Managing Risk In A Complex Environment With Competing Worldviews

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In their recent book, Gunderson and Holling (2002) note that the "fields of economics, ecology and organizational or institutional analysis have developed tested insights. Yet there is growing evidence that the partial perspective of these disciplines generate actions that are unsustainable" (p. 8). They argue that "the process of developing policies and investments for sustainability requires a worldview that integrates ecological with economic with institutional with evolutionary theory that – that overcomes disconnects due to limitations of each field."(p. 10) It is necessary, therefore, for society to develop integrative approaches that combine the disciplinary insights and strengths of the disciplines to engage in problem solving and decision-making that gives appropriate consideration to development of communities resilient to the consequences of extreme events. In studying the barriers to earthquake risk mitigation, we have learned that what appears to be simple is not, simple approaches lack an integrative framework that bridges disciplines and scales of analysis, implementation does not necessarily follow authoritative policy making, and implementation is politics continued by other means.

What is needed are integrative approaches that bridge the disciplines of science and engineering, economics, and organizational and institutional analysis in order to develop the connections and networks that will lead to the implementation of appropriate risk reduction strategies and methods. This will require learning about the various cultures that operate in the greater system and their worldviews; that is, the worldviews of the science and engineering, business, political, and free market cultures.

Science and engineering disciplines are generally characterized as being driven by a competition among ideas, the need to add to scientific knowledge and to engage in research seeking new discoveries for the sake of science. In the area of risk management, scientists and engineers seek methods and approaches that will reduce the levels of uncertainty associated with causes of an event and the fragility and vulnerability of structures subjected to the event. Individuals become advocates of methods and approaches which when accepted provide individual recognition and rewards. In addition, an important role for science and engineering is to improve knowledge about the mitigation of the effects of extreme events, effectively transfer the knowledge and facilitate collaboration among users of the knowledge.

Organizational users of the knowledge are often asked or required to invest in methods and approaches offered by the science and engineering communities and promoted by advocates. However, private organizations operate within the structure of the free market, where there is most often significant market competition. Their focus is on increased and improved sales of products and services, meeting customer needs while achieving an acceptable return on their investment. Risk mitigation is most often considered an investment competing with other short and long term demands for resources, and is based on an assessment of the return on investment. Public institutional users operate within the structure of the political system and understand that extreme events often produce broad scale damage with losses having large socio-economic impacts, or significant impacts on community resilience. Public institutions generally view mitigation of extreme event consequences as part of their responsibility to provide for public safety, which they see as occurring through regulation which in the "public interest". The conflict here is between advocates for risk management through appropriate mitigation facilitated through government action and the notion of a free market maximization of return on investments with minimum governmental regulation. Property owners are viewed as responsible for their risks and that individual risk mitigation is for protection of the private interest. There is a disconnect between the short term good of the organization and the long term good of the community.

How does society address the differences in cultures that lead to the differences in perspectives on managing the risks of extreme events in an uncertain world? A knowledge implementation gap is a major issue that must be addressed. As in the building of ecologically sustainable communities it is necessary for society to develop integrative approaches that combine the disciplinary insights and strengths of the disciplines to give appropriate consideration to the reduction of risk through both voluntary and regulatory approaches.

As a first step in bridging the knowledge gap, it will be important to characterize the consequences of the risks and how they are understood in relation to community resilience. In assessing community resilience it will be necessary to develop an understanding of building and structural fragilities and vulnerabilities, individual community and organizational needs, community standards, state criteria and standards, and federal criteria and standards. This will also require proper characterization of the decision problem, decision environment and context, stakeholder perspectives, and interest group influences. Such an approach goes beyond the application of the tools of any one discipline. A solid and robust approach to resilience based decision-making requires an integrative framework that combines the disciplinary strengths while filling the gaps that will exist between the disciplines.

The lack of sufficient data and use of expert scientific and engineering judgment produces tension in the system. To overcome this tension and enhance problem solving there is a need to develop effective communication between the disciplines. This will require full discussion of assumptions made and uncertainties inherent in the process leading to any recommendation for action. Illustrative questions that will need to be addressed openly are:

- Are current methods and domain knowledge sufficient to establish risk as a basis for decision-making?
- What is the significance of the uncertainties?
- Do computer models produce an illusory precision?

Complexity and data needs are major constraints on problem solving and decision-making. Intensive data requirements and standardized data management assessments require special knowledge and skills. Further, organizational decision makers and institutional regulators currently seek simple easy to use methods and assistance in interpreting and utilizing data. Their capacity and ability to understand and utilize risk assessments needs to be enhanced. The development of a more robust foundation for problem solving and decision-making requires an integrative approach. It is necessary to learn how to communicate the results of science, comprehend and effectively utilize scientific knowledge, and make decisions under conditions of uncertainty.

Improving risk management involves knowledge transfer that requires learning how to enhance the structure, content and control of knowledge. This has to do with how the pieces of knowledge are interrelated and organized, what is understood and included in the knowledge structure, and how knowledge is accessed and utilized in the process of problem solving. Effective knowledge transfer requires participation by both knowledge developer (e.g., SCEC) and knowledge users (e.g., engineers, building owners, public officials). Participation can affect the knowledge structure, content, and strategies for application. Successful knowledge transfer will involve stakeholders who belong to overlapping networks, interact with users that may result in modification to the research, communicate before, during and after the research is concluded, and engage in dissemination through a medium used by users, not just other researchers.

Each stakeholder approach is built upon a particular <u>worldview</u> – scientific, technological, economic or political. Compromises arrived at through the political process, with mediation among stakeholders may be totally irrelevant if it is not based on an understanding of the multiple dimensions of the problem. Enhancing risk reduction is inherently a political process with many players, each with different <u>worldviews</u>, struggling to reach some modest agreement on what constitutes the problem and what constitutes a workable solution. However, problem solving is most often constrained by the larger environment within which the process takes place. Effective implementation, then, depends on the extent to which the regulatory policy is congruent with the organizational decision environment and recognizes the needs of those expected to actually implement risk-reduction measures and to pay for them. As noted above, technology, economics and organizational or institutional analysis each have tested insights, but they are each partial perspectives that generate actions that do not necessarily produce community – system – resiliency. There is a need is to develop integrative <u>problem solving approaches</u> that combine disciplinary strengths by bridging the disciplinary gaps in knowledge and understanding. Needed are enabling technologies that provide tools for enhancing integration and improved disciplinary understanding and organizational decision making necessary for achieving improved resilience, and provide methods to aid in designing and choosing among alternative resilience enhancing strategies. Performance measures for agreed upon objectives are necessary if one is to know if community resilience has been achieved. In this regard, agreed upon objectives are a key component of performance measurements. Scientists and engineers can state what community resilience "ought to be", public policy makers "set standards" that define resilience in the public interest, and communities and organizations decide on the "acceptable level" of resilience for their situation.

Successful integration of the disciplines will be difficult to demonstrate empirically. Needed are case studies documenting experience in successful implementation of resilience enhancing standards in order to help learning. Work should be done that helps to facilitate integration of the disciplines through best practices benchmarking, software, simulations, training materials, and curriculum enhancements. Fundamental research is needed for development of understanding and methods to enhance the process of integrating technical, economic and organizational / institutional disciplines to achieve increased resilience, knowledge transfer through the development of software, simulations, training materials, as well as educational curriculum enhancements.

Policies and investments leading to risk reduction require integration of the scientific and technological with economic and institutional theory and practice to overcome disconnects due to worldview limitations in each field. Society must develop a framework to help integrate across disciplines in order to better understand systems of linked science, technological, economic and institutional processes.

Problems and challenges are: (1) obstacles to increasing resilience are more political, economic, and administrative than technical, (2) advocates have been generally ineffective in getting retrofit policies adopted and implemented, (3) unfortunately, advocates have been slow to learn how to devise "acceptable" policies and programs, (4) the system is dynamic so the problem is continually morphing, (5) new science and engineering methods will provide only "marginal gain" in increased resilience unless the built environment and systems are impacted, (6) more investment in science and engineering alone is not necessarily going to reduce risks from extreme events.

To increase a communities capacity to manage the risks of extreme events it will be necessary to provide processes for developing (1) scientific and engineering advocates with a better understanding of how to sell risk reduction methods, (2) an understanding of differences in worldviews and a means for facilitating integration, (3) an understanding of the "customers" decision making processes for investing in risk reduction in the built environment, and (4) processes to aid risk reduction advocates in understanding "customers" needs, decision processes, decision context, and capacity for investment. Design professionals are needed to design bridges to bridge gap between the disciplines, design connections to ensure resilience of the system when subjected to political and economic stress, design networks to facilitate communication and understanding.

Gunderson, Lance H. and C. S. Holling (editors), 2002, Panarchy: Understanding Transformations in Human and Natural Systems, Island Press, Washington, D.C.

Earthquakes as Extreme Events

- The human habitat is framed by a fragile "built environment" embedded in the Earth's active crust.
- Earthquakes damage this environment more than any other extreme event.
- Occurrence is highly uncertain; there is no known method for the reliable, short-term prediction of large earthquakes.
- The damage from large events can be geographically extensive.

Two Recent Urban Disasters

Attack on Twin Towers
Sept 11, 2001

Deaths: 3232
Economic loss: $35+ billion

Kobe Earthquake
Jan 16, 1995, M = 6.9

Deaths: 5650
Economic loss: $100 billion

Risk Equation

Risk = Probable Loss (lives & dollars) =

Hazard × Exposure × Fragility

Faulting, shaking, landsliding, liquifaction

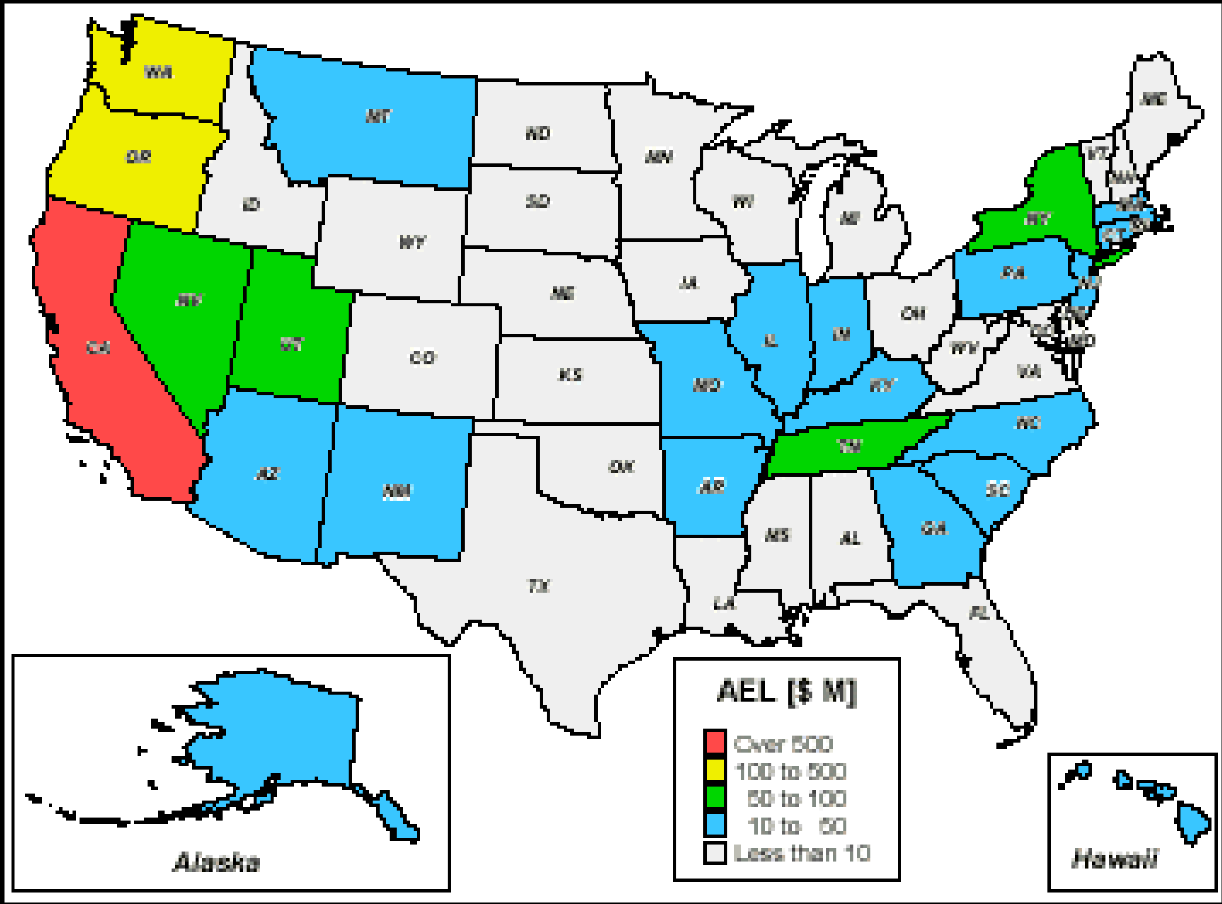
Extent & density of built environment

Structural fragility

The FEMA 366 Report

"HAZUS'99 Estimates of Annual Earthquake Losses for the United States", September, 2000

- U.S. annualized earthquake loss (AEL) is about $4.4 billion/yr.
- 74% of this total is concentrated in California
- For 25 states, AEL > $10 million/yr



Southern California is the Heartland of Earthquake Country!

Risk Equation for Southern California

20 million people +

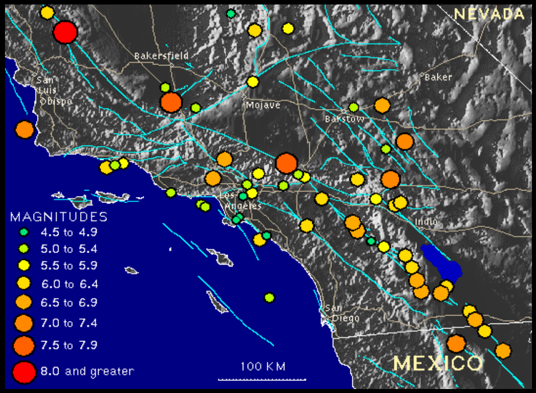
Huge economy +

Active plate boundary +

Over 300 active faults =

Almost <u>half</u> the national earthquake risk, with 25% in Los Angeles County alone...

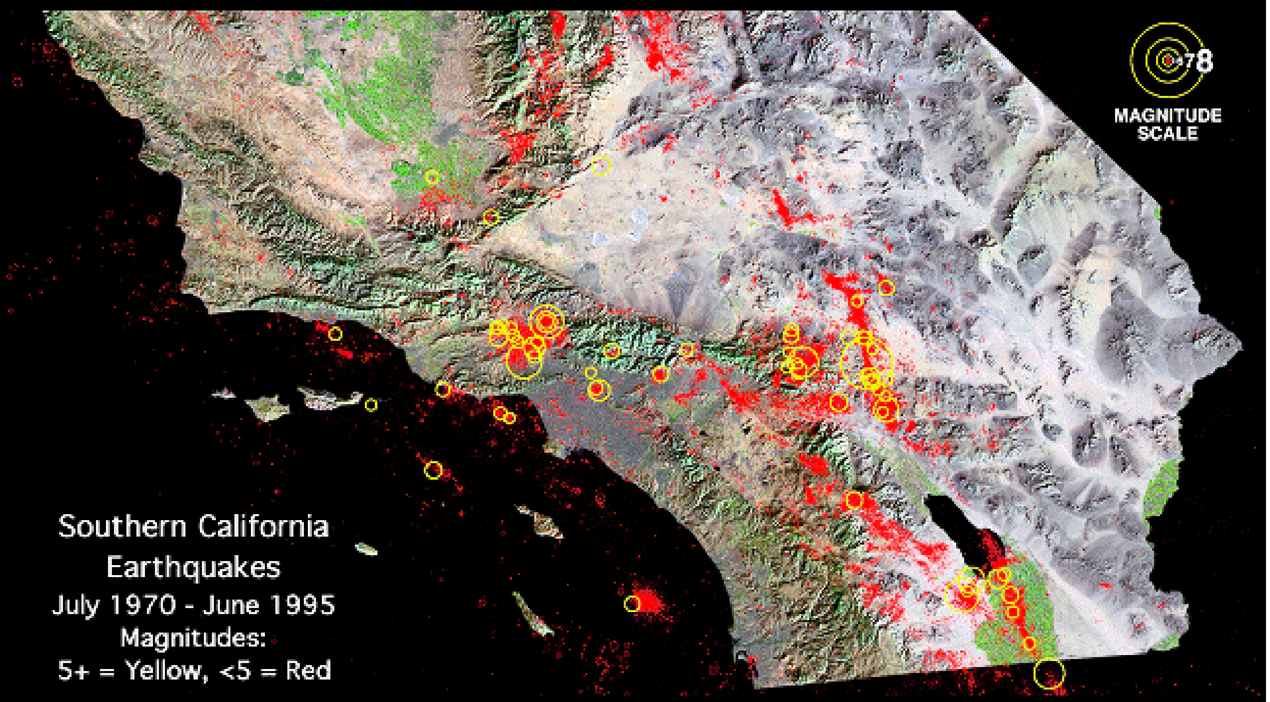
Last 65 years



Last 200 years

Southern California: a Natural Laboratory for Understanding Seismic Hazards

- Tectonic diversity
- Complex fault network
- High seismic activity
- Excellent geologic exposure
- Rich data sources
- Outstanding scientific community



- Large urban population and densely built environment

Southern California Earthquake Center

- Consortium of 11 core academic institutions and the USGS, led by the University of Southern California
- Co-funded by the USGS and NSF under the National Earthquake Hazards Reduction Program (NEHRP)
- Has the mission to promote earthquake hazard reduction by
  - gathering information on earthquakes in Southern California,
  - integrating this information into a comprehensive, physics-based understanding of earthquake phenomena,
  - communicating this understanding to the public.

Core Institutions

University of Southern California (lead)
California Institute of Technology
Columbia University
Harvard University
Massachusetts Institute of Technology
San Diego State University
Stanford University
U.S. Geological Survey (3 offices)
University of California, Los Angeles
University of California, San Diego
University of California, Santa Barbara
University of Nevada, Reno

http://www.scec.org

Earthquake Risk Reduction

A sound strategy involves four types of action:

- Land-use policies that limit the exposure of population and infrastructure to seismic hazards
- Preparation of the built environment to withstand future earthquakes
- Rapid response to earthquake disasters
- Public education

Earthquake Risk Reduction

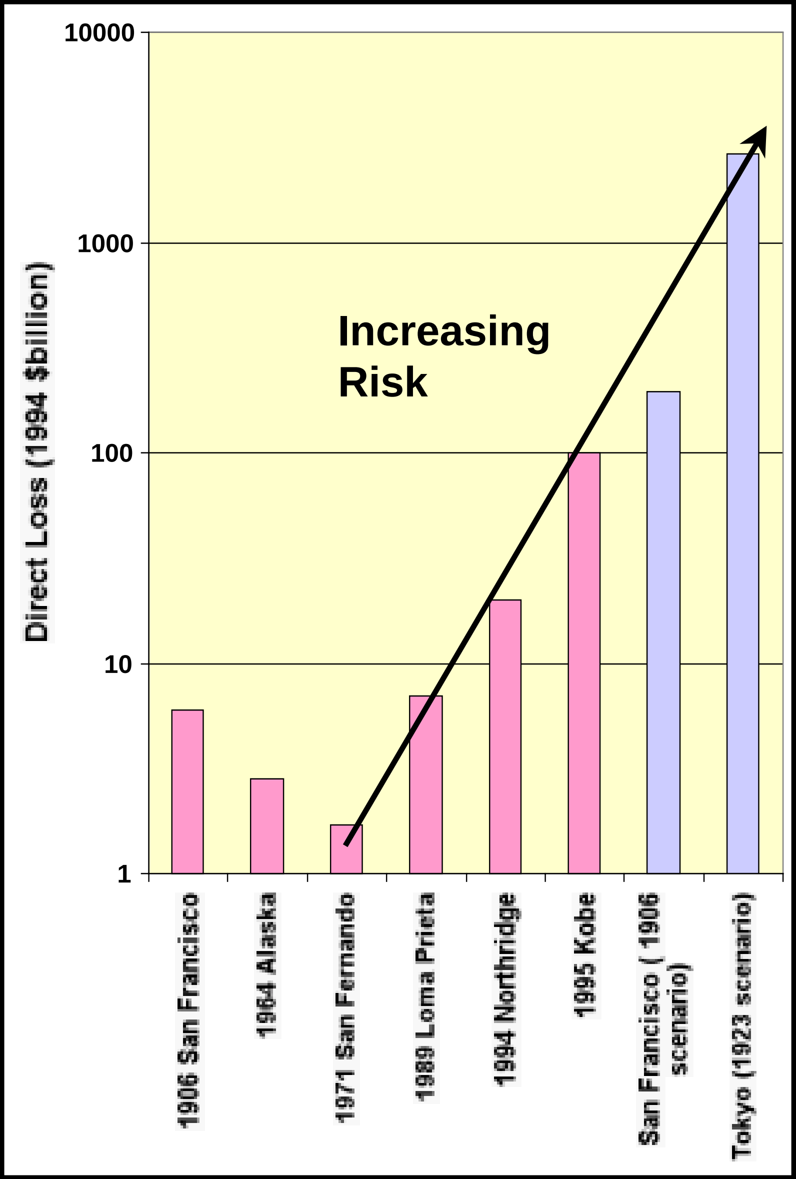
- Effective risk reduction requires a problem-solving approach that recognizes the many "dimensionalities" of the system
  - Political/cultural
  - Economic
  - Technical
  - Organizational
  - Geographic

Earthquake Preparation

- U.S. building codes have been largely successful in achieving a high degree life-safety.
  - Between 1983 and 2001, only 129 people died in 8 severe earthquakes, compared to 160,000 worldwide.
  - Success attributable to revisions in building codes prompted by vigorous post-earthquake investigations of structural failures
- However,economic losses are increasing at an exponential rate...

Economic losses from urban earthquakes are increasing with time...

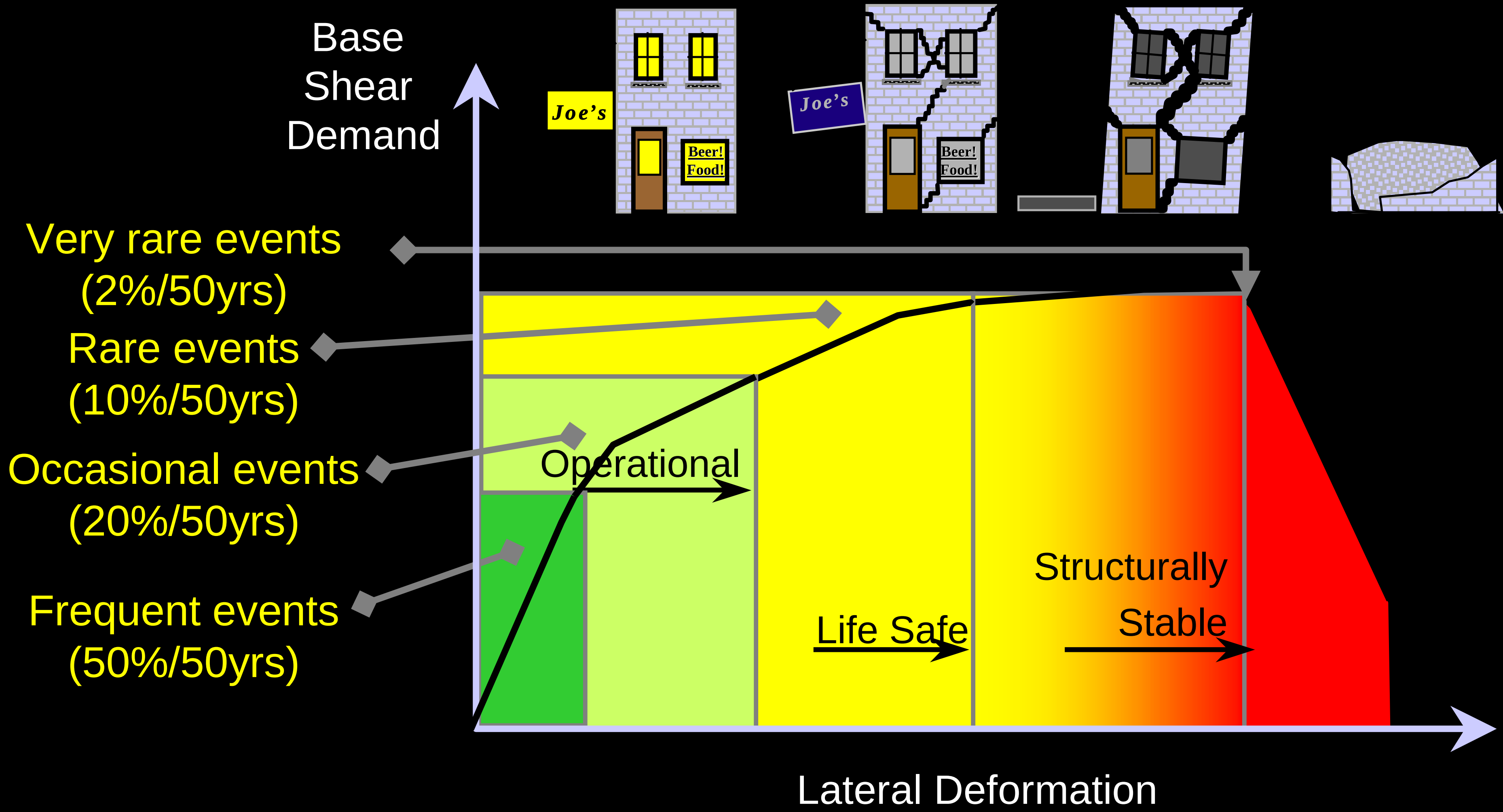
Earthquake	Magnitude	Loss (1994 $B)
1906 San Francisco	7.9	6.0
1964 Alaska	9.2	2.8
1971 San Fernando	6.6	1.7
1989 Loma Prieta	6.9	7.0
1994 Northridge	6.7	20
1995 Kobe	6.9	100
1906 SF (Repeat)	7.9	195
1923 Kanto (Repeat)	7.9	2195



Techniques are needed to design buildings that can retain specified levels of functionality even after the largest expected earthquake...

Engineers call this approach “performance-based design.”

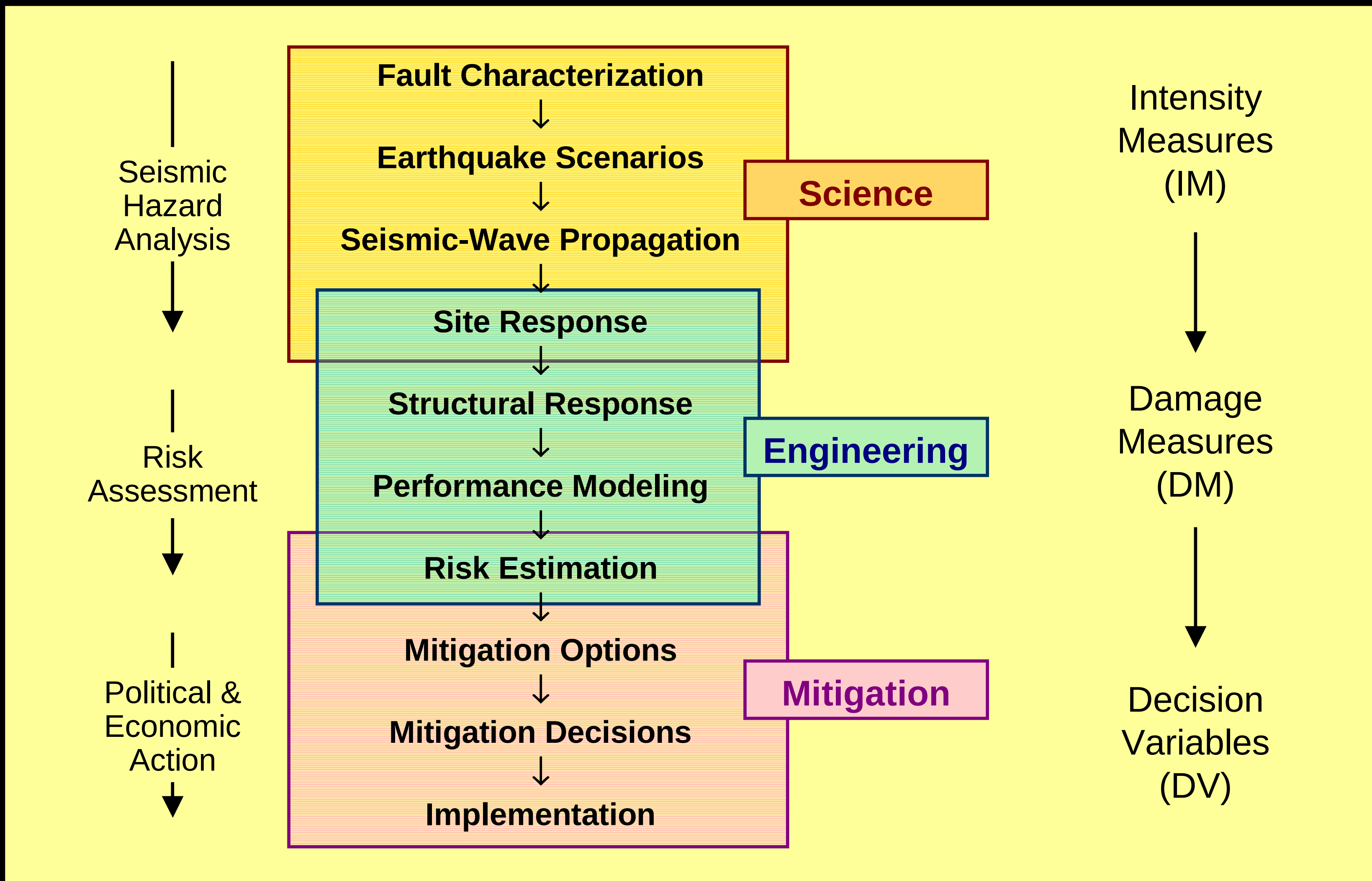
Performance-Based Design



Reducing seismic risk is a political problem:

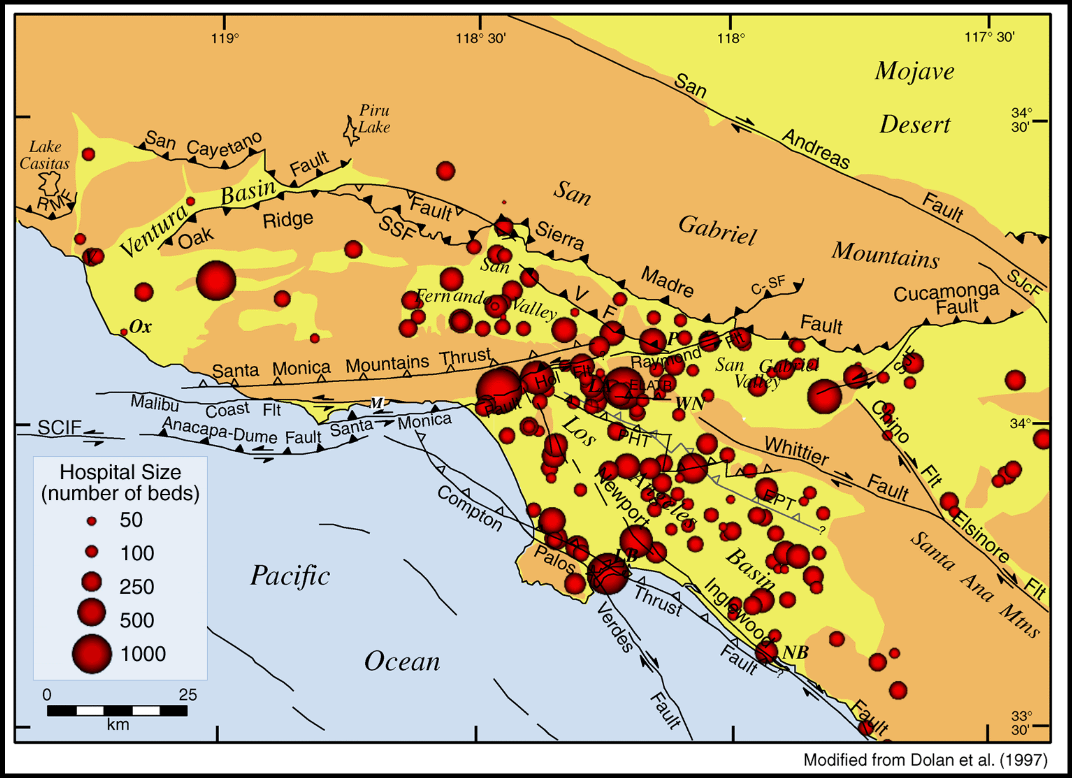
- Mitigation options must be identified and evaluated. These options include improved building codes, design enhancements, retrofitting, land-use planning, and insurance. Evaluation must include assessments of the cost and effectiveness of each option to reduce risk.
- The public, elected officials, property owners, and other decision makers must be informed about the nature of the risks, their mitigation options, and the costs of action and inaction.
- Mitigation decisions must be made and implemented. Setting priorities for action is imperative, since the need for improvement will always vastly exceed the available resources.

Multidisciplinary Approach to Risk Reduction



The "Hospital Problem"

- More than 50% of LA hospitals are vulnerable to collapse in a strong earthquake.
- All California hospitals must meet improved seismic safety standards by 2008.
- Costs for LA alone are conservatively estimated at $7-8 billion, more than the assessed value of all existing hospitals.



Hospitals and active faults in Southern California

Summary

- There is considerable controversy about how government and the private sector can best implement loss-reduction measures by through regulatory policies, economic incentives, long-term investments, and public education.
- Willingness of society to invest in risk reduction is best achieved through an active collaboration among scientists, engineers, government officials, and business leaders, working together among an <u>informed populace</u>.
- Education is the key to closing the "implementation gap."