INTRODUCING A FORMAL FRAMEWORK
FOR MULTI-RISK IMPACT ASSESSMENT SCENARIOS

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This communication aims at presenting UML representations that could be helpful to better comprehend damage scenarios of series of exposed elements subject to natural hazards. It is shown how static UML diagrams have been used to model interdependent systems, and how sequence diagrams could be employed to represent multi-risk scenarios that include successive hazards.

1 Introduction and state-of-the-art developments

The use of object-oriented modeling has already been widespread across numerous scientific fields; however the application of this paradigm to the description of natural hazards and the damage assessment of exposed assets has only recently been carried out by Cavalieri et al. (2012). This previous work has been achieved within the FP7 SYNER-G project, which aims to develop a methodology for seismic risk assessment and loss evaluation of interdependent systems of systems, including inhabited areas, lifelines, road network and critical objects such as health-care centers or harbors. In order to efficiently understand systems and components of heterogeneous types and to deal with almost limitless kinds of interactions between systems, Franchin et al. (2011) have proposed an object-oriented framework to represent the taxonomy of the systems (infrastructures) and hazards through a UML (Unified Modeling Language) diagram (see Fig. 1).

The UML formalism enables to define classes of objects with similar characteristics (attributes and methods). Hierarchical relations and inheritance links can be used to define *abstract* classes that represent a *generalization* of specified sub-classes. The same time, *composition* relations can be used to define a set of sub-classes that represent instances of a *metaclass*. This modular approach provides great adaptability in the modeling choices, since it allows to decide up to which level of detail the systems should be described (from system level to component level) or which type of system, hazard or interaction to include in the analysis.

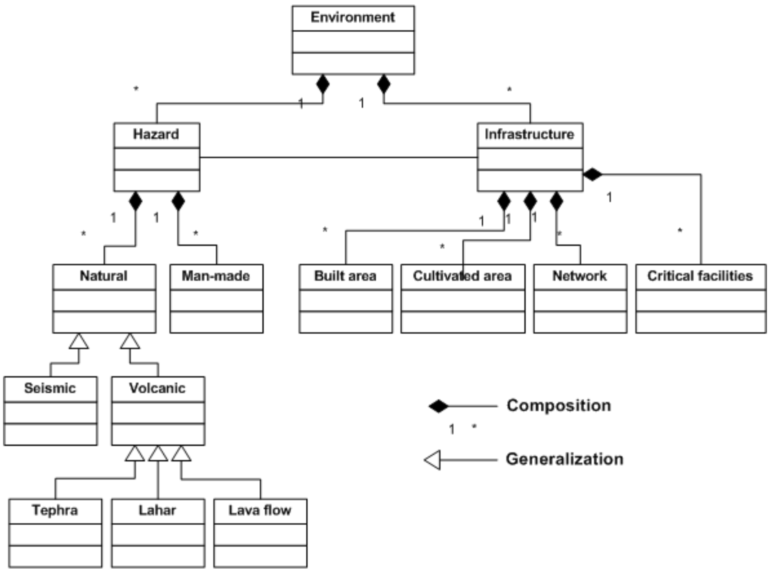

Fig. 1. Example of an UML diagram describing a set infrastructure systems exposed to potential hazards, based on the taxonomy established by Cavalieri et al. (2012) and Franchin et al. (2011) within the SYNER-G project.

This object-oriented paradigm has for instance proven very useful when the UML model for seismic risk developed by Cavalieri et al. (2012) has been effortlessly adapted and enriched to integrate volcanic eruptions as an additional natural hazard (Gehl et al., 2012), in the framework of the FP7 MIAVITA project. Extra infrastructure classes have also been added: in the same manner as inhabited areas, cultivated spaces are considered as a class of exposed elements, since crops represent very vulnerable assets to volcanic manifestations such as tephra fall or blast effects. However, in the case of volcanic event, the multiplicity of potentially damaging phenomena, as well as the timeline in which they can occur, makes a valuable distinction with the case of a single seismic event scenario. Therefore, this communication aims to present a UML-based framework to define impact scenarios with multiple coexistent or successive risks.

2 Proposed developments and perspectives

A UML sequence diagram is proposed in the case of a multi-risk scenario (such a volcanic eruption crisis) in order to describe the order in which each class is called and each method is executed (see Fig. 2). This framework could then be used to assess the successive damages or losses experienced by any given system from a succession of aggressions, as it is usually the case in a volcanic eruption. However, this simulation scheme highlights the need for vulnerability models that are able to account for previously sustained damages, thus assessing only the additional loss due to the present phenomenon. Such an issue is currently being addressed in the case of seismic risk, where ‘aftershock’ fragility curves for mainshock damaged buildings are developed (Reveillиre et al., 2012). Yet, in the case of volcanic risk, where such vulnerability models are not available, one simple alternative may be to just consider the ‘absolute’ damage models and to aggregate the global accumulated damage by removing the elements that were already destroyed or heavily damaged by the previous phenomenon (Gehl et al., 2012).

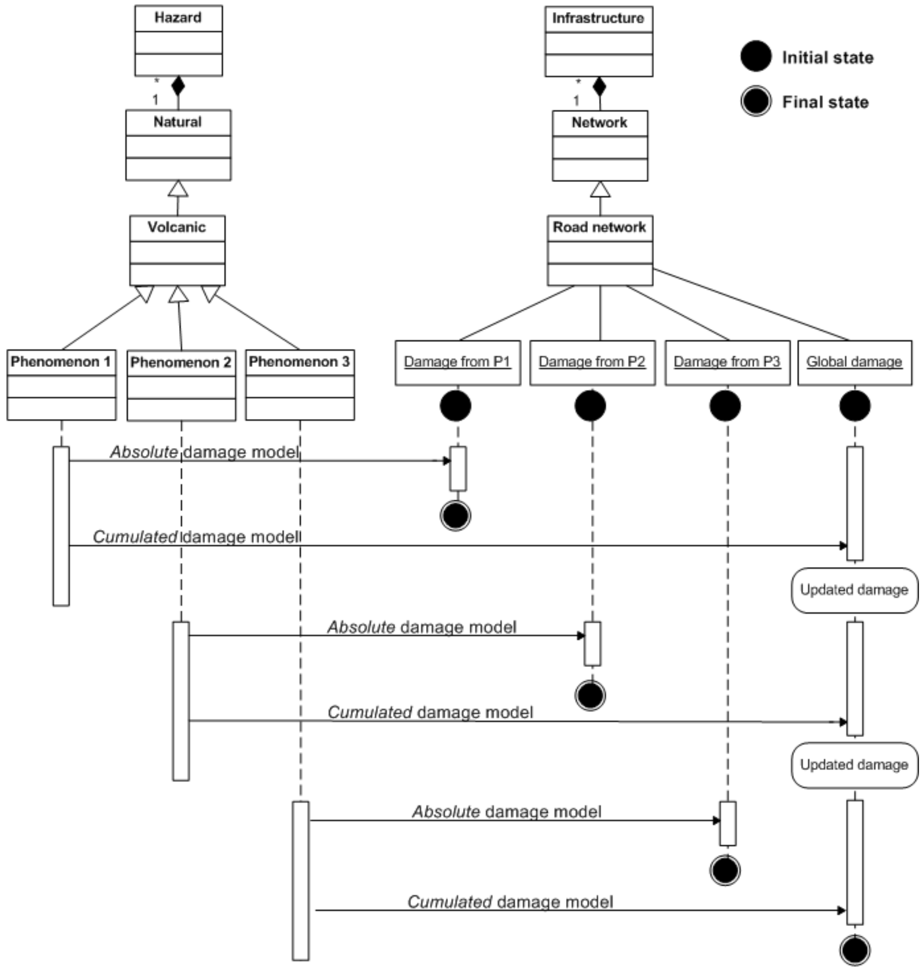

Fig. 2. Example of an UML sequence to simulate the damage accumulation of road network elements exposed to three successive volcanic phenomena P1-3.

Finally, when addressing a very complex scenario both in terms of hazard (multiple damaging mechanisms) and infrastructure (system of interdependent systems), the UML formalism might fall short to describe accurately all the interactions and evolving states. The event bush approach developed by Pshenichny and Kanzheleva (2011) could then constitute a first step to better understand the nature of the interactions between systems and the way they are evolving in a multi-risk environment, before the model formalization into UML diagrams. Plans are made to use this exhaustive conditional probability framework to help prioritize and classify the interactions between the systems or their components.

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