USGS
Earthquake Hazards Program

MEETING SUMMARY

Scientific Earthquake Studies Advisory Committee (SESAC)
February 18, 2008
Reston, Virginia

Meeting Participants

SESAC Members
Mark Zoback, *Chair*, Stanford University, Palo Alto CA
*Jim Dieterich, University of California at Riverside and Chair, National Earthquake Prediction Evaluation Committee**
*Art Lerner-Lam, Columbia University, Palisades NY**
Vicki McConnell, Oregon Department of Geology & Mineral Industries, Portland OR
Stu Nishenko, Pacific Gas & Electric, San Francisco CA
John Parrish, California Geological Survey, Sacramento CA
Ellen Rathje, University of Texas, Austin TX
Garry Rogers, Geological Survey of Canada, Victoria BC
*Ralph Archuleta, University of California at Santa Barbara and Chair, Advanced National Seismic System Steering Committee**

**unable to attend*

USGS Staff
David Applegate, Earthquake Hazards Program (EHP), Reston VA
Mike Blanpied, EHP, Reston
Rufus Catchings, Earthquake Hazards Team (EHT), Menlo Park CA
Joyce Costello, EHP, Reston
Ned Field, EHT, Pasadena CA
Art Frankel, Geologic Hazards Team, Golden CO
Linda Gundersen, Chief Scientist for Geology, Reston VA
Bill Leith, EHP, Reston
Elizabeth Lemersal, EHP, Reston
Jill McCarthy, GHT, Golden CO
Mark Myers, Director, Reston VA
Mark Petersen, GHT, Golden CO

Guests
Jack Hayes, NEHRP Director, NIST, Gaithersburg MD
Susan Newman, Seismological Society of America, El Cerrito CA
Bob Woodward, IRIS, Washington DC

Welcome and introductions

Chairman Mark Zoback welcomed committee members and guests. After introductions around the table, he turned it over to USGS Director Mark Myers for remarks on the budget and his vision for the Survey's hazard activities.

USGS Director Mark Myers Presentation

Myers stated that he considers the hazards programs to be one of the strongest parts of USGS and a good example of integration of scientific disciplines and partnerships with academic researchers, engineers, emergency responders, the states and other federal agencies through the National Earthquake Hazards Reduction Program (NEHRP). He noted the high public visibility and the positive results coming from the earthquake program. He thanked the committee members for their volunteer service and stated that he was looking forward to the committee's 2007 report, which he would consider as important input.

Myers noted the challenge of achieving sustainable, predictable funding. Some ground was gained in the fiscal year 2008 appropriations with strong support for the multi-hazards demonstration project and climate change. Since coming to USGS, he has sought to send the message of the unique role that USGS plays within a larger framework and its strength in providing long-term continuity. USGS is good at managing large systems. He also noted that the statutory responsibility for geologic hazards gives USGS visibility on the national scene. He noted the challenge of sustaining partnerships in tough budget times and recognizes his own limitations to influence budgetary outcomes. Although there is strong support for USGS hazards activities in the Administration, there are many priorities and not a lot of money.

In the fiscal year 2009 budget request, USGS lost grounds on several fronts, taking big cuts in water, the National Biological Information Infrastructure, climate and the earthquake grants activity. He emphasized that hazards activities were not targeted and that the cuts did not reflect poor performance but squeezed dollars. He emphasized the universal praise USGS received at meetings of the NEHRP Interagency Coordinating Committee with senior leadership from the White House Office of Science and Technology Policy, Office of Management and Budget, National Science Foundation, FEMA and the National Institute of Standards and Technology. Myers emphasized that the President's budget request is not the last word, and Congress has been very impressed with the USGS hazards work, because that work is occurring where their constituents live.

Myers stated that USGS has developed a 10-year science vision across six major societal benefit areas including hazards, identifying where USGS could bring significant science presence at national and international scale. He indicated that hazards activities are the most evolved of the science thrusts. He expressed concern at the challenge of trying to grown from a pilot rather than building a national framework first. Saying let's do it right in a critical place does not generate national buy-in.

Myers asked for the committee's advice on how to increase international work. He noted a recent meeting with the French geological survey about the need to do more in the Caribbean; they are favorably disposed to work with us and see earthquakes as major risk to those who live on these islands. While the USGS plan is to build national presence, he also wants to build internationally. USGS gets some funds from USAID and the Air Force, but being within the Department of the Interior, it is hard to fund international

work directly. He concluded his remarks by noting that the earthquake program was one of the easy ones for him because of the strength of the community support and the fact that he does not have to lose sleep over the quality of the work.

Ralph Archuleta questioned Myers about the lack of any mention of earthquakes in the list of highest priorities for research in the USGS fiscal year 2009 budget briefing book. Myers replied that the budget book puts a positive spin on the request, which was substantially below the fiscal year 2008 appropriated level, and he expects such questions in his budget hearings with Congress. The budget process is sausage making, where everyone gets less sausage. He noted that the external lobby for streamgages has been impressive in its ability to focus Congress. USGS has not been as successful in other areas, including hazards. He emphasized the need to maintain certain core infrastructure, whether streamgages, ANSS, or NBII in the face of rising costs for that infrastructure, which then cuts into dollars for science.

Zoback asked whether there was enough granularity in the strategy so that supporters can point to initiatives. Myers replied that in 2010, USGS will have another opportunity to present initiatives. He stated that we have become fragmented in how we address hazards since 9/11, noting that by this time in the 1940's we were no longer looking back at Pearl Harbor but were moving on from World War II. He emphasized the need for national-level datasets, seeing hazards and climate change as stand-out issues with powerful linkages building on lessons from New Orleans the need to build resilience into coastal communities and growing urbanized populations. The challenge is to shape partnerships in an apolitical way.

Vicki McConnell asked how USGS fits within major Department of the Interior initiatives. Myers felt that USGS is doing a better job of being relevant to DOI and its mission but was not being seen as a leader, instead as a support function, and when budgets are tight, the Washington Monument will always beat out science. He chose a few areas where DOI needs to engage because issues cannot be solved without baseline science information; the obvious area was climate change. From a resource allocation standpoint, if the science is not done now, decisions will be made without science. DOI recognized that the only organization that could do the science is USGS. Myers's philosophy is that initiatives should not cut into core competencies, but as it worked out the new initiatives did cut into base. He did not put a major hazards initiative forward because USGS already has one, and it is easier to build on something.

Archuleta cautioned that cutting the earthquake program's external grants in half risk losing the support of the external community and asked why this activity was targeted and how the lower-priority activities that would not be funded were defined.

Myers expressed concern over cutting external grants and indicated that he has tried to increase external grants in the Water for America initiative. He indicated that decisions were made at higher levels, and DOI is challenged to stay within budget caps. Internal cuts mean layoffs, which are further complicated by the fact that the budget is not passed until halfway through the year, making it difficult to achieve the necessary savings, so

external grants get hit instead. He recognized that this is destructive to long-term partnerships and has tried to focus increases on such partnerships.

McConnell asked how USGS would handle prioritization in the face of substantial external grant cuts. Applegate emphasized that the existing external peer-review process would be used, but that the decreased funding would mean that only the highest-ranked proposals could be supported. Myers emphasized that USGS would make the process as transparent as possible and noted that it is important to hear such criticisms about USGS funding from the committee.

Update on Geologic Discipline Strategic Planning

Linda Gundersen, the USGS Chief Scientist for Geology, told the committee that she was looking for their thoughts and ideas on what they would like to see in the Geologic Discipline's science strategy, which will build off the USGS science strategy discussed by the Director. There are five focus areas in the hazards section of the bureau science strategy:

1) Robust monitoring infrastructure including ANSS, the National Volcano Early Warning System, and advanced technology like lidar;
2) Technology for network communications;
3) Characterizing and assessing hazards;
4) Forecasts based on understanding physical processes; and
5) Partnerships.

For the first focus area, she highlighted ANSS and its ranking as the top DOI information technology capital investment. For partnerships, she highlighted the multi-hazards demonstration project in Southern California and the 1906 centennial commemoration events in the Bay Area as showing that USGS is keen to work with our partners to help communities understand risk.

McConnell asked whether GPS was recognized as part of the first focus and where risk fit in the focus areas as that was a topic that the committee discussed last year. Gundersen replied that GPS is indeed a key aspect of USGS monitoring and that risk and resilience are very strong themes in the strategy.

Stu Nishenko asked how the shift in focus from prediction to risk and mitigation was being coordinated with FEMA's mission, noting that FEMA used to be the champion for those areas. Gundersen noted that FEMA is a key customer and emphasized the USGS mission to deliver scientific information that people need in a way that is most useful, citing the structural monitoring component of ANSS as an example of serving the needs of the building community. Applegate noted that coordination with FEMA in these areas was part of the earthquake program's OMB Program Assessment Rating Tool improvement plan, setting milestones for making a more effective handoff from research to implementation in risk characterization and loss estimation. Jill McCarthy added that earthquake monitoring can only tell you so much without including an assessment of societal impact, so products like the Prompt Assessment of Global Earthquakes for

Response system represent a natural evolution. Applegate also emphasized that the earthquake program was working with the USGS Geography Discipline, which includes social science expertise focused on risk characterization.

Gundersen reported that the science strategy team had been working for the past six months, meeting with groups internally and externally, at DOI, other agencies, and Congress. The team was in the process of formulating final narratives with a draft framework being vetted internally. The hazards framework includes the following overall goals:

Goal 1. Characterize and interpret the geologic framework of the Earth through time;
Goal 2. Understand earth surface and climatic processes and anticipate their effects on ecosystem health and change;
Goal 3. Quantify the availability of earth resources in a global context;
Goal 4. Increase the resilience of communities to geologic and environmental hazards;
Goal 5. Deliver the knowledge, data, and technology needed to support research, assessments, monitoring and outreach; and
Goal 6. Develop a flexible and diverse workforce for the future.

She emphasized that there is a very strong emphasis on traditional hazards in Goal 4 with a smaller component of environmental hazards, which had been lost in a public health context. She noted that an incredible challenge we face is very few people in the pipeline for earth sciences.

Zoback asked if there was a plan to bring together initiative-scale advancements, and Gundersen replied that there was a real opportunity for initiatives. Following up on the Director's remarks, she added that DOI views the hazards initiative, which was launched in fiscal year 2007, as ongoing work. Of the new initiatives, the oceans initiative came down from the Administration, climate change was a combination of building up and building down, the Water for America initiative came out of an OSTP report. She noted that when asking for anything, something else must be sacrificed in this budget environment. The Administration embraced the initiatives but then insisted that they come out of base rather than as added funds. Archuleta expressed concern that USGS was robbing old initiatives to pay for new initiatives. Gundersen stated that the Director is sincere about his interest in hazards and would work to keep USGS hazards activities strong. Congress is certainly well aware.

McConnell suggested that USGS should build goals that will not be initiative-dependent but rather reflect the basic structure of how USGS science will be run. Garry Rodgers asked how the science would be implemented and whether the strategy adequately recognized the needs of operational infrastructure. John Parrish asked how to know when a goal has been achieved. Gundersen responded that underlying strategic objectives and products will be delineated in the plan.

Action Item (Gundersen): When the draft hazards section with details is available, it will be circulated to the committee for comment.

Archuleta asked about how a national organization like USGS sets a national scope in the face of a patchwork of regional and local interests, emphasizing that USGS needs to follow through on the national level. He raised ANSS as an example, having reached a plateau at roughly 10% implementation and thus unable to meet the goals authorized by Congress. Gundersen replied that ANSS is discussed in the draft plan as the main earthquake priority. She noted that USGS had succeeded in finishing the backbone portion of the network with support from NSF and that the tsunami supplemental helped NEIC become fully 24/7 and enhance technology. Nishenko encouraged the Geologic Discipline science strategy team to add the concept of public safety, which goes a long way towards bridging the relevance gap.

Update on Earthquake Hazards Program Activities

Applegate reviewed the action items from the committee's previous meeting.

Action Item (SESAC): Provide feedback on September 2007 meeting summary.

He discussed the earthquake program's budget history, describing the $2 million congressional increase in fiscal year 2008 for the multi-hazards demonstration project to expand the work in Southern California and build new multi-hazard activities in the Pacific Northwest and Central US. He also noted the $0.5 million increase for the Global Seismographic Network. Applegate then discussed the cuts in the President's budget request for fiscal year 2009, including elimination of the congressional increases and an additional $3 million cut to the earthquake program's external research support activity.

Nishenko asked where ANSS fit within the budget changes. Applegate indicated that nearly half of the increase for the multi-hazards demonstration project was being directed to ANSS with new instrumentation along the southern San Andreas Fault and in the Pacific Northwest. Zoback asked whether the congressional increases would become part of the base. This did not happen in the President's request but could happen if Congress continues to provide funding, especially with a new Administration.

Applegate provided an overview of progress on the multi-hazards demonstration project in Southern California. The principal product for 2008 is the scenario being developed for the Great Southern California Shakeout emergency response and public preparedness exercise scheduled for November 2008. Release of the scenario was planned for April 2008 in order to be available for planning the exercise. The scenario development included a large number of external partners to bring in needed expertise in the social consequences of a major rupture on the southern San Andreas Fault. The scenario takes a multi-hazard approach, including the expected effects from secondary hazards such as fire and landslides.

Update on Earthquake Early Warning Algorithm Testing

Bill Leith provided an overview of early-warning methodologies, including the single-station approach used for the Japanese bullet-train system, which avoided a high-speed derailment during the Niigata earthquake in 2004. The Japanese claim 100% reliability

for this system with no false alarms. The multiple-station network approach can issue alarms more broadly rather than just at a single location. Network-based earthquake early warning systems are in place and operational in Japan; Taiwan; Istanbul, Turkey; Bucharest, Romania; and Mexico City. The Europeans are developing the SAFER system. Using the network approach, Japan began issuing public warnings in October 2007. There have been no major earthquakes yet to test the system. The Japanese are taking the approach of providing the service and seeing if the users will come; the system uses push technology to cell phones, and incentives are being given to encourage the private sector through licensing. He provided a list of the various user types, noting that different users would apply such systems in different ways, utilities for example using it as a tool for situational awareness rather than automatic actions.

Leith showed examples from the Bay Area of how much warning is possible. He explained what USGS has funded and why, noting a desire by the California Integrated Seismic Network (CISN; the ANSS regional network for California) to test algorithms developed at Berkeley, Caltech and USC. The CISN regional advisory committee determined that this was a priority. USGS has funded those universities to develop a test bed on which algorithms are being evaluated for accuracy for magnitude and intensity, false alarms, missed alarms, and technical limitations of the network itself. The magnitude-5.6 Alum Rock earthquake near San Jose last October provided a test of the performance of Berkeley's Elarms performance. That example showed that dataloggers sending data in one-second packets rather than the standard 15-second packet can reduce the delay by 10 seconds. The algorithm testing is currently halfway through the three-year research effort to determine what instrumentation is necessary, how to prevent/minimize false alarms, the probability of false alarms, and the cost of a California statewide system. For ANSS, earthquake alerting currently represents an endgame once deployment is fully completed. A more transitional approach could hasten early warning deployment by deploying new stations where telemetry delays are minimal and accelerating deployment of new technology. An alternative approach is to link to specific development effort, for example the proposed high-speed rail system between San Francisco and Los Angeles. For such a multi-billion dollar project, an earthquake early warning system would be a tiny fraction of additional funding, justifiable from the standpoint of public safety, reduced liability, and protecting the investment.

Rathje asked what the real end-user interest is. Nishenko gave the Bay Area Rapid Transit subway system as an example where early warning is seen as an embellishment to existing alerting capability. He added that Pacific Gas and Electric does not want to cut off people's power, so has adopted the philosophy of building a rugged system. Nishenko asked about interest in the Central US where quakes are felt over a much wider area with potentially longer warning times. He also encouraged thinking about such systems as prototypes for other kinds of early-warning messages for rapid-onset natural disasters as well as man-made hazards, using networks to rapidly collect and disseminate information.

As chair of the ANSS Steering Committee, Archuleta noted that the steering committee did not view early warning favorably because of resource issues but also other issues raised in current discussion. The Central US would require a very large number of

stations because of the broad area. He noted the problem of uncertainty with big earthquakes and noted that the steering committee was concerned that accuracy would not be high enough without the full-deployment station densification. He added that warning is the worst possible term, because it implies that something can be done about it; the term alert is better. While researchers have significantly reduced the false-alarm rate, the real question is what the public will accept. Leith agreed that station density is very important and noted the great advantage Japan has in that respect. Another advantage is the Japanese focus on ground-shaking intensity rather than magnitude.

Zoback asked about what plans were in place to interact with user community for what products would be useful. Leith noted that there was no plan to redo the study led by Jim Goltz a decade ago for the California Seismic Safety Commission; instead the commission has expressed interest in identifying pilot users. John Parrish noted that the Governor's office lost interest when it saw the cost of an early warning system. Rufus Catchings pointed out that the high-tech industry in Silicon Valley needs only a couple of seconds of warning to make a difference to get their sensitive instrumentation into safe mode. Rathje suggested that the single-station approach could be applied in such cases. McCarthy emphasized the opportunity US has to learn from other countries.

Archuleta asked what is the purpose of getting magnitude in the algorithm tests if what one is interested in is shaking intensity, asking how important it is to determine the magnitude if USGS wants to follow the early warning route; magnitude uncertainties will impact credibility. Nishenko stated that early warning provides another motivation for building up ANSS capability and asked what justifications were made in other countries to go forward. Parrish noted that the focus in California has been on mitigation. Mike Blanpied stated that demand for an early warning system would likely come after a large earthquake, creating a situation where budget estimates and a performance evaluation system would have to be put into place very quickly; USGS is not currently in a position to do either, and the algorithm testing is a way forward. He also noted that there has been very little testing with large-magnitude events. Rodgers added that the Japanese system evolved after Kobe earthquake; he urged that emphasis be placed on building a robust network then identify what can be done with that. Applegate argued that early warning should not be treated as something entirely different from the rapid information that is currently delivered but as an improved product, dovetailing with system interests. Nishenko pointed out that early warning could be the sizzle that can sell the science and emphasized the need for a marketing strategy to achieve such large investments.

Annual Report Preparation

During lunch, the committee discussed the draft 2007 annual report that was circulated before the meeting. It was agreed that the final version would go out with an accompanying transmittal letter from Zoback that reflects the committee's deliberations on post-2007 matters, particularly the proposed cuts in the President's budget request.

Action Item (SESAC): Finalize 2007 annual report and transmit with letter describing committee concerns over President's budget request.

Update on NEHRP Developments

NEHRP Director Jack Hayes reported that the new leadership body established in the 2004 reauthorization of NEHRP – the Interagency Coordinating Council – has successfully engaged the heads of the NEHRP agencies as well as OSTP and OMB with the President's science advisor attending all but one of the meetings. The reauthorization also called for budget coordination, which is a challenge since each agency has a different budget examiner at OMB, and the agencies sit in three different appropriations bills. Nevertheless, the goal is to develop a more coordinated process for the 2010 budget cycle. The authorization also established the Advisory Committee for Earthquake Hazard Reduction (ACEHR) on which the SESAC chair sits to facilitate two-way communication between those bodies. The ACEHR met in May 2007 in Gaithersburg and October 2007 at the USGS Geologic Hazards Team offices in Golden. The committee is still determining its role. The next meeting will be April 10-11, 2008, and will focus on writing the committee's first report.

NEHRP's draft strategic plan will be released in March for public comment. The plan includes a set of eight program priority areas that were identified based on gap analyses for the program, which were done in 2006. The ACEHR added a ninth on critical infrastructure at its October 2007 meeting. These priorities form a major part of the draft plan. Emphases include ANSS, a proposed Post-earthquake Information Management System (PIMS), and scenarios to help understand more fully the consequences of a major earthquake on communities. The draft plan explicitly recognizes that these priority areas cannot be pursued within current funding. NEHRP is supporting workshops to explore these priority areas, including one on scenarios in September 2008. A workshop was held last fall on existing buildings. Others this year will focus on performance-based seismic design and PIMS.

From a budgetary standpoint, neither NIST nor NSF received the large increases that were requested in the President's budget, but the same increases are requested in the President's 2009 request. The FEMA budget suffered cuts in 2007 and again in FY08, so a small increase is hoped for in 2009. The committee has already heard about the USGS situation. Overall, NEHRP is flat funded.

Zoback asked if the ICC would discuss what investments would be needed to fill the gaps and address priorities. Hayes replied that the ICC next meets April 3, 2008, but cautioned that we are looking at the closing days of this Administration.

Future Directions for USGS Seismic Hazard Assessment

Jill McCarthy introduced the afternoon session on future hazard assessment directions for USGS. She noted that USGS was in the end game for release of the National Seismic Hazard Maps and – with its partners the California Geological Survey and Southern California Earthquake Center – the Unified California Earthquake Rupture Forecast (UCERF). The plan is to unveil both products at the same time since they depend on one another. USGS and its partners will also put out public-oriented outreach summary documents on what these products mean and how they are used.

The current round of the national maps comes close on the heels of the previous updates in 2003. The team had one year off before getting going on this update, and it is absolutely crucial for our future going forward that there be time to focus in on some of the research topics for improving products that will be discussed in the following presentations. USGS has been updating the national maps since 1985 with a fundamental change taking place with the 1996 maps under Art Frankel's leadership. While it would seem that the changes by now should be incremental, instead the process seems to be getting harder and more contentious. Seismic hazard maps are very important products, probably some of the most important that USGS puts out. While the presentations will largely focus on the national maps and UCERF, USGS has also been moving into urban hazard maps, which are a major area of future growth. These maps have the potential to deliver valuable information to communities at risk. The USGS's future focus is not just on improving its core products but expanding scope to urban problems that are near and dear to stakeholder hearts.

Mark Petersen, chief of the National Seismic Hazard Mapping Project in the Geologic Hazards Team, noted that the group working on the national seismic hazard maps is quite small. Draft versions of the new maps were delivered to the Building Seismic Safety Council (BSSC) in December 2007, and design maps were delivered in January 2008. The plan is to roll out the national seismic hazard maps, including documentation and explanatory material, in March 2008. During 2008, the team will work with the BSSC on soil maps and amplification factors, develop newARC-IMS web products, put all input and output files on website, update aggregations and design web tools, begin discussions on Hawaii hazard map update, continue work on American Samoa and Guam hazard maps, update Quaternary fault database, participate in the U.S. Nuclear Regulatory Commission's (USNRC) Next Generation Attenuation model development for the Eastern US (NGA-East), participate in a maximum magnitude workshop, and undertake research that will improve the next generation of the national maps. Petersen then described research issues around the country.

In the Central and Eastern US, there are problems with communicating the hazard to users. Last month Petersen met with a legislative committee in Arkansas that is discussing lowering building codes to standards not consistent with BSSC. Confusion about 2500-year ground motions and design maps began in Memphis where officials shifted to a 10% in 50 year criteria using older versions of design maps, lowering the code's seismic safety measures lower than before NEHRP was established. In Arkansas, the argument is that they cannot economically compete with Memphis's lower building costs so have to lower their building codes too. In part they do not appear to understand the products that are being provided to them – they did not understand the difference between hazard maps and design maps. USGS does not set the design standards, which is a BSSC issue; the USGS role is to be able to explain the consequences of using lower ground motions for design considering what their communities might experience in the future.

Petersen noted that in Kentucky, there is disagreement with the methodology of probabilistic seismic hazard analysis as well as the national maps. The state geologist has

stated repeatedly that he feels the loss of the Department of Energy's proposed Paducah facility was a hit to economy and that the high seismic hazard was a major factor in its siting elsewhere. USGS could use advice on how to interact with states in the central US that do not feel many earthquakes but have had big ones in the past. Geodetic data indicate a low strain rate across the New Madrid Seismic Zone leading Northwestern University's Seth Stein to argue that perhaps the zone has shut off as a source of future large earthquakes. A fundamental problem is that we still do not fully understand the loading and unloading processes away from a plate boundary. A great deal of geologic data has been produced in recent years with liquefaction data indicating large earthquakes in sequences similar to 1811-12 have happened repeatedly in the recent geologic past. More geophysical data are needed to better understand the fault systems.

Petersen stated that in Charleston SC, an external advisory committee has recommended more effort to understand where earthquakes are located, and USGS has promised a future workshop. Another key research topic in this region is maximum magnitude. There is a disparity in thoughts about how big earthquakes can be particularly in the eastern US. Currently, we base hazard estimates on global analogs, but data are limited. USNRC is helping USGS to hold a workshop this year on this issue. Another research topic is the need to understand uncertainties and magnitude conversions in catalogs, which are a major input to the hazard estimation.

For the Intermountain West, Petersen reported that the Western States Seismic Policy Council (WSSPC) provided recommendations to USGS on issues such as slip-rate uncertainty. USGS established external working groups to help understand the hazard. Geodetic data are an important new source but results differ from geologic and seismic data; a related question is how to quantify aseismic slip. Other questions are how does strain accumulate and how is it released. Magnitude-frequency distribution of sources is another issue, specifically how many M6.5-7 events should go into model. There is disagreement about how big an issue this should be for the Intermountain West. Working groups are addressing fault and community velocity models for Utah and Nevada, development of an urban hazard map for the Wasatch Fault, and development of a fault-block model for the region.

In the Pacific Northwest, the principal focus is the Cascadia subduction zone, specifically what is the relative number of magnitude-9 events versus magnitude-8 events, whether it differs between northern and southern ends, and the impact of tremor.

For California, many issues came up during the Working Group on California Earthquake Probabilities work on UCERF, including how much of the overall slip rate is seismic versus aseismic or small event ruptures. This version of the hazard map reduced the seismic moment budget but could match historic rate if reduced even further, which needs to be more fully explored.

In the area of ground motions, the new maps apply NGA to the Western US with additional epistemic uncertainty to account for future events that might be different from the few large-magnitude event records that control NGA. There is a need to discuss uncertainty further. In the Central US, the new maps add new equations with different

stress drops that have brought down the ground motions. The NGA-East project is being undertaken with support from USNRC over the next five years to develop better models for ground shaking in the east. Additional research is also needed for the subduction interface in the Pacific Northwest and Alaska.

Petersen stated that future work needs to focus on resolving remaining issues in 2008 version. Time-dependent maps for Alaska, Cascadia, California, Utah, and the New Madrid Seismic Zone are planned as research products. USGS needs to work with FEMA to develop a nation-wide risk assessment. Challenges are the small size of the staff and the difficulty in finding expertise in seismic hazard analysis. Better coordination is needed with Menlo Park, and project staff need to balance reimbursable work for USNRC, the US Agency for International Development and potentially the Global Earthquake Model (GEM) project against the needs for national-map directed research.

At the end of Petersen's presentation, Archuleta emphasized that USGS needs to be doing the fundamental underpinning research for the national maps rather than just carrying out USNRC application reviews.

The next presentation was by Ned Field with the USGS Pasadena office. Field oversaw development of UCERF and focused on the research needed to improve the UCERF model.

Abbreviated logic tree of 480 branches;

He walked the committee through the UCERF components from fault models to deformation models to rate models to probability models with the end result being UCERF 2.0. The report, which will be released in April, indicates that southern California is more hazardous for large earthquakes, but there is likely to be a drop in earthquake probability for southern California's San Jacinto and Elsinore faults. The use of time-dependence reduces the hazard for most faults except the southern San Andreas Fault and the Cascadia subduction zone.

Field listed a number of future improvements and research needs going forward. A key issue is what appears to be a fundamental disconnect between ground motion models and state-of-the-art slip models. He noted that many of the aspects of UCERF improvements could be solved by physics-based earthquake simulators, but those are many years off. He cautioned that USGS would be making a big mistake if it did not support simulator development efforts. Solving many of the improvement needs will require substantial IT investments; USGS needs to pay for computer skills to have any hope of delivering future products.

Archuleta noted that the bulge problem for magnitude-6 earthquakes relative to the historic catalog remains in the new California hazard maps and UCERF. Art Frankel asked how much focus should be given to paleoseismology versus simulators. Nishenko asked what it would take to turn the faults in the B-category into A-category faults to which Field replied that these categorizations were useful and necessary for UCERF 2.0 based on constraints on recurrence interval. Archuleta asked how uncertainty is assessed

and what changes would reduce the uncertainty by a factor of two. Field stated that such questions underscore the value of getting from hazard assessment to loss estimation, showing the loss estimation curve application developed by Nico Luco and others. Archuleta asked what can guide us to most important areas of scientific research. Frankel noted that there had been no trenches on the Peninsula segment of the San Andreas Fault until recently even though probabilistic seismic hazard analysis depends on how often a given site experiences large earthquakes. Zoback asked how the California Earthquake Authority, which partially funded UCERF, is going to use the results. Field reported that at this point CEA is still using the 30-year probabilities but may seek to use shorter timeframe probabilities in the future.

The final presentation in this segment of the meeting was by Art Frankel, who is a senior scientist in Golden and the earthquake program's coordinator for earthquake effects research. Frankel spoke on the ground-motion research needed to improve the next generation of the national seismic hazard maps and associated products. He noted the shift in attenuation relations over the past ten years with the NGA models developed by the Pacific Earthquake Engineering Research Center based on global data rather than just California data. The dataset is improved for close-in records for large-magnitude events, but he questioned how applicable such Taiwanese and other global records are to California or western US earthquakes, noting that we are at the mercy of the attenuation developers and that PEER will also be leading the NGA-East effort. He emphasized the need to get physical reality into attenuation relations, noting the incomplete understanding of nonlinear propagation.

Frankel views urban seismic hazard maps as an integral part of the national seismic hazard mapping effort. Memphis and Seattle have been completed, St. Louis and Evansville, Indiana, are underway to be followed by Portland, Oregon, and Salt Lake City. Others are needed, and he argued that such maps are a key way to build the USGS earthquake program, showing how to make communities more resilient. People want to know what these maps mean for their house. A key need for such maps is three-dimensional modeling to accurately represent basin surface waves at 1 Hz. Also needed is to combine maps from 5 Hz with maps for 1 Hz to account for weakening of structures during shaking.

McConnell noted that despite Frankel's negative comments on NGA, it was nonetheless being used in the national maps. Frankel replied that an external expert panel that USGS convened because of the controversy surrounding NGA unanimously concluded that these new attenuation relations are better than the previous relations. Archuleta noted that NGA represented the same people who had produced earlier relations doing the same work with a better dataset that was made to be more uniform. They had better site conditions and had access to same data, so there is no scientific rationale for saying that whatever they finally decided upon was worse than what was done before. He did, however, share Frankel's concern about the independence of NGA-East if it would be the same people and asked what data they planned to use. He added that it would be worthwhile to see what groups in other parts of the world are looking at. Rodgers asked about whether the timeframe would allow for looking at Japanese data, adding that such

investigation could be contracted out if time was an obstacle. Rathje asked how Frankel saw vector hazard fitting in, suggesting that it could be used to make hazard maps.

External research support

Elizabeth Lemersal, who manages the earthquake program's external research support component, provided an overview presentation of the current funding profile for external grants and cooperative agreements supported by the program and also highlighted the process that is used to make grant and cooperative agreement determinations.

As part of the background materials for the meeting, the committee received a memo from Jim Dieterich, who could not be at the meeting, expressing concern about what he saw as shifting focus away from fundamental research in what the grants support. Nishenko asked how the external grants dovetail with the strategic plan, and a discussion ensued about prioritization and the competing interests of funding the best science versus the mission-agency need to get work done in focused areas. Parrish asked whether grants or cooperative agreements delivered the most bang for the buck. Zoback asked whether there was any other agency that would take up the work that USGS currently supports. Rathje noted Dieterich's points about transformative research and expressed some concern about turning USGS into NSF. Archuleta added that the proposed approach would require a structural change to the grants activity. He also stated that it is not clear whether USGS goes back and looks at what came out of from particular projects.

Lemersal concluded by expressing the program office's desire to get SESAC's advice on how USGS should prioritize the cuts should they come to pass. Zoback replied that should dramatic refocusing be required, the committee stood ready to help with the decision-making process.

The meeting adjourned at 5:00 p.m.