PLINIVS Study Centre

for Hydrogeological, Volcanic and Seismic Engineering

National Competence Centre for Italian Civil Protection Department

Interdepartmental Centre of Research
Laboratory of Urban and Territorial Planning
***Raffaele d'Ambrosio* (LUPT)**

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Scientific Responsible
prof. **Giulio ZUCCARO**

www.plinivs.it

PLINIVS Study Centre (Study Centre for Hydrogeological, Volcanic and Seismic Engineering) is a structure of LUPT Research Interdepartmental Centre, University of Naples Federico II. Since 2006, PLINIVS is a National Competence Centre on Volcanic Risk for the Italian Civil Protection.

PLINIVS activity in the last 30 years included the development several **probabilistic simulation models to assess the impacts of natural hazards**, taking into account the impact distribution in time and space and the cumulative effects given by possible cascading effects, as wall as a continuous data collection activity on built environment and population, at national and regional scale, that allowed building up a comprehensive GIS database, that includes population data, classification of different building typologies (detailed at the level of technical elements: structure, wall, roof, opening, etc.), features of transport networks. The database includes vulnerability classes of each element at risk (population, building components, transport network nodes) with respect to seismic, volcanic and hydrogeological risk. The database is integrated into hazard/impact models, allowing to derive the expected impact of a given seismic, volcanic and flood/landslide event on the territory with a detail of a 500x500m mesh at national level and 250x250m at regional level.

The **philosophy of PLINIVS** is to allow different typologies of end-users (civil protection, city planning departments, insurance companies, consulting companies, etc.) to address risk planning and management activities through a **holistic "all-hazards" approach**, which allows to implement integrated strategies aimed at supporting the entire **cycle of emergency**, from preparedness to response and restore, as well as at implementing **mitigation and adaptation** measures aimed at the **resilience** of built environment and society.

The consolidated approach for the integration of adaptation and mitigation actions within hazard/impact modelling procedures, and their performance and **cost-benefit assessment**, represents a unique feature of the solutions developed at PLINIVS Centre, which widens the range of application of products and services to the targeted end-users.

All the models and tools developed can be applied in different geographical contexts through a process of **customization based on specific end-user needs**, which ranges from the support to data collection to the integration of legacy models and tools within PLINIVS procedures. The modelling approach allows to deliver such customized solution through web services, thus minimizing the technological complexity on the users' side.

PLINIVS is involved in **European and national research projects** concerning risk assessment under effect of natural hazards in the framework of emergency planning and development of adaptation and mitigation strategies. The main recent projects which are the following:

- **SAFELAND**. Living with landslide risk in Europe, EU FP7, 2009-2012 (as research unit of AMRA Scarl).
- **CRISMA.** Modelling crisis management for improved action and preparedness. EU FP7, 2012-2015 (as research unit of AMRA Scarl)
- **SNOWBALL**. Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools, EU FP7, 2014-2017.
- **REACHING OUT.** Demonstration of EU effective large scale threat and crisis management outside the EU, EU Horizon2020, 2016-2019
- **ESPRESSO.** Enhancing Synergies for disaster Prevention in the EurOpean Union, EU Horizon2020, 2016-2018);
- **CLARITY.** Integrated Climate Adaptation Service Tools for Improving Resilience Measure Efficiency, EU Horizon2020, 2017-2020.

These experiences place the PLINIVS Study Centre among the most representative research structures in the field of natural hazards modelling and assessment.

Giulio Zuccaro, Scientific Responsible of PLINIVS, is Associate Professor of Structural Mechanics and Theory of Structures at University of Naples Federico II. He is member of the Major Risks National Committee of the Italian Civil Protection Department and author of more than 160 scientific publications in the field of structural mechanics, with a focus on Mechanics of masonry, Stochastic dynamics, Active control of structures and Impact evaluation of natural hazards on the built environment.

The main models and tools developed at PLINIVS can be summarised as follows:

- *Seismic Impact Simulation* – Seismic impact model, developed and refined during 25 years of research and technical services[1], also as Center of Competence of Italian Department for Civil Protection (DPC).
  The model allows a real time estimation of expected impact of earthquakes on the entire Italian territory. During real seismic crises, the intensity and location of the event is the input provided by the INGV and the output are the "impact maps" used by the DPC to manage the early phases of the emergency and coordinate Search&Rescue activities. In peace time the model can be used to assess the effectiveness of seismic improvement actions on buildings, including the cost-benefit evaluation of measures that integrate structural and energy retrofitting.

- *Volcanic Impact Simulation* – Volcanic impact model (for explosive eruptive events), developed in the last 15 years[2], to quantify the potential losses consequent to a possible eruption of Vesuvius or Campi Flegrei. The model allows the simulation of the cumulative damage on exposed elements following the different hazardous phenomena occurring over time: earthquake (EQ), ash fall (AF), pyroclastic flow (PF), and lahars (LH).
  The dynamic simulation methodology is based on the updating of vulnerability curves following a given time history of the eruption, simulating e.g. the progressive degradation of buildings and infrastructure, the reduced population in the area following evacuation operation. The model includes a specific approach for the treatment of uncertainties.

- *Landslide Impact Simulation* – Developed within SAFELAND Project - Living with landslide risk in Europe (EU FP7, 2009-2012) to assess the behaviour of buildings under dynamic load due to rapid landslide (as debris flow). Vulnerability classes for prominent structural and non-structural elements of the building are defined, and the limit load for each of these is computed by limit state analysis related with experimental tests.

- *Climate risk Impact Simulation* – Developed within CLARITY Project (H2020, 2017-2020) to assess the impact of heat waves, extreme precipitation and hydrogeological events and their variation induced by climate change. The model is based on the elaboration of climate projections downscaled to include urban microclimate conditions and simulate the impacts on population, residential and strategic buildings, transport infrastructure and local economy. A dedicated module allows to estimate the effects of adaptation measures applied within new construction interventions, building retrofitting and/or urban redevelopment projects.

- *Cascading effects impact model* – Developed within SNOWBALL Project - Lower the impact of aggravating factors in crisis situations thanks to adaptive foresight and decision-support tools, the model allows to estimate the cumulative damage from a sequence of natural and/or technological hazards on selected elements at risk, including the propagation of damage across critical infrastructures (such as transport, power, communication and water supply networks).

- *Economic impact of natural hazards* – Developed within SPEED Project - Scenarios of Hazard and Damage at Vesuvius and Campi Flegrei, to estimate, in probabilistic terms, the direct and the indirect economic impact of a Sub-Plinian I or Strombolian type eruption of Vesuvius. The model has been implemented through a computer based simulation model. Along the expected time history of the eruptive event all the possible "direct costs" and the "factors" (indirect costs) impacting the economic growth in the event area have been identified. Each cost factor is built up through a specific algorithm that is fed by various providers, in order to run a software that will estimate the global amount of economic damage from a volcanic event. An updated version of the model has been recently released (EU-FP7 CRISMA Project) to include the cost-benefit evaluation of mitigation measures on building components (seismic strengthening of structures, strengthening of roofs against ash fall, protection of openings). EU-FP7 SNOWBALL has tested the application of the model in the context of cascading effects.

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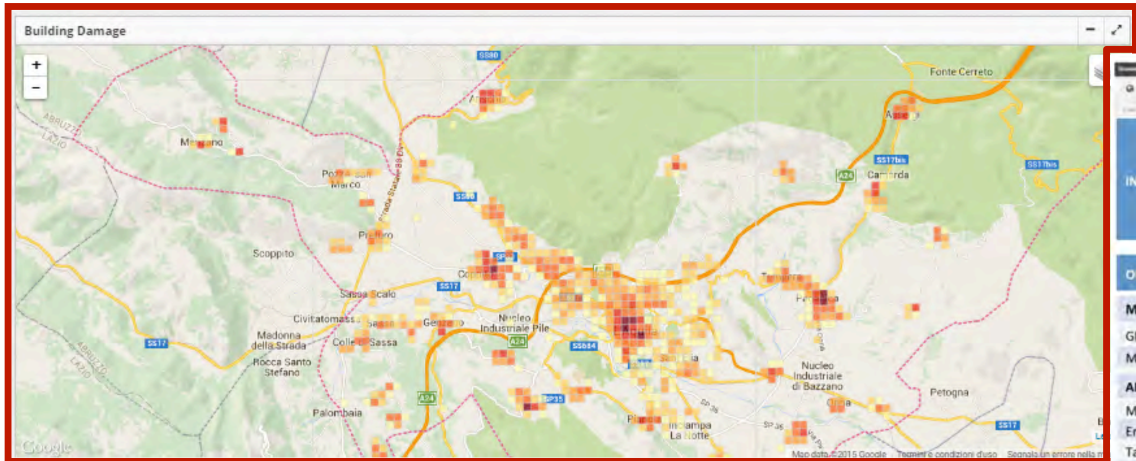
[1] SISMA, Seismic Impact Simulation Model for Regional Planning. Collaborative Project of the Centre LUPT with The Martin Centre (University of Cambridge), UK 1987; TOSQA - Earthquake Protection for Historic Town Centres, EU-DG Environment and Climate, 1993-95; SAVE. Definition and updating of Seismic Vulnerability of built environment in Italy" funded by GNDT-INGV, 2002 - 2004.

[2] VESUVIUS. Human Casualties and Structural Vulnerability consequent to a possible eruption of Mount Vesuvius, EU FP5, 1998-2000; EXPLORIS. Explosive eruption risk in densely populated EU volcanic regions and evaluation of the likely effectiveness of possible mitigation measures, EU FP6, 2002-2005; SPEED. Scenarios of Hazard and Damage at Vesuvius and Campi Flegrei, 2007- 2009.

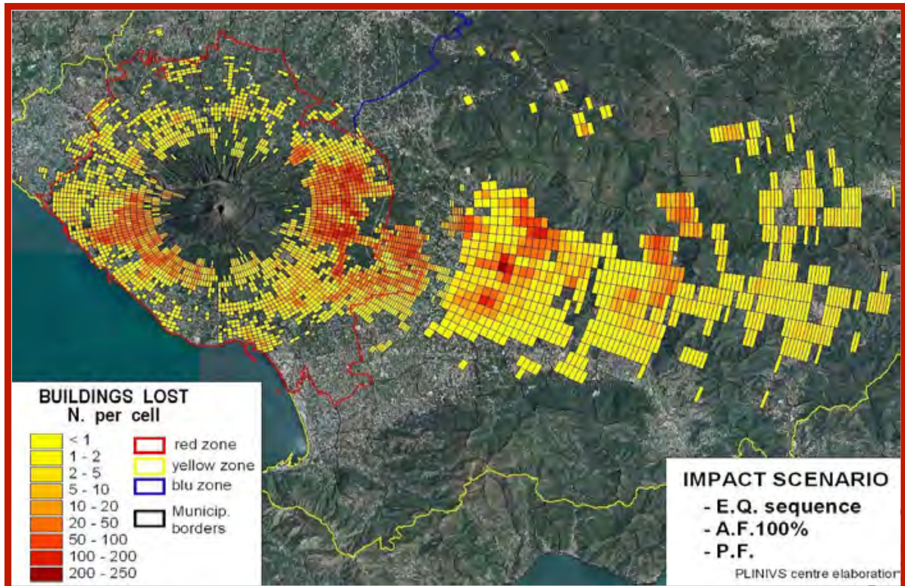
PLINIVS tools – All-hazards impact simulation and mitigation options



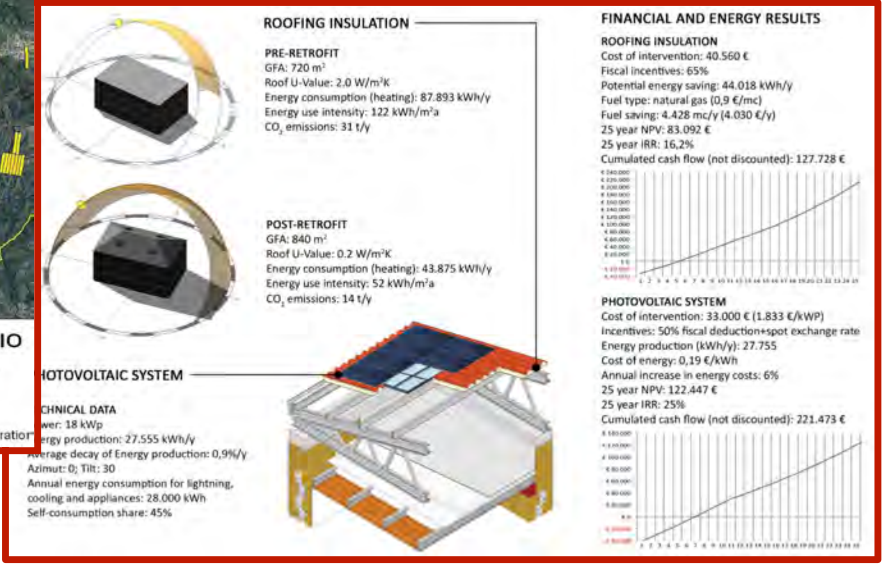
Seismic case - L'Aquila

INPUT SUMMARY	RETROFITTING						COST SHARING		TAX INCENTIVES	
		B'	C'	D'	D'En1	D'En2	Government contribution for Seismic retrofitting	60%	Seismic retrofitting (share)	65%
	A	0%	30%	50%	0%	100%			Seismic retrofitting (years)	10
	B		0%	50%	0%	100%	Government contribution for Energy retrofitting	40%	Energy retrofitting (share)	50%
	C			50%	0%	100%			Energy retrofitting (years)	10

OUTPUT	GOVERNMENT	CITIZENS
MITIGATION		
Global cost of Mitigation measure	-€ 1.225.267.257	-€ 848.693.007
Mitigation Measure Benefit Present value	€ 492.238.148	-
ADDITIONAL COSTS AND CO-BENEFITS		
Maintenance costs	-	-€ 110.860.261
Energy saving	-	€ 1.190.310.309
Tax incentives (Energy Retrofitting)	-€ 27.590.023	€ 27.590.023
Tax incentives (Seismic Retrofitting)	-€ 495.126.293	€ 495.126.293
NET PRESENT VALUE	-€ 1.255.745.425	€ 753.473.357
YEARS TO PAYBACK PERIOD		8



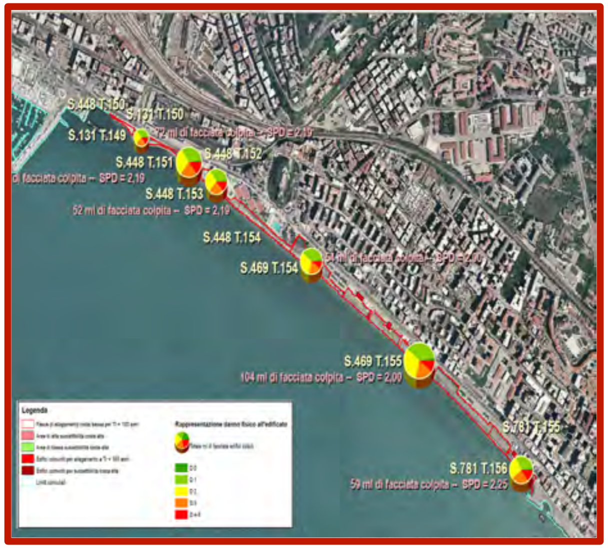
Coupling risk mitigation and energy efficiency: technical options and cost-benefit analysis



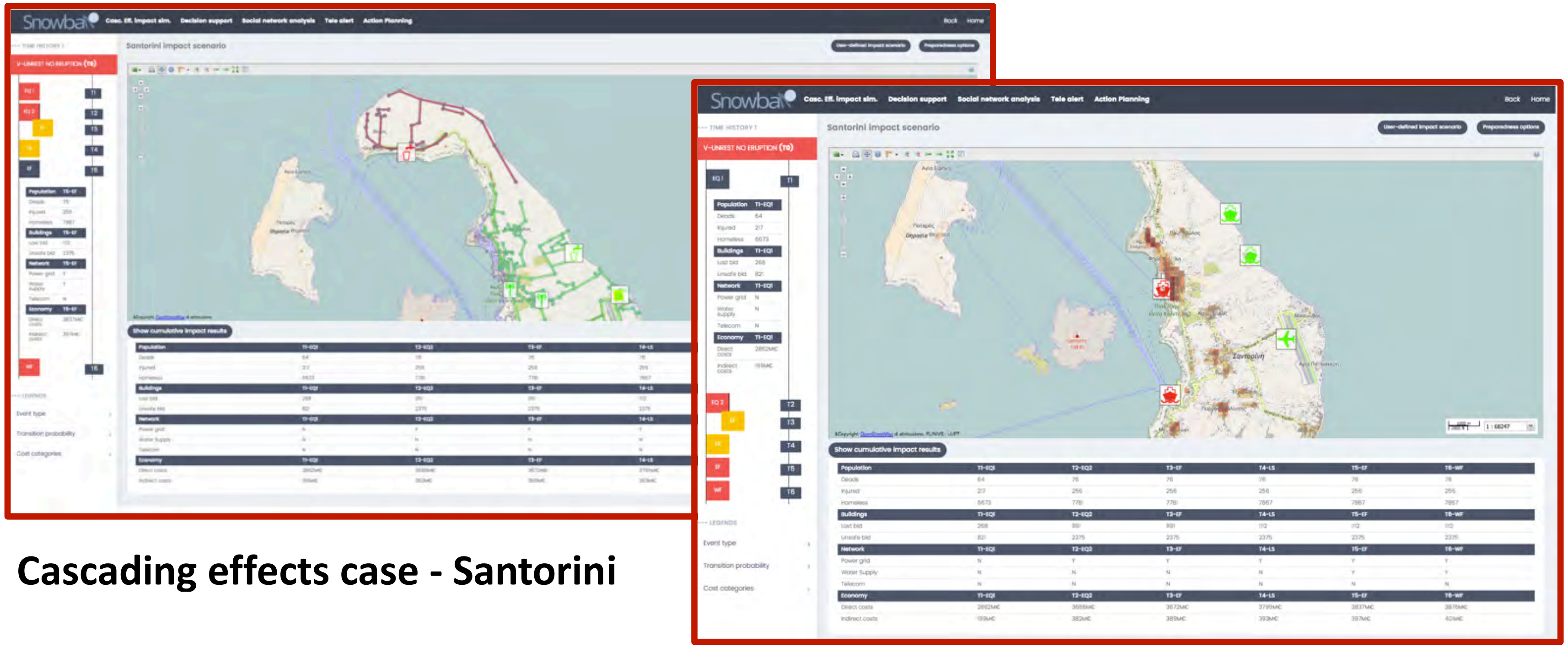
Volcanic case - Vesuvius

CENTRO STUDI PLINIVS

PLINIVS tools – All-hazards impact simulation and mitigation options



Extreme weather case - Campania



Cascading effects case - Santorini

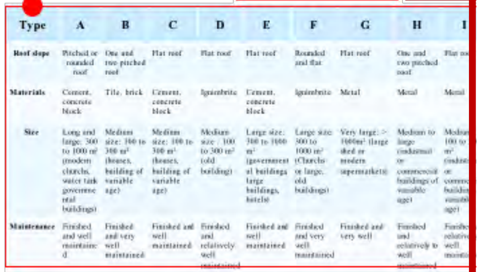
CENTRO STUDI
PLINIVS

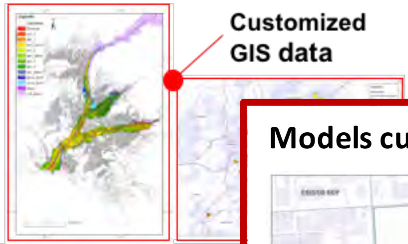
PLINIVS tools – Customization of models and and tools in different contexts and scales

Models customization (Arequipa, Perù)

Urban areas vulnerability carachterization

Vulnerability of recurring building components

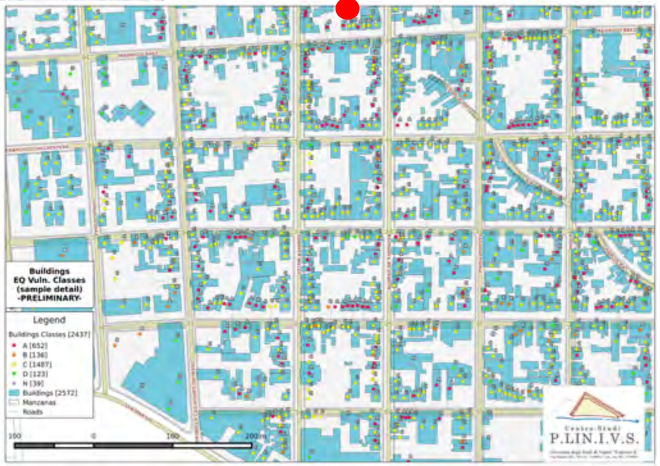




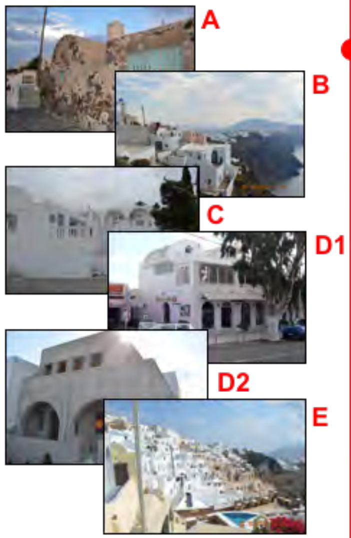
Customized GIS data

Models customization (Santo Domingo, Dominican Rep.)

Vulnerability distribution at municipal level



Models customization (Santorini, Greece)



Surveys on site and building vulnerability classes identification

Vulnerability distribution at municipal level