State of California
Alfred E. Alquist Seismic Safety Commission Memorandum

Date: **May 2, 2013**

To: **Seismic Safety Commissioners**

From: **Karen Cogan, Administrative Officer**
Seismic Safety Commission
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Subject: **"Back to Normal"** Earthquake Recovery Modeling Project Proposal

Background

The Commission has recognized a strong need to develop the methodology and software to create a new model to assist California's communities become better resilient from earthquakes. A new software computer model is necessary to estimate recovery status and recovery times after earthquakes.

Problem

Current models cannot reliably estimate the amount of recovery time for a community or region to 'get back to normal". Earthquake models can perform computer simulations that estimate consequences, such as number of collapses or fatalities, caused by past or future earthquakes, estimating damage and casualties building-by-building, for one or many possible earthquakes, based on mathematical equations. However, models cannot yet reliably estimate the amount of recovery time for a community or region to "get back to normal."

Proposal

The University of Pavia (IUSS, Instituo Universitario di Studi Superiori), proposes to develop a new computerized software model that will assist California to get "Back to Normal" after an earthquake. IUSS maintains a unique relationship with Global Earthquake Model (GEM) Foundation, which is specializes in earthquake modeling products. Because of the unique relationship between the IUSS and GEM, a new computer software model could be developed that will:

1. Produce an open -source map-based tool for non-commercial use.
2. A report summarizing the analytic methodology for modeling recovery
3. Produce an open -source software that integrates the modeling methodology
4. A report modeling actual earthquakes in the past, giving an example that the product results are reasonable
5. A case-study report of simulated results using the simulated Southern California Shakeout scenario
6. A Report analyzing the effect of various policy alternatives on speeding recovery, suitable for integration into a larger "package" of policy recommendations
7. A curriculum for software training workshops (3 proposed in Northern, Central and Southern California), and training videos available on Compact Disk for distribution.

All funds will be disbursed to the Institute for Advanced Studies IUSS, the 'honors college' and graduate program within the University of Pavia, the second-oldest public university in Italy. Together with the Global Earthquake Model (GEM) Foundation, IUSS is part of the Pavia Risk Centre, a knowledge hub of organizations with a common aim to understand risk and reduce its consequences. The Commission is an Associate Participant of GEM, serving as a non-voting, non-sponsoring member of GEM's Governing Board and an active collaborator.

Benefits

This project benefits Californians by measuring how specific policy decisions *now* can hasten building recovery after future earthquakes. By looking at specific 'future actions and measures' that can be taken before an earthquake, the project will quantify the effectiveness of these specific actions to assist communities with a speedy recovery. *This will make California more resilient against economic loss*.

Recommendation

Staff recommends the Commission review the project proposal, and approve the project to submit to the Department of General Services' Legal Division for approval.

Item VIII

GLOBAL EARTHQUAKE MODEL
working together to assess risk

"Back to Normal": Earthquake Recovery Modeling

project proposal from the Global Earthquake Model (GEM) Foundation to the California Seismic Safety Commission
May 9, 2013

This project benefits Californians by measuring how specific policy decisions could hasten recovery of the building stock after a future earthquake.

Overview

By pooling data, knowledge, and people, GEM acts as an international forum for collaboration, and leverages the knowledge of leading experts for the benefit of society. Current earthquake models can't yet reliably estimate the amount of recovery time for a community or region to "get back to normal." This project will allow GEM's OpenQuake platform to quantify the effectiveness of specific actions, now or in the future, to speed recovery of a region's building stock, through the use of a free, open-source map-based tool ('app'). This project can be used by the Commission to recommend actionable, measurable policy to the Governor and Legislature for helping the regional economy rebound after an earthquake.

Problem

Earthquake models perform computer simulations that estimate consequences, such as number of collapses or fatalities, caused by past or future earthquakes. Models estimate damage and casualties building-by-building, for one or many possible earthquakes, based on mathematical equations that represent structural engineering properties and likelihood of collapse. Currently, models can also account for social consequences and resilience, but only approximately – like applying a "fudge factor" to an otherwise complicated calculation. In particular, models can't yet reliably estimate the amount of recovery time for a community or region to "get back to normal."

Proposed Solution

This project will quantify the effectiveness of specific actions, now or in the future, to speed recovery of the building stock. To do so, this project will produce the technical basis for models to estimate recovery states and recovery times, as they do for damage. In particular, this project will conduct the activities listed below. Each activity is associated with a specific deliverable listed in subsequently.

1. Based on the methodology below, develop a **user-friendly app**, free for non-commercial use, for non-experts to make map-based comparisons showing the effects on recovery of, for example:
    - A voluntary retrofit incentive
    - Post-quake economic stimulus such as loan subsidies
    - Pre-quake proportion of buildings covered by earthquake insure
2. Develop an analytic method to **estimate post-earthquake recovery**. Specifically:
    - Aggregate recovery of individual buildings to estimate community-wide or region-wide recovery, while properly accounting for statistical correlation and uncertainty.
    - Define and quantify thresholds of building damage that relate to resilience: functionality, livability, reparability. (Current definitions instead relate primarily to monetary loss.)
    - Identify external factors that affect the process of a building's recovery, such as existing retrofits, post-quake liquidity of funds, ease of access to the site, etc.
    - Propose a logic-tree[1] method to analyze a building's state of recovery over time, based on its initial damage state and external factors.

[1] A series of if-then statements evaluated in sequence, like a flow chart

    - Develop equations ('curves') that predict how a building recovers functionality over time.
3. Integrate the methodology for **practical use** – by hard-wiring it into GEM's OpenQuake modeling platform (software).
4. Demonstrate **reasonable results** by using the methodology to model past earthquakes.
5. Conduct a **case-study** for the Southern California Shakeout scenario, as a 'community snapshot' that estimates recovery times from a large simulated earthquake.
6. **Quantify how well specific actions can speed recovery** of the building stock**,** by running the model 'before' and 'after' taking action:
    - Pre-earthquake policy such as financial incentives for retrofit (mitigation)
    - Pre-earthquake financial structures (such as insurance or loans)
    - Post-earthquake economic stimulus (such as fund reallocation)
    - Removing barriers (physical and economic) to post-earthquake reconstruction
6. Conduct three **training workshops** targeting beneficiaries listed below**.**

Deliverables

Specific project deliverables, associated with each scope item listed above, will be:

D.1. A free[2], open-source map-based tool ('app')
D.2. A report describing the **analytic methodology** for modeling recovery
D.3. Open-source **software** that integrates the modeling methodology
D.4. Report modeling past earthquakes, demonstrating that **results are reasonable**
D.5. Case-study **report of simulated results** from the southern California Shakeout scenario
D.6. Report analyzing the **effect of various policy alternatives on speeding recovery**, suitable for integration into a larger "package" of policy recommendations
D.7. A curriculum for **training workshops**, and three completed workshops

Beneficiaries

We understand that this project will be part of an integrated a set of projects, which, together, will be used by the Commission to recommend actionable, measurable policy to the Governor and Legislature for helping the regional economy rebound after an earthquake.

This project will also benefit diverse stakeholders, beyond the Commission. For example:

- A **municipal urban planner** or mapping specialist can use the 'app' to create a map of post-quake recovery predictions.
- A **policy analyst** can use the 'app' to generate recovery results (maps and statistics) both 'before' and 'after' implementing a particular policy, to investigate its effectiveness.
- A **disaster risk manager** at a state- or national-level can use the 'app' to compare recovery across multiple cities or regions to help prioritize where to implement policy first.
- An **engineering consultant**[2] can pay to use the model to conduct a risk assessment for clients such as hospitals or universities, and make recommendations that explicitly account for recovery.
- An **insurance company**[2] can pay to use the model to develop and justify new offerings that can create post-quake liquidity.

[2] GEM resources, including OpenQuake and its tools, are licensed for non-commercial use only. Permission for commercial use will be granted to organizations and companies who financially support the GEM foundation.

Limitations

This project addesses recovery as it relates to the collective effect of individual buildings. Restoration of utility services, and related effects on recovery time, is considered future work. Also considered future work is integration of this project's 'bottom-up' approach to modeling, with other approaches such as 'economic input-output models,' which take a macroeconomic perspective.

Budget and Timeline

The total funding request for this recovery modeling project is $440,000, disbursed over two years, and distributed as shown in the table below. This request represents approximately 65% of the total project budget of $680,000. The remainder will be supplemented with matching funds.

Item	Description	Budget and Proportion		Target Completion[3]
1.	Policy Evaluation Tool	$60,000	14%	Sept 2015
2.	Scientific framework for the new analysis methodology: • supporting research • probabilistic methods • logic tree structure • equations relating recovery states (functional, occupiable, reparable, irreparable) to damage states (minor, major, partial collapse, collapse) • development of recovery curves (equations) for each mitigating factor	$110,000[4]	25%	Dec. 2014
3.	Integrate analytic method into OpenQuake software	$80,000	18%	April 2015
4.	Validate reasonability of results	$30,000	7%	June 2015
5.	Case study report for Southern California	$20,000	4.5%	Sept 2015
6.	Policy Effectiveness Report	$30,000	7%	Oct 2015
7.	Training workshops • develop curriculum • project team to deliver three workshops	$20,000	4.5%	Oct 2015
Other:	Project team meetings / coordination	$22,000	5%	
	Overhead / administration	$68,000	15%	
	Total:	**$440,000**		

Matching Funds

This project leverages approximately $240,000 of direct matching funds and a $700,000 indirect match. This project will expand GEM's current $700,000 investment in Social Vulnerability and Resilience modeling, so that GEM can reach a broader set of policy advocates. In addition, should this project be funded, GEM Foundation will directly supplement Commission funding with 50% matching funds, from sponsors and in-kind contributions, to reach a total project budget of $680,000. Matching funds will be allocated primarily to developing the scientific framework.

Receiving Institution and Personnel

All funds will be disbursed to Institute for Advanced Studies (IUSS, Instituo Universitario di Studi Superiori), the 'honors college' and graduate program within the University of Pavia, the second-oldest public university in Italy. Together with the Global Earthquake Model (GEM) Foundation, IUSS is part of

[3] Assuming an October 2013 start date

[4] This budget represents approximately 1/3 of the total needed. Matching funds will supplement to reach the total.

the Pavia Risk Centre, a knowledge hub of organizations with a common aim to understand risk and reduce its consequences. The Commission is an Associate Participant of GEM, serving as a non-voting, non-sponsoring member of GEM's Governing Board and an active collaborator.

The project will be managed by IUSS faculty and carried out in collaboration with a team of scientists with a specialty in disaster resilience. Specific human resources will be assigned upon project authorization.

About the GEM Foundation

The GEM Foundation serves the moral and economic imperative to reduce the loss of lives and livelihoods from earthquake. GEM is a global non-profit providing organisations and people with open resources to assess earthquake risk anywhere in the world, build awareness, and prioritize actions that increase resilience. By pooling data, knowledge and people, GEM acts as an international forum for collaboration and exchange, and leverages the knowledge of leading experts for the benefit of society. Through global projects, open-source development, and partnership among more than ten regions, GEM contributors are jointly developing common datasets, best practices, and models for seismic hazard and risk assessment. GEM Foundation is supported financially by public institutions representing national governments, as well as private companies. Guided by the needs and experiences of governments, companies, and citizens at large, GEM works in continuous interaction with the wider community.

GEM is supported by participants from both the public and private sector:

GEM Public Participants	GEM Private Participants
Total contributions 2009-2013: **$11.8 million**	Total contributions 2009-2013: **$16.8 million**
Australia	Munich Re
Chile	Zurich Insurance
Ecuador	AIR Worldwide
Germany	FM Global
Italy	Hannover Re
Japan	Willis
New Zealand	Renaissance Re
Norway	Nephila Capital Partners
Singapore	NLIRO Japan
Switzerland	
Taiwan	
Turkey	
United Kingdom	
United States	

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