Fondazione EUCENTRE

European Center For Training and Research on Earthquake Engineering

www.eucentre.it

Kick-off meetings of projects selected under the Call for proposals 2006/C 176: 'Pilot Projects on Civil Protection cross border co-operation in the fight against natural disasters'

STEP

Strategies and Tools for Early Post earthquake assessment

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STEP – Beneficiary and Partners

- Benficiary → EUCENTRE – Pavia, Italy
- Partner 1 → Laboratorio Nacional de Engenharia Civil – Lisbon Portugal
- Partner 2 → Fraunhofer Center - Fraunhofer Germany
- Partner 3 → Dipartimento di Protezione Civile – Rome, Italy
- Partner 4 → Civil Protection Department of Portugal – Lisbon, Portugal
- Partner 5 → Dipartimento di Protezione Civile Friuli – Udine, Italy

The Foundation EUCENTRE – Pavia, Italy

- EUropean CENtre for Training and Research on Earthquake Engineering
- Established in 2003 with the contribution of Italian Civil Protection Department (DPC), University of Pavia, National Institute for Geophysics and Volcanic (INGV) and the Institute for Advanced Studies of Pavia (IUSS)
- Two Departments/Sessions TREES LAB and CAR College
- Three buildings: EUCENTRE building, EUCENTRE 2 and Collegio Riboldi
- More then 30 researchers and 50 graduated students involved in research activities
- More then 40 research activities in the earthquake engineering field
- MSC and PhD programs (www.roseschool.it www.meees.org)
- Training courses for professional engineers

EUCENTRE – European class experimental facilities for earthquake engineering research application and training

1. Uniaxial high performance shake table;
2. 3-D reaction system for structural testing;
3. High performance bearing tester;

After-seismic-event emergencies

- Earthquakes have been responsible in European Countries for significant loss of human life and damage to buildings and infrastructures (direct effect).
- After an earthquake has occurred frequently many buildings are poorly scored (considered dangerous) and people living inside are forced to leave. Based on outward and superficial controls (visual control, vulnerability checklists, etc.) frequently performed by technicians not properly trained for investigation or evaluation. Evaluators tend to be very conservative (indirect effects)
- Safety measures must be provided immediately to avoid worst loss
- Serious problems can derive such as people transfer and coordination of this movements, huge amount of money to manage (indirect effects).
- Need for faster and more refined assessment procedures formerly to reduce the interferences with emergency activities and secondly to limit the number of temporary shelters, guaranteeing at the same time the citizen's safety against subsequent aftershocks. (reduction of indirect effects)

STEP – Objectives of project

- 1. **Review of the assessment techniques** - Experimental methods for the evaluation of geometrical characteristics, mechanical properties and structural details (level of knowledge of the structure as defined in EC8 and other European code of practice) and numerical analysis for vulnerability assessment will be considered.

- 2. **Design and construction of a Mobile Unit prototype (MU)** – The results of the previous review will orient the design and construction of a Mobile Unit (mobile experimental laboratory) properly equipped to perform experimental tests to improve structural level of knowledge and to perform some analytical estimates of the seismic vulnerability.

- 3. **Design of a Coordination Unit (CU)** - A special unit with coordination function will be designed and developed to work with MU(s). Fast and reliable wireless connection (Satellite for example) will be implemented to guide MU(s) on field actions, to exchange useful information (shared and used later with other experts working in remote laboratories;

- 4. **Guidelines for optimized use of CU and MU** – The most important use of coordinated Cu and MU(s) is related to emergency periods, but these resources could efficiently be used in pre earthquake phase to increase vulnerability knowledge particularly for those buildings with special function in Civil Protection ambit. Guidelines for coordinated employment both during post earthquake emergency and in pre-shake phase will be developed and provided;

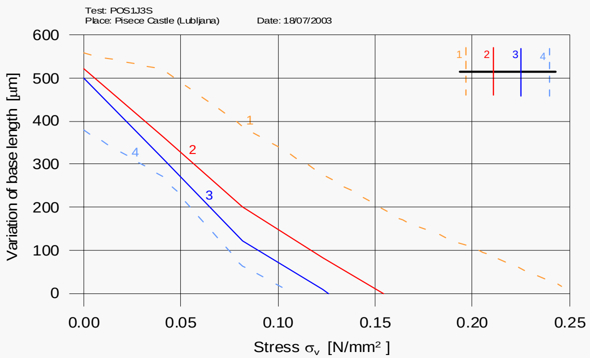
- 5. **Harmonization of cross border actions** – The advanced procedures developed in this project will be integrated into traditional Civil Protection approaches based on visual inspections and simplified evaluation with vulnerability checklists. Training courses and in field practical application involving several Civil Defence European Institutions will be prepared with the main scope of increase the new assessment tools knowledge and create common intervention procedures using both traditional and advanced assessment methods.

Actions and means involved - First part

- Critical review both of experimental and numerical methods suitable for structural properties assessment, implementation into a mobile unit with functions of experimental lab, data processing and analysis centre and wireless hub. For in field applications, flexibility, portability and reliability will be considered as fundamental requisites for their practical implementation.
- The following experimental techniques will be analysed for onboard implementation:
- - Pachometr - rebars locator: to be used for r.c. structures to locate reinforcement bars inside elements and to estimate diameters and depth (concrete cover);
- - Sclerometric and Ultrasonic - Sonreb techniques: is one of most reliable non-destructive technique today available used for concrete properties assessment (strength, elastic modulus);

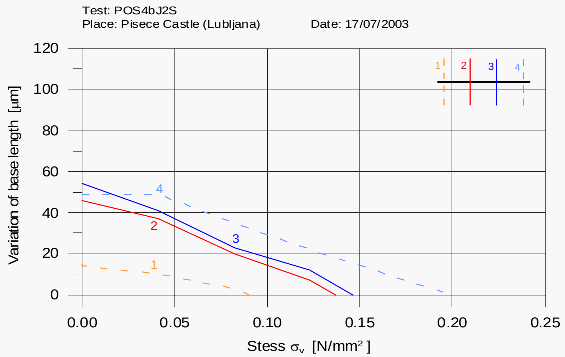
Single Flat Jack Tests performed to determine local stress

POS1J3S



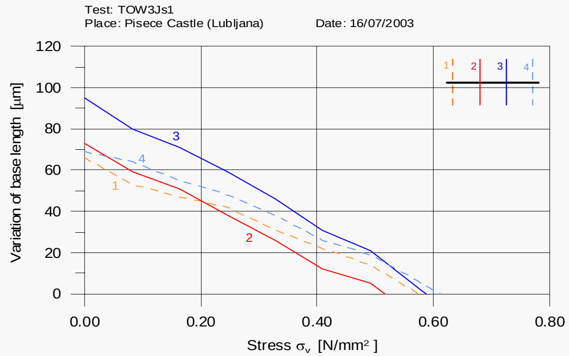
Local Stress: 0.129 *N*/mm²

POS4bJ2S



Local Stress: 0.143 *N*/mm²

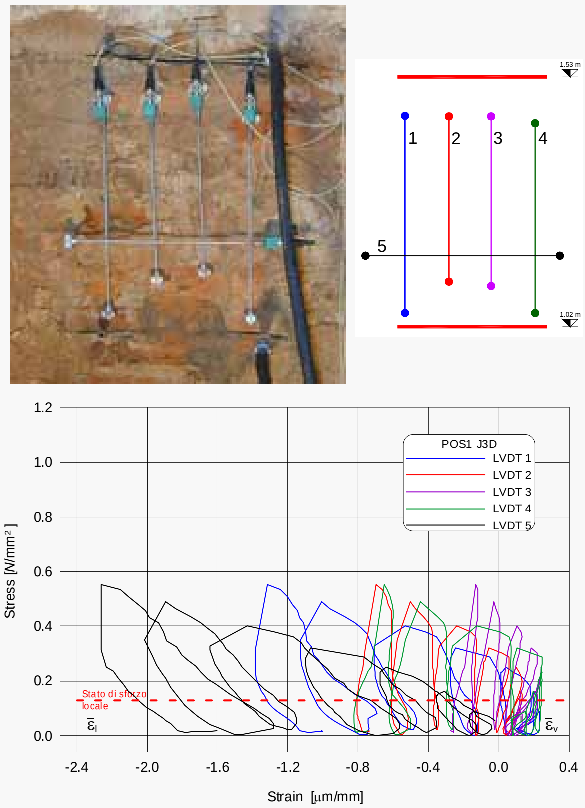
TOW3J1S



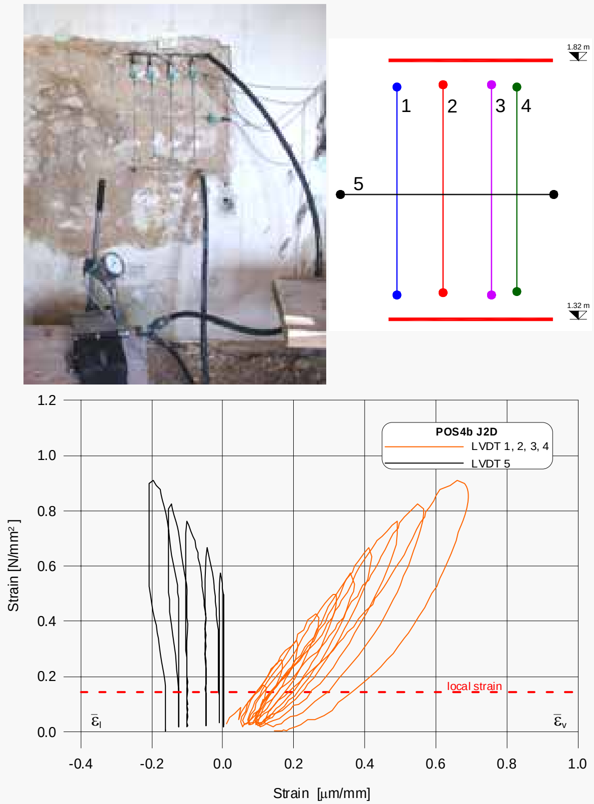
Local Stress: 0.573 *N*/mm²

Double Flat Jack Tests – Material properties identification

POS1J3D



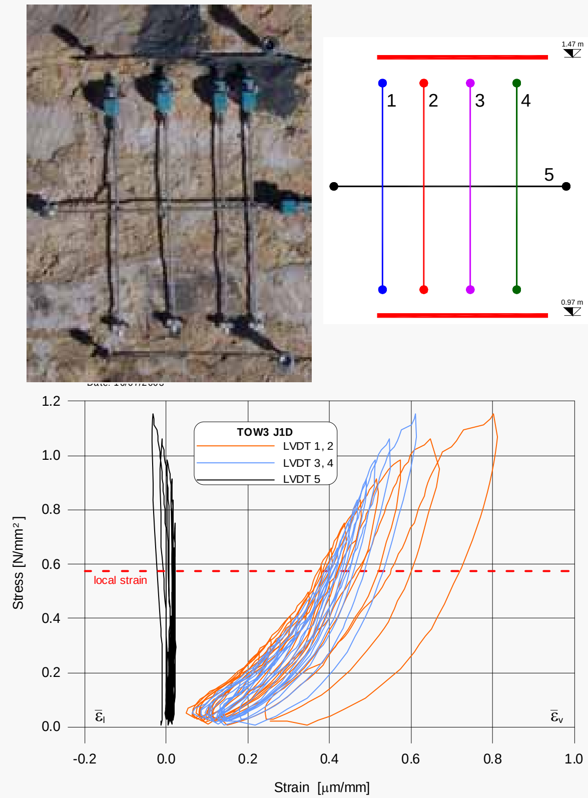
POS4bJ2D



Young Modulus (10-30%): 1490 *N*/mm²

Lateral deformation ratio (10-30%): 0.01

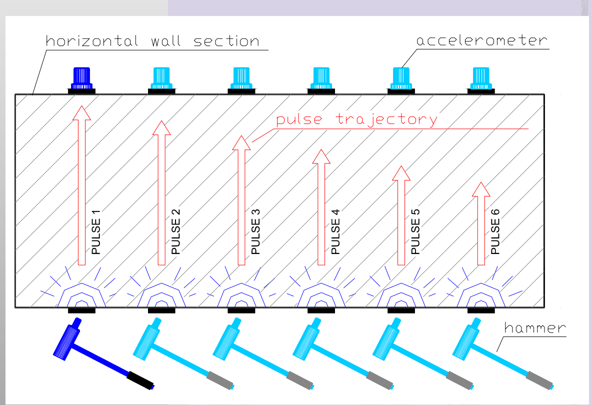
TOW3J1D



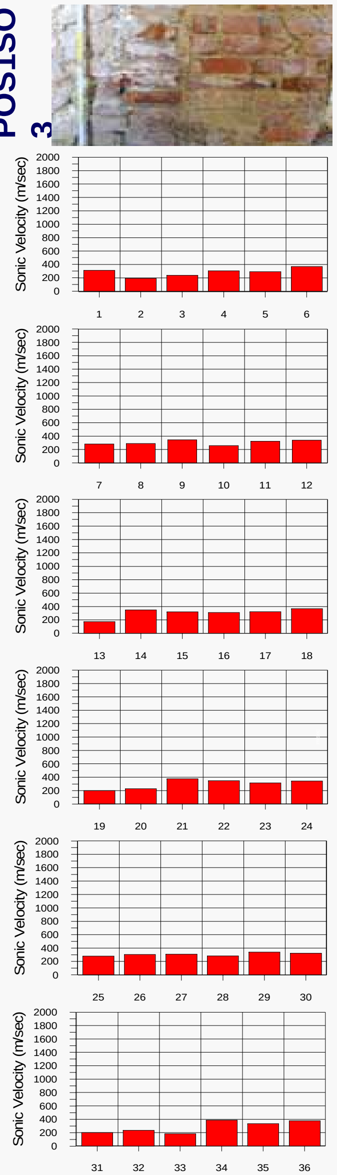
Young Modulus (10-35%): 1700 *N*/mm²

Lateral deformation ratio (10-30%): 0.03

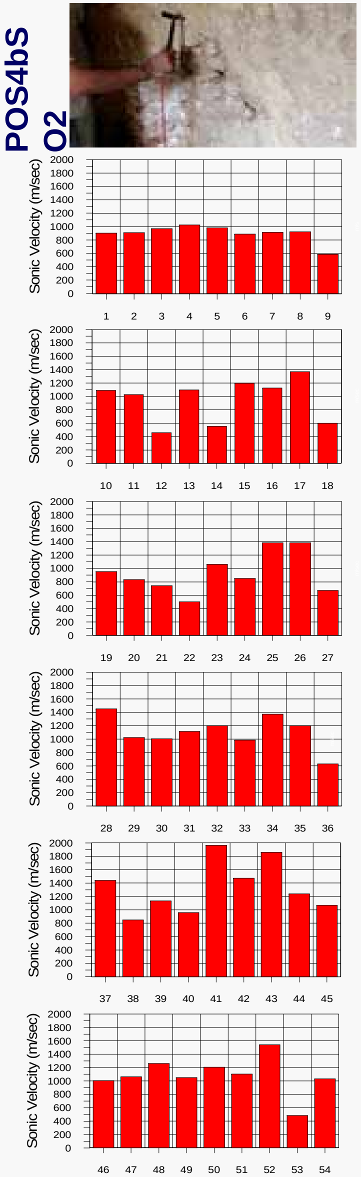
Direct Sonic Tests



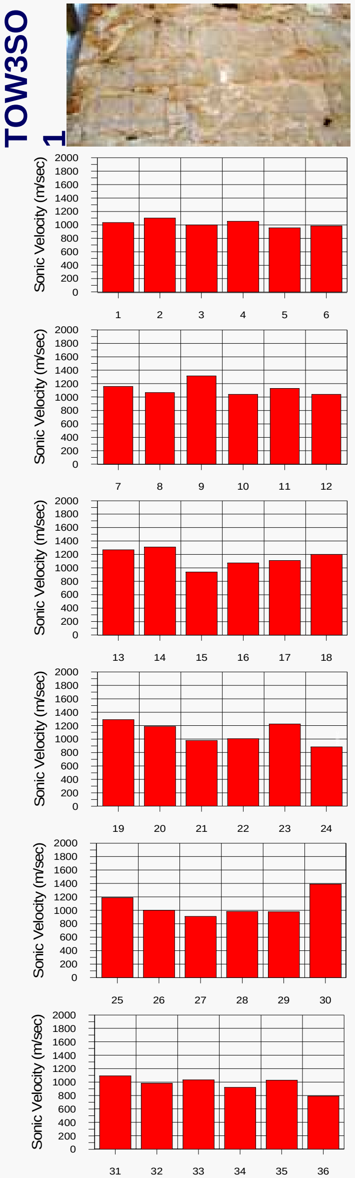
POS1SO 3



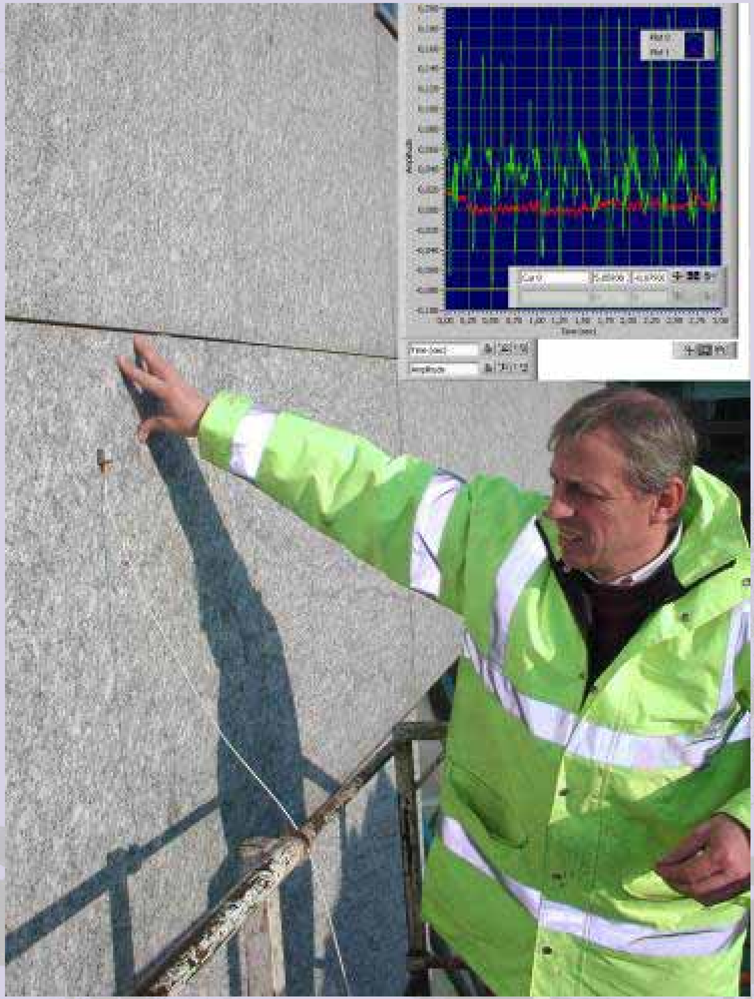
POS4bS O2



TOW3SO 1

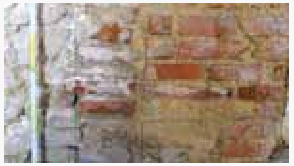


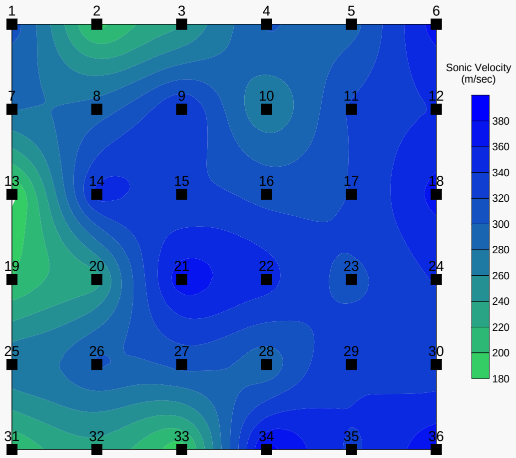
Structural identification with sonic techniques



Direct Sonic Tests and Videoscopy

POS1SO3

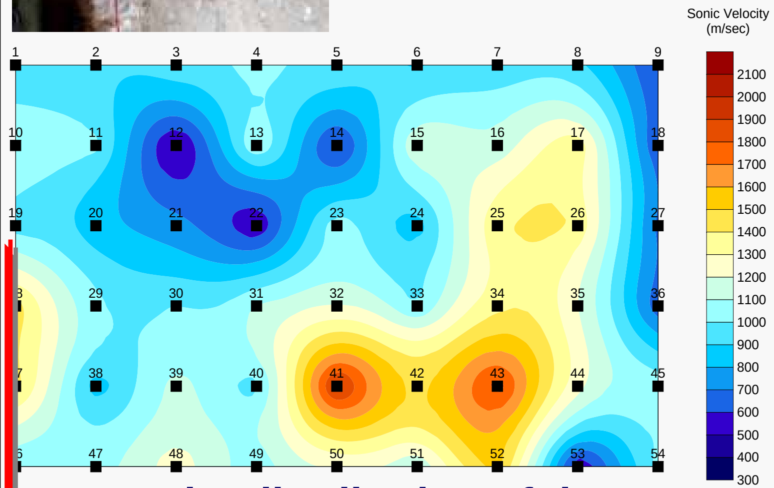




Low values reveal the presence of a remarkable void

The inspection showed a large void.

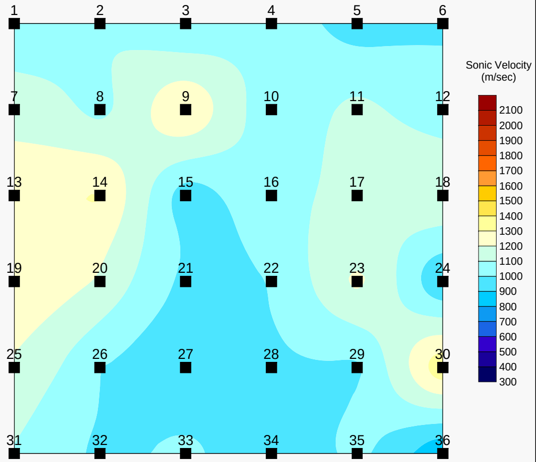
POS4bSO2



The distribution of the velocity is not homogeneous

The inspection by videoboroscopy showed an irregular masonry

TOW3SO1

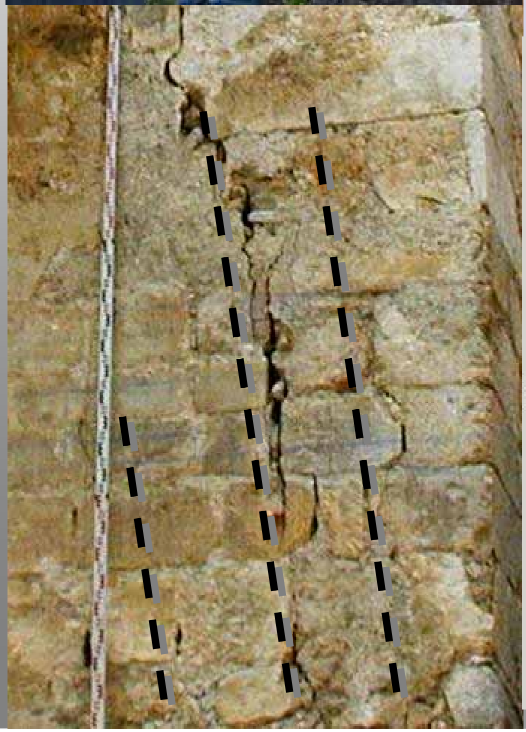


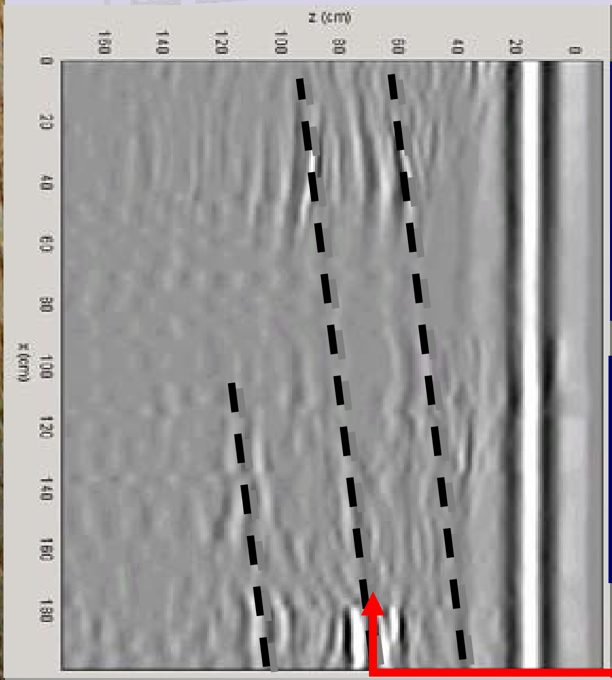
The distribution is more homogeneous

The inspection showed a regular section

Radar for crack and defects

The inspection was carried out in order to verify if the radar was able to detect the presence and the depth of the wide cracks.





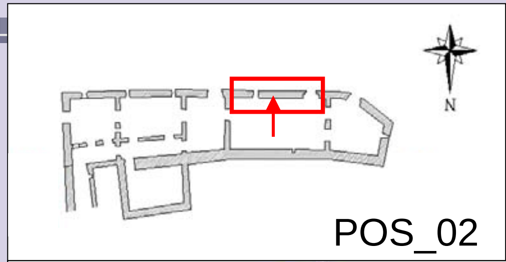
The acquisition geometry has a great importance on the effectiveness of the test, for this type of application.

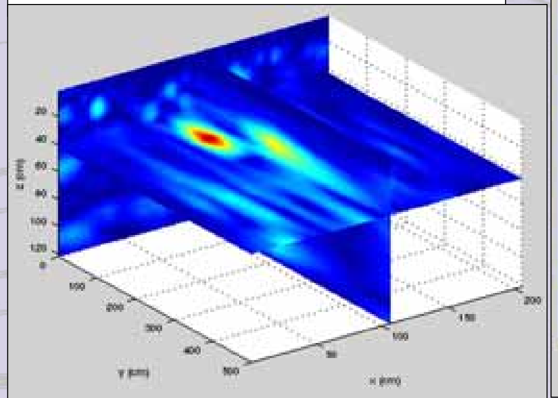
A system of three main cracks seems to be detected by the radar profile at increasing depth from the surface.

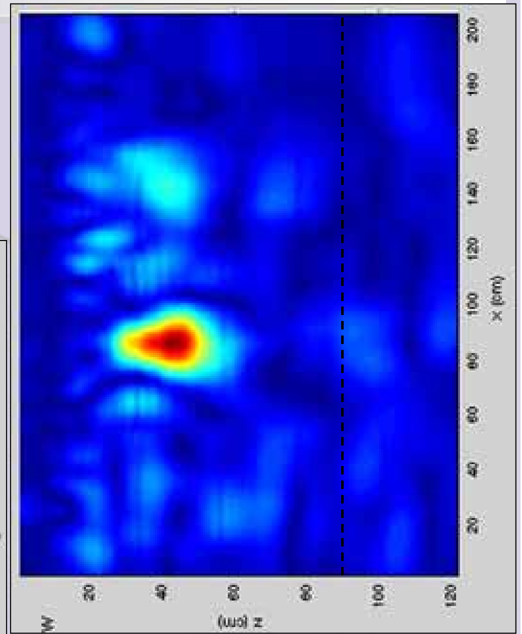
RADAR TEST Avio Castle

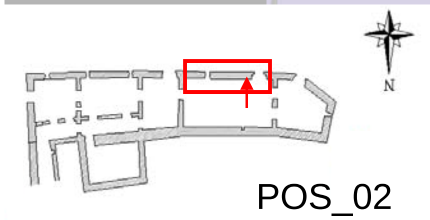
The tests were aimed to characterise the masonry morphology.

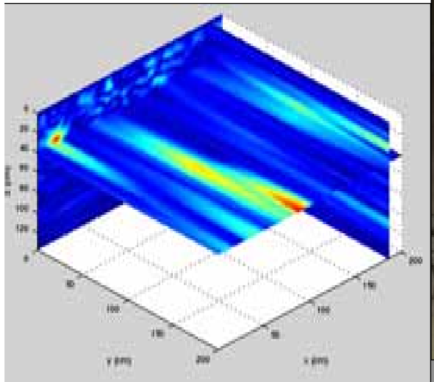
Initially, flat jack tests were planned in order to evaluate its mechanic behaviour but the radar tests seem to detect local strong energetic reflection inside the wall section.

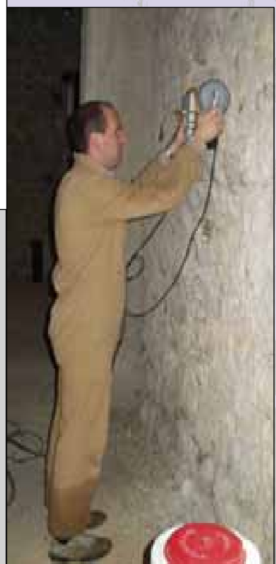


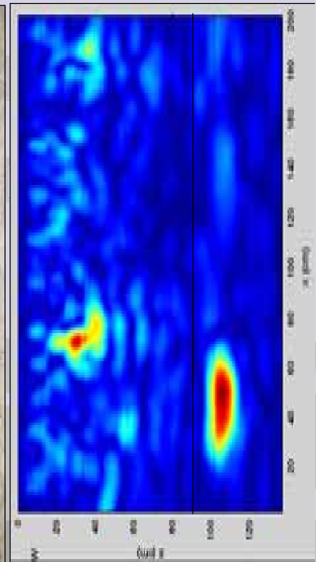




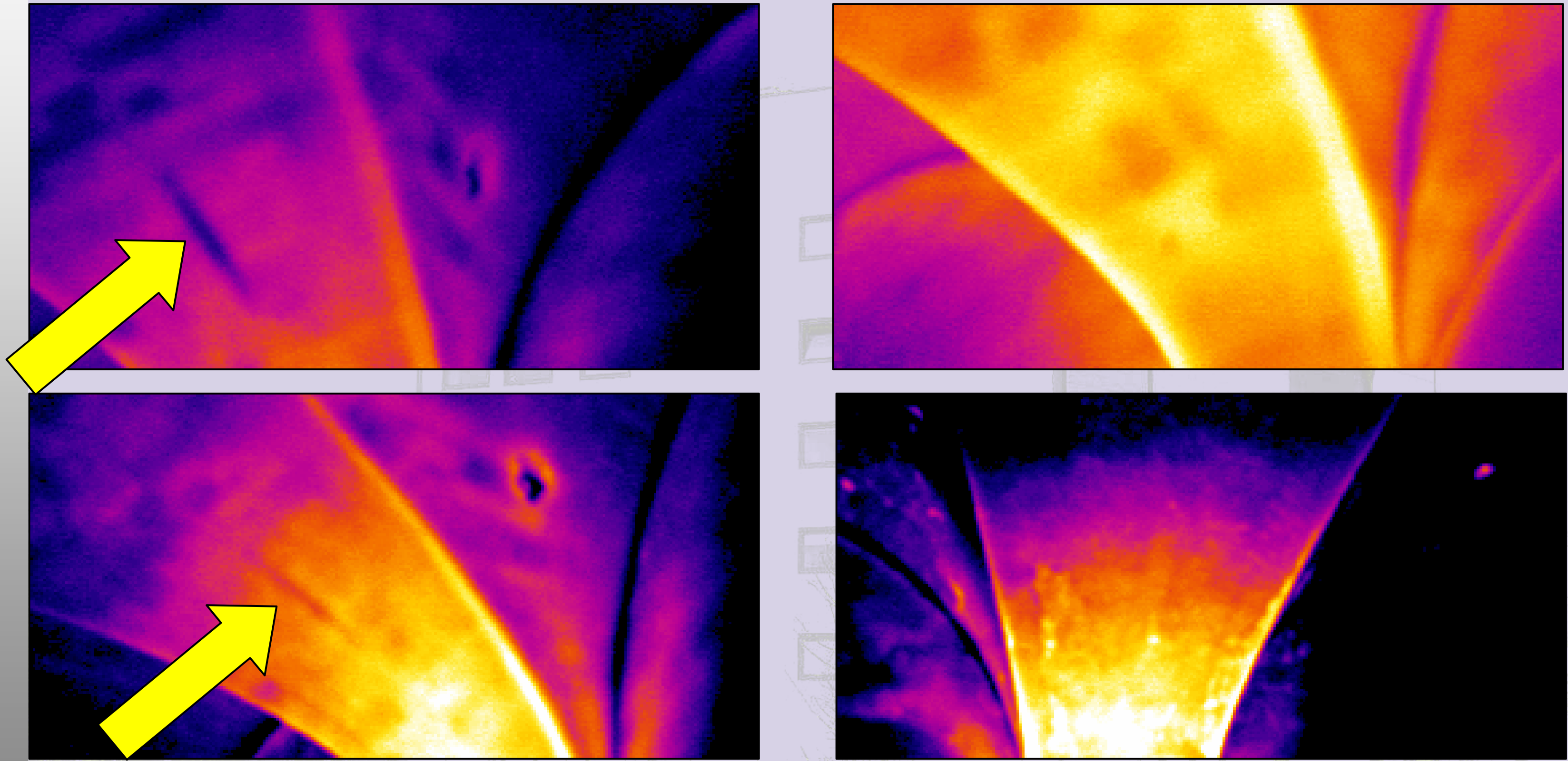




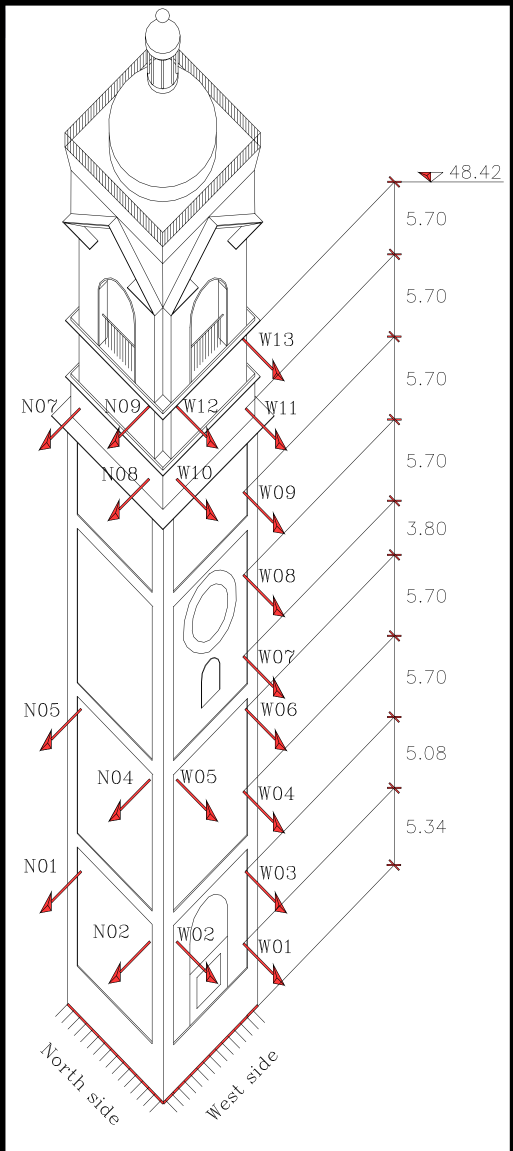


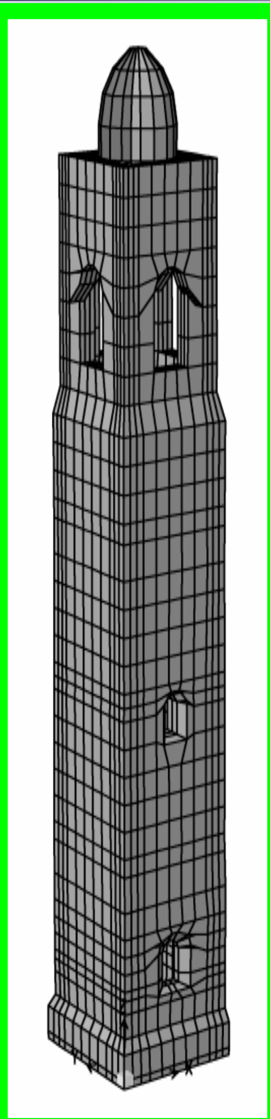


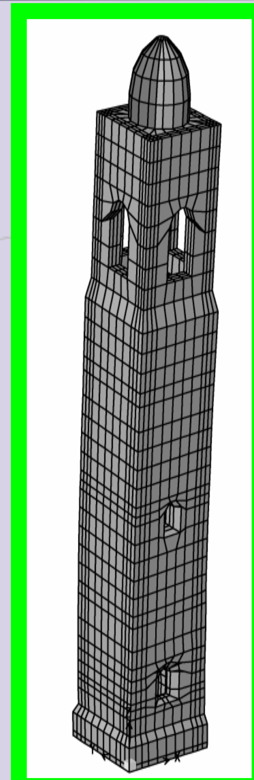
The 3D reconstructions, processing 3 and 6 sections acquired every 1 m, empathise this presence. This could suggest the presence of a local void due to the energetic reflection.



Dynamic in situ testing

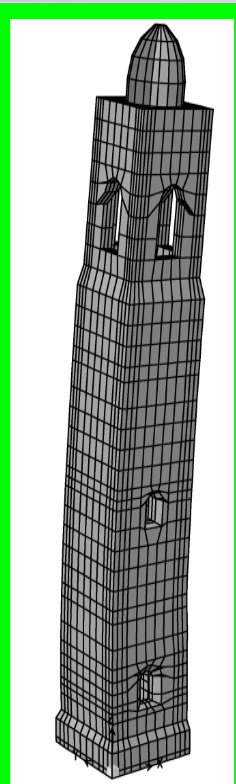






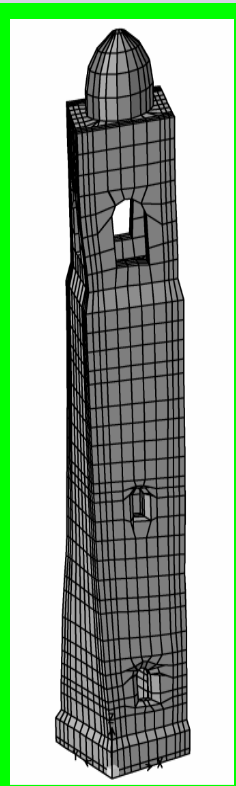
f_{FEM} = 0.585 Hz

f_{EXP} = 0.586 Hz



f_{FEM} = 0.709 Hz

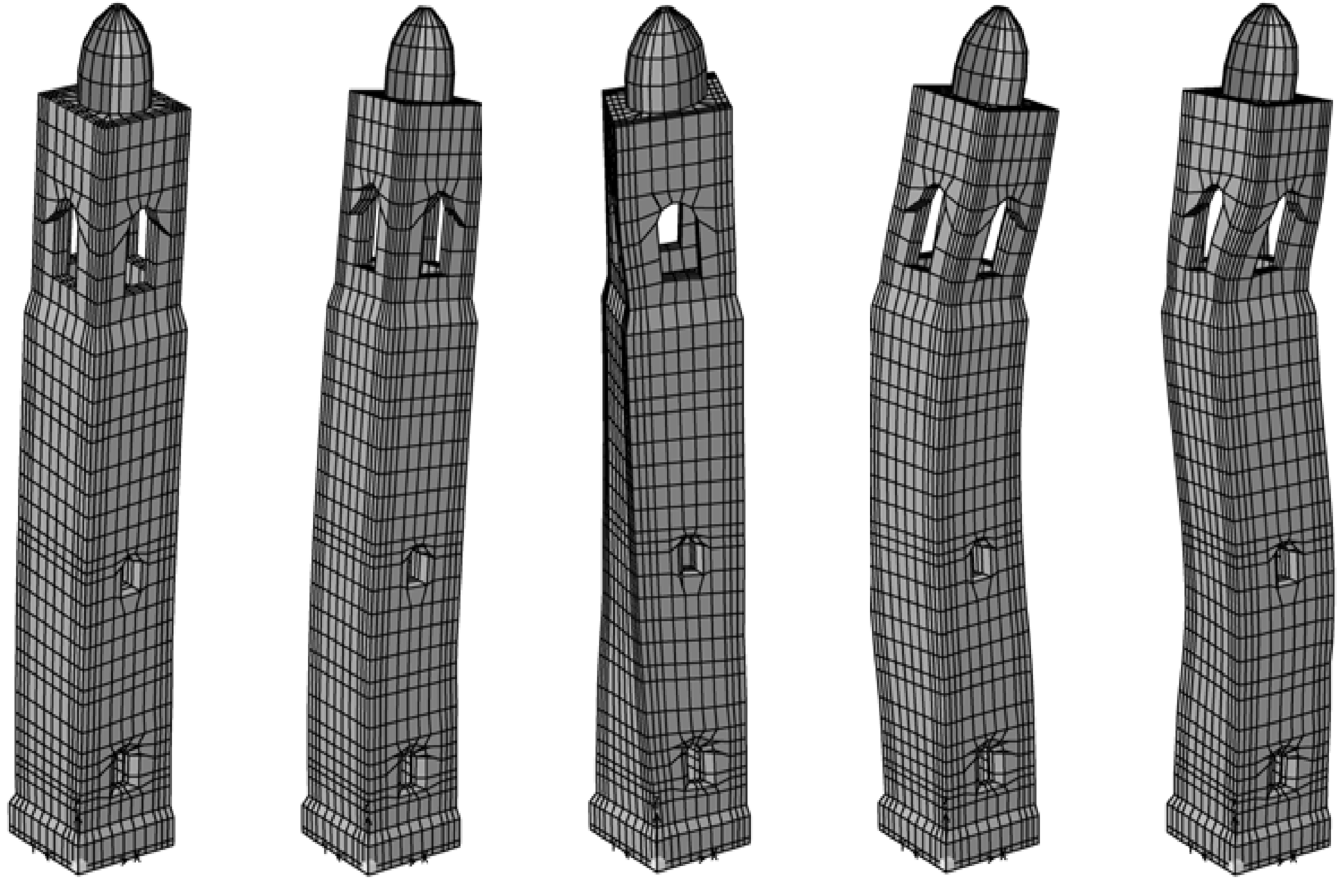
f_{EXP} = 0.708 Hz



f_{FEM} = 2.455 Hz

f_{EXP} = 2.456 Hz

Modeling and assessment



$f_{FEM} = 0.585$ Hz $f_{FEM} = 0.709$ Hz $f_{FEM} = 2.455$ Hz $f_{FEM} = 2.726$ Hz $f_{FEM} = 5.698$ Hz

$f_{EMA} = 0.586$ Hz $f_{EMA} = 0.708$ Hz $f_{EMA} = 2.456$ Hz $f_{EMA} = 2.731$ Hz $f_{EMA} = 5.706$ Hz

Second phase: Mobil Unit implementation

- Design and construction of the mobile unit, implementation of required apparatus for experimental testing chosen after the previous review will be implemented on board of a vehicle, hardware (workstations and servers), software (data processing, database, linear and non linear f.e. computer codes, etc.) and wireless connections with Central Unit and with the operative team (wireless terminals will be used for in field data acquisition, PDAs of tablet PCs for instance) will be also developed. MU and CU will be linked using satellite connection or other technologies which can guarantee comparable velocity and robustness in emergency period, while advanced Bluetooth technology can be adopted for connection between external terminals and severs of the MU.

- The mobile unit consists of an equipped vehicle (van or small truck with higher specifications) with suitable dimension and power to transport on the site where the seismic event has occurred instrumentation, transducers and digital acquisition to perform experimental investigation. Suitable ergonomics and user interfaces to ensure high productivity and simple usage under these difficult working conditions will be also studies into the project framework

- Once a stable version of the MU will be accomplished a user evaluation will be conducted to test the usability of the developed solution in a comprehensive real-life scenario. This will be based on performance metrics determined in Task 1. Depending on the type of evaluation, the evaluations will be carried out in conjunction with the CU (that is with Task 4.3).

Central Unit – Coordination, advanced analysis facilities, satellite communication, experts panel

Mobile Unit – Equipment storage, analysis and modelling, satellite communication and wireless connection

Field Units – data collection, experimental test, wireless connetion

Third phase: Control Unit implementation

- In the activities will be concentrated on the design of the central unit (CU) with functions of coordination, repository and wireless hub for connection with on line experts in remote laboratory or institutions..
- Requirements elicitation in terms of informational aggregation, visualizations, analysis functions etc. for the data received from the MUs will be conducted with the end-users of CU. The resulting concept for the CU system will be explored and validated by way of appropriate prototyping techniques.
- Again, following an iterative and participatory development process, the CU concept will be implemented. Particular attention will be paid to usability in the face of high data volumes, difficult prioritization decisions and conflicting goals. Once a stable version of the CU has been accomplished a user evaluation will be conducted to test the usability of the developed solution in a comprehensive real-life scenario. This will be based on performance metrics determined in Task 1.
- Based on the requirements determined in the previous tasks, an appropriate commercially available communication solution (e.g. satellite dish) will be selected and integrated with the MU and CU. On the application level, services will be implemented such that they can function under relatively low-bandwidth and possibly intermittent connections.
- Besides the technical means for communication, human factors are as important for effective communication. This was very evident in the communication among the different agencies involved in the response to the events of 9/11. In this task we will therefore also investigate the human factors of effective communication between MUs and CUs and how they have to be reflected in the design of services and user interfaces

Fourth phase: harmonisation and training

- That harmonization will propose a common methodology and a common form for post-earthquake safety and damage assessment. Moreover we will constitute a ***Trained European Task Force*** for damage assessment and a repository for damage data.
- The main methods used during these proposal are briefly pointed out:
- 1.Critical review of experimental methods integrated to numerical assessment techniques should determine reliability, sensitivity and robustness when applied to real cases and particularly in emergency conditions.
- 2.The mobile unit development should consider the implementation of compact tool for experimental investigation, numerical analysis, data transmission to allow remote data base access and support of experts
- 3. One Exercise in order to assess the MU performance and the usability of the operative guidelines, will be organized.
- 4. One course for technicians to be involved in these coordinated action will also be organized.
- 5. Two workshops showing the obtained results to all the EU Civil protection Departments is foreseen.

Expected results

- 1. Critical review of experimental techniques for damage detection and vulnerability assessment.
- 2. Implementation of a software package for integration of experimental and analytical results and rapid seismic vulnerability assessment.
- 3. Development of one Mobile Unit prototype to be used both for pre and post earthquake fast assessment
- 4. Development of a Coordination Unit, techniques and protocol for use in emergency conditions
- 5. Guidelines and proposal for European standardisation of emergency actions
- Training of Civil Protection teams for use of the system in this action
- Use of implemented tools both in pre and post emergency to increase the seimic risk knoloedge

STEP – Project tasks and task leaders

- *Task 1: Experimental and numerical techniques for fast assessment (Task Leader LNEC)*
- *Task 2: Mobile Unit (MU) design and development (Task Leader EUCENTRE)*
- *Task 3: Technical assessment and communication support (Task Leader Fraunhofer)*
- *Task 4: Central Communication Unit development (Task Leader P DCP)*
- *Task 5: Harmonisation of national procedures on post-earthquake damage assessment (Task Leader I DCP)*
- *Task 6: Dissemination (Task Leader Fr DCP)*
- *Task 7: Management and reporting to the EC (Task Leader EUCENTRE)*

Activities development

Task	Action	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	1.1	■	■	■	■	■	■																		
	1.2	■	■	■	■	■	■																		
	1.3	■	■	■	■	■	■	■	■	■															
2	2.1							■	■	■	■	■													
	2.2									■	■	■	■	■	■	■	■	■	■						
	2.3																■	■	■	■	■	■	■		
3	3.1							■	■	■	■	■													
	3.2							■	■	■	■	■	■	■	■	■									
	3.3													■	■	■	■	■	■	■	■				
4	4.1	■	■	■																					
	4.2				■	■	■	■	■	■	■														
	4.3											■	■	■	■	■	■	■	■						
5	5.1	■	■	■	■																				
	5.2				■	■	■	■	■	■	■														
	5.3							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	5.4																						■	■	■
6	6	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
7	7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Financial details

	Personel	Travel	Equipment	Other	Overheads	Total Costs	Requested to EC	Cofinanced
Beneficiary EUCENTRE	€ 471 840.61	€ 55 600.00	€ 215 175.00	€ 134 000.00	€ 55 734.39	€ 932 350	€ 747 280	€ 185 070.00
Partner 1 LNEC	€ 208 452.78	€ 10 400.00			€ 13 647.22	€ 232 500	€ 186 000	€ 46 500.00
Partner 2 Fraunhofer	€ 207 970.33	€ 21 500.00	€ 30 000.00	€ 20 900.00	€ 20 129.51	€ 300 500	€ 238 500	€ 61 500.00
Partner 3 I DPC	€ 79 548.39	€ 125 200.00		€ 20 000.00	€ 14 001.61	€ 238 750	€ 191 000	€ 47 750.00
Partner 4 P DPC	€ 36 663.59	€ 10 400.00			€ 2 936.41	€ 50 000	€ 40 000	€ 10 000.00
Partner 5 F DPC	€ 28 907.83	€ 52 600.00		€ 12 600.00	€ 5 892.17	€ 100 000	€ 80 000	€ 20 000.00
	€ 1 033 383.54	***€ 275 700.00***	***€ 245 175.00***	***€ 187 500.00***	***€ 112 341.31***	***€ 1 854 100***	***€ 1 483 280***	***€ 370 820.00***