2002 PROGRAM ANNOUNCEMENT
for the Southern California Earthquake Center

I. INTRODUCTION

On February 1, 2002, the Southern California Earthquake Center (SCEC) will change from an entity within the NSF/STC program (SCEC1) to a free-standing center (SCEC2), funded by NSF/EAR and the U. S. Geological Survey. This document solicits proposals from individuals and groups to participate in the first year of the SCEC2 program.

II. GUIDELINES FOR PROPOSAL SUBMISSION

A. Due Date: December 20, 2001. Late proposals will not be accepted.

B. Delivery Instructions. Proposals should be submitted electronically in PDF format to John McRaney at mcraney@usc.edu. Large files can be mounted on the investigator's web site and instructions for retrieval sent by e-mail to John McRaney. Large files (> 3Mbyte) can also be sent on a zip disk (PC or Macintosh formatted) to

2002 SCEC Proposals
Atten: John McRaney
Southern California Earthquake Center
University of Southern California
Los Angeles, California 90089-0742

- Proposals do not need to be formally signed by institutional representatives.
- Proposals should be for one year, with a start date of February 1, 2002 or later.
- Collaborative proposals involving multiple institutions are strongly encouraged; these can be submitted with the same text but different institutional budgets.
- 2001 Annual Reports for SCEC1 scientists will be due at a later date and are not requested for 2002 SCEC proposals. (Note to SCEC1 researchers: Final reports on SCEC1 research activities will be due in February, 2002. Guidelines for these reports will be available in November, 2001. P.I.'s that were funded in SCEC1 will not receive funding for SCEC2 projects until all reports are submitted.)

C. Formatting Instructions.

- Cover Page: Should begin with the words "2002 SCEC Proposal," the project title, Principal Investigator, institution, proposal category (from types listed in italics in Section IV), and the disciplinary committees and/or focus groups that should consider your proposal. Collaborative proposals involving multiple institutions should list the principal investigators from the other institutions involved in the collaboration.

- Technical Description: Should describe in five pages of text or less the technical details of the project and how it relates to the short-term objectives outlined in the SCEC2 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.
- Figures: Technical description should contain no more than five figures, which may be in color.
- Current Support: Statements of current support should be included for each Principal Investigator and follow NSF instructions.

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 SCEC Collaboratory. By submitting a proposal, investigators are agreeing to these conditions.

E. 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.

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

- U.S. academic institutions
- Private corporations
- Jet Propulsion Laboratory

Collaborative proposals with investigators from the USGS are encouraged; USGS employees should submit their requests for support through USGS channels.

III. SCEC ORGANIZATION

A. Mission and Science Goal. SCEC will remain 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 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 SCEC2 science plan, and they will make recommendations to the SCEC Planning Committee regarding support of disciplinary infrastructure. High-priority disciplinary activities are summarized in Section VI.B.1.

C. 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. SCEC2 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 activities are listed for each of these interdisciplinary focus areas in Section VI.B.2.

D. Communication, Education, and Outreach. SCEC will maintain 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. High-priority activities of the CEO program are summarized in Section VII.

IV. PROPOSAL CATEGORIES

On the cover page, investigators should designate a category for their proposal selected from the following four types:

A. Infrastructure. SCEC seeks to establish and maintain a multidisciplinary, multi-institutional collaboratory for earthquake research in Southern California. Proposals in this category should address one or more of the infrastructure issues related to the gathering, curating, analysis, and distribution of data, post-earthquake response, science implementation, and information technology outlined in Section VI.B.

B. Science. SCEC coordinates and supports basic and applied research by individuals and groups on earthquake problems related to the Center's mission (Section III.A). Proposals in this category should address one or more of the science objectives described in Section VI.B. Appropriate submissions include proposals to construct "SCEC community models", which are on-line, documented, and maintained resources for conducting and implementing SCEC research.

Investigators should identify on the cover sheet the appropriate disciplinary committee or focus group to consider their proposal; more than one can be designated, but investigators should suggest a primary committee or group to lead the proposal review. Investigators are also encouraged to include a brief description (~200 words) of potential summer projects for undergraduate students, which will be used to recruit students for the SCEC Summer Undergraduate Research Experience (SURE) program.

C. Workshops. SCEC participants who wish to host a workshop between February, 2002, and February, 2003, should submit a proposal for the workshop in response to this RFP. Workshops in the following topics are particularly encouraged:

- Organization of collaborative research efforts for the five-year SCEC2 program (2002-2007).
- Participation of earthquake engineers and other end-user groups in SCEC-sponsored research that addresses earthquake hazards.
- SCEC contributions to national initiatives such as EarthScope.

D. Communication, Education, and Outreach. SCEC has developed a long range CEO plan, outlined 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

- All science, infrastructure, and workshop 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 project steering committees (e.g., SCIGN). 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, 2002.

VI. SCEC2 SCIENCE PLAN

This section outlines the SCEC science priorities for the five-year period from February 1, 2002, to January 31, 2007. Additional material on the science and management plans for the Center can be found in the SCEC2 proposal to the NSF and USGS (http://www.scec.org/scec2).

A. Long-Term Research Goals

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.

1. 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:

a. 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?
b. 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?
c. 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?
d. 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?
e. 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?

2. 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:

a. What are the limits of earthquake predictability, and how are they set by fault-system dynamics?

b. 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?

c. 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?

d. 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?

e. 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?

f. 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?

g. 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?

h. 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?

3. 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:

a. 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?

b. 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?

c. 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?

d. 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?

e. 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?

f. 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?

g. 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?

4. 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:

a. 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?

b. How do earthquakes nucleate? What is the role of foreshocks in this process? What features characterize the early post-instability phase?

c. 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?

d. 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?

e. 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?

f. 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?

g. 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)?

h. 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?

i. What are physical mechanisms for the near-field and far-field dynamical triggering of seismicity by large earthquakes?

5. Wave Propagation

Goal: To understand seismic wave propagation 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:

1. 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?
2. 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?
3. 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?
4. 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?
5. 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?
6. Are fault-parallel, low-velocity waveguides deep-seated features of faults? How continuous are they along strike and dip? Can studies of fault-zone trapped waves constrain the effective rheological parameters of the fault zone, such as effective fracture energy?
7. Is the ability to model recorded seismograms limited mainly by heterogeneity in source excitation, focusing by geologic structure, or wavefield scattering?
8. 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?

6. 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:

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

2. 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?
3. 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?
4. 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 ?
5. 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?
6. What are the earthquake source and strong ground motion characteristics of large earthquakes (magnitudes larger then 7.5), for which there are few strong motion recordings? Can the shaking from large earthquakes be inferred from smaller events?
7. How does the nonlinear seismic response of soils depend on medium properties, amplitude, and frequency?

B. Short-Term Research Objectives

Short-term objectives are priorities for immediate research. They carry the expectation of substantial and measurable success during the first 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.

1. <u>Disciplinary Activities</u>

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 SCEC2 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:

a. *Seismology*

i. *Data gathering:* Improve the distribution and accuracy of regional seismic data, including strong-motion data, in coordination with the California Integrated Seismic Network (CISN), the Advanced National Seismic System (ANSS), COSMOS, the IRIS Data Management Center (IRIS DMC), and other organizations; plan SCEC2 seismic experiments in coordination with EarthScope and other programs
ii. *Data products:* Improve earthquake catalogs (locations, sizes, and source mechanisms), structural models, and capabilities for visualizing earthquake information; improve methods for assimilating broadband seismic data into 3D structural models.
iii. Post-earthquake response: Foster capabilities for post-earthquake deployments of portable broadband instruments in coordination with IRIS, EERI, and other organizations.

b. *Tectonic Geodesy*

i. *Data gathering:* Operate the Southern California Integrated GPS Network (SCIGN) in partnership with JPL/NASA; improve the distribution and accuracy of data from SCIGN, survey-mode GPS deployments, and InSAR systems in coordination with UNAVCO, EarthScope, and the California Spatial Reference Center; plan SCEC2 survey-mode GPS experiments in coordination with these organizations; collect other data relevant to time-dependent deformation.
ii. *Data products:* Release version 3.0 of the Crustal Motion Model (CMM); produce surface-strain maps and fault-slip models from the CMM; produce time-dependent deformation fields for use in stress-transfer investigations; incorporate InSAR imaging of tectonic deformations into the CMM.
iii. *Post-earthquake response:* Foster capabilities for InSAR imaging of co- and post-seismic deformations and for post-earthquake deployments of portable GPS instruments in coordination with UNAVCO, NASA, and other organizations.

c. *Earthquake Geology*

i. *Data gathering:* Plan, coordinate, and provide infrastructure for geologic fieldwork; formulate field tests of paleoseismic methodology; develop databases comprising high-resolution topography, slip rates of active faults, paleoseismic chronologies, slip in past earthquakes, paleo-indicators of strong ground motions, and other geologic measurements of active tectonics; foster subsurface analysis of fault systems, including blind thrusts.
ii. *Data products:* Integrate 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; produce long-term rupture histories for selected fault systems in Southern California.
iii. *Post-earthquake response:* Foster capabilities for post-earthquake field studies in coordination with EERI and other organizations.

d. *Fault and Rock Mechanics*

i. *Data gathering:* Foster scientific interactions among SCEC investigator groups and workers with active research programs in fault modeling, rock mechanics, and field studies of exhumed faults; plan modeling activities to predict fault behavior during dynamic slip with extreme weakening; plan fieldwork on exhumed fault zones to determine the relationship between fault structure and fault mechanics, with special emphasis on determining the width, energetics, and evolution of the primary sliding zone.
ii. *Data products:* Assess information and products from rock-mechanics experiments and fieldwork that will be most useful in SCEC2 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.

2. <u>Interdisciplinary Focus Areas</u>

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. SCEC2 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 these interdisciplinary focus areas:

a. *Structural Representation*

i. *Community velocity model (CVM):* Improve and evaluate the CVM by extending the parameterization to include anelastic dissipation and topography, testing the model and derived parameters (e.g., velocity, density) with available data (e.g., waveforms, gravity), and extending the model to the offshore regions; develop new data assimilation techniques for refining the CVM.
ii. *Community fault model (CFM):* Define the geometry, slip, and slip rate of seismogenic faults in Southern California, with emphasis on large faults poorly represented in current hazard models; coordinate the compilation of fault databases; produce a coarse-resolution fault model for Southern California (CFM-A); develop high-resolution fault models for selected areas (CFM-B); provide dynamic linkages between fault databases and fault models; evaluate alternative source characterizations.
iii. *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 and ground-motion prediction; begin integration of CVM and CFM into the USR; identify and prioritize data-gathering efforts to improve the USR.

b. *Fault Systems*

i. *Fault-system behavior:* Quantify the space-time behavior of Southern California seismicity using paleoseismology, tectonic geomorphology, historical records, and instrumental catalogs; compare short-term geodetic rates with long-term geologic rates and explain the differences; investigate the effects of afterslip, viscoelasticity, and poroelasticity on long-term stress transfer between faults following moderate to large earthquakes.
ii. *Deformation models:* Develop and validate 3D quasi-static codes for simulating block motions and deformations in coordination with GEM, GeoFEM, ACES, and other modeling efforts; develop deformation models of Southern California consistent with observed topography, fault geometries and rheological properties, geologic slip rates, geodetic motions, and earthquake histories; use these models to infer fault slip, rheologic stratification, and fault interactions through stress transfer.
iii. *Earthquake simulators:* Develop and validate codes for simulating earthquake catalogs in coordination with GEM, GeoFEM, ACES, and other modeling efforts; assess the utility of

these models in forecasting Southern California earthquakes and in testing empirical forecasting schemes as part of the RELM effort.

iv. *Offshore fault systems:* Plan strategies for interdisciplinary investigations of the fault systems offshore Southern California in coordination with the USGS marine program, the NSF MARGINS program, and other oceanographic activities.

c. *Earthquake Source Physics*

i. *Reference earthquakes:* Establish a set of reference events with documentation that includes databases of seismic, geodetic, and geologic observations as well as models of fault geometries, near-source structures, deformation histories, and stress changes.

ii. *Fault-zone structure:* Investigate the 3D structure of fault zones, including step-overs, transfer zones, branching points, and how this structure is coupled to stress heterogeneity and earthquake complexity; apply high-resolution location techniques to resolve the fine structure of microseismicity on active faults in Southern California, and compare with similar studies of other faults.

iii. *Source models:* Begin to develop and validate numerical algorithms for simulating 3D earthquake sources, including dynamical models of fault rupture consistent with laboratory-based friction laws and stochastic models of high-frequency radiation from faults; test source models against data from reference earthquakes.

iv. *Rupture dynamics:* Begin to develop techniques for the assimilation of laboratory-based friction, seismic, and geodetic data into dynamic rupture models; assess the discrepancies between laboratory-based friction laws that explain some observed fault-system behaviors (e.g., earthquake productivity, post-seismic response) and seismological inferences from large earthquakes (e.g., fracture energies, particle velocities, and accelerations).

v. *Earthquake interactions:* Develop more realistic models for short-term stress transfer, including rate- and state-dependent friction, dynamic triggering, and fault-zone damage/healing mechanisms; test stress-transfer models and earthquake probability estimates derived from them.

d. *Ground Motions*

i. *Deterministic wavefield models:* Develop anelastic wave-propagation codes and nonlinear site-response codes; validate these codes by intercomparisons of computed wavefields, including those for reference earthquakes.

ii. *CVM improvement:* Use data from reference events to assess, as a function of frequency, wavefield simulations based on the CVM; compare with results from other structural representations (including 1D and 2D representations); plan strategy for improving the accuracy and frequency range of deterministic wavefield modeling, including the assimilation of seismographic data into the CVM.

iii. *Stochastic wavefield models:* Develop stochastic models of high-frequency radiation that can be combined with deterministic models of low-frequency radiation to predict strong ground motions; validate the models by intercomparisons and testing with observed data.

iv. *Earthquake scenarios:* Simulate ground motions for probable earthquake scenarios by combining source, wave-propagation, and site-response models.

e. *Seismic Hazard Analysis*

  i. *Urban hazards:* Resolve strain-history discrepancies in the Los Angeles region; explore hazard implications of alternative fault geometries.
  ii. *Attenuation relationships:* Improve on the Phase-III study by incorporating source directivity, nonlinear soil amplification, and near-fault effects.
  iii. *Regional Earthquake Likelihood Models (RELM):* Coordinate with other focus groups new releases of the key infrastructure elements, including earthquake catalogs, fault-activity database, CFM, and CMM; develop prototype versions of earthquake-forecasting models based on different assumptions and information types; identify geophysical data to be used in the testing of the models.
  iv. *Probabilistic seismic hazard analysis (PSHA):* Develop and verify web-accessible, object-oriented PSHA codes; incorporate new data and models from the Phase-III and RELM efforts; provide input to seismic hazard mapping efforts by the USGS and CDMG.
  v. *Intensity measures:* In collaboration with earthquake engineers, develop new measures of ground-motion behavior that can be used in probabilistic seismic performance analysis, including vector-valued measures and their correlations.

f. *Implementation Interface*

  i. *Planning:* Explore the needs of user communities for seismic-hazard and ground-motion information, and learn how that information is used; develop a strategy for reaching and collaborating with target audiences.
  ii. *Earthquake engineering centers:* Develop collaborations in one or more research areas, such as near-fault seismic risk, rock ground motions at depth, vector representations of seismic hazards, use of earthquake simulations in risk assessment, PEER's Program of Applied Earthquake Engineering for Lifeline Systems, and the hospital retrofit problem.
  iii. *Network for Earthquake Engineering Simulation (NEES):* Develop collaborations with CUREE and other organizations to provide seismic hazard information, particularly ground-motion time histories, as input into NEES testing facilities and simulations; exchange information on IT strategies.
  iv. *HAZUS loss-estimation methodology:* Assist FEMA in the development of the Southern California HAZUS User's Group; provide seismic hazard inputs for HAZUS-based calculations in Southern California, including ground-motion maps of past earthquakes, future earthquake scenarios, and probabilistic maps.

g. *Information Technology*

  i. *Data structures:* Define the data structures needed to exchange information and computational results in SCEC research; implement these data structures via XML schema for selected computational pathways in seismic hazard analysis and ground-motion simulation.
  ii. *Community models:* Develop, verify, benchmark, document, and maintain SCEC community models.
  iii. *Visualization tools:* Develop tools for visualizing earthquake information that improve the community's capabilities in research and education.

iv. *Digital libraries:* Organize collections for and contribute IT capabilities to the *Electronic Encyclopedia of Earthquakes* (E^3).

VII. SCEC2 COMMUNICATION, EDUCATION, AND OUTREACH PLAN

SCEC has established four long-term CEO goals important to its mission:

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

Achieving these long-term CEO goals will require the involvement of many members of the SCEC community and the participation of those who will benefit from SCEC research, as listed in the following CEO Focus Areas:

SCEC Community Development and Resources ("In-Reach")
- SCEC scientists and students
- SCEC institution public information officers

Implementation Interface
- Other earth scientists
- Research engineers
- Practicing engineers and design professionals
- Risk management researchers and professionals
- Public officials (local, state, federal)
- Business and Industry

Public Outreach
- General public
- Spanish-speaking community
- News media

Education
- K-12, undergraduate, and graduate students
- K-12 educators and higher education faculty

The short-term objectives outlined below are priorities for specific CEO activities, and they carry the expectation of substantial and measurable success during the first year, either in progress toward a specific short-term objective or in building or maintaining a sustained effort to reach a long-term goal. Many these objectives present opportunities for members of the SCEC community to become involved in CEO activities. These objectives will 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.

A. SCEC Community Development and Resources ("In-Reach")

1. *Establish a diversity task force:* Promote activities to increase diversity (women, underrepresented minorities, persons with disabilities) of SCEC students, scientists, and leadership. Assess current status and document progress; assist SCEC institutions in recruiting diverse students, researchers, and faculty; suggest guidelines for selection processes for SCEC leadership positions; and serve as a resource to SCEC management to advise on diversity issues.
2. *Facilitate interactions between members of the SCEC community:* Develop innovative communication methods to facilitate interaction; foster community knowledge with SCEC Intranet web pages with internal resources, information, documents, and plans for post-earthquake activities; provide information about conferences, seminars, and other opportunities;
3. *Coordinate with SCEC institutional Public Information Officers:* Conduct workshops with PIOs about SCEC (how their institution is involved, and how to coordinate with SCEC CEO) and establish mechanisms for distributing information locally.

B. Implementation Interface

1. *Develop collaborations with earthquake engineering researchers:* Engage in interdisciplinary activities in one or more research areas, such as near-fault seismic risk, use of earthquake simulations in risk assessment, PEER's *Program of Applied Earthquake Engineering for Lifeline Systems*, the *Network for Earthquake Engineering Simulation* (NEES), and the California hospital retrofit issue.
2. *Provide useful products and programs for practicing professionals:* Conduct a *Phase III /RELM* technical workshop; hold frequent SCEC science briefings; Complete Liquefaction and Landslide Technical Reports/CD-ROM; and promote SCEC datasets.
3. *Support improved hazard and risk assessment by local government and private industry:* Identify potential SCEC research results to be included in HAZUS; assist FEMA in the development of the Southern California HAZUS User's Group; coordinate the development of earthquake scenarios; and plan post-earthquake information sharing and interaction.
4. *Promote mitigation techniques and effective seismic policies:* Produce *Earthquake Risk in L.A.* public booklet; distribute *Putting Down Roots in Earthquake Country;* and provide useful information to state and local decision makers.

C. Public Outreach

1. *Provide useful general earthquake information:* Develop *Electronic Encyclopedia of Earthquakes;* improve the SCEC Webservice; create one-page fact sheets; revise field trip guides; promote the *Wallace Creek Interpretative Trail*; distribute *Putting Down Roots in Earthquake Country;* and partner with emergency preparedness agencies to update or create earthquake materials.
2. *Develop products and programs for the Spanish-speaking community:* Develop Spanish web pages, including an online version of *Putting Down Roots in Earthquake Country*; identify existing resources (people and products); and develop resources for future Spanish activities.
3. *Develop effective media relations:* Update media earthquake manuals; hold science reporters' workshops; facilitate interviews with SCEC scientists; and work with local media during earthquake preparedness month.

4. *Promote SCEC activities:* Write and announce *SCEC InstaNET News* articles; organize press conferences; and coordinate community lectures.

D. Education

1. *Develop innovative earth-science education resources:* Develop the *Electronic Encyclopedia of Earthquakes*; promote existing SCEC online curricula, distribute Seismic *Sleuths* (web & print); and utilize *ShakeZone* earthquake exhibit and *Wallace Creek Interpretative Trail.*
2. *Attract students to earth science degree programs:* Create guide for students/advisors to promote earth science departments at all SCEC Institutions; visit high schools/ community colleges/universities to discuss careers in earth science (especially schools with large minority student populations); and create SCEC headquarters earthquake display.
3. *Involve and retain students in earthquake science:* Coordinate SCEC Summer Undergraduate Research Experience (NSF REU Site); include current SCEC science and resources in general-education earthquake courses; and invite students to SCEC workshops and other events.
4. *Provide effective professional development for K-12 educators:* Conduct courses (IRIS/USGS workshops and *Seismic Sleuths* trainings); lead field trips; and hold *Earthquake Science, Curricula, and Preparedness for Schools* symposia.