June 2013

SMARTBUILT

Newsletter#3

Univ. of Salento welcome / Project progress and News / Partners brief presentation

S.M.ART. BUIL.T WELCOME MESSAGE

from Partner 5, University of Salento, Italy

I'm really glad that me personally, as well as my host Institution - University of Salento - has been involved as a partner in the S.M.ART. BUIL.T. project.

It is demonstrating not only an important opportunity to realize a multidisciplinary research that requests knowledge of informatics, electronics, mechanical and civil engineering and knowledge of arts and history but also an important experience for creating human and collaborative relations with the others people involved. Every technical meeting or committee between all the partners is becoming an interesting moment of comparison of people of different countries (Italy and Greece) and of different type of institutions (Universities, Municipalities and Regional Direction); different mentalities and professionalisms are shared for overcoming all the difficulties that crops up inevitability in the various phases of the project.

We are all giving our best care and attention to complete the project activities and I hope that, once concluded successfully this experience, it could remain as a happy memory for all of us.

European Territorial Cooperation Programme
Greece - Italy
2007-2013
INVESTING IN OUR FUTURE
Co-funded by the European Union (ERDF) and by National Funds of Greece & Italy

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Structural Monitoring of ARTistic and historical BUILding Testimonies (S.M.ART. BUIL.T.)

S.M.ART. BUIL.T. PROGRESS

A Progress Report from Partner P5 - MIBAC

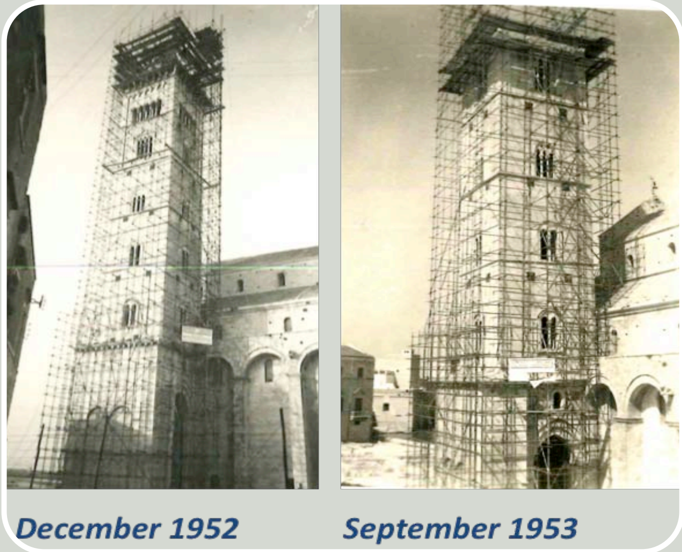
Within the project "S.M.ART. BUIL.T." the Regional Direction for Cultural Heritage and Landscape of Apulia region, among others, took office to conduct an analysis of Trani's seismic history and specifically to analyze the two Italian case studies chosen for structural monitoring. We studied the urban evolution of the old city of Trani, its seismic history and in particular we've done a philological research on two case studies (Bell tower of the Cathedral and the Castle Clock Tower) on which has been done an experimental structural health monitoring own of the project, in order to prove first the necessity of a well-founded knowledge of places and historic buildings and, in particular, the importance of the choice of the restoration when deciding to act in terms of seismic safety. The analysis of the history of urban development in the old town of Trani, the major earthquakes that have affected it and the study of the two case studies and restorations they have suffered, was necessary to establish how treat them, as preliminary phase of the structural monitoring foreseen in the project. Even if Trani is in a low seismic hazard zone, we didn't fount too much material regarding earthquakes: the lack of information regarding historical earthquakes is due for the older and intense ones to a possible lack of cataloging or however small literature, while for the most recent, given the low intensity, we can easily think of non-destructive effects on Trani's buildings, or at least not destructive enough to find again in the documentation tracks down to us.

The earthquake is an event foreign to the culture of many nations (eg. France, Germany, England, Scandinavia, the United States are exempt or almost) and is instead inherent in many other areas, including ours, from Sicily to the North East, an event which our culture has answered building over the centuries with technical strategies whenever diversified according to the material resources of the building tradition, cultural tradition, in a way that profoundly marks the building traditions of our country, to be a significant of the more interesting components. That's why our research pointed also to discover constructive and restoration techniques used for the most important monuments in Trani. Our cities have suffered almost all of the "crisis of growth" of the late medieval and Renaissance, which has weakened the buildings' bone, especially residential, irretrievably. From the fifteenth century onwards, when someone intervened, they went though repairing so less and less rational and often poorly, thus leaving the structures to weaken almost exponentially. The towns and villages that by the end of the eighteenth century are gone then impoverished have not had the opportunity to build or rebuild their structures in a workmanlike manner. At the dawn of the new millennium, moreover, it can be argued, not without knowledge of the facts and based on the experience of the effects of the first modern restoration of the 70s and the resulting seismic Italian law of 1987 (which, however, has suffered and continues fortunately to be changed, not least that of 2008), which focus only on equipment "innovative" for excellence and safety (reinforced concrete, epoxy resins, carbon fibers, etc..) does not always led the expected results. Recent studies of the CNR, the Manuals of recovery and huge amount of technique literature, leave something to be understood that in fact most often excellence and safety are found in the methods and oldest techniques that unlike the reinforced concrete, for example, are effected by additional degradation processes like the corbonatation of irons due to their surface installation, not to mention the difficulty that when it is decided to work on a historical building, meet in the management of heterogeneous materials. Studies conducted by the National Seismic Survey in the immediate aftermath of the earthquake of '97 (earthquake of Umbria and Marche regions) have found that the most frequent categories of damages in the territories affected by natural disasters derived from the intrinsic poverty of ancient buildings, repaired with old media poor and not repaired recently, or from a not well adapted application of the legislation of 1987 which prompted local professionals to cover with roofs of reinforced concrete two-storey houses made of stone slabs or creating stuck in curbs, at least two thirds of the thickness, in existing walls. The results after the earthquake are roofs displaced for more than a meter from perimeter that were intended to cover, floors that have "punched" and broke down the walls of poor context within which they were embedded and in general a strong discrepancy between the stiffness and heaviness of modern interventions and weakness, fragility, disconnection of the context in which they were placed. Our studies on restoration history, in particular regarding Trani Castle's Bell tower, confirm this thesis.

Progress Report #1 - MIBAC

MIBAC Progress Report *(cont'd)*

Intervene on historical monuments in itself is a complex operation, which often causes problems and difficult questions involving operators at a level not only professional, in the belief that the correctness of the proposals and actions depends on the actual maintenance and enhancement of the heritage subject on which intervene. However, in order to properly repair the historical buildings, especially if the intent is to protect them from earthquakes, it is necessary, therefore, to know exactly and to investigate not only their facilities, materials and their history of course, but above all it is important to be informed about construction techniques used, so as to choose the most appropriate conservation and seismic prevent work to be carried out. The aim of our work was also to set and show a philological method, useful also for the future and for different situations, to be applied when professionals want to approach to monuments in view of seismic monitoring or reinforcing, focusing the attention not only on restoring operation in itself, but also on the preventive and complete knowledge of the buildings, mostly the Historical ones, which is necessary before intervene.



The Bell Tower of Trani Cathedral dissembled for the restoration interventions made between the 1953 and the 1958

S.M.ART. BUIL.T. INTERNATIONAL CONFERENCE

First Official Announcement

In order to circulate and diffuse the information produced through the project progress as much as possible, a number of seminars and workshops have been already organized both in Italy and in Corfu. These actions were dedicated to the dissemination of the knowledge and the results produced, in order to enhance the diffusion of knowledge and information, as well as to advertise the results achieved step-by-step by the project consortium. The target audience was mainly experts, such as professional architects and engineers, building officials, educators, researchers, students, masonry construction professionals, and everyone else who might be interested in the art and science of masonry historical buildings.

The International Conference on "DYNAMIC IDENTIFICATION AND MODEL UPDATING OF HISTORICAL BUILDINGS" will be the final part of the diffusion activities of the S.M.ART.BUIL.T. project, in an attempt to extend the above scientific activity to the worldwide active research community that is focusing on the project topics of interest. Thus, the international conference target audience includes all experts in seismic and structural monitoring, as well as in historical and artistic heritage fields, in order to exchange experience of correlated research areas. The ultimate purpose is to make the conference a forum for dissemination of the latest scientific and technical developments and for exchange of new ideas in emerging topics of the S.M.ART. BUIL.T. project.

The international conference is planned to be held at the beginning of April 2014 in the city of Bari, Italy. Invited lectures on specific topics strictly related with the major research issues will alternate with presentations of high-quality papers on several fields of general interest.

The main topics of the conference are divided (but not limited to) into three areas:

HISTORICAL AND ARTISTIC AREA

- Typological and morphological characters of historical centres
- Historical aspects and general methodology of historical centres
- Conservation and restoration of historical buildings

COMPUTATIONAL AND TECHNOLOGICAL AREA

- Sensor-based monitoring infrastructures on historical buildings
- Ambient vibration testing for structural monitoring
- Mathematical modeling for early vulnerability assessment

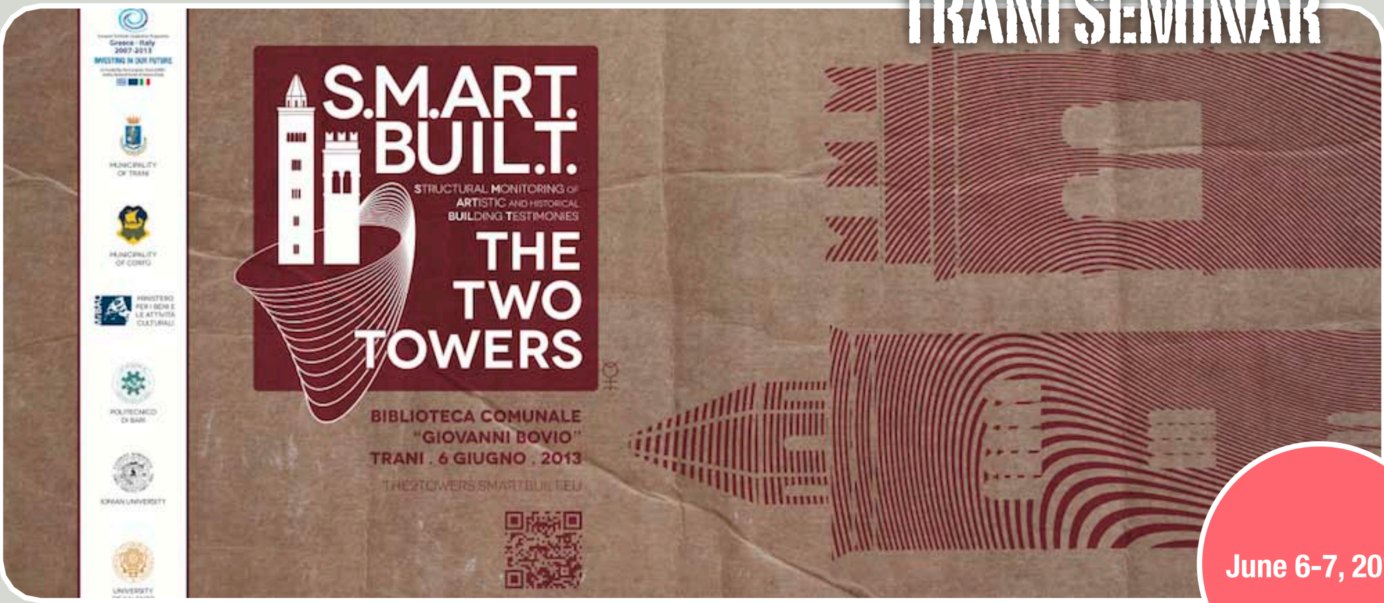
STRUCTURAL AREA

- Dynamic identification & structural monitoring of historical buildings
- Analytical and numerical approaches
- Seismic analysis and vulnerability assessment
- Case studies

Full details about the conference will be available soon through the S.M.ART. BUIL.T. web site, as well as the call for papers that will be issued.

S.M.ART. BUIL.T. Project web site is on-line!

You may visit http://www.smartbuilt.eu for a full project description and up-to-date news



June 6-7, 2013

The Two Towers - A S.M.ART. BUIL.T. Project Seminar

The "Two Towers" Seminar was held in Trani, Italy, on June 6-7, 2013. S.M.ART. BUIL.T. partners representatives participated in a high-quality scientific action, giving presentations and exchanging ideas and thoughts in various aspects that are related to the project.

More specifically, Mrs Tatiana Bianca (MIBAC) gave the first lecture on the results of the research on the old town's evolution and seismic history of the city of Trani. Next, Mr. Francesco Tucci presented the experimental tests and FEM modeling updates for the Bell Cathedral of Trani. Dr. Nicola Ivan Giannoccaro (University of Salento) talked about the dynamic identification and modeling of the Annunziata tower, followed by Francesco Paparella that provided an interpretation of a stochastic signal for monitoring and collecting data. Last but not least, Dr. Panayiotis Vlamos from Ionian University concluded the seminar with a talk on sensor network, data collection and modeling.

S.M.ART. BUIL.T. PROGRESS

Partner P5 - University of Salento

Progress Report #2 - Univ. Salento

The activities of the University of Salento in the period January-June 2013 have been numerous and really important in the development of the project. The most important will be here introduced and described.

Data analysis from Trani Cathedral

The analysis of the data obtained through the measurements of the Trani Cathedral bell tower and construction of a validated model.was conducted in collaboration with the LP.

The structural identification of the bell tower of the Cathedral of Trani has been carried out by means of the techniques of the OMA (Operational Modal Analysis). The OMA methods, based on output-only measured data, used are: the EFDD (Enhanced Frequency Domain Decomposition) that operates in the frequency domain, and the SSI (Stochastic Subspace Identification) technique that operates in the time domain. In the examined case, the extraction of the modal parameters from ambient vibration data was carried out using Artemis Extractor software (Artemis).

The frequency values estimated by means of these techniques are summarized in Table 1, together with the average values and the standard deviation evaluated for the all the examined tests for each procedure. Figure 1 also shows the first two frequencies mode shapes for one of the test. It can be easily observed that the first two modes correspond to the first flexural mode along the z and x axis and that the first two frequency values are quite close due to the symmetry of the tower section.

The experimental investigation was supported by the development of a 3D finite element model. The tower was modeled using 197073 brick elements that represent the outer surfaces of the wall and its reinforced concrete core, assuming a perfect adherence between these materials. Moreover, 350 spring elements, were added to take into account the interaction between the tower and the church. In addition to the mass of the brick elements, four lamped masses (of 4000 kg each) were considered at the corners of the 4th belfry that are representative of the bells mass.

The model was updated minimizing the differences between theoretical and experimental identified natural frequencies (the average value of all the tests); the strategy used for updating the unknown parameters is the well-known Inverse Eigen-Sensitivity.

The comparison of the experimental data with the updated FE model is shown in Table 2, in which the first five estimated experimental frequencies, the first five frequencies of the updated model, the percentage error and the MAC coefficients are shown. It is possible to note that the model natural frequencies are very close to the experimental ones and the correlation (MAC) between mode shapes shows very good agreement for the bending mode shapes (excellent agreement for the first two modes).

Table 1

Mode	EFDD		SSI	
	f [Hz]	σ	f [Hz]	σ
1	2.04	0.004	2.03	0.002
2	2.26	0.012	2.28	0.013
3	7.03	0.020	7.07	0.112
4	7.60	0.024	7.68	0.088
5	9.16	0.173	8.94	0.064

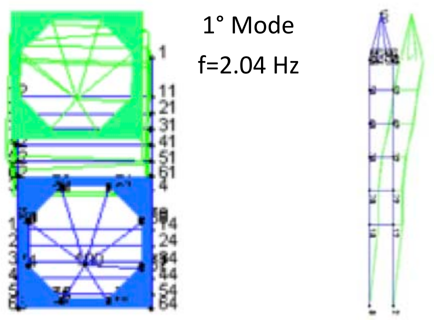
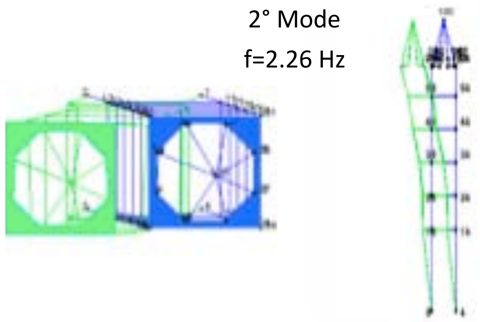


Table 2

Frequency number	Theoretical frequency [Hz]]	Experimental frequency [Hz]	Percentage error [%]	MAC[%]
1	2.0355	2.0365	0.06	97.6
2	2.2452	2.2458	0.02	95.8
3	7.0555	7.0589	0.04	10.6
4	7.6155	7.6184	0.03	14.8
5	9.2460	9.2466	0.006	34.0



A complete scientific relation about this activity will appear on the paper 'Dynamic identification and finite model updating of Trani cathedral's bell tower', authors M. Diaferio, D.Foti, N.I. Giannoccaro, F. Tucci that will be published on the Proceedings of the 4th International Conference on integrity, reliability & failure tha will be held in Madeira (Portugal), 23th-27th June 2013.

Data analysis from Announziata Tower in Corfu

The analysis of the experimental results was performed. A specific software (ARTeMIS) was used for the extraction of the modal parameters from ambient vibration data. A preliminary analysis was conducted on the time series of the accelerometers for evaluating the effects of the urban traffic and the functionality of the accelerometers considering the difficult environmental conditions. The preliminary analysis permitted to individuate as not properly running some accelerometers.

A statistical based analysis of the tests using the classical methods of the operational modal analysis (OMA) has permitted to identify the frequencies of the building and the modal shapes with an extreme repeatability for all the tests.

Two different OMA methods were used for each analysis (Artemis, 2012): the Enhanced Frequency Domain Decomposition (EFDD) in the frequency domain and the Stochastic Subspace Identification (SSI) using Unweigthed Principal Components (UPC) in the time domain. The estimated frequencies with the two methods for three different tests named a, b, c are reported in Table 3. The extreme repeatability of the first six estimated frequency is evident from the Table.

The first and second frequency were identified as the first couple of flexional modes directed respectively on the x and y axis. A graphic of the first two experimental identified mode shapes is shown in the figure laying on this page for the test a, considering the SSI method.

The finite element (FE) model of the Announziata tower has been realized considering the plant as perfectly squared (length 3.5 m). The model has two typologies of elements: the 'frame' and the 'shell'. The frame, prismatic linear elements, have been used for structural components such as the stone columns supporting the bell tower openings and the bells supporting framework and they assume the corresponding materials properties. The shell elements have been used for modeling the masonry walls, such as the vertical walls; for the vaults caps specific shell elements with 4 nodes have been used for combining the membrane behavior with that of a flexible plate.

An adequate mesh was created in such a way to model the real behavior of the structural elements. The preliminary mesh was composed by 362 shell elements and 10 frames for a total of 404 nodes. In order to increase the reliability of the numerical model, the mesh was refined dividing opportunely the starting elements (the thickened model has 10541 elements and 10668 nodes)..

The parameters selected for the model updating procedure are the stiffness k of the springs, the Young's modulus Ei and the densities pi of the different materials. The strategy used for updating the unknown parameters is the Inverse Eigen-Sensitivity.

The comparison of the experimental data with the updated FE model is shown in Table 4, where the first six estimated experimental frequencies, the first six frequencies of the updated model, the percentage error and the MAC coefficients between theoretical and experimental frequencies are shown. It is possible to note that the model natural frequencies are very close to the experimental ones and the correlation (MAC) between mode shapes shows a good agreement especially for the bending mode shapes.

A complete scientific relation about this activity will appear on the paper 'Non-destructive characterization and dynamic identification of an historical be tower', authors A. Carone, D.Foti, N.I. Giannoccaro, R. Nobile that will be published on the Proceedings of the 4th International Conference on integrity, reliability & failure that will be held in Madeira (Portugal), 23th-27th June 2013.

Table 4

Frequency number	Theoretical frequency [Hz]]	Experimental frequency [Hz]	Percentage error [%]	MAC[%]
1	2.6541	2.6332	0.79	56.5
2	2.7884	2.8309	-1.50	39.3
3	5.5677	5.5721	1.12	6.5
4	6.8895	7.0265	-1.95	10.4
5	8.1261	8.0241	1.27	26.8
6	11.826	11.272	4.92	26.6

Table 3

Frequency [Hz]	EFDD test a	SSI test a	EFDD test b	SSI test b	EFDD test c	SSI test c
1°	2.62	2.621	2.639	2.639	2.624	2.639
2°	2.834	2.829	2.842	2.842	2.829	2.831
3°	5.495	5.517	5.526	5.526	5.539	5.554
4°	7.061	7.036	7.053	7.053	7.029	7.061
5°	8.035	8.034	8.058	8.058	8.106	8.036
6°	-	11.31	11.29	11.29	11.23	11.29

S.M.A.R.T.
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S.M.A.RT. BUIL.T. MEETINGS REPORT

Steering Committee

The Steering Committee regular meeting was held in Trani, on May 10th, 2013. During the meeting, an overall report of the progress from all partners was delivered, aiming to finalize the decisions regarding the project next tasks.

Meeting in Trani, May 10th, 2013

Comparison tests initiation

The meeting was hosted in Trani, aiming to initiate the comparison tests between the classical, fully wired monitoring sensor network system to the novel wireless one assembled by the dept. of Informatics- Ionian University. The comparison tests were held on the bell tower of the Cathedral of Trani.

UPCOMING PROJECT EVENTS	STEERING COMMITTEE MEETING	INTERNATIONAL WORKSHOP	INTERNATIONAL CONFERENCE
	S.M.ART. BUIL.T. Steering Committee Regular Meeting **Corfu, July 10, 2013**	“Sensor Networks for Effective Building Monitoring” **Corfu, July 9, 2013**	“Dynamic Identification and Model Updating of Historical Buildings”, **Bari, April 2014**

DEPT. OF INFORMATICS IONIAN UNIVERSITY

A S.M.ART. BUIL.T. project partner

The Department of Informatics of the Ionian University is a relatively new department founded in 2004. Its mission is to advance scientific and research activities relating to the design, use, applications and implications of information technology. The main focus is on novel applications in the areas of Information Systems and Humanistic Informatics. Information Systems are crucial in production, services and management in enterprises nowadays. Humanistic Informatics. On the other hand, addresses the need for education and research within the area of Informatics, consistently with the nature of the Ionian University.

The purpose of the Department of Informatics of the Ionian University is:

- To cultivate and promote the Science of Computing, focusing on the theory and the applications of Informatics in the areas of Humanistic Informatics as well as on the design, development, operation and management of Information Systems.

- To offer the latest knowledge and state-of-the-art support to the students, enabling them to engage in the study, research, and application of Informatics, and to appreciate its profound effect in administrative, social, and financial activities.

Students are following a four year course under the previously mentioned disciplines and they specialize at their areas of interest during the last year when a thesis submission is required to fullfil their studies.

A postgraduate course under the general title "Informatics" has been established since 2009 aiming to further specialize studies in the areas of Information Systems and Humanistic Informatics. It accepts students not only from informatics background but also from humanistic studies the purpose being to bring together students from informatics and other humanistic-oriented backgrounds.

visit:
di.ionio.gr

The Department of Informatics is engaged in leading research that spans the theoretical and applied. The department's research activities are orientated towards the development of novel applications in the research areas of Information Systems and Humanistic Informatics. Research is organized around the following thematic areas: Security-Cryptography, Biometrics, Internet copyright protection systems, Distributed Architecture of high performance computer systems, Real time embedded systems, Architecture of Systems with Advanced Computational Power, Development of computational applications for non-local, non-linear dynamic systems, Signal Processing, Development of computational applications for random systems, Development of computational applications for bio-systems, Computational grids, Artificial Intelligence - Genetic Algorithms, Wireless computer networks, ad hoc and mesh networks, Autonomous networks, performance analysis and scalability issues.

The role of the Department of Informatics (partner P6) in the S.M.A.R.T. BUILT Project is mainly to develop a wireless sensor network system measuring ambient vibrations in historical buildings. For this purpose accelerometers and acquisition point devices were supplied by the market and the team of the Department of Informatics was responsible to develop a wireless system distributedly synchronized in order to realize the overall system in a wireless manner. In addition, the obtained data are studied and analyzed to provide for observations regarding the idiosyncrasies of the considered buildings.

Ionian University

The Ionian University opened to students in 1985. It is situated in Corfu, an island with rich history and natural beauty. During the past twenty years, the University has shown remarkable growth and progress, with new academic departments and a staff of young scholars and skilful teachers.

Ionian University in numbers

- 3 Faculties
- 6 Departments
- 3 Departments with unique fields of study in Greece
- Teacher-to-student ratio in the range of 1:10
- Located in the city of Corfu, Greece

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DEPARTMENT OF INFORMATICS

Project Partners

MUNICIPALITY OF TRANI

MINISTERO PER I BENI E LE ATTIVITÀ CULTURALI

REGIONAL DIRECTION FOR THE CULTURAL AND LANDSCAPE HERITAGE OF PUGLIA

CORFU MUNICIPALITY
SOLE SHAREHOLDER COMPANY S.A.

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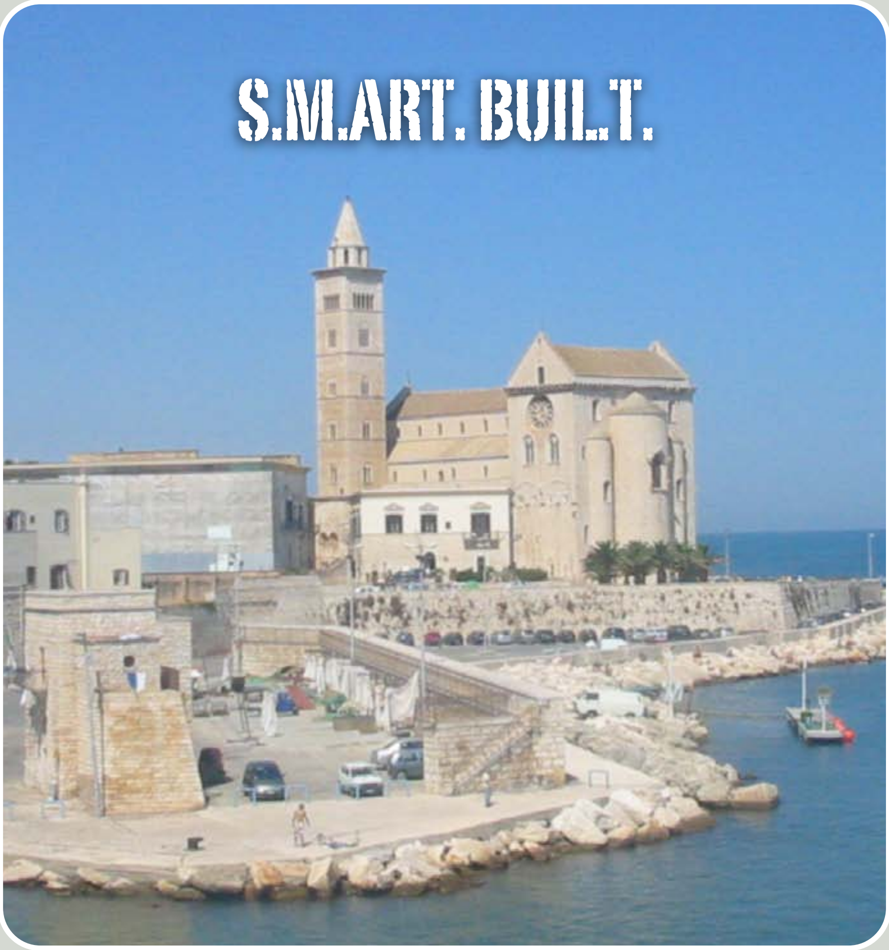

Structural Monitoring of ARTistic and historical BUILding Testimonies

About the newsletter

The S.M.ART.BUIL.T. NEWSLETTER is published every 4 months, conatining information about the progress and the outcomes of the project.

It is electronically distributed in portable document format (pdf). Printed copies can be supplied on demand.

For any additional information regarding this publication, you may contact the publication coordinator via e-mail, using the address smartbuilt.bari@gmail.com