SIBYL

(SeIsmic monitoring and vulnera**B**ilit**Y** framework for civi**L** protection)

Agreement number: ECHO/SUB/2014/695550

Deliverable DA2: First Progress Report

(Covering period 01.01.2015 to 31.08.2015)

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General reminder

The occurrence of seismic swarms or foreshocks may require Civil Protection (CP) authorities to promptly assess a threatened area's vulnerability. This is especially true for regions where there is a dearth of up-to-date and reliable information. Similarly, methods are also required for assessing an area's vulnerability prior to a seismic (or any) hazardous event for risk estimation and response planning. The aim of SIBYL is therefore to develop an operational framework for CP authorities to rapidly and cost-effectively appraise the seismic vulnerability of the built environment, and to efficiently use the acquired information prior to, or given the occurrence of a damaging event, to optimize the management of the subsequent emergency situations. Such a framework will advise decision makers as to the most appropriate preventative actions to take and will consider when there is a need for short-notice vulnerability assessments in a pre-event situation, as well as monitoring the built environment's dynamic vulnerability during a seismic sequence and undertaking vulnerability assessment as part of a longer-term risk management strategy. The framework (which includes software and hardware tools) will have the flexibility to be applicable to multiple spatial scales, while its modular structure will allow its adaptation to other natural hazard types. Training of CP personal in the developed methods will see the framework integrated into their operational protocols, enhancing their operational capacities at the pre- and post-event stages, thus ensuring the legacy of the SIBYL results.

The consortium is coordinated by the Centre for Early Warning Systems of the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences (GFZ). GFZ has extensive experience in seismic hazard and risk assessment, including the development of low-cost monitoring and exposure and vulnerability data gathering systems. The other members of the consortium are AMRA S.c.a.r.l., (AMRA, Naples, Italy), a Centre of Competence in the area of analysis and monitoring of environmental risk, the Geotechnical Engineering Division of the Aristotle University Thessaloniki (AUTH, Thessaloniki, Greece), and the Department of Civil Engineering, Technical University – Berlin (TU-BERLIN, Berlin, Germany).

The expected outcomes and deliverables from the project are as follows:

- Guidelines for CP authorities on implementing the developed framework to optimize prevention actions at various spatial scales and stages of a seismic crisis. The guidelines will cover the use of a mobile mapping system and the remote analysis of its imagery, remote-sensing methodologies, building appraisal and short-term monitoring procedures (including instrumentation), site-effects surveys and assessing time-variant seismic risk.
- Easy-to-use software tools exploitable by CP practitioners with the minimum amount of training required for acquiring and analysing different types of observations covering various spatial scales, their integration to identify a structure's dynamic seismic behaviour, and the consideration of other factors such as site effects.
- Training and capacity building for CP practitioners with regards to the optimal exploitation of the framework, including cost-benefit analyses.
- Outreach activities to interested parties on the aims and results of the project.

General summary of the project's implementation process

The consortium believes that the implementation of the project's activities is proceeding reasonably well, and within the schedule outlined during the project's proposal development. Considerable communication between the partners has allowed this successful start to the project, assisted in no small part to the partners all, to varying degrees, being involved with each other in previous and on-going projects.

The first payment from the EC-ECHO was distributed amongst the consortium partners in proportion to their total planned budget. The human and financial resources appear to have been appropriately allocated by each partner during the first reporting period of the project, allowing the intended developments that are outlined in this report.

At this stage of the project, most efforts have involved preparation for the main technical activities, namely planning field activities, compilation of available information about the structures to be investigated in detail, and the development/expansion of existing structural response models and monitoring systems. This includes various software applications being developed and tested, namely structural modelling tools and a tool box for real-time array processing and the processing of acquired data from a multi-parameter monitoring system.

Evaluation of the project management/implementation process

Thus far within the consortium, no difficulties have arisen that have required significant intervention by the project management, nor has there been any need for assistance from the EC-ECHO project office (excluding general enquiries into, for example, reporting requirements). Extensive communication within the consortium has allowed for details, and where necessary, changes, of the proposed activities to be effectively elaborated upon. Again, overall the consortium believes that the activities are proceeding on schedule.

Activities

- The project's website was established when expected and is now active and is being continuously updated (see below).
- Software tools for seismic array analysis and building response modelling and analysis have been developed and will be tested (see below).
- A prototype multi-parameter monitoring system and accompanying software has been developed for structural health monitoring and other activities, such as on-site and regional earthquake early warning.
- AUTH and TU-BERLIN have collaborated in terms of collating the blueprints and plans of the selected Thessaloniki test buildings, with AUTH undertaking a numerical analysis of the refined 3D-model and TU-BERLIN using the supplied information for simplified structural modelling of seismic vulnerability.
- GFZ, AUTH and TU-BERLIN in September/October 2015 will deploy temporary arrays for noise measurements in the target buildings in Thessaloniki (AHEPA hospital, administration building of the university, and the Faculty of Philosophy, Figure 1). Coupled with this is the further development and testing of the structural analysis tools.
- These activities are believed to be within the expected timing when formulating the project proposal.

AHEPA hospital | Administration building | Faculty of Philosophy

Figure 1: The Thessaloniki test sites selected for the project and which will be instrumented in September/October 2015.

Presentation and evaluation of technical results and deliverables

None of the technical deliverables are due for completion until the end of the project (month 24). Furthermore, as most of the current activities need be considered as serving multiple tasks and deliverables, it is not especially meaningful to comment on the completeness of the final documents. Hence, the following outlines what technical activities have been and are being undertaken upon which the final outcomes will be built.

Task B "Rapid data collection and integration":

- A spatial-data-infrastructure (SDI) schema has been implemented in order to integrate information coming from different sources (remote sensing and aerial imagery, ground based imagery, in situ observations) into a consistent geo-spatial model that can be linked with the vulnerability models provided by task C. The geospatial model has been implemented in a postgresql/postgis database platform compatible with the QGIS[1] environment, and is based on state-of-the-art, free and open source solutions (FOSS). A flexible exposure taxonomy is being proposed to provide a standardized description of the assets to be mapped (relevant to different natural hazards), while also considering the already existing national procedures of the partners.
- Guidelines for the use of remote sensing methodologies and the mobile mapping system are in progress and will be soon completed.

Task C "Rapid and low cost in-situ building vulnerability assessment":

- Two approaches to simplified integral structural models have been developed (Task C.1 "Simplified integral structural model approach to seismic vulnerability assessment"): (1) a 1-D multi-degree of freedom system where each floor is a single mass, and (2) where the building is reduced to a 2-D frame. These tools are being evaluated using results from a previous project involving a building in Bishkek, Kyrgyzstan. Specific software for in-situ data acquisition and topological modelling has also been developed. Available structural information about the buildings that will be studied in detail has been acquired and distributed to the relevant partners, with detailed 3-D analysis currently underway (see above and below).

[1] www.qgis.org/ Qantum GIS is a free and opensource geographical information system.

- Buildings for Task C.2 “Short-term structural monitoring and model analysis of buildings” have been selected and will be instrumented in the near future (Figure 1, see above). The AHEPA hospital building has already been instrumented within the context of other projects, including recording two small magnitude events. The resulting data will be used for evaluating their dynamic behaviour and used in a predictive modelling tool to represent their actual seismic response and vulnerability. A comparative review of current monitoring approaches is in progress and existing guidelines for the design of optimal dynamic monitoring strategies will be evaluated. Currently, efforts are concentrated on the organization of the experiments (e.g., logistics, design of the instrumentation array etc.).
- A first release of a toolbox for real-time array processing (using the python language) has been developed. It includes dispersion curve estimation by using the extended spatial autocorrelation (ESAC) method and a singular value decomposition algorithm to provide a preliminary shear wave velocity profile. A V_{s30} value can be directly extracted from the dispersion curves, following the approach of Albarello and Gargani (2010)[2]. The results can be included directly into QGIS databases and also used for vulnerability assessment. The toolbox is linked to a SeisComP3[3] acquisition system, which acquire the real-time data following the SeisComP3 data structure. This tool is likely to be extended to include, for example, real-time analysis of data recorded in buildings (e.g., spectral analysis, interferometry).

Task D “Real-time monitoring during a seismic sequence”

- A closed-form model approximating the structural reliability problem during a seismic sequence has been developed[4]. The model is based independent increments stochastic processes, and refers to non-evolutionary elastic-perfectly-plastic single degree of freedom (SDoF) systems. The model is also able to account for different levels of knowledge about the structural damage state and can proficiently be coupled with information acquired by the sensing system. However, because it refers to a non-evolutionary SDoF system, some simplifications have to be accepted. The importance of these simplifications is obviously dependent on the structural characteristics of the monitored building: e.g., it can be supposed that in the case of masonry building, the non-evolutionary hypothesis may appear too strong while on the other hand, it could be acceptable for steel structures.
- In order to overcome some of these approximations, AMRA is developing a new analytical model for structural reliability assessment in which the hypothesis of non-evolutionary behaviour. Such a model will possibly be based on Markovian processes and state-dependent fragility curves.
- A multi-parameter monitoring system for structural health monitoring, on-site and regional earthquake early warning and other uses has been developed and is being tested by GFZ, along with the associated software. The sensors that may be considered include: standard strong motion and weak motion sensors, broadband seismometers, MEMS sensors including accelerometer and gyroscope, camera, temperature and humidity sensors and a low cost GNSS system.

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[2] Albarello, D. and Gargani, G. (2010) Providing NEHRP soil classification from the direct interpretation of effective Rayleigh-wave dispersion curves, *Bulletin of the Seismological Society of America*, vol. 100 (6), pp. 3284-3294.

[3] https://www.seiscomp3.org/

[4] Iervolino I., Giorgio, M., Chioccarelli, E. (2014) Closed-form aftershock reliability of damage-cumulating elastic-perfectly-plastic systems. *Earthquake Engineering and Structural Dynamics*, vol. 43, pp. 613–625.

In terms of project management (Task A “Task management and reporting to the commission”) and publicity (Task F “Task publicity”), the following actions have been undertaken:

- The management of the SIBYL project took part in the EC-ECHO kick-off meeting in Brussels (20.01.2015), with its start-up technical meeting taking place in Potsdam (28.01.2015) The kick-off-meeting report (deliverable DA1 “Kick-off-meeting report”) is available from the project website.
- This report covering the first reporting period (deliverable DA2 “First progress report”).
- The project’s website is operational (deliverable DF1 “Project website”, http://www.sibyl-project.eu/), and is being continuously updated.
- During the technical kick-off-meeting in Potsdam, Dr. Florian Weber of THW[5] (Bundesanstalt Technisches Hilfswerk, Germany) took part and provided valuable input.
- A detailed dissemination plan is being finalised (DF2 “Detailed plan for project publicity”). Various publicity items are currently being prepared, including a brochure outlining the project’s aims and context, which is currently in an advanced stage of development and will be distributed via the website and by the consortium members through their websites and by individuals attending appropriate meetings, and a poster for use at conferences and other meetings.

Owing to the early stage of the project, the training and capacity building activities (Task E) have not received much attention. However, the activities associated with this will increase significantly during the next and final reporting periods.

Follow-up

The following outlines the activities to be undertaken during the next reporting period (until month 16):

- Field activities (see above) in Thessaloniki involving the data acquisition and installation of instruments in selected buildings by TU-BERLIN, AUTH and GFZ (September/October, 2015). The results will be used to validate the simplified models for rapid vulnerability assessment and demonstrated to local civil protection representatives and the university.
- Ambient noise measurements (Task C.3 “Site effects assessment”) will be performed in the fall of 2015 to assess soil conditions and site effects characteristics (i.e., resonant frequency, amplification factor and shear wave velocities with depth) at Thessaloniki and Cologne, and possibly at the Italian test site in 2016.. The results from noise measurement and array measurement records will be compared with available geotechnical data and past geophysical surveys.
- Field activities in Cologne are being prepared, including data acquisition via the installation of instruments in selected buildings by TU-BERLIN, AUTH (possibly) and GFZ (November 2015). The results will be used to validate the simplified models for fast vulnerability assessment.
- The development of an analytical model will continue in the next period of this project and results will be presented at the 16th World Conference on Earthquake Engineering.
- It is expected that several presentations of results from SIBYL will be made at the EGU 2016 meeting in Vienna, Austria, and at the Seismological Society of America meeting in Reno in April, 2016.

[5] http://www.thw.de/DE/Startseite/startseite_node.html

ANNEX – UPDATED FORMS T1 and T2

Note in FORM T2 the highlighted deliverables have been completed or are in place (e.g., the website).

Form T1

SUMMARY OF THE PROJECT

Objectives of the project.

SIBYL's aim is to develop an operational framework for Civil Protection (CP) authorities to rapidly and cost-effectively assess the seismic vulnerability of the built environment. The framework will provide information to advise decision makers as to the most appropriate preventative actions. It will cover cases where there is a need for short-notice vulnerability assessment in a pre-event situation, and the monitoring of the built environment's dynamic vulnerability during a seismic sequence. The framework will be flexible enough to be employed over multiple spatial scales, and its modular structure will ease its applicability to other natural hazard types. Training of CP personal in the developed methods will see the framework integrated into their operational protocols.

Why is this project necessary?

The occurrence of seismic swarms or foreshocks demands CP authorities to rapidly assess the threatened area's vulnerability. This is especially the case for regions where there is a dearth of up-to-date and reliable information. Such deficiencies result from, for example, no previous knowledge of the area's seismicity and inadequately documented urban development. As the crisis unfolds (i.e., the occurrence of a main shock), there is moreover a need for real-time information, that will allow CP responders to adopt their actions to the evolving situation. Such a situation, which may well involve cross-border areas, is an example of what the Community Mechanism for Civil Protection must deal with.
The actions called upon for CP will include the dynamic tagging of those structures that have, or may become, unsafe. Such actions will, for example, advise the population as to their movement back to their residences, or in helping to plan emergency accommodation. There is therefore the need for a rapid, cost-effective and flexible framework within which such information may be acquired. Furthermore, such a framework must be readily useable by CP operators, especially considering the frequent disconnection between the research/development and practitioner groups in hazard and risk assessment.

Describe the problem the proposal is supposed to address, background and what has been done already.

Unfortunately, most state-of-the-art approaches that can provide such information are costly and expertise intensive, hence limiting their large scale applicability and thus their capacity to contribute to efficient prevention actions. The consortium will therefore call upon experience gained from other EC supported projects to develop a practical framework for use by CP. The SAFER and REAKT projects have contributed to the development of new low-cost seismic instrumentation, suitable for rapid deployment, as would be required in an evolving crisis. Likewise within these and the MATRIX project, developments in understanding and modelling temporal changes in vulnerability due to repeated seismic events have been made, all of which can build upon the work on structural vulnerability undertaken in SYNER-G. Another source of information involves exploiting remote sensing, making use of the tools and methodologies developed within the SENSUM project.

Actions and means involved

- Selection of suitable test sites for the refinement of the field-based methodologies and training.
- Based on the analysis of remote sensing observations and knowledge of previously identified critical infrastructure, undertake in situ mobile mapping surveys, building inspections and characterisations, and the instrumentation of a selected subset of the inspected buildings.
- Further development of the required software for the integration and interpretation of the different types of data being acquired.
- During all these activities, interaction with CP participants will ensure the relevance of the developed tools to their needs, while also contributing to the required training and capacity building activities.

Expected results

- Guidelines for CP authorities on how to implement the developed framework to optimize prevention actions at various spatial scales and stages of the seismic crisis.
- Easy to use software tools exploitable by CP practitioners for the acquisition and analysis of different types of observations covering various spatial scales, their integration to identify a structure's dynamic seismic behaviour, and the consideration of other factors such as site effects.
- Training for CP practitioners on the optimal exploitation of the framework, including cost-benefit analyses.

Form T2

Project Acronym	SIBYL				
Task ID	**Task Title**	**Start Date**	**End Date**	**Actions**	**Deliverables**
A	Task management and reporting to the commission.	01.01.2015	31.12.2016	A.1 Technical coordination and communication (GFZ). A.2 Technical reporting (GFZ). A.3 Financial reporting (GFZ).	DA1: Kick-off-meeting report. DA2: First progress report. DA3: Second progress report. DA4: Final technical and financial report.
B	Rapid data collection and integration.	01.01.2015	31.12.2016	B.1 Preliminary field characterization by remote-sensing (GFZ). B.2 Rapid pre/post event assessment via mobile-mapping (GFZ). B.3 Evolutionary exposure/vulnerability model (GFZ).	DB1: Guidelines for the remote-sensing assessment methodology. DB2: Software platform including processing tools with related manual. DB3: Guidelines of the mobile mapping system and remote rapid visual screening.
C	Rapid and low cost in-situ building vulnerability assessment	01.01.2015	31.12.2016	C.1 Simplified integral structural model approach to seismic vulnerability assessment (TU-BERLIN). C.2 Short-term structural monitoring and modal analysis of buildings (AUTH). C.3 Site-effects assessment (AUTH).	DC1: Guidelines for the building assessment procedure and short-term monitoring. DC2: Guidelines for undertaking site-effect surveys. DC3: Documentation for the developed software tools. DC4: Reports on the case studies.
D	Real-time monitoring during a seismic sequence	01.01.2015	31.12.2016	D.1 Installation of low-cost sensing units for building-specific monitoring. (AMRA)	DD1: Guidelines for the assessment of time-variant seismic risk of monitored single structures.
E	Training and capacity building	01.01.2015	31.12.2016	E.1 Training and capacity building of Civil Protection representatives (GFZ). E.2 Investigation of the transfer of the system to other hazard types (GFZ).	DE1: Training materials for the use of the developed framework and tools. DE2: Report on the potential for the developed system to be transferred to other hazard types.

Project Acronym	SIBYL

F	Task publicity	01.01.2015	31.12.2016	F.1 Project website (GFZ). F.2 Multi-media dissemination material (TU-BERLIN). F.3 Public outreach and events (GFZ). F.4 Technical and professional dissemination (AUTH).	DF1: Project website. DF2: Detailed plan for project publicity. DF3: Report on public outreach events/activities. DF4: Report on technical and professional outreach.