

Report of the Advisory Council

Southern California Earthquake Center

2009 SCEC Annual Meeting

Advisory Council Membership

Mary Lou Zoback, Risk Management Solutions-RMS (Chair)*

Gail Atkinson, University of Western Ontario*

Lloyd S. Cluff, Pacific Gas and Electric Company

John Filson, USGS (Emeritus)*

Jeffrey T. Freymueller, University of Alaska*

Jim Goltz, CA Emergency Management Agency*

Mariagiovanna Guatteri, Swiss Re Capital Markets*

Anne Meltzer, Lehigh University

Dennis Miletti, University of Colorado, Boulder (Emeritus)*

Kate C. Miller, University of Texas at El Paso*

Steve Mahin, Pacific Earthquake Engineering Research Center (PEER)

John Rudnicki, Northwestern University*

**Attended 2009 Annual Meeting and contributed to this report*

Introduction

The Advisory Council of the Southern California Earthquake Center (SCEC) met during the 2009 SCEC Annual Meeting, held in Palm Springs, California, 13-16 September 2009. The principal meeting of the Advisory Council was during the afternoon and early evening of 15 September; an earlier session was held prior to the start of the Annual Meeting on 13 September to outline areas of focus. The Council chair summarized the principal Council findings and recommendations in an oral report delivered during the closing session of the Annual Meeting on the morning of 16 September.

Prior to the Annual Meeting on 11 September the SCEC Director circulated to the Advisory Council a confidential report summarizing how SCEC had responded to Advisory Council recommendations from the previous year and raised a number of new and continuing issues warranting Council attention. Those issues included:

- Evaluation of the Communication, Education, and Outreach (CEO) Program
- Input on Collaboratory for the Study of Earthquake Predictability (CSEP)
- Advice on initiatives in earthquake simulation and ground motion prediction
- Input on SCEC4 planning process
- Leadership development /succession planning within SCEC
- Science planning discussions at annual meeting

After a few general remarks below, we provide input on these issues raised by the Director in his 11 September mailing; we also comment on a number of recurring topics (documenting and leveraging SCEC3

earthquake system science accomplishments, visibility and vital role of workshops within SCEC) and make recommendations on some additional issues raised by the AC at this meeting. Those additional issues include:

- Risk and crisis communication training
- Expanding high risk/high return research opportunities

Some General Impressions

Congratulations are in order on multiple fronts. The unparalleled success of the November 2008 Southern CA ShakeOut drill, actively engaging more than 5.5 million Southern Californians and a myriad of local, state and federal agencies to prepare for a large earthquake, was the culmination of years of planning by SCEC's CEO program, under Mark Benthien's superb leadership. Informed by social science research on effective messaging, the ShakeOut exercise was backed by a detailed and scientifically rigorous scenario developed with input from more than 100 earthquake scientists and experts in diverse fields led by Lucy Jones, USGS. The exercise was an integrative opportunity that involved the entire SCEC community. SCEC's researchers used ShakeOut to design and test post-quake response programs. We view the ShakeOut exercise as a unique scientific leadership outcome that was only possible as a result of the shared vision, the stature, strong participatory spirit, and integrative organization of SCEC as a dedicated science center.

While on the topic of CEO, we also want to strongly commend the outstanding, on-going commitment to involving undergrads in SCEC research through intern programs under the leadership of Bob de Groot. The enthusiasm, breadth and diversity of the outstanding undergrads getting an opportunity to participate directly in earth science research is inspiring. We are pleased that so many of them take advantage of the opportunity to participate in the annual meeting and present posters on their work.

Since members of the Advisory Council are not also members of SCEC, the Annual Meeting provides an important opportunity for Council members to assess the community's annual progress on the Center's goals and programs. The 2009 meeting and associated workshops proved again to be impressive demonstrations of the energy and enthusiasm of the SCEC community. The 121 registrants who were attending their first SCEC Annual Meeting (more than 25% of the 460+ total registrants), including many students and interns, provided heartening evidence of the center's growing participation and its compelling mission. The Advisory Council particularly applauds SCEC's continually strengthening of partnerships with the earthquake engineering community. It is heartening to see their ranks grow at each meeting.

The Advisory Council also lauds the entire SCEC membership for its persistently selfless community spirit which enables considerable progress in developing communal, system-level models and representations that are advancing the goals of both fundamental and applied earthquake system science. In particular, we would like to recognize Deputy Director Greg Beroza's superb leadership of the science collaboration process. Beroza's kickoff keynote on SCEC scientific accomplishment did a superb job of highlighting breakthrough science and the progress made towards SCEC3 goals. We found the new structure of the 2009 meeting particularly conducive to interactive discussion. The uncompleted, 2 hour plenary sessions were kicked off by outstanding and provocative overview talks mostly by early-career scientists and were then followed by 1.5 hours of open discussion around a focused but complex question involving the entire SCEC membership and actively moderated by group leaders in the topical areas.

Finally, the Advisory Council would like to particularly acknowledge Tom Jordan's exemplary leadership of SCEC over the past 9 years. Tom arrived in 2000 and brought an infusion of energy and creative ideas to SCEC as it went into its SCEC3 planning process. Under his direction the SCEC3 proposal was funded and a number of new research directions were launched. Tom's vision and ability to cultivate and seize funding opportunities outside of the core support has brought new perspectives, expertise and tools to address earthquake system science. Under Tom's initiative and leadership, SCEC now leads the earthquake science community in active engagement of the high performance computing community, as evidenced once again by the success of their \$1.6/24 months PetaSHA3 NSF grant in a highly competitive pool. In addition, the new \$2M, 32-month grant from the California Earthquake Authority for work on UCERF3 is particularly rewarding. The UCERF2 analysis succeeded in a uniform statewide assessment of earthquake likelihood consistent with the 150+ years of historical seismicity data, but left a number of significant issues impacting earthquake likelihood unresolved and outstanding. The fact that the CEA was interested and willing to fund

the follow-up research for an improved reassessment is a strong statement of their perceived value of this endeavor.

As Tom is always the first to admit, the outstanding staff support provided by John McRaney, SCEC's Associate Director of Administration and Tran Huynh, Special Project Manager, are vital to the success of SCEC. John and Tran keep SCEC running smoothly and money flowing to researchers in a timely fashion, they make sure workshops are easy to organize and run flawlessly, and we especially thank them for providing all manner of cheerful and indefatigable assistance, while managing all the details involved in carrying out another highly successful Annual Meeting.

Looking Forward

Before moving to our recommendations on specific topics, the Advisory Council noted several issues for the leadership to be mindful of:

- Maintain focus and avoid getting spread too thin (especially going into new funding cycle)
- Continue to take advantage of creative funding opportunities, seek ways of engaging new core sponsors, as well as explore untapped potential funding sources including some kind of industrial associates program or perhaps a utilities/infrastructure owners groups.

When the above points were raised in the oral presentation of the AC report at the Annual Meeting on Sept 16, they led to a vigorous discussion as to whether the AC was providing conflicting advice. The AC does not feel that the suggestion to be mindful of focus contradicts the advice to continue to seek and take advantage of new research and funding opportunities. One reason for suggested focus is a simple matter of resources – USGS funding has been flat, and while NSF funding has been going up slightly, we think a big increase in core funding is unlikely and certainly will not be enough to do all SCEC would like to do. Therefore, some choices will need to be made. We feel it is far better for SCEC to make these choices rather than have them made for them or have to make them suddenly without sufficient thought. The need for focus is also relevant to prevent overloading and eroding what has been an outstanding level of staff support. All of the AC recommendations below for new efforts emphasize collaboration or interaction with other agencies that could provide additional support to the proposed SCEC activities or leverage SCEC activities with modest support levels.

Focus is also important for perception of SCEC3 accomplishments and for the SCEC4 proposal presentation. We feel that SCEC must avoid the impression (and reality) of going in too many (e.g., 19) directions. We suggest that a better impact and marketing strategy for SCEC4 would be to organize around 2 to 4 main themes or grand challenges. We don't think it is prudent or wise for the AC to make recommendations on dropping specific programs. However, we feel an evaluation in terms of the question "is impact on the field and practitioners commensurate with 20 year investment" is a useful context to weigh SCEC3 accomplishments and use for planning for SCEC4. In terms of CEO activities, the answer to that question would be a resounding yes. In other areas, such as ground motion modeling, the discussion on that topic at the Annual Meeting highlighted the fact that more effort is needed to understand and provide the kind of products and outcomes that will facilitate adoption of ground motion simulations by the engineering community. This is not a comment on the scientific quality of that research (which is excellent), but rather a recommendation that SCEC4 should continue and extend its initiatives to improve communications with engineering users, and thereby gain a wider appreciation and application of their scientific products.

CEO Program

Formal Evaluation of the CEO Program

Following up on past AC recommendations, a formal retrospective review of the CEO program over the past 5 years occurred directly following the 2009 Annual Meeting. One important rationale for the review was to help assess the impact of the CEO program and to provide supporting information and data on its efficacy for the SCEC4 proposal. Two members of the AC, Dennis Mileti and Mary Lou Zoback, served on the review panel. The panel's report was submitted to SCEC on December 1, 2009 and was forwarded to the AC by Director Jordan on the same day.

The Advisory Committee will respond to the "Phase 1" retrospective CEO evaluation within the January 2010 timeframe.

In last two years the AC has also recommend a second (Phase II) forward-looking review of the CEO program utilizing an external panel informed by a wide range of disciplines (e.g., marketing and psychology) to explore potential new CEO activities and directions, and refining existing ones.

The Advisory Committee will update last year's recommendation proposing a phase II planning effort following its evaluation of the Phase I review.

ShakeOut and the Earthquake Country Alliance

The 2008 Southern California ShakeOut became the largest earthquake drill in history and it was an unparalleled success: it had 5.5 million participants, broad-based appeal from many constituent categories, and it was very effective at publicizing the M7.8 southern San Andreas scenario and its impact throughout the region. And, even though it was not funded, we congratulate SCEC CEO for interesting a non-SCEC University of California social scientist in writing a proposal to the National Science Foundation to evaluate the ShakeOut and to inform future best practices.

We also congratulate the SCEC CEO for both growing the Earthquake Country Alliance throughout southern California and effectively utilizing this broad "Alliance" to support the 2008 ShakeOut and also for taking the "Alliance" and future ShakeOuts state-wide. The creation of a single, state-wide annual preparedness event and the creation of a state-wide earthquake "Alliance" of regional preparedness partners are herculean accomplishments that will contribute to earthquake safety in the state for many years to come. These represent the largest steps forward for public earthquake preparedness in California in decades. These achievements are particularly noteworthy considering that they were made without any additional funding beyond core SCEC CEO staff salary funding.

We have two recommendations for these efforts:

1. We support the SCEC CEO Program's decision to continue with its plans to grow the "Alliance" and to conduct state-wide annual ShakeOuts in the future. However, we recommend that SCEC CEO give consideration to seeking funding from agencies such as the California Emergency Management Agency (Cal-EMA) to support these state-wide activities so that they may be enriched where appropriate.
2. We recommend that SCEC CEO continue to work with its partners to identify year-round public education and outreach activities to supplement the now annual ShakeOut events. It is well established scientifically that ongoing, repetitive messaging over the long-haul is more effective at motivating public preparedness action-taking than any annual (or rare anniversary event) public information program. We feel that positioning the annual ShakeOut as the "crown jewel" in an ongoing and year-long public preparedness information campaign that delivers preparedness information to the public, regardless if they seek it out on their own or not, would be the most effective strategy.

Targeted Leveraging of CEO Activities

We heartily applaud the accomplishments of SCEC's CEO Program in leveraging funds for its activities. According to the Phase I report, more than \$4.4M of outside funds were leveraged to support the ECA and ShakeOut activities between 2003-2009 (compared to \$2.7M in core funding over the same time interval). In fact, AC knows of no other science center in the country that has accomplished as much leveraged success for CEO activities as has SCEC's CEO Program. People in other states and even nations use the SCEC CEO Program as the "gold standard" to which they aspire and seek to replicate. We will not here offer more detailed comments on the accomplishments of this program since an elaborate evaluation of the SCEC CEO program has recently been completed.

We recommend SCEC CEO play off their success and consider two innovative pathways for leveraging additional future funding:

1. **Engage in program activities social and behavioral scientists that can carry out related research drawing on their own funding resources.** Some elements of the SCEC CEO Program, e.g., the ShakeOut exercise, have drawn the attention of hazards researchers in the social and behavioral sciences across the nation. We recommend that the SCEC CEO Program capitalize on their strong reputation by either working with and through social scientists on the Advisory Council or on its own to seek out and involve social and behavioral scientist researchers (at the University of Southern California, at other California universities, and at universities in other states). Although there are likely diverse mechanisms available to create such involvement, we foresee two SCEC CEO objectives that might be addressed:
 - a. First, increase the number of social scientists that provide input to CEO activities, e.g., on-line questionnaire development from public involvement in the ShakeOuts, analysis and publication of journal articles based on the data collected, assessment of participation in the Earthquake Country Alliance, etc.
 - b. Second, grow enthusiasm in these social and behavioral scientists for writing proposals to outside funding agencies with which they might be already familiar to do research whose findings might inform subsequent CEO activities. Although what might actually be researched would depend on the interests of the involved social and behavioral scientists, candidate fundable projects for external funding that we can imagine include: laboratory testing of messages contained in the document “Putting Down Roots in Earthquake Country”, exploring which elements of ShakeOut are most and least effective, and more.
2. **Explore special grants/contracts with federal agencies.** The ability of SCEC to attract external funds for CEO research are impacted by the fact that SCEC does not, nor should it have, affiliated social and behavioral scientists with Ph.D.s who can compete for research funds from national funding agencies, e.g., the National Science Foundation. However, this does not constrain SCEC CEO from using its existing hard won national reputation for success from seeking funding from federal agencies with program missions, e.g., the Federal Emergency Management Agency (FEMA). Moreover, a catastrophic earthquake in southern California is one of the fifteen high profile catastrophic events singled out by the U.S. Department of Homeland Security, FEMA’s parent agency, as deserving of special national preparedness attention. We recommend that the SCEC CEO Program capitalize on this overlapping “event of interest” with FEMA/DHS, by either working with appropriate members of the External Advisory Council, SCEC scientists, others, or act on its own to explore what SCEC CEO activities match FEMA preparedness program elements for possible FEMA funding for future SCEC CEO activities, or possibly, FEMA core funding.

Risk Communication

Several decades ago the subdiscipline of risk communication (also known as crisis communication) arose from the merger of the disciplines of psychology, sociology and public relations. Today, risk communication is a well developed, scientifically-informed, and diverse enterprise legitimated by specialty area classification in professional research associations. It is an established service routinely provided by consulting firms and it is often used to inform public communication practices in both government agencies, e.g., the U.S. Department of Homeland Security, the U.S. Environmental Protection Agency, and by private sector hazard-related businesses.

SCEC currently does not have a public information officer trained in risk communication to speak on its behalf when scientific information developed by SCEC is made public. Instead, some SCEC scientists speak out publically on their own on matters regarding earthquake occurrence and risk without the benefit of what is known from risk communication research about how to maximizing both the appropriateness and effectiveness of their public statements. We recommend that:

1. SCEC determine how to appropriately access the knowledge and techniques in risk communication, and, then, how to make some appropriate and acceptable level of training in public risk and crisis communication available to SCEC scientists who might speak publicly for SCEC on matters of earthquake occurrence and risk.

Collaboratory for the Study of Earthquake Predictability (CSEP)

The SCEC leadership and staff are to be commended for developing and implementing CSEP for the testing of earthquake prediction techniques and aiding and promoting the development of test centers in several other countries besides the U. S. Crucial to the development of CSEP was funding provided by the Keck Foundation, approximately \$425K for each of three years. The rational, quantitative, and transparent approach to the evaluation of earthquake prediction techniques developed by CSEP is sorely needed by the earthquake community, relevant government organizations, private interests, and the public in general. SCEC now faces major challenges to ensure the future of CSEP. The Keck Foundation funding will come to an end in early 2010. CSEP's first challenge is to secure significant new support in order to continue to be active at near its current level. The second challenge requires that SCEC "walk a fine line" between evaluation of earthquake prediction methodologies and endorsement of methodologies and specific earthquake predictions.

CSEP provides a platform for the testing of earthquake prediction techniques in an open and standardized manner. This platform includes evaluation software and access to data needed in proposed earthquake prediction processes. Replica CSEP testing centers have been established in New Zealand, Japan, and Switzerland. These serve as evidence of the acceptance and enthusiasm for the CSEP concept as developed by SCEC. Regions currently falling under testing for prediction techniques include California, Italy, Japan, New Zealand, and the northwest and southwest Pacific. The international dimension of the CSEP concept allows collaboration in development of evaluation procedures and software, and provides a broad, consistent base of experience in earthquake prediction.

Assuming that CSEP has now reached a development plateau, SCEC now faces the problem of sustaining the CSEP effort. An obvious source of funding should be the U. S. Geological Survey (USGS), the agency that has responsibility for evaluating earthquake predictions in the United States and its territories. It is unlikely that USGS funding could reach the level provided by Keck or that the USGS could provide support for foreign CSEP centers. The Federal Emergency Management Agency (FEMA) and other federal and state agencies involved in public safety and continuity of operations may represent additional sources of support.

In approaching other funding sources, SCEC should emphasize the point that CSEP is providing a service to the earthquake research community by evaluating earthquake prediction methods. In particular, since other federal agencies, such as the National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA), support earthquake prediction research, they should feel some obligation to support the open and objective evaluation of prediction methods developed with their support. Private sector utilities and financial interests may also have an interest in the evaluation of prediction techniques. Finally, the concepts developed by CSEP may have application in evaluating long-range earthquake hazard studies such as fault rupture forecasts and earthquake hazard assessments.

As the current private funding environment is rather challenging, one idea to build this support for CSEP could be to create a consortium of private entities stakeholders, e.g. insurance companies. Possibly such a consortium could be explored at a workshop with industry representative's design to engage them in discussion with CSEP scientists to discuss industry informational needs and possible CSEP products that could address those needs. In the consortium model, each member company would pay a small annual fee and participate in an annual one-day meeting to discuss the research directions and results. This may provide additional visibility to CSEP in the private sector and could lay down the foundation for larger financial support. Additional visibility in the private sector could also be achieved by approaching media such as, e.g., Bloomberg News, Insurance Day or other similar trade magazines.

SCEC should be cautious to avoid potential liability exposure in its CSEP work. CSEP should be limited to the evaluation of prediction techniques and not stray into the endorsement of specific techniques or specific predictions. As a private institution, the University of Southern California (USC) may face litigious exposure related to earthquake predictions from which state and federal institutions and agencies are immune.

However, as CSEP is gaining increasing public visibility, the role of CSEP scientists should also include a strict collaboration with policy makers and communication with the media. The task of translating scientific results into risk communication and decision making is very critical and difficult at the same time, and therefore it should be carefully addressed within CSEP planning.

We recommend that:

1. The SCEC CSEP effort should be continued as a valuable platform for the open, rigorous, and consistent evaluation of earthquake prediction methodologies.
2. SCEC CSEP should continue its foreign involvements but limit these to collaboration on implementation of evaluation procedures and to sharing results and evaluation outcomes.
3. Because of likely funding restrictions, SCEC CSEP should evolve from its current developmental phase to one of sustained operations based on the evaluation concepts already established.
4. SCEC should explore public and private sector partnerships to expand the awareness, scope, role as well as and future support for CSEP operations.
 - a. Target public sector groups include the USGS, NSF, NASA, FEMA, CALEMA and other agencies with concerns in earthquake prediction, either through their statutory evaluation and public safety responsibilities or through support of earthquake prediction research.
 - b. A consortium of private entity stakeholders (e.g. insurance industry and, potentially, capital markets) could be established in order to raise some private funding while building momentum and visibility within the private sector.
 - i. An excellent method of raising awareness and interest from the private sector would be for SCEC/CSEP to host a workshop soliciting input from industry representative on which potential products and timeframes would be of most interest.
 - c. A process should be established for the exchange of forecast concepts and results between the CEA-funded UCERF3 California earthquake likelihood study and CSEP.
5. SCEC should seek assessment by the legal offices of USC any concerns regarding liability exposure that may result for CSEP activities and determine which, if any, specific steps might mitigate those concerns.
6. Given the critical role that CSEP may have in evaluating predictions and reporting results, SCEC should review the social sciences research literature on the societal aspects of earthquake prediction and adopt and apply relevant aspects of this research.

Initiative in Earthquake Simulation and Ground Motion Prediction

Another special project area within SCEC that is undergoing rapid growth is large-scale earthquake simulation and ground motion prediction. It is the view of the Advisory Council that physics-based simulations and coupled hazard assessments represent a valuable integration of much of the knowledge and new understanding gained from SCEC's earthquake system science approach. These simulations are gaining more acceptance in the engineering design community, particularly as an important alternative to the use of a limited set of 'real' earthquake recordings and as a means to explore ground motions expected at a site for various scenarios and conditions. The simulations are also being used as a means to provide theoretical confirmation and physical insights into the commonly-used empirical ground-motion prediction equations that form the backbone of probabilistic seismic hazard analysis. We agree that this remains a critical direction for SCEC.

Despite these successes and the important role of simulation in encapsulating scientific knowledge of earthquake ground motions and effects, there remains a palpable resistance within the practical engineering community to the use of simulated motions in the place of "real" records, due to qualms amongst the engineering community that the state-of-the-art in ground-motion simulation may not be sufficiently advanced to apply simulated motions to real engineering design problems. SCEC has a valuable role to play in engaging with the engineering community so that they better understand the strengths and limitations of simulated ground motions – and, just as importantly, SCEC scientists need to better understand the engineering perspective, including an appreciation for what is important in earthquake records from a structural analysis perspective.

The Advisory Council recommends:

1. A strong focus on understanding those aspects of ground motion prediction that have significant engineering impact
2. A strong connection between simulation and empirical validation with existing data – what aspects of simulation-based predictions can be validated with ground-motion data, and what aspects are currently untestable? Are there alternative ways to test such aspects?
3. More close collaboration between the Ground Motion Simulation group and the Fault and Rupture Mechanics focus group with an attempt to include or evaluate some of the more elaborate physical modeling being developing. For example, how much complexity of fault geometry is needed to accurately simulate strong ground motions for engineering applications? Does off-fault damage affect strong ground motions, and if so how should it be included?
4. Consider a robust code validation effort, similar to CSEP, and conducted jointly with leaders in the earthquake engineering community, for ground-motion simulation methods. Such an effort could be critical in establishing user acceptance of simulated ground motions as input to engineering designs.
 - a. The effort should include comprehensive analysis and documentation of the sensitivity of simulation-based ground motions to the input parameters (and their interaction and uncertainties), with investigation of the extent to which each input parameter can be determined and constrained by data.
 - b. Considerable thought should be given to the most effective organization and home of such a code validation effort so that it would have the greatest likelihood of success in attracting NSF Engineering funding.
5. Consider also providing suites of ground motions and documentation to engineering groups, in collaboration with them, to allow them to better evaluate the engineering implications of using simulated ground motions in comparison to recorded motions. For example, PEER recently completed an important evaluation project of ground-motion selection and scaling methods, from the perspective of the sensitivity of structural response to the input motions:

http://peer.berkeley.edu/publications/peer_reports/reports_2009/reports_2009.html

All of the proposed selection and scaling methods for this exercise (which engineers were free to propose according to their preferred methods) began with “real” earthquake records. An extension to this project that considered the role of simulated motions would be very useful and would build acceptance for such motions within the engineering community.

The engineering community has indicated their need for understanding the sensitivity of simulations to input source conditions (this was a focus of the engineering feedback comments at the SCEC workshop). Acceptance of simulated records for engineering applications will grow with further engagement and collaboration with engineers in the use of simulations. In short, engineers need to understand the simulations and their uncertainties in order to use them. Just as importantly, scientists need to understand how simulations are used in order to generate them effectively.

Leadership Development

The AC is very impressed with SCEC’s effort to constantly renew its leadership group and to be cognizant of and proactive about the need for succession planning at the director’s level. We make special note of the diversity and youth present both within the SCEC community and within the Planning Committee. Rotation within the leadership group is essential for the health of the center and this is clearly ongoing. It is critical that young scientists learn to fully appreciate the importance of participating in leadership activities to the success of a large collaborative interdisciplinary research community. We again, encourage SCEC senior leadership to continue to remember that leadership skills are learned and that they should remain attentive to mentoring and leadership development of new members of the leadership group.

In thinking about the future, the AC wishes to first gratefully acknowledge USC's long-term generous support of SCEC. USC's support of SCEC in the form of facilities, key scientific hires to its faculty, and outstanding staff has been central to the success of SCEC. We also want to recognize and thank USC for its strong effort to recruit a new director in the last year, even though that effort was ultimately unsuccessful. This effort was yet another manifestation of USC's commitment to the Center. The AC believes that USC's support of the center will continue to be central to the future of SCEC's success and thus we strongly endorse a decision that SCEC remain at USC for SCEC4.

The AC is delighted that Tom Jordan has committed to continue to lead SCEC through the SCEC4 proposal process. However, with Tom Jordan's stated desire to step down from the directorship after the SCEC4 proposal process is complete, the challenges of attracting a new director remain. The AC strongly recommends that a plan be defined as soon as possible for recruiting a new director, keeping in mind that the plan could not be fully executed until after the SCEC4 proposal process is complete. We recommend that the plan be clear cut, with a specific time table. The plan should also include strategies for cultivating a pool of potential candidates such as engaging them in SCEC by inviting potential candidates to serve on the Advisory Council, or by inviting them to attend SCEC meetings and workshops. It will also be important to consider alternate leadership structures for the future as an element of this succession planning. For example, the leadership should consider the possibility that there should be separate directors of special projects that are not funded through the core science budget. This kind of thinking might be important both to the future growth of SCEC and to attracting a new director with management strengths different from the current director.

Visibility and Vital Role of Workshops Within SCEC and Increasing Awareness of Their Outcomes

SCEC is filling a tremendous need for the community by facilitating easy-to-convene topical workshops in a very short time frame—as evidenced by the requests for many more such workshops in the coming year. The Advisory Council noted that while many SCEC members were aware of recent workshops in a related area, in general they were not very aware of the workshop outcomes if they did not personally attend.

Last year the Advisory Council recommended:

1. Continued SCEC-wide promotion of workshop opportunities, this part of the process seems to be working well.
2. Workshop conveners be required to prepare a brief summary for posting on the SCEC website shortly (within 30 days?) after the workshop, with email notification to the SCEC community containing a link to the summary.

We understand from Director Jordan's report that the above recommendations are being implemented, but since they had not yet happened as of the Annual meeting they are repeated here for completeness.

Science Plan Discussions at the Annual Meeting

The AC was very impressed with the format of this year's meeting and noted a significant improvement from the preceding year. Last year AC report noted a wide variability in format and level of interaction in the Focus Groups' science planning sessions. This year's format of a single plenary talk for each session unified the diverse aspects of SCEC and fostered collaboration. AC applauds SCEC planning committee for making this change. They should ensure, however, that in the future there is adequate seating in all the plenary sessions.

Success of plenary sessions was due, in large part, to the outstanding speakers. The presentations were excellent in terms of content, timeliness and accessibility for the entire audience. Despite the disparate backgrounds of AC members, all felt they learned from the presentations. The presentations also laid a solid foundation for the science discussions to follow.

Framing the science plan discussions in terms of a few provocative questions was effective for promoting focused discussion. Audience participation was impressive. Discussion leaders do, however, need to be

vigilant in preventing a few members from dominating discussion and should continue to encourage participation from as many SCEC members as possible.

Evaluating SCEC's Progress Towards Its Goals and Documenting and Disseminating SCEC3 Accomplishments

In the AC deliberations this year, it became apparent to us that in addition to the myriad of SCEC scientific and outreach accomplishments, the center itself has become an extremely successful and effective national model for interdisciplinary collaboration and its system-level scientific approach. We therefore recommend that:

1. SCEC seize the opportunity to document and highlight their role as an extremely effective and vital interdisciplinary science center in a national forum, perhaps in a Perspective piece for Science. Such exposure would be well-timed moving towards SCEC4 proposal submission.

In 2008 the Advisory Council was told that the SCEC Planning Committee would be tracking progress toward the achievement of Center objectives. We have yet to receive the results of this tracking and report on the status of progress on the various goals, we look forward to receiving status synthesis and assume that creating it will be part of the SCEC4 planning process.

Documenting the accomplishments of the earthquake system science done by the SCEC community is challenging—both in determining the appropriate medium for such interdisciplinary work and in capturing the full impact of the contributions. Despite these challenges, the Advisory Council continues to believe that creating an integrated synthesis of contributions by SCEC3 will be a critical part of the Center's legacy, not just within the earth sciences—but in the broader scientific community.

The Advisory Council reiterates our previous recommendations that:

2. SCEC soon to produce an integrated (but not exhaustive) accomplishment synthesis (monograph) that focuses on the progress made towards the 3 or 4 main goals of SCEC3. We believe that the synthesis required to produce such a document will be essential to the SCEC4 planning--- and such a report will be an important supporting document for the SCEC4 proposal.
3. Venues and formats outside of traditional publication medium should be explored-- however, independent and stringent peer review must be assured.
4. A speakers program to broadly disseminate the results of all aspects of SCEC work be established. (We understand that the speaker's program has now been organized, but we decided to again include this recommendation until it is actually implemented).

SCEC4 Planning

SCEC3 will mark 20 years of investment in a focused attack on a complex scientific problem with a unique interdisciplinary, system-level approach. Both the funders and the broader Earth Science community will expect products and deliverables commensurate with such a 20 year investment. SCEC4 presents an exciting opportunity to build upon a number of major scientific products and contributions of SCEC3 as well as the huge outreach and preparedness success of ShakeOut.

There is no question that SCEC has been successful in advancing system science in general and earthquake science, in particular. We think a compelling case for SCEC4 must be based on demonstrating the impact of SCEC's interdisciplinary approach focused on building system-level community models – a demonstration that these models and new understanding are changing the way both earthquake scientists and earthquake engineers solve problems and approach their research.

It is fair to ask if the SCEC scientific accomplishments have made the impact on both the scientific community and practitioners (engineers, planners, public officials) that a 20 - year investment would warrant. Certainly, as noted previously, for the CEO program the answer is a resounding "yes". An important aspect of documenting the accomplishments of SCEC3 will be to identify other specific areas in which the broader impact can clearly be demonstrated. If it is determined that the impact has been less than

desired in some areas, are there additional scientific challenges that remain to be met? How will SCEC4 improve upon the translation of that science into practice?

Obviously, SCEC is a big tent and has many diverse aspects. But it is important for documenting the success of SCEC3 and proposal of SCEC4 to avoid the impression of going in too many directions. SCEC should avoid the impression (and reality) of going in too many (e.g., 19) directions. We suggest that a better impact and marketing strategy for SCEC4 would be to organize around 2 to 4 main themes or grand challenges. With regard to overall SCEC4 planning, the AC recommends that:

1. SCEC distill its diverse aspects into a unifying and clearly articulated vision. AC suggests that this can best be done by identifying a few overarching goals and showing how the collaboration of the individual focus groups and disciplinary groups supports these goals.
2. Expanded partnerships may be essential for both increasing SCEC's impact and developing additional funding sources, particularly in the current funding environment. Collaboration or interaction with other agencies could provide additional core support for the proposed SCEC activities or leverage SCEC activities with modest support levels. For example:
 - a. NASA Earth Sciences had indicated strong support for research in prediction of natural disasters. Last year's AC report endorsed "a joint SCEC-NASA workshop to explore potential guidelines for engaging space-based earthquake forecasting techniques in CSEP's rigorous and independent testing environment."
 - b. Other possible partnerships include FEMA in the area of preparedness and mitigation, NIST or NSF Engineering and PEER in engineering practice, and private sector affiliates for special projects.

Obviously, the planning for SCEC4 should strongly be built on the experience and framework of SCEC3. This framework includes technology transfer across disciplines, consolidation and synthesis of results into accessible databases, encouragement of collaborations with international research groups, and finally a reassessment of staffing needs and tasks – especially in views of the demanding job to manage special projects. With regards to these topics, the AC has several additional recommendations:

3. **Technology transfer: High performance computing.** The successful application of high-performance computing to ground motion simulations highlights the unique position of SCEC's scientists in large-scale earthquake simulation and ground motion prediction. As part of SCEC4, we recommend that other SCEC disciplines and focus areas evaluate the potential role of high-performance computing to accelerate their investigations while leveraging the experience and technical framework of the ground motion group.
4. **Consolidation and Synthesis.** A key benefit of SCEC that should be trumpeted in the SCEC4 proposal has been the creation of major databases, community models, and community software. Initiatives should be proposed for SCEC4 that will further enhance the value of these important products, and extend the reach of SCEC to a wider audience. This could involve development of user-tools to make databases, software and models more accessible and user-friendly – including to non-SCEC scientists and to engineers. There could also be a link with CEO activities here, in devising new educational activities that utilize SCEC databases.

An important issue in SCEC4 planning will be to elucidate the role for international collaborations, while still maintaining the traditional southern California natural laboratory focus of SCEC that has made it so successful. CSEP in particular is an obvious project in which international collaboration will be important to the success and significance of the project. Defining how this collaboration will be fostered and managed will be a significant challenge in SCEC4.

5. **International collaborations.** The CSEP experience highlights the critical role of international collaborations to achieve synergies within the scientific community. SCEC4 could build on this experience and evaluate the feasibility of establishing international collaborations within other SCEC projects or working groups. The identification of suitable international collaborations could be focused on projects which can benefit from relevant datasets, technology and research framework already in place or under development outside the US.

Finally, throughout its history as a center SCDEC has been blessed with a small but extraordinarily effective staff. Looking forward to SCEC4 we recommend:

6. **Staffing needs.** While the SCEC program has largely benefited from the success in bringing in special projects, the achievement of a sustainable growth should be high priority. The management of scientific research within large-scale collaborations requires a lot of “behind-the-scene” work and effort by staff members. A careful examination of future staffing needs and resources should be part of SCEC4 planning.

High Risk / High Return Research Opportunities

The AC encourages SCEC to recognize and identify high risk/high return activities in order to continue moving forward and remaining at the forefront of earthquake science. For example, the Keck Foundation provided funding for CSEP precisely because it recognized it as a high risk/high return opportunity. SCEC’s access to a large scientific community is a unique asset to support research in potentially controversial topics such as CSEP. The AC encourages SCEC to consider the following recommendations although it recognizes that neither will be easy to implement.

The AC recommends:

1. SCEC should try to identify other research opportunities that would be attractive to organizations focused on funding these high risk research activities. One idea would be to find a mechanism to generate a small pool of “venture” funds dedicated to explore and develop such projects.
2. SCEC needs to establish a process to leverage the results of some high risk projects to create a self-sustaining system or a platform for generating further funding.

Final Comments

It is the current sense of the Advisory Council that the researchers and, particularly, the senior leadership of SCEC are doing an outstanding job. The many individuals now leading committees and focus groups constitute a broadly diverse, extremely able, and committed group, including a number of rising stars. The Advisory Council applauds SCEC’s continued role in catalyzing and supporting special projects such as UCERF3, high performance computing, and CSEP. Developing new support for these kinds of activities are essential to growing the community of scientists who are engaged in earthquake science and to leverage the knowledge and understanding developed in SCEC.

The Advisory Council is pleased to continue to provide assistance to SCEC in its efforts to formulate and accomplish the center’s major goals. At any time the Council welcomes comments, criticism, and advice from the seismological community, including individuals and groups both inside and outside SCEC membership, on how best to provide that assistance.

Finally, the Advisory Council welcomes new members Jim Goltz of CALEMA and Steve Mahin from PEER. We congratulate and regretfully say goodbye to Kate Miller, new Dean of Geosciences at Texas A&M University. As TAMU is a SCEC -affiliated organization, Kate must cycle off the Advisory Council. She has been a valuable member of AC for a number of years and we will miss her input and perspective. We look forward to working with SCEC leadership assist in SCEC4 planning and to help ensure that the products and progress of the center in the SCEC3 era continue to be commensurate with agency and community investment.