SYNER-G

Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructures Safety Gain
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Duration: 36 months (starting date: Nov. 1st, 2009)
Project Webpage: www.syner-g.eu
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SYNER-G Project summary

SYNER-G is research project which has the following main goals: (1) To elaborate appropriate, in the European context, fragility relationships for the vulnerability analysis and loss estimation of all elements at risk, for buildings, building aggregates, utility networks (water, waste water, energy, gas), transportation systems (road, railways, harbors) as well as complex medical care facilities (hospitals) and fire-fighting systems. (2) To develop social and economic vulnerability relationships for quantifying the impact of earthquakes. (3) To develop a unified methodology, and tools, for systemic vulnerability assessment accounting for all components (structural and socio-economic) exposed to seismic hazard, considering interdependencies within a system unit and between systems, in order to capture the increased loss impact due to the interdependencies and the interactions among systems and systems of systems.

The methodology and the proposed fragility functions will be validated in selected sites (urban scale) and systems and it will implemented in an appropriate open source and unrestricted access software tool. Guidelines will be prepared and the results and outputs will be disseminated in Europe and worldwide with appropriate dissemination schemes.

SYNER-G is integrated across different disciplines with an internationally recognized partnership from Europe, USA and Japan. The objectives and the deliverables are focused to the needs of the administration and local authorities, which are responsible for the management of seismic risk, as well as the needs of the construction and insurance industry.

The 14 participants in the SYNER-G consortium represent a variety of organizations, from universities and academic institutions to research foundations and SMEs. Together, they represent some of the best available expertise in different aspects of earthquake vulnerability assessment and loss estimation. The consortium takes advantage of the knowledge available with international partners from the US and Japan. The SYNER-G Consortium includes the main actors of the participating organizations.
SYNER-G Elements at risk

- Buildings and building aggregates at city level
- Energy systems (gas and oil pipeline systems and electric power networks)
- Water and sewage systems
- Transportation systems and infrastructures (bridges, roadway, railway and port systems)
- Hospitals
- Fire-fighting system
SYNER-G Background and overall objective

a) **Past and ongoing research** on the vulnerability assessment and seismic risk analysis of assets and urban systems, at international, European and national level are focused on the vulnerability assessment of individual elements exposed at risk. The uncertainties associated with the proposed empirical, semi-empirical and analytical fragility functions and loss estimate models are very important and further research is needed to improve them.

b) There is an urgent need to develop **fragility functions** for all elements at risk in the **European context** respecting the European distinctive features of the elements at risk and the European seismotectonic characteristics.

c) **Systemic vulnerability** and the associated increased impact have not been considered so far in a rigorous and unified way for all kind of systems. It is important to evaluate both the vulnerability of independent elements and the systemic vulnerability of systems as well as systems of systems.

d) There is a need in **Europe** to develop a **unified tool** to evaluate seismic vulnerability and losses considering both **physical** and **socio-economic aspects** that reflect the European communities with their special characteristics as well as the European know-how.
General graphical layout of the concept and goals of SYNER-G

Hazard Event

Physical Damage

Assessment of Impact

Social and Economic Consequences

Building Stock

Transportation Systems

Utility and Infrastructure Systems

Critical Facilities

Systemic vulnerability

Social and Economic Vulnerability

Short Term
- Emergency Shelter, Temporary Housing

Long Term
- Relocation, Displacement

Economic Loss
- Direct Damage, Price Increases, Business Interruption, Supply Disruption

Health
- Fiscal Impacts, Business Failure, Job Loss, Reconstruction
- Psychological Distress, Chronic Injury

Social Disruption
- Casualties, Fatalities, Health Care Disruption
- Emergency Supplies, Family Separation

Family Stress, Neighborhood Disruption
SYNER-G Goals

a) To propose and further develop appropriate, in the European context, fragility relationships for the vulnerability analysis and loss estimation of all elements at risk.

b) To develop social vulnerability relationships and other means of quantifying the impact of earthquakes on vulnerable communities.

c) To develop the basis and principles of a unified methodology, as well as appropriate tools, for systemic vulnerability assessment accounting for all components (structural and non-structural) exposed to seismic hazard, considering interdependencies within a system unit and between systems belonging to a complex grid that comprises a functioning community. Socio-economic issues will be thoroughly considered as an impact factor for the holistic evaluation of vulnerability and loss estimates.

d) To test and validate the methodology and the particular fragility functions in adequately selected sites (city level) and systems.

e) To implement the methodology in an appropriate open source and unrestricted access software tool.

f) To prepare guidelines and to disseminate the results and output with appropriate dissemination schemes in national, European and worldwide level.
SYNER-G Main objectives

1. Encompass all past and ongoing knowledge and know-how on this topic at a European and International level.

2. Select the most advanced fragility functions and methods to assess the physical and societal-economic vulnerability of all assets, improving and further developing new ones where necessary, considering European distinctive features.

3. Propose the most appropriate means of selecting seismic scenarios at system level.

4. Develop a unified methodology to assess vulnerability at a system level considering interdependencies between elements at risk (physical and non-physical), belonging to different systems and between different systems as a whole at city and regional scale.

5. Build an appropriate open-source software and tool to deal with systemic vulnerability.

6. Validate the effectiveness of the methodology and the tools to specific and well selected case studies at city and regional scale.

7. Propose adequate guidelines and to build appropriate dissemination schemes for all products of the project at European and International level.
SYNER-G Project workflow

WP1. Coordination

Executive Committee

WP2. GENERAL METHODOLOGY

WP3. PHYSICAL VULNERABILITY & LOSSES
Fragility functions for elements and systems

WP4. SOCIO ECONOMIC VULNERABILITY & LOSSES
for elements and systems

WP5. SYSTEMIC VULNERABILITY & LOSSES

Buildings & aggregates
Utility systems
Transportation infrastructures
Critical facilities

Interdependencies between systems

WP6. APPLICATION & VALIDATION

Urban scale
Thessaloniki city
Vienna city

Utility-Transportation
Pipeline network
Motorway in Italy
Electric network in Italy
Harbor of Thessaloniki

Critical facilities
Hospital facility in Italy

WP7. SOFTWARE TOOLS

WP8. GUIDELINES - DISSEMINATION

Project Management

Seismic Hazard Scenarios
SYNER-G Key material / deliverables

More than **80 deliverables**, including reports, software tools, dissemination material, etc. will be produced. There will be a short number of **consolidated reports** presenting the essential developments and results.

Besides classical reporting, other materials comprise:

- **SYNER-G Web portal.**
- Prototype **software tool** for the systemic vulnerability assessment and loss estimation.
- **Applications** and validation of the methodology and tools.
- Project **newsletter** issues.
- **Dissemination material** of all products and educational tools.
- **Guidelines** and recommendations.
- Reference reports and synthetic documents.
- **Journal** and conference papers.
- **Technical workshops** and **final international workshop.**

Most of the dissemination material will be in **electronic form**.
SYNER-G Impact

Technology: A unique European approach will be created making us independent from the U.S. approach.

Society: The protection and safety of the population will be considerably improved.

Economy: The results will enable an improvement of the European building environment, infrastructures and lifelines, thus avoiding dramatic losses from earthquakes to come.

Standards: A standard modular methodology will be created allowing a European approach to the subject and allowing application all over the continent and enabling the construction industry to improve the built infrastructure.

ERA: The European Union will be enabled to implement greater economic integration with its neighbors who are also considerably in need of these new methodologies.

International Collaboration: The results of the project will make collaboration with Europe more attractive particular from the view of the U.S. and Japan. Europe will be enabled to take the lead on this subject.

Technology Transfer: Europe will be seen as enabling the rising problems of mega cities in earthquake prone areas.
SYNER-G Specific impacts of the deliverables (1/3)

• The development of a unified methodology for the systemic vulnerability and loss assessment of buildings, utility and transportation networks and critical facilities due to seismic hazard at a European level, will help policy-setters and decision makers to optimize urban development and infrastructure planning and the efficiency of seismic risk mitigation strategies.

• The development of advanced methods and software for systemic vulnerability and loss assessment of buildings, lifelines and networks related to earthquakes will provide an increased understanding of vulnerability of various societal elements at risk, including the inter-element dependencies. The validation of the tools through appropriate test sites will investigate their applicability and effectiveness in European level.

• The available fragility functions will be reviewed and evaluated in order to propose the most appropriate ones for all elements at risk or improve and in some cases develop new ones. This is a key step for the whole methodology which will include the setting up of fragility formulations considering the specific typological features of Europe.
SYNER-G Specific impacts of the deliverables (2/3)

• The guidelines and recommendations concerning the fragility and loss assessment of individual elements at risk and the systemic vulnerability and losses of the entire networks and of a system of networks will constitute a European reference worldwide. They will provide guidance to stakeholders on where to direct research and development efforts and to allocate resources where uncertainties need to be reduced or where cost-effectiveness can be increased.

• The reports and guidelines on innovative and state of the art methods produced within SYNER-G, will provide the roadmap beyond the state-of-the-art in lifeline earthquake engineering research, and a benchmark for future research in the field.

• The establishment of links and collaborative research between the engineering community (universities, research institutes and centers, companies) and the insurance industry will lead to significant developments regarding the financial and social losses due to earthquakes, and facilitate direct output to interested stakeholders with an immediate impact for decision makers and policymakers.

• The collaborative activities carried out in the consortium will lead to a global improvement in the knowledge about the seismic response of buildings, lifelines and infrastructures in Europe, with particular reference to systemic and social vulnerability.
SYNER-G Specific impacts of the deliverables (3/3)

- The importance and special nature of the seismic risk in Europe is recognized with the European Parliament (2007) resolution on the regional impact of earthquakes. The resolution focuses in particular on measures for prevention, education, research, risk management, protection and solidarity at a community level. SYNER-G, responding to these priorities, intends to develop an integrated methodology for seismic risk assessment and management.

- The involvement of End-Users from the European Community will transfer the practice and know how of the recommended methodology for systemic seismic risk assessment.

- The various dissemination activities and the web portal, together with the guidelines and recommendations will be the instruments to disseminate the latest developments in lifeline risk assessment and management and the proposed approaches and tools. In this way, a valuable toolbox will be provided to the decision-makers to assist the development of mitigation measures, while their implementation in practice will be encouraged, thus again contributing to changing the perception and confidence in risk management.
SYNER-G Dissemination of project results-Implementation

- **End user networks** within and across the case studies and clarification tests.
- **Generic and comparative dissemination material** in different formats and for different media to reach the intended target audiences.
- **Local dissemination activities** such as presentations and workshops in selected regions.
- **Project web server** and document exchange platform for global dissemination and in support of the local and regional dissemination strategies in each case.
- **Long term networks of collaboration** with interested parties across the applications.
- **Strategies to implement** and institutionalize the methods developed in each case for continuing use, based on the feedback from the local networking and dissemination activities.
- **Feedback** from the targeted end users, industries and services.
- **Exploitation plan** for individual and collective exploitation of the project results by each project partner. Identification and finding of new end users based on the experience from the dissemination activities.
SYNER-G Management structure and procedures

- **European Commission (EC)**
- **Coordinator (P1)**
- **Project Manager (P2)**
- **Executive Committee (also functions as Scientific Committee)**
- **International Advisory Committee (IAC)**
- **General Assembly (PROJECT CONSORTIUM)**
- **L1, L2, ......., L8 Work Package Leaders**
- **P1, P2, ......., P14 Participants**
- **Subcontractors**
- **End-Users Group (EUG)**
- **Web-based Project Platform**
- **Guidelines, recommendations for Europe – Dissemination Work Package 8**
SYNER-G International Advisory Committee (IAC)

Professor Domenico Giardini
Professor Mauro Dolce
Professor Joern Birkmann

Its role is to act as an advisory body to the project, and to provide external assistance to the Executive Committee and the Coordinator. The purpose of this committee is also to stimulate international cooperation, international dissemination of results and knowledge andconcerting of international research activities in the field of hazard mitigation.
SYNER-G End-Users

**Italy:** Department of Civil Protection.

**Turkey:** Istanbul Metropolitan Municipality’s Directorate of Earthquake and Grounds Research, Ministry of Public Works and Settlement-General Directorate of Disaster Affairs.

**Greece:** Region of Central Macedonia, State Company of Natural Gas, Water and Waste Water Authority of Thessaloniki, Egnatia Odos S.A.

**Slovenia:** Administration of the Republic of Slovenia for Civil Protection and Disaster Relief.

**Austria:** City of Vienna.

**Germany:** Munich Re.

Further potential end-users will be identified and invited to participate.