Discussion Paper: Addressing Cascadia Earthquake Risks

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Abstract [Top]

Interest in Cascadia -- including parts of Northern California, Washington, Oregon, and British Columbia -- earthquake risks has been fostered by several developments in recent years. The emerging consensus among the scientific community of the potential for a great earthquake has led to increased attention to interface (subduction) events. The recent Mendocino earthquakes and definition of the "Seattle fault" serve as reminders that the Cascadia zone contains a variety of earthquake sources. This discussion paper addresses issues surrounding creation of a Cascadia regional risk-reduction and preparedness effort.

At issue in determining the desirability of a regional effort are two basic questions: (1) the extent to which a regional-Cascadia effort is appropriate; and (2) the extent to which interface (subduction) events should be a focal point for a regional effort. An affirmative response to the first issue requires agreement that there is sufficient commonalty of earthquake hazards and risk-reduction needs to warrant a regional effort. An affirmative response to the second issue requires evidence that interface events are credible and their impacts sufficiently differentiated from other seismic events to warrant special risk-reduction and preparedness efforts.

We believe there is a strong case to be made for a regional-Cascadia risk-reduction and preparedness effort. However, the case for an exclusive and/or primary focus on interface (subduction) events is more mixed at this time. These conclusions are based on the following discussion of:
(1) potential rationale for and arguments against a regional-Cascadia effort;
(2) the role that subduction-zone events might play in such a regional effort;
(3) potential risk-reduction strategies for the region;
(4) relevant regional organizations to consider; and
(5) necessary steps for a fuller assessment of the appropriateness and feasibility of a Cascadia-regional effort.

Rationale For and Against a Regional Cascadia Effort [Top]

The primary rationale for the formation of a Cascadia regional-reduction effort is the exposure of the region to a common set of earthquake hazards. Just as the Central United States Earthquake Consortium was formed to address a common multi-state earthquake threat (the New Madrid fault zone), the Cascadia zone contains a common set of earthquake sources. However, unlike the central-United States, the Cascadia zone contains multiple hazard sources:

- Potentially catastrophic interface (subduction) earthquakes accompanied by prolonged damaging aftershock sequences, pronounced elevation changes, local tsunamis, and unique damage patterns;

- Large, deep intraplate earthquakes related to the stretching of the downward moving plate, causing regional damage;
- Shallow, crustal earthquakes with uncertain distribution and relationships to each other, including a newly defined "Seattle fault"; capable of major damage and
- Volcanic eruptions related to the Cascadia zone.

Any of these hazard sources within the Cascadia zone present regional risks crossing state and national (United States-British Columbia) boundaries. As such, a second rationale for a Cascadia regional effort is that damaging earthquakes within this zone are likely to be regional in nature. A regional risk-reduction effort could facilitate intergovernmental and regional response planning, cooperation in regional mitigation planning (e.g., for lifelines), dissemination of information (e.g., preparedness and mitigation), and cooperation in information sharing about site-specific events. There is a presumed economy-of-scale stemming from the fact that similar impacts are to be addressed throughout the region. Among other things, the foci for a regional effort could consist of:

- Development of common sets of planning assumptions, based on an understanding of the Cascadia earthquake sources. Viewing the threat from a single-state or substate perspective has proven to provide an incomplete basis for planning. For example, based on only the available historic record in Oregon, the earthquake threat was thought to be minimal. A greater understanding of Cascadia source zones has led to a rethinking of the Oregon earthquake threat.
- Regional response and recovery planning in order to provide stronger capabilities of dealing with earthquakes in the region.
- A regional strategy for risk-reduction. A regional focus provides opportunities for linking risk-reduction efforts across states (including British Columbia) in order to avoid sub-optimal risk reduction efforts. It also has the advantage of providing opportunities to learn from other jurisdictions' risk-reduction in the region that would not normally be addressed through more localized risk-reduction programs.
- Earthquake specialists within state government, local government, and professional associations are currently cognizant of these issues, but nonetheless significant gaps exist in the ability to communicate and effectively use knowledge about earthquake impacts in the Cascadia zone. These gaps are both ones of inadequate translation of information and ones of a lack of willingness to address earthquake hazards. There is both a "need for users" and a demand for better meeting existing "users needs." Filling these gaps provides one primary rationale for a regional-Cascadia effort.

In concept, a Cascadia regional risk-reduction and preparedness effort makes much sense. The arguments against such an effort are largely practical ones stemming from questions about the ability to launch and sustain such an effort. Moving forward with a Cascadia effort implies judgments that: (1) the existing state, local, and nongovernmental risk reduction and preparedness planning effort are not capable of addressing regional events; and (2) there is sufficient willingness or ability, given likely resources, to mount an effective Cascadia-regional effort.

In assessing the feasibility of any regional effort, several factors must be confronted:

- The uncertainty associated with Cascadia earthquake sources and the likely changes in the scientific understanding of interface events in future years. This necessitates any strategy be capable of incorporating new information within reasonable timeframes;
- The varied capabilities and willingness of existing state, local, and nongovernmental organizations to advocate (or for that matter address) earthquake issues. Within this region there is considerable difference in these regards among state emergency management organizations, and among different professional organizations (e.g., active structural engineers' associations versus relatively inactive professional planning organizations);
- Differing constraints and opportunities within states in the region brought about by different mandates governing land use, building practices, and development patterns.

- The widely varied risk reduction prospects among local jurisdictions in the region. (This variation is documented by Peter May's study of local earthquake related policies and practices of 43 major jurisdictions in the Puget Sound and Portland areas.)
- The varied willingness and abilities of the professional design community within the region. (This variation is documented by Peter May's and Nancy Stark's interviews with design professionals in the Pacific Northwest.)
- Limited resources available for sustaining risk-reduction and preparedness efforts. Each of the states in the region (California, Oregon, Washington) are experiencing noteworthy budget restrictions and/or reductions, suggesting future state funding for any initiatives will be limited if non-existent.

Rationale For and Against a Subduction Focus for a Regional Effort [Top]

A second issue in considering a Cascadia effort is the extent to which potentially catastrophic interface (subduction) events should be a dominant focus of regional risk reduction and preparedness efforts. Such emphasis requires a consensus that interface events are credible and their impacts sufficiently differentiated from other seismic events to warrant special risk-reduction and preparedness efforts.

In comparison to crustal and intraplate events, an interface (subduction) event potentially introduces:

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- More geographically widespread impacts;
- Sustained aftershock sequences which imply different ways of dealing with immediate response and personal preparedness;
- Greater impacts on distributed systems like lifelines and transportation systems, stemming from the broader geographical area that is affected;
- Local tsunamis capable of inundating coastal regions, with relatively little warning;
- A different set of damage patterns to structures, relating to longer periods (e.g., 10-12 story nonductile concrete buildings) and longer duration shaking;
- Increased number of ground failures due to the longer duration shaking and more widespread impacts of a subduction-type event.

Several arguments against a subduction focus for a Cascadia effort need to be more fully evaluated: (1) subduction interface events are not sufficiently credible (unlikely argument); (2) their impacts are not sufficiently unique to warrant special attention, since preparing for other seismic events addresses subduction zone events (yes and no); and (3) attention to subduction-type events would supplant attention to other, perhaps more likely in the short-term events.

Although the interface events clearly raise important questions about the scale of event to plan for and unique damage patterns (e.g., tsunamis, aftershocks, differences in shaking periods), most of the above impacts are more differences of degree than in kind when compared with the impacts of intraplate and crustal sources. *As such, we do not feel that the interface (subduction) events are sufficiently differentiated for them to have a dominant focus for a Cascadia risk-reduction effort at this time. Such events should be considered as one of several credible earthquake sources within the Cascadia zone.*

Potential Cascadia Risk Reduction and Preparedness Strategies [Top]

Discussions to date of a regional risk-reduction and preparedness program have raised various issues about appropriate organizational structures, like the Central United States Earthquake Consortium (CUSEC) in the mid-West, the Bay Area Earthquake Preparedness Program (BAREPP) in the San Francisco Bay Area, and similar organizations created to promote risk reduction and preparedness in other parts of the county. In focusing on the appropriate organization for the Cascadia zone, the discussions to date have tended to beg the

question of the functions any such organization will perform. It makes sense to first address the relevant tasks then talk about appropriate organizations to accomplish them.

The assumed, though not explicitly stated, purpose of a Cascadia regional organization is to improve risk-reduction and preparedness in the region. Thinking about an appropriate organization requires first thinking about a strategy to achieve that purpose. Prospective risk-reduction strategies range from a relatively passive one of hazards-information dissemination (essentially the status quo) to more active efforts to seek policy reforms or to influence practices. Although these strategies are not mutually exclusive, limited resources dictate that choices must be made as to which strategies to emphasize. The primary issues in choosing between the different strategies are the focal points within the region and the mechanisms for promoting risk reduction. These differences in foci are summarized in the chart accompanying this discussion paper.

Each of several selected potential risk-reduction strategies are outlined in the remainder of this section. (For further discussion see the forthcoming chapter in the Pacific Northwest Professional paper by Peter May.)

Disseminate Hazards Information (status quo). This strategy consists of dissemination of new scientific information about earthquake hazards in the region through professional publications, newsletters, and meetings. Such information could be translated into hazards maps prepared at a scale that would show information relevant to at least the major jurisdictions in the region. Demonstration uses of geographical information systems that translate hazards into the risks posed for people or structures might also be undertaken. It might also contain an expanded (mass) public information program, such as the newspaper insert undertaken in the San Francisco Bay area.

One strength of hazards-information dissemination is that it is fairly easy to implement. Several activities are already being jointly undertaken by the U. S. Federal Emergency Management Agency and the U. S. Geological Survey. The key uncertainty for this strategy concerns who is likely to act upon the new information. Although the details depend on both the substance and the form of the information, the variety of situations faced by local jurisdictions within the region suggests that only a few categories of cities and counties are either capable of or willing to act upon such information without further external efforts to influence risk-reduction practices.

Other potentially responsive audiences are attentive professional groups such as the structuralengineers associations of Washington and Oregon. These groups effectively translate the information into new engineering or design practices. Depending on the extent of change in risk assumptions and the credibility of the information, the professional groups might use the information to lobby state building agencies and private code-writing authorities for changes in building standards.

Mass public education, or more focused educational programs focusing for example on schools, could also be appropriate. However, it is clear from previous experience with risk communication that any such educational efforts will not be effective unless: (a) there is greater certainty and specificity about earthquake impacts within the region; (b) specific actions that individuals (or target groups) can and should take can be effectively communicated, and (c) such information be communicated in a way so as not to be alarmist and therefore discounted. Public awareness of earthquakes within this region appears to be surprisingly high due to previous media coverage of the potential for earthquakes. As such, awareness per se is not much of an issue.

Clearly, better hazards and risk information is necessary. However, dissemination of risk-reduction information, without other efforts to influence policies or practices, will likely produce limited reduction of earthquake-hazards risk. The more capable cities and counties may make use of the information. However, little likely will happen in the remaining jurisdictions. Some structural engineers, geotechnical consultants, and others who design structures may use the new information as part of their practice while others will find the information to be irrelevant or too esoteric to be of much use. Parts of the general public will find publicity about subduction events interesting. However. unless the above conditions for information transfer are met, they will not act to increase preparedness or reduce risks.

Seek Mandate Revisions. This strategy consists of directly seeking revisions in state-level building-code. land-use, and lifeline-related mandates or licensing. The specific changes sought will depend upon the nature of the information developed from the scientific research. These revisions might include new seismic-zone delineation, new design standards, special code provisions for particular categories of buildings, or better delineation of seismic hazards within land-use mandates. Building codes could be changed either by state amendments or through the code-revision process of the International Conference of Building Officials. Neither procedure would be easy, and both would require considerable technical justification.

Because state building-codes and land-use mandates establish the foundation for local risk-reduction policies, the mandate-revision strategy could lead to desired changes in local policies. Moreover, the changes would be more or less uniform within each of the states. However, this strategy for influencing risk reduction has three main limitations. The first is the difficulty of achieving changes, particularly significant ones, in state building codes, private codes, or state land-use mandates. The second limitation is that changed policies will only address future development and construction. Even with substantiation of sizable risks, retroactive state-level policies concerning seismic-risk review or retrofit of existing, potentially hazardous buildings are very unlikely to be enacted in Oregon or Washington. (California's existing legislation related to hazardous buildings provides an avenue for addressing these concerns in Northern California.) The third limitation is that although local policies closely mirror state mandates, local practices till vary considerably. Implementation of the policies and the discretion used by building and land-use officials depends on the broader political and economic environment.

Influence Local Government Practices. This strategy consists of efforts to influence the practices of emergency services, building, and planning departments in carrying out state mandates and local policies, and in promoting earthquake risk-reduction and preparedness. This influence might entail providing jurisdiction-specific seminars on seismic risk, preparing guidelines for using discretionary building-code and land-use judgments, providing technical assistance in land-use planning or construction-plan review, or funding geologists or structural engineers as part of local staffs. These actions could be targeted to specific jurisdictions or classes of jurisdictions.

This strategy has several strengths. The targeting of assistance would respond to the varied situations of jurisdictions in this region. The emphasis on practice, as opposed to policy, would influence important discretionary judgments concerning such things as renovation of buildings. Also, several model risk-reduction efforts could be developed that could potentially be transferred to other jurisdictions.

The limitations of this strategy result from the constraints imposed by state mandates on local exceptions to those mandates. The Washington state building code allows local jurisdictions to enact stronger provisions than state mandates with appropriate state-level review. The Oregon state building code does not permit exceptions. Therefore, the effectiveness of this strategy is a function of the amount of discretion that exists within existing codes. This strategy would improve risk-reduction efforts the most among those jurisdictions in which current risk-reduction efforts are the weakest.

Influence Private Professional Practices. This strategy consists of efforts to influence the practices of the private-sector engineering and building-design community. This influence might entail providing special seminars on seismic risk and earthquake engineering, funding creation of special guidelines by professional associations, or providing some other form of professional development opportunities. These actions could be targeted to different types of engineers and building-design professionals.

The strength of this strategy is in the prospective direct influence on the design and engineering recommendations of this community in reducing earthquake risks. The results are likely to be greatest in those sectors that rely extensively on the judgments of design and engineering professionals, such as the utilities and ports. Indirect benefits of changes in practices or knowledge might lead to interest in lobbying for code changes.

Obvious implementation difficulties for this strategy are identifying and reaching appropriate professionals and then convincing them of the need for changes in practice. If these difficulties were overcome, the main limits to the effectiveness of this strategy are the constraints under which the design and engineering community practices its professions. Without code changes, competitive pressures and client desire to reduce costs may restrict the extent to which practices exceed minimum code requirements. The main beneficiaries of this strategy may be the professionals and supportive clients who already are doing the most to address earthquake risks. Insurance companies and financial institutions could potentially be important in endorsing or requiring new seismic design practices. However, competition and other factors have limited the influence of insurance companies and financial institutions in stimulating stronger risk-reduction efforts.

Considering Potential Organizational Structures [Top]

The form of a Cascadia organization should follow from and not pre-determine the desired Cascadia risk-reduction and preparedness strategy. As shown in the last column of the attachment, each of the above risk-reduction and preparedness strategies implies a different set of organizational arrangements. The arrangements also differ in terms of the implied scale of activity. The organizations fit one of three types of models:

A fairly lean clearinghouse for information transfer and education. The clearinghouse would serve as a conduit for hazard and risk-reduction information to be given to relevant state lead agencies. States would in turn undertake the main dissemination functions to relevant groups within each state. An example of this clearing house function is the *Wasatch Forum* newsletter and associated clearinghouse functions that involve the University of Utah, Utah Geological and Mineral Survey, and Utah State Department of Emergency Management.

A newly created, or revised, regional entity with several potential emphases, depending on the risk-reduction strategy that is selected. This could consist of a regional information and transfer entity (perhaps based at a university, or within a state geological survey), a regional-like BAREPP or CUSEC emphasizing efforts to influence local-level policy and practice, or a private association (e.g., EERI) or newly funded entity charged with carrying out technical assistance functions related to subduction-type earthquakes.

A network of existing organizations with core staffing (or funding) for carrying out relevant tasks. The membership of the network would depend upon the particular strategy selected: a network of state policy influentials for influencing state policy (e.g., modified Western States Seismic Policy Council, or a variant of CUSEC); or a network of key influentials among professional organizations representing members of the Cascadia design community (e.g., a regional-like Building Seismic Safety Council).

Working through development of an appropriate organizational structure clearly requires more detailed consideration of available (and potential) resources, interest on the part of relevant organizations, and ability to recruit and maintain strong staff. None of these are simple undertakings and each is critical to the success of any such organization. The track record so far in this region with respect to creating and sustaining these functions is not good.

Necessary Steps Toward a Regional Effort [Top]

Development of a regional-Cascadia risk-reduction and preparedness effort entails a series of actions for which definition of an organizational structure is but one supporting element. We define the necessary steps, in order of undertaking, as follows:

1. An assessment of existing risk-reduction efforts in the region in order to identify gaps in risk-reduction and prospects for reducing those gaps, as an additional component of the targeting of risk-reduction activities;

2. Development of a long-term risk-reduction and preparedness strategy for the region, as illustrated by the types of strategies noted in this discussion document;
3. Re-orientation of federal funding so that extramurally funded activities are consistent with the above needs;
4. Development of mechanisms for continued monitoring of the status of risk reduction and preparedness within the region;
5. Initiation and support for an appropriate regional clearinghouse, entity, or network for carrying out the desired risk reduction strategy, as illustrated by the types of organizations noted in this discussion document; and,
6. A new set of vulnerability studies focusing on identifying vulnerable geographic areas, sectors of the population and economy that would serve to inform the targeting of future risk-reduction activities.

It is important to note that the prospects for some form of national earthquake insurance do not alleviate these needs. Any mitigation component of a national program will place extensive requirements for creating the type of information and technical assistance described here.

Examples of Future Risk-Reduction Strategies and Organizations for the Cascadia Zone [Top]

Strategy and examples	Target groups	Strengths	Limitations	Potential Organizations
Disseminate hazards information (status quo) Workshops; publication of hazard maps, public education.	Widely-disseminated information (targeting possible among selected jurisdictions, professionals, or public groups)	Easily implemented, although requires leaving stronger translation of information than currently exists	- Only the more capable jurisdictions and professionals will act on information. - Public awareness already reasonably high, motivating public to act is more difficult	-Clearinghouse information transfer & education, actual education up to states -Regional information transfer and education effort (in place of state efforts)
Seek mandate revisions - Develop and advocated changes in state building-code, emergency management, land-use mandates, and guidelines governing lifeline siting and construction.	State agencies, public and private code-writing authorities -- through provision of information and funding technical assistance.	Addresses key leverage points for influencing risk reduction, dovetails with current federal efforts with respect to code revision and lifelines	-Limited to new buildings or development (as a practical matter, except possibly California); -Long time frames to accomplish change due to length of mandate revision cycles -Presumes local practices will change as the result of mandate changes.	-Network of state influentials who advocate policy changes at state level (perhaps through Western States Seismic Policy Association), potentially modeled after CUSEC -Regional technical assistance and advocacy group, focusing on state issues (newly created entity, or staff within

				existing regional agency)
Influence local government practices (including special districts) Workshops, staff funding, demonstration programs, technical assistance.	Local building officials, emergency managers, and planners; public utilities and ports.	Can target jurisdictions with greatest needs; does not require policy changes.	-Limited resources of many jurisdictions may limit willingness to participate -Changes in some practices (e.g., building regulation) may require statutory changes	-Regional technical assistance and advocacy organization, potentially modeled after BAREPP or aspects of CUSEC (with focus on local jurisdictions)
Influence private professional practices Workshops, publication of guidebooks, technical assistance.	Architects, engineers (design and engineering community).	-Can target specific groups; does not require state or local endorsement -These groups, in turn, can influence state policy (e.g., with respect to building codes).	-Limited ability to reach less interested professionals; -Economic considerations may limit ability to influence practice -Influence on state policy is rather indirect	-An existing organization within the region funded to take lead in transferring information and advocating professional practices (e.g., EERI) -Network created among professional organizations, with emphasis on seismic considerations (e.g., a regional BSSC)