WP 6: Tools and guidelines for improving/designing a resilient BE assessed through case studies and virtual training

T6.2 - Assessment of the B-based resilience of the case studies in their current and after applying selected strategies through simulations, users' feedback from VR training. Selection of the best strategies and their technical reliability. Development of tools/guidelines supporting the holistic decision-making process.

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Abstract
Thanks to the toolkit functional modules discussed in D6.2.4 from a technical perspective and relying on the related core modules, – Informative modelling, SUOD/SLOD simulation, Agent-based simulation, KPIs & metrics –, complementary modules – Risk mapping, Communication & Training –, and repository modules – General Issues, General Strategies, this document trace the overview of the BES²CURE toolkit from an operational standpoint. The toolkit is composed of a network of modules corresponding to the project developed methods, tools and solutions to support decision-makers in assessing and increasing the resilience of real case studies of urban built environment, based on the main project outcomes. Complementary results could be achieved by adaptation from general Built Environment Typologies (BET)-based concepts and/or by specific development of analyses and strategies for the target context.

Keywords

Multi-risk scenarios, BIM models, ABM simulation, SLOD/SUOD simulation, VR environments, resilience metrics, resilience design, real-word case studies.

Approvals

Role	Name	Partner	Date
Coordinator	Quagliarini Enrico	UNIVPM	20.12.2023
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Revision versions

Revision	Date	Short summary of modifications	Name	Partner
01	05.12.23	Minor changes on graphical layout and linked documents	Fabio Fatiguso	POLIBA

Summary

1. Introduction

The BES²CURE toolkit is conceived as a network of modules corresponding to different methods, tools and solutions that might support decision-makers in assessing and increasing the resilience of real case studies of urban built environment, based on the main project outcomes. To this end, the toolkit trelies on a comprehensive framework, , shown in Figure 1, where several and complementary results could be achieved by adaptation from general Built Environment Typologies (BET)-based concepts and/or by specific development of analyses and strategies for the target context.

2. Case study: input data

Starting from the collection of relevant data on a specific case study, the **survey of morphological, constructive and functional features** is paramount to address, on the one hand, the **selection of a representative BET**, in order to benefit by representative and validated project achievements (see **BET:ANALYSIS** below)**,** and, on the other hand, to start up a step-by-step process for assessment and mitigation of the main features and issues (see **CASE STUDY:ASSESSMENT** and **CASE STUDY: MITIGATION** below).

Firstly, the survey results in the development of a Building Information Model (BIM) and a Virtual Tour (VT), through the toolkit module ***SCAN-TO-BIM*** from direct Close Range Photogrammetry (CRP), Terrestrial Laser Scanning (TLS) and spherical photography. Particularly, the BIM environment supports the model-based representation, data collection and management, and visualization of built environment conditions and **selection of hazards** (SLOD and/or SUOD), thus leading to phenomenological analyses. Such data comprise inputs concerning **UTCI and AQI for microclimate conditions about SLODs**, and **seismic vulnerability and terrorist act risks for SUODs**. Data on **users' exposure and vulnerability** are collected to include users' data affecting the normal and emergency fruition of the built environment, considering thus also behavioural inputs for users' response to SLODs and SUODs.

3. BET: analysis

Once the **survey of morphological, constructive and functional features** leads to the **selection of a representative BET,** the analysis of the case study benefits from the assessment of the corresponding typological environment, in terms of ex-ante **BET-based multi-risk scenarios** and ex-post **BET-based multi-risk mitigation solutions.** The toolkit module ***AGENT-BASED SIMULATION*** is applied to these typological environments and to representative SLODS and SUODs conditions, to predict the generalized/idealized interaction patterns among the users during evacuation and it is used to evaluate pre-mitigation configurations and post-mitigation actions, depending on general **morphological / constructive / physical aspects and emergency management strategies,** through a behavioural-based approach. Furthermore, BET-based VR training is available at this stage, by the toolkit module ***SERIOUS GAME***, providing with wide ranging instructions to the BE users for preparedness and awareness in facing SLODs and SUODs. All the resulting insights pave the way for specific assessment and testing of the case study (see **CASE STUDY:ASSESSMENT below**).

4. Case study: assessment

BIM-managed data are used as inputs for the toolkit module ***RISK MAPPING***, which relies on SLOD/SUOD and AGENT-BASED SIMULATIONS. Their application to the case study takes into account its peculiar site characteristics, hazard effects and users' exposure and vulnerability, and offers results about **pre-mitigation risk levels**, also enabling to compare outcomes from BET and case study. Then, thanks to the **BET-based multi-risk scenarios**, the toolkit module ***KPIs & METRICS ASSESSMENT*** enables the evaluation of relevant parameters that are able to meaningfully describe the resilience aspects of the typological environment for representative SLODS and SUODs conditions and address the estimation of an overall resilience score within the project resilience metrics**.** At the pre-mitigation assessment level, further tools are available, including: the above-mentioned **BIM-based multi-risk maps** (see **CASE STUDY:INPUT DATA** above); the photorealistic 360 panorama-based **VR testing**, through the toolkit module ***VIRTUAL DEMOLAB***, which enables the consolidation of **the BET-based VR training** by transferring of knowledge and applying of skills to real settings; and the identification of **feasible, compatible and multi-effective solutions,** as a sub-group of **BET-based multi-risk mitigation solutions**, that meet full applicability with regard to the peculiarities and restraints from the case study.

5. Case study: mitigation

The **identification of feasible, compatible and multi-effective solutions** is the prerequisite for application of the **post-mitigation metrics** and subsequent comparison with the pre-mitigation metrics though the toolkit modules ***KPIs & METRICS ASSESSMENT*** and as well as for the development of the **post-mitigation multi-risk maps**. Such module exploits the same tools of the simulation modules in the assessment actions, but it apples it to the scenario in which selected strategies are implemented. It hence includes the foreseen design modifications, eventually displayed in modified **VR tours** for easy and intuitive dissemination of results with public/private stakeholders & end-users. Thus, all the mitigation outputs merge in the final toolkit module ***RESILIENCE DESIGN,*** where priority solutions are detailed in terms of layout and performance, as well as in communication strategies.

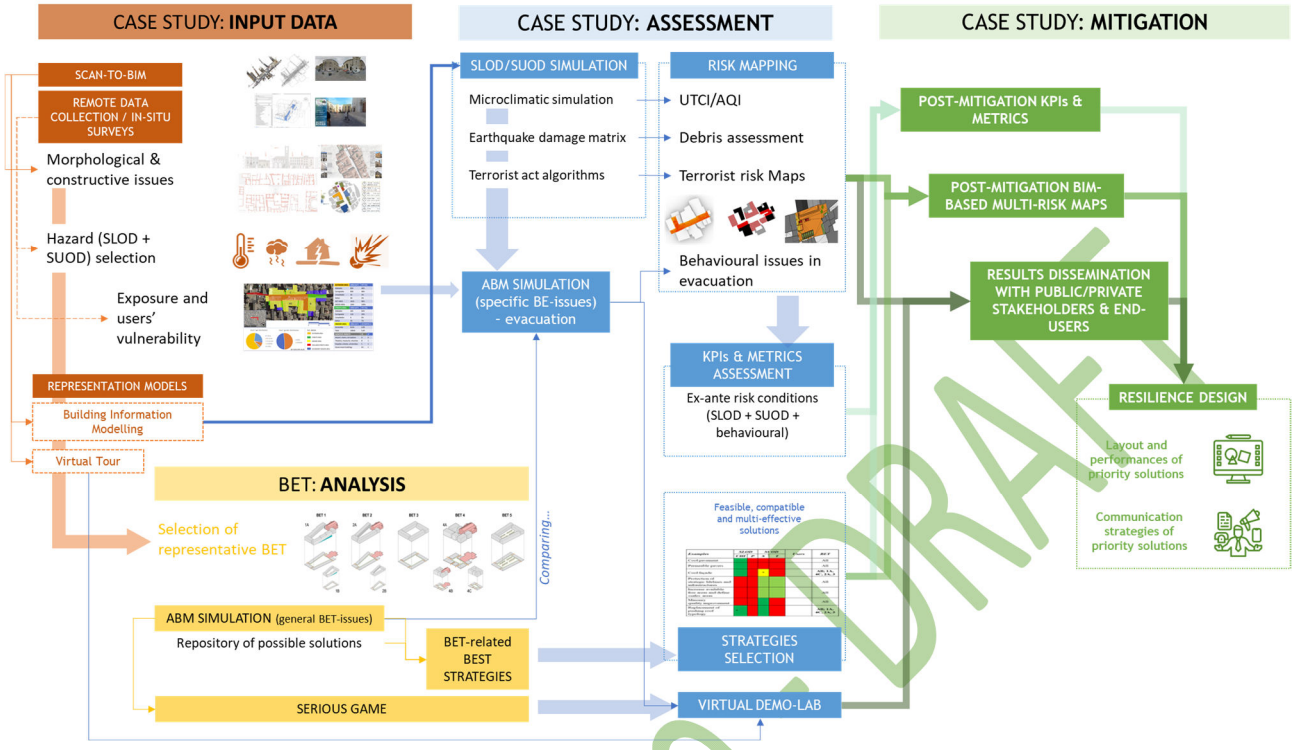

Figure 1. Overview of toolkit framework