



PROMOTING THE DEVELOPMENT AND USES OF EARTHQUAKE SCENARIOS

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ABSTRACT

Earthquake scenarios are effective tools that can increase interest in and support for earthquake hazard mitigation designed to reduce earthquake risk in a community. Scenarios can provide opportunities to examine “alternative futures” and stimulate creative thinking about the need for new policies and programs. The process of scenario development can result in greater understanding and improved communication between members of the scientific, engineering, emergency management, and policy communities resulting in a “new community” dedicated to seismic risk reduction. In 2008, the Earthquake Engineering Research Institute was funded by the U.S. Geological Survey to: (1) develop and hold a national workshop, (2) promote the development and use of scenarios, (3) develop and maintain a web-based resource and contact program after the workshop to help those in the process of scenario development confer with those who have recent experience, and (4) prepare guidelines that can be used by other communities to develop their own scenarios. A successful two-day workshop was convened in September 2008. Based on the inputs of the workshop participants, a resource website has been developed and guidelines have been prepared. Establishing a network where individuals interested in promoting and developing a scenario project for their community or agency can interact with individuals who have scenario experience was a key result of this project.

Introduction

Earthquake scenarios can be extremely effective tools to enable communities to reduce their risk. Scenarios in general provide opportunities to examine *alternative futures* and stimulate creative thinking about the need for new policies and programs. Incorporating the latest scientific, engineering and societal knowledge about a region’s seismic hazard, local soil characteristics, building types, lifelines, and population characteristics, a scenario can create a compelling picture that members of the local community can recognize and relate to. Not only can a scenario stimulate new policies and programs, the process of scenario development itself often results in

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greater understanding and improved trust and communication between members of the scientific, engineering, emergency management, and policy communities resulting in a “new community” dedicated to seismic risk reduction.

In 2008, the Earthquake Engineering Research Institute (EERI) was funded by the National Earthquake Hazards Reduction Program (NEHRP) through the U.S. Geological Survey to: (1) develop and hold a national workshop, (2) promote the development and use of scenarios, (3) develop and maintain a web-based resource and contact program after the workshop to help those in the process of scenario development confer with those who have recent experience, and (4) prepare guidelines that can be used by other communities to develop their own scenarios.

Background

During the past few years, EERI has played a leadership role in two very successful scenario development efforts and in the creation of the 2006 *Guidelines for Developing an Earthquake Scenario* guidance document (EERI, 2006), which was designed to encourage and enable communities to develop their own scenarios. The *Scenario for a Magnitude 6.7 Earthquake on the Seattle Fault* (EERI, 2005) and *When the Big One Strikes Again – Estimated Losses due to a Repeat of the 1906 San Francisco Earthquake* (Kircher et al., 2006) have each been successful in generating considerable interest in the media and among the various segments of the general public, and have attracted interest and concern from building officials, planners, and others, who are in a position to promote and enforce policies and programs to reduce seismic risk.

In both cases, the scenarios benefited during their development from close collaboration between earth scientists, engineers, urban and emergency planners, members of academia, local and national professional associations, and government decision makers. They used the latest research on fault behavior and earthquake propagation to estimate magnitude, intensity, and duration, and combined this with updated building inventories and professional engineering assessment of the performance of buildings by age and type. They drew as much as possible on expertise from their region’s utilities to estimate impacts to bridges, highways, and critical supply and distribution networks. In each case the developers employed HAZUS, FEMA’s loss estimation software, and to the extent possible, augmented the software’s default data with more current inventory and ground motion estimates. As a result, these recent scenarios present highly credible forecasts, focusing attention on the complexity of issues that must be addressed to save lives and reduce future earthquake losses.

In some seismic regions, scenarios were developed in the past in an attempt to heighten awareness and guide planning and development. However, today we have new tools, such as HAZUS, and greater understanding of earthquake source mechanisms, fault behavior, ground motion and structural response. Much of this information was not available when earlier scenarios were created for the Hayward fault and the Los Angeles Basin.

Today we have the ability to integrate science, engineering, public policy, and emergency management with excellent loss estimation programs. In some cities we have new information and maps on corollary hazards, such as landslides, liquefaction potential, and fire. Working in

multidisciplinary teams, regional groups can now transform scientific and engineering knowledge into readily understood projections of potential loss, to generate interest in and support for new policies and programs that improve mitigation and preparedness, including code adoption and enforcement, and support for programs in the public and private sectors, that will reduce loss of life and economic disruption in seismically prone communities throughout the nation.

It is time to review and update these earlier scenarios, taking into account new knowledge, and the considerable growth and development that has occurred in many of these areas. It is also time to promote the development of scenarios in seismic regions that have never had their own scenarios.

National Workshop

EERI convened a National Workshop to promote the development and use of earthquake scenarios and to develop guidelines that will enable other jurisdictions to develop their own scenarios. The workshop drew upon the skills that have been developed in recent efforts to enable participants to determine the scope and goals of their own scenarios, identify needed resources and expertise, and learn how best to organize working groups that can provide the necessary scientific, engineering, emergency management, and societal input for their regions.

A Steering Committee was created to develop the workshop structure, identify workshop participants and suggest techniques that would be effective in promoting the further development of scenarios. The successful two-day workshop was held in San Francisco on 17 and 18 September 2008 and was attended by 78 individuals. The specific objectives of the workshop were to: (1) identify major lessons from past scenario efforts (e.g., 2005 Seattle Fault; 2008 Great California Shakeout), (2) design an effective process, (3) develop specific recommendations on how to conduct a scenario, and develop a structure for a post-workshop web resource.

The Underlying assumptions for the workshop included:

- Scenarios enable communities to improve their understanding of earthquakes and their own specific level of risk. Community leaders and individuals are able to adopt the most appropriate techniques, policies, and programs to reduce their risk.
- Scenarios can provide opportunities to examine alternative futures and stimulate creative thinking about the need for new policies and programs.
- Scenarios should incorporate the latest scientific, engineering and societal knowledge about a region's seismic hazard, building types, lifelines, and population characteristics.
- The process of scenario development can result in greater understanding and improved communication between members of the scientific, engineering, emergency management, and policy communities resulting in a "new community" dedicated to seismic risk reduction.
- Today, we have the ability to integrate science, engineering, public policy, and emergency management with excellent loss estimation programs.

Given these basic assumptions, it was decided that the workshop should bring together individuals who had been involved in the development of recent scenarios with those who were beginning to move forward with plans for their own scenarios, as well as with representatives from communities that were just beginning to consider the possibility of embarking on such a journey. It included initial presentations by those who had already developed scenarios and provided guidance on how to gather specific information. The workshop also provided opportunities to share experiences in small groups dealing with scenario organization, leadership, consensus building, administrative support, logistics, ownership, promotion, PR, and fund raising.

The presentations on the first morning focused on the experiences of various scenario efforts, while the presentations on the second morning focused on tools that could be helpful to a community in building its own scenario. The break-out sessions focused on five components of the scenario process:

- Designing the scenario (what is the purpose of scenario planning, what is it that the scenario should accomplish, what is required in order to best implement a scenario).
- Launching the scenario (what is involved in launching a scenario).
- Organizing the Scenario (how to organize the planning effort—schedule, workgroups, leadership, management, funding).
- Constructing the scenario (what are the components of the scenario—earthquake event, estimating damage and impacts, response and recovery, beyond the earthquake, what tools to use).
- Strategies for presenting the scenario (what are the most effective approaches to conveying the results of the scenario to those who need to know).

The group as a whole also discussed how to insure that a scenario is effective and that it reaches its intended audience. Some of the major points identified for each of the above components are listed below:

Designing the Scenario

Purpose of Scenario Planning. Reasons for conducting a scenario include:

- **Collective problem-solving:** A scenario affords the opportunity for a community, organization or group to come together, get buy-in for the issues, and discuss problems and potential solutions associated with a future earthquake.
- **Providing a common foundation or “mental model”:** A scenario is an effective way to make sure everyone participating in the process is talking about and visualizing the same issues.
- **Identifying flaws and strengths in the system:** When used as part of an emergency response or management exercise, a scenario can identify weaknesses and highlight strengths in a response or management system, allowing for modifications before a real disaster.
- **Serving as an advocacy tool:** A scenario can serve as an advocacy tool to build community commitment to the earthquake risk reduction, as well as to secure funding and resources for solutions to the hazards laid out in the scenario.

- **Engaging and informing stakeholders and community decision-makers:** A scenario is a useful tool for informing key stakeholders and leaders in the community on the local hazards in a way that makes the hazard come alive.
- **Examining alternative futures:** A scenario is a useful tool for providing a picture of alternative outcomes or futures in a community, with and without risk reduction actions.
- **Exercising and improving:** A scenario can be used effectively as the basis of exercises and trainings in a community or organization, helping to answer the questions of “what if?”, which are necessary to an exercise.
- **Testing and training:** A scenario is a useful tool for testing a community’s ability to respond, and for training community and organizational leaders to better respond.

Implementing the Scenario. What is necessary for the effective development and implementation of a scenario planning process?

- **Buy-in from stakeholders:** By involving stakeholders from day one of the planning effort, it increases buy-in and ownership of the scenario.
- **An understanding that the process may be more important than the product:** The scenario product may not be as useful as the process of bringing stakeholders together, examining possible alternative futures, and understanding the interconnectedness of community planning issues.
- **Considering a variety of approaches, with a scalable format (an incremental framework):** A flexible process will be key to successful implementation, including the ability to scale the planning effort up or down, depending on volunteer commitments, data availability and management support.
- **Public and leadership credibility and acceptance:** Increase acceptance by working with local “champions” for the scenario, choosing a credible scenario, involving leaders and experts who are respected in the community or organization.
- **Specific calls to action (link consequences with mitigation actions):** If the scenario is meant to educate and persuade decision-makers to take action, it is useful to have specific clear suggestions.
- **Making the scenario a living document:** To keep the scenario process alive and relevant, it will be helpful to involve new stakeholders and leaders as they change over time, and to re-evaluate assumptions, data available, conclusions.
- **Using community workshops to engage wide audience of stakeholders in accepting and taking responsibility for reducing risk identified in scenario:** Making such workshops part of the implementation process can be an important tool in developing acceptable, community-based mitigation actions.

Launching the Scenario

Suggested strategies to get started with scenario development in your community include:

- **Identify stakeholders (consider using focus groups):** These will typically be community, business, academic leaders.
- **Form action groups/task forces:** These groups can be given specific issues, problems or areas to research and develop alternatives for.

- **Use existing earthquake safety groups where possible:** Some communities already have such groups and they are a logical core to manage the scenario development process.
- **Have professional PR or media person on team:** Such a person can provide invaluable advice in terms of communicating goals of the scenario, engaging prospective participants, explaining results of the scenario to community decision-makers.
- **Have scenario led by people whose job it is to outreach:** Communicating technical information is a complex skill, and it is helpful to engage people with experience in outreaching to community and business leaders.
- **Need overall leader/manager:** While it is important to have representation in the scenario development from a diverse, large cross section of the community, it is also important that there be one designated strong leader who can guide the overall effort.
- **Discipline leaders:** To help manage the work load and assure coverage of the many complex community issues addressed by a scenario, it is helpful to designate leaders for various disciplinary areas, such as structural engineering, earth sciences, health sciences, emergency management, lifelines.
- **Need clearly stated objectives:** Every community or organization considering a scenario needs a clear objective, which can of course vary, depending on the complexity or purpose of the scenario.

Organizing the Scenario

- **Build on the strategic plan that identifies the audiences and stakeholders, effort, goals, timeline and budget:** Use skills needed for other community or organizational planning efforts, starting with this basic planning structure. Deciding who to involve can depend on purpose of the scenario.
- **Identify the process (project manager, management team, work groups, budget, schedule):** This can be critical to the success of the scenario. Explicitly identify the leadership, the budget, the timeframe, the decision-making process. Will work groups work in tandem, or sequentially?
- **Bring key leaders in at front end:** In particular, leaders who will be necessary to implement any change that comes from the scenario should be a part of the planning process.
- **Make it a flexible process:** Strong leadership should also acknowledge the need for flexibility, as the community or organization works through the planning process. The process needs to accommodate enthusiasm from participants, as well as information and people that may not have been available when the scenario was first scoped out.
- **Need time to get buy-in:** Buy-in from the various stakeholders, audiences, and leadership needed for implementation is critical to the ultimate success of the scenario. Time necessary for educating these stakeholders and leaders about the scenario should be built in to the process.
- **Interpret in terms of consequences—what does the community value?:** When organizing the approach, consider what is important to the community, and how might these values be affected by an earthquake? Bring in the concept of community resilience.

Constructing the Scenario

Ideas from the workshop that can guide the construction of a scenario:

- **Need to build from a credible event:** The scenario that is chosen needs to be credible to local audiences—a smaller, more plausible earthquake as the basis for a scenario is often more credible than a catastrophic event.
- **Consider initial investment in building inventory:** Building inventory data can be expensive and time-consuming for a community to collect, but once collected it can be used in all future scenarios. An initial investment in collecting such valuable data can reduce future costs associated with scenarios and planning exercises.
- **Identify data available, needed data improvements:** Involve experts and stakeholders in identifying what data are available at the community level. Any one agency is unlikely to have all the experts needed. A consistent depth of information is needed.
- **Estimate damage and impacts:** Request state agencies to make estimates of damage based on expected ground motions. Involve stakeholders in estimating impacts from their perspectives. It is important to decide on the scale and scope for these estimates.
- **Determine impact on response and recovery:** Different stakeholder groups may be involved in these estimates. The scenario can start to focus attention on needs that lead to pre-packaged mission requests to state and federal response agencies. Response is better understood than recovery, which will likely include effects on housing, jobs, transportation networks, schools, hospitals, etc. The interrelationship of such community characteristics should be acknowledged.
- **Build in process for vetting and review:** Need to address divergent opinions during development and review. The vetting process should take place before the scenario is shared widely, so that any scientific and engineering disagreements can be resolved beforehand.
- **Focus on resilience:** Focus attention on a community's or organization's ability to survive and prosper—what economic strategies might be needed (and what is existing economic situation)? It is possible a community or organization may have a net “gain” from an earthquake in terms of receiving funding assistance.
- **Include a Call to Action:** Develop specific recommendations for change that can be implemented, that form the basis for new policy. Keep such recommendations simple and practicable.

Strategies for Presenting the Scenario

What is necessary for the effective development and implementation of a scenario planning process?

- **Buy-in from stakeholders:** By involving stakeholders from day one of the planning effort, it increases buy-in and ownership of the scenario.
- **An understanding that the process may be more important than product:** The scenario product may not be as useful as the process of bringing stakeholders together, examining possible alternative futures, and understanding the interconnectedness of community planning issues.
- **Considering a variety of approaches, with a scalable format (an incremental framework):** A flexible process will be key to successful implementation, including the

ability to scale the planning effort up or down, depending on volunteer commitments, data availability.

- **Public and leadership credibility and acceptance:** Increase acceptance by working with local “champions” for the scenario, choosing a credible scenario, involving leaders and experts who are respected in the community or organization.
- **Specific calls to action (link consequences with mitigation actions):** If the scenario is meant to educate and persuade decision-makers to take action, it is useful to have specific clear suggestions.
- **Making the scenario a living document:** To keep the scenario process alive and relevant, it will be helpful to involve new stakeholders and leaders as they change over time, and to re-evaluate assumptions, data available, conclusions.
- **Using community workshops to engage wide audience of stakeholders in accepting and taking responsibility for reducing risk identified in scenario:** Making such workshops part of the implementation process can be an important tool in developing acceptable, community-based mitigation actions.
- **Understand the audience in order to make the correct presentation:** Technical audiences will likely require more data while policymakers and political leaders will want shorter, more focused presentations describing what actions are required.
- **Distinguish between the public and the private sector audiences:** Tailor materials for the different audiences and the different actions that would be required of each.
- **Prepare a short (one-page) summary for decision-makers:** The summary should be clear and credible, with recommended actions for the decision-maker.
- **Make a product and go out and make tailored presentations:** The product (scenario) can be described for different audiences, with presentations that focus on different elements and different desired outcomes or actions.
- **Make maps that are personal—that speak to a stakeholder or decision-maker:** As a way of engaging them in the process, develop maps that focus on the areas of interest for the stakeholder.
- **Explore beyond the 2-dimensional:** What other ways besides a written document could a scenario be presented—through a website, interactive kiosks, role-playing exercises.
- **Push towards presenting the scenarios online:** A website allows for wide sharing of the information, and for organizing and presenting information in multiple ways.

Website

After the workshop, the notes from each of the break-out groups were summarized and combined, and used to develop the structure of the website. It was decided by the group that the website would be the most effective way of sharing information on various scenario efforts and encouraging communication among scenario developers.

The website (www.nehrpsenario.org) lays out scope and goals for communities embarking on their own scenario development process, identifies needed human and financial resources, discusses successful strategies used in previous efforts and provides a plan for the successful completion of scenarios (Figure 1). The guidance, through the website, is available to workshop participants and others who wish to embark on their own community-based scenarios. The website has been developed as a living resource, with the ability to add more scenarios as

more are created. Short video clips are interspersed throughout the site to give more of a “live” feel to the points being expressed (Figure 2). The site currently has three scenarios underway and nine major scenarios that have been completed. In addition, there are smaller case studies that are interspersed in the site, including using scenarios for a NEHRP post-earthquake investigation exercise, using scenarios for rebuilding decisions (New Orleans area), and using scenarios as part of the resilient city (San Francisco) and resilient state (Oregon) concept. The most extensive scenario ever developed (the Great ShakeOut in Southern California) is described, as well as HAZUS runs for various communities in Utah and Nevada. It is intended that these guidelines will have utility not only in the earthquake community, but will be useful in developing other natural and technological hazard scenarios to guide mitigation efforts. In addition to the various scenarios and planning efforts, links to resources that can be helpful in scenario development, such as HAZUS, some of the USGS mapping products, and tools for communicating scientific information to the public are included.

Further development of the website could create a blog or discussion forum where scenario developers can discuss ideas and issues among themselves. Workshop participants and others will also be encouraged to submit materials as they are developed to share on the site.

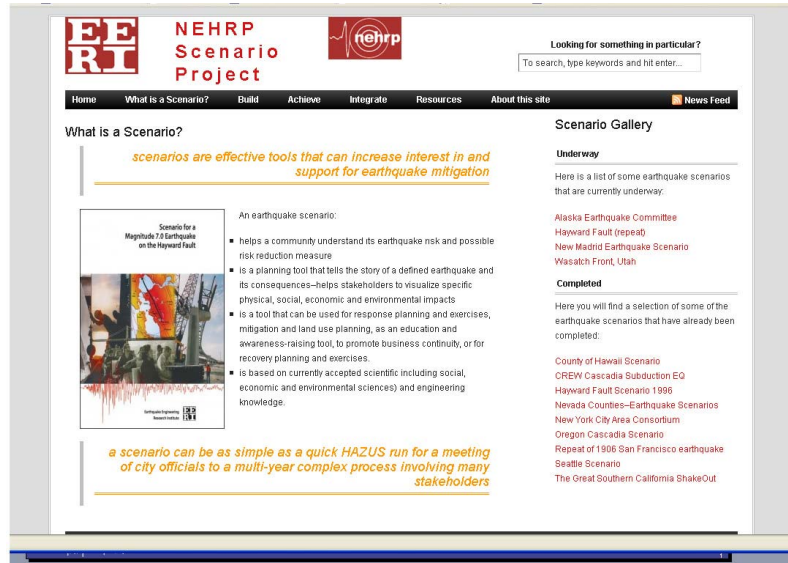


Figure 1. Short definitions and points to remember are highlighted throughout the site.

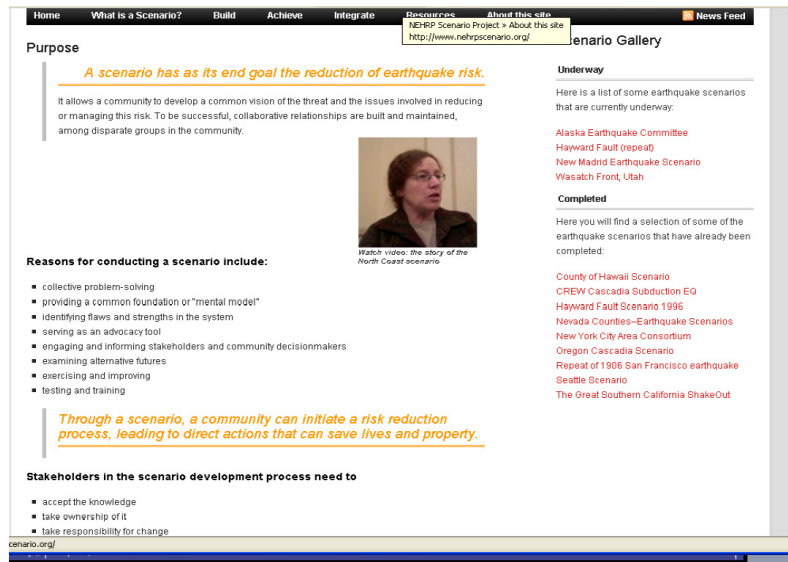


Figure 2. Links to videos are interspersed throughout the site.

Post-Workshop

EERI staff will support each of the regional efforts, to the extent possible, so as not to lose the momentum and enthusiasm built by the Workshop. EERI is creating a virtual Scenario Center to provide Workshop materials to connect those in the process of scenario development with resource individuals on an as-needed basis for advice and counsel. EERI will use the results of the Workshop to revise EERI's *Guidelines for Developing Earthquake Scenarios*. A final report summarizing the project was produced and is available at <http://earthquake.usgs.gov/research/external/research.php?yearID=2007&pi=®ionID=&award=&keyword=&institution=eeri&submit=Find+Projects>.

Summary

Scenarios can provide opportunities to examine “alternative futures” and stimulate creative thinking. The process of scenario development can result in greater understanding and improved communication between members of the scientific, engineering, emergency management, and policy communities resulting in a “new community” dedicated to seismic risk reduction. By enabling communities to improve their understanding of earthquakes and their own specific level of risk, community leaders and individuals are able to adopt the most appropriate techniques, policies and programs to reduce their risk.

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