VISUS Methodology: A Quick Assessment for Defining Safety Upgrading Strategies of School Facilities.

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Abstract – Ensuring the safety of people in case of natural hazards is one of the main concerns of public administrators in hazard-prone territories, particularly with reference to strategic and relevant major public buildings, such as schools. This requires the definition of a rational and effective strategy for risk reduction based on the level of risk, criticalities, countermeasures and costs. In order to evaluate these aspects, the SPRINT-Lab researchers of the University of Udine in Italy (1) developed the VISUS method (Visual Inspection for defining the Safety Upgrading Strategies). VISUS was first developed aiming to assess schools in a seismic scenario, but it has evolved into a holistic and multi-hazard approach that considers five issues: site conditions, structural performance, local structural criticalities, non-structural components and functional aspects. Each issue is analysed using a pre-codification of the expert reasoning, splitting the assessment in two main phases: the characterization and the evaluation. As a result, simple graphical indicators summarize the evaluation pointing out the main weaknesses and the needs of intervention. VISUS could be used as effective decision making tool for planning actions in risk mitigation at a regional scale following a rational approach. VISUS is adaptable to different local contexts and needs. The method provides different sub-products, such as the transfer of scientific knowledge through the capacity building of local engineers and decision makers; a mobile application for collecting related data; the production of school’s individual and collective reports; and geo-referenced national inventories of schools in mapping platforms such as OpenStreetMap or GeoNode. The method was elaborated and applied in the ASSESS project aimed at assessing more than 1000 schools in the Friuli Region (N-E of Italy) and recently it has been adopted in a prototypal project of UNESCO in 100 selected schools of three geographical departments of El Salvador (La Paz, La Libertad and San Salvador). UNESCO is planning to start new pilot projects in different countries worldwide.

Keywords – Multi-hazards safety, school safety, VISUS method, holistic approach, risk mitigation, intervention planning

1. Introduction

Disasters have a major impact on children, youth and education systems. Studies of disaster trends and the likely consequences of climate change suggest that each year 175 million children are likely to be affected by natural hazard related disasters alone. During the 2010 Haiti earthquake, some 38000 students and 13000 teachers and education personnel died. The Ministry of Education offices were destroyed along with 4000 schools – close to 80% of educational establishments in the Port-au-Prince area. During the 2008 Sichuan earthquake in China, approximately 10000 students were crushed in their classrooms and more than 7000 school rooms collapsed (Bastidas and Petal, 2012).

During the second session of the United Nations International Strategy for Disaster Reduction (UNISDR) Global Platform for Disaster Risk Reduction held in June 2009, participating countries expressed their commitment to “national assessments of the safety of existing education and health facilities should be undertaken by 2011” (UNISDR, 2009). During the third session in 2011 the commitment was reiterated: “By 2015, concrete action plans for safer schools and hospitals should be developed and implemented in all disaster prone countries.” (UNISDR, 2011).

In order to support different countries in the development and implementation of concrete action plans
for safer schools, UNESCO together with other major UN agencies and International Non-Governmental organizations committed to disaster risk reduction, joined the Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector (GAD3RES). The Alliance promotes, the Comprehensive School Safety Framework (CSS) (GAD3RES, 2012), a comprehensive approach to DRR education based on three overlapping areas of focus (pillars):

1. Safe School Facilities;
2. School Disaster Management; and
3. Risk Reduction Education.

The goals of this Comprehensive School Safety (CSS) framework are:

a. To protect children and education workers from death and injury in schools;
b. To plan for educational continuity in the face of expected hazards;
c. To strengthen a disaster resilient citizenry through education; and

d. To safeguard education sector investment.

In order to facilitate the strengthening of the different elements related to Pillar 1 (Safe Learning Facilities), administrators and policy-makers are often confronted to answer questions such as:

1. What are the schools that need priority interventions?
2. What are the reasons to intervene in those schools?
3. What types of interventions are needed?
4. How much would be the cost of each intervention?
5. How many interventions are possible with the resources available?
6. How to communicate the level of risk to the educational community?

Taking into consideration the important number of schools that administrators are responsible, there is an imperative need for a quick but reliable assessment methodology, which allows them, in one hand, to characterize the initial situation, and in the other hand, support them with concrete information for the decision-making process. Moreover, in the cases of limited resources (human and economic), and when a priority of intervention is necessary, a multilevel approach is also useful for facilitating the decision process to upgrade the safety level.
Researchers of the SPRINT Laboratory of the University of Udine (I) developed a specific methodology, named VISUS (Visual Inspection for defining Safety Upgrading Strategies) that is specifically conceived to answer the above highlighted questions and challenges. In particular, the methodology is based on a technical triage approach, which allows through visual inspections or visits at every single school to obtain information that can be directly used to define comprehensive safety upgrading strategies for school facilities. Due to the specificities of the VISUS methodology, the methodology has been recently adopted by UNESCO and has been positively tested in a prototypal project in El Salvador.

Background information on the concept, main principles and first applications of the VISUS methodology are presented below.

2. VISUS Methodology

The VISUS methodology has been developed by researchers of the SPRINT Laboratory, University of Udine, Italy (1), in order to develop a quick assessment of the safety conditions of school facilities. The aim of assessment is to provide the decision-makers with substantial information to define the safety-upgrading strategies for schools.

The SPRINT laboratory has a long experience in developing assessment methods based on expert reasoning process (in particular, using the elementary-scenarios reasoning – ESR technique) to different contexts. One of the firsts applications developed by SPRINT is Gri.S.U. (Grimaz and Pini, 1999), a method for the assessment of fire risk and equivalent safety in none-conventional buildings (heritage buildings). The method was first applied on historical buildings in the centre of Venice after a fire destroyed La Fenice theatre in 1996. VISUS method is a further application of the ESR technique on the evaluation of the seismic safety of schools. In particular, VISUS is based on the pre-codification of the expert reasoning process, who has to judge the level of safety, within an approach of technical triage, aiming to plan effective measures of risk mitigation and control. In practice, the VISUS methodology permits to emulate the judging skills of experts and their decision-making ability through a rapid visual inspection and collection of data.

Technical triage assessments and expert judgment pre-codification processes are the two main elements on which VISUS methodology is based. Hence, some specifications on these two aspects are illustrated below.

2.1. VISUS as technical triage assessment

In order to answer administrators’ concerns, mainly but not restricted to Pillar 1 of the CSS framework, it would be necessary to adopt a methodology that provides as outcomes a characterization of the safety weaknesses, the required intervention-needs, and the corresponding cost estimation aimed at increasing safety. Furthermore, administrators need a decision support tool to define intervention strategies on the basis of multiple criteria.

Different levels of assessment could be identified aiming to answer the above mentioned requirements (figure 2). Low assessment levels (starting point or data-mining levels, figure 2) are usually implemented through a collec-
tion of data (desk analysis, questionnaires, forms, checklists, etc.). These approaches allow to quickly rank buildings through indexes; nevertheless, such approaches cannot be detailed enough to properly answer all of the administrator’s concerns, inasmuch usually coarse the quality of input data, which could be often mistrusted. On the other hand, deeper analyses (detailed investigation and design level, figure 2) can surely answer the majority of administrator’s concerns, with in-depth/specific assessments, detailed design and cost quantification. However, these inspections are costly and timely consuming, limiting the number of facilities that could be inspected. Based on these two different levels of assessment: desktop assessment and detailed assessment, SPRINT researches suggest adopting an intermediate level of assessment, founded on visual expert-based inspections and technical triage assessments: i.e. VISUS methodology. The outputs of the VISUS technical triage are directly usable by administrators as decision-making support for defining safety upgrading strategies; furthermore, the outcomes permit to characterize safety weaknesses, intervention needs and costs with a certain degree of detail in a more rapid and economical approach. Finally, it is worth noting that VISUS method has been developed in order to characterize a large number of schools (or other “targets”) providing uniform and comparable evaluations, thus facilitating the planning of intervention strategies.

The VISUS methodology aims, by reducing as much as possible the time and cost of assessments, to identify the necessary measures to take in order to upgrade the safety of individual schools, taking into consideration the limited available resources. Indeed, the scarcity of resources against the needs implies the adoption of triage approaches (Iserson and Moskop, 2007a), which indicates the necessity to quantify and prioritize requests. The methodology should follow pre-defined goals and values. In particular, VISUS assumes the health and care values (1. human lives; 2. human health; 3. efficient use of resources; 4. fairness [Iserson and Moskop, 2007b]) with the specified priorities, for achieving safety of learners and education workers in schools. Anyway, it is possible to add simply other values, such as the operational continuity (e.g. educational continuity) or the protection of the educational sector investments.

Assessing the safety of school facilities is a complex problem; hence a quick and effective assessment is not an easy task. Therefore, VISUS triage assessment has been based on the 20/80 rule (also known as Pareto principle) “which states that 20 percent of the known variables will account for 80 percent of the results” (Basile, 1996: 53). For this reason, particular efforts have been spent in order to identify, through a joint work with experts, the most relevant variables and discard the non-essential data in order to assess a final judgment on safety.

2.2. VISUS as pre-codified expert-based assessment

VISUS methodology is based on the pre-codification of the expert reasoning and the application of the ESR technique: This permit to analyse a more accurate representation of the current situation and further express it through a set of pre-defined elementary scenarios useful before formulating stating judgments on school safety. In order to explicate the phases of these cognitive operations, it is necessary to further analyse the expert reasoning process.

When an expert is called to develop a rapid inspection (usually visual), to assess and define a safety judgment, to elaborate a brief report of the criticalities found during the process, and to suggest needed possible interventions to improve the safety of the evaluated school, it is possible to identify the different steps that the expert reasoning undertakes and can be interpreted on the basis of three main questions:

- What to look for/collect as substantial information?
- How to evaluate what it has been seen/collected?
- How to express the final judgements?

In practice, in the expert reasoning process, it is possible to recognise two main phases (characterisation and evaluation). In fact, the decision-making ability of an expert moves from the capability of “reading/interpreting the reality” (characterisation phase), to the interpretation and evaluation of the acquired data in order to achieve a judgment on pre-defined safety issues (evaluation phase) (figure 3).

The characterization phase deals with the identification of substantial information and the collection within specific groups/sections (for example, VISUS methodology considers information on site, structure, non-structural elements or on the organization of emergency systems and egress paths). The evaluation process allows the expert to elaborate all the collected information through known rules and criteria, and to formulate final judgments on specific main issues. It is worth to note that, usually, experts directly define the judgment independently, in which the characterization and evaluation phases at each single step towards the judgement are hidden between other experts. It is also important to highlight that an expert is able to formulate a judgment, even when the necessary substantial elements that allow him
to formulate that judgement, are correctly provided by another source.

The expert uses his/her experience as knowledge for identifying specific predispositions that could produce critical behavioural effects in case of a particular event. By considering the characteristics of the analysed reality, the expert is able to evaluate the likelihood of activation of the associated critical effects and their magnitude, in terms of consequences for the people potentially involved (figure 4).

**Figure 4:** The expert uses his/her experience as knowledge for formulate the evaluation. The expert is able to recognize specific behavioural scenarios (predisposition) associated to a potential critical behaviour and to the likelihood of critical effect activation.

The core idea of the VISUS methodology is supported on the understanding that, being the reasoning process of the expert’s knowledge pre-codified, and taking into consideration the substantial elements (data) collected by a trained surveyor, the formulation of judgments on each of the evaluated issues could be automatically provided.

**Figure 5:** VISUS pre-codifies the expert reasoning process and uses graphical indicators for describing the results.

For this reason, VISUS methodology is based on the main phases of characterization and evaluation, and keeps them clearly divided. The use of ESR technique permits to make the expert's reasoning explicit, both in terms of elements that have to be collected and criteria of evaluation, facilitating the training of surveyors and the knowledge transfer from expert to non-expert. The characterization phase is done by a VISUS surveyor that is trained for identifying substantial elements, in a process of comparing the reality (what the surveyor visually identify in the visit) with the pre-codified graphical scenarios of reference. The identified scenarios containing the substantial elements constitute the input for the evaluation process that will be effectuated through the implementation of pre-codified criteria and rules. Automatically, the evaluation process generates judgments on the main issues considered for safety. Furthermore, the evaluation process permits to obtain uniformity and standardization in the final report through the adoption of specific predefined indicators. This facilitates comparative evaluations, and introduces a sort of standard language. These characteristics make VISUS an intrinsic tool for knowledge transfer and capacity building.

Regarding the main issues on which the judgments are formulate, an important question to keep in mind is: "What does safety of school facility mean?". The question could appear trivial, but it permits to approach the problem from the correct point of view. In fact, by paying attention to human safety, it is important to consider every situation that could cause specific difficulties, injuries or deaths, as a consequence of an adverse event. This way of viewing safety indicates that a holistic approach is not only opportune but also necessary (Grimaz, et al. 2010).

**Figure 6:** Main issues considered in the safety assessment of school facilities

The holistic view produces immediate substantial consequences on practice. In fact, considering the safety of school facilities, it appears evident that a holistic approach allows to take into account not only the building structural performance, but also all the elements that can cause deaths or injuries or specific difficulties.

In order to check all the potential criticalities of a school facility, VISUS methodology identifies five main issues: site, structural global, structural local, non-structural and functional (figure 6). Site evaluations refer to the environment and context in which the school facil-
itities are located; it is essential to identify if there are natural or man-made threats, or conditions that could increase the perverse effect of a hazard. For example, site unstable conditions (such as inundate areas, cavities in the ground, faults in the near field, potential liquefaction, impeding rock falls or landslides) imply the need to evaluate the opportunity of retrofitting the building or relocate it to another, stable and safer, site.

Structural global evaluations refer to the global response of the structure to a hazard. In the case of seismic hazard, the global response is evaluated for each structural unit. The seismic design of the structure is essential for the evaluation of the seismic response: if the construction of a structural unit complies specific seismic designs, it follows that the minimum level of seismic response is the one defined by the adopted seismic code. Otherwise, if no seismic rule has been adopted, it is necessary to assume typology-based structural evaluations (for example, fragility curves) for the global seismic behaviour.

Structural local evaluation refers to portions of structures, and their potential collapse. The structural local potential scenarios are defined a priori and the surveyor has to identify if the structure shows some predisposition to exhibit each scenario. Furthermore, it is necessary to identify if the hazard (i.e. seismic ground motion) can activate the predisposed effects, and finally assess the potential consequences on people (irrelevant consequences, difficulties, heavy consequences). An example from VISUS handbook (Grimaz and Malisan, 2013) is illustrated in figure 4.

Non-structural evaluations refer to non-structural elements and their potential effects on people. In particular, in the case of seismic hazard the evaluations synthesize the potential problems connected with the presence of non-structural elements that can fall or overturn causing injuries or deaths (e.g., false ceilings, bookcases, chimneys, etc.). These non-structural elements could be located inside the building, such as libraries, AC, fans, etc., or outside the buildings, such as ornaments or decorative components.

Functional evaluations refer to access and egress paths and emergency systems (safety areas for evacuation, early warning, etc.) in case of a specific hazard (e.g. earthquakes, tsunamis, etc.). Particular attention is paid to the egress of people with disabilities and their possibility to reach a safe area, as well as to the difficulties of emergencies services to access to the school in case of an emergency. The functionality issue could also refer, for ordinary conditions, to the operational aspects of the schools, e.g. water and sanitation, among others.

As result of the evaluation process, the expert expresses its judgment on each main issue. Here it is present the delicate problem of using of an appropriate language for communicating the scientific/articulated results of the evaluation to the end users (mainly public administrators). VISUS methodology expresses the judgment on each safety issue in terms of a warning level:

- Level 0 indicates the absence of concern for people safety;
- Level 1 indicates the recognition of potential difficult situations for people safety; and
- Level 2 indicates the recognition of potential situations implying heavy consequences for people safety.

Following the expert reasoning process, the judgment has to provide also a definition on potential interventions useful for upgrading the safety (description and extension of the interventions, and related cost range).

In order to allow a synthetic visualization of the outcomes, VISUS provides a set of graphical indicators (figure 7):

- Warning levels (figure 7.a): the indicators express the level of warning in term of potential negative consequences on people safety. The indicator revokes the acoustic level of a siren alarm;
- Performance classes (figure 7.b): If quantitative detailed data are available, the warning level can be better described through the adoption of a performance class indicator. This indicator revokes the energy-label classification;
- Rose of intervention needs (figure 7.c): the rose of intervention needs synthetizes the judgments on the five safety issues (level 0, 1, 2 for each issue), by associating a warning needle to each judgment. A rose without warning needles implies that no intervention is required; and
- Safety stars (figure 7.d): all the evaluations are synthetized in the assignment of the safety stars.

The total number of safety stars assigned to a school expresses a summary of all the judgments; the assignment of stars is done evaluating if a specific criterion is satisfied. The criteria for assigning each star are:

- No star assigned: Unsuitable site (presence of level 2 of concern for site);
- 1st star assigned: The site is suitable (there is no level 2 of concern for site);
- 2nd star assigned: Stability of the building (there is no level 2 of concern for structural global evaluation of structures): This means that the global collapse of a building is very unlikely in case the school is subject to the design seismic action;
- 3rd star assigned: life safeguard (absence of level 2 of concern in any safety issue): there are no criticalities that could imply heavy consequences on people safety (this implies no collapses and similar);  
- 4th star assigned: Rapid resume of operations (absence of level 1 of concern for structural global and local): in case of event, there are only criticalities that could imply difficult situations for people safety; this implies no diffuse damage; and
- 5th star assigned: Immediately operational (absence of level 1 of concern for all issues): after the event it is possible to immediately re-use the school without interventions.
2.3. VISUS reporting

The VISUS methodology can be applied to any “target” (in particular, buildings), or a set of targets, potentially subject to specific hazards/threats. The definition of “what is the target” depends on the hazard considered during the application of the procedure (seismic, flood, wind, hurricane, typhoon, etc.) and on the inspected safety issue. The target can be identified considering that it has its own specific response to the hazard.

In the seismic case, VISUS is applied on school complexes that are defined as a system of one or more school buildings located at the same site and belonging to the same school administration. Furthermore, within each school complex there is one or more school buildings and each building can be separated in many structural units, so that each structural unit has its own response to a specific hazard (figure 8).

The different safety issues refer to different parts of school complex, and in particular:

- Site evaluations: Refer to the whole school complex;
- Structural global evaluations: Refer to each structural unit: the design of structures considers each structural unit as a standing structure, so the evaluation has to be performed on each structural unit;
- Structural local evaluations: Refer to each structural unit;
- Non-structural evaluations: Refers to each structural unit; and
- Functional evaluations: Refer to each building and to the school complex; functional evaluation mainly refer to the egress system that characterizes a building (egress paths could involve more structural units); the safe areas evaluations could refer to each class or building or to the whole school complex depending on the emergency plan. In VISUS methodology, it has been associated to the building.

At the end of the procedure of data characterization and evaluation, a report is automatically produced, synthesizing all of the useful data related to the school complex.

The report has a standardized structure (figure 9): The first page shows a synthesis of the school complex data, together with the aggregate judgments that are the cumulative indicators of all individual judgments of all buildings (and the respective structural units). In this page a representative photo of the school complex together with the identification data and geolocation are documented. The geolocation of the school also permits to identify the potential hazards to which the school is potentially prone. The hazard level and the site characteristics are also indicated. Furthermore, specific parameters that permit to evaluate the potential cost increase of interventions caused by an unfavourable or complex construction site location are reported. A sketch of the school complex permit to identify the school buildings and structural units’ composition. In addition, data on the number of people attending the school complex by periods of time are indicated.

In the following pages, the relevant data for each building are documented, through a photo of the building, information on exposed values, geometry, characteristics of each structural unit, together with structural global and local, non-structural and functional evaluations, with the assigned warning level.

Finally, photo reportage for each building and each unit is documented. Whenever it is possible, a photo of the identified problem is shown with the description of the weakness and of the intervention needs.

3. Applications of VISUS Methodology

VISUS methodology was firstly applied on more than 1000 schools in Friuli Venezia Giulia region (Italy), in the frame of the ASSESS project (Slejko et al., 2012 and Grimaz et al., 2011) and considering only the seismic hazard. VISUS was applied with different degrees of detail, with the coarsest level being a desk analysis of available documentation that permitted to identify the buildings requiring a visual survey and a further zoom to buildings that needed de-
tailed engineering, geophysical and geotechnical data acquisition and quantitative analyses. The data of each level permitted to identify how and where to move in the next level, and also to adjust and calibrate the evaluations of the previous level. The evaluations where finally summarized in a list, and an atlas (both on paper and implemented in a GIS) (figure 10). The outcomes of the project constitute the information for decision makers in order to plan the strategies and the actions for risk mitigation in the whole regional territory.

In February 2014, VISUS methodology has been applied in the survey of 100 selected schools of three departments of El Salvador (La Paz, La Libertad and San Salvador); the purpose of the trial was both assessing the safety of schools and testing the possibility of using VISUS as a methodology for knowledge transfer, capacity building and training of VISUS trainees and surveyors. With the purpose of simplifying the characterization process and the collection of data, a mobile application was developed. A group of 15 civil engineering university students was trained on the general concept of the VISUS methodology, as well on the utilization of the mobile application for collecting the data (characterization), and in the strategy for implementing the consequent survey in every single school. The training consisted in 40 hours of lessons, with the support of images and examples. The trained students were able to inspect the 100 schools of the selected area (for a total amount of almost 300 buildings and about 450 structural units) in 10 days, collecting both data and photos. Later, acquired data was automatically processed (evaluation process) in order to reach final judgments and define final indicators for each school, together with a report for each school complex. Results were reported on maps, exploiting the potentialities of the most used mapping platforms (Google maps, OpenStreetMaps, GeoNode).

The El Salvador pilot had very positive feedback from students involved in the assessment, and proved to be a good methodology for transferring knowledge and building capacities. Furthermore, the experience permitted to draw useful suggestions for improving the mobile application, in order to simplify and make more effective the data collection during the surveys.

4. Implementation

VISUS methodology is implemented following a procedure that can be summarized in figure 11.

![Figure 11: VISUS methodology as support for Governments that would implement assessment and intervention planning within the Comprehensive School Safety framework.](image)

This procedure were firstly applied in El Salvador in the geographical departments of San Salvador, La Paz, and La Libertad and permitted to identify in the implementation process eight main steps that are:

a. Identification of Local Partners. The first step in order to adapt the VISUS methodology to the local realities of the country where the assessment is foreseen is to identify the different actors related to school safety issues in the country. The potential partners will have different roles based on their own mandate, and provide information and data required for the adaptation of the methodology to the local context, such as hazard maps.

For the case of El Salvador, the main identified partners were: 1) Ministry of Education, and the different divisions concerned with educational infrastructure and disaster risk reduction, 2) Ministry of Environment and the SNET (“Servicio Nacional de Estudios Territoriales”); and, 3) the faculty of Civil Engineering and Architecture of the University of El Salvador.

b. Conformation of a Scientific Committee and Adaptation of the VISUS Methodology for the Specific Context. A Scientific Committee is constituted by the identified local partners, the SPRINT-Lab of the University of Udine Italy, and UNESCO. The Committee had as a mandate to analyse the different aspects and elements of the VISUS methodology in order to adapt and contextualize them to the local reality of the country (e.g. different typology of buildings, typical materials, geomorphology of the country, hazard identification – maps and data collection-, construction cost, etc.). The scientific Committee defines also the pre-codified criteria for the evaluation process, taking into account the peculiarities of the country.
c. Preparation of Tools. Based on the adaptation process developed by the Scientific Committee, a specific 'country' handbook for training of trainers, and, a handbook for training surveyors, involving the general concepts of the methodology, the characterizations, and the different elements to be assessed, is produced. Also, a mobile application for data collection, and the elaboration of logic and mathematical algorithms, completely adapted for the country context are developed in order to facilitate the data processing and the automatized reports.

d. Training of Trainers (ToT). A training of trainers on the use of the methodology is required in order to ensure sustainability of the knowledge transferred. For the pilot in El Salvador, a three days training of trainers involved about sixty (60) people, including university professors, engineering associations and technical staff from the Ministries of Education and Environment.

e. Training of Surveyors. Surveyors are in charge of visiting the schools and collect the specific data, which is based on the adapted characterization of VISUS for the country. Surveyors normally have a minimum understanding of engineering/architectural basic concepts, and understand the VISUS methodology as a method for identifying the safety issues of every particular school. In the case of the pilot developed in El Salvador, and in close cooperation with the Faculty of Civil Engineering and Architecture of the University of El Salvador, it was decided that the students from the last year of academic formation of the faculty will participate in the training, and will act as a surveyors in close coordination with the Dean of the faculty. Fifteen (15) students were trained in the different aspects of the VISUS methodology and in the data collection. Their participation on the assessment was validated by the University as a part of the requirements for obtaining their graduation diploma, better known as a social service.

f. Planning and Development of the Assessment on the Field. During the planning phase it is important to identify the schools that will be assessed; in particular, it is necessary to define how many schools will be visited, and identify them by specific criteria, related to the aim of the assessment. For example, the attention could be addressed to schools of different educational level, construction period or material, or schools in a specific area of the country. The data collection is facilitated by the mobile application that has been developed and adapted for the specific local context. Through it, the collected data could be easily transferred to the UNESCO and SPRINT servers. For the case of El Salvador, hundred (100) schools were assessed in a period of ten days in three geographical departments of El Salvador (San Salvador, La Paz and La Libertad, figure 12). These departments were chosen due to the different particularities that each of them were offering for the pilot (e.g. urban and rural area, costal and mountain area, etc). Five groups integrated by three (3) surveyors were visiting one school in the morning and another one in the afternoon. The data collection was done using the VISUS mobile application off-line. After the school visits were completed, the surveyors sent the collected information via internet to the servers of UNESCO and the SPRINT-Lab.

g. Production of Individual Reports. Based on the information collected by the surveyors, the SPRINT-Lab in close coordination with the local committee and UNESCO, double-check the congruence of the collected data. After this process was finalized, automatic reporting was produced and implemented in GIS databases. The reports (3 to 6 pages) resume in a coherent way the different elements found and analysed during the assessment, mainly related to weakness found in the five areas of analysis (site, global and local structure, non-structural elements and functionality). It finalizes with a series of recommendations/interventions that will allow upgrading the level of safety of the school. The report includes photographic evidence and three indicators that summarize the state of the school vis-a-vis the potential hazards. For El Salvador pilot study, local committee was leaded by University of El Salvador that coordinated the survey campaign. As result, hundred (100) reports are online and accessible to the educational community and general public in OpenStreetMap.

h. Production of a Collective Report. The collective report is mainly addresses to the national and local authorities. It provides decision makers and the educational community with practical information that allow making evidence based decisions on the related investment needs and areas of concern where this investment should be prioritized. The collective report includes the individual reports, a general report of the assessed schools and an estimation of the cost of every proposed recommendation/intervention, stating also the area of focus of that intervention and the schools that should be prioritized. These outcomes provide
administrators with information and key-elements for defining an effective safety upgrading strategies. For El Salvador, the beneficiaries of the results of the project and main decision-makers for defining safety upgrading strategies are the Ministry of Education and Ministry of Environment.

5. Conclusion

VISUS (Visual Inspection for the definition of Safety Upgrading Strategies) is a methodology developed for the assessment of school facilities safety, which has been accommodated to fulfil the assessment requirements of the CSS framework, mainly but not restricted to pillar one. VISUS is based on a triage approach and exploiting expert judgment capacity in order to define strategies for knowledge transfer and capacity building, and for providing critical information to administrators and decision-makers of the education sector. VISUS methodology has been applied in two countries (Italy and in El Salvador) and these experiences permitted to draw the following key points.

a. Adoption of Technical Triage and Expert Reasoning. VISUS adopts a triage approach, that investigates "as in-depth as enough" in order to allow governments to characterize the situation in a fast but pragmatic way, without huge amounts of economic and human resources. The pre-codification of the expert’s reasoning facilitates the transfer of knowledge and the capacity building and ensures the uniformity of the judgments.

b. Importance of the Role of VISUS Surveyors. The trials of VISUS methodology highlighted the importance of surveyor’s ability to identify the relevant data during the characterization phase. The accuracy of the characterization process is essential, inasmuch as it can affect all the successive phases and the final judgments. For this reason, it is important that even the non-expert surveyor can acquire specific skills, both during the training lessons and through the application of the methodology. Anyway, the ability of recognizing specific technical scenarios is a skill that can be easily taught to high-level scholars with technical background.

c. Function of VISUS as a Knowledge Transfer Mechanism and Capacity Building. The training of surveyors on the general concepts of the VISUS methodology, together with the development and utilization of the different related tools, such as the handbooks and the mobile application, contribute to increase the knowledge and the awareness of VISUS surveyors on safety issues. The elicitation and pre-codification of expert reasoning processes with the ESR technique allow the knowledge transfer to non-expert. Good responses from students involved in the trials support this statement.

d. Adaptability of VISUS to Specific Context Through Involvement of Local Committee. VISUS is based on the pre-codification of expert reasoning process, and the data acquired during the survey are evaluated though these pre-codified criteria and rules, in order to judge each safety issue. Consequently, the procedure requires a local committee (local experts and stakeholders) in order to contextualize the methodology to the local peculiarities; local experts also permit to characterize the recurrent local problems/criticalities and the associated intervention needs together with costs.

e. Effectiveness of Graphical Indicators for the Communication of Results. The products of VISUS are the synthesis graphical triage indicators and the reports for each school. These data can be included in GIS, permitting different representations on maps and queries on data. Indicators and mapping representations become a decision making support to governments for reaching their school safety commitments and define effective safety upgrading strategies. Furthermore, the learned experience learned demonstrated that the graphical indicators can be used as a communicative tool for transferring scientific results and for increasing the awareness on the safety problems.

f. Applicability for Overall Multi-Hazard Assessments. The trials of VISUS aimed at assessing safety of schools in relation to seismic hazard; are going to be extended to other hazards/threats (such as floods, wind, hurricane, fire, etc.). In fact, previous experience in the use of VISUS highlighted that a holistic and multi-hazard approach is essential in order to reach comprehensive safety in schools. The multi-hazard approach requires expert contribution for the definition of the characterization and evaluation phases together with an oversight of the whole process in order to ensure a uniformity of the approaches among all the hazards.

The two trials permitted to improve the methodology, thus proving that VISUS methodology is adaptable and customizable to specific needs and competences of the specific country in which it will be applied. Furthermore, the experience highlighted that VISUS indicators were an effective tool for communicative aims, facilitating the rapid comprehension of assessments outcomes by decision makes. El Salvador pilot had good responses from the students involved in the trial proving to be an excellent mechanism of knowledge transfer and a good capacity building tool. National and local authorities of El Salvador have all welcomed the results and are studying the feasibility of extending the application of the VISUS methodology throughout the whole national geography.

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