SPA Risk LLC

User Needs Assessment for the Global Earthquake Model (GEM)

Prepared for
GEM1
ETH Zurich

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This is an external report, produced within the scope of the GEM1 project. GEM1 was a focused pilot project of the Global Earthquake Model initiative, which ran from January 1st 2009 to March 31st 2010 and was aimed at generating GEM's first products and developing GEM's initial IT infrastructure. The technical achievements of GEM1 have been summarised in a series of 10 reports; 6 internal and 4 external GEM1 reports. The internal reports are based on the achievements of the GEM1 team, the external reports are written by external experts who had been awarded a sub-contract to carry out a specific task. In addition to reading this external reports, it is suggested to also read the rest of the GEM1 reports and in particular the GEM1 Executive Summary. These can be downloaded from www.globalquakemodel.org/node/747

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www.globalquakemodel.org

ABSTRACT

Successful development of software such as the Global Earthquake Model (GEM) requires a structured process involving defining the product requirements, based on which the software requirements are specified, actual software is constructed and a number of subsequent steps up to and including deployment and maintenance are implemented. A key part of developing the product requirements document is a User Needs Assessment – that is, defining *Who* the users of GEM will be, and *What* their needs are. In order to address these questions, a User Survey was conducted, consisting of 17 questions each in English, Spanish, Chinese, Hindi and Japanese. The survey was accessed over 800 times from over 74 countries, with over 400 completed responses, which are summarized in Section 2 of this report.

Key findings of the User Survey were that Academics and consultants (specializing in the three domains of hazard, risk and socio-economics) are currently GEM's core constituency, with their primary interest being a multiple site (i.e., portfolio) probabilistic analysis capability, for shaking and as many hazards as GEM's resources permit, for existing buildings and infrastructure. Government officials and Insurance Industry professionals are the next largest segments of the user community, and their needs can probably be met by focusing on academic's and consultant's needs, but will also need (a) canned explanatory material and (b) identifying consensus options, i.e., choices that are endorsed by the majority of experts. Since a substantial portion of the current GEM user community is technically sophisticated, GEM's development strategy might first focus on a more sophisticated product first, with a more simplified perhaps pruned-down "GEM-lite" product for use by lay users developed later. Half of survey respondents need GIS in some format other than ESRI. This argues for complying with OpenGIS standards and specifications. Accuracy, uncertainty quantification, good documentation, graphical results and user interface and flexibility of data entry and use are all attributes GEM will need to provide. Each of these attributes will need to be defined in the product requirements document, and followed throughout development. Lastly, GEM is positively seen by the user community, but some skepticism exists, not so much about motives but more about being able to accomplish and maintain GEM's ambitious agenda. Users want to see GEM avoid commercial and administrative pitfalls, and want to see GEM succeed.

Based on the User Survey, the third section of this report defines 32 "use cases", which are specific user needs that GEM will have to meet. Each of the use cases is thus a product that GEM will be required to provide, and forms the basis on which a product requirements document can begin to be written.

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1 INTRODUCTION

1.1 Background

The Global Earthquake Model (GEM) will be an open-source system of authoritative analytical models, software, and data for researchers and professionals to perform earthquake hazard and risk analysis for single assets, portfolios of assets, or societal-level risk located virtually anywhere in the world. Current software and other tools (GSHAP, HAZUS, EXTREMUM, OpenSHA, OpenRisk, PAGER, EQRM, Selena, etc.,) offer many of these features, and GEM software will attempt to integrate them into proof-of-concept or prototype software. To successfully develop GEM for success will require answers to five important and inter-related questions:

- **Who** are the current and potential users of hazard and risk information and software;
- **How** do users of hazards and risk information use the information – what are their risks, what decisions are they making, how is the information used in that decision-making?
- **How** do risk analysts and software users currently perform their analyses, and what particular capabilities could GEM offer that would materially improve upon these approaches;
- **How** might users interact with GEM, on a step-by-step basis, to implement these enhanced capabilities;
- **What** data interchange standards are needed to most easily interact with existing and developing hazard and risk software; and
- **How** could GEM best encourage, direct, and absorb voluntary data and software contributions by user-developers.

To partially answer these questions, this Report presents the findings of a user needs assessment (UNA). A UNA assesses *who* the users are, and *what* are their needs.

1.2 Scope of Work

In order to perform the UNA and develop answers to the above questions, the following scope of work for the user needs assessment was presented in our proposal of 29 Jan 2009, and consisted of:

> *User needs assessment for GEM (UNA1). The second task of this project will address the above questions related to who will be the likely users of GEM*[1] *– both directly and in*

[1] During early stages of the project, the focus of the UNA was shifted from GEM to GEM.

derivative form, and what are their needs? While SPA will be the contracting entity, the UNA will be developed collaboratively with members of the Alliance for Global Open Risk Assessment (AGORA), an international professional society of approximately 200 hazard and risk researchers and practitioners from the Americas, Europe, and Asia. In particular, a draft UNA1 will be prepared in collaboration with up to 3 key AGORA members from Asia, Europe, and/or Central or South America. The draft UNA1 will be prepared for GEM's June 2009 annual meeting and will be reviewed at a general meeting of the AGORA membership planned for June 2009 in Cambridge, UK. The following tasks will be undertaken to create the UNA.

Identification of potential GEM users. The types or classes of GEM users were briefly discussed at the June 2008 GEM kickoff meeting in Zurich, and included GEM sponsors, the GEM science team, and community members who contribute directly to the GEM global components. SPA personnel have extensive professional experience with each class. From information in our files and through discussions with GEM users at the March 2009 meeting in Canberra, GEM sponsors, and AGORA members, and using other readily available information, we will estimate how much effort each expends on hazard or risk analysis. We will describe the typical technical resources and sophistication of each class of user, which may be a wide spectrum. For each class we will identify up to three principal uses of hazard and risk software and describe how such analysis is used to advance the user's primary business or research objectives.

Business use cases. Having defined classes of GEM users, the next question relates to how users will employ the results of GEM prototype software, and/or how they personally perform such hazard or risk analysis. Such uses are termed business use cases, defined as "in technology-free terminology… the business process that is used by its business actors (people or systems external to the business) to achieve their goals…. The business use case describes a process that provides value to the business actor, and it describes what the process does[2]*." That is, using structured survey instruments, we will explore the methods and context in which GEM users currently use hazard and risk analyses, what value they derive from such uses, and how GEM might augment this value. Based on our*

[2] http://en.wikipedia.org/wiki/Use_case

experience with users, and with additional feedback from AGORA members, we will provide a series of brief business use case for several classes of potential user and their uses of hazard or risk information. The business use case will include the input information available, the required output, the time available to perform the task, and how the information is used.

System use cases. As used here, a system use case specifies the function or the service that the software system provides for the user. For each of the business use cases described in the previous task, we will propose a GEM system use case: a step-by-step description of the user's interaction with the software, including the means to give users access to GEM products. The system use case does not detail user interfaces and screens; that task is left to the user-interface design, but it does provide an adequate level of detail for the software developer to create a user interface. The system use case also does not detail the mathematic algorithm required to implement the system. Several of these are available in the hazard and risk literature; to the extent practical we will provide pointers to or quote from the risk literature to inform the GEM developers on these technical details, and where appropriate identify experts who can provide additional domain expertise. The system use cases will be informed by our own past experience developing hazard and risk software, and on that of our AGORA collaborators. To the extent practical and appropriate, we will document each system use case including: use case name; version; goal; summary; actors; preconditions; triggers; basic course of events; alternative paths; postconditions; business rules; notes, assumptions, exceptions, recommendations, or other technical requirements; and author and date.

Report - AGORA contribution and review. A preliminary draft of each section of the UNA1 report will be prepared by the primary authors and selected subject-area contributors from AGORA and GEM. The UNA1 will be drafted on a wiki that will initially be visible to the primary developers and to GEM. When a draft is ready for external review, the wiki will be made available to the broader AGORA community. The draft will be discussed at the June 2009 GEM annual meeting and in breakout sessions of an AGORA meeting currently planned for June 2009. After an appropriate period for review and comment, the draft will be finalized in an electronic document suitable for publication.

Note that the second paragraph of the scope of work specifically states *The types or classes of GEM users* …[are]… *GEM sponsors, the GEM science team, and community members who contribute directly to the GEM global components.* That is, and this is emphasized, the User community addressed in this UNA is that group that directly interact with the GEM software, either in a "hands-on" mode, or as derivative users of the direct output. Not addressed by this UNA are the broader group of humanity subject to seismic risk that will indirectly benefit from the increased access to scientific knowledge that GEM will provide. Those Users are not users of GEM – they are Consumers of products derived from GEM's outputs.

This distinction is important because (a) as explained in the next section, a UNA of the software's users is an initial step in the critical path for the software's development, whereas needs of users of derivative products are not on the critical path for software development – they are downstream; and (b) one UNA cannot serve both classes – that is, Users and Consumers – since their very natures are entirely different, one being technically cognizant and responsible, and the other relying on the first's technical expertise and trustworthiness.

1.3 User Needs Assessment and its Place in Software Development

Before proceeding further with the UNA, it is useful to explain why a UNA is needed – that is, the critical role of a UNA in the development of any software.

The various stages in the development of software are shown in Figure 1, and also in Figure 2 which depicts the so-called 'waterfall' model of software development, a sequential process commonly but not always used for developing software[3]. Using as an example the waterfall model, software development more or less consists of the following overall steps:

- User needs assessment (UNA, defines who the users are, and what are their needs)
- Product requirements document (PRD, developed from the UNA to state what the software product is required to do to meet the users' needs)
- Software requirements specification (SRS, states much more precisely each step the software is required to perform). Part of the SRS development is prototyping – that is, the development of 'dummy' screen shots of what the software will look like. The

[3] Other models for software development include Agile, Chaos, Iterfall, Sashimi and Spiral.

prototype establishes the look and feel of the software, specifies to the software code writer how the graphical user interface (GUI) will look and function, what buttons go where and what actions they are associated with, etc. The prototype is extensively tested interactively with a user group.

- Implementation, that is, code writing and code integration, including unit testing (using test cases)
- Verification, also known as verification and validation (V & V), which verifies that the integrated software was *built right* (verification) and the *right software was built* (validation). That is, two aspects need to be established as correct – (i) verification – that the software correctly implements the algorithms, and (ii) validation – that the correct algorithms have been employed, so that the software accomplishes the intended purpose. Verification can be accomplished by for example comparing software results with hand calculations, while validation is more complex, and usually involves a combination of professional judgment together with comparison with other software products that have been independently developed.
- Deployment, not shown in Figure 2, but a crucial and often underestimated step. Most people know from experience that software is very quickly judged, often harshly – if it crashes or is not intuitively easy to use, many users will discard it, often within minutes. Therefore, deployment must be a gradual and phased procedure, in which alpha versions are released within the project and revised until acceptable; then beta versions are released to a select user group, composed of individuals supportive to the project who can be trusted with some level of confidentiality (i.e., not to share negative experiences with outsiders), and revised until acceptable; and finally version 1.0 is released, together with hotlines, help desks and other infrastructure to support users and the inevitable bugs and problems they will encounter. While not addressed in this report, the importance of a properly designed deployment for GEM is emphasized.
- Maintenance – the "totality of activities required to provide cost-effective support to software. Activities are performed during the pre-delivery stage, as well as during the post-delivery stage. Pre-delivery activities include planning for post delivery operations, for maintainability, and for logistics determination for transition activities.

> Post-delivery activities include software modification, training, and operating or interfacing to a help desk." (Abran and Moore, 2004)

Within software development, a user needs assessment is the initial step in the requirements process. Software requirements are

> "…concerned with the elicitation, analysis, specification, and validation of software requirements. It is widely acknowledged within the software industry that software engineering projects are critically vulnerable when these activities are performed poorly. Software requirements express the needs and constraints placed on a software product *that contribute to the solution of some real-world problem*." (Abran and Moore, 2004)

The software requirements process is shown in more detail in Figure 3, within which selected portions are enclosed within a red box – those portions of the software requirements process are partially addressed in this report, by performing a user survey, and developing a set of business/system use cases, which together constitute a user needs assessment.

Also before proceeding further, it may be useful to clarify what a business/system use case is. A *use case* in software engineering is a description of a system's behavior as it responds to a request that originates from outside of that system. In other words, a use case describes "who" can do "what" with the system in question, where "who" is termed the *actor* (since the user is performing actions). Business use cases describe the business process, while system use cases describe the actor-system interaction, where the system in this case is the software. Note that use cases do not detail or even identify <u>how</u> the process is accomplished – they only identify the actor-system interaction. In this sense, the system is treated as a black box – what's inside is not the focus of a use case.

For example, to deposit a check at a bank, the business use case consists of the actor performing the following actions [with teller responses in brackets]:

1. Hand teller the check and completed deposit slip, saying you wish to make a deposit [May I see some ID?]
2. Show identification and sign the check. [Thank you]
3. Teller enters information and generates a receipt. [Give customer the receipt]
4. Receive receipt and/or cash from teller [Is there anything else? Have a nice day.]

The system use case (i.e., the depositor's interaction with an automatic teller machine, or ATM), would consist of the (with system responses, that is, ATM, shown in brackets)

1. Insert ATM card [request PIN]
2. Enter PIN [request action, such as get cash, deposit check, etc.]
3. Enter amount (to be deposited, and insert check) [indicate successful receipt of check; ask if additional checks are to be deposited]
4. Respond with additional checks or indicated finished [Ask if receipt required]
5. Respond Y/N as to receiving a receipt [Generate receipt; ask if customer wishes other actions]
6. Indicate if other actions are required (e.g., get cash etc) [Go to sequence for next set of actions or, if no further actions required, return ATM card, close transactions, generate welcome screen for next customer].

Actually, the business use case above was in a sense a system use case, where the system was not software but rather the human teller at a bank counter. The customer (i.e., actor) – bank business use case is:

1. Actor establishes identity to bank
2. Actor identifies bank action to be performed
3. Actor submits check and associated data
4. Bank confirms correctness and authenticity of actor's check and data
5. Bank returns a confirmation of deposit

At their simplest, use cases consist of 'who does what' – that is, a subject ('who') modified by a predicate ('does what'), where the predicate must contain a verb (but not necessarily an object). An example in the above is 2. Actor identifies an bank action to be performed. Where actor = subject, identifies = verb, bank action to be performed = object.

To emphasize further the 'black-box' nature of the system in a use case, note that in describing the ATM system use case, no software was described, and details such as whether the deposit button was red or green (or whether it was a physical button, or a virtual button on the screen) were not addressed. Such details come later.

In this report, we have conflated the business use case and system use case into a business/system use case (hereafter termed use cases) for brevity and because the reader is assumed to have a grasp of seismic risk analysis.

The user needs assessment's place within overall software development, and within the software requirements part of software development, has therefore been defined**. The UNA identifies who GEM's users are, and their needs, and via the use cases precisely states those needs.**

1.4 Organization of Report

Section 2 of this report presents the online user survey: the process we employed to develop it, the particular questions asked, count of responses, a discussion of each question, and our interpretation of the meaning of the results for GEM. Section 3 contains use cases. The report concludes with references, a glossary, and an appendix containing survey results.

2 USER SURVEY

2.1 Survey Instrument

A UNA survey instrument was developed by SPA, reviewed by a review panel consisting of Profs. R. Spence, M. Erdik and O. Cardona, and then tested on a limited sample of GEM participants and other persons. Based on comments received, the survey instrument was modified and then posted to the web, and promoted through a variety of means. Ms. Nicole Keller of the GEM Secretariat provided significant assistance in promoting the survey.

The instrument consisted of 17 questions (the first asking what language would respondents prefer, following by 16 technical questions, some of the questions being multi-part), and is shown in Appendix A. In addition to being in English, the instrument was translated into Chinese, Hindi, Spanish and Japanese, and totals (in all languages) 61 pages as printed in Appendix A. However, the survey in any one language had three on-screen sections (an introduction, the main survey, and a closing page) and could typically be completed in about ten minutes. Completion of the survey took a participant to the GEM home page.

The instrument was developed using SurveyMonkey (www.surveymonkey.com) and deployed on that site on 9 September 2009 with the last survey being completed on 10 March 2010. The survey site was accessed 880 times, with 414 completions of the survey[4], for an overall response rate of 47%.

2.2 Survey Results

This section presents and discusses response to each of the 17 questions in the survey. For each question, we tabulate all responses received in all languages, and provide a graph showing breakdown of responses in the English language (patterns of responses were generally the same in all languages. **The complete set of 880 responses to each question is delivered in an Excel spreadsheet accompanying this report.**

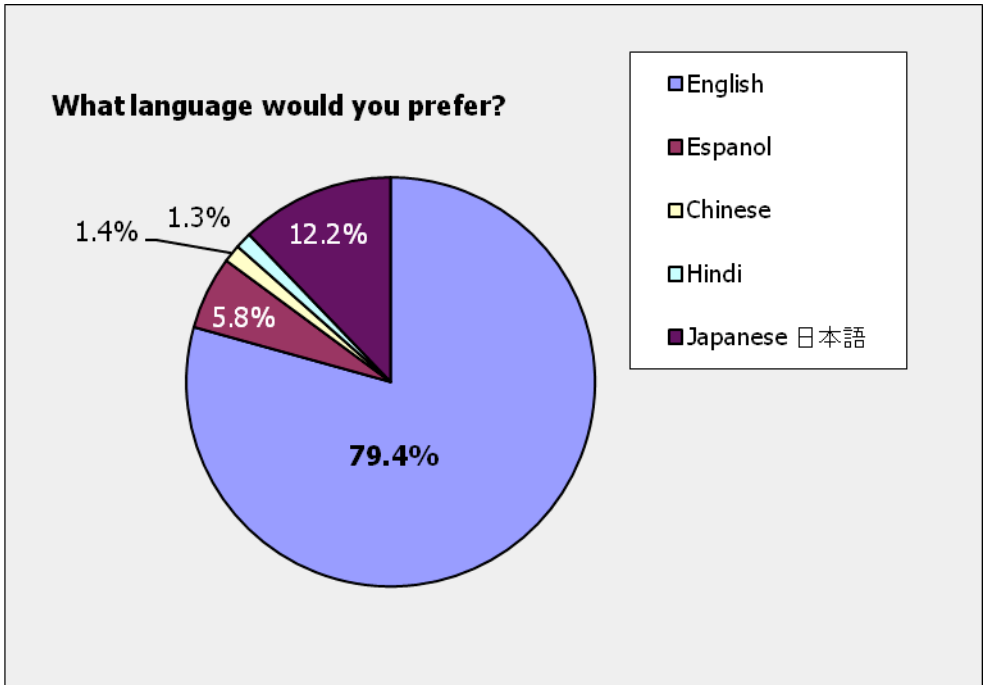
[4] The actual number of participants may be somewhat lower (and the completion rate higher), since some participants may have first accessed the survey site out of curiosity, and then returned later to complete the survey.

In the following, selected comments are listed, and followed by a discussion of the responses. Finally, we provide our interpretation of the significance for the development of GEM, of each question's responses.

2.2.1 Question 1: What language would you prefer?

This question followed a welcome screen in all five languages, and simply asked the language preference, with the participant then being directed to the following 15 questions in the language of their choice. Of the 880 participants accessing the site, almost 700 responded in English:

Q1. What language would you prefer?		
Answer Options	Response Percent	Response Count
English	79.43%	699
Espanol	5.80%	51
Chinese	1.36%	12
Hindi	1.25%	11
Japanese 日本語	12.16%	107
	answered question	880



Discussion: While extensive efforts were made to reach out to non-English speakers, including for example a visit by Prof. Pinho to China and Japan (reflected in the higher

Japanese response), and announcements of the survey in non-English publications, the high response rate for English is not surprising for several reasons:

- Earthquake risk analysis as a formal process is less established in non-English speaking countries – China and India are still developing economies and while large in absolute population levels, the penetration and practice of risk analysis is restricted to a small fraction of the technical community.
- English is the established international language – some non-English native speakers may have chosen to respond in English anyway.
- Earthquake-related insurance and finance, and the modeling of earthquake risk for those industries, are dominated by English communications.
- The relatively low response rate for Spanish speakers may have had to do with problems with the translation[5].

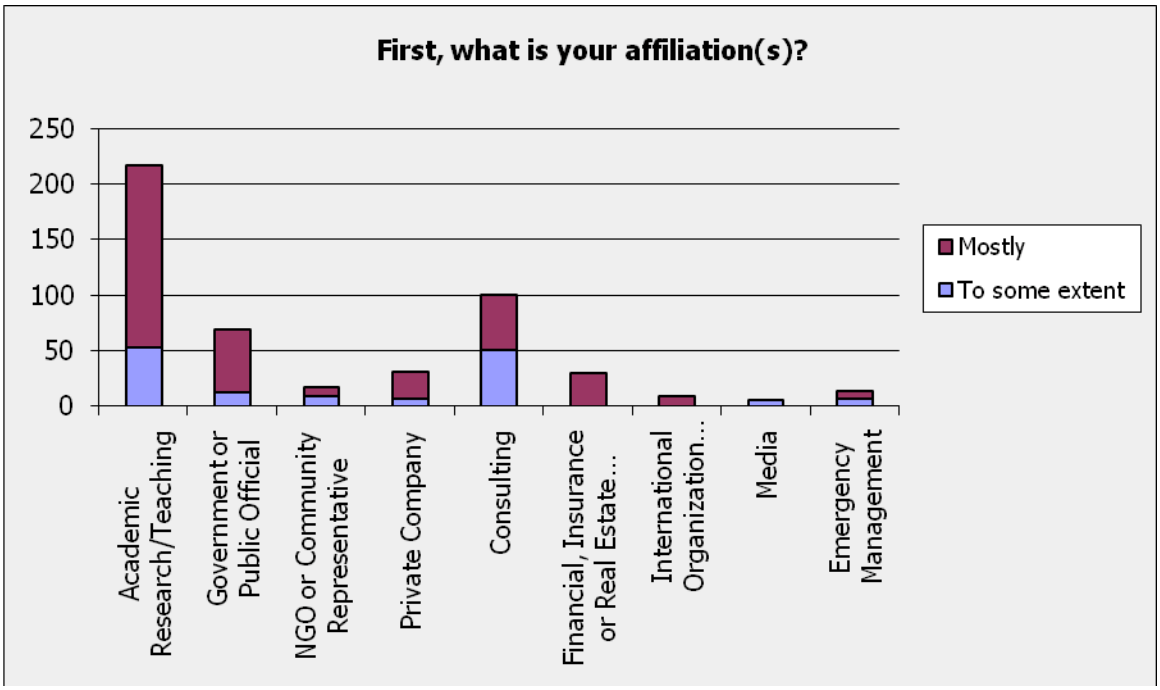
Interpretation: While English was the predominant response language, and many technical users of GEM will probably be able to functionally employ GEM in English, we believe that since 1 in 5 respondents prefer a language other than English, GEM should be designed so as to be multilingual, even if its initial deployment may only be in English. Multilingualism can probably be achieved at a relatively modest cost for the software (only screens and output information need be translated) but will probably come at a higher cost for translation of technical documentation and user's manuals. How to accommodate multilingualism will need further study, but is a goal GEM should seriously consider.

2.2.2 Question 2: First, what is your affiliation(s)?

This question was the first in each of the five languages, and asked the participant to provide a general affiliation (dominant, and secondary).

[5] All translations were by native speakers, but a correct Spanish translation proved elusive. The first translation was criticized by native speakers, and a second translation was made (by a different translator) which nevertheless still had problems, even after being 'corrected'.

Q2. First, what is your affiliation(s)?			
	All Respondents		
Answer Options	Mostly	To some extent	Response Count
Academic Research/Teaching	201	61	262
Government or Public Official	61	14	75
NGO or Community Representative	8	10	18
Private Company	34	6	40
Consulting	57	54	111
Financial, Insurance or Real Estate Industry	31	-	31
International Organization (UN, MDBs...)	8	1	9
Media	-	5	5
Emergency Management	6	9	15
Comments	-	-	66
answered question	-		414



Comments: 66 comments were received in all, some of where were:

- 20+ years experience in earthquake engineering research. Associate Professor of Civil Engineering
- a Retired Firefighter with an interest in Earthquakes

- Actively participate in the research and development of advances in mitigation of nonstructural building components at the academic, code development and improved regulatory practices at a global level.
- Actually, a government research scientist.
- AFES, NEMO, First Responder,
- Canadian federal government
- Centre for Geodesy and Geodynamics, Toro Bauchi, Nigeria is a government agency mandated for researches on earthquake phenomenon.
- Consultant in a private company that identifies the seismic/geologic hazards that cities and counties are most vulnerable and provides policy recommendations (mitigation) that can be implemented to reduce the potential risks associated with these hazards.
- Earthquake scientist with US Geological Survey
- Geoscience Intergovernment organization of East and South-east Asia Region
- Gero Michel, gmichel@endurance.bm SVP headf of Int Cat UW and analytics
- Global Engineering consulting company providing sesimic hazard assessmnet services to multi-national natural resource development companies (e.g. mining)
- GNS Science is a Crown Research Institute, i.e. a State Owned Enterprise. We do about 50% government funded research and about 50% non-government funded research and consulting. GNS Science is the largest Earth science research entity in New Zealand.
- Government research into earthquake hazards
- Governmental research institute
- I am a Professor who does a lot of consultancy
- I am a seismologist
- I am an earthquake researcher at a government organization.
- I am currently doing field research in the Comoros Islands, Southwest Indian Ocean- so my interest is for the people of the Comoros as well as the State University program for which I work
- I am employed by a geotechnical engineering/engineering geologic consulting firm that evaluates the presence and risk of onsite and regional geologic/seismic hazards and provides recommendations for the design of public and private works taking these hazards into account.
- I am highly interested in carrying out research in the field of disaster risk reduction.
- I am on the staff of the California Seismic Safety Commission, a public policy advisory agency of the state of California Government.
- I build models using geodetic, seismic, and other geophysical data to describe the physics of continental deformation on both long-term and seismic cycle time scales.
- I have worked in Nuclear Power Corporation of India, Department of Atomic Energy, Government of India for almost 14 years and presently working in Risk Management Solutions India (RMSI) at Noida, India office.
- I usually work for a public research institute that does some consultancy
- I work for an Investor Owned Utility.
- I work for IRIS, a not-for-profit consortium of 109 US universities, each with a research program in seismology.

- I work for the US NRC as a seismic hazard and risk specialist, and I have a private consulting firm
- I work in risk assessment
- I'm an independent museum registrar
- Independent consultant specialising in earthquake resistant design
- Institutional ILS investor
- International reinsurance company
- Joint Reseach Centre - European Commission
- Large Engineering firm
- Massachusetts Institute of Technology
- M-PLIFY, developer of multi media procedure backed alert management solution AlarmTILT (www.alarmtilt.com)
- Museum registrar, which means that I help to identify and manage risk to museum artifacts and specimens and work with colleagues at other institutions in arranging for loans and traveling exhibitions.
- NOAA Pacific Tsunami Warning Center
- None of the above seems to encompass either "geological survey organisation" or "seismic network operator" which would be the most appropriate affiliation. We are NOT government of public officials - we are a non-departmental public body, which puts us at arm's length from government. Of course we do many other things too, including consulting, academic research, teaching.
- PhD student in seismology/seismic hazard
- President of Insurance and Risk Management Country Project for Chile under auspices of Colegio De Ingenieros (Engineering trade association) and Government
- Previous EWC3 invitation
- professional association
- Project manager and researcher at the University of Zagreb, Faculty of electrical engineering and computing.
- Providing structural-earthquake engineering services.
- Reinsurance company. i think that quite a number of reinsurance companies and or brokers are interested in this product.
- research and development of risk assessment models for application to government policy, emergency management, insurance, etc...
- Science policy office
- Structural engineering, building code development, risk reduction policy
- Tsunami Warning Center
- US Federal Government
- US Government Hazard Research
- World Food Programme, Asia/Pacific Emergency Preparedness and Response (AEPR) Project, Bangkok, Thailand

Discussion: Participants were not asked to identify themselves in the survey, and most did not. Anonymity also extended to not asking the country of the participant. Nevertheless, based on an analysis of responses, the Survey was accessed from over 74 different countries, with the 880 accesses distributed as shown in :

As would be assumed, many respondents were scientists, engineers and insurance professionals, but participants also included emergency responders and museum registrars. More than half the participants identified themselves as academics, and over 100 as consultants, followed next by government officials and insurance industry professionals.

Interpretation: Academia and consultants were strongly represented in the response, and should be carefully considered by GEM as its core constituency. Government officials and insurance industry professionals' needs can probably be met by focusing on a user profile that emphasizes academic needs (research, ability to 'get under the hood and tinker', education) and consultant's needs (ease of use, standard and accepted models, productivity, ability to customize). Low cost (discussed below) is desirable for both. Broad geographical coverage (also discussed further below) is highly desirable (and already 'mandated' for GEM). However, to a greater extent than academics and consultants, government officials and some insurance industry professionals will tend to need clear statements about which software represent best practices for policymaking purposes. That is to say, where the software offers two or more options to achieving some computational end that has policy implications, such as a choice among ground-motion prediction equations, GEM should provide a statement identifying which option(s) have widespread support among experts. One way to achieve this is for GEM to poll a carefully selected and broadly representative group of experts in a highly transparent process.

2.2.3 Question 3: To what degree are you especially concerned with earthquake, as opposed to other issues.

This question sought to identify to what extent users would be earthquake-focused, versus a broader orientation, and drew 414 responses.

Comments included:

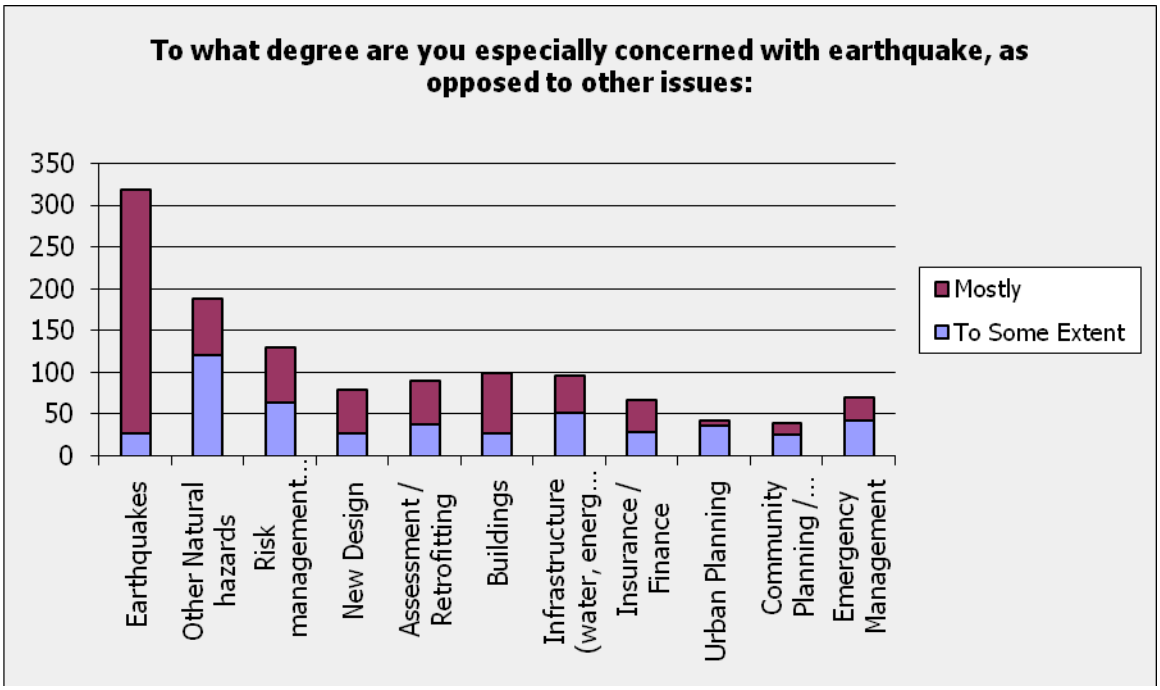
- advising private clients and small museums on Earthquake and other risk mitigation issues
- again, my concern is mostly related to field work, in the Comoros
- American Red Cross Chapter Emergency Services Director
- I am a geotechnical engineer with a dam safety program in Washington State USA. So, I am concerned about static & seismic slope stability, cyclic mobility, and internal erosion (piping) - any threat to a dam's integrity not directly arising from floods. We have hydrologists for that.
- I am an earthquake seismologist, but also do seismic hazard assessment and considerable outreach including associated risks such as tsunami, landslide,

liquefaction, etc. I also work with emergency managers toward better planning, mitigation, communications, etc.
- I am interested in fires following earthquakes
- I operate a seismic network and report on EQs
- I work mostly on earthquakes but also on volcanoes.
- If "hazard characterization" had been an option it would have been my "mostly."
- My core activity is seismic hazard assessment
- My speciality is multidisciplinary earthquake hazard modelling, but my skills and responsibilities have been applied to other hazards on many occasions.
- Risk is key to our decision-making.
- Safety and disaster for my family and neighborhood.
- Seismic Instrumentation.
- Tsunami Warning System

Discussion: Almost all respondents indicated a strong bias towards earthquakes, and less towards broader issues such as new design or urban planning.

Q3. To what degree are you especially concerned with earthquake, as opposed to other issues:

Answer Options	Mostly	To Some Extent	Response Count
Earthquakes	346	28	374
Other Natural hazards	93	135	228
Risk management (professionally)	92	77	169
New Design	70	37	107
Assessment / Retrofitting	71	49	120
Buildings	101	37	138
Infrastructure (water, energy, transportation...)	59	66	125
Insurance / Finance	49	46	95
Urban Planning	15	47	62
Community Planning / Organization	28	38	66
Emergency Management	52	52	104
Comments	-	-	37
answered question	-		414



Interpretation: We interpret this to mean that, at least initially, GEM users will be knowledgeable about earthquakes and their effects, so that a certain technical sophistication can be assumed in the design of the GEM interface. From a development strategy perspective, this implies that GEM could develop a more sophisticated product first, with a more simplified perhaps pruned-down "GEM-lite" product for use by lay users developed later. This has the added advantage of conferring acceptance and credibility on derivative products. We also interpret these results to mean that many GEM users are considering earthquake hazard and risk to facilities or people within a broader context of other natural hazards. The software's expressions of hazard and risk should therefore facilitate comparison with hazard, risk and mitigation from other natural hazards.

2.2.4 Question 4: In what regions of the globe would GEM be most useful for you? (more than one region can be selected)

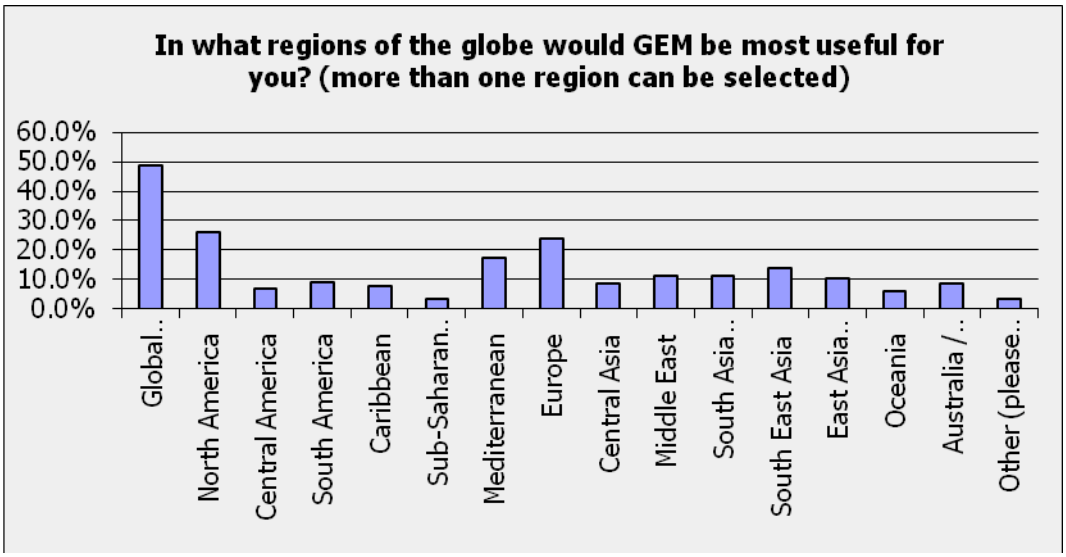
The purpose of this question was to ask where GEM should devote its resources.

Q4. In what regions of the globe would GEM be most useful for you? (more than one region can be selected)	
Answer Options	Response Count
Global (i.e., extensive use in multiple regions)	209
North America	101
Central America	35
South America	45
Caribbean	35
Sub-Saharan Africa	12
Mediterranean	67
Europe	92
Central Asia	34
Middle East	43
South Asia (Persian Gulf to India)	42
South East Asia	57
East Asia (including Japan)	58
Oceania	23
Australia / New Zealand	31
Other (please describe)	12
Comments	36
answered question	414

Comments included:

- Africa
- All activity involving the New Madrid Fault is of particular interest to me and many others.
- also South and west Pacific
- Antarctica
- basically worldwide. especially helpful would GEM be in countries where the commercially available products don't have models. by commerciall models i mean RMS (rms.com) AIR (air-worldwide.com) and EQECAT (Eqecat.com) those models cover quite a range of countries worldwide but by no means all countries. so a global GEM model would be helpful those countries where so far no other model exists.
- East African coast/Southwest Indian Ocean - this is an often overlooked area in ALL forms of research, and it would be great to have more information on any active faults, etc.
- East African Rift
- Effectively you need to start where data is weakest, and where it is likely that the host country will require international support in the event of an earthquake
- GEM would be useful for the globe (more than one region). But, GEM could not serve the purposes because the methodology it is based on - probabilistic seismic hazard analysis (PSHA). PSHA is not consistent with modern earthquake science - wrong earthquake source model (single point), invalid math, and confusing hazard and risk.
- I am specially concerned in North-West region of Argentina

- I suggest that there is no possibility of a useful global earthquake model. Earthquakes are critical systems and any model depends on details of starting point (Geller et al., Science, 275,1616-1623, 1997). This means that every/any earthquake is unrepeatable.
- In particular, North America, Central and Eastern Europe, Japan, China, India and Australia.
- India is the country for which Earthquake information would be most useful to me. I feel India has seen lot many Earthquakes, but most peaple I think are not aware of its risks. India would definitely welcome information about how to reduce its impact through mitigation steps. A very good media vehicle is also extremely important to communicate these information in order to make it available to all stakeholders including people/property owners who are exposed to Earthquake Risks, the government who can provide large scale mitigation, the academicia/professional institutes who can utilize science to understand and mitigate risks. At some stage in the GEM, I think media coverage is needed.
- Islands in the Atlantic
- Mostly Canada and surrounding regions
- North Sea in Europe
- Northern California
- Northern Pacific/Aluetians
- Pacific Northwest
- Previous invitation from AGSE 2009
- South Africa
- Southern California
- The list reflects my main areas of consultancy work
- The value of GEM is precisely its global approach, there is urgency in addressing hazard and disaster risk collectively by all governments given the rapidly increasing vulnerabilities (urban growth in particular for EQ, and ecosystem degradation and climate change for other hazards).
- The working scale should be the main issue
- UK
- Very interested in advances toward common assessment of ground motion parameters.
- We need a consistent benchmark in terms of modeling and risk assessment - which can then be overlaid with region-specific compnonents/analytics.
- we need all territories WW in both detail as well as creating cross-calibrated results
- WE work worldwide
- Wherever local resources are minimal. I checked North America because that's where my practice is, but we do already have ample resources and information here, as well as programs to identify and fill knowledge gaps.



Discussion: Given the nature of GEM, the overall response was the perhaps to-be-expected 'everywhere'. That is, slightly more than half of participants need a Globally capable model, with regions next of most interest being North America, Europe/Mediterranean and South East/East Asia, the latter perhaps reflecting the composition of the respondents.

One comment was quite interesting: *"Effectively you need to start where data is weakest, and where it is likely that the host country will require international support in the event of an earthquake",* meaning effectively 'fill the gaps first'. This highlights a policy issue for GEM's development, which is that, from a data acquisition perspective:

a. Should all regions of the globe be given equal weight (i.e., resources), even where population and even perhaps where seismicity, is low?

b. Should highest population, or seismicity-weighted population, be given highest priority for resources?

c. Should highest concentrations of capital, or seismicity-weighted capital, be given highest priority for resources?

d. Should least developed economies (e.g., as measured by per capita income) , be given highest priority for resources?

e. Should weakest data regions be given highest priority for resources?

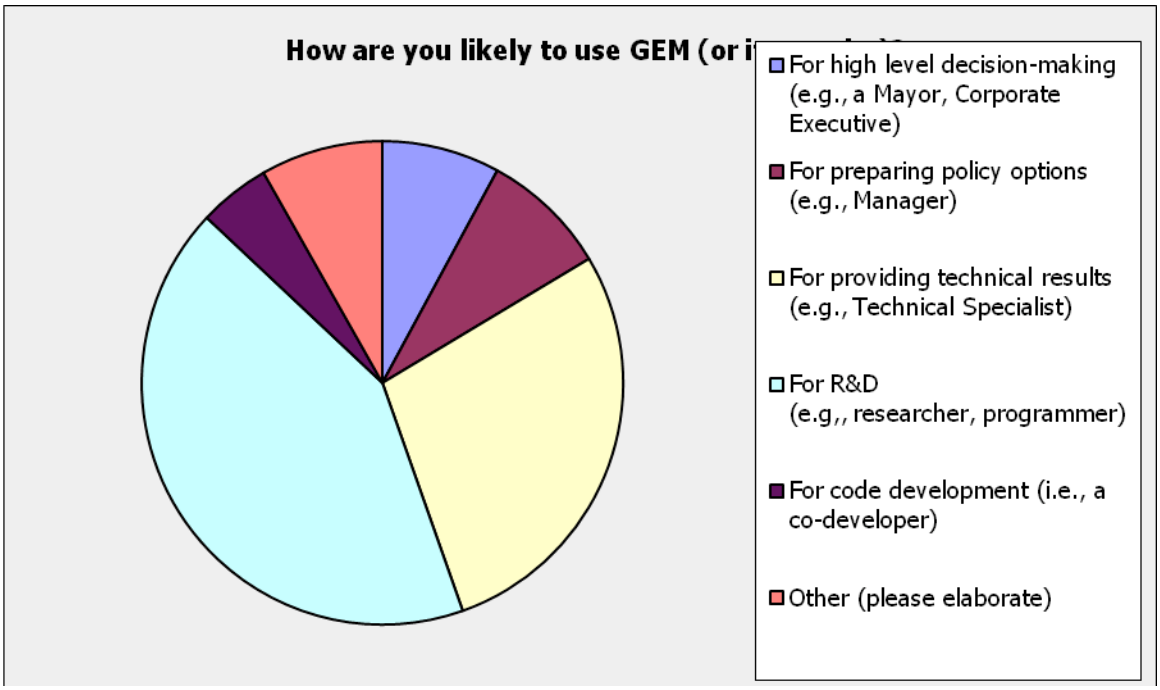
Rubrics for these strategies might be uniform, population-focused, capital-focused, developmental and data-focused, respectively. These strategies are not necessarily mutually exclusive, and a combination of them could be used in a weighted manner for GEM's data acquisition strategy. This policy issue should be addressed as early in GEM's development as possible.

Interpretation: GEM's mandate for a global model is validated although regional resource-weighting is an issue.

2.2.5 Question 5: How are you likely to use GEM (or its results)?

This question sought to determine if the user was the end decision-maker, or served the decision-maker.

Q5. How are you likely to use GEM (or its results)?	
Answer Options	Response Count
For high level decision-making (e.g., a Mayor, Corporate Executive)	35
For preparing policy options (e.g., Manager)	36
For providing technical results (e.g., Technical Specialist)	118
For R&D (e.g., researcher, programmer)	178
For code development (i.e., a co-developer)	18
Other (please elaborate)	29
Comments	51
answered question	414



Comments included:

- All of the above. As an investor, I need to understand the science, modeling methodology and use the results in trading decsions.
- As Student to learn more and gain knowledge .
- catastrophe modeling
- Chilean National Risk Map, Life Line charting, 20 year country Risk Management program
- Earthquake hazard studies
- Earthquake locations and tectonic interpretations
- Emergency Preparedness Planning
- Emergency Preparedness & Disaster Recovery Planning
- Emergency Responder
- For decision support software, such a global alerting for humanitarian disasters
- for physical and environmental risk analysis
- For Project Management in the event of an earthquake and scenario planning
- For raising awareness of political and economic leaders for them to promote disaster risk reduction as a top priority in their constituencies, and of the public in general (through media) to change behaviour with regard to risk management and to put pressure on leaders to act more decisively.
- For use in research into all aspects of emergency management (scenarios, land use planning for risk reduction, risk mitigation etc)
- I plan to feed GEM data, results and tools into our own computer codes for risk assessment, as a basis for decision making on capacity allocation, pricing and development of new markets. In addition, I may use Gem results directly for trigger based risk transfer to capital markets
- I still don't know. It depends on the quality of the final output
- I would rely on it for background for technical studies, e.g. for preliminary design, but for final design I would typically want a poject-specific study.
- I'd like to use GEM as a research and teaching tool. It needs to be installable on laptop computers. It should be able to use GEM from self-written programs and to feed other data into it to see the impact of various datasets on hazard and risk. This will make it a perfect research tool.
- information would greatly help communities in the Comoros and could be used to plan communities/construction/infrastructure in the developing areas, as well as planning for existing communities
- Integration of GEM in own studies that deal with human induced and triggered seismicity.
- Interest in the problem.
- Likely to use GEM results as a basis for comparing our own in-house hazard models.
- may make use of GEM models if they offer
- Much of the baseline seismic data from from us, so we are more likely to use our own datasets and applications
- multiple choices apply here.: R&D primarily but also high-level decision-making and preparing policy options
- No. because GEM prodives neither seismic hazard nor seismic risk because of its methodology (PSHA).
- None at all.
- Operations Management and Contingency Planning

- other: assistance to teaching at University and for dissemination to the public through seminars
- outreach, explaining to the public
- Research and education
- Research and policy, infrastructure planning Investment in earthquake insurance and capital market risk transfers
- Research AND teaching
- Responding with shelter immediately post disaster
- Safety and disaster for my family and neighborhood.
- Teaching
- teaching
- To alert immediate family and friends in particular, and local public in general
- To better understand and test existing Earthquake models and provide inputs to GEM for possible enhancements.
- To communicate to other museums what the level of earthquake risk is at my institution and to evaluate the level of risk at other institutions to which we might lend artifacts or specimens. In the museum field, this information is exchanged via an American Association of Museums form called the General (formerly Standard) Facility Report.
- To have a first draft which could help to define the key issues to develop a detailed formal study.
- To learn and share best practices.
- To see how other countries react to Natural disasters
- while I am very supportive of the GEM mission, I doubt I will use GEM in my work (which is fundamental research on earthquake physics)
- would help me fine tune recommendations for internal disaster policy standards as well as physical renovation to mitigate potential losses

Discussion: A relatively low number of respondents indicated their use of GEM would directly feed into a significant decision (i.e., only 71/414 or 17% would inform a manager or more senior executive). However, consultants were about 25% or respondents, and government officials about 18%, yet they don't seem to feel they'll be influencing decisions. This may reflect the diffused nature of decision-making in most organizations or, perhaps simply be a reflection of the 'academic' nature of the respondents.

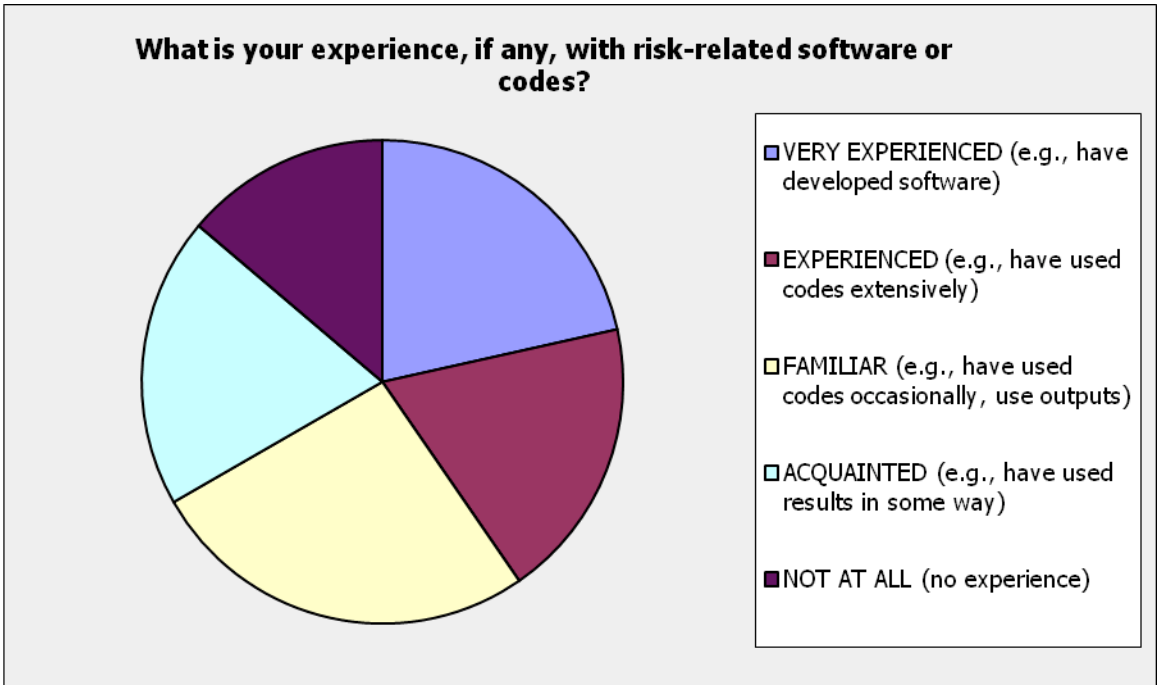
Interpretation: Even if GEM's goal is to influence decision-makers, it is unrealistic to expect them to actually be using GEM hands-on. GEM must therefore provide users with results that are directly usable by decision-makers, meaning 'big picture' summary financial and casualty results, effectively communicated in summary tables, maps and figures. This argues for a powerful graphical and GIS backend for GEM. Since users will be providing results to decision-makers, they will also benefit from "canned" explanations, written for a nontechnical audience possible by people who have been decision-makers themselves, of

what the summary tables, maps, and figures express. These canned explanations can be handed to decision-makers along with the results, so that as little as possible further explanation or documentation is required for that decision-maker to fully understand the meaning and provenance of the product.

2.2.6 Question 6: What is your experience, if any, with risk-related software or codes?

This question sought to determine the experience level of users.

Q6. What is your experience, if any, with risk-related software or codes?	
Answer Options	Response Count
VERY EXPERIENCED (e.g., have developed software)	90
EXPERIENCED (e.g., have used codes extensively)	79
FAMILIAR (e.g., have used codes occasionally, use outputs)	100
ACQUAINTED (e.g., have used results in some way)	81
NOT AT ALL (no experience)	64
Comments	50
answered question	414



Comments included:

- Not so much experienced as innovative in developing approaches to fit circumstances. Have developed approaches to loss assessments and benefit-cost studies.
- Only acquainted with risk software, but I am very experienced with physics-based computational modeling of earthquake shaking. I would like to input the computational results to risk software.
- Probabilistic Seismic Hazard Evaluation (own development) EZFRISK
- Produced - MDBELA, MHAZUS, OPAL. Used - SELENA, OPENRISK, OSRE, HAZUS, EQSIM, QLARM, QL, PAGER, DBELA, ELER, EQRM, MAEviz.
- Project interface to professions/users for development of HAZUS. No technical expeience in developing or use of code
- Rotinely develop my own analytical tools, which interface to comercial products - or remain stand-alone.
- Seisrisk III
- self developed proprietary codes, HAZUS, SELENA, RMS Risklink, WorldCat Enterprise, CATRader
- using IS codes and designing of the building as per standards.
- vendor software and own developments
- Very experienced with earthquake hazard software
- We use HazUS extensively for both earthquake and flood estimation models - we . We once considered V-Risk but found it to be too out-of-the-box and generic to be useful.

Discussion: About 70% of users are at a minimum familiar with earthquake loss estimation tools, with over 20% being developers. GEM's development strategy can therefore probably count on a cadre of very strong users within its user community. These users can be a test bed for beta releases, a source for bug identification and innovation (particularly given that GEM is open source), and, with good outreach, a source for promoting GEM to a wider community. That many respondents are also academics reinforces the last point. However, there is also a significant fraction of respondents (35%) with modest or no familiarity with risk software.

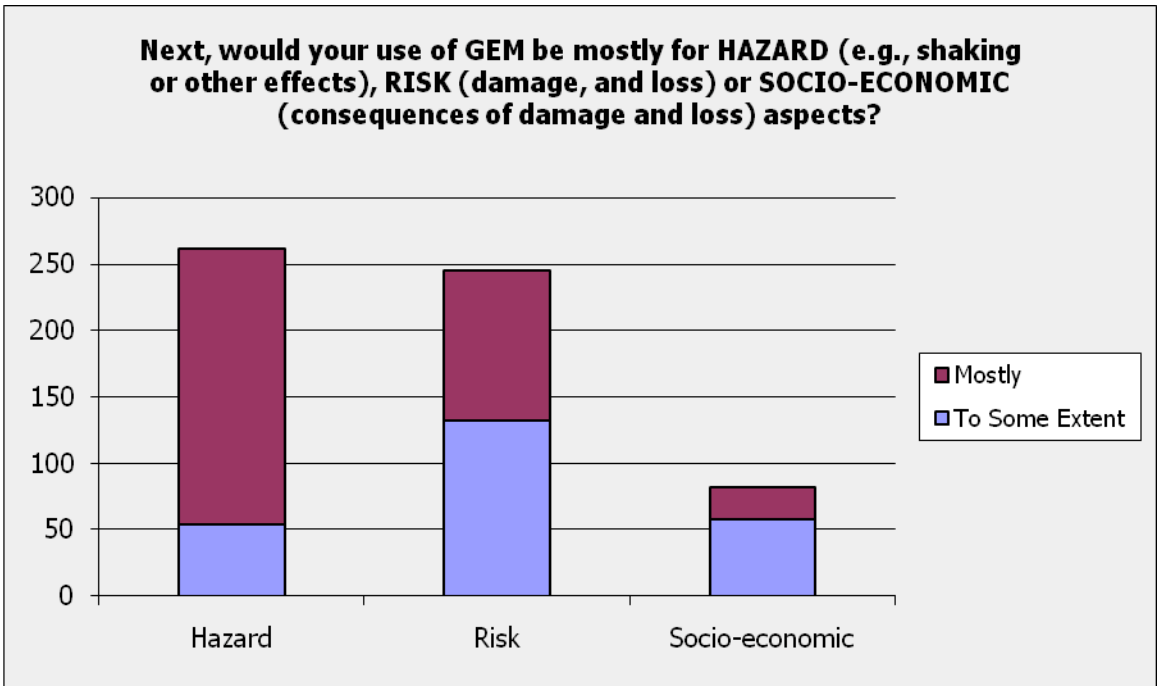
Interpretation: GEM's development strategy should plan on, and be structured to encourage, user participation, in the ways described above. To serve the community of potential users with modest or no familiarity with risk software will require extensive and easily accessed help information written in fairly nontechnical terms. If it wishes to serve this user group, GEM should consider providing case studies: explanations of how others have used earthquake hazard and risk software to solve particular problems, and step-by-step instructions on how to use the software to do that.

2.2.7 Question 7: Next, would your use of GEM be mostly for HAZARD (e.g., shaking or other effects), RISK (damage, and loss) or SOCIO-ECONOMIC (consequences of damage and loss) aspects?

Q7. Next, would your use of GEM be mostly for HAZARD (e.g., shaking or other effects), RISK (damage, and loss) or SOCIO-ECONOMIC (consequences of damage and loss) aspects?			
Answer Options	Mostly	To Some Extent	Response Count
Hazard	239	62	301
Risk	131	154	285
Socio-economic	31	68	99
answered question	-		414

Discussion: This question did not allow for comments. Responses were about evenly divided between hazard and risk foci, with a significantly fewer fraction being concerned with socio-economic. As discussed above, this response may reflect the nature of the GEM community at the time of the survey. The response is also a bit surprising in that there are a number of hazard codes readily available, whereas, excepting HAZUS, risk codes are almost unavailable in most parts of the world. Another way to interpret this akin to the 'highway traffic' phenomena, where (a) a highway is built to relieve traffic jams, (b) the existence of the highway attracts more traffic and development, which generates more traffic, so that (c) another highway is needed to relieve the traffic jams. That is, more users currently envision using GEM for hazard, because the existence of hazard codes has created more hazard code users. The lack of risk codes means there are relatively fewer risk practitioners (i.e., risk users). In other words, GEM will create its own demand.

Interpretation: GEM should be designed to serve all three communities (hazard, risk, socio-economic) well. The existence of good hazard codes, and the lack of good risk and socio-economic codes, should not result in GEM neglecting the needs of the hazard community (which in any case would need to be served, as hazard is a fundamental of risk).

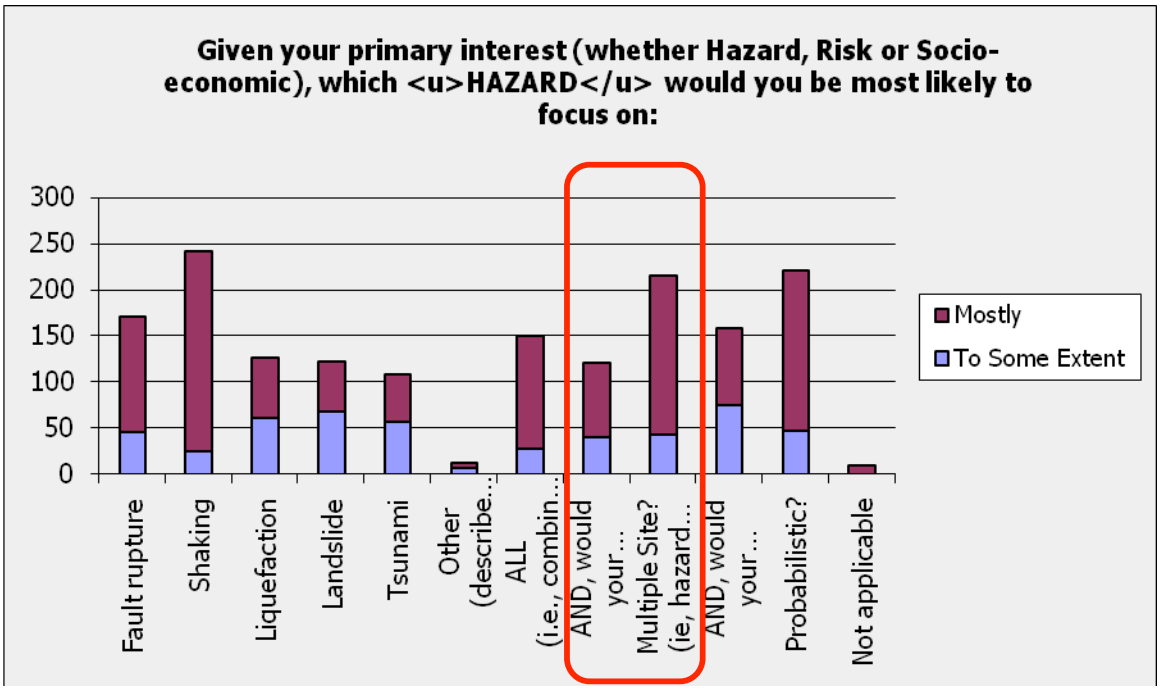

Next, would your use of GEM be mostly for HAZARD (e.g., shaking or other effects), RISK (damage, and loss) or SOCIO-ECONOMIC (consequences of damage and loss) aspects?
300
250
200
150
100
50
0
Hazard
Risk
Socio-economic
Mostly
To Some Extent

2.2.8 Question 8: Given your primary interest (whether hazard, risk or socio-economic), which HAZARD would you be most likely to focus on:

This was a relatively complex three-part question, seeking to identify the salient hazards of interest, and whether single site or portfolio analysis was more important, and whether deterministic or probabilistic analysis was more important. In the bar chart below, these three separate issues are demarcated via the red box.

Q8. Given your primary interest (whether hazard, risk or socio-economic), which HAZARD would you be most likely to focus on:

Answer Options	Mostly	To Some Extent	Response Count
Fault rupture	151	54	205
Shaking	263	26	289
Liquefaction	78	77	155
Landslide	72	80	152
Tsunami	63	76	139
Other (describe below)	9	8	17
ALL (i.e., combined or total effect)	140	34	174
AND, would your analyses be mostly Single Site?, or	96	50	146
Multiple Site? (i.e., hazard mapping)	205	54	259
AND, would your analysis be mostly Deterministic?, or	108	87	195
Probabilistic?	199	51	250
Not applicable	7	2	9
Comments	-	-	20
answered question	-		414



Comments included:

- All credible scenarios would be of interest
- Although the analysis has been described as either deterministic or probabilistic, deterministic and probabilistic analyses both use the same principle of probability theory, but express it in different ways in the end results. The Deterministic analysis considers a single or several large earthquakes and provides hazard or risk with an explicit level of confidence (mean, median, or 84%), while the probabilistic analysis (PSHA) considers all earthquakes (small and large) and provides hazard or risk with an implicit level of confidence (unknown).
- As a layperson, I don't know the difference between deterministic and probabilistic in this context.
- both actual and possible (contingency Planning)
- Fire following earthquake
- I am not clear on how to distinguish deterministic/probabilistic, and not sure what scale the database will be for a "site" - I would want to determine the risk level of the events listed for the Comoros, and if possible look at specific in-country locations (specific communities, or regions of each island)
- I would be interested in using GEM to compute the risk based on my own hazard models.
- In general I am interested in site effects (soft soil amplification, topography effects, basin response)
- Interested in public probabilistic seismic hazard models for locations outside the U.S.
- Other Catastrophic
- Provide all source code on the web page. without the source code, GEM is useless.
- Seismic risk mapping

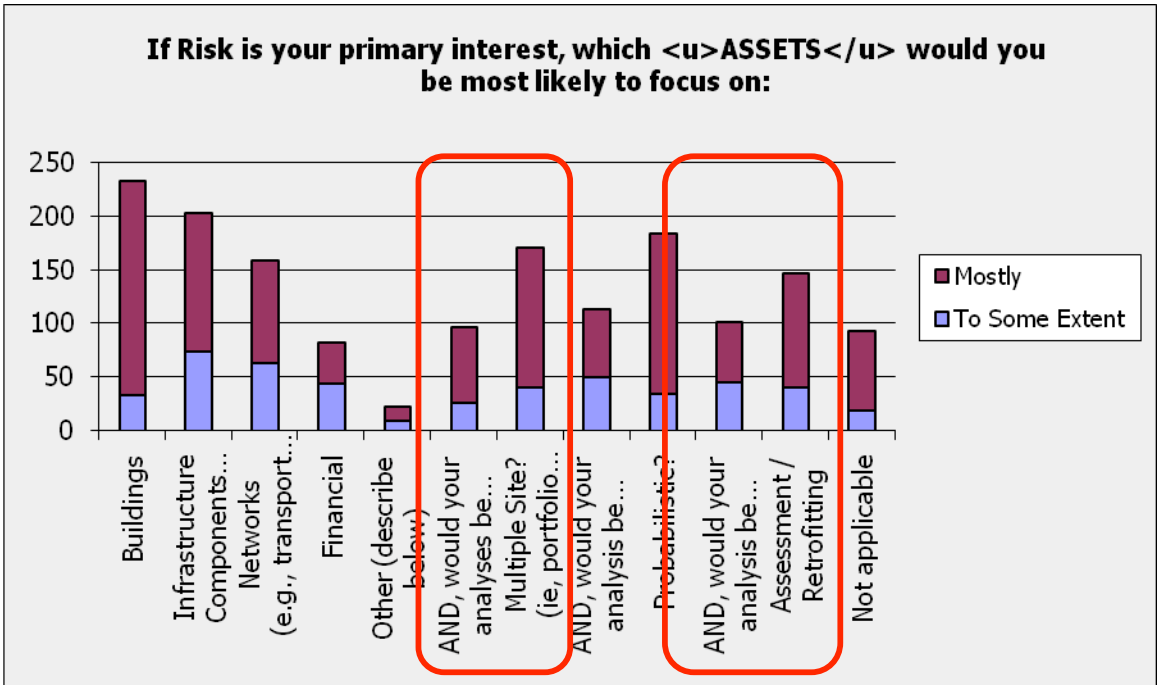
Discussion: Respondents dealt well with a question that, in retrospect, probably should have been three questions. Shaking emerges as the single most important hazard, but all hazards are of interest. Fault rupture is a greater need than one would have guessed, and whether GEM can meet this very site-specific need at a global scale is problematic. Both multiple site and probabilistic analysis capability are strongly preferred (about two to one). Since they seemed to understand what "probabilistic" means, users are likely to demand to know which uncertainties have been addressed and how. Since they are also interested in portfolio risk, they are likely to be concerned with treatment of correlation.

Interpretation: GEM's users need multiple site and probabilistic analysis capability, for at least shaking and for as many hazards as GEM's resources permit, with careful treatment of uncertainty and correlation. The design should therefore accommodate, perhaps at a later date, graphical depictions of sensitivity to uncertain variables (both so-called epistemic and aleatory), perhaps through the use of tornado diagrams, etc.

2.2.9 Question 9: If risk is your primary interest, which ASSETS would you be most likely to focus on:

Analogous to the previous question, this was a four part question, focusing in this case on Assets.

Q9. If risk is your primary interest, which ASSETS would you be most likely to focus on:			
Answer Options	Mostly	To Some Extent	Response Count
Buildings	243	38	281
Infrastructure Components (e.g., roads, bridges, pipelines...)	167	81	248
Networks (e.g., transportation, water supply, communications)	117	74	191
Financial	45	59	104
Other (describe below)	17	15	32
AND, would your analyses be mostly Single Site?, or	83	36	119
Multiple Site? (ie, portfolio analysis)	155	45	200
AND, would your analysis be mostly Deterministic?, or	76	63	139
Probabilistic?	182	40	222
AND, would your analysis be mostly for New construction?, or	73	55	128
Assessment / Retrofitting	130	46	176
Not applicable	75	20	95
Comments	-	-	27
answered question	-		414



Comments included:

- Active fault mapping using historical earthquakes and field measurements to produce vulnerability maps, hazard and hence rank zones of zones very high, high low and very low risks
- Agricultural consequences
- Alert
- All of the above - any insured interest.
- As insurer/ reinsurer we are concerned with mainly nonmovable property, so buildings are the primary focus, with infrastructure components and contents following second. The interest is always on the risk curve for a large portfolio of objects. So the individual analysis of an object has some merit, but is of no value compared to the loss probability distribution for the total portfolio.
- Assets which form the foundation of livelihoods for low income households such as bikes, ploughs, basic equipment etc
- Building contents, non structural components, fire suppression equipment, and fragile equipment that is critical to response and recovery operations, such as hospital equipment and telecommunications equipment.
- Depending on the client, it would be retrofitting existing collection storage and exhibition spaces with modern strategies to minimize the potential risks from natural disasters, i.e.; structural shaking, flooding, loss of climate controls, physical security, etc.
- Electric Transmission & Distribution
- Humans, animals, natural basis of life, cultural heritage
- I need to determine whether a museum is at a moderate or significant risk for earthquakes, and therefore find out if appropriate steps have been taken to minimize risk to artifacts and specimens within the museum.
- Institutional buildings, schools, health centers etc would be area of interest
- Interested in social impacts of loss of lifeline utilities
- Major engineering projects (dams, bridges) but primarily nuclear power plants
- Mitigation plan and public awareness.
- My interest is in policy -- what risk reduction actions (voluntary, mandatory, or triggered) are best suited to a given jurisdiction.
- Population impact (for humanitarian response)
- Possible future news of events that have not taken place yet [risks preparedness and prediction]
- Provide all source code on the web page. without the source code, GEM is useless.
- Scenario and rapid loss assessment for the entire society and infrastructure of the affected region.
- Survival
- The urgent need is to address vulnerability growth not just impact, the academic expert community as well as governments have been gradually focusing more and more on how to reduce risk since more than 20 years ago.
- What is most useful is broad assessments of shaking intensity and data on asset vulnerability, again in a broad sense.

Discussion: Buildings and infrastructure were the dominant Assets of interest, with multiple site probabilistic analysis of existing buildings and infrastructure being the priority, but with a substantial minority concerned with new design

Interpretation: For risk users, the need is multiple site probabilistic analysis of existing buildings and infrastructure. Since new design is of interest to a large minority of users, GEM should be designed to accommodate, perhaps at a later date, the import and use of design maps, perhaps for multiple codes and eras.

2.2.10 Question 10: If Socio-economic is your primary interest, then what sorts of consequences would you tend to focus on:

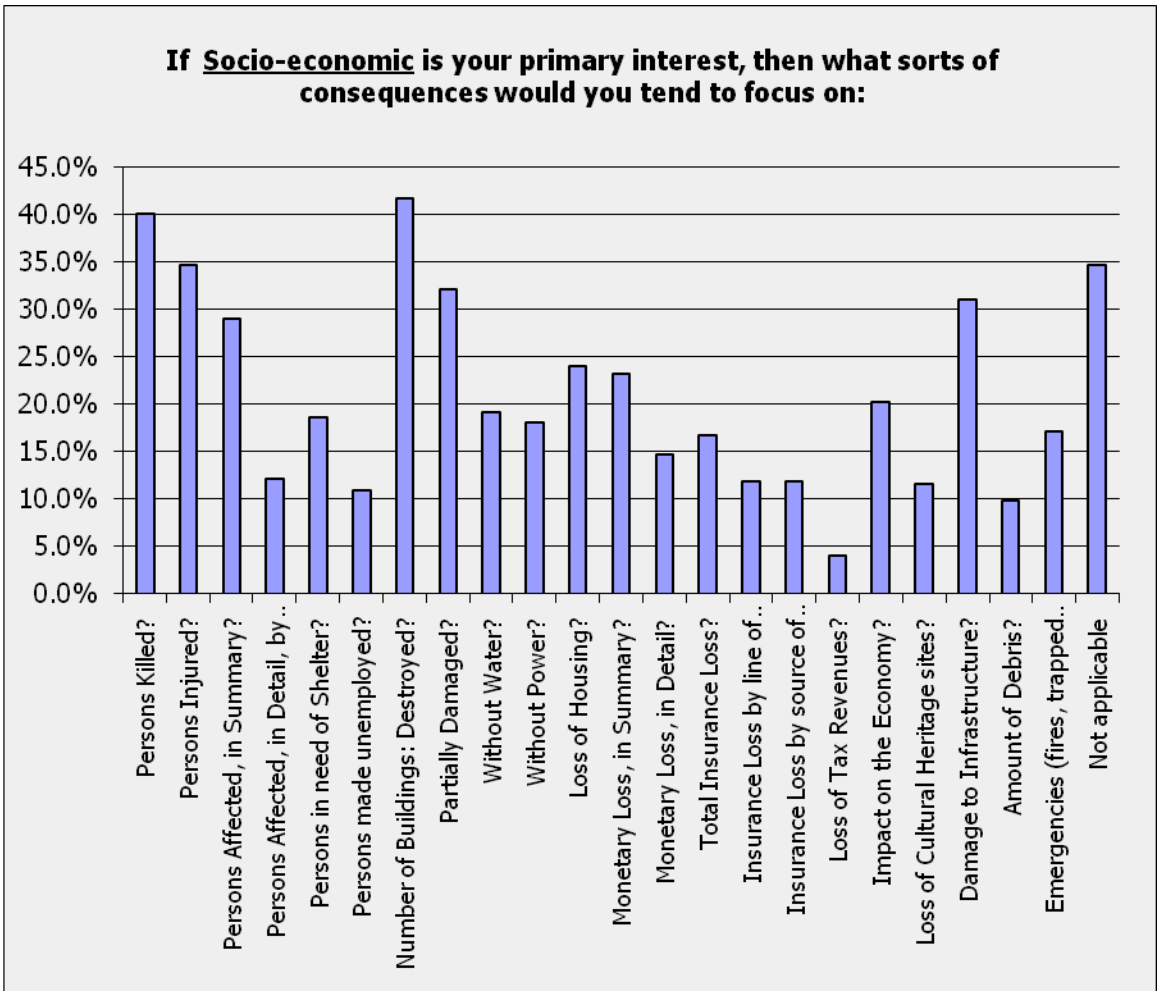
Analogous to the previous questions, this question focused on socio-economic needs.

Q10. If Socio-economic is your primary interest, then what sorts of consequences would you tend to focus on:

Answer Options	Response Count
Number of Buildings: Destroyed?	188
Persons Killed?	176
Persons Injured?	150
Partially Damaged?	147
Damage to Infrastructure?	134
Persons Affected, in Summary?	127
Monetary Loss, in Summary?	109
Loss of Housing?	100
Impact on the Economy?	96
Without Water?	87
Persons in need of Shelter?	84
Without Power?	78
Emergencies (fires, trapped victims...)	72
Total Insurance Loss?	70
Monetary Loss, in Detail?	67
Persons Affected, by gender, age, economic or other groupings?	57
Insurance Loss by source of damage (e.g., shaking, landsliding, fire...)	57
Loss of Cultural Heritage sites?	51
Insurance Loss by line of business?	49
Persons made unemployed?	46
Amount of Debris?	37
Loss of Tax Revenues?	16
Not applicable	123
Comments	17
answered question	414

Comments included:

- Analysis of persons affected (by many categories) in order to determine needs.
- Comoros is a developing country where insurance/economic interests are not really applicable - to me, number of lives at risk is MOST important (and like in Haiti, cinder-block construction methods are popular, and infrastructure is poor)
- Depends on the jurisdiction. In Northern California, we've done a pretty good job limiting deaths and injuries and, frankly, should not be spending many resources to try to do marginally better. Rather, we should be focusing on other types of losses and on community stability and resilience. In other places, high casualties are still possible, and resources should be spent to reduce them.
- I have strong interest in the optimal deployment of emergency response assets in the hours and days after an earthquake and the probabilistic optimization of this deployment provided seismicity on faults nearby, based on a regional distribution of fragility, and based on a regional distribution of population.
- I work over a wide range. For example to assess construction resources required to rebuild after a major earthquake
- Impact on the economy and its linkages to poverty and recovery
- Impact on the economy should include agriculture and domesticated animals.
- Insurance loss to multi-location policies or large single risks
- Interested in loss statistics from actual events and correlation of exposure-vulnerability-hazard, as well as predictions for specific scenarios
- Primary concern is with management of the emergency response, relief, recovery and reconstruction parameters
- Protecting life is always the highest priority but next comes loss of property under the broad heading of irreplaceable cultural patrimony.
- Provide all source code on the web page. Without the source code, GEM is useless.
- Schools destroyed and damaged will be special area of interest student death,injury and if possible nature of injuries also health units



Discussion: Number of buildings destroyed headed the list of Socio-economic needs, closely followed by several categories of mortality/morbidity, and then economic issues.

Interpretation: Socio-economic concerns cover a broad spectrum, and GEM should be structured so as to grow with the socio-economic community's involvement. That is, a flexible architecture should be developed that allows introduction of new socio-economic measures, and approaches to quantifying losses. This can be accommodated by encoding the option to save or output detailed intermediate and final results in text files or database tables, even if those detailed results are not of immediate use. If the detailed results are encoded in internal GEM database tables, then it will be important to design an API so that later GEM modules or outside software can access the results without the risk of corrupting the database. In the mean time, GEM can begin by estimating buildings destroyed, casualty estimates and economic impacts.

2.2.11 Question 11: What are your results format preferences?

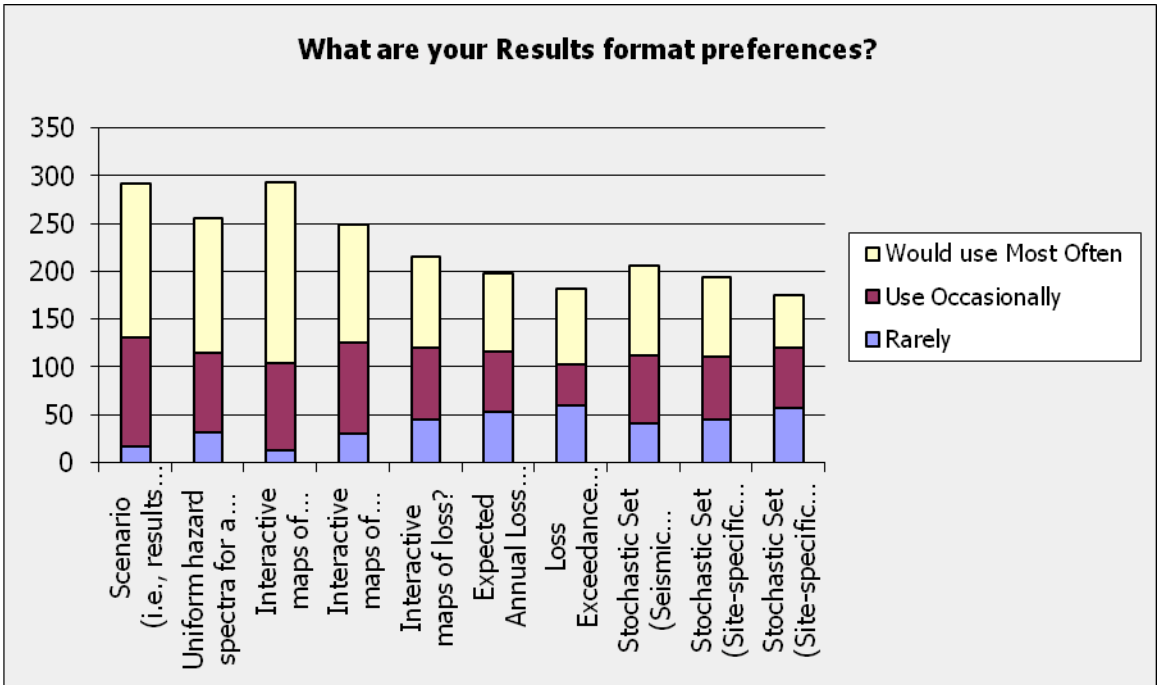
This question addressed results formatting needs.

Q11. What are your results format preferences?				
Answer Options	Would use Most Often	Use Occasion-ally	Rarely	Response Count
Interactive maps of hazard?	228	104	15	347
Scenario (i.e., results given a specified event)?	195	128	19	342
Uniform hazard spectra for a range of return periods?	170	99	36	305
Interactive maps of damage?	152	116	33	301
Interactive maps of loss?	118	93	50	261
Expected Annual Loss (i.e., the long term averaged loss per year, also termed pure premium)	100	78	64	242
Stochastic Set (Seismic Events)	110	88	44	242
Stochastic Set (Site-specific shaking measure)	95	85	50	230
Loss Exceedance Curve	95	55	72	222
Stochastic Set (Site-specific Damage/Loss)	65	81	63	209
Comments				15
answered question				414

Comments included:

- At this moment in time Swarms on the outside of the ring of fire is of great value, and Artic Ice movment, and the African Rift, Volcano associations. Swarms of depths, shallows, greater than 500'. Also there is a Great Need for sudden water drop inquiries, on lakes, and wells.
- I am very much interested in interfacing probabilistic response analyses I have developed with the GEM PSHA results for geotechnical problems. Since many geotechnical problems (e.g., liquefaction) are duration-dependent with magnitude being used as a proxy for duration, I need access to the disaggregation data (marginal distribution of magnitude for each return period considered). If this data can be output in a consistent format, it will allow my PB code to be used in conjunction with the GEM code. Alternatively, I would be happy to work with GEM to merge my code into the GEM product(s).
- In insurance/ reinsurance/ structured financial products the loss exceedance curve is the base from which the actual loss expectations to a contract are derived. So that is the main focus in that sector.

- Interactive maps of vulnerability trends, please. We know already a great deal about the hazard and damages, we urgently need to focus on vulnerability trends, and develop vulnerability and risk reduction policies and measures.
- Most of the above options relevant to us are offered by stochastic (and/or historic) Event Loss Tables, comprising the event definition (location, magnitude, rupture parameters) and a loss distribution for the respective scenario, which may provide a break down of cause of loss and affected type of exposure. Combined in a relational db, these results can easily coupled with event footprints (hazard/loss) and seismic hazard maps or seismotectonic maps.
- Most of us in the museum field found the old Zones 0,1,2 etc. map very useful for a simple guide to a region's earthquake susceptibility. I realize that this system was abandoned because it doesn't encompass the complexity of seismic activity, but it was very helpful for our purposes.
- None of the above - the input data are more important. For site studies it is incorrect to use a generic model. Source models should always be composed for the specific site/use.
- Overall event loss for each and every event in a stochastic set
- Provide all source code on the web page. without the source code, GEM is useless.
- The ability to compare losses of similar structures in similar geographic areas (to a clients facility) would provide more precise research data



Discussion: No clear preference emerged with regard to results format – different users expressed differing needs, and GEM should be able to provide either a base set of results that are readily adaptable to a wide variety of formats, or the software and interfaces to readily permit a wide variety of output formats.

Interpretation: GEM should provide either a base set of results that are readily adaptable to a wide variety of formats, or the software and interfaces to readily permit a wide variety of output formats. We suggest GEM revisit the data interchange formats to ensure that whichever ones GEM implements are sufficient to provide the necessary data for each of these outputs.

2.2.12 Question 12: In getting GEM results, what degree of Importance do you assign to (listed attributes):

This question sought to prioritize a number of "non-functional" aspects of the GEM interface, such as accuracy, uncertainty measures, graphical results, and so on ("non-functional" here as used for use cases, in the sense that the attribute is not a direct part of the business function, but rather enhances that function – of course, all of these attributes have useful functionality, in the broader context).

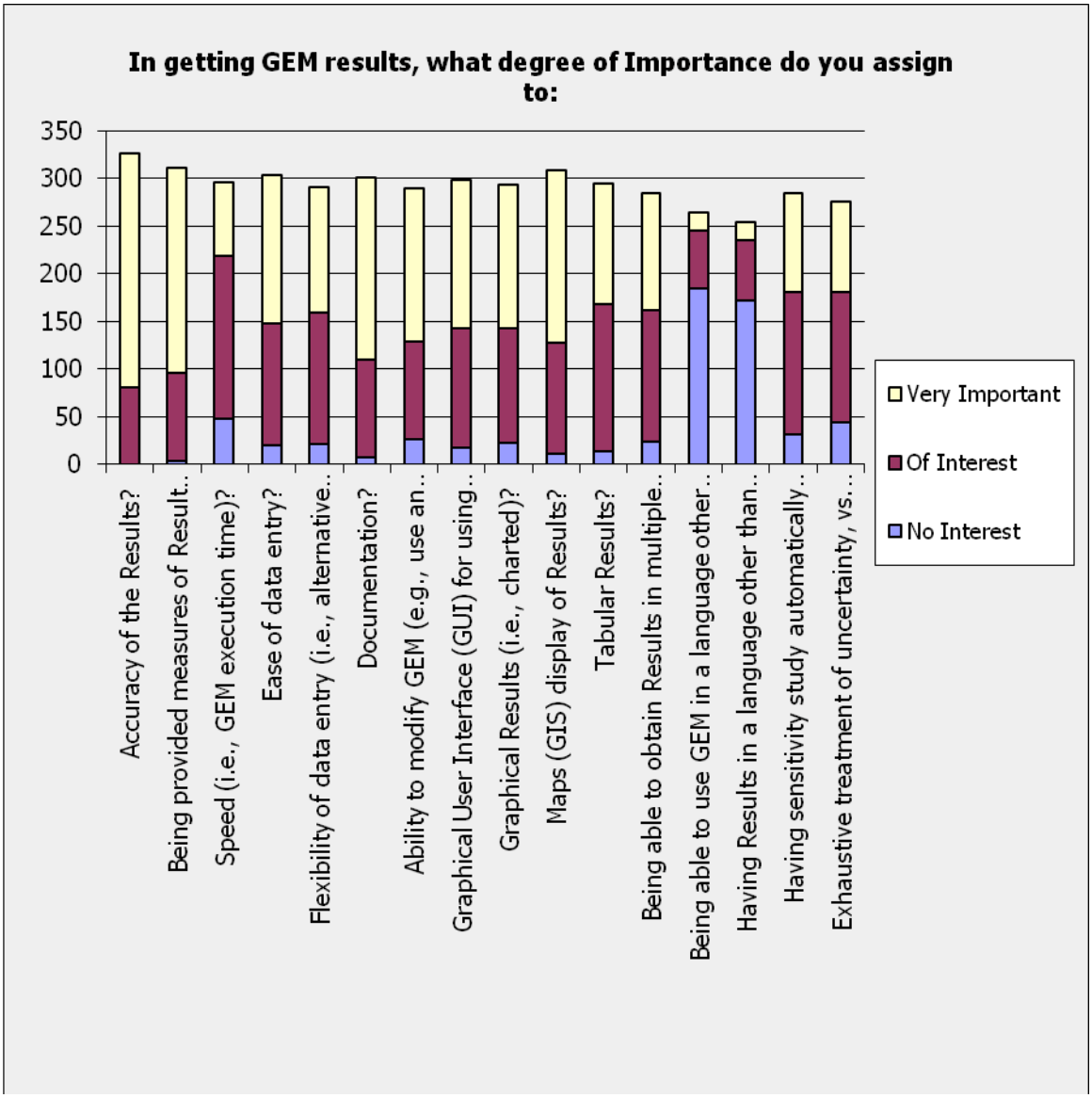
Q12. In getting GEM results, what degree of Importance do you assign to:

Answer Options	Very Important	Of Interest	No Interest	Response Count
Accuracy of the Results?	283	98	1	382
Being provided measures of Result uncertainty (e.g., confidence bounds)?	251	109	5	365
Maps (GIS) display of Results?	222	130	13	365
Documentation?	220	123	9	352
Ability to modify GEM (e.g., use an alternative attenuation equation, or damage function)?	198	118	29	345
Ease of data entry?	190	147	20	357
Graphical User Interface (GUI) for using GEM?	184	145	19	348
Graphical Results (i.e., charted)?	182	142	23	347
Flexibility of data entry (i.e., alternative ways to input data)?	159	158	24	341
Tabular Results?	154	174	17	345
Being able to obtain Results in multiple formats?	149	159	28	336
Having sensitivity study automatically generated (i.e., a report on the effect of different parameters on the Results)?	125	175	36	336
Exhaustive treatment of uncertainty, vs. simplified treatment?	117	161	47	325
Speed (i.e., GEM execution time)?	95	197	53	345
Being able to use GEM in a language other than English?	40	85	192	317
Having Results in a language other than English?	40	85	180	305
Comments	-	-	-	22
answered question	-	-		414

Comments included:

- Accuracy is important, of course, but I acknowledge that there are constraints dictated by the quality of available data.
- Accuracy is paramount. The hazards and vulnerabilities must be based upon the most up to date models.
- For the first question, accuracy is important, but precision less so.
- GEM needs to be fully open-source software and documented to the level that (academic) users can use parts of it for research and teaching purposes. In particular, support of open standards and open file formats is important to not exclude people from using it.
- Having transparency in ALL parameters and corresponding equations used.
- I want it all, really ;-)
- I would want to know how the results are generated and how certainty is determined, and what information helps to increase certainty of results
- I'm not sure this question will help very much in setting priorities. We all want everything. For example, of course we would want uncertainty to be treated "exhaustively" but this comes with a price. What level of resources would a user apply to it? It would be more instructive to the GEM staff to require responders to force-rank preferred features, or allocate a fixed number of "points" to each feature.
- It may be useful to keep data entry options consistent so users can learn the system once and not get confused.
- It's important to be able to integrate GEM results in other systems. Results should be available in XML format, or stored in a database accessible to other systems. Either an extension of GeoRSS or GML are good candidates.
- Language other than English: Italian
- None of the above - the input data are more important. For site studies it is incorrect to use a generic model. Source models should always be composed for the specific site/use.
- Provide all source code on the web page. without the source code, GEM is useless.
- The big thing GEM could provide would be a scientifically reviewed best estimate. making the modification easy is delegating the scientific decision back to the user. Output formats are easy to modify, so as long as the format is simple that part is user specific anyway. But the basic usage of GEM has to be simple and accessible to make GEM successfull.
- The most important thing GEM can do is to be modifiable by the user. i.e. not too difficult coding wise. i.e. not require a IT specialist to modify it.
- Use and results in Spanish would be very helpful.
- What is accuracy in such assessments? I think GEM should focus on getting good data on hazard and on asset vulnerability. This should be easily accessible and able to be worked on using whatever approach is appropriate for the user. I sense that GEM wants to develop an all-singing, all dancing model with so many things built in. I like to know what is going on and favour basic information. GEM should focus on these simple things rather than spend valuable time and resource on slick software. All too often researchers get carried away with the process of calculation and forget that assessment of effects of earthquakes on real buildings and infrastructure is an art not a science. The precision of the calculation process is not the same as the accuracy of

the answer. I urge GEM to focus first on broad brush information covering the world, rather than fine tuning the easy areas and leaving the harder areas untouched.



Discussion: This was a big question, from which the following Attributes were all identified as most Important, although all the Attributes are of value:

- Accuracy of the results
- Being provided measures of result uncertainty (e.g., confidence bounds)
- Maps (GIS) display of results
- Documentation
- Ability to modify GEM (e.g., use an alternative attenuation equation, or damage function)
- Ease of data entry

- Graphical user interface (GUI) for using GEM
- Graphical results (i.e., charted)
- Flexibility of data entry (i.e., alternative ways to input data)
- Tabular results
- Being able to obtain results in multiple formats

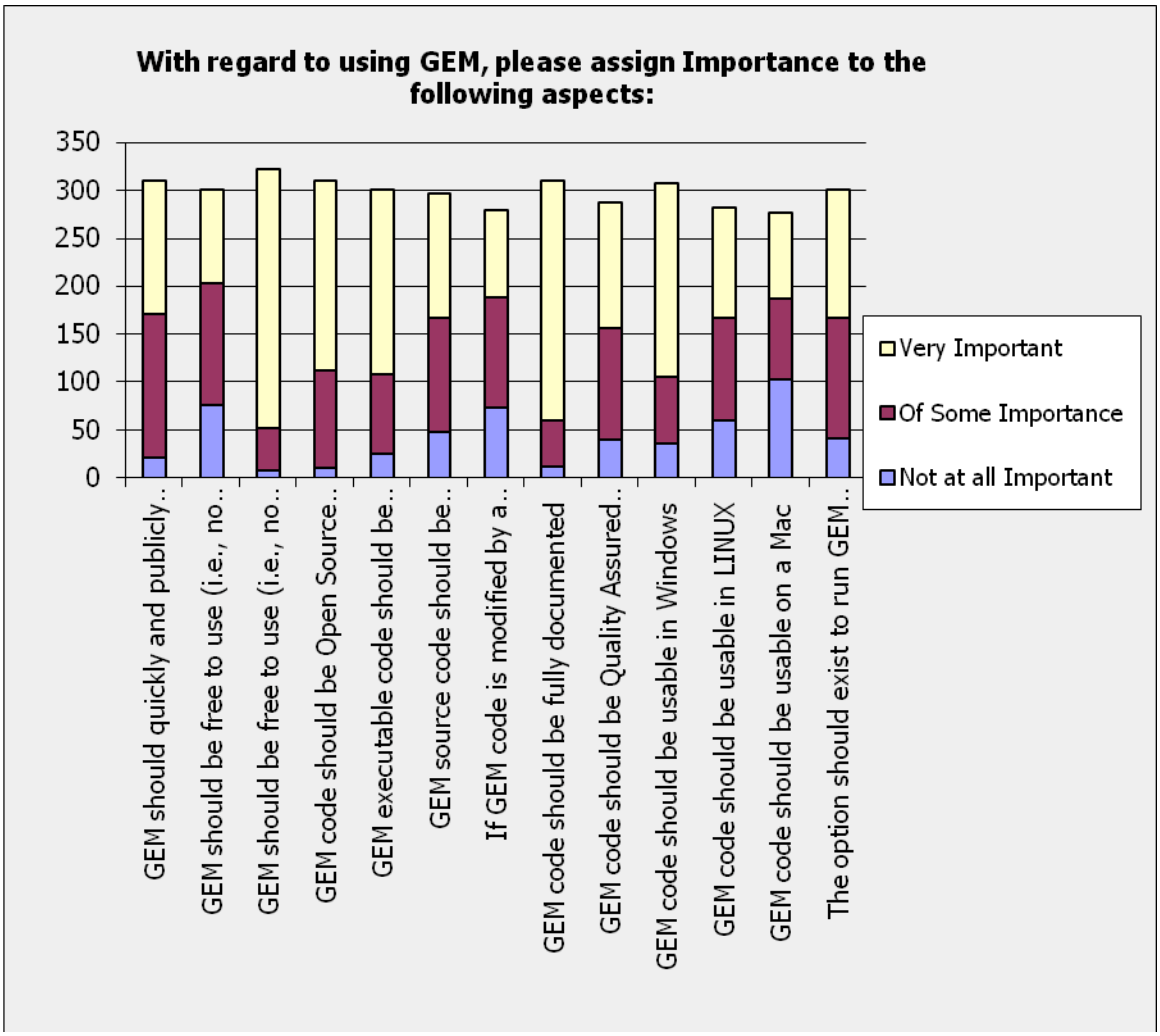
Interpretation: Accuracy, uncertainty quantification, good documentation, graphical results and user interface and flexibility of date entry and use are hallmarks of good software, which GEM should strive to provide. Each of these Attributes will need to be defined in the product requirements document, and followed throughout development.

2.2.13 Question 13: With regard to using GEM, please assign Importance to the following aspects (list of Attributes):

Analogous to the previous question, this question sought to assign priorities to a number of administrative or "business" aspects affecting users of GEM.

Q13. With regard to using GEM, please assign importance to the following aspects:

Answer Options	Very Important	Of Some Importance	Not at all Important	Response Count
GEM should be free to use (i.e., no cost) for ACADEMIC purposes (teaching, students, non-profit research)	326	49	7	382
GEM code should be fully documented	290	60	12	362
GEM code should be Open Source (ref: http://opensource.org/)	245	109	12	366
GEM code should be usable in Windows	244	77	40	361
GEM executable code should be downloadable for use on my own machine	235	91	26	352
GEM should quickly and publicly acknowledge uploaded code	168	173	24	365
GEM source code should be downloadable, so I can modify it	160	137	52	349
The option should exist to run GEM online (i.e., wthout downloading and installing)	159	145	47	351
GEM code should be Quality Assured (e.g., conform to ISO 9000)	153	133	50	336
GEM code should be usable in LINUX	135	125	71	331
GEM should be free to use (i.e., no cost) for COMMERCIAL purposes (i.e., for profit applications)	120	146	87	353
If GEM code is modified by a User, the User MUST upload modifications back to GEM	118	130	81	329
GEM code should be usable on a Mac	106	102	116	324
Comments	-	-	-	20
answered question	-	-		414



Comments included:

- An open source framework to add/expand/learn from new code would be highly valuable - to enlarge the contributing community as much as possible. I'd put more weight on the open source nature of the code than having multiple versions running on various IT platforms (contents before format).
- assuming that LINUX = UNIX, then by default it should include Macintosh
- Default worldwide building data is very important.
- Do not exaggerate on software development. The software cycle is so short. Better publish clearly the algorithms in scientific publications
- Free software to universities is often abused often not intentionally. So many university people are consulting that data that is free to universities should also be free to companies.
- Having the option to use GEM online is extremely important. Many developing countries may not have the capacity to download software and run it efficiently.
- I think the GEM should be focused on data (hazard and vulnerability) availability not methodologies for loss assessments. Acceptable methodologies (is that what you mean by coding?) could be outlined, leaving the user to choose options, or use their own software. Give people the materials and the tools to make their own product.

Don't attempt to deliver a whole range of finished products - it will take too long, cost too much and not really improve understanding of what is going on.

- If GEM is going to be useful in any way, there we will be intermediate to high requirements to the hardware where it can run. So the downloadability is of secondary relevance. Open source and documentation are core to the project, otherwise it is a commercial coproduction of the partners. To be accepted by the public and industry, there will be maintenance and distribution costs coming up. So commercial users should also contribute to these costs.
- If GEM is open source (as I understand it will be) then there cannot be any requirement for users to send in modified code. It also makes basically no sense for GEM to receive such modified codes.
- If there were an importance rating of "extra-super important," I would assign this value to the online option and nothing else. In the long run, this will be far and above the most valuable format for GEM use.
- If used in ISO 9000 -compliant processes, local QA procedures would demand full documentation of compliance and modification of code for specific internal use would likely be administratively onerous.
- Not clear what it means to "publicly acknowledge code".
- Our project is largely based on other open source software so it is easy and cheap to share with partner organizations.
- Particular attention should be paid to editable code. Modifications should be possible on specific routines which could then possibly recompiled via uploading. In this way the use of user defined routines should be made evident (e.g. by graphical warnings, etc.) to the end user.
- Provide all source code on the web page. without the source code, GEM is useless.
- The input data are more important. For site studies it is incorrect to use a generic model. Source models should always be composed for the specific site/use. Therefore running GEM software is not really valuable.
- With respect to: "If GEM code is modified by a user, the user MUST upload modifications back to GEM": Not sure what this means. There needs to be a single revision controlled version of GEM that is not subject to revision by users. If users wish to develop additional code, then they should have to option to test it, document it, and submit it as a potential enhancement. The main GEM code should have a way to interface user codes that meet certain specifications.

Discussion: This was a big question, from which the following Attributes were all identified as most important, although all the attributes are of value:

- GEM should be free to use (i.e., no cost) for ACADEMIC purposes (teaching, students, non-profit research)
- GEM code should be fully documented
- GEM code should be usable in Windows
- GEM code should be open source (ref: http://opensource.org/)
- GEM executable code should be downloadable for use on my own machine

Interpretation: The responses reflect a general understanding that GEM has committed to free (at least for non-commercial users), well documented, readily accessible, open-source software. GEM should strive to meet these expectations. Each of these attributes will need to be defined in the product requirements document and GEM's business plan, and followed throughout development. While "open source," "free," and Windows-compatible are fairly (though not completely) unambiguous, there can be a good deal of subjectivity to what constitutes "fully documented" code; it is easy to produce useless Javadocs. We suggest GEM consider empanelling an independent software review committee that reports to regularly on how well documented the code is.

2.2.14 Question 14: Any analysis requires data. What is your current situation regarding data?

This question examined the state of user's data.

Comments included:

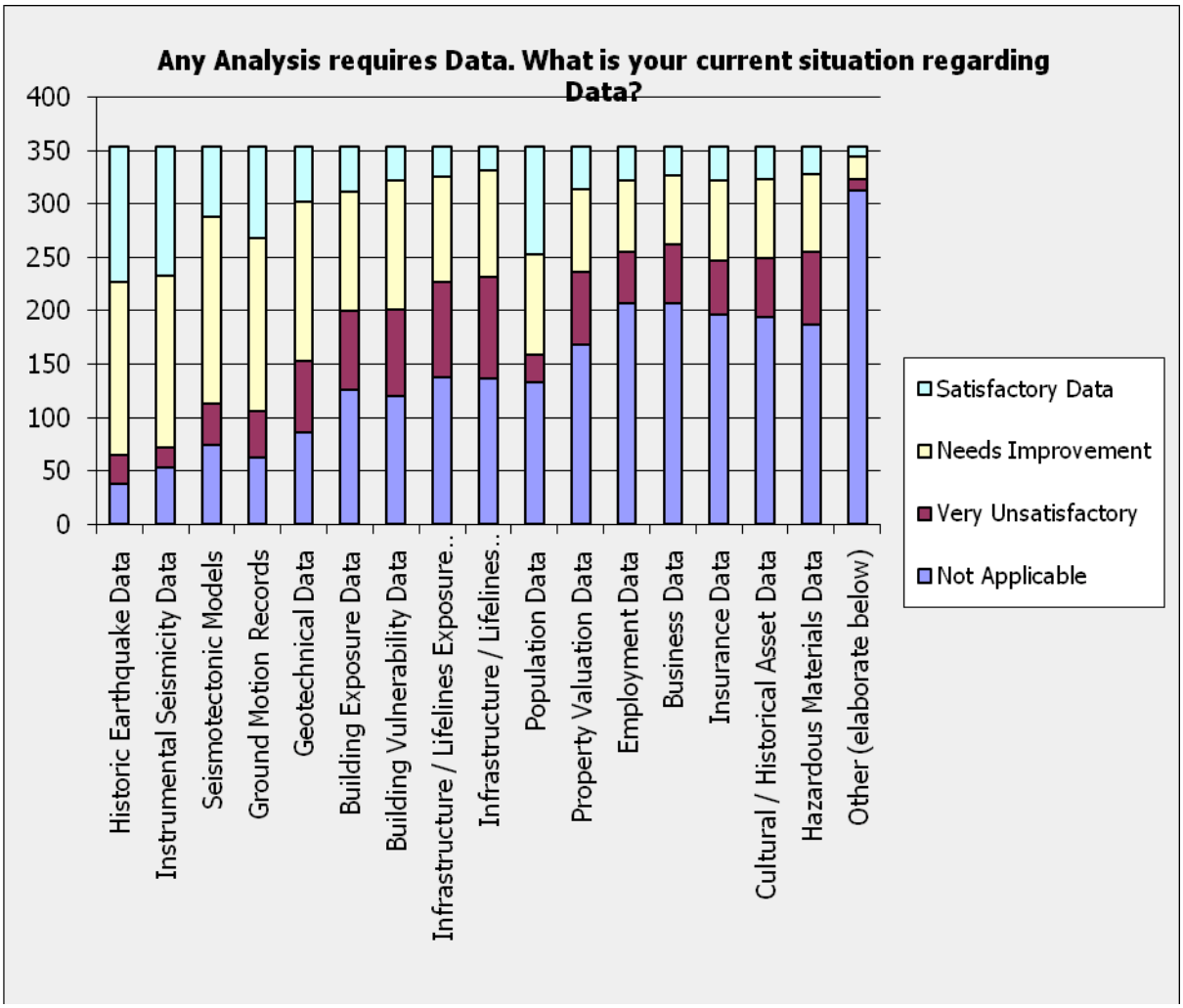
- Active fault models - needs improvement
- Answers apply to Australia, but not to other countries in region, where the exposure and vulnerability data in particular are lacking.
- Building stock and historic loss information is only available in very bad quality. Insurers and reinsurers have done a very bad job of keeping the information of what was insured and what the losses to these values are together.
- Critical facilities
- Dams, nuclear power plants
- Data should be bilateral in content.
- Doesn't this depend entirely on where my project is? I'm generally satisfied with the data available in California, but if I had to solve a problem elsewhere I might find the data "very unsatisfactory".
- Don't collect or analyze data in raw form - need analysis and actuality reports in respect of consequences!!
- Fragility of nonstructural components required for continued operation of critical facilities.
- Historic disaster database: past tsunamis, landslides, etc.
- I am referring to data specific to the Comoros - very little is available.
- I can't answer this question as the quality of data depends on where you are in the world. In some places data is good in others not so.
- Investment data and detailed demographic data (population characteristics etc)
- Response infrastructure (nearby airports for cargo planes, hospitals, emergency services, etc.)
- We do not carry out seismic hazard analyses. We sub-contract those analyses and use the outputs for structural/earthquake engineering design.

The following table is sorted in descending order of "very unsatisfactory", so that the topmost item is the most in need of improvement, from a pure data perspective.

Q14. Any analysis requires data. What is your current situation regarding data?					
Answer Options	Satisfa-ctory data	Needs improve-ment	Very unsatis-factory	Not appli-cable	Response count
Infrastructure / Lifelines Vulnerability Data	25	120	113	156	414
Infrastructure / Lifelines Exposure Data	30	122	106	156	414
Building Vulnerability Data	39	143	99	133	414
Building Exposure Data	51	137	91	135	414
Hazardous Materials Data	29	89	87	209	414
Property Valuation Data	46	99	84	185	414
Geotechnical Data	60	187	75	92	414
Cultural / Historical Asset Data	37	96	72	209	414
Business Data	28	76	61	224	389
Insurance Data	40	91	61	222	414
Employment Data	40	83	57	234	414
Ground Motion Records	99	201	48	66	414
Seismotectonic Models	81	211	43	79	414
Historic Earthquake Data	151	195	29	39	414
Population Data	120	116	28	150	414
Instrumental Seismicity Data	139	197	22	56	414
Other (elaborate below)	10	27	13	364	414
Comments	-	-	-	-	30
answered question	-	-	-		414

Discussion: Physical infrastructure (including building) exposure and vulnerability data appears most in need of improvement.

Interpretation: GEM should devote considerable effort to developing a robust database and diverse methods related to exposure and vulnerability of physical infrastructure (including buildings).



2.2.15 Question 15: Regarding GEM's Interface

This question sought to explore GEM's interface.

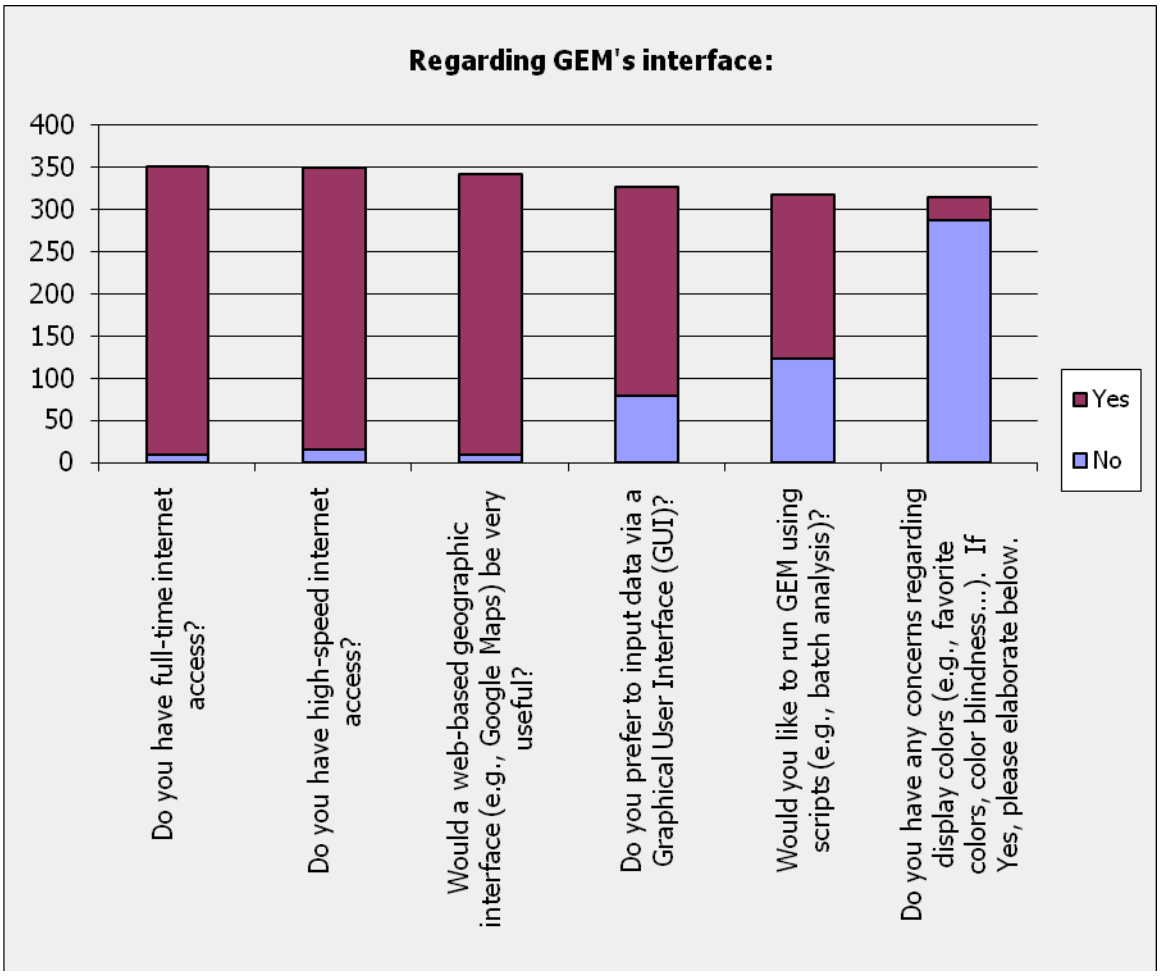
Q15. Regarding GEM's interface:			
Answer Options	Yes	No	Response Count
Do you have full-time internet access?	400	11	411
Do you have high-speed internet access?	390	19	409
Would a web-based geographic interface (e.g., Google Maps) be very useful?	387	15	402
Do you prefer to input data via a Graphical User Interface (GUI)?	296	88	384
Would you like to run GEM using scripts (e.g., batch analysis)?	228	144	372
Do you have any concerns regarding display colors (e.g., favorite colors, color blindness...). If Yes, please elaborate below.	35	334	369
Comments	-	-	24
answered question	-		414

Comments included:

- A couple colleagues are red-green colourblind. Also, I like to have control over colours to coordinate with standards used in my work.
- Actually not sure what Graphical User Interface is, but it sounds helpful. also not sure what batch analysis is, but it also sounds helpful.
- Am red-green colour blind. If possible options / colour schemes should be used to minimize the impact of this. It would also be good to plan the GEM display so that it will print clearly in black and white.
- Are you really asking the users what color the GUI should be? Come on... You can always count on 10% of the male population being red-green colorblind, and a higher percentage among the technical community.
- Availability as a web service is important. For instance as a OGC WPS (Web Processing Service). This will allow the use of the software in a system of systems.
- Avoid low contrast colour combinations (e.g. yellow and white, red and brown together)
- Bing (Microsoft maps) is an alternative to google maps. Use of well thought out map elements is important, e.g. see colorbrewer.
- Color blindness could be an issue. The display should be readable by older analyst with less than perfect vision. Variable screen resolution is a good feature.
- Color schemes are easy enough to modify at run time. Having settings that read preferences is just good form.
- Display colors must be EASY to differentiate: Optimum contrast.
- For colors, it would be better to write your application in a platform-independent way so that it not only works on any operating system but also takes on the look and feel (including colors) of the window manager in the user's operating system.
- For governmental and insurance use there will be large datasets to be uploaded, e.g. 10% of a countries building by location. So a good upload process to the databases for processing will be very relevant, much more than the entry of an individual object.
- GUI input is necessary for GEM to gain popularity. Batch analysis is necessary for experts to use the software efficiently.
- I am color blind so large color contrast will be needed
- I am red green color blind. I call people over to help me differentiate colors. It would be nice to have a tool to hover over a point to tell me the value rather than to use dithering in many instances.
- I have internet service but only during office hour and of low speed.
- I prefer dark colors. I prefer light letters and lines on a dark background.
- Really a question of development cost and efficiency
- red-green color blind
- Using Google Maps would completely jeopardize the open-source character of GEM. No component of GEM should be dependent on a commercial product or a service that can change their policies. There is NO guarantee that Google Maps will stay open. Furthermore, given the interest of Google in collecting data, I consider it irresponsible in using such a service for a policy-relevant product like GEM.
- Who would not prefer GUI? Most of us would prefer a high quality car to a low quality car that does the job but does not make us feel so good. (I am not sure exactly what GUI is, but I would guess it involves a lot more software development.)

Discussion: As with most of the questions, the comments vary widely – interestingly, some dismissed the issue of color, yet of the 414 respondents, four indicated red-green colorblindness (lower than the 7 to 10% in the male population). In any event, color schemes are a standard part of software design, with Microsoft and other standards readily available. While respondents of course had to have some web access in order to answer the survey, most in fact indicated they had good access, and that a geographic interface and batch capability would be very desirable.

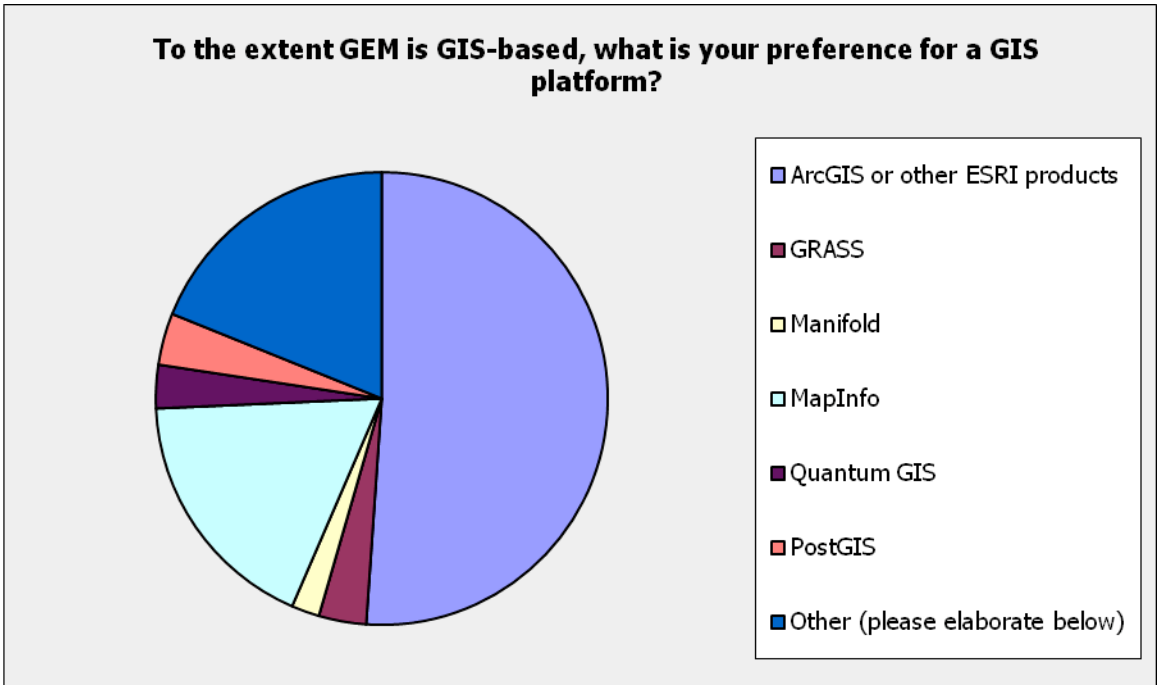
Interpretation: A geographic interface and batch capability are desirable attributes for GEM's interface.



2.2.16 Question 16: To the extent GEM is GIS-based, what is your preference for a GIS platform?

This question addressed what GIS platform is most preferred among the respondents.

Q16. To the extent GEM is GIS-based, what is your preference for a GIS platform?	
Answer Options	Response Count
ArcGIS or other ESRI products	211
GRASS	14
Manifold	7
MapInfo	77
Quantum GIS	14
PostGIS	15
Other (please elaborate below)	76
Comments	77
answered question	414



Comments included:

- again for Comoros, GIS not applicable
- Although GEM should create products readable by popular GIS packages, it should have no dependence on any commercial GIS package.
- any Mac friendly platform
- Any open-source GIS packae

- At this point I am not familiar enough with GIS. But, whatever platform is used, it must be user friendly, intuitive....
- Could you make it simple? Could it possible to use without specialized software, so perhaps through something like Google Maps?
- don' t know
- Don't know any of these softwares.
- Don't know.
- ESRI more widely used by universities, and ESRI files can be easily imported in MapInfo. MapInfo is second choice.
- free software
- GEM should also be made with interfaces to make it usable with tools like GMT (Generic Mapping Tools)
- GMT would be more useful. It's a bit nefarious that so much of the community relies exclusively on commercial GIS software.
- GMT, GeoMapApp, GeoCap
- Google Earth
- Google Earth
- Google Earth
- I am not familiar with any of the above platforms
- I am not familiar with the others, but if any of them are free, I could see that as a viable alternative.
- I am not familiar with these different programs, but the most important thing is that it is a widely available and affordable program.
- I am not familiar with these systems.
- I am not very familiar with the platform yet.
- I can't decide
- I do not now much about GIS systems but I would recommend the open source WorldWind.
- I do not use GIS
- I don't know
- I have no preference
- I prefer a lower end delivery platform such as googlemaps. We have an out of date version of Map info. Ther rest are either too expensive to maintain or unknown to us.
- I use MapInfo, and have GRASS, but am willing to change
- In order to have a full distribution, free and open source softwares are preferable
- Include surfer and GMT formats - surfer is simple program, relatively cheap, easy to use for students.
- KML- For use on Google-earth
- Matlab Mapping Toolbox
- N/A
- no experience with GIS
- No experience with GIS systems but if GEM runs on one it must be free, in order to be consistent with GEM principles.
- No preference at this time. Contenders are probably GRASS and Quantum GIS because they run on Linux.
- No preference, except that I prefer platforms that can run on Mac.
- No preference.
- None in particular

- None, don't use commercial GIS
- Not a particular preference, but we own Mapinfo licenses.
- Not acquainted with these systems
- Not determined at this time
- Not familiar with GIS
- OGC compliant custom applications.
- Open GIS platforms developed for online usage
- Open Source GIS
- Open Source GIS - not PostGIS as it is mostly involved with Linux. Use IlwisOpen or uGIS.
- Open Source ONLY. any public domain software to a 3rd party vendor restricts its use by about a factor of 10. On the other hand, widespread use of an untested and illogical and error-filled piece of software is also problematic.
- Open source products would be valuable to developing countries in the region.
- OpenGIS
- Really not a big item as long as it is easy to use and transfer data and results to others
- Some general text format that can be loaded into any program (ie, Matlab)
- Something free
- something open source
- The GIS platform should be fully open source and supported on multiple platforms. Otherwise, the use of GEM in developing countries will be impossible.
- the most easy to get and the less expensive
- Use shapefiles as exchange format
- Usually does not matter.
- Web-mounted Geographical data services, especially WFS
- Would be good to see close integration with Generic Mapping Tools

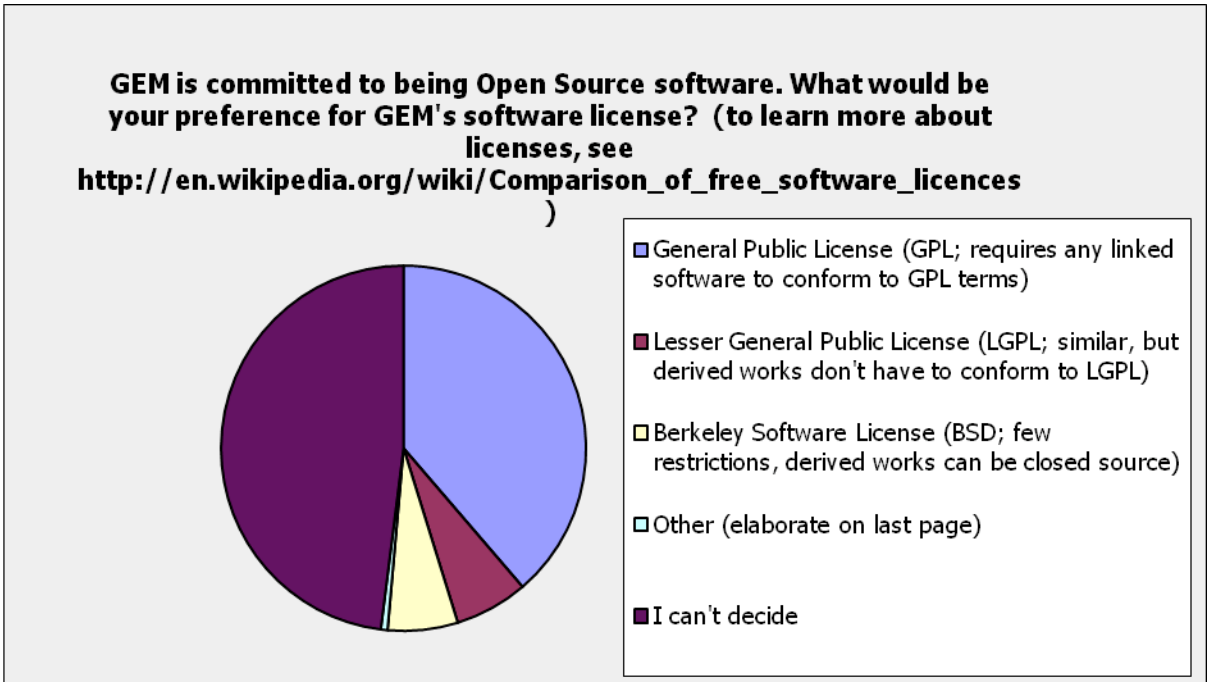
Discussion: About half of respondents indicated they currently employ an ESRI product, with the other half spread across a wide variety of other products and appearing to have cost constraints that preclude ESRI usage. The comments indicate quite a few (more than 10%) quite unfamiliar with GIS at all. This will be a difficult issue for GEM since GIS is more or less a common technology that is difficult to do without, yet being tied into a proprietary product will inevitably result in constraints for users.

Interpretation: About half of respondents employ ESRI products. The choice of GIS interface for GEM will need further study, but GEM should consider at least providing output GIS files that are accessible to non-ESRI packages. We suggest the output data files comply with the standards offered by the Open Geospatial Consortium (e.g., http://www.opengeospatial.org/standards).

2.2.17 Question 17: GEM is committed to being Open Source software. What would be your preference for GEM's software license?

This question asked respondent's their wishes regarding Open Source license.

Q17. GEM is committed to being Open Source software. What would be your preference for GEM's software license?	
Answer Options	Response Count
General Public License (GPL; requires any linked software to conform to GPL terms)	163
Lesser General Public License (LGPL; similar, but derived works don't have to conform to LGPL)	30
Berkeley Software License (BSD; few restrictions, derived works can be closed source)	25
Other (elaborate on last page)	2
I can't decide	194
answered question	414



Discussion: No comments were sought for this question. The respondents basically split between "Can't Decide" which probably indicated insufficient knowledge, and choosing the GPL license.

Interpretation: GPL is the respondent's choice for an open source license, to the extent they feel qualified to comment. This is an important question with implications for software

adopted from other sources, e.g., OpenSHA. It also relates to whether and how GEM wishes its software to fit into the broader risk-software ecology. Adopting GPL will tend to isolate GEM from commercial cat modelers, which could be a good thing or a bad thing. Commercial cat modelers will not be able to grab GEM code and bury it in their proprietary software, but on the other hand they may re-code GEM algorithms and claim to have improved upon GEM. In either case, adopting GPL may promote an adversarial relationship with commercial cat modelers. GEM leadership should carefully consider the license issue, in consultation with intellectual property lawyers and with the architects of other software developed in a similar, potentially competitive environment such as open-source GIS.

2.2.18 Last Comments

Lastly, respondents were given an opportunity for any last comments, which included the following:

- Before I would consider using GEM it would have to be faster and more convenient than spreadsheet & fortran applications that I have written.
- Being from a field of Engineering Seismology with professional experience of over 17 years, I would love to work for GEM. I wish a good luck to GEM foundation for taking up this mammoth task of developing Global Earthquake Model to serve the mankind.
- Do you track whether answers come from GEM participants or "the outside world" - GEM probable customers?
- Exciting project, looking forward to working with it.
- From the survey, the value of GEMS as a TEACHING tool appears to be underestimated.
- GEM should be open-source and Public-Domain, with no restrictions on incorporation into commercial software.
- Good luck!
- great initiative -- I hope it is successful! If so, I will have a PhD student take a careful look at it and work with GEM software.
- Great Work!
- I am eager to see the GEM in place !! Wishing all the best...
- I need technical details regarding the model development (not the coding but various functions such as attenuation functions, wave propagation, building damage functions and likewise)
- I think that because of self-organized criticality, the whole concept of GEM is baseless.
- If GEM encourages people to think that a generic model can be used for site-specific tasks, it will be a very bad thing. This is quite contrary to all guidance on best practice.
- In the next round of the UNA, I hope the survey is distributes broadly to lay users, so that GEM doesn't suffer the fate of "by engineers (and scientists), for engineers (and

scientists)." Also, consider using Survey Monkey or something similar, for ease of responding. [*Editor comment: the survey was on the SurveyMonkey website]*.
- It is happy to see developing Gobal Earthquake model for better humanitarian
- it is hoped that this survey may be useful for mankind in future
- It is important to use the GPL license to ensure that further GEM developments will stay open source. Otherwise, GEM may end providing a great tool after 5 years and from there on companies will take the code and develop it further without providing the users with the source. In such a case, GEM would have been simply a facilitator for commercial hazard- and risk-assessment tools. From the public perspective, this would be a waste of money.
- It is very import that GEM provides seismic hazard and risk information based on sound sciences and engineering. It is of great concern that GEM uses PSHA that is not consistent with modern earthquake science.
- Keep up the great work. The world needs GEM!
- Seismo-tectonic models should be easily configurable using a standard format that can then be uploaded by users to help assemble a global model. A wiki-type forum could be used to modify and improve the seismo-tectonic models with time.
- Siempre es un agrado poder contribuir para la mejora de la generaciÃ³n de conocimiento, mÃ¡s cuando este tiene la finalidad de hacerse llegar al pÃºblico general y contribuir con la enseÃ±anza. Quedo a sus Ã³rdenes en caso de que requieran alguna informaciÃ³n adicional con la que pueda contribuir al correo electrÃ³nico:
- Something like GEM would be very useful for all regions of the world and particularly for those countries which are not able to study in detail about their geological risk, hazards and vulnerability and impacts etc.
- thank you for consulting our opinion.
- This is a good initiative. Keep it simple and dynamic. Best wishes
- Transparency is important. Fully documented models with code are critical.
- Use Creative Commons copyright license.

Interpretation: GEM is positively seen by the user community, but some skepticism exists, not so much about motives but more about being able to accomplish and maintain GEM's ambitious agenda. Users want to see GEM avoid commercial and administrative pitfalls, and want to see GEM succeed.

2.3 Key Findings

Based on our interpretation of the user survey, the following key points emerge:

- GEM should be multilingual. Japanese and Spanish are the 2nd and 3rd-most preferred languages among survey respondents, respectively, after English.
- Academics and consultants (specializing in the three domains of hazard, risk and socio-economics) are currently GEM's core constituency, with their primary interest being a multiple site (i.e., portfolio) probabilistic analysis capability, for shaking and

as many hazards as GEM's resources permit, for existing buildings and infrastructure. Government officials and Insurance Industry professionals are the next largest segments of the user community, and their needs can probably be met by focusing on academic's and consultant's needs, but will also need (a) canned explanatory material and (b) identifying consensus options, i.e., choices that are endorsed by the majority of experts. To garner consensus efficiently, with some accountability, consider using a web-based approach such as SurveyMonkey without an option for anonymity. Alternatively, Tuomisto (2009) described an open-ended wiki-based approach entitled OpaNET.

- A substantial portion of the current GEM user community is technically sophisticated, implying that GEM's development strategy might first focus on a more sophisticated product first, with a more simplified perhaps pruned-down "GEM-lite" product for use by lay users developed later. In intermediate approach to lay users could be to offer case studies with step-by-step examples to guide the lay user through common hazard or risk decision analyses.
- The Socio-economic message emerging from the survey is weak, due perhaps in part to the timing of GEM's outreach to that segment of its user community. In order to serve this segment, GEM should be structured so as to grow with the Socio-economic community's involvement, but GEM should begin now with a capability to estimate buildings destroyed, casualties and economic impacts. It should include options to output detailed results that anticipate future needs for socioeconomic analysis.
- In order to reach decision-makers, GEM's results packages will need careful study, and should probably be based on a base data set that is readily adaptable to a wide variety of formats, or GEM will need software and interfaces that readily permit a wide variety of output formats. GEM should provide its users with results that are directly usable by decision-makers, meaning 'big picture' summary financial and casualty results, effectively communicated in summary tables, maps and figures, with "canned," brief explanations of the meaning of the summary information. This argues for a powerful graphical and GIS backend for GEM.
- Half of survey respondents need GIS in some format other than ESRI. This argues for complying with OpenGIS standards and specifications.

- Accuracy, uncertainty quantification, good documentation, graphical results and user interface and flexibility of data entry and use are all attributes GEM will need to provide. Each of these attributes will need to be defined in the product requirements document, and followed throughout development. Quantifying accuracy probably needs ongoing verification and validation efforts. Uncertainty quantification and the need for portfolio risk analysis have major implications for speed and the choice among competing uncertainty propagation methods. Consider a separate, thorough study of the choice among, and various means of implementing, Monte Carlo, Latin Hypercube, moment matching, etc., Good documentation, particularly of code, may need an independent software review panel.
- Other features or products that the user community would like to have are a satisfactory exposure and vulnerability database and methods related to physical infrastructure (including buildings), a geographic interface, and a batch processing capability. The user community also feels strongly that GEM should be open source, with the GPL license being the respondent's choice for an open source license, to the extent they feel qualified to comment. (This decision is potentially fraught with implications for GEM's relationship with commercial catastrophe models, and should be carefully considered by GEM leadership in consultation with intellectual property lawyers and possibly with architects of other open-source software developed in a potentially competitive environment such as open-source GIS.)
- Lastly, GEM is positively seen by the user community, but some skepticism exists, not so much about motives but more about being able to accomplish and maintain GEM's ambitious agenda. Users want to see GEM avoid commercial and administrative pitfalls, and want to see GEM succeed.

3 GEM USE CASESIntroduction

This section presents use cases for GEM. As discussed above, use cases describe "who" can do "what" with the system, with the emphasis in this section on the "what". Most of the following use cases can be of interest for both single-asset and portfolio calculation, where a portfolio is a collection of assets, typically at different locations. Portfolio calculations would typically be done with a portfolio data input file and an interactive control. Less common would be a portfolio input file and a batch command file. Least common for portfolio calculation would be interactive portfolio input and an interactive control.

The following use cases simply specify the input and output, and omit the more detailed steps and sequence of enter the inputs, causing the calculation to initiate, monitoring progress, and the precise appearance of the outputs. In general, wherever results could be displayed in a curve or table, GEM should offer both output formats. We envisage each GEM use case being implemented within a "calculator," in the sense as used in OpenSHA. For example, the single-asset benefit-cost-ratio use case would be encoded in a single-asset BCR calculator. We anticipate that steps of data entry are largely already dictated by OpenSRA developments to date, and focus here solely on the kinds of calculators needed by users. For ease of reference, use cases are also tabulated in Table 1, which clearly shown users, inputs and outputs.

The following abbreviations are used:

BCR = benefit-cost ratio

EAL = expected annualized loss

ERF = earthquake rupture forecast

GMPE = ground-motion prediction equation, aka intensity measure relationship, aka attenuation equations

IML = intensity measure level

IMT = intensity measure type

lat = decimal degrees latitude north

lon = decimal degrees longitude east

LEC = Loss Exceedance Curve

lnmean(x) = expected value of the natural logarithm of x

lnstdev(x) = standard deviation of the natural logarithm of x

NEHRP = (US) National Earthquake Hazard Reduction Program

Vs30 = average shearwave velocity in the top 30m of soil, m/sec

3.2 Use Cases

In the section, three categories of use cases are presented: Site Attributes, Hazard, and Risk. Defining location is fundamental to almost all use cases, and is ideally defined in terms of latitude and longitude of the site. Alternative methods to define location would be via address and geolocator software, or via a aerial photo/map software such as Google Maps.

3.2.1 Site attributes

The following use cases involve site attributes.

3.2.1.1 Site attributes lookup.

Given location defined via latitude and longitude (or via Google Maps and/or address), the following data are returned:

- VS30,
- NEHRP site soil class,
- topographic slope,
- zonation per applicable design codes (e.g., national building code), and
- (optionally) a list of all soil boring logs within a settable distance R from the site. (This last anticipates a future point in time when soil boring logs can be uploaded to GEM either as scanned images or in some standard text format).

Users would be engineers, owners and insurers.

3.2.1.2 Site attribute uploader.

User enters location as above plus soil boring data (e.g., SPT or CPT versus depth, depth to water, date of test, etc., formatted per a GEM standard format) and calculator updates a selected soil map [such as (Allen and Wald, 2007)] analogously to how ShakeMaps are adjusted based on instrumental intensity.

Users would be engineers. This is a product for the mid-term future, i.e. 5+ years away.

3.2.2 Hazard calculations

The following use cases involve seismic hazard.

3.2.2.1 Historical catalog.

Given location, IMT, and IML, list all events in a catalog of ShakeMaps causing mean shaking intensity > IML. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.2 Hazard curve calculator.

Return hazard curve, Given location, GMPE, ERF, IMT, choice of probability + time period vs. frequency, and optionally soil type (Vs30 or NEHRP site soil class). If soil is not given, look it up from internal soil database. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.3 Invert hazard given probability.

Like hazard curve calculator, but given probability and time return only corresponding IML Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.4 Invert hazard at frequency.

Like hazard curve calculator, but given mean frequency return only corresponding IML. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.5 Evaluate hazard probability at IML.

Like hazard curve calculator, but given IML return probability for specified time. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.6 Evaluate hazard frequency at IML.

Like hazard curve calculator, but given IML, provide frequency. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.7 Hazard deaggregation bar chart.

Given location, IMT, IML, and optionally soil type (Vs30, NEHRP, etc.), deaggregate hazard: return bar chart of contribution to total probability or frequency of exceeding that IML by M, R, and optionally interevent term. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.8 Hazard deaggregarion map.

Like hazard deaggregation bar chart, but rather than plotted on a graph, show a Google Earth map with bars located at midpoints of sources. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.9 Interpolate design map.

Return design value(s), Given location, and other adjustable parameters defined by the design map. ("Adjustable parameters" is a term used in OpenSHA to indicate a parameter defined by a particular GMPE or ERF as required for carrying out a calculation.). Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.10 Source map.

Show an interactive Google Earth map of sources in an ERF. Each item is clickable to display relevant data, e.g., name, geologic era of most recent activity, authority providing the data, etc. Break layers into eras of activity, e.g., so that one can see only sources with historic activity. Whenever data is displayed, include a clickable link for downloading layer data in a table or other document. Users would be Seismologists, Engineers, Planners, Owners, Insurers.

3.2.2.11 Soil map.

Like source map, but soil. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.12 Catalog map.

Like source map, but historic earthquake catalog. Catalog is broken into several layers, perhaps by geographic region, year or decade, magnitude, etc. (Filled colored circles, footballs?). Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials including emergency planners and responders.

3.2.2.13 Exhaustive event set shaking calculator.

Return a list of all events (source number, rupture number) in an ERF capable of exceeding a specified lnmean(IML) at specified locations, given one or more specified GMPE. Return a table with source number, rupture number, occurrence frequency, GMPE ID, site ID, magnitude, distance, IMT, lnmean(IML), total lnstdev(IML), interevent lnstdev(IML). This is the OpenSHA event-set calculator. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.14 Synthetic event set shaking calculator.

Generate a synthetic catalog of events within a specified distance of specified sites, for a specified length of time, consistent with an ERF. Inputs and returns are like event set shaking

calculator, but with year/date/time instead of occurrence frequency. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.15 Synthetic event set.

Like synthetic event set shaking calculator, but return only a table with source number, rupture number, year/date/time, magnitude, interevent term. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.2.16 Hazard product catalog.

Show a catalog of all GEM data hazard projects with clickable links to download interim or final reports along with any electronic tables or other files delivered by the project. Users would be Seismologists, Engineers, Owners, Insurers.

3.2.3 Risk calculations

3.2.3.1 Risk product catalog.

Like hazard product catalog, but for risk. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials including emergency planners and responders.

3.2.3.2 Single-asset BCR calculator.

Like the OpenRisk BCR calculator: given ERF, GMPE, lat, lon, asset type & replacement cost before retrofit, asset type & replacement cost after retrofit, retrofit cost, discount rate, planning period, calculate benefit-cost ratio. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.3 Single-asset scenario loss calculator.

Given ERF, GMPE, lat, lon, asset type & replacement cost, source ID (possibly selected interactively on map), rupture ID (ditto), calculate mean and stdev or lnstdev (and possibly higher moments) of loss. Return occurrence frequency (or probability in 1 yr) of source-ID-rupture-ID combination. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.4 Single-asset LEC calculator by hazard curve.

Given location, asset type & replacement cost (V), and selection of a gridded seismic hazard map, calculate the frequency (or alternatively probability in time t) with which loss is

exceeded, as a function of loss. Use the gridded seismic hazard in the calculation. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.5 Portfolio scenario loss calculator.

Given ERF, GMPE, portfolio data file, source ID (possibly selected interactively on map), rupture ID (ditto), calculate mean and stdev or lnstdev (and possibly higher moments) of portfolio loss. Output table of loss by asset: asset ID, asset type, asset replacement cost, soil type, distance, mean loss, lnstdev of loss. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.6 Portfolio scenario loss mapper.

Show results of portfolio scenario loss calculator in Google Earth. Show each asset as a filled circle whose diam is proportional to the log of replacement cost and whose fill color from cold to hot is proportional to the log of loss. Both scales (replacement cost and loss) can have settings adjusted by user, i.e., log versus real, lower bound value, upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.7 Portfolio scenario damage-state calculator.

Given ERF, GMPE, and portfolio data file, calculate for each asset the probability of being in specified damage states. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.8 Portfolio scenario damage-state mapper.

Given rsults of portfolio scenario damage-state calculator, map most-likely damage state of each asset. Show each asset as a filled circle whose diameter is proportional to the log of replacement cost and whose fill color from cold to hot is in order of damage state. Rreplacement-cost scale can have settings adjusted by user, i.e., log versus real, lower bound value, upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical. Results also shown in table, with asset ID, lat, lon, replacememt cost, most likely damage state, and damage-state probability. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.9 Portfolio LEC calculator (exhaustive).

Given ERF, GMPE, and portfolio data file, calculate frequency (or probability in 1 yr) with which a single event causes portfolio loss of value L versus loss. Also output list of events (source ID + rupture ID) with median and lnstdev of portfolio loss. Integrate over the exhaustive event set. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.10 Portfolio LEC calculator (synthetic).

Portfolio LEC calculator by integration over a sythetic event set. Given the output of a synthetic event set, GMPE, portfolio data file, calculate frequency (or probability in 1 yr) with which a single event causes portfolio loss of value L versus loss. Also output list of events (source ID + rupture ID) with median and lnstdev of portfolio loss. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.11 Portfolio annual cumulative LEC calculator.

Given ERF, GMPE, portfolio data file, calculate probability that within any single calendar year (or other settable period) the total portfolio loss will exceed loss of value L versus loss. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.12 Portfolio EAL calculator by hazard curve.

Given portfolio data file and gridded hazard file, calculate expected annualized loss to portfolio, by summing single-asset EALs calculated by integrating vulnerability and canned hazard curves. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.13 Portfolio EAL calculator by exhaustive event set.

Given frequency output of portfolio LEC calculator, integrate to calculate portfolio EAL. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

3.2.3.14 Portfolio EAL deaggregator.

Given results of either portfolio EAL calculator, show results in Google Earth. Show each asset as a filled circle whose diameter is proportional to the log of replacement cost and whose fill color from cold to hot is proportional to the log of EAL. Both scales (replacement cost and EAL) can have settings adjusted by user, i.e., log versus real, lower bound value,

upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical. Results also shown in table, with asset ID, lat, lon, replacememt cost, and EAL. Users would be Seismologists, Engineers, Owners, Insurers, Governmental officials.

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GLOSSARY

BCR	benefit-cost ratio
Business use case	Business use cases describe the business process. See use case
EAL	expected annualized loss
ERF	earthquake rupture forecast
GMPE	ground-motion prediction equation, aka intensity measure relationship, aka attenuation equations
GUI	Graphical user interface
IML	intensity measure level
IMT	intensity measure type
lat	decimal degrees latitude north
lnmean(x)	expected value of the natural logarithm of x
lnstdev(x)	standard deviation of the natural logarithm of x
lon	decimal degrees longitude east
NEHRP	(US) National Earthquake Hazard Reduction Program
LEC	Loss Exceedance Curve
Software requirements	What the software must do – that is, the needs and constraints placed on a software product *that contribute to the solution of some real-world problem*.
System use case	System use cases describe the actor-system interaction. See use case
Use case	A description of a system's behavior as it responds to a request that originates from outside of that system. Business use cases describe the business process, while system use cases describe the actor-system interaction. In this report, business use case and system use case are conflated and termed a use case.
Vs30	average shearwave velocity in the top 30m of soil, m/sec

TABLES

Table 1 Number of Responses per Country

Argentina	7
Australia	21
Austria	2
Azerbaijan	1
Belgium	4
Bermuda	1
Bhutan	1
Bulgaria	3
Canada	15
Chile	5
China	13
Colombia	5
Costa Rica	9
Croatia	2
Cyprus	1
Denmark	1
Ecuador	1
Finland	1
France	16
Georgia	1
Germany	39
Greece	17
Guatemala	1
Hong Kong	1
Hungary	2
Iceland	1
India	35
Indonesia	5
Ireland	2
Islamic Republic Of Iran	5
Israel	2
Italy	74
Jamaica	1
Japan	118
Jordan	5
Kuwait	1
Lebanon	2
Liechtenstein	1
Luxembourg	2
Malaysia	1
Malta	1
Mexico	5
Nepal	1
Netherlands	7
New Caledonia	1
New Zealand	18
Nicaragua	1
Norway	3
Pakistan	3
Peru	3
Philippines	2
Portugal	13
Puerto Rico	6
Qatar	1
Republic Of Korea	1
Romania	2
Russian Federation	7
Saudi Arabia	2
Serbia	1
Singapore	5
Slovenia	1
Spain	10
Sweden	4
Switzerland	30
Syrian Arab Republic	2
Taiwan	1
Tajikistan	1
Thailand	3
Trinidad And Tobago	1
Turkey	36
United Arab Emirates	2
United Kingdom	33
United States	244
Venezuela	4

Table 2 GEM Use Cases

Name	User(s)	Inputs	Outputs	Comments
Site attributes lookup.	Engineers, Owners, Insurers	location defined via latitude / longitude or other means (e.g., pointing and clicking on Google Maps, or inputting address)	VS30, NEHRP site soil class, topographic slope, zonation per applicable user-selected design codes. Optional output: soil boring logs within a settable distance R from the site.	The option anticipates a databased of soil boring logs uploaded to GEM in a standard format.
Site attribute updater	Engineers	location defined as above, plus soil boring data defined in a standard format.	revised data as above	This is a product for the mid-term future, i.e. 5+ years away. Updating is analogous to how ShakeMaps are adjusted based on instrumental intensity.
Historical catalog.	Seismologists, Engineers, Owners, Insurers	location, IMT and IML	all historical events causing intensity > IML, and the actual IML values.	
Hazard curve calculator.	Seismologists, Engineers, Owners, Insurers	Given location, GMPE, ERF, IMT, choice of probability + time period vs. frequency, and optionally soil type (Vs30 or NEHRP site soil class).	hazard curve	If soil is not given, look it up from internal soil database
Invert hazard at probability.	Seismologists, Engineers, Owners, Insurers	Like hazard curve calculator, but given probability and time period	return corresponding IML	

Name	User(s)	Inputs	Outputs	Comments
Invert hazard at frequency.	Seismologists, Engineers, Owners, Insurers	Like hazard curve calculator, but given mean frequency X	return corresponding IML	
Evaluate hazard probability at IML.	Seismologists, Engineers, Owners, Insurers	Like hazard curve calculator, but given IML return probability for specified time	return probability of given IML	
Hazard frequency	Seismologists, Engineers, Owners, Insurers	Similar to above, but given IML	return frequency of IML	
Hazard deaggregation bar chart	Seismologists, Engineers, Owners, Insurers	Given location, IMT, IML, and optionally soil type (Vs30, NEHRP, etc.),	deaggregate hazard: return bar chart of contribution to total probability or frequency of exceeding that IML by M, R, and optionally interevent term.	
Hazard deaggregarion map	Seismologists, Engineers, Owners, Insurers	Like hazard deaggregation bar chart	show a Google Earth map with bars located at midpoints of sources.	
Interpolate design map	Seismologists, Engineers, Owners, Insurers	location, and other adjustable parameters defined by the design map.	design values	("Adjustable parameters" is a term used in OpenSHA to indicate a parameter defined by a particular GMPE or ERF as required for carrying out a calculation.)

Name	User(s)	Inputs	Outputs	Comments
Source Map	Seismologists, Engineers, Owners, Insurers, Governmental Officials	Show an interactive Google Earth map of sources in an ERF.	Each item is clickable to display relevant data, e.g., name, geologic era of most recent activity, authority providing the data, etc. Break layers into eras of activity, e.g., so that one can see only sources with historic activity. Whenever data is displayed, include a clickable link for downloading layer data in a table or other document.	
Soil Map	Seismologists, Engineers, Owners, Insurers	Similar to above but for soils		
Catalog Map	Seismologists, Engineers, Owners, Insurers	Similar to above but historical earthquake catalog	Catalog is broken into several layers, perhaps by geographic region, year or decade, magnitude, etc. (Filled colored circles, footballs?)	

Name	User(s)	Inputs	Outputs	Comments
Exhaustive event set shaking calculator	Seismologists, Engineers, Owners, Insurers	one or more specified GMPE. Return a table with source number, rupture number, occurrence frequency, GMPE ID, site ID, magnitude, distance, IMT, lnmean(IML), total lnstdev(IML), interevent lnstdev(IML). This is the OpenSHA event-set calculator.	Return a list of all events (source number, rupture number) in an ERF capable of exceeding a specified lnmean(IML) at specified locations	
Synthetic event set shaking calculator	Seismologists, Engineers, Owners, Insurers	Inputs and returns are like event set shaking calculator, but with year/date/time instead of occurrence frequency.	Generate a synthetic catalog of events within a specified distance of specified sites, for a specified length of time, consistent with an ERF.	

Name	User(s)	Inputs	Outputs	Comments
Synthetic event set	Seismologists, Engineers, Owners, Insurers	Like synthetic event set shaking calculator,	return a table with source number, rupture number, year/date/time, magnitude, interevent term.	
Hazard product catalog	Seismologists, Engineers, Owners, Insurers	location, project information, user or dates	Show a catalog of all GEM data hazard projects with clickable links to download interim or final reports along with any electronic tables or other files delivered by the project	
Risk product catalog.	Engineers, Owners, Insurers, Governmental Officials	Like hazard product catalog, but for risk.	Losses per user definitions – for example, damage state, monetary costs, or casualties, or downtime	
Single-asset BCR calculator.	Engineers, Owners, Insurers, Governmental Officials	Like the OpenRisk BCR calculator: given ERF, GMPE, lat, lon, asset type & replacement cost before retrofit, asset type & replacement cost after retrofit, retrofit cost, discount rate, planning period,	benefit-cost ratio	

Name	User(s)	Inputs	Outputs	Comments
Single-asset scenario loss calculator.	Engineers, Owners, Insurers, Governmental Officials	Given ERF, GMPE, lat, lon, asset type & replacement cost, source ID (possibly selected interactively on map), rupture ID (ditto), calculate mean and stdev or lnstdev (and possibly higher moments) of loss.	occurrence frequency (or probability in 1 yr) of source-ID-rupture-ID combination.	
Single-asset LEC calculator by hazard curve.	Engineers, Owners, Insurers, Governmental Officials	Given location, asset type & replacement cost (V), and selection of a gridded seismic hazard map,	frequency (or alternatively probability in time t) with which loss is exceeded, as a function of loss. Use the gridded seismic hazard in the calculation.	
Portfolio scenario loss calculator.	Engineers, Owners, Insurers, Governmental Officials	Given ERF, GMPE, portfolio data file, source ID (possibly selected interactively on map), rupture ID (ditto), calculate mean and stdev or lnstdev (and possibly higher moments) of portfolio loss.	table of loss by asset: asset ID, asset type, asset replacement cost, soil type, distance, mean loss, lnstdev of loss.	

Name	User(s)	Inputs	Outputs	Comments
Portfolio scenario loss mapper.	Engineers, Owners, Insurers, Governmental Officials	Similar to above, and/or output of Portfolio scenario loss calculator	Show results of portfolio scenario loss calculator in Google Earth. Show each asset as a filled circle whose diam is proportional to the log of replacement cost and whose fill color from cold to hot is proportional to the log of loss. Both scales (replacement cost and loss) can have settings adjusted by user, i.e., log versus real, lower bound value, upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical.	
Portfolio scenario damage-state calculator.	Engineers, Owners, Insurers, Governmental Officials	Given ERF, GMPE, and portfolio data file	for each asset the probability of being in specified damage states.	

Name	User(s)	Inputs	Outputs	Comments
Portfolio scenario damage-state mapper.	Engineers, Owners, Insurers, Governmental Officials	Given rsults of portfolio scenario damage-state calculator, map most-likely damage state of each asset.	Show each asset as a filled circle whose diameter is proportional to the log of replacement cost and whose fill color from cold to hot is in order of damage state. Replacement-cost scale can have settings adjusted by user, i.e., log versus real, lower bound value, upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical. Results also shown in table, with asset ID, lat, lon, replacememt cost, most likely damage state, and damage-state probability.	
Portfolio LEC calculator (exhaustive).	Engineers, Owners, Insurers, Governmental Officials	Given ERF, GMPE, and portfolio data file	frequency (or probability in 1 yr) with which a single event causes portfolio loss of value L versus loss. Also output list of events (source ID + rupture ID) with median and lnstdev of portfolio loss. Integrate over the exhaustive event set.	
Portfolio LEC calculator (synthetic).	Engineers, Owners, Insurers, Governmental Officials	Portfolio LEC calculator by integration over a sythetic event set. Inputs are the output of a synthetic event set, GMPE, portfolio data file	frequency (or probability in 1 yr) with which a single event causes portfolio loss of value L versus loss. Also output list of events (source ID + rupture ID) with median and lnstdev of portfolio loss.	

Name	User(s)	Inputs	Outputs	Comments
Portfolio annual cumulative LEC calculator.	Engineers, Owners, Insurers, Governmental Officials	ERF, GMPE, portfolio data file,	probability that within any single calendar year (or other settable period) the total portfolio loss will exceed loss of value L versus loss.	
Portfolio EAL calculator by hazard curve.	Engineers, Owners, Insurers, Governmental Officials	portfolio data file and gridded hazard file,	expected annualized loss to portfolio, by summing single-asset EALs calculated by integrating vulnerability and canned hazard curves.	
Portfolio EAL calculator by exhaustive event set.	Engineers, Owners, Insurers, Governmental Officials	Given frequency output of portfolio calculator	Portfolio EAL	
Portfolio EAL deaggregator.	Engineers, Owners, Insurers, Governmental Officials	Given results of either portfolio EAL calculator,	each asset as a filled circle whose diameter is proportional to the log of replacement cost and whose fill color from cold to hot is proportional to the log of EAL. Results also shown in table, with asset ID, lat, lon, replacememt cost, and EAL.	Both scales (replacement cost and EAL) can have settings adjusted by user, i.e., log versus real, lower bound value, upper bound value, lower bound symbol size, upper bound symbol size, and color scheme. Possibly also user can select symbol, if that is practical.

Figures

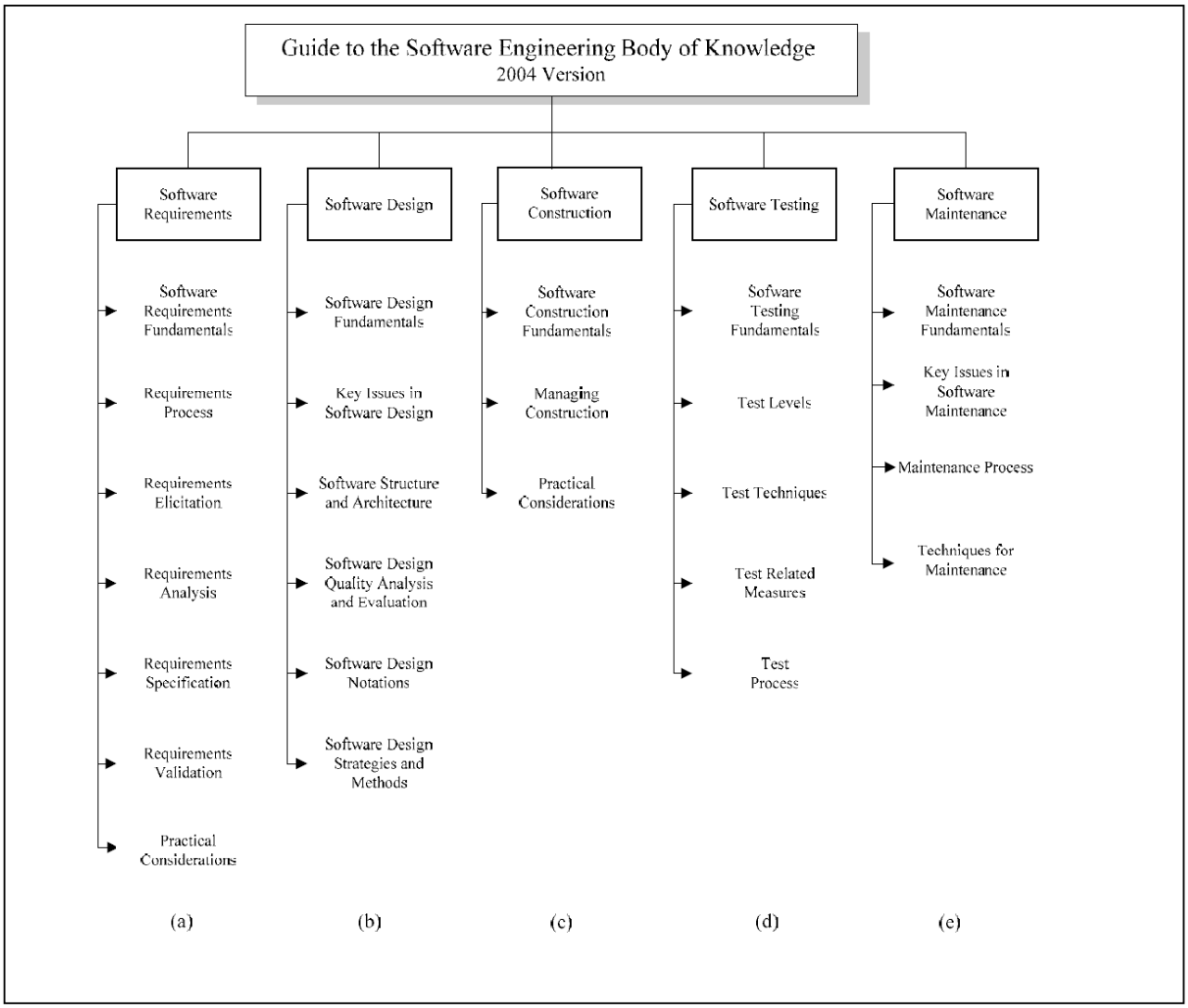

Figure 1 Software Engineering (Abran and Moore, 2004)

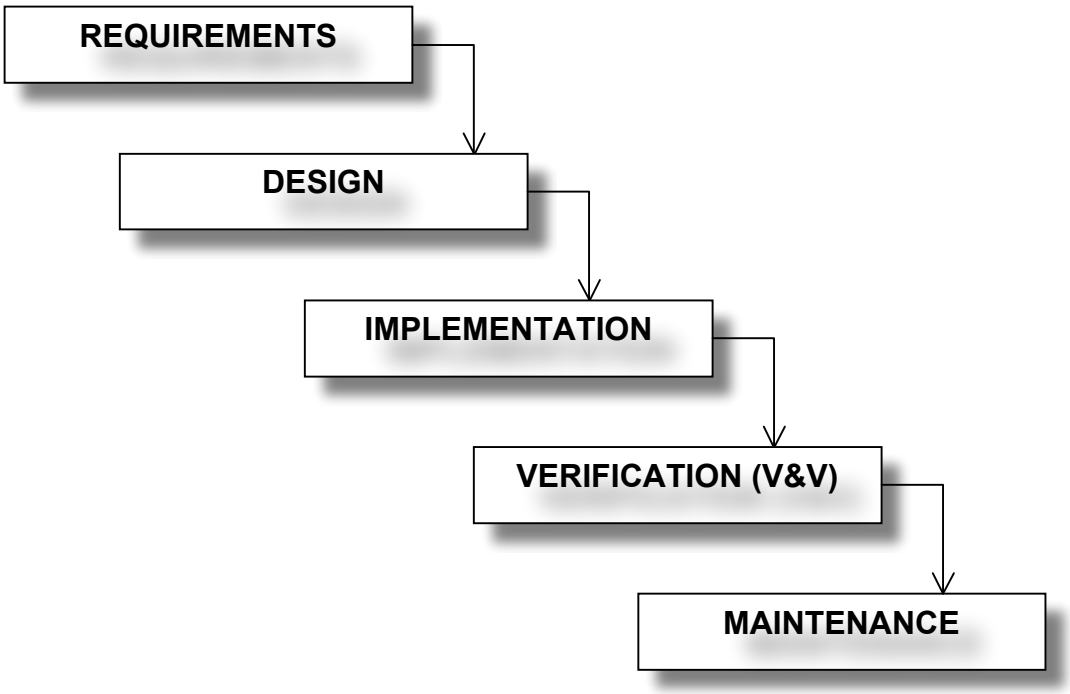

Figure 2 "Waterfall" model of software development

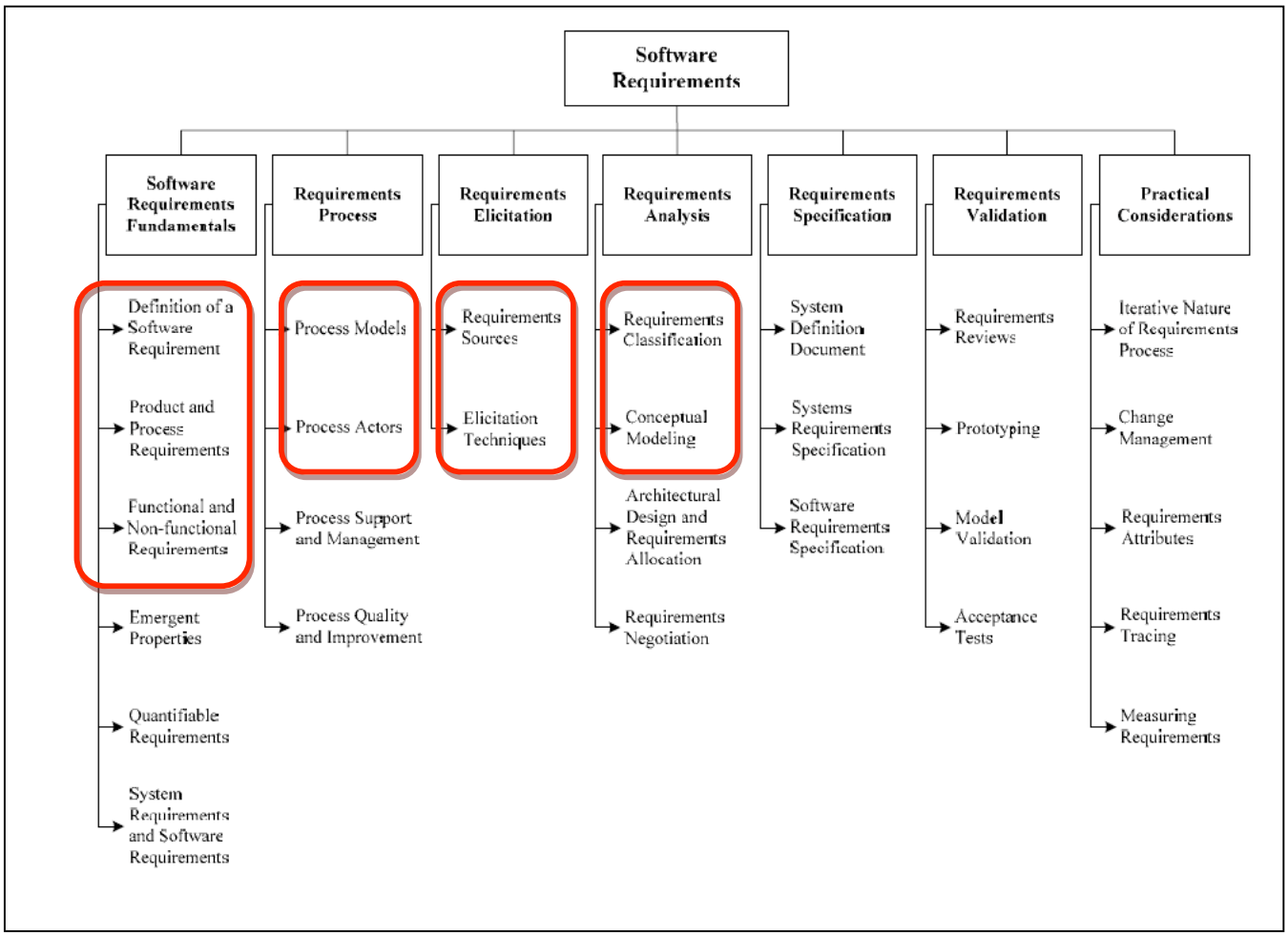

Figure 3 Software Requirements Process, in detail (Abran and Moore, 2004)

APPENDIX A – SURVEY INSTRUMENT