READINESS – TF2

Thematic enhancement and adaptation reports

Detailed Pilot methodologies for enhanced SPB Seismic Monitoring procedure

The consistency analysis done by each partner on his surveyed capitalizing HOLISTIC outcomes and best practices and proposition of some enhancement or adaptation measures considered essential for their capitalisation has identified a benchmark methodology for the execution of pilot projects.

Instrumental and professional SPB Seismic Monitoring mixed procedure.

It combines the SPB Seismic Monitoring procedure with instrumental one (both experimented in HOLISTIC project) to carry out a Monitoring Campaign measuring SPBs vulnerability level over time and on widespread territory.
It envisages periodical or continue instrumental surveys of SPBs through passive measurements (Geologist teams) of SPB dynamic parameters and underlying soil to detect resonance mechanisms and identify "in danger of soil-structure resonance" SPBs.

Then Human ground screening (Engineer and Architect teams) limited to identified critical SPBs to evaluate their (SSHS) using specific software.

Finally, where Seismic Structural Hazard Scale overcomes the local Seismic Hazard Risk, a preliminary design of SPBs' restoration interventions

Instrumental monitoring:

Accelerometers and microtremors will be used for Passive measurements and broadband seismometers for permanent monitoring to identify the risk of soil-building resonance and to monitor building structural integrity.

tasks:

a) Measurements for each SPB with mobile seismic station
b) Periodical repetition of measurements
c) Periodic comparison of the frequencies of each SPB with the soil's ones to evaluate its predisposition to soil-structure resonance (double resonance phenomenon)

Alternatively, tasks a) and b) can be performed by permanent measurement with fixed seismic instrumentation

The building resulted " in danger of soil-structure resonance" SPBs during earthquakes they will be taken in charge by the next phase.

Ground screening: Team of technicians (Civil Engineers and Architects) performed: The visual, geometric survey, material-constructive and conservation status of the building; The seismic vulnerability assessment and the Adaptation, improvement or repair suggested interventions.

tasks:

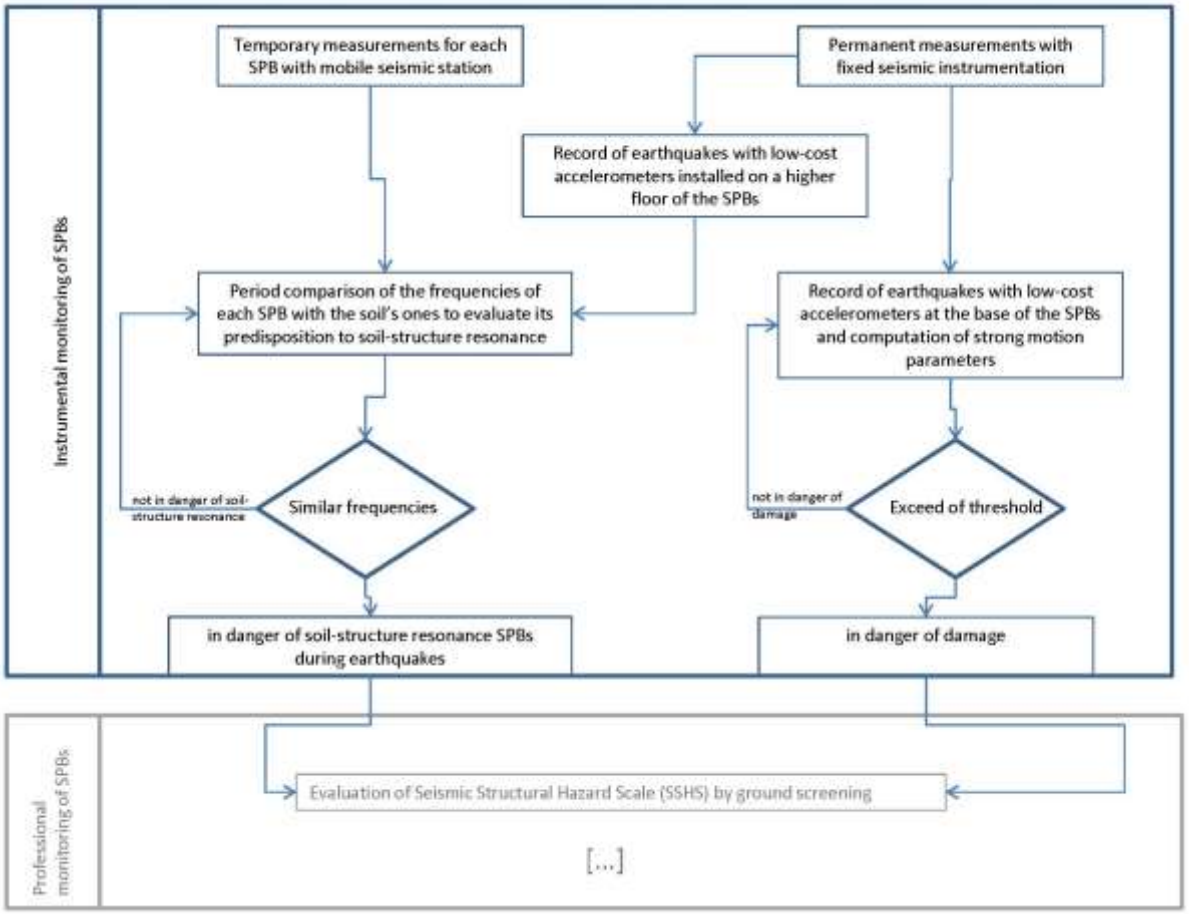
a) evaluation of Seismic Structural Hazard Scale (SSHS) by ground screening

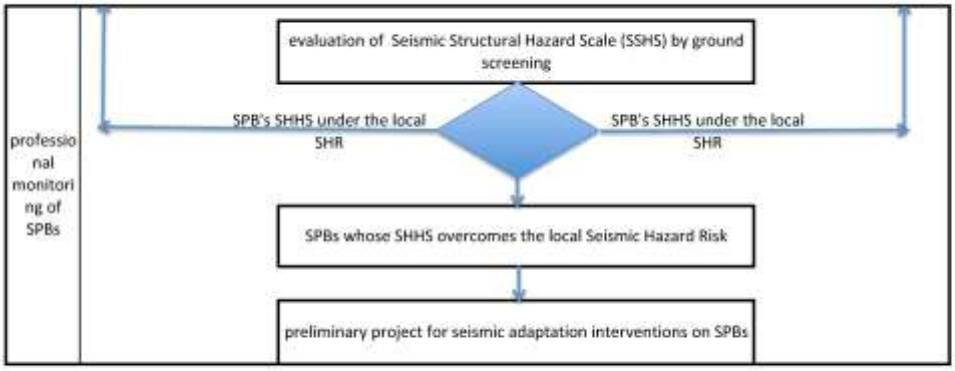
Team of technicians (Civil Engineers and Architects) will perform:

I. The visual, geometric survey, material-constructive and conservation status of the building
II. Elaboration and Evaluation of their (SSHS) using specific software.

On SPBs, whose SHHS overcomes the local Seismic Hazard Risk, the team will prepare a preliminary project for seismic restoration interventions.

Procedure - flow chart




professional monitoring of SPBs
evaluation of Seismic Structural Hazard Scale (SSHS) by ground screening
SPB's SHHS under the local SHR
SPB's SHHS under the local SHR
SPBs whose SHHS overcomes the local Seismic Hazard Risk
preliminary project for seismic adaptation interventions on SPBs

Project targets

Instrumental monitoring: 90 SPBs

Ground survey: 18 SPB

Preliminary restoration designs: 6 SPBs

Proposed share of target deliveries among the partners

PP	Instrumental monitoring	Visual and dimensional screening	Preliminary building Seismic reinforcement Design
LP	18	5	3
PP1	15	5	1
PP2	18+1	0	0
PP3	10	2	1
PP5	18	5	0
PP6	10	2	1
Total	90	19	6
Delivery targets	**90**	**18**	**6**

Partner's abstracts about planned Seismic Monitoring pilot interventions

LP- MOLISE REGION

1. Locations, types of buildings and number

This action promotes the identification of 15 strategic buildings from the logistical and functional point of view, located in the Molise Region.

A preliminary list of structures involved in the survey and monitoring activities has been drawn up. Homogeneous structures have been selected from the point of view of the material (reinforced concrete conglomerate) in order to allow comparative analyzes, albeit in a simplified way. The buildings selected, in the number of eighteen, are listed below:

1. Regional Operational Room of Civil Protection – Campochiaro
2. Central Police Station of Campobasso Sez- Polstrada – Campobasso
3. Central Police Station of Isernia – Isernia
4. Police Station – Termoli
5. Palace of the Regional Council of the Molise Region - Campobasso
6. Carabinieri barracks – Termoli
7. Carabinieri barracks – Isernia
8. Forestry Carabinieri Barracks – Isernia
9. Forestry Carabinieri Barracks – Termoli
10. Fire Brigade Barracks – Campobasso
11. Fire Brigade Barracks – Isernia
12. Station 118 – Trivento
13. Cardarelli Hospital - Block hospitalization 1 – Campobasso
14. Cardarelli Hospital - Block hospitalization 1 – Campobasso
15. Cardarelli Hospital - Central Block 118 – Campobasso
16. AGGIUNGI STRUTTURA
17. AGGIUNGI STRUTTURA
18. AGGIUNGI STRUTTURA

19. Phases of pilot intervention

- Instrumental monitoring

For each building we will proceed, in a first phase, to a dynamic characterization starting from environmental vibration measurements. To measure the structural response, high performance IEPE accelerometric sensors will be used: frequency range from 0.15 to 1000 Hz, resolution 0.000008 g rms, full scale ± 0.5 g pk and sensitivity 10 V / g.
The acquisition system is characterized by 24-bit resolution sigma-delta ADC, with simultaneous sampling and integrated anti-aliasing filter. The dynamic range is more than 100 dB. The measurement chain will therefore allow accurate measurement of vibrations even of very small amplitude such as those typically found in civil structures under operating conditions.
The number and position of the sensors will vary according to the structural configuration. On average, we will proceed with the installation of eight accelerometric sensors per structure, suitably arranged so as to allow the observability of the fundamental vibration modes.
For each building, the instrumental survey activity will last seven days, acquiring data continuously. These data will be analyzed using state-of-the-art analysis methods [1-4]. At the same time, we will proceed to a rapid survey of the structures in order to identify possible structural and non-structural vulnerabilities. To this end, suitable visual relief sheets will be used.
From the data collected on the 18 buildings, we will select 5 buildings on which we will operate a second campaign of integrative surveys with mixed techniques (chech list, NTC critical survey, structural assessments and integrative dynamic tests) in order to increase the level of knowledge.
At the end of the second session of inspections and analyzes, from the 5 buildings evaluated, we will proceed to the identification of 3 buildings, carrying out a thorough evaluation. The objective of the third evaluation and analysis session will be the identification of possible seismic improvement interventions, which will be reported in a technical report, an in-depth document analysis and an additional photographic survey with drone, evaluating both interconnection aspects between buildings and therefore context, both on the building. In addition, an important campaign will be carried out using thermographic techniques to evaluate the efficiency of the building.
The data collected, together with the documentation provided by the administrations of the bodies/bodies involved in the surveying and monitoring activities, will be analyzed for the purpose of selecting three buildings from those previously listed for in-depth analysis of instrumental surveys. Non-destructive investigation techniques (such as, for example, infrared thermography) can be used to obtain further qualitative or semi-quantitative information on the structures in-depth, as well as to confirm the data collected in the preliminary screening phase .

- Visual and dimensional screening

On the buildings non-detailed visual and structural screening will be carried out, as well as the assessment of the state of conservation of the buildings with photographic report, and an

instrumental monitoring campaign (1 week) with dynamic tests through the use of suitable instruments.

- Preliminary building Seismic reinforcement design
  The results of the instrumental investigations, the visual surveys and the analysis of the documentation will constitute the basic information base for the drafting of the final project report, which will include possible intervention scenarios for the mitigation of the seismic risk for the buildings under investigation.
  The owners of the identified buildings (15) will have to guarantee, during the week of dynamic instrumental survey, the following actions:
  1. 220V electric current
  2. 1 protected room for PC recovery
  3. Access to the building for assembly of equipment (eg: Tuesday) - 1 day
  4. Access for disassembling equipment (eg: following Monday) - 1 day
  5. Photographic relief authorization

  The owners of the buildings selected for Session 2 (5) will have to guarantee the following actions:
- access to the building for instrumental monitoring - 1 day
- photographic relief authorization

The owners of the buildings selected for Session 3 (3) will have to guarantee the following actions:
- access to the building for instrumental monitoring - 1 day
- photographic relief authorization

At the end of the three study sessions, the following products will be produced:
- Photo DBs
- Location mapping DBs
- Document DB of the buildings analyzed
- Technical report on the accelerometer monitoring campaign, thermographic, with drone
- Technical report on the comparison of results
- Technical report on possible structural improvement interventions on 3 buildings

Per each phase: Start and end dates, a brief description of procedure, number of buildings affected and monitoring teams composition and professional competences of members.

Activities	Month	1 month				2 month				3 month				4 month				5 month				6 month			
	Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Elaboration CSA																									
Administrative activities delivery																									
Release of authorizations																									
Dynamic minitoring Building 1																									
Dynamic monitoring Building 2																									
Dymanic Monitoring Building 3																									
Dynamic Monitoring Building 4																									
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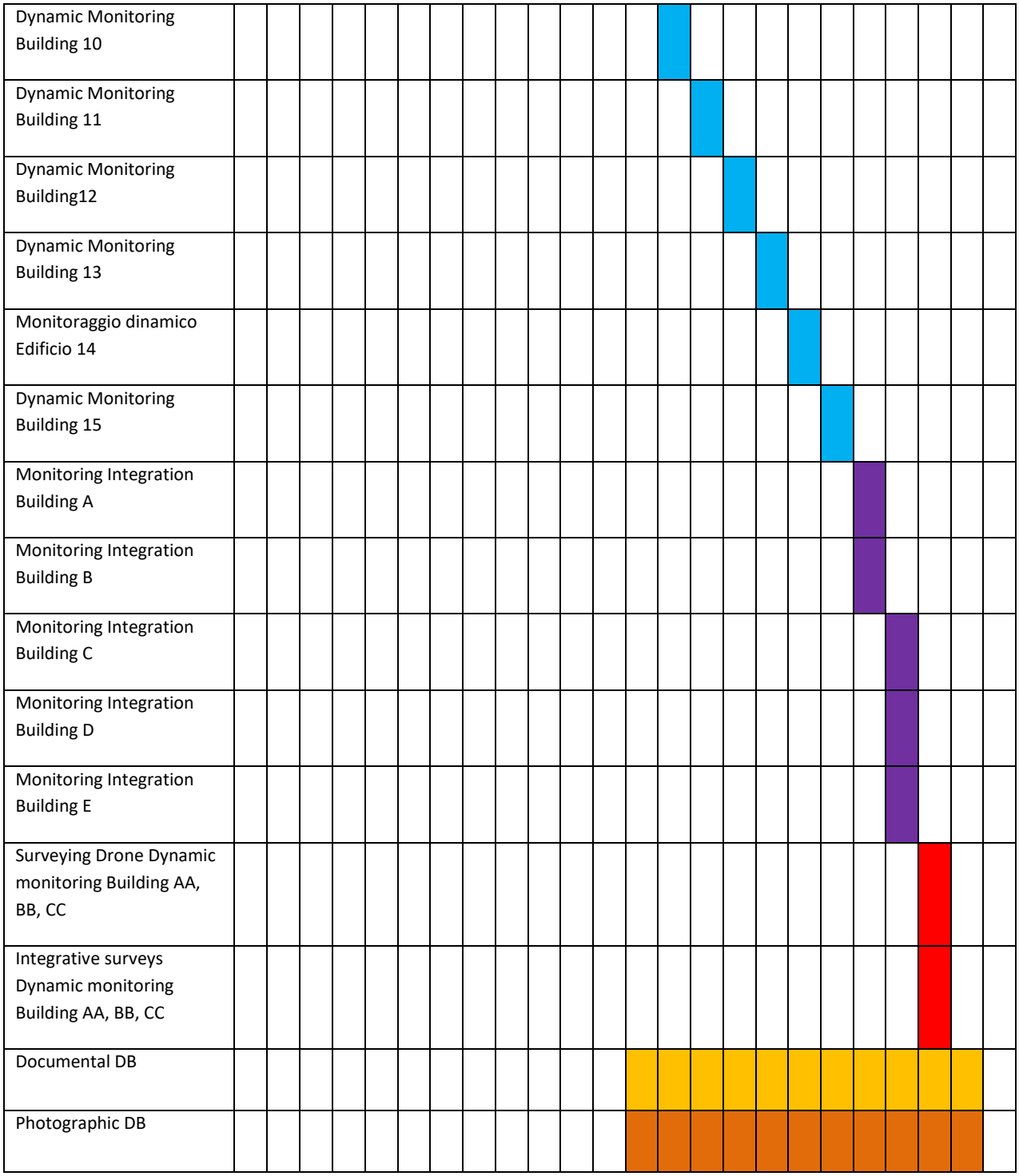
Dynamic Monitoring Building 6																									
Dynamic Monitoring Building 7																									
Dynamic Monitoring Building 8																									
Dynamic Monitoring Building 9																									


Dynamic Monitoring Building 10
Dynamic Monitoring Building 11
Dynamic Monitoring Building12
Dynamic Monitoring Building 13
Monitoraggio dinamico Edificio 14
Dynamic Monitoring Building 15
Monitoring Integration Building A
Monitoring Integration Building B
Monitoring Integration Building C
Monitoring Integration Building D
Monitoring Integration Building E
Surveying Drone Dynamic monitoring Building AA, BB, CC
Integrative surveys Dynamic monitoring Building AA, BB, CC
Documental DB
Photographic DB

Technical Report on the results																							
Technical Report on interventions																							
Presentation of final results																							
Administrative closure of the activity																							

20. Estimated budget

- Instrumental monitoring:
  External expertises: *details on committed/ing professional, number and duration + forecast amount*
  Equipment: *list + forecast amounts*
- Visual and dimensional screening
  External expertises: *details on committed/ing professional, number and duration + forecast amount*
  Equipment: *list + forecast amounts*
- Preliminary building Seismic reinforcement design
  External expertises: *details on committed/ing professional, number and duration + forecast amount*
  Equipment: *list + forecast amount*

About the estimated budget, it is not possible to give an answer now.
We have formally asked the University of Molise to provide us with a cost estimation for the implementation of the whole activity, and we are still waiting for an answer.

PP 1- DUBROVNIK NERETVA REGION

Abstract about seismic monitoring of SPB

To mitigate seismic risk in urban areas, it is important to estimate dynamic parameters of strategic public buildings (SPB) and underlying soil in order to determine its amplification properties and identify possible resonance phenomena, which may cause severe structural damage or collapse of buildings during earthquake shaking.

SPB's dynamic parameters – fundamental frequency, corresponding damping coefficient, response spectra – will be estimated by performing measurements of its microvibrations induced by ambient noise. These passive measurements are non-invasive and without any influence on the residents or normal usage of the building. Minimum of two measurements should be performed for each SPB, one inside of the building at the highest possible floor, and the second one in the nearby free-field. Risk of soil-building resonance phenomena will be estimated for each SPB.

For one selected SPB more detailed seismic analysis will be made based on 1) continuous instrumental measurements performed using accelerometer or seismometer installed at the highest possible floor in order to monitor its structural integrity and response to ground shaking induced by an earthquake and 2) operational modal analysis (OMA) performed in order to provide fundamental modal shapes together with corresponding natural frequencies and damping coefficient which will be used for calibration of initial numerical model constructed on the basis of the collected building data and field surveys. Seismic analysis will be carried out using initial and detailed three-dimensional finite elements, numerical models, which include geometric and material non-linearities. Finally, the response of this one selected SPB to representative earthquake scenarios will be determined, in order to assess its seismic vulnerability and to propose strengthening measures (if needed).

In order to enable high quality analysis, preliminary screening of the SPB's will be carried out before performing measurements to collect some valuable information about the buildings – e.g. Age of construction, year of design, dimensions of the building, number of stories and height, function, type of construction, occupancy, etc.

Equipment and instruments

The instrument used to perform passive measurements is Tromino, small all-in-one portable instrument for passive and active seismic surveys and vibration monitoring. The instrument is very small in size and with low power consumption, includes a 3-component geophone, digitizer, GPS receiver, batteries and 512Mb flash memory for storage, all in one case.

The instrument used for performing continuous instrumental measurements in one selected SPB can be either a 3-component seismometer or an accelerometer (given the expected higher level of signals), with 24 bit digital and characterized by high performance – high sensitivity and dynamic range and low noise. The instruments used to perform measurements necessary for the derivation of the detailed numerical model of this selected SPB are high sensitivity accelerometers PCB 393B1, Brüel & Kjær 5-channel portable data acquisition system type 3560 C and software package Pulse OMA.

Preliminary information on procedures

For reliable estimation of SPB's dynamic parameters it is recommended to perform at least two 10–20 minutes long passive measurements: inside of the building, preferably at the highest floor where the amplitudes of vibrations are the largest, and in the free-field near the building (reference measurement). The orientation of the instrument should be the same for all measurements – inside the building and in the free-field – and oriented along the buildings longitudinal direction. Measurements do not have to be synchronous, but they have to be performed without large time delays, as soon as possible one after another (preferably within an hour). The best option is to perform synchronized measurements on each floor and in the free-field. Dynamic parameters of SPB's will be estimated by the method of matching the observed Standard Spectral Ratio (SSR) to the theoretical SDOF system response, where SSR is computed by dividing the Fourier spectra of vibrations measured inside the SPB with the corresponding spectra of the excitation signal (microtremors recorded in the vicinity of the SPB, free-field measurement). Afterwards, the selected peak in SSR – representing one of the building's modes, is fitted with the SDOF theoretical response, and based on the best fit, dynamic parameters of that mode are estimated. This should be done in two orthogonal directions of the SPB, longitudinal (along the long axis) and transversal (along the shorter axis).

For free-field measurements, horizontal-to-vertical-spectral-ratio (HVSR) of microtremors will be computed and used to try to estimate the fundamental soil frequency, and hence its amplification and the potential of the soil-building resonance phenomena.

For one selected SPB, continuous instrumental measurements will enable its structural health monitoring by tracking possible fluctuations of building's dynamic parameters and trying to correlate them to weather conditions, potential damage induced by seismic shaking, natural degradation of material properties or potential mechanism of soil-structure interaction. Moreover, OMA measurements will be performed during excitation induced by ambient noise. Multiple DOF's, in two orthogonal horizontal directions at each measuring point, will be measured at all floors of this selected SPB (approx. 50-100 DOF's in total). Natural frequencies, modal shapes and damping coefficients will be determined by the methods of Frequency Domain Decomposition (FDD) which is based on singular value decomposition (SVD) of power spectral density (PSD) matrix of the measured responses. This will enable more detailed evaluation of

dynamic behavior of the selected SPB and calibration of initial three-dimensional finite element numerical model. Detailed models will include geometric and material non-linearities of structural elements and analysis of building response to representative earthquake scenarios which will be performed using a piecewise exact step by step method. The representative ground surface, shaking on the location caused by an earthquake will be estimated on the basis of synthetic accelerograms (several different scenarios). Seismic vulnerability assessment will be made on the basis of the obtained results, including the building collapse mechanism and identification of critical structural elements. Moreover, strengthening procedures can be proposed for structural and non-structural building components and recommendations to limit reconstruction. In addition, optimal evacuation alternatives can be recommended in the form of safest and most efficient routes. In order to enable high quality seismic analysis, detailed building data will be collected from existing documentation before performing measurements. Data should include date of construction/retrofit, the structural system (material, geometry, cross sections with reinforcement if applicable, number of stories, lateral load-resisting system, roof, floor, foundation system), position in the block, soil characteristics, occupancy, etc.

Estimated cost per SPB and number of buildings

The costs listed below cover the accommodation and travel expenses, usage of contractor's equipment, performance of measurements, data analysis and interpretation, and compilation of the Report:

Passive measurements: 15000 EUR

Visual screening: the project READINESS budget will not be charged – 5 buildings

Detailed seismic analysis (continuous instrumental measurements, numerical model and representative ground motion scenarios): 25000 EUR – 1 building

PP 2- MARCHE REGION

1. Locations, types of buildings and number

The area considered is the Marche Region.
Continuous monitoring for a total of 18/19 SPBs.
The chosen SPB's are public buildings (schools, municipalities…).

2. Phases of pilot intervention

- Instrumental monitoring

Continuous monitoring of the 11 SPB already instrumented in Holistic project.

New sites will be instrumented: 3 buildings already instrumented within the convention between INGV and Marche Region will be integrated into the project Readiness; 4 new SPB will be instrumented at the base of structures. Two buildings will be chosen among all those monitored with sensors at the base where 2 low-cost accelerometers will be installed on a higher floor.
In each new SPB, at least three temporary seismic noise measurements will be recorded to analyze the frequency of the fundamental mode of vibration of the structure and the frequency of the resonance of the soil. Permanent seismic instrumentation will be installed at the base of the selected 4 buildings. The aim is to record strong motion during significant seismic events.

- Visual and dimensional screening (NO)

- Preliminary building Seismic reinforcement design (NO)

Per each phase: Start and end dates, a brief description of procedure, number of buildings affected and monitoring teams composition and professional competences of members.

The team will consist of external expertise from Istituto Nazionale di Geofisica e Vulcanologia (INGV), Osservatorio Nazionale Terremoti (ONT), Sede di Ancona, composed of 4 researchers and a technician. Moreover, the team also is composed by personnel of the Civil Protection of Marche Region to assist surveys and search for cartographic and digital material.

2. Estimated budget

- Instrumental monitoring:
  External expertises: *details on committed/ing professional, number and duration + forecast amount*
  Equipment: *list + forecast amounts*

Technical External expertise (all included: travel, installed new seismic sensors, upgrade of database and web site, field campaign)

Budget 101.964 EUR (vat included)

500 euro for Civil Protection Staff

PP 3- SPLIT DALMATIA COUNTY

1. Locations, types of buildings and number

Split-Dalmatia County has chosen 10 public buildings (schools) in the most seismological active area in the County (north- south part of the County) to implement the seismological pilot operational plan.

2. Phases of pilot intervention

Phase 1: Visual screening of the buildings
Collection of documentation, estimation of the vulnerability index and categorization of the buildings according their vulnerability (this phase will be carried out for all of the analyzed buildings)

Phase 2: Measurements of dynamic parameters for the building and underlying soil
(this phase will be carried out for all of the analyzed buildings)

Phase 3: Soil classification
According to Euro-code 8 based on the value of average shear wave velocity which is obtained by seismographs (applied to 20% or two of the selected buildings with high value of vulnerability index and/or in danger of soil-structure resonance)

Phase 4: Evaluation of the behaviour of the building subjected to design acceleration and estimation of failure mechanism and collapse ground acceleration.
(this phase will be carried out for 20% or two of the analyzed buildings)

Phase 5: Preliminary building Seismic reinforcement design
(this phase will be carried out for one of the analyzed buildings that studies show is the most endangered)

Phase 1 – 4 completion time-frame: August 2018. to February 2019.
Phase 5 completion time-frame: February to April 2019.

3. **Estimated budget**

- Phase 1: (~ 3.125 EUR per building)
  External expertises: *to be contracted*
  Equipment: *provided by contractor*
- Phase 2: (~ 1.500 EUR per building)
  External expertises: *to be contracted*
  Equipment: *provided by contractor*

- Phase 3: (~ 3.125 EUR per building)
  External expertises: *to be contracted*
  Equipment: *provided by contractor*
- Phase 4: (~ 4.375 EUR per building)
  External expertises: *to be contracted*
  Equipment: *provided by contractor*
- Phase 5: (to be defined)
  External expertises: *to be contracted*
  Equipment: *provided by contractor*

PP 5- FIRULI VENEZIA GIULIA

1. Locations, types of buildings and number

15 strategic buildings, most located in little towns of FVG Region, will be monitored.

Municipal mains functions are exercised in these locations as: Mayors' and others relevant offices, as those related with Civil Protections Functions, Local Policy and Forest Fire Brigade.

Some buildings are just been investigated in Holistic previous monitoring campaigns.

They present different construction features: the recent buildings, realized after the 1976 big earthquake, are usually supported by concrete; the most middle-aged building are supported by masonry bricks/squared stones and the oldest ones are often realized with rounded stones.

More detailed informations on structural details will be collected during the measurement campaign and visual screening.

2. Phases of pilot intervention

- Instrumental monitoring: 15 buildings; from 15.09.2018 to 15.02.2019

Methodology

The objective of the work program is to develop monitoring procedures that, through the use of low-cost instruments and through dynamic experimental analysis, allow to evaluate the vibrational characteristics of strategic buildings and to make judgments about their status based

the variations found in subsequent experimental campaigns or through changes in parameters derived from continuous monitoring.
For this purpose, instruments (accelerometers and velocimeters) capable of recording the three components of environmental seismic noise will be used. Noise measurements will be conducted in succession on the structures that will be investigated (in various positions and at different floors) and in the free field at a distance from those. The study of the relationships between the noise spectra obtained on the structure in the different positions and those related to the free field will allow a clear identification of the first vibration modes of the structure (flexural and transversal).
The comparison of the vibrating mode of the structure with the fundamental frequency of the site deduced from the analysis of the measurements performed in the free field and elaborated with the Nakamura (HVSR) method allows then to estimate any possible phenomena of seismic resonance.
This estimate is of great importance if we consider that under the action of an earthquake both a building than the foundation soil behave like oscillating systems with their own period and consequently the most severe damage occurs when a structure presents ways of vibration close to the frequencies proper of the ground.
To analyze the dynamic characteristics of the building in more detail, the damping calculation will also be carried out.
For this purpose, the RDM (Random Decrement Method) will be used related to the fundamental frequency only; for a building its typical value ranges between 1 and 10% while its variations can be correlated to damages.
Another index to be calculated in order to evaluate the characteristics of the structure is the vulnerability index, this index was introduced by Nakamura (2000) and is defined as the ratio:

$$K_b = \frac{A}{(2\pi F)^2} \cdot \frac{10000}{H}$$

where:
A: floor amplification;
H: height of the structure in meters.
F: frequency

By reporting this data to the change in frequency that is found before and after an earthquake, it has been noted that the damage increases with the increase of this index, even if there are no "absolute" references to link this value to a probable damage in a preventive phase analysis.
Tests will be carried out will allow to obtain indispensable information to eventually develop models that are able to simulate the real behavior of buildings and derive indications that can be used for diagnostic purposes, through appropriate procedures.
In addition to these "ground screening" activities, it is also intended to make comparisons between measuring instruments with possible joint monitoring with other Project Partners.

Activity will be conducted with internal staff, purchasing new equipment and using the one already acquired in the Holistic Project.

- Visual and dimensional screening: 5
  A goal of the project is to test a new report format created by Udine University for buildings fast monitoring after an earthquake.

- Preliminary building Seismic reinforcement design: No

4. Estimated budget

For WP 3 activities PP5 (PC FVG) can use € 20.00,00 for acquisition of new instruments and 2.455,00 for internal expertise's.

- Instrumental monitoring:
  Internal expertises: 2 geologist and 2 civil engineers
  External expertises: scientific support based on preexisting agreement with Istitute Naz. Sperimental Ocenography and Geophysics and University of Udine and Trieste
  Equipment:
  Visual and dimensional screening
  External expertises: no one;
  Equipment:
- Preliminary building Seismic reinforcement design: no
  External expertises:
  Equipment:

PP 6- ZADAR COUNTY

1. Locations, types of buildings and number

Considering the time of construction and type of construction, we can bring a rough estimate of their seismic resistance. The area of Zadar County can be divided into V categories of objects according to the type of housing construction:

- I - masonry buildings up to 1920 - ceiling structures exclusively made of wood - 10%
- II - masonry buildings with reinforced concrete springs from 1921 to 1945 - 5%
- III - reinforced concrete skeleton buildings from 1946 to 1964 - 15%
- IV - reinforced-concrete supporting wall system from 1965 to 1980 - 50%
- V - skeletal buildings with reinforced concrete barriers from 1980 to present - 20%

The measurement will be at 10 SPB and determination of SPB will be based on importance of buildings for Zadar County and on soil and geological data. Measurements will be performed at schools, emergency medical help building, County building, and buildings which determines the Law on Critical Infrastructures (NN 56/13) in the Zadar County.

5. Phases of pilot intervention

- Instrumental monitoring

Phase 1:
- Measurements of microseismic disturbance on the ground (at the foot of the building) and on the top floor of the building. Measurements are performed on 10 selected SPB, minimum one measurement on the ground and one on the top of the building. Total 20 measurements.
- Calculation of HVSR spectrum, dominant ground frequency and building frequency. Preparation of the preliminary report.

Phase 2:
- Repeat measurement after six months in the same buildings and positions.
- Calculation of HVSR spectrum, dominant ground frequency and building frequency. Preparation of the preliminary report.

Preparation of the Phase 1 and Phase 2 measurement results, comparison of dynamic parameters of Phase 1 and Phase 2, Absorption Risk Assessment in Earthquake.

- Visual and dimensional screening

The evaluation of Seismic Structural Hazard Scale of in danger of soil-structure resonance buildings will be made by a professional team through visual and dimensional screening of its structural characteristics, result of instrumental monitoring and conservation status then evaluation will be described in the elaborate. This phase will be carried out for 20% (equal to two buildings) of all the analyzed buildings.

Monitoring and screening team composition: 2-3 Geologists/Civil Engineers/Architects.

- Preliminary building Seismic reinforcement design

When measurements, visual and dimensional screening are made then preliminary building seismic reinforcement design will be approach. This phase will be carried out for one of the analyzed buildings that studies show is the most endangered.

Activities to be carried out during the project:

- Overview of various available documents containing relevant information about SPB (e.g. year of construction, type of structure, dimensions, number of floors, reconstruction data, soil characteristics…) for which measurements will be performed;
- Overview of accessible literature about the results of measurement of dynamic parameters of SPBs (fundamental period and damping coefficient, response spectra) for which measurements will be performed (if any).
- Overview of accessible literature about the results of microzonation studies performed for the areas in Zadar County, where SPBs for which measurements will be performed are located (if any).
- Organisation of measurement implementation.
- Measurements of dynamic parameters (fundamental period and damping coefficient, response spectra) of 10 strategic public buildings (SPB) in Zadar County and of underlying soil, using microtremor as an excitation signal (passive measurements) and ground screening of the buildings.
- Installation of accelerometer or seismometer for continuous instrumental monitoring of one SPB for time period of at least 6 (six) months.
- Repeated measurements of dynamic parameters (fundamental period and damping coefficient, response spectra) of SPB and of underlying soil, using microtremor as an excitation signal (passive measurements) and ground screening of the buildings, after time period of minimum 6 (six) months.
- Uninstallation of accelerometer or seismometer for continuous instrumental monitoring of one SPB for time period of at least 6 (six) months.
- Data analysis and interpretation. Presentation of final result in the form of Report, presenting for each SPB estimations of its dynamic parameters (fundamental period and damping coefficient, response spectra) and danger of the soil-structure resonance during earthquakes, and results of monitoring structural integrity of SPB by identifying possible changes in dynamic parameters due to the natural degradation of material properties and/or the cumulative damage from continuous low-level seismic activity, including results from continuous instrumental monitoring of one SPB for time period of at least 6 (six) months.
- Preparation of guidelines for performing passive measurements of microvibrations of buildings and microtremor measurements in the nearby free-field, which are used for estimation of dynamic parameters of buildings and danger of the soil-structure resonance during earthquakes

Team composition: 2-3 Geologists/Civil Engineers/Architects

Instrumental monitoring and Visual and dimensional screening completion time-frame:

August 2018 to February 2019

Preliminary building Seismic reinforcement design completion time-frame:

February to April 2019

Estimated budget

- Instrumental monitoring and Visual and dimensional screening: *cca 33.000 EUR*
  External expertise: *to be contracted*
  Equipment: *defined in coop. and with the assistance of contracted expert*

- Preliminary building Seismic reinforcement design: *to be defined*
  Equipment: *to be contracted*
  Equipment: defined in coop. and with the assistance of contracted expert