323; benthien@usc.edu) before submitting a proposal.

V. EVALUATION PROCESS AND CRITERIA

- Proposals need to be responsive to the RFP. A primary consideration in evaluating proposals will be how directly the proposal addresses the main objectives of SCEC. Important criteria include (not necessarily in order of priority):
 - Scientific merit of the proposed research
 - Competence and performance of the investigators, especially in regard to past SCEC-sponsored research

- Priority of the proposed project for short-term SCEC objectives as stated in the RFP
 - Promise of the proposed project for contributing to long-term SCEC goals as reflected in the SCEC science plan (see Appendix A).
 - Commitment of the P.I. and institution to the SCEC mission
 - Value of the proposed research relative to its cost
 - Ability to leverage the cost of the proposed research through other funding sources
 - Involvement of students and junior investigators
 - Involvement of women and underrepresented groups
- Proposals may be strengthened by describing:
 - Collaboration
 - Within a disciplinary or focus group
 - Between disciplinary and/or focus groups
 - In modeling and/or data gathering activities
 - With engineers, government agencies, and others. (See Section VII.B, Advanced Implementation Interface)
 - Leveraging additional resources
 - From other agencies
 - From your institution
 - By expanding collaborations
 - Development and delivery of products
 - Community research tools, models, and databases
 - Collaborative research reports
 - Papers in research journals
 - End-user tools and products
 - Workshop proceedings and CDs
 - Fact sheets, maps, posters, public awareness brochures, etc.
 - Educational curricula, resources, tools, etc.
 - Educational opportunities
 - Graduate student research assistantships
 - Undergraduate summer and year-round internships (funded by the project)
 - K-12 educator and student activities
 - Presentations to schools near research locations
 - Participation in data collection
 - Application and implementation of SCEC research is especially important during the next year as SCEC plans activities for the ten-year anniversary of the Northridge earthquake (2004). These activities will provide venues for communicating outcomes of all SCEC funded-projects.

- All research proposals will be evaluated by the appropriate disciplinary committees and focus groups, the Science Planning Committee, and the Center Director. CEO proposals will be evaluated by the CEO Planning Committee and the Center Director.
- The Science Planning Committee is chaired by the Deputy Director and comprises the chairs of the disciplinary committees, focus groups, and special projects. It is responsible for recommending a balanced science budget to the Center Director.
- The CEO Planning Committee is chaired by the Associate Director for CEO and comprises experts involved in SCEC and USGS implementation, education, and outreach. It is responsible for recommending a balanced CEO budget to the Center Director.
- Recommendations of the planning committees will be combined into an annual spending plan by the Executive Committee of the SCEC Board of Directors and forwarded to the Board of Directors for approval.
- Final selection of research projects will be made by the Center Director, in consultation with the Board of Directors.
- The review process should be completed and applicants notified in February, 2003.

Note: Coordination of Research between SCEC and USGS-EHRP

Earthquake research in Southern California is supported both by SCEC and by the USGS Earthquake Hazards Reduction Program (EHRP). EHRP's mission is to provide the scientific information and knowledge necessary to reduce deaths, injuries, and economic losses from earthquakes. Products of this program include timely notifications of earthquake locations, size, and potential damage, regional and national assessments of earthquakes hazards, and increased understanding of the cause of earthquakes and their effects. EHRP funds research via its External Research Program, as well as work by USGS staff in its Pasadena, Menlo Park, and Golden offices. The EHRP also supports SCEC directly with \$1.1M per year.

SCEC and EHRP coordinate research activities through formal means including USGS membership on the SCEC Board of Directors and a Joint Planning Committee, and through a variety of less formal means. Interested researchers are invited to contact DR. Lucy Jones, EHRP coordinator for Southern California, or other SCEC and EHRP staff to discuss opportunities for coordinated research.

The USGS EHRP supports a competitive, peer-reviewed, external program of research grants that enlists the talents and expertise of the academic community, State and local government, and the private sector. The investigations and activities supported through the external program are coordinated with and complement the internal USGS program efforts. This program is divided into six geographical/topical 'regions', including one specifically aimed at southern California earthquake research and others aimed at earthquake physics and effects and at probabilistic seismic hazard assessment (PSHA). The Program invites proposals that will assist in achieving EHRP goals.

The Program's web page, <http://erp-web.er.usgs.gov/>, describes program priorities, projects currently funded, results from past work, and instructions for submitting proposals. The EHRP external funding cycle is several months offset from SCEC's, with the RFP due out in February and proposals due in early May. Interested PI's are encouraged to contact the USGS regional or topical coordinators for Southern California, Earthquake Physics and Effects, and/or National (PSHA) research, as listed under the "Contact Us" tab.

USGS internal earthquake research is summarized by topic at <http://earthquake.usgs.gov/scitech/research/> and by project at <http://earthquake.usgs.gov/research/program/>. Projects of particular relevance to SCEC are described under the following titles:

- Southern California Earthquake Project
- FOCUS on Quaternary Stratigraphy in the Los Angeles Region
- National Seismic Hazard Maps
- Earthquake Probabilities And Occurrence
- The Physics of Earthquakes
- Earthquake Effects
- Deformation
- U.S. National Strong Motion Program
- Earthquake Information
- Seismograph Networks

VI. RESEARCH OBJECTIVES

The research objectives outlined below are priorities for immediate research. They carry the expectation of substantial and measurable success during the coming year. In this context, success includes progress in building or maintaining a sustained effort to reach a long-term goal.

How proposed projects address these priorities will be a major consideration in proposal evaluation, and they will set the programmatic milestones for the Center's internal assessments.

A. Disciplinary Activities

The Center will sustain disciplinary science through standing committees in *seismology*, *geodesy*, *geology*, and *fault and rock mechanics*. These committees will be responsible for planning and coordinating disciplinary activities relevant to the SCEC science plan, and they will make recommendations to the SCEC Planning Committee regarding the support of disciplinary infrastructure. High-priority disciplinary objectives include the following tasks:

1. Seismology

Data Gathering: Maintain and improve the ability of SCEC scientists to collect seismograms to further the goals of SCEC. Efforts may include: 1) Maintaining and adding to the network of borehole seismometers in order to improve resolution of earthquake source physics and the influence of the near-surface on ground motions, and 2) maintaining and upgrading a pool of portable instruments in support of targeted deployments or aftershock response.

Other activities might include seed money for design of future experiments such as dense array measurements of basin structure and large earthquake properties, OBS deployments, and deep basement borehole studies. Workshops to explore SCEC's interface with EarthScope are encouraged.

Data Products: Improve the ability of users to retrieve seismograms and other seismic data and enhance the usefulness of data products, such as catalogs of earthquake parameters, arrival time and polarity information, and signal-to-noise measures. A central resource of SCEC is the Southern California Earthquake Data Center (SCEDC), which continues to be an integral part of the Center. The continued operation of the SCEDC is essential to deciphering Southern California seismicity and fault structure.

Enhancements to the SCEDC are encouraged that will extend its capabilities beyond routine network operations and waveform archiving, and assist researchers in using more of the data. Desirable improvements include support hardware and software enhancements, better integration with data centers in other regions, and expansion of catalogs, including the offshore region. Specific goals include: 1) developing the ability to preview seismograms and construct record sections before downloading, 2) implementing software that permits accessing both northern and southern California data with a single data request, 3) saving and making available

continuous data from all stations for 6 to 24 hour intervals before and after significant seismic events to aid in foreshock/aftershock studies, 4) improving feedback mechanisms for users to report problems and assist in network quality control, 5) incorporating additional catalogues of locations and moment tensors as they become available, and 6) keeping the database up to date with current data.

2. Tectonic Geodesy

Data gathering: Provide support to assist in the operation of, and data distribution from, the Southern California Integrated GPS Network (SCIGN); such support will be provided in response to a single proposal addressing all aspects of SCIGN, submitted through the SCIGN Coordinating Board. Provide support to assist in the operation of, and data distribution from, the WInSAR archive. Support the collection of survey-mode GPS data when such data will improve the coverage or accuracy of the SCEC Crustal Motion Map (CMM), including the offshore area. Provide support to assist in the collection of other data relevant to time-dependent deformation. Support acquisition and distribution of high-resolution topographic data bases in areas of geologic interest.

Data products: Release Version 4.0 of the CMM, which should incorporate vertical motions, additional data, and (subject to cost) data from a wider area of the plate boundary. Better define the spatial and temporal pattern of postseismic deformation from previous earthquakes. To move towards the incorporation of InSAR data into the CMM, support small-scale projects to use such data, singly or in conjunction with other datasets, to determine areas of nontectonic deformation (e.g., subsidence), coseismic displacement fields, or interseismic fields in areas of special interest.

3. Earthquake Geology

Data gathering: Plan, coordinate, and provide infrastructure for onshore and offshore geologic fieldwork, including chronologic support and shared equipment; formulate field tests of paleoseismic methodology; collect new information on fault slip rates, paleoseismic chronologies that span multiple recurrence cycles, slip in past earthquakes, and other geologic measurements of active tectonics; develop, build and contribute new and existing data to the southern California fault activity database (FAD; www.scec.org/FAD); develop methodology to test and improve resolution of event chronologies and correlations; foster subsurface analysis of fault systems, including blind thrusts and the role of off-fault deformation; compile and generate data on vertical motions to compare to geodetic and

InSAR results. Compile existing information and conduct studies of exhumed faults to elucidate conditions at seismogenic depths in Southern California.

Data products: Integrated field and laboratory efforts to date geologic samples and events, including standardized procedures for field documentation, sample treatment, dating methodologies, and data archiving and distribution (FAD); production of long-term rupture histories for selected fault systems in Southern California, with specific interest in the Los Angeles, Mojave, and southern San Andreas systems; construction of a community vertical motions map (10^5 yr timescale).

4. Fault and Rock Mechanics

Data gathering: Foster collaborative interactions for research on fault and earthquake processes. Specific areas of rock mechanics research include fault modeling, laboratory studies, and field studies of exhumed faults. Emphasis will be given to: 1) pilot studies to determine the feasibility of using a variety of new experimental techniques to measure sliding resistance at seismic slip rates, with the aim of ascertaining whether these techniques, or perhaps a new facility using these or other techniques, might allow the collection of these important data, 2) exploring the capabilities of a variety of existing and analytical techniques, and laboratories, to detect and characterize small amounts of rheologically important materials on slip surfaces in experimental and natural fault zones, and 3) planning modeling activities to predict fault behavior during dynamic slip with extreme weakening.

Data products: Assess information and products from rock-mechanics experiments and fieldwork that will be most useful in SCEC studies of earthquake source physics and fault-system dynamics; begin to outline an IT framework for an open database of experimental, model, and field results.

B. Interdisciplinary Focus Areas

Interdisciplinary research will be organized into five science focus areas: **1) unified structural representation, 2) fault systems, 3) earthquake source physics, 4) ground motion, and 5) seismic hazard analysis.** In addition, interdisciplinary research in risk assessment and mitigation will be the subject for collaborative activities between SCEC scientists and partners from other communities – earthquake engineering, risk analysis, and emergency management. This partnership will be managed through: **6) an implementation interface**, designed to foster two-

way communication and knowledge transfer between the different communities. SCEC will also sponsor a partnership in: **7) information technology**, with the goal of developing an advanced IT infrastructure for system-level earthquake science in Southern California. High-priority objectives are listed for each of the five interdisciplinary focus areas below. Collaboration within and across focus areas is strongly encouraged.

1. Structural Representation

- **Community velocity model:** Improve and evaluate the Community Velocity Model (CVM; version 3.0 is currently available) by improving the definition of model objects (basement surface and stratigraphic horizons). Extend the parameterization to include attenuation, test the model with available data (e.g., waveforms, gravity), and extend the model to offshore regions. Quantify the uncertainties in the model. Provide interface with focus and disciplinary groups to permit ready use of the model.
- **Community fault model:** Improve and evaluate the Community Fault Model (CFM-A). Emphasis will be placed on: a) defining the geometry, slip, and slip rate of major faults that are incompletely, or inaccurately represented in the current model and extending the model into the offshore regions; producing and evaluating alternative fault representations, and b) delivering the model and database to users.
- **Unified structural representation (USR):** Develop specifications for a unified, object-oriented representation of active faults and 3D earth structure for use in fault-system analysis, earthquake source physics, and ground-motion prediction; begin integration of CVM and CFM into the USR.

2. Fault Systems

- **Fault-system behavior:** Investigate the system-level architecture and behavior of fault networks to better understand the cooperative interactions that take place over a wide range of scales, assessing the ways in which the system level behavior of faults controls seismic activity and regional deformation; produce fault-slip and surface-strain maps from the CMM; compare, quantitatively, short-term geodetic rates with long-term geologic rates and explain the differences; quantify the space-time behavior of the Southern California fault system, both on-shore and off-shore, using tectonic geomorphology, paleoseismology, historical records of seismicity, and instrumental catalogs; foster collaborations to obtain outside funding to investigate paleoseismic earthquake history in places where observations would

best illuminate disagreements between geodetic and geologic inferences of fault slip rates and discriminate among competing stress evolution and seismicity simulation models; determine how geologic deformation is partitioned between slip on faults and distributed off-fault deformation and how geodetic strain is partitioned between long-term and short-term elastic strain and on-fault slip or permanent distributed strain.

- Deformation models:*** Develop, validate, and facilitate use of modular 3D quasi-static codes utilizing realistic rheological properties (e.g., USR fault geometry and elastic structure; Kelvin-Voigt and Maxwell viscoelasticity, rate-state friction, poroelasticity, proxy representations of effects of small-scale structures) and realistic, highly resolved geometries for simulating crustal motions; develop proxy approaches to represent the effects of fault system behavior on scales smaller than can be resolved on computationally feasible meshes; develop Community Block Model (CBM-A) based on CFM-A, assess mechanical compatibility of CFM-A and how slip is transferred between recognized fault segments; generate realistic finite element meshes of Southern California consistent with CFM-A and CVM/USR structure; develop models of time-dependent stress transfer and deformation of Southern California over multiple earthquake cycles addressing geologic slip rates, geodetic motions (including CMM 4.0), and earthquake histories; use these models to infer fault slip, 3-D rheologic structure, and fault interactions through the transfer of stresses; test model predictions of stress evolution by comparisons with observations of state of stress, high-resolution earthquake location and mechanism studies, and constraints from earthquake source physics models; develop systems which can be used to estimate earthquake parameters to rapidly provide information, such as expected postseismic deformation, useful in planning post-earthquake geodetic deployments.
- Seismicity evolution models:*** Develop, validate, and facilitate use of codes for simulating earthquake catalogs using CFM-A fault structure, USR and CBM-A; incorporate constraints from geologic slip rates, geodetic data, realistic boundary conditions, and fault rupture parameterizations, including rate-state friction and normal stress variations; assess the processes that control the space-time-magnitude distribution of regional seismicity; quantify sources of complexity, including geometrical structure, stress transfer, fault zone heterogeneity, and slip dynamics; assess the utility of these models in forecasting Southern California earthquakes as part of the RELM effort; search for statistically significant signals in the space-time-magnitude distribution of seismicity and understand their physical origin.

3. Earthquake Source Physics

- ***Reference earthquakes:*** Establish a database on well-studied large earthquakes for testing future ideas of earthquake physics. Target the Landers, Hector Mine, Northridge, and Imperial Valley dataset of geological, geodetic, and seismic information relevant to these sources.
- ***Earthquake triggering as an approach to explain earthquake physics:*** Determine what seismicity patterns and triggering observations can tell us about the physics of earthquake rupture nucleation, propagation, and arrest.
- ***Numerical simulations of the earthquake source:*** Conduct numerical simulations of spontaneous rupture propagation that include known complexity in fault geometry, material properties, and stress state and can test constitutive relations. Compare results with source observations. Use this information to reject or confirm previously proposed hypotheses or present new testable hypotheses about earthquake source physics. Use results to guide SHA fault segmentation decisions, and to ascertain which features of the source generate high-frequency waves.
- ***Laboratory studies of the earthquake source:*** Conduct lab experiments on faults in rock or analog materials, to determine shear resistance at slip speeds of 1 m/s and earth-related stress conditions (or appropriately scaled conditions for analog materials), especially experiments on rupture propagation. Determine how or if changes in normal stress affect shear resistance during dynamic rupture. Conduct theoretical studies of expected behavior for possible high-speed weakening mechanisms. Compare results with source observations. Use this information to reject or confirm previously proposed constitutive relations or present new testable constitutive relations.
- ***In-situ studies of fault-zones (exhumed faults and cores from depth):*** Examine and document features of fault zones in Southern California that reveal the mechanical, chemical, thermal, and kinematic processes that occur during dynamic rupture on faults having varying amounts of fault slip. Include measurements and inferences of on-fault stresses, slip-zone thickness, fine-scale fault-zone geometry, adjacent damage, and fluid content at seismogenic depths.
- ***Earthquake scaling:*** Determine how earthquakes of different sizes are similar and how they differ. Investigate scaling of key parameters to understand rupture physics.

4. Ground Motions

- ***Deterministic wavefield models:*** Develop anelastic wave-propagation codes and nonlinear site-response codes; validate these codes by inter-comparisons of computed wavefields, including those for reference earthquakes. Compare wavefields for moderate-sized events (M 3.5 to 5.0 earthquakes) with synthetics. Determine at what frequencies such events can be successfully modeled deterministically. Quantify the goodness-of-fit criterion. Use data from well-recorded large events to understand how the complexity of the source manifests itself in the resulting ground motion. Determine if the complexity can be quantified such that there is an understandable relation between complexity in the source and the resulting variation in the ground motion.
- ***CVM improvement:*** Use data from reference events to assess, as a function of frequency, wavefield simulations based on the CVM. Develop models for seismic attenuation ($1/Q$) based on data recorded by CISN and borehole instruments in Southern California. Attenuation models are to complement the SCEC CVM and be used in comparisons between data and synthetics for reference earthquakes. Develop methods for incorporating nonlinear site response for large amplitude ground motion events in Southern California. Ideas that improve our understanding of linear site response should make a significant improvement over the SCEC Phase 3 work or lead to a new understanding of how site response affects ground motion. Develop methods for improving the accuracy and frequency range of deterministic 3D wavefield modeling, including the assimilation of seismographic data into the CVM. Compare 3D results with those from other structural representations including 1D and 2D representations that will allow propagation of higher frequencies.
- ***Stochastic wavefield models:*** Develop stochastic models of high-frequency ground motion that can be combined with deterministic models of low-frequency ground motion to predict strong ground motions. Develop methods that assess broadband ground motion that include nonlinear site response. Validate the models by comparisons and testing with observed data.
- ***Earthquake scenarios:*** Simulate ground motions for probable earthquake scenarios by combining source, wave-propagation, and site-response models. Validate hybrid models—models that combine deterministic low-frequency—by comparing different metrics of the radiation versus data. For example, metrics that might be useful can be found in *Geotechnical Earthquake Engineering*, Chapter 3, Section 3, by Steven L. Kramer..

5. Seismic Hazard Analysis

- ***OpenSHA***: Contribute to the developing Community Modeling Environment for Seismic Hazard Analysis (known as OpenSHA; www.OpenSHA.org). This is an open-source, object oriented, and web-enabled framework that will allow various, arbitrarily complex (e.g., physics based) earthquake-rupture forecasts, ground-motion models, and engineering response measures to plug in for SHA. Part of this effort is to use information technology to enable the various models and databases they depend upon to be geographically distributed and run-time accessible. Contributions may include: 1) implementing any of the various components (in Java or other language), 2) testing any of the various components/applications, and 3) extending the existing framework to enable other capabilities, such as vector-valued hazard analysis, to interface with existing risk/loss estimation tools, or to web-enable the testing of the various RELM forecast models.
- ***Regional Earthquake Likelihood Models (RELM)***: Via the RELM working group, develop various, viable earthquake-forecast models for southern California (the more physics-based approaches should be developed in coordination with the Fault Systems focus group). Continue the development of shared data resources needed by the RELM working group, especially in terms of making them on-line and machine readable. These should be coordinated with other focus/disciplinary groups as appropriate (e.g., the needed quantification of alternative, internally-consistent fault-system representations should be coordinated with the CFM effort). Establish quantitative tests of the various forecast models using observed seismicity, precarious-rock constraints, historically observed intensity levels, or other viable approaches.
- ***Improved Intensity-Measure Relationships***: Work with the Ground Motion focus group and/or the Implementation Interface to develop improved models for predicting intensity measures (empirical attenuation relationships, theoretical models, or hybrid approaches). Proposals to implement new types of Intensity Measures (new functionals of ground motion, or vectors of functionals) that predict engineering damage measures better than traditional peak acceleration or spectral response are encouraged.

C. Special Projects

The following are SCEC special projects with which proposals in above categories can be identified.

1. SCIGN (www.scign.org)

Southern California now benefits from a state-of-the-art geodetic array for monitoring earthquake-related crustal deformation, and we encourage use of these data in support of the SCEC science goals and mission. The Southern California Integrated GPS Network (SCIGN), an array of 250 continuously operating GPS stations and one long-baseline laser strainmeter, tracks regional strain changes with unprecedented precision. Scientists of organizations participating in SCEC designed and manage SCIGN; SCEC also played a vital coordinating role in making SCIGN possible. The array is now operational and is already providing horizontal station velocities good to within 1 mm/yr for most stations. This new network provides data with which to improve seismic hazard assessments, through the innovation of new methods as part of the SCEC seismic hazard analysis efforts. SCIGN will also enable us to quickly measure the larger displacements that occur during and immediately after earthquakes, and it is important that these static deformation data are integrated with other intensity measures for use by emergency responders and the engineering community, through SCEC's Implementation Interface efforts. SCEC encourages proposals that make innovative use of the openly available data from this unique array to further any of the short or long-term scientific goals of SCEC, and in any of the interface areas that will potentially foster greater use of SCIGN data throughout an even wider range of applications.

2. Continental Borderland (www.scec.org/borderland)

SCEC recognizes the importance of the offshore Southern California Continental Borderland in terms of understanding the tectonic evolution, active fault systems, and seismic hazard of Southern California. SCEC encourages projects that focus on the offshore region's: 1) plate-boundary tectonics, including the currently active Pacific-North American plate motions, and the crust and upper mantle seismic and geologic structure; 2) fault systems, including the distribution and subsurface geometry of the active fault systems, Quaternary rates of fault slip, high-resolution techniques for conducting paleoseismology in a submarine environment, interactions between intersecting fault systems in three dimensions with time, and how high-angle and low-angle faults interact to accommodate long-term oblique finite strain; and 3) offshore earthquakes, including their parameters and the hazard potential of offshore geologic structures in general.

To address these issues, new methods, new datasets, and some cases new technology may need to be developed and/or acquired. For example, detailed mapping of the active offshore faults requires complete coverage of the Borderland with high-resolution multi-beam bathymetry or other high-resolution seafloor imaging systems. Long-term monitoring of earthquake activity and geodetic strain in the Borderland requires the establishment of seafloor observatories. Such efforts may be best developed in collaboration with other disciplines (climate, oceanography, marine habitat studies, etc.) and other agencies (NOAA, NSF, etc.). SCEC wishes to encourage and endorse cooperative and collaborative projects that promote these objectives.

3. Information Technology (www.scec.org/cme)

SCEC needs to implement the tools of information technology (IT) to carry out its research agenda. A major collaboration involving SCEC scientists and IT researchers was recently funded by the NSF Information Technology Research Program to develop an advanced information infrastructure for earthquake science in Southern California (the SCEC/ITR project). The Center encourages participation by SCEC scientists in its IT activities, either directly or as part of ongoing research projects. These include: 1) defining the data structures needed to exchange information and computational results in SCEC research, including implementing these data structures via XML schema for selected computational pathways in seismic hazard analysis and ground-motion simulation; 2) developing, verifying, benchmarking, documenting, and maintaining SCEC community models; 3) developing tools for visualizing earthquake information that improve the community's capabilities in research and education; and 4) organizing collections for, and contributing IT capabilities to, the *Electronic Encyclopedia of Earthquakes (E³)*.

VII. SCEC COMMUNICATION, EDUCATION, AND OUTREACH PLAN

SCEC is a community of over 500 scientists, students, and staff from 39 institutions across the United States, in partnership with more than 50 other science, engineering, education, and government organizations worldwide. To facilitate applications of the knowledge and scientific products developed by this community, SCEC maintains a *Communication, Education, and Outreach* (CEO) program with four long-term goals:

- Coordinate productive interactions among a diverse community of SCEC scientists and with partners in science, engineering, risk management, government, business, and education.
- Increase earthquake knowledge and science literacy at all educational levels, including students and the general public.
- Improve earthquake hazard and risk assessments
- Promote earthquake preparedness, mitigation, and planning for response and recovery.

Short-term objectives are outlined below. Many of these objectives are opportunities for members of the SCEC community to become involved in CEO activities. These objectives set the programmatic milestones for the Center's internal assessments, guide the development of research results needed for effective education and outreach, and identify priorities for information technology and other resources.

Management Objectives

- M1. Develop CEO five-year strategic plan
- M2. Establish additional collaborations with partner organizations and pursue funding opportunities
- M3. Represent the SCEC Community in partner organizations, science, engineering and education conferences, etc.

CEO Focus Area Objectives

SCEC Community Development and Resources (*activities and resources for SCEC scientists and students*)

- SC1 Increase diversity of SCEC leadership, scientists, and students
- SC2 Facilitate communication within the SCEC Community
- SC3 Increase utilization of products from individual research projects

Education (*programs and resources for students, educators, and learners of all ages*)

- E1 Develop innovative earth-science education resources
- E2 Interest, involve and retain students in earthquake science
- E3 Offer effective professional development for K-12 educators

Public Outreach (*activities and products for media reporters and writers, civic groups and the general public*)

- P1 Provide useful general earthquake information
- P2 Develop information for the Spanish-speaking community
- P3 Facilitate effective media relations
- P4 Promote SCEC activities

Implementation Interface (*activities with engineers and other scientists, practicing professionals, risk managers, and government officials*).

- I1 Engage in collaborations with earthquake engineering researchers and practitioners
- I2 Develop useful products and activities for practicing professionals
- I3 Support improved hazard and risk assessment by local government and private industry
- I4 Promote effective mitigation techniques and seismic policies

A. Potential CEO-Supported Projects for 2003

Current projects managed by CEO staff and partners are listed online at <http://www.scec.org/ceo>. Projects listed below are new opportunities for involvement within the CEO program. To support as many of these activities as possible, budgets for proposed projects should be on the order of \$5,000 to \$10,000. Therefore proposals that include additional sources of support (cost-sharing, funding from other organizations, etc.) are recommended. Those interested in submitting a CEO proposal should first contact Mark Benthien, director for CEO, at 213-740-0323 or benthien@usc.edu.

Application and implementation of SCEC research is especially important during the next year, as SCEC coordinates plans for activities related to the ten-year anniversary of the Northridge earthquake (January 17, 2004). Products and activities, developed around a consistent theme, will be promoted throughout 2004 at earthquake-related annual conferences, seminars, and workshops. A public awareness campaign at multiple levels will include earthquake education, mitigation advocacy, and involvement of policy makers. These activities will be opportunities for communicating outcomes of projects within all SCEC focus groups, disciplinary committees, special projects, and CEO focus areas.

1. Education Focus Area

College Course Development. CEO seeks proposals from SCEC faculty for a project manager to oversee the development of resources for undergraduate general-education earthquake courses. Materials will include online PowerPoint files for lectures, portable demonstrations, and interactive online exercises for use in the classroom for by students at home. The online materials will be freely available to instructors at any school. The project may eventually lead to the development of a consensus-based course that could allow interaction between students and faculty at separate institutions. Goals for 2003 will be to organize a committee of instructors of these courses, develop lists of existing and needed resources, catalog resources within the Electronic Encyclopedia of Earthquakes project (with the help of CEO staff), and develop proposals for further course development that will be submitted to funding agencies.

SCEC Student Network. This network will involve students at SCEC institutions (and elsewhere) in SCEC activities (research, seminars, workshops, annual meeting), provide educational and career resources, and encourage continuation into graduate school. The network will eventually be expanded to include high schools students through mentoring by SCEC undergraduate and graduate students. CEO seeks proposals for creation of this network,

including developing a database of potential student members, establishing communication tools (e-mail lists, web pages, etc.), and coordinating participation in SCEC activities.

Education Products and Activities Assessment Planning. In order to understand and improve the effectiveness of SCEC's educational activities, CEO is developing a formal evaluation plan. Partners experienced in evaluation of education products and activities are invited to help CEO staff in this process. This first phase will be to develop evaluation methodologies for SCEC's activities, based on decisions of what should be evaluated and why the evaluation is needed. Proposals that combine education assessment and public outreach assessment planning will be considered.

2. Public Outreach Focus Area

Putting Down Roots in Earthquake Country (handbook). In 1995 SCEC and the USGS developed a graphically illustrated, 32-page color handbook on earthquake science, mitigation and preparedness. Over 1.5 million copies have been distributed, and it is still very popular. CEO is planning to update the handbook (in English and Spanish), to include advancements in earthquake science and mitigation since 1995, and in preparation for the Northridge earthquake ten-year anniversary. Members of the SCEC Community are invited to participate (voluntarily) in the update process, and proposals are welcome from those who could provide coordination.

Putting Down Roots in Earthquake Country (video). As a companion to an updated version of the "Roots" handbook (see above) and in preparation for the Northridge earthquake ten-year anniversary, CEO plans to develop a video documentary that will depict the tectonic evolution of the L.A. area, explain the role of earthquakes in shaping topography, climate, and culture, and describe where earthquakes may happen, how the ground will shake, and how to be prepared. Proposals are welcome from those who could coordinate the development of the video.

Spanish-Language Products and Activities Development. To be responsible to a large portion of the southern California population, CEO plans to develop products and activities in Spanish. These will include the update of "Roots" (see above) as well as portions of the SCEC web pages, fact sheets, media interactions, etc.

Public Outreach Assessment Planning. In order to understand and improve the effectiveness of SCEC's public outreach activities, CEO is developing a formal evaluation plan. Partners experienced in evaluation of public outreach products and activities are invited to help CEO staff in this process. This first phase will be to develop evaluation methodologies for SCEC's activities, based on decisions of what should be evaluated and why the evaluation is needed.

Proposals that combine education assessment and public outreach assessment planning will be considered.

3. Implementation Interface Focus Area

Implementation Interface Management. CEO provides coordination for developing research partnerships between SCEC scientists and partners that are involved in earthquake engineering or other earthquake-related technical disciplines. Proposals are requested from investigators with multi-disciplinary expertise for management of this coordination.

Southern California HAZUS User Group. CEO is coordinating the development and activities of the Southern California HAZUS Users Group (SoCalHUG) with the Federal Emergency Management Agency (FEMA) and the California Office of Emergency Services (OES). HAZUS is FEMA's earthquake loss estimation software program. SCEC is also encouraging the improvement of USGS ShakeMap (to include scenarios based on SCEC Research) for use in HAZUS scenarios. Proposals are requested for assistance with coordinating user group activities, such as: coordinating meetings, trainings, and presentations; working with local governments getting started with HAZUS; and working with the HAZUS Resource Committee to develop a system for sharing building inventory, demographic, and geological data.

Implementation assessment. In order to understand and improve the effectiveness of SCEC's implementation interface activities, CEO is developing a formal evaluation plan. Partners experienced in evaluation of technical products and activities are invited to help CEO staff in this process. This first phase will be to develop evaluation methodologies for SCEC's activities, based on decisions of what should be evaluated and why the evaluation is needed.

B. Advanced Implementation Interface Projects

The purpose of the Implementation Interface is to implement knowledge about earthquake hazards developed by SCEC into practice. Essential to this objective is fostering collaboration between SCEC scientists and partners that are involved in research or practice in earthquake engineering, or other earthquake-related technical disciplines. Individual SCEC investigators or groups of SCEC investigators are encouraged to identify collaborative projects with individuals or groups of investigators from other organizations. SCEC investigators should request funding within SCEC Focus Groups, and describe how the project will relate to projects with partners, such as those listed in the tables below. Engineers and other potential partners should seek funding from their own organizations. As a guide to this process, Tables 1 and 2 list current ongoing projects and potential future project topics that could involve collaboration between SCEC and earthquake engineering organizations.

Table 1. SCEC Implementation Interface Research Partnerships -Current and Planned Projects with PEER and PEER-Lifelines

THEME	PROJECT	SCEC / OTHER ORGANIZATION INVESTIGATORS	SPONSORS
Ground Motion Prediction using Rupture Dynamics	Pseudo-Dynamic Modeling Project	Beroza, Guatteri	PEER-Lifelines, SCEC
Ground Motion Simulation Code Validation	3D Basin Code Validation Project	Day, Bielak, Dreger, Graves, Larsen, Olsen, Pitarka	PEER-Lifelines (admin through SCEC); SCEC (recent co-fund)
	Foamquake Data Interp. Project: Phase 1: Modeling of directivity Phase 2: Validation of source inversion procedures	/ Day, Graves, Pitarka, Silva, Zeng	PEER-Lifelines, admin through SCEC
Probabilistic Seismic Hazard Analysis	Object Oriented PSHA Framework Project (Open-PSHA)	Field /	SCEC
	PSHA Code Validation Project	/ Wong et al., Field to use results to validate Open-PSHA	PEER-Lifelines
	Surface Faulting Hazard	/ Schwartz, Petersen; Wills; Rockwell (Adv)	PEER-Lifelines
	Vector-Valued Hazard Project	Somerville / Cornell	SCEC, PEER
Ground Motion Time Histories	Time Histories for PEER Performance Based Earthquake Engineering Testbeds	Somerville	PEER, SCEC
Ground Motion Prediction Model	Next Generation Attenuation Ground Motion Model	/ Power, Chiou, Abrahamson	PEER-Lifelines

The following table lists topics for potential future collaboration between SCEC and earthquake engineering and other organizations, which are identified in the table as potential co-sponsors of collaborative implementation-oriented work. The identification of these potential collaborative projects and potential co-sponsors does not imply a commitment on the part of these organizations to co-fund projects. These organizations have their own internal processes for reviewing and approving projects, whose schedules are not necessarily synchronous with the SCEC schedule. Accordingly, Table 2 should be viewed as a preliminary identification of potential mutual interests that could be pursued with additional discussion, and does not preclude other ideas for collaboration with these or other earthquake-related research organizations

Table 2. Potential Advanced Implementation Interface Projects

THEME	PROJECT	POTENTIAL CO-SPONSORS
Ground Motion Time Histories	Provide spatial wavefield and distributed input ground motions for bridges	PEER
	Provide ground motion time histories for use in earthquake engineering testing facilities and simulation software	NEES
	Validation of simulated ground motions for performance assessment of buildings and bridges, including site effects	PEER
Information Technology	Exchange information on information technologies	NEES
	Simulation and visualization of earthquake hazards, ground motions, geotechnical/structural response and damage	PEER
Ground Motion Response	<ul style="list-style-type: none"> Improved regional site response factors from detailed surface geology and from geotechnical borehole data bases (follow through on SCEC Phase III) 	CGS, PEER-Lifelines
	<ul style="list-style-type: none"> Seismic velocity profiles from microtremor arrays for deep Vs profiles to complement SASW testing 	PEER-Lifelines
	<ul style="list-style-type: none"> Mapping of basin edge effects using geological data consistent with engineering model from the “Basins” project (see Table 1) 	CGS, PEER-Lifelines (future)
Relationship Between Ground Motion Characteristics and Building Response	<ul style="list-style-type: none"> Identify damaging characteristics of ground motions e.g. through PEER PBEE Testbeds, and mapping of associated hazard intensity measures 	PEER
	<ul style="list-style-type: none"> How ground motions enter low rise buildings 	PEER
Societal Implications of Earthquake Hazard	<ul style="list-style-type: none"> Risk and implications of earthquake hazards on distributed lifeline systems and regional economies 	PEER, PEER-Lifelines