GEM
GLOBAL EARTHQUAKE MODEL
Working together to assess risk

Celebrating achievements & looking forward

2009
-2013
-2018
-2023

SECTION 1
Working Together to Assess Risk

Our Vision

GEM's collaborative efforts will build a heightened public understanding and awareness of seismic risk, leading to increased earthquake resilience worldwide, as the GEM community:

- shares data, models, and knowledge through the OpenQuake platform
- applies GEM tools and software to inform decision-making for risk mitigation and management
- expands the science and understanding of earthquakes.

Celebrating Achievements & Looking Forward

Thanks to our worldwide community, GEM has grown to become a relevant and tangible reality.

As we near the close of GEM's first Working Programme (2009-2013), this document summarizes our achievements in these past five years, and looks ahead to GEM's evolution and activities for the next Working Programme (2014-2018).

- Through involvement of global scientists and stakeholders, GEM has already made a significant contribution toward advancing the science and technology needed for global state-of-the-art seismic hazard and risk modelling, data collection, and risk assessment at scales from local to national, regional, and global.
- From 2014 onwards, we will shift GEM's focus towards practical implementation, public communication and development of the datasets and tools at a local scale, to increase the applicability of the products in the OpenQuake platform for reliable risk mitigation.
- We will continue to advance the science required to assess the risk of the complex interconnected systems within which we live.

About GEM

Vulnerability to earthquakes is increasing, yet reliable risk assessment tools and data are out of reach in many areas of the world. There are few global standards that allow us to compare seismic risk, yet recent events have taught us that we need to work together globally to improve our understanding of earthquake behaviour and its consequences.

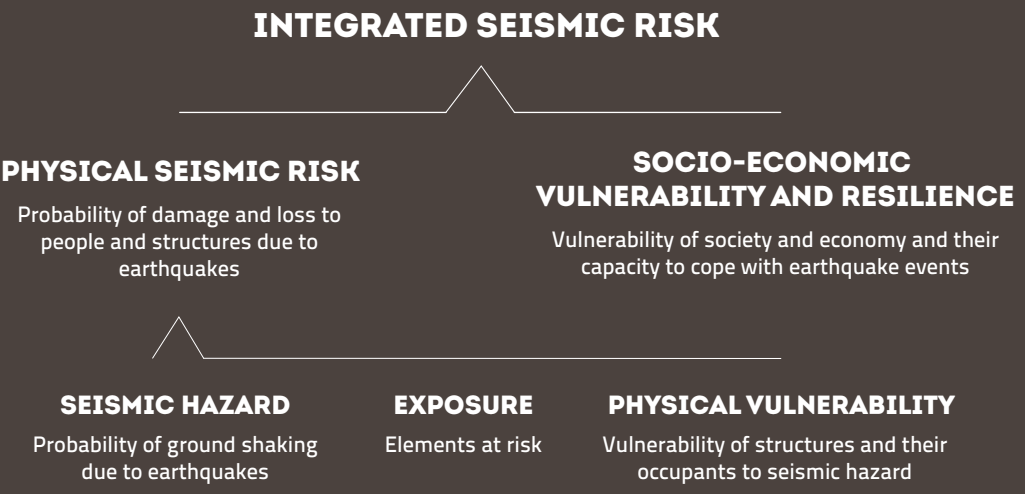
Under the auspices of the OECD Global Science Forum, the Global Earthquake Model (GEM) was created to bridge these critical gaps, and thereby support risk awareness and actions that increase resilience. GEM is a public-private effort, headquartered in Pavia (Italy) with the backing of the Italian government, to collaboratively develop and use cutting-edge tools and resources to assess the likelihood of earthquakes and their consequences for societies and economies worldwide.

Through global projects, open-source development, and collaboration in more than ten regions, leading scientists are jointly developing common datasets, best practices, and models for seismic hazard and risk assessment. Guided by the needs and experiences of governments, companies, and citizens at large, we work in continuous interaction with the wider community.

By pooling data, knowledge and people, GEM acts as an international forum for collaboration and exchange, and leverages the knowledge of leading experts for the benefit of society.

All contributions are being integrated into the web-based OpenQuake platform that will be accessible to organisations and individuals from the end of 2014 onwards. Stakeholders worldwide will be able to calculate, visualise and investigate earthquake risk, capture new data, and share findings for joint learning.

The framework below has guided GEM development in the first Working Programme



INTEGRATED RISK ASSESSMENT

GEM takes pride in collaboratively taking risk assessment to the next level. In order to manage risk effectively, it is critical to understand all drivers of risk, and appreciate to what extent risk derives from possible ground shaking (hazard), the vulnerability and exposure of people and structures (physical risk) and the vulnerability of the socio-economic system to earthquakes.

Models of seismic hazard are built upon a complex ensemble of geophysical and geological data. Historical and instrumental catalogues of events, in conjunction with databases of active faults and models of geodetic strain, form a critical basis for the development of global models of earthquake hazard. At regional scales, the data and models of earthquake behaviour are developed together with local experts to form a reliable basis for seismic hazard assessment.

Potential losses from earthquakes in terms of damage to structures and people can be estimated for the first time on a global scale and in a consistent manner. Composite indices of social vulnerability, resilience and indirect economic loss can be coupled to physical risk (loss and damage estimates) in order to assess risk holistically.

GEM fulfils key objectives as outlined in European Commission Working Paper Risk Assessment and Mapping Guidelines for Disaster Management (2010):

- Focus on stakeholders, including those in both the public and private domains
- Inform decisions for resource allocation
- Contribute to raising public awareness
- Serve as a credible scientific foundation for future mapping

Given GEM's integration of global technical expertise on seismic risk with the concerns of policy makers and practitioners in the area of disaster risk reduction, **GEM has been selected as one of UNISDR's Thematic Platforms**. These platforms are independent groups in the disaster risk reduction community focused on supporting the implementation of the Hyogo Framework for Action.

SECTION 2

2009-2013 Achievements

Cornerstones of Earthquake Resilience

GEM achievements would not be possible if we had not first laid cornerstones of earthquake resilience. Our guiding principles define who we are and what we do and ultimately serve as a measure of GEM's success.

TRUSTED SCIENCE - credible

Through our commitment to engaging and collaborating with the scientific community, GEM has earned a degree of credibility that has been strengthened by the alliance of the public and private sectors. Trust is critical for any source of information used for public good. Assessing earthquake risk holistically requires multidisciplinary knowledge – seismology, geotechnical and structural engineering, economics and social science – combined with the latest technology. GEM brings together this diverse scientific community with a common language, whilst keeping discussion and debate alive.

WIDER IMPACT - public good

GEM was founded on the principle of equitable risk information. Bridging gaps – both from science to practice, and from knowledge to action – is what we strive for. Even for deliverables that are, at their root, information, their true purpose is to serve risk reduction. Information is an essential precursor to risk reduction and risk mitigation, but only if it is available to all stakeholders. By creating resources that inspire sponsorship by both public and private sectors, we also benefit a broad range of stakeholders, from non-profit to commercial, bringing a once-scarce resource to all sectors and beneficiaries. By making risk assessment inclusive, despite its complexity, we create a culture of awareness and resilience.

TRUE TRANSPARENCY - transparent

The OpenQuake platform is being designed to allow users to evaluate the impact of any assumption on results, implement alternative data or models, and explicitly account for uncertainty. Accompanying OpenQuake will be extensive, open documentation and user-friendly workflows. Source code of the software and tools is publicly accessible and can be utilised and even extended by GEM stakeholders. Transparency is essential not only to our products, but also our processes and information-sharing. GEM resources include global best practice for all methods and approaches. Community feedback and open debate are the drivers of our continuous improvement.

WORKING TOGETHER - collaborative

GEM is all about people with a passion for contributing to the mitigation of seismic risk. We succeed only by collaborating across sector, geography, and discipline. Academia links up with decision makers, the private sector and international organisations within GEM's public-private partnership. GEM deliverables are the result of global scientific collaboration, and it is through regional partnerships that the GEM mission and implementation will be fully realised. By providing a common understanding of risk, GEM becomes the critical link in creating successful resilient partnerships between policy makers, the private sector, and scientists.

GEM began a strong collaboration with the World Bank's GFDRR in 2010 at the Understanding Risk Forum in Washington. In the second Understanding Risk Forum in Cape Town, 2012, Rowan Douglas (Chief Executive Office, Global Analytics, Willis Re) noted:

"What we previously talked about in theory is now happening in practice. Two years ago the Global Earthquake Model (GEM) Foundation was being talked about in theory. Today you can attend a training session in the OpenQuake modelling platform. As a result, a number of communities have been connected."

"GEM will provide communities with a great opportunity to strengthen their capacity to respond to disasters, invest in disaster reduction and therefore make themselves stronger and more resilient"

CLAUDIO BOETTCHER
ZURICH INSURANCE GROUP

GEM's Milestones

GEM's tangible achievements since 2009 can be divided into three broad categories: Advancing Science, Software Development, and Community Engagement. The contributions in these categories are fundamental to developing state-of-the-art global and regional models of hazard and risk.

ADVANCING SCIENCE THROUGH GLOBAL PROJECTS

Through open calls for proposals released to the scientific community, we have funded international consortia of leading experts to assure that best practice is applied to the development of datasets, models and tools.

Instrumental Earthquake Catalogue | Completion Date: December 2012

The ISC-GEM Global Instrumental Earthquake catalogue is a homogenous global catalogue of nearly 20,000 earthquakes. Archiving and re-assessing records from the early days of instrumental seismology at the beginning of the 20th century through to the present day, the catalogue represents the most state-of-the art record for earthquake locations and magnitudes available today.

Historical Catalogue and Archive | Completion Date: April 2013

More than just a catalogue, the partners and contributors of this project have archived almost a thousand earthquakes. Using the most detailed and up-to-date studies in the scientific literature, this archive spans nearly a millennium, from the early Middle Ages (1000 CE) to the advent of instrumental recording at the start of the 20th century (1903 CE). The catalogue itself provides detailed parameters on 827 earthquakes of magnitude greater than 7 across the globe.

Ground Motion Prediction Equations | Completion Date: December 2012

Led by widely renowned experts in the field of ground motion modelling, this initiative conducted a critical appraisal of ground motion prediction equations (GMPEs) in published scientific literature from around the globe. Defining a clear and reproducible process for the selection of ground motion models across all tectonic settings worldwide, the group proposed a set of ten GMPEs for use in seismic hazard analysis in subduction, active shallow crust and stable continental regions around the globe.

Active Faults Database and Tools | Completion date: June 2013

GEM has assembled available national, regional and global active fault databases worldwide, and created a common repository into which active faults, folds and subduction sources can continue to be populated. This database accompanies a taxonomy of earthquake geological data and strategies for assembly, defined by leading scientists in the field. Recognising the necessity for local and regional scientists to contribute local active faults, a capture tool has been developed to allow geologists to feed in data for use in the OpenQuake platform. Subject to quality assessment, new faults will be integrated into the common database.

From basic datasets to uniform comparisons of global seismic hazard

The global instrumental and historical catalogues, the geodetic strain rate model, the active faults database and the set of globally applicable GMPEs are all key ingredients to a global uniform hazard model for stakeholders to consistently compare seismic hazard around the world.

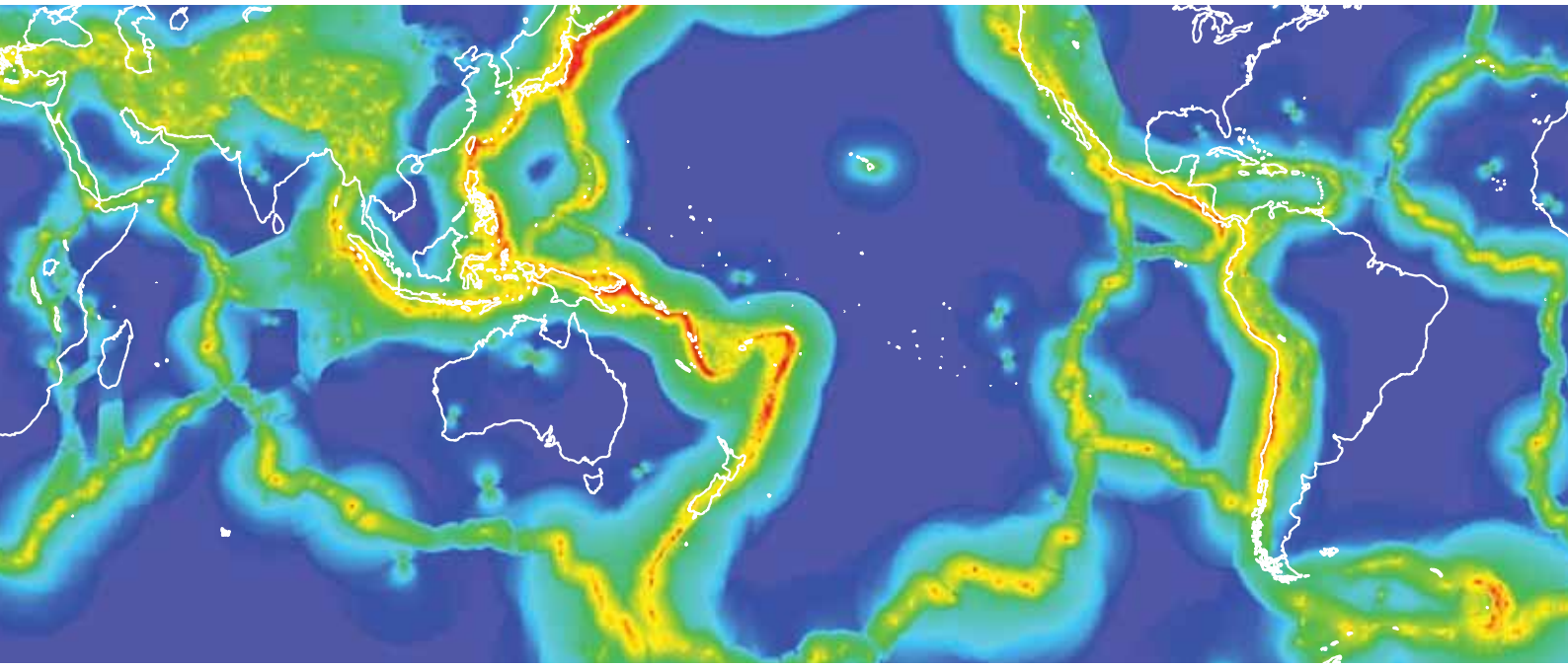
GEM's Milestones

Geodetic Strain Rate Model | Completion date: June 2013

This model estimates deformation rates on the Earth's surface based on measurements from the global network of geodetic instruments using the Global Positioning System (GPS). Building upon a dataset of more than 18,000 GPS velocity measurements worldwide, the GEM Global Geodetic Strain Rate model represents a five-fold expansion from its 2004 predecessor. The model features global coverage and high resolution in actively deforming regions.

Exposure Database | Target Completion: December 2013

The first open database of global buildings and population distribution is being built through the GED4GEM project. Much of the 'exposure' information that is needed for reliable risk assessment is incomplete, not homogeneous or only available at coarse levels of geographic resolution. GEM's Global Exposure Database (GED) will be a multi-scale, multi-level database that will be an integral part of the OpenQuake platform. It has been designed to accommodate data at four levels of resolution, from national to individual-building scales.



More historical earthquakes than previously available in global datasets:

by a factor of **12** in Indonesia,

and a factor of **6** in the Himalaya

5x

more strain rate data since 2004

SECTION 2
2009-2013 Achievements

Inventory Data Capture Tools | Target Completion: August 2013

This set of open-source tools captures data on buildings (inventory) both pre- and post-earthquake disaster. Tools include those which transform data from satellite photos and other 'remote sensing' images of buildings into exposure datasets and models. Other data collection tools can be used in the field and on the streets, with a tablet or a paper form. In addition, protocols/guidelines will help users extract data from remote images. After validation, this data can contribute to the Global Exposure Database or the Global Earthquake Consequences Database.

Building Taxonomy | Target Completion: August 2013

The GEM Building Taxonomy is a method to categorize buildings uniformly across the globe. It features 13 building 'attributes' spanning building occupancy to roof and wall material. Selected characteristics are those affecting the seismic performance of a building, and also those used to describe exposure. This 'common language" also facilitates global collaboration to grow our joint knowledge on the diversity and seismic vulnerability of buildings.

Earthquake Consequences Database | Target Completion: November 2013

The database captures a full spectrum of consequences from 66+ past earthquakes between 1923 and 2011. Consequences include damage, casualties and socio-economic consequences and recovery data, due to ground shaking, landslides, liquefaction, tsunamis and fire following an earthquake.

Physical Vulnerability | Target Completion: December 2013

A team of international experts has developed a dataset of existing and newly derived fragility and vulnerability functions ('damage curves') from around the world, derived from empirical, analytical and expert opinion methods, and quality rated. The functions form the basis for estimating damage and loss in terms of fatalities and building repair costs. Also included is the methodology behind the dataset and guidelines for creation of new functions.

Socio-Economic Vulnerability and Resilience | Target Completion: September 2014

This project covers data, tools, and indices to understand and visualize social and economic vulnerability, and disaster resilience, enabling integrated assessment of earthquake risk worldwide, by combining physical risk with the socio-economic vulnerability and resilience. Transparent indices for all countries will help users understand the impact of the socio-economic environment in earthquake disasters. Moreover, several tools and a large database will allow OpenQuake users to develop custom indices and risk assessments, incorporating local knowledge.

The impact of physical and social vulnerability on seismic risk.

The global exposure, physical vulnerability and social vulnerability indicator databases, when combined with uniform global hazard, provide a perspective of the world's seismic risk hotspots.

Resources and tools for locally-driven risk assessment.

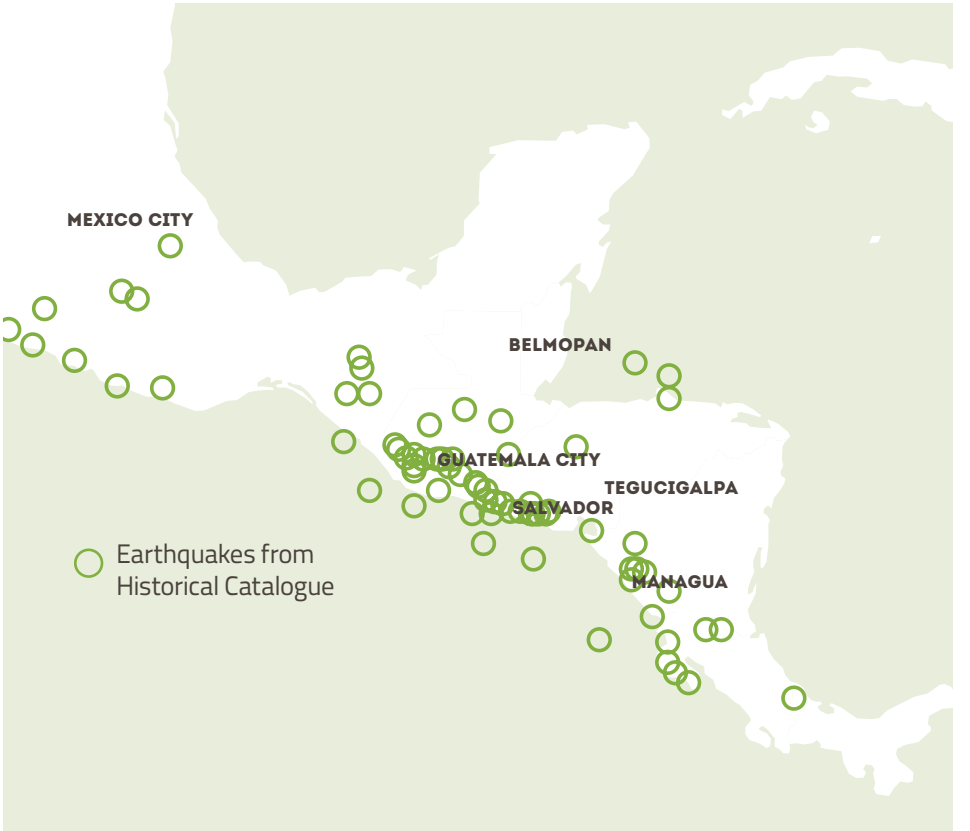
The physical vulnerability guidelines, the GEM building taxonomy, the tools for collecting building data and for developing custom indices of social vulnerability based on local knowledge all support local experts in the collection of data and the development of models for the assessment of physical and integrated risk.

GEM's Milestones

The first global hazard datasets to be released by GEM show a significant improvement over previously available datasets in terms of coverage, uniformity and quality control. For example, all events in the instrumental catalogue have been individually processed with the same procedure, for a more homogeneous identification of the magnitude, location, depth and uncertainty in these parameters. GEM has also invested in developing historical catalogues, given the different picture they can help paint of the seismicity in a region, as evident in the figure below which shows how different the spatial distribution of events can be when a historical catalogue (top) is combined with events from the instrumental catalogue (bottom) in the Mexico/Guatemala region.

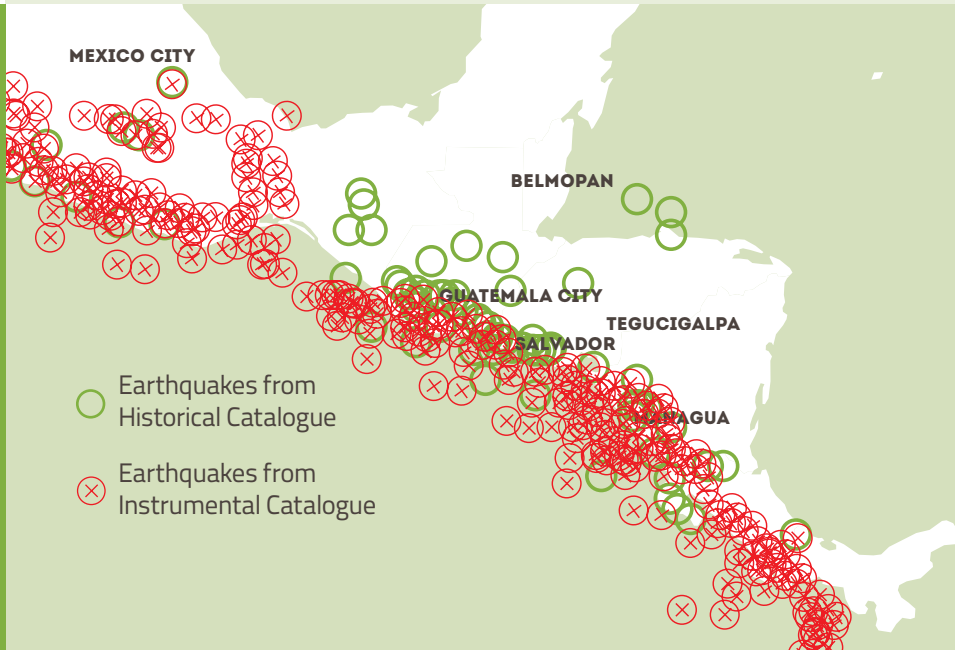
1000+

years of seismicity, each earthquake evaluated individually



20,000+

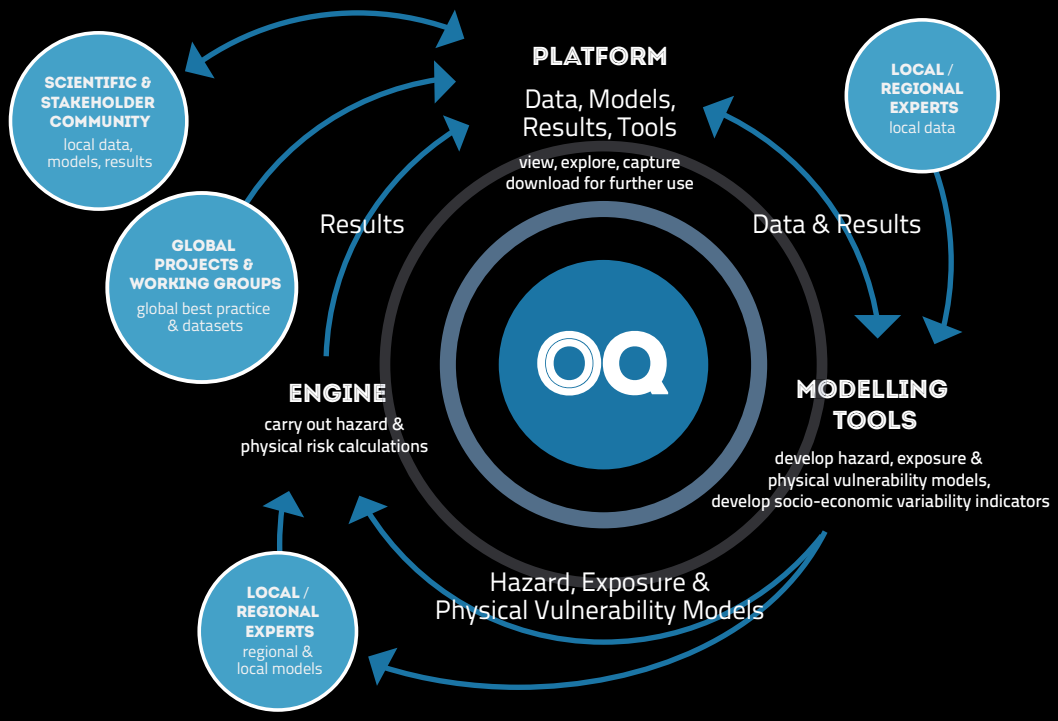
instrumentally recorded earthquakes given new magnitudes, locations and depths



SECTION 2
2009-2013 Achievements

SOFTWARE DEVELOPMENT

We are on-track for the 2014 delivery of OpenQuake, our community-driven, open-source software suite used to model and assess integrated earthquake risk. OpenQuake refers to all tools, apps and IT-infrastructure being developed to support our stakeholders in assessing risk. The core of OpenQuake is the web-based risk assessment platform, which will offer an integrated environment for modelling, viewing, exploring, and managing earthquake risk.



OPEN-SOURCE TEST-DRIVEN DEVELOPMENT

The source code behind the platform, engine and tools is openly available from a public repository: www.github.com/gem. Live development of the code takes place on this repository, and documentation facilitates contributions by external software developers. In test-driven development, each new feature begins with the implementation of its corresponding test code, such that test coverage reaches 100%.

88,000+
lines of OpenQuake engine and library code

42,000+
lines of test code

1300
code reviews completed

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2009-2013 Achievements

GEM's Milestones

OpenQuake Engine Version 1.0

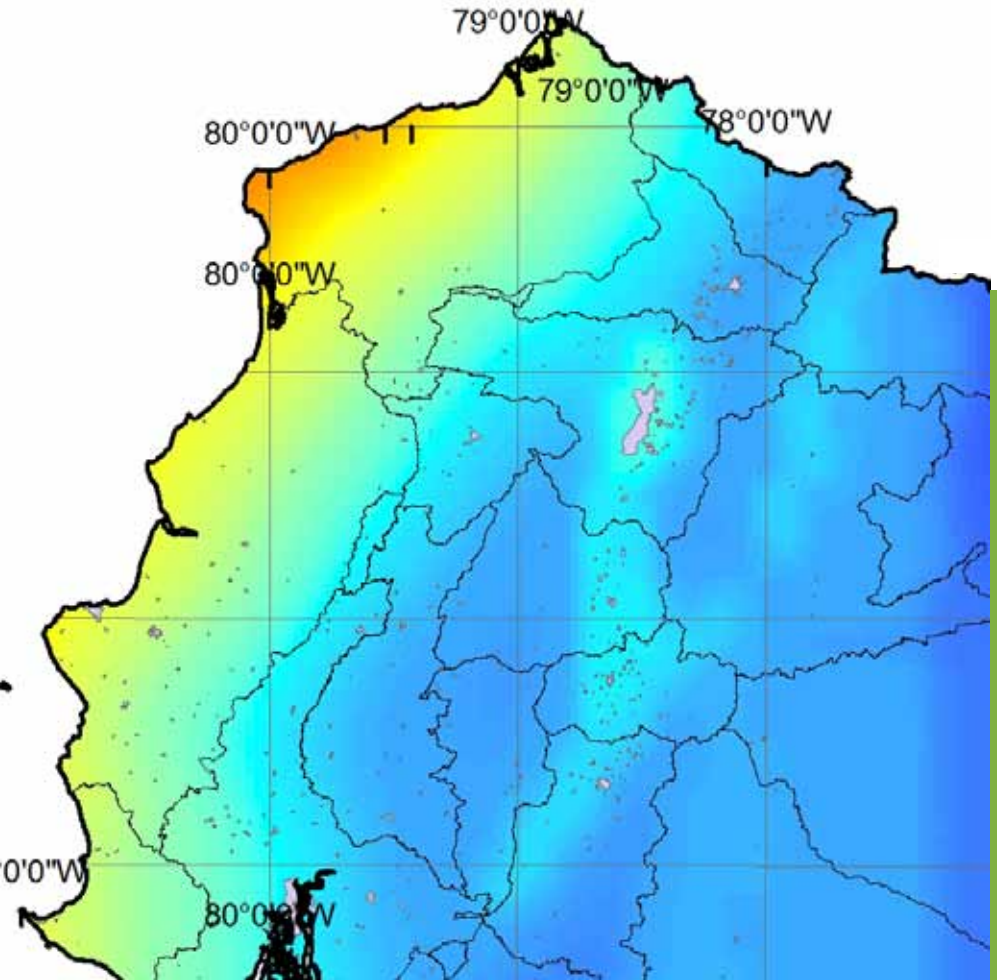
After 2.5 years of open-source test-driven development, the first version of the OpenQuake engine has been released, together with a user instruction manual, tutorials and demos. This software can be used for state-of-the-art hazard and physical risk assessment and includes the following calculators and features:

Hazard Calculators and Outputs

- classical Probabilistic Seismic Hazard Assessment (PSHA): hazard curves, maps, Uniform Hazard Spectra (UHS), disaggregation
- event based hazard: earthquake rupture forecasts (i.e. complete event set), stochastic event sets (samples of the earthquake rupture forecast), event-based ground-motion fields (i.e. intensity footprints), hazard curves
- scenario hazard: ground motion fields

Physical Risk Calculators and Outputs

- classical PSHA-based: asset-specific loss exceedance curves, loss maps, building typology disaggregation
- event based risk: event loss tables (i.e. loss for each event in the stochastic event sets), loss exceedance curves - asset-specific and aggregated, average annual loss, event and building typology disaggregation
- scenario risk: loss statistics, loss maps
- scenario damage: damage statistics, collapse maps



Through a unique collaboration between French and Ecuadorian scientists, with support from hazard scientists working for GEM, the OpenQuake engine was used to estimate seismic hazard for Ecuador, which formed the basis for the new seismic zonation map for the building code.

Since 2010 GEM has been part of the GeoNode community, actively contributing to this open-source project, together with other organisations such as World Bank and Australia-Indonesia Facility for Disaster Reduction (AIFDR). GeoNode is a platform for the management and publication of geospatial data, and currently forms the backbone of the OpenQuake platform.

GEM's Milestones

OpenQuake Features

- large set of source typologies for modelling faults as well as distributed seismicity
- explicit representation of uncertainty, including separation of epistemic (missing knowledge) from aleatory (random)
- logic tree support (representing epistemic uncertainty)
- calculates ground motion fields taking into account the spatial correlation of ground-motion residuals
- accounts for spatially variable site conditions
- insured loss extension (based on simple limits and deductibles)
- benefit-cost ratio extension
- supported asset typologies: structure/ non-structural components/contents/ occupants
- vulnerability uncertainty correlation
- risk calculators can run with pre-computed hazard curves and ground-motion fields
- comprehensive documentation for all methods, assumptions, and data.

The GEM community can investigate and provide feedback on the latest version of the OpenQuake engine, through the OpenQuake Alpha Testing Service (OATS), a cloud-based solution for everyone to freely test the software before installing locally. OATS is maintained and updated in parallel with our development cycles, so the community always has access to the latest version. Sample outputs, such as hazard maps; hazard curves; loss curves; maps of benefit-cost ratios, etc. can be obtained by running demonstration files.

GEM's Milestones

Overcoming the Licensing Challenge

A key achievement, for the release of GEM resources, is the selection of a licensing scheme which shall guarantee both openness and transparency of GEM products, as well as the sustainability of this unique initiative. We extensively investigated issues related to open data and software licensing, and chose to adopt and promote the use of GPL-compatible and Creative Commons licenses.

In particular:

- GEM software is released under the GNU Affero General Public License (AGPL). A dual licensing scheme is employed, such that the GEM Foundation can give permission to private participants to incorporate and redistribute the software as part of a proprietary system.
- GEM data and models have been initially released under the Creative Commons Attribution Non Commercial-ShareAlike 3.0 Unported license, with an extension to cover 'Sui Generis' Database Rights, where applicable. A dual licensing scheme has enabled the GEM Foundation to allow its private participants to employ GEM resources beyond the terms of CC-By-NC-SA 3.0 (unported) license.
- GEM's first public dataset, the ISC GEM Global Instrumental Earthquake Catalogue, was released under the Creative Commons Attribution Non Commercial-ShareAlike 3.0 Unported license in January 2013. GEM has recently decided to adapt this license and remove the restriction on the use of this product in commercial contexts, with a view to facilitate the adoption and widespread use of this important catalogue.

ATTRIBUTION —
You must attribute the work in the manner specified by the author or licensor (but not in any way that suggests that they endorse you or your use of the work).

SHARE ALIKE —
If you alter, transform, or build upon this work, you may distribute the resulting work only under the same or similar license to this one.

SECTION 2

2009-2013 Achievements

GEM's Milestones

COMMUNITY ENGAGEMENT

Community collaboration is central to GEM. We have actively fostered international and interdisciplinary collaboration between leading scientists, experts and professionals, in three modes: regional partnerships, regional projects, and regional workshops and training.

Regional Partnerships

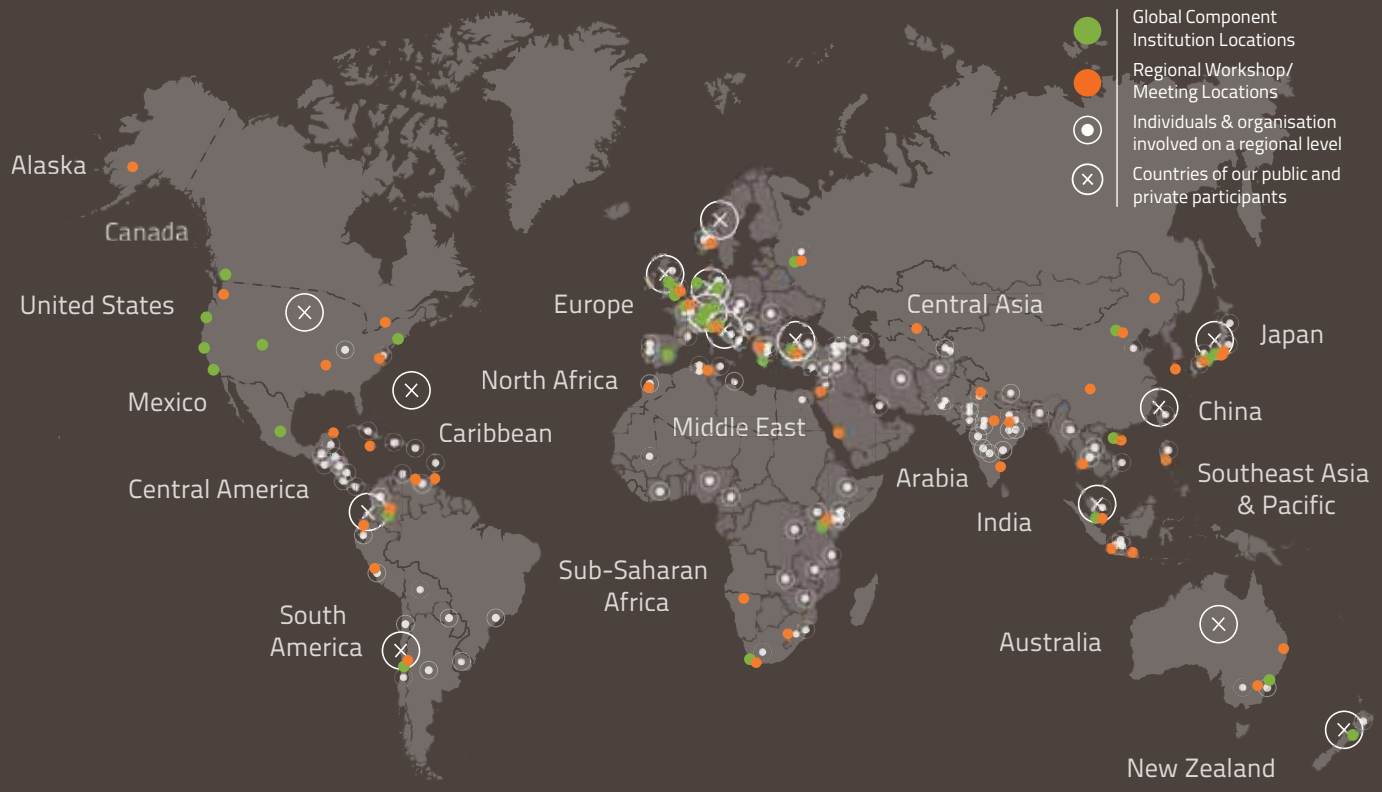
In the period 2009-2013 GEM collaborated with independent regional initiatives in three key regions. These initiatives were deployed in parallel with GEM's similar efforts at a global scale, and they set the standard for development of datasets and models at a regional scale.

In Europe GEM collaborated with SHARE (www.share-eu-org), SYNER-G (www.syner-g.eu) and NERA (www.nera-eu.org), each EU-funded projects providing, respectively, harmonised hazard assessment, fragility functions and an exposure model.

In the Middle East, GEM collaborated with the EMME project (Earthquake Model for the Middle East, www.emme-gem.org), which covered Iran, Turkey, Jordan, Pakistan, Lebanon, Syria, Georgia, Azerbaijan and Armenia.

EMME developed city risk scenarios in Mashad (Iran), Gulshen-Karachi (Pakistan), Irbid (Jordan), Tblisi (Georgia), Yerevan (Armenia) and Tyr (Lebanon), providing a unique opportunity to match the needs of policy makers with expert knowledge and resources.

In Central Asia, GEM collaborated with EMCA (www.emca-gem.org), the Earthquake Model Central Asia. The programme has focused on cross-border assessment of seismic hazard and risk, and covers Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The project involved intensive collaboration with local institutions from all five countries as well as collaboration with other international organisations working in the region.



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GEM's Milestones

COMMUNITY ENGAGEMENT

Regional Workshops and Training

In other regions, GEM activities have taken the form of facilitating scientific collaboration between local experts, making the first steps towards integrated regional hazard and risk modelling.

In the African continent, GEM funded workshops/ meetings in Kenya, South Africa, Morocco and Tunisia which involved the participation of hundreds of local scientists and engineers. GEM Operations Managers, from Ethiopia and Egypt, were appointed to help link up with efforts in ongoing projects in the region.

In the Caribbean, experts and stakeholders from nine Caribbean countries (Trinidad & Tobago, Barbados, Cayman Islands, Costa Rica, Dominica, Cuba, Jamaica, Martinique and Venezuela) participated in a GEM-funded workshop, and seven working groups were created to develop follow-up actions on Seismic Hazard (Active faults, Seismicity, PSHA and GMPE's, Site Effects) and Risk (Exposure, Vulnerability, Socio-Economic Impact).

GEM has linked up with seismic hazard modelling efforts in Central America, the Caribbean and the bordering countries in South America in an attempt to facilitate the harmonisation of cross-border hazard. Workshops in South America (Venezuela and Chile) have been organised; Operations Managers, from Venezuela, Colombia and Cuba, have been hired.

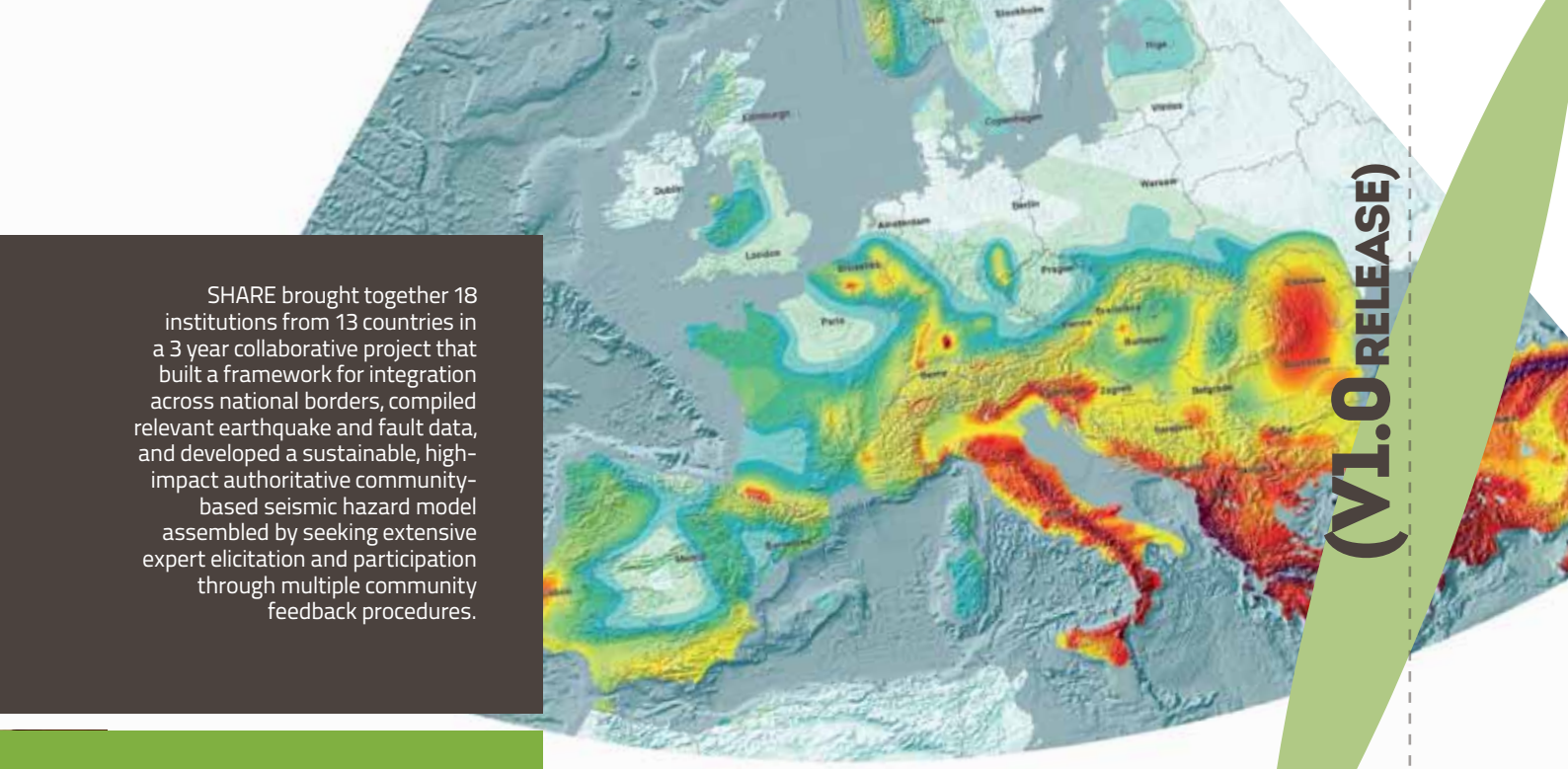
In the Asia and the Pacific regions, GEM meetings were organised in Singapore, Taipei, Bangkok, Canberra, Dehli, Chennai, Nepal, and Beijing, again bringing together hundreds of local experts to foster integrated seismic risk modelling. In addition, GEM has actively participated in training workshops held in Nepal, Manila, and Brisbane, partnered with a seismic hazard and risk project in the State of Gujarat, India, and has taken part in the China-Japan-Korea trilateral strategic cooperation programme meetings. GEM is engaged regionally with the Association of South East Asian Nations (ASEAN) Committee on Disaster Management and the Secretariat of the Pacific Community on earthquake hazard/risk modelling through training and information sharing.

550+

SCIENTISTS PARTICIPATED IN REGIONAL WORKSHOPS

Regional Projects

In 2012 GEM launched its first directly-managed regional project, a collaborative initiative covering all countries in South America. The project aims to calculate seismic hazard and risk, and to estimate the compounding social and economic factors that increase the physical damage and decrease the post-event capacities of populations to respond to and recover from damaging earthquake events in South America, by involving local experts from throughout the region. The project also focuses on the risk to cities from selected scenarios, to acknowledge the importance that such studies have on the communication of risk. Lima and Quito have been selected for the city scenarios. The project is being carried out with experts and institutions from the regions, who can build on what is being developed within the context of GEM: more uniform data sets and methodologies than have ever been attempted, using GEM's new open source software, the OpenQuake engine and other OpenQuake tools.



SHARE brought together 18 institutions from 13 countries in a 3 year collaborative project that built a framework for integration across national borders, compiled relevant earthquake and fault data, and developed a sustainable, high-impact authoritative community-based seismic hazard model assembled by seeking extensive expert elicitation and participation through multiple community feedback procedures.

10+

funded global projects on seismic hazard, exposure, physical and social vulnerability

Testing the OpenQuake Engine

We have encouraged the use of the OpenQuake engine during its pre-v1.0 development phase, in order to receive feedback from the scientific community on bugs, missing features, usability etc.

The cumulative number of OpenQuake engine users has continued to increase since the code was released for open-source development in 2009. With the release of v1.0 in June 2013, this number is expected to exponentially rise.

Even though it is still under development, users have tested the OpenQuake engine all over the world, through the OpenQuake Alpha Testing Service (OATS) and through attending training workshops that have taken place in Kathmandu, Potsdam, Pavia, Cape Town, Brisbane, and Manila.

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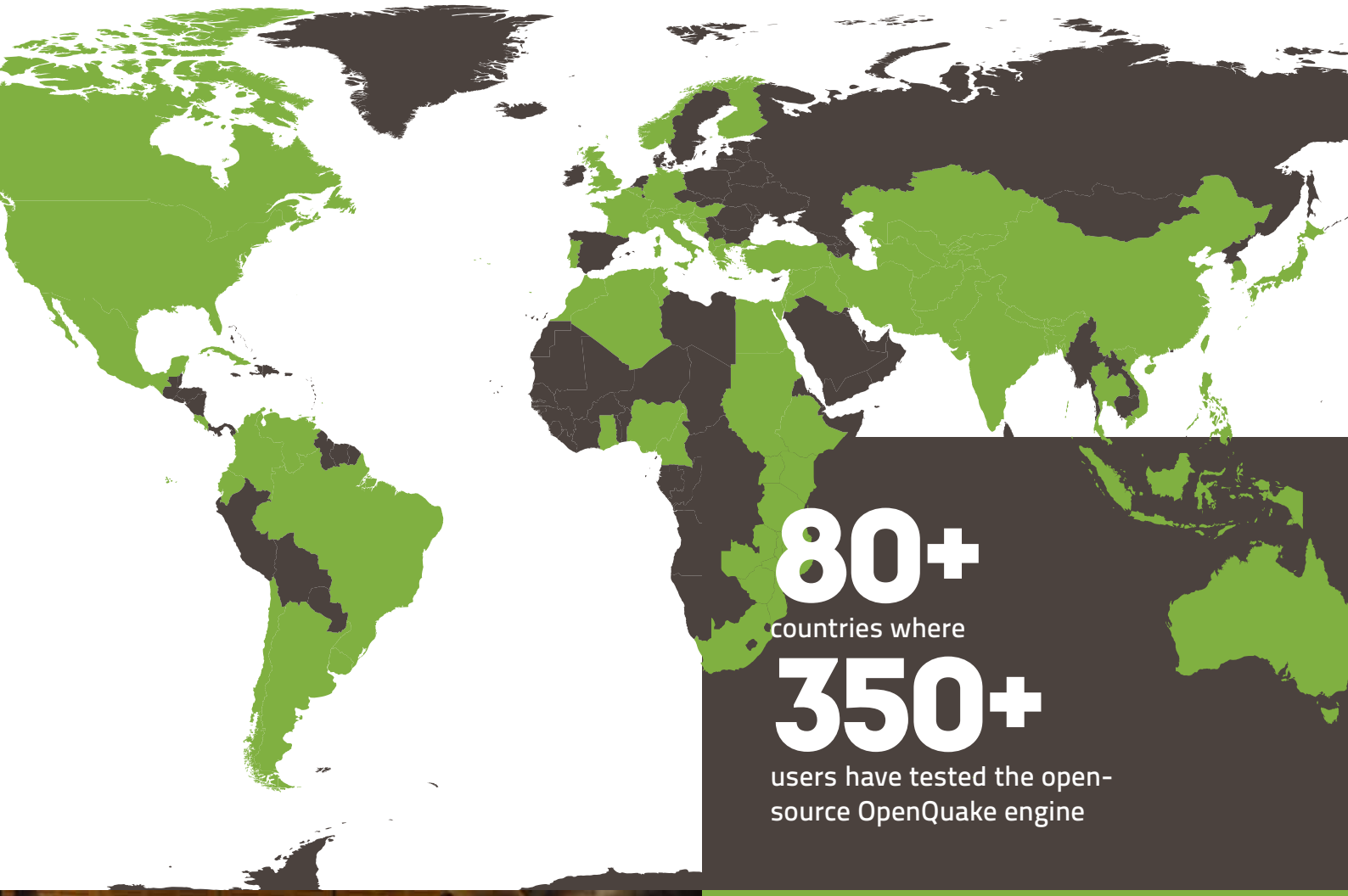
GEM's Milestones



80+
countries where
350+
users have tested the open-source OpenQuake engine

During the Understanding Risk 2012 Forum 40 local scientists from sub-Saharan Africa participated in sessions on seismic hazard assessment and training exercises with the OpenQuake engine and modelling tools.

"It is great to finally use sophisticated software for free. In Congo we do not have many resources and even though the tools are still under development, they are exactly what I need to assess the hazard in my area. I look forward to collaborate further with GEM within the scope of the regional programme for sub-Saharan Africa".

GEORGES MAVONGA TULUKA, SEISMOLOGIST IN GOMA, DEMOCRATIC REPUBLIC OF CONGO

SECTION 3

OpenQuake Platform in 2014

Core Elements of Platform

A first version of the OpenQuake platform will become available towards the end of 2014, with the core elements described below.

CALCULATE

The OpenQuake platform integrates open-source applications with homogenized data and models, allowing users to calculate seismic hazard and risk transparently and according to the latest scientific developments. From ground-motion fields to uniform hazard spectra to maps of estimated human loss and economic loss; users will be able to produce a great variety of custom outputs by combining their own data and (local) knowledge with GEM products.

EXPLORE

The platform leverages upon open-source geospatial technologies to allow users to work in an intuitive map-based environment. Users will explore earthquake hazard and risk by interacting with dynamic maps, indicators and graphs: They can also develop their own maps, and capture and integrate new data. To help users develop a better understanding of risk and to facilitate risk management, decision support tools are also planned to be part of the platform.

SHARE

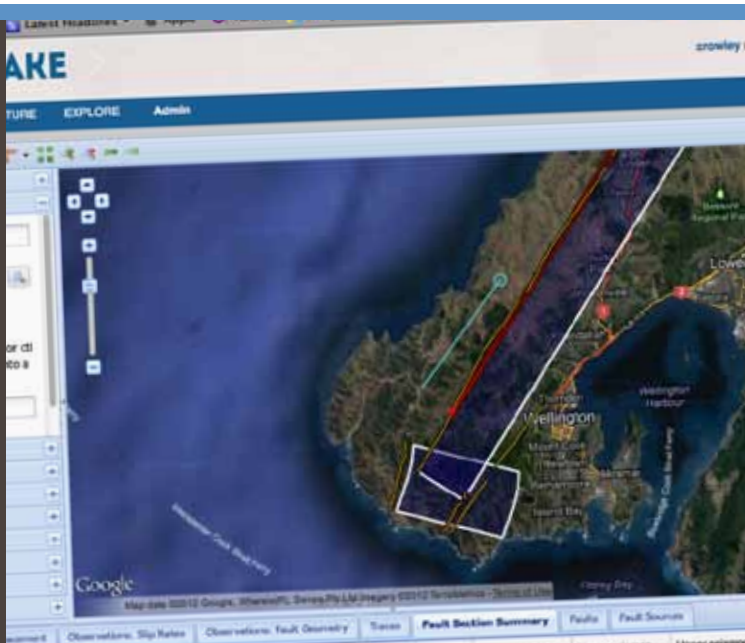
Sharing of data and risk information, best practice and approaches is key to assessing risk better. The platform is to serve as a clearinghouse for all critical inputs and outputs. It will link users from around the globe so they can work together to assess risk.

ENGINE

The OpenQuake engine is GEM's state-of-the-art software for seismic hazard and risk assessment at varying scales of resolution, from global to local. It can be used on a laptop, in the cloud or on a cluster. It is open-source, fully transparent and can be used with GEM or user-developed models. Version 1.0 has already been released (in June 2013), with the features described previously, and thus in 2014 the OpenQuake Platform will integrate the latest version of the engine.

WORK IN PROGRESS

A first version of the platform and accompanying resources will become available towards the end of 2014: OpenQuake will be accessible to stakeholders worldwide through two different suites. Preliminary tools, data and other products are shared when possible. We envisage the platform and its various components will be continuously enhanced by the user community and through new global projects and intensified regional collaboration.



SECTION 3
OpenQuake Platform in 2014

DATA AND MODELS

The platform will feature the following global homogenized datasets, described earlier, which will be continuously enhanced for increased use at the local community level.

- ISC-GEM Global Instrumental Earthquake Catalogue [1900-2009] – publically released January 2013
- GEM Global Historical Earthquake Catalogue [1000-1900] – publically released June 2013
- GEM Global Geodetic Strain Rate Model
- GEM Global Active Faults Database
- GEM Tectonic Regionalisation Model
- GEM Global Exposure Database
- GEM Global Earthquake Consequences Database
- GEM Physical Vulnerability Functions Database
- GEM Socio-Economic Vulnerability and Resilience Indicator Databases

The individual early release of some of these datasets before the end of 2014 (as indicated above for the cases of the Instrumental and Historical catalogues) has and will continue to allow the scientific community to further test them and integrate them within research. However, the main advantage of the OpenQuake platform is that such datasets will be brought together for the first time within a single environment, allowing users to explore, for example, how strain rate data and catalogues are correlated, how many buildings are located near active faults, and so on.

TOOLS

In addition to the engine, the OpenQuake platform will contain a variety of online and offline tools, for users to interact with the data.

- Data Capture: add and use new data, for own use and for inclusion in the global datasets
  - capture new data on active faults by drawing them directly on the GIS mapping interface of the platform
  - a suite of tools will be available to support GEM stakeholders in extracting datasets, models and information on buildings from field observations as well as remote sensing, both pre- and post- earthquake disaster
- Model Development: suite of mainly offline tools that help experts to develop input models for the OpenQuake engine, either for hazard and for (physical) risk calculations / modelling:
  - Hazard: Earthquake catalogue homogenization tool
  - Hazard: Modelling Tools for seismic source and ground motion models
  - Risk: Exposure Modelling Tools
  - Risk: Physical Vulnerability Modelling Tools
- Toolkit for Socio-Economic Indicators and Integrated Earthquake Risk
  - Tools for stakeholders with knowledge of the local context to compose mathematical models based on indicators for socio-economic vulnerability and disaster resilience
  - Tools that allow users to calculate and combine earthquake hazard and physical risk with measures of socio-economic vulnerability, to understand the drivers of risk in an area

'A LIBRARY OF HAZARD AND RISK MODELS'
GEM will not present the community with a single view of hazard/risk, but will instead provide users of the OpenQuake platform with multiple, coexisting hazard and risk models at varying scales of resolution and applicability (local, national, regional and global). All models will be documented and classified in terms of a number of attributes (such as transparency to upstream data, use of logic trees, local involvement, consensus etc.). Because the purpose of any one model is scale-dependent, regional centres and local experts will be able to provide support to stakeholders around the world on which models to use for different applications.

'GLOBAL UNIFORM MODELS'
refer to those based on the GEM global datasets and hence follow as much as possible a uniform strategy. These models can be used for benchmarking regional models, comparisons of estimated losses or socio-economic resilience across countries, and as a basis for learning and joint improvement. Global models hence incorporate the knowledge and data currently publicly available, and best practice put together by international experts, using GEM tools. They will improve over time with contributions from stakeholders worldwide, as new data and science can be incorporated.

'REGIONAL MODELS'
refer to hazard and risk models developed collaboratively with local experts and institutions – where possible with GEM tools. Examples include the SHARE hazard model for Europe, the Earthquake Model of the Middle East (EMME), and the Earthquake Model of Central Asia (EMCA).

SECTION 3

OpenQuake Platform in 2014

Reaching Multiple Stakeholders

When the OpenQuake platform is delivered in 2014, GEM will already serve a diverse set of stakeholders to support risk reduction. We anticipate two complementary sets of resources, suited to either 'power' or 'standard' users.

- 'Power users' will comprise academics, technical agencies (e.g., public/government), risk consultants, insurance and large engineering companies that are interested in and have the background knowledge to develop and enhance earthquake hazard and risk models and will execute custom calculations, setting the parameters as needed.
- 'Standard users' are all others who want to view and overlay datasets, access maps or projections of hazard and risk, to inform decision-making and increase risk understanding. In addition to the same categories mentioned above, envisaged 'standard users ' will also include individuals, multinationals and international (non-profit) organisations.

As three examples, each of the following will use GEM and OpenQuake to different benefit.

- A public-domain Emergency Management Official will benefit from OpenQuake tools to facilitate disaster preparedness and policy recommendations for improving resilience. In particular, this 'standard' user can collaborate with local experts to use OpenQuake in the support of cost-benefit analysis of risk transfer (insurance) as well as retrofitting ('seismic upgrade'). The resulting maps results will intuitively show these users, in both relative and absolute terms, how each neighbourhood will benefit from a policy being evaluated.
- A Corporate Risk Manager will use OpenQuake to conduct holistic risk assessment to a common standard worldwide, and inform capital investment decisions. These users will especially benefit from understanding the effects on earthquake risk from indicators of social vulnerability, resilience, and indirect economic loss.
- A private-insurance Modelling Analyst will benefit from OpenQuake by conducting sensitivity testing to develop a custom view of earthquake risk. These 'power' users will be able to estimate loss under varying assumptions. Repeating part(s) of the calculation, while adjusting parameters or investigating the underlying event sets, will provide insight to variability/uncertainty in the results.

THE FORMATION OF GEM:

GEM was triggered in 2006 by the first of three workshops on Earthquake Science organised under the auspices of the OECD Global Science Forum.

Four scientists played a particularly relevant role in bringing GEM to fruition:
- Jochen Zschau (GFZ Potsdam)
- Ross Stein (US Geological Survey)
- Domenico Giardini (ETH Zurich)
- Anselm Smolka (Munich Re)

2009-2013

FIRST PHASE OF GEM:

Build up of the collaborative effort

Development of all critical elements for risk assessment

Release of the OpenQuake platform v1.0 and related tools allowing stakeholders worldwide to work together to assess risk and thereby support risk understanding, awareness, mitigation and management.

Main focus is on development of global databases, global best practice and globally applicable tools for risk modeling and risk communication.

2014-2018

SECOND PHASE OF GEM:

Leveraging the OpenQuake platform, supporting a worldwide community to carry out hazard and risk assessment and share their outputs and knowledge through the platform, increasing its value.

Release of the OpenQuake platform v2.0 incorporating new science, data and developments

Main focus is on regional collaboration, knowledge sharing and technology transfer.

2019-2023

SUBSEQUENT PHASES:

Through continuous enhancement of the products and services through the global collaborative effort changing the landscape of earthquake risk assessment and risk management.

2024-2028

SUBSEQUENT PHASES:

Through continuous enhancement of the

SECTION 4

Looking Ahead

From 2014-2018, GEM will build on the successes and achievements of its first Working Programme, and add new activities, all with the purpose of contributing to increased earthquake resilience around the world.

Setting Priorities Collaboratively

Specific goals for Working Programme 2 (2014-2018) are being determined together with partners and through interactions with the community.

We anticipate that the primary intent of Working Programme 2 will be to broaden the use and application of GEM resources, including OpenQuake. This will require a significant proportion of resources for 1) enhanced regional partnerships, as well as 2) maintenance and improvements of OpenQuake tools, models, data, and software. Pending sufficient funds, we also hope to deploy new global projects to develop further datasets, models, and best practice. We hope to move forward together with an ever-growing group of partners and collaborators.

In the sections that follow, we present proposed strategies, not as foregone conclusions, but rather as a way to initiate a rich dialogue among GEM stakeholders regarding the best way forward. We actively seek thoughtful feedback on our future activities. Detailed strategies, milestones, and an implementation plan for Working Programme 2 will be developed after integrating and vetting feedback from all sources.

Selection criteria for setting priorities in Working Programme 2 are not firmly established, but the following considerations may aid in providing feedback: ease of implementation; potential effect on reducing losses; alignment with GEM identity and mission; and geographic scale, which includes how well an initiative can potentially be implemented by local experts so that GEM continues to contribute meaningfully to local-scale accumulation of expertise.

SECTION 4
Looking Ahead

Strengthening Partnerships Around the World

Enhanced collaboration of GEM with similar initiatives is indispensable for increasingly-broad ownership of the data and models, and sufficiently-granular global coverage.

From 2014, we intend to expand regional activities and partnerships, with a focus on learning and knowledge exchange around the OpenQuake platform. Regional partnerships will have a designated place in the structure of GEM, with a high degree of visibility and inclusiveness.

Our proposed strategies for expanding regional partnerships are related to an objective to increase public participation in GEM, particularly from developing nations, where technology resources are most scarce but social risk of earthquakes is highest.

Specifically, we envision five potential forms of 'regional partnerships,' i.e., collaboration between GEM and geographically-defined initiatives. In addition, we anticipate adding within the GEM Foundation an advisory body populated by representatives of regional collaboration activities.

1. Regional Partnerships: Continue our current mode of collaboration with independent, separately-funded regional initiatives (whether existing or new), adding leverage, access to global data and science, and training in GEM resources including OpenQuake.
2. Regional Federation: Establish a network of strategic partnerships with institutions willing to serve as regional centres and thus host local instances of the OpenQuake platform so as to facilitate access to GEM data, models, tools and computational power within the region.
3. GEM-initiated regional projects: As we have done to-date in South America, GEM will take an active role to initiate and support regional collaboration. The outcome of such projects would be analogous to those of external regional initiatives: regional hazard or risk mapping, together with contributions of data and models back to the GEM community.
4. Worldwide Collaboratives: This category is meant to capture a broad set of potential initiatives, focused on a specific geographic area, with which GEM collaborates but does not fund or manage directly. For these initiatives, GEM would offer visibility, access to intellectual capital, including training, and integration of OpenQuake resources to suit a particular use. This mode of collaboration is meant to promote engagement of local experts, and add richness to GEM's resources, through sharing-alike of data, models, and results. Such initiatives might take one of many forms:
    a. National-level activities such as hazard mapping or risk assessment
    b. 'City Scenarios,' or urban risk assessments (maps of hazard and risk for a metropolitan area, together with hypothetical results after taking measures to build resilience). GEM may fund or co-fund and collaborate in pilot projects for a few cities, which can then be used as a catalyst for future, independent urban assessment projects by others.
    c. Separately-funded initiatives at any geographic scale, for example, national-level disaster assessment projects funded by aid or development agencies aimed at building local capacity. Many such initiatives would be aligned with goals related to sustainable development and implementation of the Hyogo Framework for Action (HFA) as well as the forthcoming HFA-2.
5. Targeted Training: GEM intends to build a dedicated programme of technology transfer and training workshops, targeted to public participants, regional programmes, and worldwide collaboratives.

SECTION 4

Looking Ahead

"Enhancing risk knowledge should be a key element of an effort to improve the integration of the scientific community in HFA2...Standardisation of risk assessment approaches, the creation of a system of risk indicators and certification of risk analyses were identified as priorities."

SYNTHESIS REPORT: CONSULTATIONS ON A POST-2015 FRAMEWORK ON DISASTER RISK REDUCTION (HFA2).

Next Generation of Scientific Features

Looking Ahead to GEM's next Working Programme, we recognize the need to balance continued investment in science with increased stakeholder engagement and population of regional data. In addition, any potential modelling gaps must be filled before adding new scientific features.

GEM nevertheless hopes to leverage on a number of scientific developments being carried out by researchers around the world on activities such as tsunami hazard modelling, infrastructure risk assessment, supply chain interdependency and indirect loss modelling, in order to introduce these scientific features into the OpenQuake platform. The selection and prioritization process will be based on identifying critical uncertainties at each geographic scale, while also considering available funds.

With OpenQuake we have created a resource and framework of potential value for modelling perils such as flood, wind, volcano, etc. However, GEM has no plans to directly implement non-earthquake-related perils and is encouraging other scientific communities to leverage the OpenQuake architecture.

Growing the GEM Community

Once the first version of the OpenQuake platform is released, a user community is envisaged to grow around it. Users from a variety of backgrounds will calculate and explore risk and share findings, working together to advance seismic risk assessment. Dynamic interaction with an ever-growing community of users and experts will support GEM's activities and mission going forward.

In particular, the most predictive measure of longevity for open-source initiatives has been the size and engagement of the contributor-user network. Accordingly, sustainability of GEM as an organization will require deliberate cultivation of a network of user-developers in both the public and private sectors, through activities such as the following:

1. GEM will actively support its growing community through training, dedicated resources, and outreach. We plan to initiate a programme to 'train the trainers': certifying a finite number of potential OpenQuake experts who, themselves, could conduct training on behalf of GEM.
2. We anticipate a potential need to develop specific, tangible incentives to encourage data sharing. The intent is to organically increase the number of models and the quality of resulting maps, graphs and other results.
3. We foresee a growing, interactive online network in which GEM users can post data, results, and methods; as well as review and provide feedback on the work of others.

   Accordingly, we anticipate a significant need to streamline and integrate community contributions of data or applications while assuring their quality.

   Each model is expected to be accompanied by information on the development process and those that developed it, including uncertainty treatment, testing, and methodologies applied. GEM is establishing objective criteria on which members of the community can evaluate models and data contributions.

   Contributions which evolve into best practices and become embraced widely through the community can be considered to have "passed the first filter" of community scrutiny, tagged for further evaluation by GEM scientists, and potentially incorporated into GEM datasets and products. In such a scheme, the GEM online network becomes a clearinghouse of resources, to which many different levels and categories could be assigned.

SECTION 5

Governance and Sustainability

Financial Overview 2009-2013

Before presenting the funding strategy for the next phase, it is worth reviewing how the funding for the first phase was obtained and distributed.

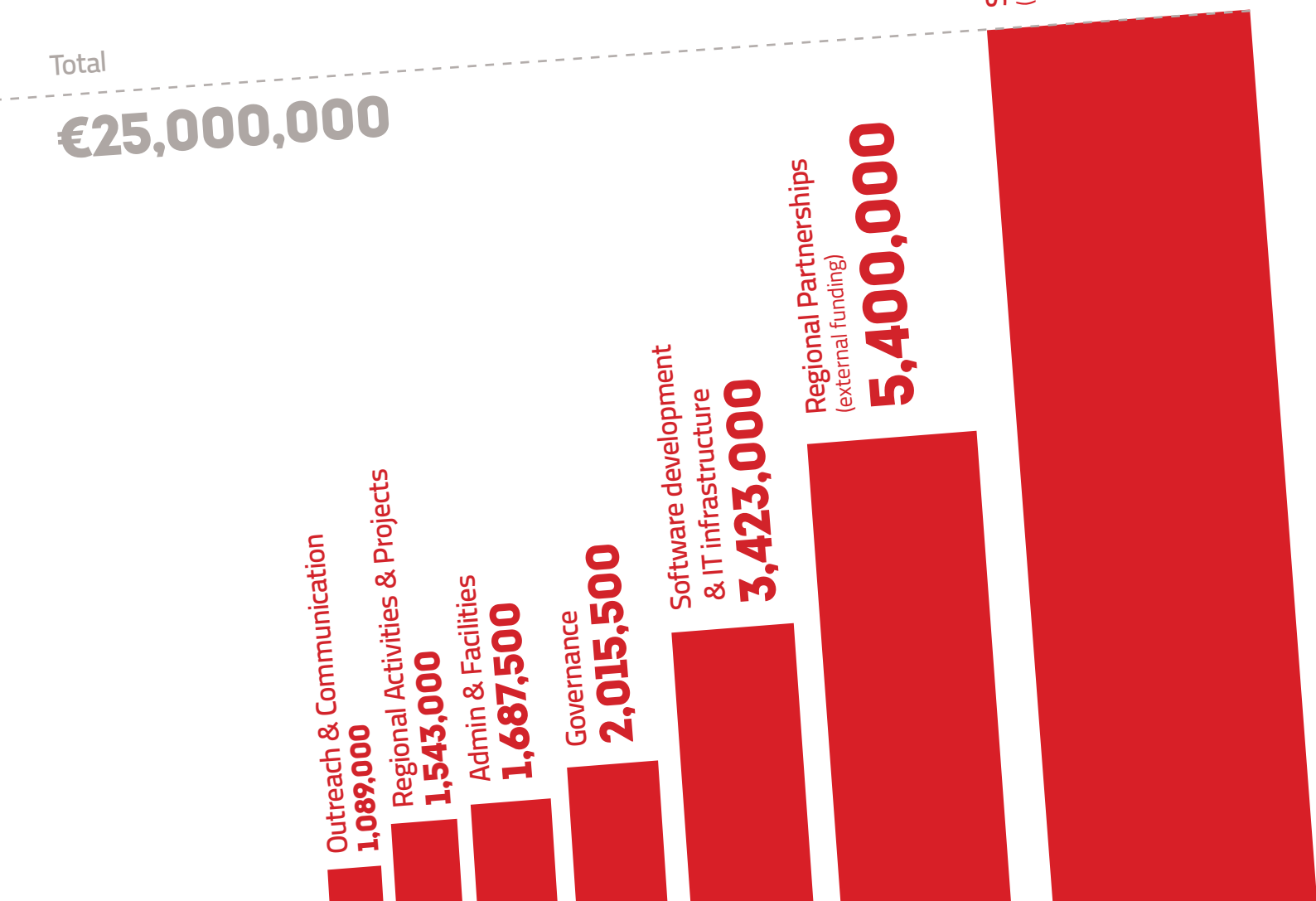
During the 2009-2013 phase, GEM received €5.6 million from 14 public participants and €14 million from 11 private participants.

In-kind contributions, not budgeted in the tables herein, have exceeded €10 million thanks to the commitment of a number of scientists and institutions that have participated in the GEM initiative.

Expenditures in the first Working Programme will have totalled €25 million.

This amount has funded collaborative development of tools and resources for worldwide risk assessment and international exchange of science and knowledge. The figure below includes €5.4 million of external funds for regional programmes that are accounted for separately and funded by international organisations and companies.

GEM's activities can be divided into 7 core areas. This graph shows how much has been spent and allocated to each of these areas from January 2009 to December 2013. Global science projects comprised the largest proportion of funds (~50%). Development of OpenQuake software accounts for ~20%.



Financial Plan 2014-2018

An annual **€5** million target operating budget for Working Programme 2 would allow continued investment in new science (approximately €1.2 million a year to cover the aforementioned next generation science), together with necessary maintenance (bug fixes, enhancements for optimization and interoperability), user support and updates of the platform (including data curation), and continuation of mission-driven regional partnerships and community-building (approximately €1.4 million a year).

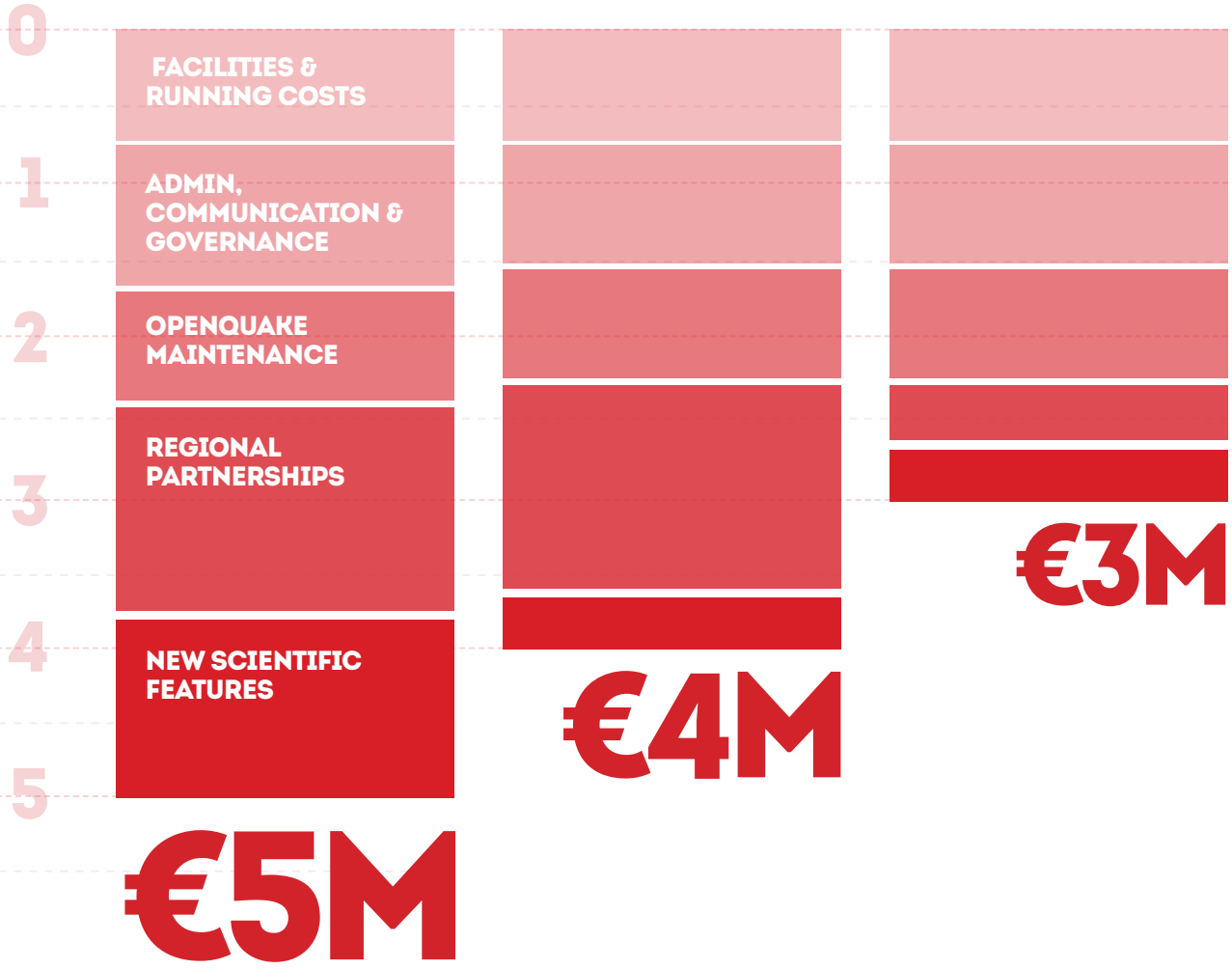
In comparison to Working Programme 1, this budget represents an increased allocation to regional partnerships, additional human resources as required for a maturing organization, and re-allocation of scientific human resources toward continuous improvement of datasets and models.

Two other possible operating budgets are also foreseen:

A **€4** million operating budget would limit GEM scientific advances to those that can be achieved without funding external consortia.

A **€3** million operating budget would also limit GEM's regional activities to those that can be achieved without funding regional projects.

Indicative Proposed Resource Allocation under three different Operating Budgets:



Sustainability

We plan to sustain our activities going forward through:

- Participation in / governance of the effort (public and private participants)
- Project and programme funding for: regional activities, technology transfer, special science projects, development of OpenQuake
- In-kind contributions, including local/ regional data and models as well as effective facilitation of the GEM effort, coming through the Associate Participants category and the Worldwide Collaboratives

PUBLIC PARTICIPATION

Two modes are proposed for collaboration with public entities, with contributions and privileges as defined below: Public Participation and (newly-added) Worldwide Collaboratives (WC), described in greater detail previously. The intent of adding this latter category is to more clearly define the relationship with initiatives that relate to and coordinate with GEM but which remain financially independent.

Defined financial contributions from Public Participants follow a sliding scale based on the OECD formula relating contributions to a country's national expenditure on research and development (see table). In exceptional cases, when it is of special interest for GEM, participation is also possible by organisations at the regional, sub-national or city scale, with contributions and related privileges subject to mutual agreement and Governing Board approval.

Gross Domestic Expenditure on Research and Development (GERD) (current PPP $)[1]	Annual GEM contribution
GERD > $50,000 million	€ 275,000
$50,000 m > GERD > $25,000 m	€ 170,000
$25,000 m > GERD > $10,000 m	€ 100,000
$10,000 m > GERD > $2,000 m	€ 70,000
$2,000 m > GERD > $1,000 m	€ 30,000
GERD < $1,000 m	€ 15,000

The Worldwide Collaboratives are meant to capture a broad set of potential initiatives such as national level risk assessment/mitigation endeavours and city scenario projects, focused on a specific geographic area, with which GEM collaborates but does not fund or manage directly.

PUBLIC PARTICIPANT

Contributions
- € Variable [1]
- Intellectual Contributions [2]

Privileges
- Governing Board Voting Seat
- Early Insight
- High Visibility
- Training Workshops

WORLDWIDE COLLABORATIVE

Contributions
- Intellectual Contributions [2]

Privileges
- WC Council Membership
- Visibility
- Integration and Support
- Training Workshops

[1] sliding scale relative to GERD, per table
[2] data, models, expertise, results, etc.

SECTION 5

Governance and Sustainability

PRIVATE PARTICIPATION

Private participants contribute funds to the GEM Foundation and earn privileges related to governance, insight, interaction, and visibility. Four categories of participation are available, distinguished by sector and level of contributions. The 'advisor' and 'affiliate' categories are newly added, and targeted to engineering organizations (outside the insurance and catastrophe modelling industry), so as to expand GEM's reach and OpenQuake's use.

INSURANCE & RISK MODELLING SECTOR [1]

Governor

Contributions	€250,000[3] Intellectual contributions[4]
Privileges	Governing Board Voting Seat Redistribution of OpenQuake[5] Early Insight High Visibility Certification Training[6] Workshop Invitations[7]

Patron

Contributions	€125,000[3]
Privileges	Redistribution of OpenQuake[5]

ENGINEERING SECTOR [2]

Advisor

Contributions	€60,000[3] Intellectual contributions[4]
Privileges	Technical Advisory Council Membership Redistribution of OpenQuake[5] Early Insight High Visibility Certification Training[6] Workshop Invitations[7]

Affiliate

Contributions	Up to €30,000[3]
Privileges	Redistribution of OpenQuake[5]

[1] although predominantly from this sector, also available to any organization

[2] also available to any organization outside the insurance, financial services, and risk modelling sectors

[3] annual amount, assuming a 5-year contribution

[4] data, models, expertise, results, etc.

[5] private participants are granted a waiver to the license clauses that prevent incorporation and redistribution of software as part of a proprietary system

[6] every other year

[7] twice a year, allowing for discussions with GEM staff and scientists and providing direct influence in GEM strategy and product development

Benefits of GEM Participation

ENTER INTO AN INSPIRING NETWORK

GEM is an exciting collaboration among top-level experts and public, private and international organisations from around the globe that play a leading role in earthquake risk assessment and management.

GEM's Governing Board features renowned professionals who meet formally twice a year to take all strategic decisions related to GEM.

STRATEGISE IN GEM's FIRST PHASE

Between 2013 and 2014 many GEM products come to fruition and are being integrated into the OpenQuake platform.

GEM Foundation participants actively take part in strategic planning during this last phase of GEM's first Working Programme. Public Participants, Governor and Advisory Private Participants make strategic choices and decide on changes in focus when and where needed.

SHAPE GEM's FUTURE

GEM's partners decide together on GEM's second Working Programme, globally and regionally. The 2014-18 Working Programme emphasises continued development of regional and other collaborations, facilitating use of OpenQuake to support a worldwide community in carrying out risk assessments and increasing the global knowledge base. At the same time we will continue to support groundbreaking science globally.

STAY AHEAD

Public Participants obtain early access to interim research, test results, preliminary products and datasets, for application in their organisation.

Workshops are organised to share know-how and insights with our partners, to discuss their needs, and to connect them directly to the global community of scientists. Through training collaborators gain hands-on skills to effectively use the various GEM products.

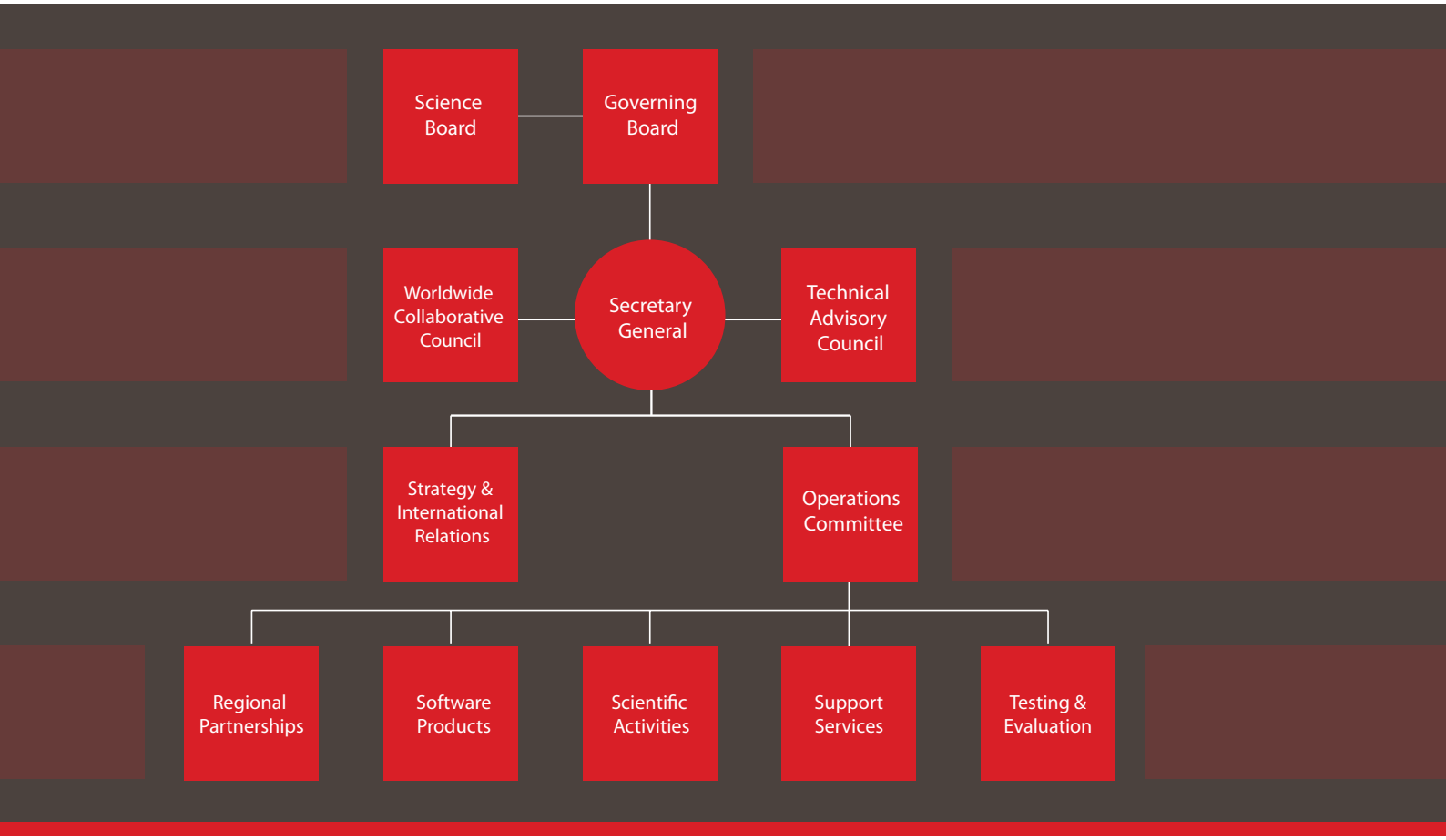
CONTRIBUTE TO RISK REDUCTION

GEM's ultimate goal is facilitating risk awareness and decisions that lead to a more resilient society. Partners play a key role in ensuring that tools and resources developed within GEM help to reduce earthquake casualty, destruction, dislocation and monetary losses from the global down to the local scale. Partners also help to build new collaborations to leverage GEM's resources for mutual benefit.

SECTION 5

Governance and Sustainability

Organisation Structure



The 2014-2018 organisation structure is an evolution of its 2009-2013 counterpart, reflecting the fact that GEM is now maturing as an organization.

The figure shows the intended adaptations of the organization to suit the next phase of GEM, reflecting our growing needs, and changes in priorities, many of which have been outlined in this document.

GOVERNING BOARD

GEM is governed by public and private participants of the GEM Foundation; one representative of each organisation takes a seat on GEM's Governing Board, which is convened twice a year. They are accompanied by non-voting representatives of GEM's associate participants, typically international organisations that do not contribute funds. The Governing Board takes all strategic decisions and is advised on technical matters by the Science Board. Voting weight for private participants, taken as a group, is equal to that of public participants, taken as a group.

SCIENCE BOARD

The Science (formerly 'Scientific') Board is the body through which the global scientific strategy of the GEM Foundation and corresponding implementation is monitored, reviewed, advised and guided. It provides the Governing Board with proposals on all matters related to the implementation of the technical work programme. The Science Board is made up of not more than 20 international experts selected by the Governing Board, with proven expertise on GEM-related scientific fields (hazard, vulnerability, risk, social-economic vulnerability/ resilience, and IT) as well as experience in collaborative projects, and international connections. The Science Board convenes on a semi-annual basis.

SECTION 5

Governance and Sustainability

Organisation Structure

TECHNICAL ADVISORY COUNCIL

The Technical Advisory Council is a newly-proposed group, not yet formalized. It will comprise representatives from any organization sponsoring GEM and it will meet every six months to provide strategic input related to usability, cultivation of the user community, and development to support expansion of GEM and OpenQuake with offshoot tools and services, with particular focus on private-sector implementation.

WORLDWIDE COLLABORATIVE COUNCIL

The Worldwide Collaborative Council is a newly-proposed group, not yet formalized. It will comprise representatives of the GEM Worldwide Collaboratives and it will meet every six months to provide strategic input related to usability, cultivation of the user community, and development to support expansion of GEM and OpenQuake with offshoot tools and services, with particular focus on public-sector implementation.

SECRETARY-GENERAL

The Secretary-General is the organisational leader and chief executive of GEM. The newly-characterised role has primarily an external focus, with greater emphasis on developing and maintaining collaborative and strategic partnerships, in addition to more active interaction with Governing Board members.

STRATEGY & INTERNATIONAL RELATIONS

This group reports to the Secretary-General and aids him/her in activities related to interacting with the wider GEM community. This group thus has a predominantly external focus, which includes user community management, international liaisons, external communication, strategy implementation, and sponsorship development.

OPERATIONS COMMITTEE

The Operations Committee is chaired by the Director of Technology and Development and includes the regional partnerships manager, the software development manager, the leaders of hazard, risk and social vulnerability and resilience activities, the support services manager and the Testing and Evaluation Facility manager. The Director of Technology and Development reports to the Secretary General and has the authority to take operative decisions and measures on all technical and scientific matters.

REGIONAL PARTNERSHIPS

The Regional Partnerships refers specifically to regional activities directly managed and funded by GEM. This group coordinates extensively with regionally-focused activities of the Strategy and International Relations group as well as with the software development and science teams. The manager of this group reports to the Director of Technology and Development.

SOFTWARE DEVELOPMENT

This group carries out the OpenQuake software development in close collaboration with the scientific group. The manager of this group reports to the Director of Technology and Development.

SCIENTIFIC ACTIVITIES

This group is responsible for leading the hazard, physical risk and social vulnerability and resilience within GEM, in particular for what concerns the scientific specifications for tools and software, the technical training of the use of these tools, and the interactions with the external technical expert groups working in these fields. Leaders of each scientific activity sit on the Operations Committee.

SUPPORT SERVICES

The personnel working within this group are at the service of the whole GEM Foundation, and include secretarial activities (for organisation of meetings, workshops, travel etc.), accounting activities, graphic design for the website and communication material (such as those needed by the Strategy Executive Group for external communication), contracts and licensing, human resource management, and system admin. The manager of this group reports to the Director of Technology and Development.

TESTING & EVALUATION

This refers to what is currently an external facility at GFZ, Potsdam, Germany. The focus of this facility has been on prospective testing within three main areas: 1) testing of the seismicity rate model, 2) testing of prediction of ground motions and hazard, 3) testing of risk forecasts.

SECTION 6

Acknowledging Our Supporters

We are very grateful to all who provide support to GEM, both financial and in-kind. Most funding comes from the public and private participants of the GEM Foundation. Public participants in the GEM effort are countries/regions/cities that partner with the GEM Foundation (often through a public institution), contributing to the effort through their funding, network and experiences.

GEM has five Private Founders that have a special role within the initiative. They have become key players in the undertaking and participate actively in the various components. Since then a number of additional private organisations have become sponsors of GEM. GEM also receives important contributions from its Associate Participants, as well as other non-profit organisations or collaborating institutes who provide vital support for critical elements of GEM.

Thanks to our worldwide community, which includes hundreds of institutions and thousands of individuals whose names cannot all be reported here for reasons of space, GEM has grown to be an important and tangible reality. Through this collaborative effort we strive to change the landscape of earthquake risk assessment and thereby support risk understanding, mitigation and management.

PRIVATE PARTICIPANTS

Munich RE

ZURICH

AIR WORLDWIDE

EUCENTRE
European Centre for Training and Research in Earthquake Engineering

Willis

FM Global

hannover re®

Renaissance Re
RISK SCIENCES FOUNDATION, INC.

Foundation Swiss Re

Nephila

NUBO

SECTION 6

Acknowledging Our Supporters

PUBLIC PARTICIPANTS

Australia
Geoscience Australia

Chile
Pontifical Catholic University of Chile

Ecuador
Ministry of Housing & Urban Development

Germany
GFZ German Research Centre for Geosciences

Italy
Civil Protection Department

Japan
National Research Institute for Earth Science & Disaster Prevention

New Zealand
Ministry of Business, Innovation & Employment

Norway
The Research Council of Norway

Singapore
Nanyang Technological University

Switzerland
State Secretariat for Education and Research

Taiwan
Taiwan Earthquake Model

Turkey
Turkey Catastrophe Insurance Pool

United Kingdom
Natural Environment Research Council

United States
United States Agency for International Development

Venezuela
Venezuelan Foundation for Seismological Research

ASSOCIATE PARTICIPANTS

California Seismic Safety Commission

Earthquake Engineering Research Institute

International Association of Earthquake Engineering

International Association of Seismology & Physics of the Interior Earth

International Council for Science / Integrated Research on Disaster Risk

The Institution of Structural Engineers

Organisation for Economic Co-operation & Development

United Nations Educational, Scientific & Cultural Organization

United Nations International Strategy for Disaster Reduction

The World Bank

Be Part of GEM

JOIN:

Become a public or private participant in the GEM Foundation; sustain GEM, provide guidance, obtain early access to (preliminary) tools and resources and enter into an inspiring network

SUPPORT:

Fund activities in the regions, global studies or technology transfer, or render your services available to GEM

EXPLORE:

Try GEM tools as they become available and provide feedback

REGION:

Share knowledge and data within a regional partnership

SCIENCE:

Provide feedback on the global best practice

DATA:

Collaborate on data to enhance the global datasets for everyone's use

DEVELOP:

Join one of our open-source projects

FOLLOW:

Stay up-to-date through our newsletter and website

GEM

GLOBAL EARTHQUAKE MODEL

Working together to assess risk

GEM Foundation

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