Ten Projects
Horizon 2020 for Cultural Heritage
Pre-Kick Off Meeting

RESTORA
Project

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A.I.C. – Associazione Investire in Cultura

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B - TECHNICAL ANNEX

COVER PAGE

Title of Proposal: Restoration of damaged historical buildings

Acronym: RESTORA

List of Participants:

Participant No*	Participant organisation name	Country
1	X	X
2	Y	Y
3	Z	Z
4	W	W
5	K	K
6	K	K
7	K	K
8	K	K
9	K	K
10	S	S
11	L	L
12	A	A
13	O	O

Table of Contents

1 – Excellence

1.1 Objectives

1.2 - Relation to the work programme
1.3 -Concept and approach
1.4 - Ambition

2 - Impact
2.1 – Expected impacts
2.2 – Measures to maximize impact

3 - Implementation
3.1 – Work plan, work packages, deliverables and milestones
Table 3.1a: Work package WP1 description
Table 3.1a: Work package WP2 description
Table 3.1a: Work package WP3 description
Table 3.1a: Work package WP4 description
Table 3.1a: Work package WP5 description
Table 3.1b – List of Work packages
Table 3.1c – List of Deliverables

3.2 – Management structure and procedures
Table 3.2a – List of milestones
Table 3.2b – Critical risks for implementation

3.3 - Consortium as a whole

3.4 – Resources to be committed
Table 3.4a – Summary of staff effort
Table 3.4b – "Other direct cost" items

4 – Members of the Consortium
4.1 – Participants
4.2 – Third parties involved in the Project

5 – Ethics and Security
5.1 – Ethics
5.2 – Security

RESTORA - Buildings
Restoration of damaged historical buildings

1 – Excellence

1.1 – Objectives

This project deals with:
1 - Design and development of protectives
Suitable products will be prepared for an effective protective action against decay agents. These products will be developed by taking into account the supports they have to cover. The possibility to use traditional materials, already used in the past, will be carefully evaluated.
Furthermore photo catalytic products will be prepared and tested on different stone materials in order to verify their effectiveness as self-cleaning agents and the absence of damages on the surfaces.
2 - Biotic damage: characterization, treatment and protection
Particular attention will be devoted to autotrophic (algae, lichens, musk, bacteria, weeds, etc.) and heterotrophic organisms (fungi, insects, etc.). The different species and their danger will be established together with adequate methodologies of protection against the risk, and, in case of attack, the best way of treatment which, taking into account the nature of the assets, must be respectful both of them by not causing further damages and also of the people who will benefit from the work of art.
3 - Moisture in wall paintings.
As well known rising damp is a major cause of decay to masonry materials such as stone, brick, mortar and plaster. Rising damp occurs as result of capillary rise (suction) of water from the ground through the network of pores in the permeable masonry material. Accurate diagnosis of the cause and extent of the damp problem is a fundamental step in the case of conservation science of wall paintings. The porous mortar backing provides an easy route for the flow of diluted salt solutions. Salts contained in the mortar can be transported to the plaster underlying the painting. The volumetric expansion associated with the crystallization of these salts affects the plaster-pigment adhesion and leads to the disintegration of the surface. Such processes of leaching, transport, accumulation, solute concentration, precipitation, fractionation, and local concentration depend on the moisture content of the masonry which in turn is subject to seasonal variations in atmospheric humidity. For these reasons, before performing any restoration treatment the moisture distribution in a wall painting should be known.
The efficiency of products already used in the past will be checked in order to evaluate their possible reuse, also after a modification of their physico-chemical properties and/or of the application techniques.
Research and development of specific instruments and technologies for evaluating the effectiveness of the products by natural or artificial ageing processes.
Indication of techniques, methods, materials and protectives to be used in the conservation and in the scheduled clearing treatments to be executed on artifacts, after the intervention, also taking into account the environmental variations.
Development of guide methodologies for the preliminary analysis of the buildings, for the design and for the intervention of architectural restoration.
Preparation of stable protectives against sun or artificial-light. Setting up of a protocol for the conditions of lighting, aimed at reducing the photo decay action, with an acceptable availability of the work of art.
List of the main bio deteriogenic organisms for the different classes of goods and for the related danger, with the indication of the degree of possible damage, of the threshold of the intervention and of the more appropriate fighting for every typology.

RESTORA - Mobile

Restoration and conservation of mobile Cultural Heritage

1 - Excellence

The Objectives

Works of art consist of an extremely complex and variable set of objects and artifacts differing both historically and physically. Such works have been produced in different periods and geographical areas, and therefore within different cultural environments using different techniques. They have been retouched by the artist himself or modified and restored by others or, finally, altered by the elements over the centuries.

A deep analytical approach is therefore necessary to guarantee a correct interpretation, which is not only based on the evident morphology or the object under examination.

The analytical methodologies may be applied to a wide variety of works of art that include paintings, sculptures, metallic artifacts, potteries, paper, etc.

In addition to a series of analytical methods in chemistry, physics, mineralogy, petrography and geochemistry currently applied in the Cultural Heritage field, it is necessary to set up new specific methodologies suitably designed to aid in a correct way a reliable characterization of the material composition of works of art.

Another aspect of paramount importance, which affects subsequent investigations, concerns the sampling techniques. Indeed we like to consider in principle every sample extraction “invasive”, even though the modern technology can allow for microscopic sampling.

However, it is also necessary to keep in mind the relationship between the significance of the measurements and the completeness of the investigated (and therefore sampled) area.

From the above considerations it becomes necessary to develop analytical techniques and methodologies which are completely non-invasive or that minimize the need for micro samples, exploiting the complementary information from various sensors and detectors, designed to provide multiple information from the same sample.

Task 1 - Development and application of analytical methodologies for the knowledge of nature and structure of the works of art.

Task 2 - Development of nondestructive techniques

Task 3 - Set up mobile units: design and development of prototypes

Task 4 –Evaluation of damage: restoration and conservation of paper, parchment, etc.

Task 5 - Electronic restoration and retrieval of information on documents

RESTORA – Seismic risks

Seismic risks of historical buildings

1 - Excellence

The Objectives

Although many territories on Earth (Mediterranean Sea, Pacific islands, Central America) face seismic risk from the origin of civilization, events from the past seem to suggest that the ancient architects and builders gave not enough importance to earthquakes. But if one goes deeper into the matter, one can put into evidence the existence of brilliant seismic strategies in ancient buildings. These strategies were implemented through intuitive and simple solutions, like e.g. the symmetric distribution of the masses in plan, the proportions of walls and openings, which indeed never prevail over the aesthetical rules of old times. It is therefore important to investigate more deeply these solutions, which display in different manners in different geographical areas, but always share a great simplicity and sustainability.

Further, it will be important to translate the above ancient strategies into modern solutions, possibly adaptive to many building typologies. The economic and environmental sustainability of these strategies should be coupled with the architectonic feasibility of the intervention (i.e., obeying as much as possible the rules of reversibility), as compared to invasive and expensive modern solutions like base isolators and viscous or tuned mass dampers, which are normally very difficult to apply to the historical heritage buildings.

Synthetically, three categories of seismic strategies can be outlined in ancient buildings:

a) Seismic isolation

For instance in the Alhambra complex in Granada (XIV century A.C.), the columns in the patio of "Los Leones" contain thin lead plates in between the marble pieces, which allow a smoother load transmission through the disks and help to isolate the upper parts from the foundations.

b) Energy dissipation

The barracked houses, diffused throughout Europe during XVIII and XIX centuries, were normally made with limestone regular masonry walls with oblique timber beams embedded inside the masonry. The role of these timber beams was only partly that of an elastic reinforcement able to prevent crack opening, but mostly that of a dissipating mechanism. Thanks to the high friction coefficient between limestone blocks and timber beams, a relevant amount of shaking energy can be dissipated during seismic oscillations, optimizing the dynamical behavior of the bearing walls.

c***) Ductility***

Japanese pagodas, entirely made of timber, show many interesting anti-seismic solutions, ranging from the wing-shaped flooring system (which is itself very deformable thanks to the usage of cantilever beams), to the presence of the central tall mast. The latter, called shinbashira, is suspended like a pendulum from the top roof and simply supported on the soil below, obeys to the Buddhist mysticism and plays a fundamental role for energy absorption swinging freely backward and forward. The vertical loads are transmitted to the foundation through two orders of columns, and each floor is simply supported upon the lower one, leaving the freedom of relative horizontal movements. The result, under an earthquake or a hurricane, is a kind of "snake dance" of the pagoda, with high ductility and energy absorption capacity.

Protecting existing construction heritage from seismic risk is one of the most challenging tasks of the new millennium. Its basic concern is a mix of technological, economic and cultural issues at the same time. Safeguard of constructions from earthquake, in fact, would mean in first place protecting human beings from life-threatening situations, but also protecting valuable buildings from severe damage or even from destruction, and this has an indubitable economic sense. Such considerations help to understand the importance of the use of new technologies in the field of seismic rehabilitation. Innovative reversible technologies, indeed, ensure an increased safety level under

any load condition, with an overall cost comparable with or lower than the one required by traditional options.

1.2 – Relation to the Work programme

The work programme topic Restora relates to be decided because the proposal fulfils the Call requirements, ie.:

a) Call Specific Challenge:
b) Call Scope:
c) Call Expected impact:
d) Call Types of action:

Code 1 (to be written once all Work packages are ready)

1.3 – Concept and approach

Code 2 (to be written once all Work packages are ready)
(Describe the overall project starting from the activities of WP2, WP3, and WP4: their approach, methodology, etc. and any national or international research linked to this project).

1.4 Ambition

Code 3 (to be written once all Work packages are ready)
(Describe for the overall Project, i.e. for the activities reported in WP2, WP3, and WP4:
1 - the state-of-the-art
2 – the progress beyond the state-of-the-art
3 – the literature concerning the previous points)

2 – Impact

2.1 –Expected impacts

Code 4 (to be written once all Work packages are ready)
(Describe how a lasting impact of the Project will be ensured by the following strategic Project choices): ……..
(In particular, describe the following Project outcomes that will become available in a practical use): ……..

2.2 –Measures to maximize impact

Code 5 (to be written once all Work packages are ready)

a) Dissemination and exploitation of results
Preparation of a draft plan for dissemination of project results
All Partners will prepare items for publication (scientific papers, conference abstracts, website updates, etc.). Full details about how to publish Project results are outlined into the Consortium agreement.

b) Communication activities
All partners will describe, according to their opinion:
- Market impacts of the project
- Market size and potential
- Steps towards commercialization
- Necessity of a European approach

3 – Implementation

3.1 Work plan - work packages, deliverables and milestones

Code 6 (to be written once all Work packages are ready)

(Describe the overall Work Plan based on the activities of the five Work packages.)

Timing of the Work plan (Gantt chart)

Inter-relation of the components (Pert chart)

The following five Work Packages: WP1, WP2, WP3, WP4 and WP5 represent the structure of this Work plan

Table 3.1a: Work package WP1 description

Work package number 1		**Start Date or Starting Event**					
Work package title							
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

This WP guarantees that:

- an effective coordinating structure is created
- the research project is carried out according to the time schedule and budget established,
- meetings are organized to enable collaboration and management of consortium partners,
- the project progress of the WPs is managed and monitored against contractual deliverables,
- the WPs objectives are achieved efficiently,
- a system is created to provide a continuous evaluation feedback and a constant project monitoring.
- the project is managed according to the contract between the RESTORA consortium partners and the EC, maintaining a continuous link with the EC, and the overall legal, contractual, ethical, financial and administrative management activities are performed ensuring accurate and timely distribution of funds, reporting on activities, etc.).

Description of work

WP 1 is the Coordination Work Package, which will last for the whole duration of the project.

1 - Coordinator

The responsibility of the project coordination will be taken by …… who will supply the Project Coordinator. The project coordinator is responsible for all deliverables.

The coordinator's main activities concern the monitoring and management of the agreed deliverables and milestones in the contract between the consortium and the EC, and the smooth running of the project as a whole. The coordinator will maintain continuous relationships with the General Assembly including the Work Package leaders and will report to the EU. For the day-to-day project management, the Project Officer (PO) supports the coordinator. She/he will focus on the daily management, coordination and administrative and financial aspects of the project.

Coordinator activities:

a) Kick Off meeting.

Upon signature of the contract with the European Commission, the project coordinator will organize an initial kick-off meeting for all personnel involved in the project. This kick-off meeting will enable the participants to obtain a better perspective of their role in the RESTORA project. Prior to concluding the contract with the EC, a Consortium Agreement will be signed between the project partners

b) Process Management tasks.

The Project Coordinator will conduct the overall project management, as specified in the contract between the consortium and the EC, i.e.:

- Organize the project meetings, workshops, and receive reports;
- Oversee the drawing up and timely signing of the Consortium Agreement;
- Ensure that all parties will sign the contract with the EC on time;
- Initiate, prepare and preside over regular project progress meetings and the dissemination of information to all partners pertaining to these meetings;
- Act as liaison to the European Commission on behalf of the group in all verbal and written communication;
- Inform the Commission properly about the situation and progress of the work;
- Inform the Commission in advance of the date and subject of the meetings;
- Coordinate the overall financial, administrative and contractual activities of the project, including monitoring and maintaining the overall adherence to the financial budgets;
- Report the overall budgetary situation of the project to the EC, based on the cost declarations from the individual partners;
- Coordinate the dissemination of knowledge and deliverables.

3 - Operational project management

The consortium agreement and contract conditions with the EC will be monitored by the General Assembly to

ensure compliance by all participating parties.

For each work package, a WP leader has been appointed to take primary technical control of and responsibility for the proper management and execution of the tasks related to the particular WP. He/she establishes (in co- ordination with the Project Coordinator) the detailed schedule of his/her WP. He/she is also responsible for the quality of, and the correct and timely submission of deliverables relating to his/her WP. Each WP leader is also appointed to chair the meetings among the partners participating to his/her WP and will communicate frequently both formally and informally with the workers in the WP.

4- Monitoring:

a) Internal reporting

In order to monitor and guide the consortium, each individual partner will regularly (after the first four months and thereafter at four-monthly intervals) submit a progress report to the respective Work Package leaders. On the basis of these reports, the WP leaders will monitor progress and take any necessary action to ensure the work package remains on schedule.

Each WP leader is required to provide the PC regularly (after four months and thereafter at four monthly intervals) with a progress report concerning his/her WP and containing sufficient technical information to enable the PC to be assured that work is progressing according to plan.

The status of the project will be updated by the PC in a Project Dashboard that will highlight all key progress indicators of the project and areas at risk.

b) External reporting

The combined WP reports (task of the PC) will be discussed and evaluated during meetings of the General Assembly and will constitute the interim reports and form the basis for the annual and final reports that will be submitted to the European Commission by the PC.

Based on the EU model format the coordinator will ensure that all partners provide a consistent flow of information containing key points on the financial progress in the form of a financial report and associated financial plan, as well as an activity report and updated implementation plan.

c**) Internal communication**

A communication plan will be agreed upon by the General Assembly at the kick-off meeting and will define means and methodology of communication among the project partners.

5- Financial / administrative management

The Project Officer of …… will ensure that all budgetary actions are performed according to the rules and regulations of the EC and the consortium agreement. This includes amongst others establishing a good operating practice for financial management adapted to the financial system of each participating party, to ensure that the received funds are correctly distributed, accounted for, cost statements are received.

Deliverables

– ***Consortium Agreement.*** A Consortium Agreement will be concluded among the project partners.
– ***Kick-Off meeting minutes.***
– ***Meeting/workshop minutes.***
– ***General Assembly meeting minutes.***
– ***Internal website with public areas for communication and data sharing***
– ***Partners progress report.*** Each individual partner will regularly submit a progress report to the respective Work Package leaders in order to monitor progress and to ensure the work package remains on schedule.
– ***Work Package progress report.*** Each WP leader is required to provide the PC regularly with a WP progress report concerning his/her WP to enable the PC to be assured that work is progressing according to plan.
– ***Interim reports.*** The PC will combine the WP progress reports and will constitute the interim reports.
– ***Progress reports to the EC.*** Annually the PC will submit progress reports to the EC.
– ***Final report (technical, financial, deliverables).*** The PC will submit the final report to EC.

Table 3.1a: Work package WP2 description

Work package number 2		**Start Date or Starting Event**					
Work package title	**Design and development of protectives**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

Suitable products will be prepared for an effective protective action against decay agents. These products will be developed by taking into account the supports they have to cover. The possibility to use traditional materials, already used in the past, will be carefully evaluated.
Furthermore photo catalytic products will be prepared and tested on different stone materials in order to verify their effectiveness as self-cleaning agents and the absence of damages on the surfaces.

(Mosoarca)

1. Creation of a database with information on the historic buildings, characteristic for the historic zone;
2. Description of the degradations recorded by these types of buildings;
3. Cause analysis of the degradations of the historic buildings;
4. Proposal for solutions and techniques of consolidation of historic buildings
5. Development of a preliminary design guide for the interventions on damaged historic buildings.

(Mosoarca)

(Arroyo) Suitable products will be prepared for an effective protective action against decay agents. These products will be developed by taking into account the supports they have to cover. The possibility to use traditional materials, already used in the past, will be carefully evaluated.
Furthermore photo catalytic products will be prepared and tested on different stone materials in order to verify their effectiveness as self-cleaning agents and the absence of damages on the surfaces. **(Arroyo)**

(Stefanidou) During the last decades of the previous century, many research projects have been carried out and knowledge has been accumulated regarding monumental structures, historic stones, bricks and mortars, as well as repair materials and techniques on the benefit of the cost of restoration projects and on the protection of the authenticity of the monument. Therefore, during the last 20 years, a critical mass of knowledge has been accumulated.The protection of old authentic materials from external aggressive parameters is a topic which hasn't been successfully anticipated until now. The problems lie in the fact that the skin of each material possesses different properties concerning porosity, roughness, water absorption capacity, cohesiveness. The conservation of those materials requires materials compatible to those used during their creation or construction. But this is only one aspect. All buildings, monuments or works of art undergo in their life time several refurbishments. In many cases it is not documented which materials and substances were used in these steps. Many examples are well known in which the use of incompatible materials has caused additional new damage. Hundreds of different conservation materials are on the market. In some cases also extremely dangerous substances are in use. The development of new, advanced materials for conservation and restoration of cultural heritage assets has to take the environmental compatibility of the substances into account. Such aspects were neglected in the past in many cases. Also the characterisation of environment and health impacts of existing materials and techniques would enhance the safety both for restorers and the public.
Almost in every preventive intervention, repair materials are used. Their importance in protecting the authenticity of the built cultural testimony and mitigating the decay effects is essential.
A compatible repair material defined that which is in aesthetic harmonization with the old structure and does not disturb the behaviour of the original structure and at the same time is effective (adequate early strength is developed for the work progress) under the environmental conditions and resistant as much as possible to the mechanisms of deterioration.
The compatibility is mostly influenced by:
- Surface features (colour, texture, roughness)
- Composition (type of binder, granulometry of aggregate)
- Strength level (compressive, tensile)
- Elasticity (modulus of elasticity, deformability)
- Porosity (porosity, pore size distribution)
- Coefficient of thermal dilation

New materials and techniques for conservation include mainly consolidation agents and systems. The degraded materials can be characterized as systems of different needs for intervention the remedy of which cannot be typically accommodated with a single measure or agent, e.g. for material impregnation. Therefore, for development of advanced compatible materials and techniques a system approach combining various materials and technologies has been adopted in this project as a principle of optimization of a final marketed product.

Modified traditional materials and new materials and techniques which present effective long-lasting effects where the assessment of their applicability would be possible and there will be a combination of sustainability and also compatibility with the substrate. These innovative materials may also present self healing / self cleaning properties with improved resistance to degradation. Additionally, socio-economic benefits will be recorded as there will be new job positions
Nanoscale particle could modify the microstructure of materials so as the macrolevel properties and behaviour (such as porosity and strength) to be balanced or interfaces to be enhanced for the benefit of longevity of monumental heritage. The new materials, devices and systems of nanotechnology, are the much promising tools for the protection of the skin of the historical structures which suffered from the heavily polluted environment and climatic changes.
The production of materials either containing or treated with solutions enriched with nanoparticles is a challenge to explore in order to test their effectiveness on protecting the structures. The addition of nanoparticles (of different nature) either as additives or as a part of binders in structural mortars based on lime can be explored in order to test the durability of the mortars gained in salt loaded environment or in achieving durable materials capable to use in structures which are exhibited in aggressive environment (polluted). Nano- dimension particles can be applied in renders and plasters in order to improve the

absorption behaviour of these materials which consist the protective "skin" of the structure, blocking humidity from entering into the structure by modifying the structure of the material and the distribution of the pores without altering the tissue of the structure. **(Stefanidou)**

(Paladini 1) Photo physical and photochemical studies will be devoted to establish the possible decay effects on the artifacts and on the surface protectives in consequence of the frequency of the incident radiation light. In the architectural field, modes and effects of the color change of paintings and decorations will be investigated. **(Paladini 1)**

(Paladini 2) Suitable products will be prepared for an effective protective action against decay agents. These products will be developed by taking into account the supports they have to cover. The possibility to use traditional materials, already used in the past, will be carefully evaluated.
Furthermore photo catalytic products will be prepared and tested on different stone materials in order to verify their effectiveness as self-cleaning agents and the absence of damages on the surfaces. (Paladini 2)

(Smolik) Particular attention will be devoted to autotrophic (algae, lichens, musk, bacteria, weeds, etc.) and heterotrophic organisms (fungi, insects, etc.). The different species and their danger will be established together with adequate methodologies of protection against the risk, and, in case of attack, the best way of treatment which, taking into account the nature of the assets, must be respectful both of them by not causing further damages and also of the people who will benefit from the work of art.
The special attention will be paid to surface deposition of atmospheric Particulate Matter (PM) containing secondary inorganic (ammonium sulphate and nitrate) and organic compounds. Deposited particulate ammonia can be transformed by nitrifying bacteria to nitrite followed by oxidation of nitrite to nitrate. Both of the acids attack calcium carbonate and other materials. Deposited organic compounds can act as energy and carbon source for chemoorganothropic mickroorganisms (Fungi, Actionomycetes). Both microbiota have deteriorating effects caused by hyphae penetration leading to swelling and by production of acid metabolites with solubilising effect on many minerals (1,2). Further, they can grow epilithically on surfaces and cover areas that are the most valuable because sculptured or painted (2).
Recently, detailed characterization of indoor air quality was performed in the Baroque Library Hall of the National Library in Prague, Czech Republic. The Library, completed in 1726 is a part of a large historical complex of Baroque buildings Clementinum and holds approximately 20.000 theological books written in different languages dating from the 16th century until recent times. Apart from the collection, the Hall is decorated with frescoes illustrating themes such as science and art. The results revealed that the most of indoor air pollution comes from the outdoor environment with the largest contribution of the atmospheric particles composed of soot, organic matter and ammonium sulphate and nitrate. Due to thermal instability ammonium nitrate decomposed indoors producing gaseous ammonia and nitric acid (3,4). Remaining particles with soot organic matter and hygroscopic sulphate were deposited on all available surfaces (5). In 2010 revitalization of Clementinum has started and should last till 2015. Since, task is also improvement of climatic conditions indoors, the objective is to ascertain what is the effect of revitalization on indoor air quality and hence what is its impact on preventive preservation of library collections. **(Smolik)**

(Maravelaki)
1. Design and development of protectives
- Use traditional materials, already used in the past, will be carefully evaluated.
- Photo catalytic developed products will be tested on different stone materials in order to verify their effectiveness as self-cleaning agents and the absence of damages on the surfaces.
2. Assessment of the efficiency of products already used in the past in order to evaluate their possible reuse, also after a modification of their physico-chemical properties and/or of the application techniques.
3. Indication of techniques, methods, materials and protectives to be used in the conservation and in the scheduled clearing treatments to be executed on artifacts, after the intervention, also taking into account the environmental variations. Development of guide methodologies for the preliminary analysis of the buildings, for the design and for the intervention of architectural restoration.
4. Preparation of stable protectives against sun or artificial-light.
(Maravelaki)

(Macchioni) The RESTORA projects wants to be active on the restoration of damaged buildings, but is centred only on masonry and stones, while a building is comparable to an organism, thus is not only made of a single material but of a series of materials interconnected among them, in a continuous dialogue.
Wood and timber structures are an important, we can say basic, part of the European buildings, even in

Mediterranean countries where buildings are principally made out of stones and bricks. Nevertheless timber beams support a large part of floors and timber frames support almost all roofs. All those structures are an important part of human European culture, reflecting the knowledge of the past, even in hidden structures. Due to the loss of knowledge on historic timber structures, caused by the cultural domination of modern materials during the last decades, there is nowadays a frequent expertise demand for rare wood technologists, coming from structural engineers and architects.
Our first proposal is then to include timber structures within the project, disregarding the wooden decorations (such as claddings and parquet floorings) not because they are not important, but because they open a too large spectrum of possible activities (may be a proposal on wooden decorations of buildings?).
Then, in order to restore the damaged historical building we need to know the state of preservation of the structures: in Italy already does exist a standard (UNI 11119:2004) dealing with the on-site diagnosis of timber structures, but it need to be improved and applied in particular in Northern European countries, where other timber species and different climates interact with wood.
Indeed the standard is already applied without big problems in Southern European countries (such as Spain and Portugal). The aims of this kind of diagnosis are: the estimation of the residual strength of each structural member and of the residual real collaborating section (through NDT); the evaluation of the performances of the structural joints and the individuation of the origin and damages made by the possible biotic organisms that attack timber.
The study of the buildings include also the dating of the different parts, e.g. through dendrochronological studies. Within this specific topic first step of the work will be to find, retrieve, collect and organize samples of wood, such as logs or beams, that have different times of felling. The material in this first phase will be abundant as in later phases will be selected and part of it will be discarded. The species of the samples will be anatomically identified. The samples will be dated through dendrochronological analysis, measuring the variation of the tree rings and comparing them with reference chronologies. At this point there will be a selection of suitable material, homogenous in the species and abundant enough to have at least two samples for every 100 years from today back to 500 BC. Once selected the final study material, a series of physical and chemical analysis will be carried out and put in relation to their age.
On the already listed aspects a lot of work was already done by spotted research centres within each country, but it need to be interconnected and improved at European level (see also the results from the COST Actions IE0601 and FP1101).
Second step is the improvement and implementation of the existing structural restoration schemes, and their application tested in different environmental typologies.
Aspects to be investigated are the structural design, the design of the details to improve the durability (through the study of the environment around wood surfaces), the set-up of specific resins, the protection of wood surfaces against the biotic attacks (thus study of the damaging organisms and of the surfaces to be treated) through the development of protection strategies, to set up according to the organisms.
Examples of possible studies are the following:

- contribution in the development and characterization of various protective coatings (traditional and new products) to be applied on wood surfaces.
- Characterization of bio-materials before and after biotic damages.
- Evaluation of effectiveness of protecting products taking into account environmental variations.
- Analysis of the photodegradation of wood surfaces due to electromagnetic radiation.
- Studies on mechanisms and defending strategies against degrading agents acting on wood.
- Numerical analysis and in-field measurements of the water-wood relations in the historical objects including wall painting and other wooden artifacts.

Final aspect, but only from the logic succession point of view is the codification of a maintenance activity. On timber structures generally speaking a continuous and effective maintenance can avoid any future hard restoration interventions. Moreover any surveyor of timber structures knows that most of the present damages are due to bad conceived and bad made recent restoration interventions.
Thus the maintenance codification should be divided into two main branches: one working on the evaluation of the efficacy of a restoration intervention; the second branch should state the surveys to be made on a timber structures on which the restoration has been judged to be not useful.
The first activity is strictly based on the applied restoration methodology, taking into account the interaction between the existing structure and what have been applied on it through the restoration. The second one, on the opposite, is based on the results of the diagnostic survey that judged the reliability of the existing structure and, knowing the structure, the timber and the possible future damages (mostly biotic), states nature and timing of the controls. **(Macchioni)**

(Caridys) Preserving and restoring historic buildings is vital to understanding our nation's heritage. In addition, it is an environmentally responsible practice. By reusing existing buildings, historic preservation is essentially a recycling program of 'historic' proportions. Existing buildings can often be energy efficient through their use of good ventilation, durable materials, and spatial relationships. An immediate advantage of older buildings is that a building already exists; therefore energy is not necessary to demolish a building or create new building materials and the infrastructure may already be in place. Minor modifications can be made to adapt existing buildings to compatible new uses. Systems can be upgraded to meet modern building requirements and codes. This not only makes good economic sense, but preserves our legacy and is an inherently sustainable practice and an intrinsic component of whole building design.
It is a fact that preservation keeps our history and culture alive and we learn much from the methods and practices of those who came before us. With our threatened environment, it is imperative that we make sustainable living a part of our lives. The public benefits of both preservation and sustainability are very clear and there is no reason why these goals cannot work together. **(Caridys)**

(Fatta) In the historical buildings, especially in the monumental ones, the differentiation of solutions and construction techniques, related not only to cultural aspects but also to the availability of local materials, peculiar in that geographic areas, is currently one of the main problems to engage, comparing with the recovery and preservation of historical heritage. The issue is even more complex if it is referred to the surface high-value finishes, which in many cases contribute to characterize qualitatively the traditional architecture.
In order to design, develop and test protective products, in the light of the ineffectiveness or even damage produced by inaccurate and uncultivated interventions, which sometimes not take a careful account of the material and executive specimen of the original artificial stone plasters, the research aims to:
- design of guidelines useful to suggest a compatible and economically sustainable recovery of plaster and artificial stones finishes that characterize the historical building of the study area;
- evaluation of many protection products on the market, through laboratory tests that could allow a critical opinion about their efficacy and duration. **(Fatta)**

(Spyros Apostolos)

- Chemical characterization of products (traditional or novel) used for the restoration and protection of cultural heritage materials by NMR spectroscopy
- Estimation of chemical damage of cultural heritage materials prior to restoration and analysis of possible degradation products
- Follow up of the restoration procedure by chemical compositional analysis of both protectant and materials to-be-protected

(Spyros Apostolos)

Description of work

(Mosoarca)

Task 1. Creation of a database

Historic buildings are of many types: churches, residential houses, industrial buildings, archeological sites, arenas, etc. These buildings are not identically developed throughout Europe, and therefore regional databases must be implemented which should contain information on the most representative types of historic buildings. An online platform can be used in order to upload information on these types of buildings from every part of Europe if possible. Surveys will be made and historic data will be collected for the most representative buildings.

Task 2. Identification of the damage types

Damages of the selected representative historic buildings will be analyzed in function of the load types which act on the structures. The most sensible parts of these buildings will be identified and categorized, based on field investigations. Also, there will be presented unauthorized man-interventions and changes of the environment under extreme events i.e. extreme wind, snow, floods, landslides, earthquakes etc. which produced less known damages.

Task 3. Analysis of the damage mechanisms
Where it is possible, there will be performed in-situ experimental tests on the damaged structures, giving information on the material physical characteristics. The results will be compared with those obtained numerically with the help of FEM software. There will be identified the failure mechanisms characteristic for every type of historic building.

Task 4. Innovative consolidation techniques
New methods of consolidation of historic buildings will be developed, starting from new materials developed by existing industrial producers from Europe. Experimental tests on the consolidated elements with the innovative materials will be carried out. The results will be checked with the help of FEM software in order to calibrate the models and obtain valuable information for design codes and values which should be used in the current design practice. Recommendations for a correct construction and installation, using these new technologies and innovative materials will be issued.

Task 5. Elaboration of a preliminary design code
The innovative solutions, checked by experimental and theoretical testing, are new and their behavior and influence in time on the historic buildings is not well known. Due to this fact, it is necessary to elaborate a preliminary design code which should try to predict as accurate as possible the in-time behavior of the applied modern consolidation measures on the historic buildings. Preliminary intervention guidelines will be provided for each type of historic building from Europe, in function of the parameters which led to their deterioration. **(Mosoarca)**

(Arroyo) Selection of the supports to be treated. We have been working with different construction materials used in historic buildings in our region: Macael marble and gypsum plasters from the Alhambra (Granada), calcarenitic stone from the cathedrals of Seville and Jerez, roman Opus Caementicium from the roman theater of Cadiz. All these materials could be incorporated to the study.
After the preparation of protectives, their behavior will be studied following this procedure:
1. Characterization of the properties of the materials samples: SEM observation, porosity, pore size distribution, surface hardness, ultrasonic velocity, mechanical resistance, hygric properties, color. When possible, European or Spanish standards will be apply to carry out the tests.
2. Treatments application to the samples, following the defined protocol, or comparing different systems to identify the most suitable one for each material.
3. Characterization of samples properties measured previously, to determine the effect of treatments.
4. Design of accelerated weathering tests to evaluate the resistance of samples. The tests will be defined in order to reproduce the environmental conditions of the buildings or the use conditions of the materials. Besides the conventional version of the accelerated weathering tests (salt crystallization, freezing-thawing, termohygrometric) new procedures, best fitted to the real conditions, will be developed. For example: salt crystallization test with impregnation of samples by capillarity absorption; termohygrometric test with heating on one face of samples and moisture on the opposite one.
5. Development of the tests with treated and untreated samples, continuing up to a predefined number of cycles or until a certain degree of alteration is obtained. During the tests, some properties, easily measurable like ultrasonic velocity or color, could be measured in order to determine the behavior of samples.
5. After submitting the samples to accelerated tests, and depending on the degree and type of alterations produced, material properties will be measured again to substantiate which are the best treatments for each of the studied materials.
6. Development of a multicriteria decision methodology (MDM) to evaluate the conservation treatments.
7. Development of a software to be used as a tool for common usage in heritage conservation. (Arroyo)

(Stefanidou) Characterization of historic materials which will be incorporated in the Action Taking advantage of the State-of-the-Art as already described and experience of the project consortium from previous EC (e.g. STONECORE, CHIC, REACH), as well as national research projects a material part of a multi-facet matrix supporting optimization of interventions will be defined. It will contain decisive material characteristics important for successful interventions prolonging the life and/or restoring the performance of historic materials. The state of preservation should also be recorded. Scales of degradation will be formed for the materials tested. Data bases will be formed in order to understand the nature and properties of the materials. These data will be the guidelines for the design of the coating. The environment under which the materials function will also be taken under consideration.
Design and application of several solutions in laboratory scale will be performed and the specimens will be subjected to deterioration cycles in order to record the durability and the compatibility with the substrate. From the results modifications may come of.

The solutions will be either traditionally used but nano-modified to examine their effectiveness or polymeric matrices in which nano-modifications will be made.

Performance of developed products will be verified by their application on selected monuments or pilot test objects. The real on site behaviour will be monitored and compared to accelerated tests on materials **(Stefanidou)**

(Paladini 1) This Work package aims to use light sources of different wavelength and intensity, continuous or pulsed, in order to study the photo-damaging effects on the surface of fixed (i.e. wall painting, plasters, mosaics) or movable (i.e. pictures, decorate pottery also as fragments) items of interest for the cultural heritage. A graphical reconstruction of the surface will be preliminary performed, in order to localize the micro-areas where to collect samples and to perform analysis. Whenever possible Open Source software will be used.
The photo-damaging effects will be investigated by optical analysis and by non-destructive and/or micro-destructive spectroscopic and diffrattometric techniques. The studies will be performed on different way depending on the artifacts: in situ, in laboratory or on model samples.

1 - In situ. Different lamps and laser diodes will be used for irradiating the surface. The effects will be monitored by a camera and by Raman Spectroscopy. Actually, the Institute is acquiring part of the portable instrumentation, which will be furtherly implemented in the frame of this project.

2 - In laboratory. The artifacts or their fragments will be irradiated in laboratory by using lamps and laser source of different wavelength and intensity. The studies can be performed also on micro-fragments of the artifacts, which can be collected in collaboration with qualified personnel, in order to be as less intrusive as possible. All the optical, spectroscopic and diffrattometric techniques available in the Institute will be used, with a preference for the non-destructive diagnostic techniques.

3 - On model samples. If the artifact is not reachable or cannot be irradiated neither on microareas, a model sample will be reconstructed in laboratory. Qualified personnel will be involved for the reconstruction. All the optical, spectroscopic and diffrattometric techniques available in the Institute will be used for the study of the photo-damaging effects. **(Paladini 1)**

(Paladini 2) This Work package aims to evaluate the state of the artifacts before and after a protective or restoration treatment. The analysis can be performed on both fixed (i.e. wall painting, plasters, mosaics) or movable (i.e. pictures, decorate pottery also as fragments) items of interest for the cultural heritage. A mapping of the artifact will be preliminary performed for the localization of the areas which need the restoration or protective intervention. Whenever possible Open Source software will be used.
The conservation state of the artifact will be investigated by different diagnostic techniques (non-destructive and/or micro-destructive) in situ and/or in laboratory.
1 - In situ. A portable Raman Spectrometer will be used for the characterization of the artifact before and after the treatment. The probe of the spectrometer will be mounted on a XY translational stage in order to scan the surface. Actually, the Institute is acquiring part of the portable instrumentation, which will be furtherly implemented in the frame of this project.
2 - In laboratory. The artifacts or their fragments will be analyzed by all the optical, spectroscopic and diffrattometric techniques available in the Institute, with a preference for the non-destructive diagnostic techniques. As the Institute has also a research unit at Elettra, the Synchrotron Radiation Laboratory in Trieste (Italy), synchrotron X-ray diffraction analysis will be performed on selected samples.

The studies can be performed also on micro-fragments of the artifacts, which can be collected in collaboration with qualified personnel, in order to be as less intrusive as possible. (Paladini 2)

(Caridys)

The benefits of historical buildings restiration include:
Retention of history and authenticity

- Commemorates the past
- Aesthetics: texture, craftsmanship, style
- Visitor appeal

Increased commercial value (Economic Benefits)

- Materials and ornaments that are not affordable or readily available
- Durable, high quality materials

Retention of building materials

- Less construction and demolition debris
- Less hazardous material debris
- Less need for new materials

Existing usable space—quicker occupancy
Rehabilitation often costs less than new construction
Reuse of infrastructure
Energy savings

- No energy used for demolition
- No energy used for new construction
- Reuse of embodied energy in building materials and assemblies

Taking the above benefits into account the Ionian University, via the Laboratory on Museology, Restoration and Exploitation of Cultural Heritage, shall base the methodology on five steps: Identify, Investigate, Develop, Execute, and Educate. Successful restoration design also requires frequent consultation with a variety of organizations and close collaboration among technical specialists, architects, owner/occupants, and restoration professionals.

The Ionian University's contribution should be mainly focused on identifying the problems and describing the required mechanical, chemical and physical characteristics that the carious materials must possess, according to the type of structure to which they will be installed, the specific location and structural or aesthetic function, etc.

Members of our research team, have been also members of the Central Council of the Greek Ministry of Culture and have collected and classifies all the problems of the Cultural Heritage that have been introduced to the Council for discussion, approval, rejection, modification, etc. **(Caridys)**

(Fatta)
- characterization and knowledge of the constituent elements of the finishing plaster and "artificial stones" of Mediterranean areas;
- to draft an exhaustive repertoire of surface external finishes using artificial stone, through the analysis of significant examples, in relation also to the bibliographic-archive sources, the physical-chemical characterization, the study of the application techniques, the chromatic results and surface textures;
- identification of study buildings for samples, intervention tests, ..., for which the constructive phases are known and well documented, even about previous interventions of consolidation and surface protection;

In this phase, it will be necessary to correlate the occurrence of the phenomena of degradation to intrinsic factors related to the nature of the finishes or to environmental aspects:
- evaluation, through in situ and laboratory tests, of the most common degradation and identification of the main activating agents (physical, chemical, biological, ...);
- evaluation of consolidation and protection systems offered by the industry based on their effectiveness.

We will use laboratory and in situ tests to compare the characteristics of the finishing samples before and after treatment (chromatic test, physico-chemical, biological and weathering and accelerated ageing tests,...). **(Fatta)**

(Spyros Apostolos)
NMR spectroscopy is an excellent tool for the chemical characterization of organic materials of both low and high molecular weight (polymers). Traditional restoration materials can be either natural, comprised of a complex organic matrix of low MW compounds (resins, varnishes, etc), or synthetic (polymeric products). Novel restorants are most often synthetic materials comprised of polymers or blends of different polymers with suitable properties. The chemical composition of both types of materials can be assessed by NMR spectroscopy, in order to attain the full chemical composition of the protectant.

Prior to restoration work, a crucial step is the assessment of the state of the artifact to be restored. Possible physical damage may be traced to chemical degradation due to aging effects (hydrolysis, oxidation, etc), and the type of degradation is important in choosing the appropriate restoration protocol. The excellent analytical capabilities of NMR spectroscopy will be used to assess any chemical degradation on the materials to be protected/restored. It will also assist in following the restoration procedure by verifying that chemical degradation processes have been halted by the restorant.
(Spyros Apostolos)

Deliverables

(Mosoarca)

- Database implementation (D.1), to be delivered in X months, and regularly updated;
- Typical degradations (D.2), to be delivered in X months;
- Cause analysis (D.3) of the recorded degradations in historic buildings, to be delivered in X months;
- Solutions and consolidation techniques (D.4) to be implemented for historic buildings, to be delivered in X months;
- Preliminary design recommendations (D.5) of the interventions, to be delivered in X months.

(Mosoarca)

(Arroyo)

Results of tests at laboratory scale of properties of stone materials before conservation treatments

Effect of conservation treatments on hydric, physical and mechanical properties of stone materials (conservation treatments application)

Design of accelerated weathering tests, with definition of cycles structure. Tests results: weathering indicators for each material. SEM inspection of samples.

Evaluation of conservation treatments alterability

Global evaluation of conservation treatments studied by DIQA-ETSI-US using MDM tools

Testing and usage of software with others partners data

(Arroyo)

(Stefanidou)

-Innovative products used as coatings:
1.Development of self-healing coatings for masonry protection,
2.Development of coatings with hydrophobic properties,
3.Development of advanced materials for the prevention of biodeterioration (antifouling properties)

- Train new scientists in new technologies and possibly create job positions

- Project results will be disseminated through presentations on professional conferences, fairs, workshops and training events.

- Contact with SMEs and representative of industry

(Stefanidou)

(Paladini 1)

- The experimental results obtained from the analysis.
- A multimedia database (available also online) containing all the obtained information.
- A GIS (Geographic Information System) platform containing all the obtained information.
- Data integrated in the project website.
- Papers in scientific journals.
- Communications at conference.
- Support for the activities of restorers.
- Best practice/procedure for the characterization of the surface degradation of ancient items due to irradiation

Contribution to the conservation, valorization, preservation and fruition of the Cultural Heritage.

(Paladini 1)

(Paladini 2)

- The experimental results obtained from the analysis before and after the treatment performed by other

Units.
- Best practice guidelines for the used diagnostics.
- A multimedia database (available also online) containing all the obtained information.
- A GIS (Geographic Information System) platform containing all the obtained information.
- Data integrated in the project website.
- Papers in scientific journals.
- Communications at conference.
- Support for the activities of restorers
- Contribution to the conservation, valorization, preservation and fruition of the Cultural Heritage

(Paladini 2)

(Caridys) Since we have a full data bank of the last 15 years of work on the field we will offer the above, concerning specifically the Greek monuments:

Classification of all the problems that have been encountered till today (sea, earthquakes, use of inappropriate methods of restoration, problematic interventions, use of bad materials, manmade hazards, etc)
A classification of the consequences of the above problems to the sustainability of the structures
We shall propose special specifications for restoration interventions based on the different building categories (mansory, wooden, adobe, steel, etc) **(Caridys)**

(Fatta)
- evaluation and judgment on the applicability of protectives in the Mediterranean areas;
- guidelines for a recovery compatible and economically sustainable of high-value finishes.

(Fatta)

(Spyros Apostolos)
- Compositional analysis and characterization of traditional and novel restorants developed
- Degradation assessment of cultural heritage artefacts and model restoration systems
- Characterization of both restorants and restored materials during the restoration procedure.

(Spyros Apostolos)

Table 3.1a: Work package WP3 description

Work package number 3		**Start Date or Starting Event**					
Work package title	**Biotic damage: characterization, treatment and protection**						
Participant number	X	Y	Z	W			
Short name of participant (Sprocati Anna Rosa)	**ENEA**	CNR-ICM proposed	CNR-IFAC proposed	UNI-NICE proposed	German SME proposed		
Person/months per participant:	X	Y	Z	W			

Objectives

Particular attention will be devoted to autotrophic (algae, lichens, musk, bacteria, weeds, etc.) and heterotrophic organisms (fungi, insects, etc.). The different species and their danger will be established together with adequate methodologies of protection against the risk, and, in case of attack, the best way of treatment which, taking into account the nature of the assets, must be respectful both of them by not causing further damages and also of the people who will benefit from the work of art.

(Patelli) The detrimental effects of microorganisms on stone and wall paintings may be aesthetic, biogeochemical and/or biogeophysical. Microbial cells may contribute directly to the deterioration of stone/paint layer and plaster by using it as a substrate or indirectly by imposing physical stress, serving as nutrients for other organisms, or providing compounds for secondary chemical reactions. The contribution of algae, bacteria, fungi and lichens to the decay of stone, mortar and paint layers in cultural heritage monuments has long been recognized but great challenges for inactivation of deterioration processes remain. Biocide treatments on microorganisms on building materials provide methods that cannot always be used with cultural heritage due to the combination of heterogeneous materials, the unpredictable degree of interpenetration between the different layers, their different ageing processes and sensitiveness. Traditional products are rarely designed specifically for the conservation of objects made of sensitive materials and the compatibility of biocide treatment and substrate is rarely considered. Moreover, antimicrobial treatments for cultural heritage monuments are problematic, because methods of moderate toxicity are not effective enough and such that are effective tend to be hazardous to operating staff and visitors. Serious drawbacks of the traditional methods for microorganism inactivation and biofilm destroying stimulate a development of novel approaches to the protection against biofouling and biodamage processes.
The present project provides solutions for this challenge and aims to evaluate restoration and protection materials specifically designed for preserving Cultural Heritage stones and wall paintings with significantly improved performances compared to the commercial products currently in the market. Significant drawbacks of commercial products, such as toxicity, cracking and poor adhesion to the substrate or low compatibity with carbonate stones or with the different materials used in wall paintings will be prevented.
Atmospheric Plasma can offer highly innovative solutions in the field of conservation as it was demonstrated in FP7 EU PANNA Project. Dry process answers new environmental issues (vs. chemical treatments). Plasma Afterglow is generated at atmospheric pressure and ambient temperature. Material integrity is assured (non-invasive process). These specifications permit the disinfection or sterilization of thermosensitive materials and allow in situ applications, opening a new and larger spectrum of possible applications. Therefore, this proposal is dealing with non-thermal plasma sterilization of microorganisms that can lead to the eventual abandonment in usage of the heat and chemically aggressive, toxic and environmentally harmful liquid and gaseous agents.
A combination of plasma and antimicrobial treatment (using new developed materials) and the use of plasma deposition itself of antimicrobial coatings will be tested.
An extensive characterization will be performed at different stages. Firstly, plasma and nanomaterials characterization and evaluation of their effectiveness and durability will be carried out at laboratory scale by SME restoration groups in close collaboration with research groups.
Secondly, products evaluation will be carried out on real stone monuments and wall paintings. In the meantime routes for scalability and commercialization of the most suitable products will be developed in collaboration with the industrial SMEs and commercial formulates will be produced for trade. **(Patelli)**

(Manachini) Particular attention will be devoted to autotrophic (algae, lichens, musk, bacteria, weeds, etc.) and heterotrophic organisms (fungi, insects, etc.). The different species and their danger will be established together with adequate methodologies of protection against the risk, and, in case of attack, the best way of treatment which, taking into account the nature of the assets, must be respectful both of them by not causing further damages and also of the people who will benefit from the work of art. The goal of this WP is to develop new strategies to control degradation due to biotic colonization that have not been tackled extensively so far, or for which unsatisfactory results have been produced (despite obvious potential), or where emerging/invasive species are involved in the damaging and degradation of cultural and natural heritage. The WP will pay particular attention to: produce a data-base on the invasive species attacking cultural heritage, introduced in Europe and that can potential enter, evaluating the novel high potential control by new substances and methods, also derived from agriculture, botanic, zoology fields. One of the mission of RESTORA is to protect the Natural and Cultural Heritage from the negative impacts of invasive alien species (IAS) such as microorganisms, algae, fungi, weeds and insects that can arrive and that can

easily acclimate in relationship to climate changes. Invasive species are one of the top threats to the quality livelihoods and also cultural heritage. Some invasive species have been in EU for decades, others are recent arrivals. A systematic review of the situation and the impact on cultural heritage is still necessary and even urgent. The review and survey will be done according to the most modern techniques. The potential spread of these species IAS, in Europe and the potential arrival of new species, that could be pests of cultural heritage will be assess, moreover their potential adaptation will be forecast. This project examines categories of pest risk facing in the Mediterranean, with special emphasis on the partner's Nation. Different case studies of species recently introduced in Europe and that affected natural and cultural heritage to understand their impact on Cultural Heritage and on the European Identities will be used. In fact the new species not only damage cultural heritage, but can also makes changes in our identity and landscape. Trough an interdisciplinary approach, on the basis of the situation in Italy and other European countries, we analyse how IAS could be considered not only agricultural/forest pests but also a cultural and natural heritage pest and we will suggest how to improve Pest Risk Analyses (PRA) including the value of cultural heritage. RESTORA estimates the potential impact, introduction, the spread and acclimation of new IAS in Natural and cultural heritage using traditional and modern approaches (e.g. bio molecular analysis, bioinformatics models).
In order to control the IAS but also the other infesting species RESTORA will test and develop more environmentally-sound and sustainable pest management methods and will promote them by their wide adoption by several stakeholders (museum, restorers/conservators). This would help reduce the negative effects of chemical pesticides on human health (restorers/conservators, employers, visitors).
This WP has the ambition to deliver the simultaneous optimisation of current control methods and the development of novel ones, and to promote their rapid adoption through the design of IPM packages and exploitation by end-users. In particular, to optimise existing control methods and evaluate them against IAS and to optimize them according to the nature of the assets. Evaluation and optimisation of novel protection and control methods and products (such as antimicrobial and/or insecticidal peptides from different source e.g. marine animals, weeds, plants) against infesting species including IAS, will be done.
Moreover in order to better prevent the "catastrophe", resulting from IAS, WP will suggest lines for defence and rigorous control of entry promoting biosecurity protocols, needed at EC level (Wright and Slawson, 2010), in which the estimation of value and loss in natural and cultural heritage is considered. IAS will soon become the major engines of adverse ecological change in the future because of their increased spread and establishment. **(Manachini)**

(Madariaga 1) To study, in the field of Biotic Damage, the important impact of birds and seagull drops in the roof and facades of historical buildings (including those near the sea) due to the permanent formation of ammonium nitrate and other organic acids.
The ammonium nitrate formed when the drops from birds are metabolised by microorganisms can migrate due to rain wash events from the area of direct impact to other areas down of the building. When dissolved, the ammonium nitrate is dissociated in the ammonium cation and the nitrate anion. The ammonium cation is an acid that neutralise the calcium carbonate (an any other basic compound) and dissolve it, leading at the end to the formation of calcium nitrate, a very damaging salt due to its solubility. There are other organic acids that can react with the basic mineral phases outdoors of the buildings, promoting the formation of soluble ions that can be migrate to the inner porous of the stones/mortars, with the subsequent problem of salt damage. Thus, bird dropping is not only an aesthetical problem; it is also the source of permanent acid attack to alkaline compounds in facades and roofs and the formation of soluble salts. **(Madariaga 1)**

(Madariaga 2) To ascertain, in the field of Biotic Damage, the nature of the products coming from the metabolism of the biota that can impact in the colonised facades of historical buildings through the formation of biopatinas.
For the measurement of the products formed during the biotic damage, we have a very interesting instrument for in-situ measurements: the Raman spectrometer working with the 532 nm laser source, that produces a Resonance Raman effect in most of the carotenoids and compounds from the biotic metabolisms, aiding to their most adequate identification.
Other techniques at the laboratory scale can be used to ascertain the nature of such metabolic products and the new compounds that can be formed after their chemical reaction with the original mineral compounds of the facades. **(Madariaga 2)**

(Paladini 3) Particular attention will be devoted to autotrophic (algae, lichens, musk, bacteria, weeds, etc.) and heterotrophic organisms (fungi, insects, etc.). The different species and their danger will be established together with adequate methodologies of protection against the risk, and, in case of attack, the best way of

treatment which, taking into account the nature of the assets, must be respectful both of them by not causing further damages and also of the people who will benefit from the work of art. **(Paladini 3)**

(Stefanova) The detrimental effects of microorganisms on stone and wall paintings may be aesthetic, biogeochemical and/or biogeophysical. Microbial cells may contribute directly to the deterioration of stone/paint layer and plaster by using it as a substrate or indirectly by imposing physical stress, serving as nutrients for other organisms, or providing compounds for secondary chemical reactions. The contribution of algae, bacteria, fungi and lichens to the decay of stone, mortar and paint layers in cultural heritage monuments has long been recognized but great challenges for inactivation of deterioration processes remain. Biocide treatments on microorganisms on building materials provide methods that cannot always be used with cultural heritage due to the combination of heterogeneous materials, the unpredictable degree of interpenetration between the different layers, their different ageing processes and sensitiveness. Traditional products are rarely designed specifically for the conservation of objects made of sensitive materials and the compatibility of biocide treatment and substrate is rarely considered. Moreover, antimicrobial treatments for cultural heritage monuments are problematic, because methods of moderate toxicity are not effective enough and such that are effective tend to be hazardous to operating staff and visitors. Serious drawbacks of the traditional methods for microorganism inactivation and biofilm destroying stimulate a development of novel approaches to the protection against biofouling and biodamage processes.
The present project provides solutions for this challenge and aims to evaluate restoration and protection materials specifically designed for preserving Cultural Heritage stones and wall paintings with significantly improved performances compared to the commercial products currently in the market. Significant drawbacks of commercial products, such as toxicity, cracking and poor adhesion to the substrate or low compatibity with carbonate stones or with the different materials used in wall paintings will be prevented.
Atmospheric Plasma can offer highly innovative solutions in the field of conservation as it was demonstrated in FP7 EU PANNA Project. Dry process answers new environmental issues (vs. chemical treatments). Plasma Afterglow is generated at atmospheric pressure and ambient temperature. Material integrity is assured (non-invasive process). These specifications permit the disinfection or sterilization of thermosensitive materials and allow in situ applications, opening a new and larger spectrum of possible applications. Therefore, this proposal is dealing with non-thermal plasma sterilization of microorganisms that can lead to the eventual abandonment in usage of the heat and chemically aggressive, toxic and environmentally harmful liquid and gaseous agents.
A combination of plasma and antimicrobial treatment (using new developed materials) and the use of plasma deposition itself of antimicrobial coatings will be tested.
An extensive characterization will be performed at different stages. Firstly, plasma and nanomaterials characterization and evaluation of their effectiveness and durability will be carried out at laboratory scale by SME restoration groups in close collaboration with research groups.
Secondly, products evaluation will be carried out on real stone monuments and wall paintings. In the meantime routes for scalability and commercialization of the most suitable products will be developed in collaboration with the industrial SMEs and commercial formulates will be produced for trade. **(Stefanova)**

(Piervittori 1) Research activities will be particularly focused on lichens as model organisms for the development and validation of an index as practical tool to quantify the biodeterioration impact on stonework.

In 2009, we proposed a new index, i.e. index of Lichen Potential Biodeteriogenic Activity (LPBA), to quantify the overall lichen impact on stonework on the basis of the volume of influence of each species, quantified both on the surface of and within the substratum, and of other parameters related to reproduction, physico-chemical action, and bioprotection (Gazzano *et al.,* 2009, *Int. Biodet. Biodegr.*; Piervittori *et al*., 2009, Proceedings 4th Int. Congress "Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basis", Cairo, 6th-8th December 2009)

In this first index formulation, ordinal values were suggested for the different parameters and no interpretation scales were defined.

The objective of our proposal will be:

(a) the standardization of suitable protocols to make each parameter used in the index calculation a measurable parameter;

(b) the definition of suitable interpretation scales to apply the index to different kinds of stonework (buildings, statues, archaeological areas …) and in different bioclimatic areas (temperate, arid, alpine, Mediterranean);
(c) the discussion of the validated index as a model for the development of analogous indices for the other

components of the lithobiontic communities. **(Piervittori 1)**

(Balocco) Most of Italian museums belongs to historical buildings converted into this use. Vapor diffusion and mass transfer from indoor/outdoor environment though building components depends from partial pressure variation and gradient of concentration phenomena, strongly affected from outdoor climatic condition and indoor microclimatic often with impulsive aspects. Moisture diffusion in wall paintings is conditioned by two crucial phenomena (vapor diffusion and rising damp). Then, in the first case, it should be evaluated considering the connection and integration between building and plant systems. Therefore, the study of thermo-physical properties of materials and thermo-physical building performance, combined with thermodynamic performance of the present plant system (if they are present), based on experimental measurements and multi-physics numerical model solved by transient simulations is crucial. This allows to individuate and define the correct approach to reduce deterioration and material degradation phenomena and provide a useful method for conservation and restoration programming phases. **(Balocco)**

(Sprocati Anna Rosa)
Task 1: Microorganisms: bacteria, cyanobacteria and fungi. **ENEA (+other partners to be included)**
Task2: Plant (there is already a partner or have I to suggest?)
Task3:Insects (there is already a partner or have I to suggest?)
(Sprocati Anna Rosa)

Description of work

(Patelli) task1: Defining and preparing the experimental Lab substrates and selecting real artifacts for testing of biocidal effect of plasma (VN, BTZ)
Detection, identification and quantification of the microbial flora, stone and wall paintings, representative of cultural heritage assets exposed to different environments. In a first step, different microorganisms will be selected and cultivated on laboratory prepared samples (stones and wall paintings).
Biodeterioration processes are rarely caused by one distinct group of microorganisms, but are rather an interaction of co-existing groups and factors. In the preparation of Lab samples particular attention will be paid to the factors including stone/wall characteristics, geographical location, architectural features, climate and microclimate, surface roughness or texture of the stone/plaster, building maintenance and the extent of existing biological growths.
task2: Laboratory biocide efficacy evaluation (NDR)
Biocide efficacy of APP will be assessed through tests carried out on laboratory prepared samples inoculated with cultures of the target organisms.
task3: Development and characterization of biocide nanomaterials (VN)
Development of new biocide/consolidating materials
The novel nanomaterials will be applied on targeted stones, as well as on wall paintings which will be representative of European Cultural Heritage. Identification of most innovative commercial solutions to be used as bench mark for new developed techniques and products.
Comparison between the traditional solutions and the developed new materials;
task4: Field biocide efficacy evaluation (VN, BTZ)
Application and validation of plasma and nanomaterials on monumental and archaeological sites.
Based on the laboratory evaluation performed in WP2, the most relevant products and parameters will be tested.
Veneto Nanotech (VN, Italy) is a research center with well equipped labs to carry on all the activity
Botega Z (BTZ, Bulgaria) is a restorers SME that will take care of all the "conservators" aspects and will try the final treatments in order to write operational protocols
Nadir srl (NDR, Italy) is the atmospheric plasma jet developer **(Patelli)**

(Manachini) Initially a careful systematic review, according to DEFRA (2011) and Guidelines for Systematic Review (2010), of IAS presence, distribution and impact in natural and cultural heritage in Europe will be done. Moreover the aspects of how IAS made changes in the cultural heritage and identity will be taken into account.
A survey and monitoring of IAS in natural and cultural heritage in some selected areas and countries.

Historical and botanical gardens as well Museums will be selected for this purposes. Based on that information, a model with specific steps for monitoring and control IAS in cultural heritage assets will be provided. The biology of selected IAS species will be studied in laboratory and compared, when possible, with the biology of native one to understand their relationships and invasiveness.
Many biological systems damaging cultural heritage assets, in particular alien invasive species, have not been studied in an applied cultural heritage context yet (mostly owing to a focus of efforts on other, e.g. already commercialized products or just chemical treatments), despite obvious potential for more sustainable approaches.
Combinations of several control methods, related to the different biodeterioring agents including IAS show low adoption by cultural heritage context, because of complex trophic mechanisms occurring among species and the particular value of the assets.
New control method such as bio - techniques (pheromone traps, biocontrol agents, new substance and peptides) will evaluated and compared in terms of efficacy and preservation of the cultural heritage assets.
We will assess and develop novel or understudied methods already existing (alone or in combination) for controlling and prevent degradation due to the biotic agents both authotrophic and heterotrophic. Novel bioactive molecules extracted from invertebrate marine organisms, recently identified in our laboratory, will also be tested in order to replace chemical biocides. Biodeteriogens are controlled not only through methods targeting them directly, but also taking advantage of the environment, exploiting in particular environmental conditions, monitoring approaches, biocontrol services and temporary ecological infrastructures, these approaches will be tested to design “lab-museum” planning for promoting and maximising alternative control on targeted pests. **(Manachini)**

(Madariaga1) On the roofs and facades of selected buildings we will study the mineral areas around the drops, using the following methodology:
(a) a first in-situ inspection with portable spectroscopic instrumentation (Raman, Diffuse Reflectance, XRF and LIBS portable-handheld devices) will be performed through very careful measurements, even at microscopic scale in the field
(b) an initial diagnosis will be assessed from the in-situ information, sampling selected areas where the damage is more evident
(c) laboratory analysis with the same spectroscopic techniques will be carried out on the sampled materials to search for other minor compounds that could be considered as markers of particular decaying process or impact
(d) soluble salt tests will be performed on the samples taken just to quantify the concentration of soluble cations and anions, applying chemometric tools on the results to find clusters that will give us information about possible sources of impact.
(e) chemical modeling will finally conducted to define the chemical reactions taken place, those reactions explaining why the original materials are transformed into the degraded ones by the action of the chemicals introduced during the biotic activity (attack). **(Madariaga 1)**

(Madariaga 2) Biopatinas from the selected buildings will be studied following this methodology:
(a) a first in-situ inspection with portable Raman spectroscopic instrumentation, using an excitation laser at 532 nm to promote the Resonance Raman effect, will be performed through very careful measurements, even at microscopic scale in the field.
(b) an initial diagnosis will be assessed from the in-situ information, defining sampling selected areas where the damage is more evident to collect composed samples (biopatina with the living organisms plus mineral substratum) for laboratory analysis.
(c) laboratory analysis with confocal Raman micro-spectroscopy and other spectroscopic techniques like SEM/EDX imaging and Raman imaging will be carried out on the sampled materials to search for other metabolic compounds and biominerals present in the interface organism/substratum, that could be considered as markers of the colonisation process or impact. **(Madariaga 2)**

(Paladini 3) This Work package aims to evaluate the state of the artifacts before and after a protective or restoration treatment. The analysis can be performed on both fixed (i.e. wall painting, plasters, mosaics) or movable (i.e. pictures, decorate pottery also as fragments) items of interest for the cultural heritage. A mapping of the artifact will be preliminary performed for the localization of the areas which need the restoration or protective intervention. Whenever possible Open Source software will be used.
The conservation state of the artifact will be investigated by different diagnostic techniques (non-destructive and/or micro-destructive) in situ and/or in laboratory.

1 - In situ. A portable Raman Spectrometer will be used for the characterization of the artifact before and after the treatment. The probe of the spectrometer will be mounted on a XY translational stage in order to scan the surface. Actually, the Institute is acquiring part of the portable instrumentation, which will be furtherly implemented in the frame of this project.
2 - In laboratory. The artifacts or their fragments will be analyzed by all the optical, spectroscopic and diffrattometric techniques available in the Institute, with a preference for the non-destructive diagnostic techniques. As the Institute has also a research unit at Elettra, the Synchrotron Radiation Laboratory in Trieste (Italy), synchrotron X-ray diffraction analysis will be performed on selected samples.
The studies can be performed also on micro-fragments of the artifacts, which can be collected in collaboration with qualified personnel, in order to be as less intrusive as possible. **(Paladini 3)**

(Stefanova) task1: Defining and preparing the experimental Lab substrates and selecting real artifacts for testing of biocidal effect of plasma (VN, BTZ, TESS)
Detection, identification and quantification of the microbial flora, stone and wall paintings, representative of cultural heritage assets exposed to different environments. In a first step, different microorganisms will be selected and cultivated on laboratory prepared samples (stones and wall paintings).
Biodeterioration processes are rarely caused by one distinct group of microorganisms, but are rather an interaction of co-existing groups and factors. In the preparation of Lab samples particular attention will be paid to the factors including stone/wall characteristics, geographical location, architectural features, climate and microclimate, surface roughness or texture of the stone/plaster, building maintenance and the extent of existing biological growths.
task2: Laboratory biocide efficacy evaluation (NDR)
Biocide efficacy of APP will be assessed through tests carried out on laboratory prepared samples inoculated with cultures of the target organisms.
task3: Development and characterization of biocide nanomaterials (VN)
Development of new biocide/consolidating materials
The novel nanomaterials will be applied on targeted stones, as well as on wall paintings which will be representative of European Cultural Heritage. Identification of most innovative commercial solutions to be used as bench mark for new developed techniques and products.
Comparison between the traditional solutions and the developed new materials;
task4: Field biocide efficacy evaluation (VN, BTZ, TESS)
Application and validation of plasma and nanomaterials on monumental and archaeological sites.
Based on the laboratory evaluation performed in WP2, the most relevant products and parameters will be tested.
Veneto Nanotech (VN, Italy) is a research center with well equipped labs to carry on all the activity
Botega Z (BTZ, Bulgaria) is a restorers SME that will take care of all the "conservators" aspects and will try the final treatments in order to write operational protocols
Nadir srl (NDR, Italy) is the atmospheric plasma jet developer **(Stefanova)**

(Piervittori 1)
Experimental work to standardize methods to measure:
- lichen cover (parameter "a" in ILPBA)
- reproductive potency (parameter "b" in ILPBA)
- depth of hyphal penetration (parameter "c" in ILPBA)
- physical action (parameter "d" in ILPBA)
- chemical action (parameter "e" in ILPBA)
- hyphal spread (parameter "f" in ILPBA)
- bioprotection (parameter "g" in ILPBA)

Calibration and statistical validation of evaluation scales for the index application on different stonework types and in different bioclimatic areas.
(Piervittori 1)

(Balocco) The proposed approach is based on extended in-situ monitoring campaigns into existing museums. Outdoor climatic conditions (solar radiation., air temperature and humidity values, wind velocity and direction) and indoor microclimatic condition (indoor air temperature and relative humidity values, mean radiant temperature air velocity and air pressure scheme) will be integrated with a detailed monitoring campaign of different materials of building components.
Thermal (heat fluxes, surface temperatures) and thermo-graphic analysis (using infrared technology, FLIR) and thermo-hygrometric measurement (humidity values from vapor diffusion or rising damp) will allow to

carry out numerical models in order to identify and quantify hazards, compare threshold limit values of the fundamental parameters with those suggested by national and international standards, for the preservation and conservation of artifacts and works of art. Long-term prevention models will be developed to determine and evaluate refurbishment or retrofitting solutions. **(Balocco)**

(Spyros Apostolos)
See WP.2 for general description of the NMR methodology capabilities.
For biotic damage, we could help in identifying organisms based on their metabolite profiling from the analysis of organic residues on affected cultural heritage materials. The same analysis could identify biodegradation products from the original CH materials, and identify the damage caused, as well as the degradation state of the materials.
The effect of any treatments on the CH materials may also be studied through compositional and structural analysis.
(Spyros Apostolos)

(Sprocati Anna Rosa)
Task1a:
Early detection of biodeteriogens on stone surfaces, their viability and characterisation are all key factors for the implementation of an adequate conservation strategy of our stone cultural heritage. The difficulty in defining the complexity and biodiversity of microbial communities actually present on the surface and in distinguishing true biodeteriogens is mainly due to methodological difficulty linked to culture-dependent techniques. Integrated highthoughput techniques (molecular, phenotypic, microscopy) will provide more complete information about the whole microbial community colonizing a manufact, both at structural and functional level, including bacteria and fungi. Establishing which microorganisms are naturally able to colonise that monument in the course of time, it will be provided a reasonable base for the development of monitoring protocols for the prevention of the biodeterioration and for the safeguard of the monument. Molecular and cellular data set (ENEA) will be integrated in a predictive mathematical model of re-colonization of microbial biofilms (CNR-I.C.M_Roma, Université Nice Sophia Antipolis), to provide a prevention protocol. Also non-invasive fluorescence methods and lidar remote sensing fluorescence techniques may be comparatively applied on site for the detection of biodeteriogens (CNR-IFAC-Firenze could likely be involved, so as Laser groups at ENEA-Frascati). The integration of such biological and physical data sets is definitely a way to provide non invasive tools and methods for a knowledge-based overview of microbial community related to biodeterioration, its causes and effects, and for its long-term monitoring aimed at a sustainable management of CH.

Task1b:
Following the characterization of the microbial bioteriogens communities (see Task1a), a series of bio-based products from both microbial (ENEA) and plant origin (likely a German SME producer of plants extracts could be involved) will be tested for the control of biodeteriogens. The bio-based antimicrobial products that will be considered may be currently available at ENEA (i.e a raw extract Bio-Z,) or may be new finding from the microbial collection“ENEA-Lilith”(biosurfactants, bioemulsifiers and other molecules of microbial origin). Novel standardised plant extracts with interesting fungicidal activities are available from a German SME (to be asked). Following laboratory assays to check the antimicrobial activity against a list of bacteria and fungi known to be biodeteriogens, the compatibility of the selected bio-products with the nature of the assets to be treated will be evaluated. Finally, they will be tested in situ on the real biofilms (active collaboration with Superintendence of Rome are underway in archaeological sites). Aim is to develop achievable treatments against microbial biodeteriogens, selective, non-toxic, environmental compatible, suitable to overcome the serious drawbacks of biocides products actually used.

(Sprocati Anna Rosa)

Deliverables

(Manachini)

- Protocol (s) for systematically review of IAS linked to cultural heritage presence and distribution in

EU and their social and economic impact on cultural heritage and tradition.

- Systematically review followed by the protocol
- Diagnostic tools and guideline to recognised potential IAS.
- Diagnostic tools, ready to do, to detect and recognize the major biological agents for deterioration.
- Document or gather information on the distribution of the invasive species in the surrounding area.
- Document on how to improve PRA (Pest Risk Assessment) including the impact of IAS on cultural heritage.
- Biology of the selected IAS in Europe and potential impact of them changing the environmental parameters (e.g. temperature, humidity) and eventually compare with the biology and the response of the native species,
- Protocol for implementation of the existing control methods according to the sustainability and overall on the compatibility to the preservation of cultural assets
- Data on efficacy and potential use of new biocides on cultural heritage assets.

(Manachini)

(Madariaga 1) The effect of bird dropping depends on the kind of stones/mortars, the presence or not of anthropogenic impacts, and the distance to the coastal sea line. Our experience when analysing the effects of seagull drops in a lighthouse suggests a 9 month period to perform the whole study in a given scenario.

Two kinds of deliverables are recommended per scenario.

The first one should contain the initial diagnosis after the in-situ analysis with the spectroscopic instruments, including a tentative decaying pathway and the election of the area to take samples for the laboratory studies. This deliverable could be prepared in the 4th month.

The second one should contain the final diagnosis after the laboratory works, including the proposed decaying pathways and the recommendations for future actions. This should be ready for the 9th month.

We can estimate a man power of four researchers during 6 effective months per scenario (24 man month)
(Madariaga 1)

(Madariaga 2) The effect of microorganism colonisation depends on the nature of the organisms but also on the properties of stones/mortars where the colony is living. Our experience when analysing the effects of biopatina suggests a 6 month period to perform the whole study in a given scenario.

Two kinds of deliverables are recommended per scenario.

The first one should contain the initial diagnosis after the in-situ analysis with the Raman spectroscopic instrument, including the election of the area to take samples for the laboratory studies. This deliverable could be prepared in the 2th month.

The second one should contain the final diagnosis after the laboratory works, including the proposed pathways and conditions to growth the colony. This should be ready for the 6th month.

We can estimate a man power of two researchers during 4 effective months per scenario (8 man month)
(Madariaga 2)

(Paladini 3)

- The experimental results obtained from the analysis before and after the treatment performed by other Units.
- Best practice guidelines for the used diagnostics.
- A multimedia database (available also online) containing all the obtained information.
- A GIS (Geographic Information System) platform containing all the obtained information.
- Data integrated in the project website.
- Papers in scientific journals.
- Communications at conference.
- Support for the activities of restorers.
- Contribution to the conservation, valorization, preservation and fruition of the Cultural Heritage.

(Paladini 3)

(Piervittori 1)

- Guidelines for the application of the standardized protocols for measuring the different parameters involved in lichen deterioration (parameters “a”, “c”, “f”: month 6; parameters “b”, “d”: month 12; parameter “e”: month 18; parameter “g”: month 24)

- An improved practical tool for the evaluation of the lichen biodeterioration of stonework which may help scientists involved in the conservation of Cultural Heritage and could be a model for similar indices for other taxonomic groups (month 24).

- Interpretation scales for the measured ILPBA (month 30)

- Kit for the dissemination of the index to the stakeholders in the Cultural Heritage fields (managers of the Cultural Heritage, restoration enterprises, …) (month 36)

(Piervittori 1)

(Balocco)

Experimental data analysis and comparison. Measurement error evaluation.

Calibration and validation of numerical models from post-processing phase of experimental data and error analysis.

Transient Multiphysics simulations carried out for different proposed solution and comparison.

Scenarios for refurbishment and/or retrofitting solutions and innovative conservation and restoration works based on numerical model and multiphysical simulation results.

(Balocco)

(Sprocati Anna Rosa)

Task1a: Integrated methods and tools for an early detection of microbial biodeteriogens on stone surface

Task1b- Bio-based products of microbial and plant origin, selective, non toxic, environmental compatible and respectful of the assets, for innovative treatments against microbial biodeteriogens.

(Sprocati Anna Rosa)

Table 3.1a: Work package WP4 description

Work package number 4		**Start Date or Starting Event**					
Work package title	**Moisture in wall paintings.**						
Participant number	X	Y	Z	W			
Short name of participant	X	Y	Z	W			
Person/months per participant:	X	Y	Z	W			

Objectives

As well known rising damp is a major cause of decay to masonry materials such as stone, brick, mortar and

plaster. Rising damp occurs as result of capillary rise (suction) of water from the ground through the network of pores in the permeable masonry material. Accurate diagnosis of the cause and extent of the damp problem is a fundamental step in the case of conservation science of wall paintings. The porous mortar backing provides an easy route for the flow of diluted salt solutions. Salts contained in the mortar can be transported to the plaster underlying the painting. The volumetric expansion associated with the crystallization of these salts affects the plaster-pigment adhesion and leads to the disintegration of the surface. Such processes of leaching, transport, accumulation, solute concentration, precipitation, fractionation, and local concentration depend on the moisture content of the masonry which in turn is subject to seasonal variations in atmospheric humidity. For these reasons, before performing any restoration treatment the moisture distribution in a wall painting should be known.

(Madariaga 3) To study, in the field of Moisture in Wall Paintiungs, the important impact of rinse damps and infiltration waters.
We have measured the damage caused by infiltration waters at different heights in mural paints of churchs and also in their stone structures. Our experience indicate that is not only a matter of describing the humidity picture in the walls, but also the pH variations and the variation in the concentrations of cations and anions coming from the soluble salts formed with time in the mineral units (stones and joint mortars) of the walls. For instance, we have measured nitrates even in the ceilings and vaults of the churches. **(Madariaga 3)**

(Madariaga 4) To monitorise, in all the workpackages related to Testing the new Protective Products, the spectroscopic response before and after the application of treatments.
For the whole work packages applying new products in the surfaces, it should be interesting to measure the response of the surfaces to different spectroscopic variables (visible, infrared, Raman, etc.). And this can be performed using hand held instruments in the field, performing the spectroscopic measurements directly on the treated surfaces.
This can be done after accelerated ageing tests and/or after the application of selected treatments in real case studies. **(Madariaga 4)**

(Fiadeiro)
- Carry out the measurement of the spectral reflectance of art painting object surfaces using an hyper-spectral imaging system;
- From the spectral reflectance image (hyper-spectral) and selecting the spectral power distribution of illumination one can estimate the spectral radiance image, that is, an image were each pixel represents its colour signal;
- Adequate integration of the spectral radiance image enables us to represent the corresponding colours in any colour space such as: RGB, XYZ (CIEXYZ), *xyL* (CIE 1931), *uvL* (CIELUV), *u'v'L'* (CIE 1976), *L*a*b** (CIELAB), and some others;
- Spectral reflectance image, therefore provides essential information about art painting object material proprieties, such as colour and composition;
- Using the CIELAB colour space we will be able to evaluate the colour differences, or colour changes, that occurred in a specific study art painting object;
- Create spectral archives – Spectral Database – of art paintings or objects;
- Monitor paint and/or varnish degradation;
- Complement pigment identification and classification;
- Help the conservation and restoration processes (virtual visualization and representation);
- Study of the best conditions for a better colour discrimination.

(Fiadeiro)

(Fatta)
In the historical buildings, in particular in the monumental ones, the problems related to moisture involve not only the painting surfaces, but also the much more extended ambit of the high-value finishes.
The study of the moisture causes and the choice of appropriate intervention systems are essential for the preservation of this building heritage.
<u>The research has as objectives</u>:
- drafting of guidelines in support of the preliminary analysis of the buildings for the compatible and economically sustainable recovery of finishes plaster and artificial stones that characterize the historical building of the study area.

(Fatta)

Description of work

(Madariaga 3) The used methodology must monitorise the humidity in the wall, and the pH, together with the other spectroscopic in-situ measurements to have a picture of the distributions of the different parameters. We must take into account that all the ions do not move vertically in the same way, thus it is expected to have in the lowest part of the walls the sulphates, in the middles the chlorides and in the upper parts the nitrates.
To describe properly the whole picture, we propose the following methodology:
(a) a first in-situ inspection with portable spectroscopic instrumentation (Humidity, pH-meter, Raman, Diffuse Reflectance, XRF and LIBS portable-handheld devices) will be performed through very careful measurements, even at microscopic scale in the internal and external parts of the walls.
(b) an initial diagnosis will be assessed from the in-situ information, including the recommendation of sampling selected areas where the presence of ions is more evident
(c) laboratory analysis with the same spectroscopic techniques will be carried out on the sampled materials to search for other minor compounds that could be considered as markers of particular decaying process or impact.
(d) soluble salt tests will be performed on the samples taken just to quantify the concentration of soluble cations and anions, applying chemometric tools on the results to find clusters that will give us information about possible sources of impact.

(e) chemical modeling will be finally conducted to define the chemical reactions taken place, those reactions explaining why the original materials are transformed into the degraded ones, defining the source of the impact (attack). **(Madariaga 3)**

(Madariaga 4) Different spectroscopic techniques (Raman, DRIFT, XRF and color) can be used to follow the response of the surface, starting before applying anything, just after applying, and at different time periods after the application, to quantify the spectroscopic evolution obtaining an instrumental evidence of the goodness (or problems) of the applied treatments. In particular, we have the experience on the use of Raman spectroscopy to follow the behavior of a new cleaning procedure based on the use of EDTA and ion exchangers.
Taken that expertise as the starting point, we propose the following methodology to monitorise the adequacy of the tested protective procedures:
(a) always in-situ inspection with portable spectroscopic instrumentation (color, Raman, Diffuse Reflectance and XRF portable-handheld devices) will be performed on the surfaces to be treated, in order to set their initial spectroscopic characteristics (background state).
(b) the spectroscopic response of all the chemicals used in the treatments will be measured and stored, to have set of standards for comparison when monitoring after the application of the treatments.
(c) then the same spectroscopic inspection will be carried out just after the application of the treatments, performing an initial diagnosis on the variations suffered by the treated surfaces.
(d) the inspections will continue at regular time intervals to set the spectroscopic evolution with time, analyzing the whole spectra by chemometric tools to find differences with regard to the background state.

The whole work should contain four field campaigns per real scenario under study. For the study of the accelerated tests (if included in the workpackage), the work should contain again four (before treatment and 3 after treatment) testing periods but with half of man month; thus, a real scenario can be considered equivalent to two accelerated tests. **(Madariaga 4)**

(Fiadeiro)
A hyper-spectral image database with the measurements of the spectral reflectance of art painting objects surfaces can be created and updated any time. It is our purpose to create a database with images that can be used to carry out studies of colour paint degradation, varnish degradation, ink composition, follow up the conservation and restoration processes using virtual visualization by displaying the manipulated hyper-spectral images on calibrated monitors, and also the evaluation of the hyper-spectral image quality under

different conditions of observation. We are ready to start the main facilities are available for usage and the software application is also ready for usage.
The fundamentals of hyper-spectral imaging are based primarily on the interaction between light and matter. The ratio between the reflected or scattered light energy and the incident light energy is termed the reflectance (spectral reflectance).
Our hyper-spectral imaging system is semi-portable and is composed by an cooled image detector (ORCA-R2 1344x1024), a tunable interference filters (CRI Varispec VIS), a macro-objective lens (Schneider), an optical fiber Xenon light source (Newport), 2 halogen light lamps (500W), and a xy scanning system 25cm x 25cm (ESP-300 Newport). This hardware is fully controlled by a dedicated software application written in MATLAB.

We can operate the hyper-spectral system in one of the following configurations:
A – Filters in the image sensor (mostly outdoor usage)
Lower spatial resolution (~8 pixels/mm), low image quality, art painting objects subject to light not used by the image detector UV and IR;
B – Filters in the light source (mostly indoor usage)
Higher spatial resolution (~20 pixels/mm), high image quality, art painting objects subject only to visible monochromatic light (400-720 nm).

Additionally, we also have a tele-spectroradiometer (PR-650) and several white-reference surfaces (Spetralon and Opal) for system calibration purposes.
Within the scope of this projects we intend to upgrade the hyper-spectral system with another image detector (higher spatial resolution), extend the acquisition to the near infrared range (NIR) using the appropriate tunable interference filters, introduce a 3rd axis (z) to the existing (xy) scanning system in order to carry out spectral reflectance measurements in depth, when the art painting objects are not flat surfaces (statuary or high relief), and purchase an automatic crane to digitize walls and/or large paintings. The corresponding upgrade of the MATLAB software application will be also necessary.
Our research team is able to carry out these activities to fulfill the RESTORA project objectives. According the needs, some of the hyper-spectral image acquisitions could be carried in our facilities or through fieldwork. We are able to travel to perform fieldwork in our country, or abroad, by planning it accordingly if it is necessary to the project.
We intend that hyper-spectral imaging technology, which combines non-invasive analytical capabilities and imaging, should become a powerful tool for both conservators and conservation scientists.
Also, for material identification and mapping, the expected development of near infrared spectral imaging system, combined with the existing, and possibly ultra-violet extended system, should make the technique a useful method for investigations in field of art.
Hyper-spectral imaging systems are definitely a useful tool with high precision and accuracy that can be applied in arts, making possible a better knowledge, understanding, conservation and preservation of our cultural heritage
(Fiadeiro)

(Fatta)
- characterize and understand the different types of Mediterranean masonries, analysis of the physical-chemical characteristics, also in relation to specific environmental conditions that may conditioned the causes and formations of moisture;
- characterization and understanding of the constitutive elements of quality plaster finishes and "artificial stones" of the Sicilian area (the western one) and drawing up a comprehensive catalogue of external surface finishes using artificial stone, analyzing bibliographic-archive sources, the chemical-physical characterization, the study of the application techniques, the chromatic effects and surface textures;
- identification of study buildings or examples, in which make samples, intervention tests, ..., for which the constructive phases are known and well documented, even about previous interventions of moisture damage of surfaces.
In this phase it will be necessary to correlate the occurrence of the damage phenomena to intrinsic factors related to the nature of the finishes or to environmental aspects:
- evaluation, through in situ and laboratory tests, of the most common degradation and identification of the main activating agents (physical, chemical, biological, ...);
- evaluation of the best intervention systems, related to the types of finishing and support.
(Fatta)

Deliverables

(Madariaga 3) The effect of moisture in the walls depends on the water sources but also on the kind of stones/mortars and the presence or not of anthropogenic inputs. Our experience when analysing the effects of rising damps and infiltration waters suggests a 9 month period to perform the whole study in a given scenario.

Two kinds of deliverables are recommended per scenario.

The first one should contain the initial diagnosis after the in-situ analysis with the hand held devices, including the election of the area to take samples for the laboratory studies. This deliverable could be prepared in the 4th month.

The second one should contain the final diagnosis after the laboratory works, including the proposed decaying pathways and the recommendations for future actions. This should be ready for the 9th month.

We can estimate a man power of four researchers during 5 effective months per scenario (20 man month) **(Madariaga 3)**

(Madariaga 4) The monitoring of the effectiveness of the newly proposed protective treatments, requires several field campaigns, one initial and others at different time periods starting after the conclusion of the treatment. This suggests a 6 (or 12) month period to perform the whole study in a given scenario.

Two kinds of deliverables are recommended per scenario.

The first one should contain the initial spectroscopic response of the surfaces to be treated. This deliverable could be prepared in the 1st month.

The second one should contain the final diagnosis on the adequacy (or not) of the treatment under evaluation. This should be ready for the 7th (or 13th) month, one month after the conclusion of the monitoring at predetermined time periods. **(Madariaga 4)**

(Fiadeiro)

- Hyper-spectral system ready for usage (hardware and software).
- Database with hyper-spectral reflectance image data of art painting object surfaces.

(Fiadeiro)

(Fatta)

- evaluation and judgment on the applicability of the interventions in the Sicilian architecture (western area)
- draft of guidelines for a compatible and economically sustainable recovery of high-value finishes.

(Fatta)

Code 7 (All Partners received empty templates for Work packages WP2, WP3, and WP4; please, any Partner should return these templates to each2014@gmail.com compiled as a first draft).

Table 3.1a: Work package WP5 description

Work package number five		**Start Date**					
Work package title	**Project results diffusion**						
Participants number							

Short name						
Pearson/months per Participant:						

Objectives

Objectives if this Work package are
1 - Dissemination and exploitation of results

Definition of a work plan for dissemination and exploitation of the project results; implementation of a social platform

2- Communication activities
Organization of events concerning the partners of the Consortium; preparation of a website; organization of mid term workshops and final conference open to EU Commission experts

Description of work

This Work package aim is to improve the dissemination of information about the project results and deliverables: it is a core measure of the project's success. According to this preliminary consideration, different promotion and dissemination actions are foreseen and addressed to both experts in the field and any other Stakeholders.

1 - Dissemination of project results through scientific journals and through participation in Congresses, conferences and workshops

All project results will be shared and disseminated among the project Partners. In order to ensure high visibility of the project within the scientific community, publication in high impact factor scientific journals will be encouraged, as will be presentation at relevant workshops and conferences. Each research institution in this proposal will contribute to this dissemination as participants in WP 5.

2 - Organization of a workshop and a conference

In particular, within six months from the starting of the project a workshop will be held open to specific stakeholders.

3 - Demonstration event. In close collaboration with the WP2, WP3 and WP4 teams a demonstration event will be arranged in order to show how the newly developed techniques work.

This will exhibit the validity and usefulness of the new tools to a competent audience, able to comment and discuss the results obtained.

4 - RESTORA Website. Promotion of the demonstration event will be made through this website.

Other activities:

1 – Organization of the partners consortium meeting before and throughout the project activity according to the Coordinator suggestions (for 24 months); application of tools and methodologies of risk management to the governance of single parts of the project according to the suggestions of the project coordinator.

2 - Dissemination and exploitation of results deliverables, elaboration of a website concerning the activities of the project; maintenance and adjournments of the website during and after the project preparation; organization of events.

3– Project internal communication of documents and deliverables among the project partners
Deliverables ~ ***Workshop and conference in and related information & dissemination material*** ~ ***Papers in scientific journals*** ~ ***Launch of fully functional Knowledge Base*** ~ ***Demonstration even*** ***- Commercial service development*** ***-Business Plan for exploitation of products and services***

Next Table 31b shows the list of work packages:

Code 8 (to be written once Work packages are ready)

TABLE 3.1b – List of Work packages

Work Package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End Month
One						
Two						
Three						
Four						
Five						
				Total months		

Next Table 3.1c shows the list of Deliverables for each Work package:

Code 9 (to be written once Work packages are ready)

TABLE 3.1c – List of Deliverables

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date
		One				
		Two				
		Three				
		Four				
		Five				

3.2–Management structure and procedures

In order to efficiently manage the project, a specific WP dedicated to coordination and management has been foreseen in the project work plan, to ensure that suitable priority and attention will be given to project management. Within this WP 1 all the aspects related to administrative and quality management of the project will be included. The responsibility of the project coordination will be taken by XXX that will supply the Project Coordinator (PC) and a Project Officer (PO).

The project partners are fully committed and agree to work together with the utmost cooperation for the timely fulfilment of their responsibilities. Previous experiences and participations in European framework programs have led to the decision to keep this management structure as simple as possible. The **overall organizational structure** proposed for the RESTORA project is presented in Figure 1. It is aimed at ensuring the fulfilment of the project objectives, by allowing clear and continuous communication among the project partners.

a) Project Coordinator

The overall management of the project will be the responsibility of XXX as coordinating partner. Key to this is the role of the Project Coordinator, which will be carried out by …….

The **Project Coordinator** (PC) will be responsible for the **overall coordination** of the **technical and scientific activities, and all other aspects of the project** including **management of potential conflicts** and compromise negotiation in the unlikely event of conflict and will also be the primary contact person for the European Commission. Hence he/she will be responsible for all communication with - and reporting to - the EC.

The **Project Officer** (PO) will be responsible for day-to-day **legal and contractual management** of the project and **administrative and financial activities.** The PO will report to the PC.

In particular, according to the Consortium Agreement, the Coordinator shall be responsible for:

- Monitoring compliance by the Parties with their obligations
- Keeping the address list of Members and other contact persons updated and available
- Collecting, reviewing and submitting information on the progress of the project and reports and other deliverables (including financial statements and related certification) to the Funding Authority
- Preparing the meetings, proposing decisions and preparing the agenda of General Assembly meetings, chairing the meetings, preparing the minutes of the meetings and monitoring the implementation of decisions taken at meetings
- Transmitting promptly documents and information connected with the project
- Administering the financial contribution of the Funding Authority and fulfilling the financial tasks
- Providing, upon request, the Parties with official copies or originals of documents which are in the sole possession of the Coordinator when such copies or originals are necessary for the Parties to present claims.

The following Table 3.2a gives a list of milestones.

Code 10 (to be written once Work packages are ready)

TABLE 3.2a – List of milestones

Milestone number	Milestone name	Related work package(s)	Estimated date	Mean of verification

The following Table 3.2b gives the critical risks identified and the possible mitigating actions.

Code 11 (to be written once Work packages are ready)

TABLE 3.2b – Critical risks for implementation

Description of risk	Work package(s) involved	Proposed risk-mitigation measures

b) The General Assembly

The General Assembly is the decision making body of the Consortium.
The General Assembly shall consist of one representative of each Party (hereinafter referred to as "Member").
Each Member shall be duly authorised to deliberate, negotiate and decide on all matters listed in the Consortium Agreement.
The Coordinator shall chair all meetings of the General Assembly, unless decided otherwise by the General Assembly.
The Parties agree to abide by all decisions of the General Assembly.
This does not prevent the Parties from submitting a dispute for resolution in accordance with the provisions of settlement of disputes.
Operational procedures for the General Assembly representation in meetings
Any Member:

- should be present or represented at any meeting;
- may appoint a substitute or a proxy to attend and vote at any meeting;
- shall participate in a cooperative manner in the meetings.

c) The Work Package leaders

All technical and scientific issues of the project, in particular relating to the interdependence between and coherence of the different WPs - will be managed and consolidated by **the Work Package leaders** who will **report to the PC directly**. To achieve the R&D objectives of the project, the experimental, scientific and technical work has been organized into 3 R&D WPs (WP2,WP3, and WP4).
For each of them, a WP leader will be appointed to take primary technical control of and responsibility for the proper management and execution of the tasks related to the particular WP. In particular, he/she establishes (in coordination with the PC) the detailed schedule of his/her WP and the work in progress. Each WP leader is also responsible for identification of risks and for proposing solutions to the PC in respect of his/her WP. Taking into account that any of these R&D WPs will be the responsibility of three/four partners, WP leaders will be rotated among partners any four months.
Each WP leader is required to provide the PC at four monthly intervals with a progress report concerning his/her WP and containing sufficient technical information to enable the PC to be assured that work is progressing according to plan.

d) Means for governance and control

The means for governance and control (quality assurance, consortium agreement and communication plan) will be tailored to the scale of the RESTORA project. A correctly empowered governance and control for the overall project management will be guaranteed by following means:
The Consortium Agreement: All the RESTORA rules will be included and described in detail in the **Consortium Agreement**.
This document will define:

- the responsibilities, mutual obligations and roles of the partners;
- the division of the budget;
- the strategy for the exploitation of results;
- the rules for the settlement of disputes

The Consortium Agreement will be signed within the first month of the project and will define in a very clear and detailed way: roles of each partner, formal rules of participation, voting mechanisms, criteria for evaluation of activities realized by each partner, rules for budget re-allocation, etc.
The Quality Plan: A **quality plan** will be agreed by the General Assembly at the Kick-off meeting, and will ensure that appropriate quality assurance is undertaken. It will include:

- persons responsible for quality assurance, quality standards, methodologies and procedures;
- procedures for identification, distribution, collection, filing, maintenance and disposal of quality records resources, schedule and responsibilities for conducting the quality assurance activities

Quality control will represent a key issue in the overall management of the project, since it plays a critical role in keeping the action aligned towards its final objectives.

d) Project Meetings

An initial „launch/kick-off meeting will be organized at the start of the RESTORA project for all the personnel involved in the project. The purpose of the kick-off meeting is to:

- Present to all involved an overview of the project;
- Enable each participant to obtain a better perspective of his/her role in the RESTORA project and set this in context with the roles and skills of other project members;
- Define the main outline of the Consortium Agreement;
- Establish procedures for Quality Assurance and formalize policies for publication, intellectual property rights and any arbitration procedures.

3.3 –Consortium as a whole

Partners of the Consortium will be all the partners working on the five Work packages. Each partner will designate a member to participate to the meetings of the Consortium.
All the rules reported in the EU suggested Consortium Agreement must be followed.
The Consortium partners belong to very different scientific disciplines, from IT engineers to archaeologists, from robotics and mechanical experts and they have to complement one another in order to create a Robotic System suitable for this project.
Analogously, the presence inside the Consortium of Enterprises is fundamental for building and experimenting the products of project.
The RESTORA project is proposed by a consortium of xx **partners** from **X EU Member States** and comprises all the appropriate key players to ensure the availability of resources, capacities, technologies, capabilities, technical and operational knowledge required for the timely achievement of the goal of the project.
The consortium will bring together European efforts and methodological/technological developments and has therefore a high potential for developing and validation of innovative non-destructive diagnosis techniques to assess and monitor the state of preservation of the European heritage.
The partners to the RESTORA project have the following areas of interest and activity, Table 3.3.

Code 12 Any Partner should send these data by mail to each2014@gmail.com; please only one sentence!)

Table 3.3 Areas of interest/activity for Restora project partners

P	Area of interest / activity
DIQA	Characterization and evaluation of properties of materials and conservation treatments testing Application of non destructive tests to cultural heritage **(Arroyo)**
CNR ISM	Diagnostic and mapping to characterize the artifact damaging and conservation state (Paladini)
UniTO	Lichen deterioration: development of a model index to quantify the potential risk related to the biological colonization of stonework **(Piervittori)**
1	**(Spyros Apostolos)**NMR Spectroscopic analysis of organic materials**(Spyros Apostolos)**

3.4 – Resources to be committed

Code 13 (Section 3.4 to be written only after all other points and sections are ready)
According to costs as stated in the budget table in Part A of the Proposal, the following Table 3.4.1 shows the costs distribution.

Table 3.4.1 Total Costs

	WP 1	WP 2	WP 3	WP 4	WP 5	Total
Personnel costs						
Other costs						
Total direct costs						
Indirect costs						
Subcontracting						
Total costs						
Requested subsidy	2					

In order to achieve the objectives of RESTORA, duration of 24 months has been foreseen for the project. The overall project cost is € xxx.xxxx and **the overall EU contribution requested is € xxxx.xxx**, both reasonable and necessary considering the number of partners, the ambitious objectives and the duration of the project.
In the following, more details are provided about the costs in the main cost categories of the project.

3.4.1 - Personnel Costs

Personnel costs represent a significant part of the project budget, in total **€ xxxx.xxx**. For each work package, the personnel costs have been calculated considering the appropriate man-power (see Table 3.4 a – Summary of staff effort) needed to complete the proposed activities.

TABLE 3.4a – Summary of staff effort

	WPn	WPn+1	WPn+2	Total Pearson/ Months per Participant
Participant Number/Short Name				
Participant Number/Short Name				
Participant Number/Short Name				
Total Person/Months				

The weighted average monthly rate costs of the personnel that will be working in the work package are provided in Table 3.4.2

Table 3.4.2 – Weighted average monthly personnel costs in € per partner and work package

Partner	W	W	W	W	W

Next Table 3.4b shows "other direct costs" for participants where those costs exceed 15% of the personnel costs.

TABLE 3.4b – "Other direct cost" items

Participant Number/Short Name	Cost (€)	Justification
Travel		
Equipment		
Other goods and services		
Total		

3.4.2 - Travel costs (other direct costs)

The total travel costs are **€ xxxx** and refer to meeting, working session and other issues related to the coordination of participants' contributions, as well as to the attendance of conferences and events for dissemination purposes. In more detail, the following travels have been foreseen, so far, for calculating the travel costs:

Project meetings: technical and management meetings where all participants will be present, and where technical issues as well as management issues will be discussed. 6 project meetings are foreseen for the project duration (one meeting each 6 months of project).

Technical meetings: meetings needed among two or more partners collaborating on the same tasks. The twice yearly Project meetings will form a significant venue for inter WP discussions, and will make provision for specific subsets of WP managers to meet outside the main workshop on request, e.g. for inter- and intra-WP decision-making purposes.

***Dissemination meetings*:** participation to international conferences/workshops to present the RESTORA results, and for attendance to the RESTORA workshop. Each participant involved in WP5, will receive travel costs.

3.4.3 - Consumables (other direct costs)

The total costs for consumables amount to **€ xxxxx**.
The consumables with RESTORA are mostly related to preparation, analysis, characterisation, validation, process optimisation, pre-prototype development and tests and are summarized in table 3.4.3

Table 3.4.3.a – Consumables per work package

	Consumables description

A total of **€ xxx** has been included for the purchase of durable equipment by the project partners. The equipment costs were calculated on depreciation basis, considering the duration of usage of the equipment within the project. The table 3.4.3.b provides an overview of the planned equipment purchases

Table 3.4.3.b – Equipment purchase per participant

Partner short name	Valu	Eligi	Description	WP

3.4.4 - Other costs (other direct costs)

The other remaining costs amount to **€ xxxx**. These are listed in Table 3.4.4

Table 3.4.4 – Other direct costs per Work package

	Other costs

4 – Members of the Consortium

*Code **14** (All Partners, starting from now, should write at least about three pages plus the relevant publications lists, concerning both the Organizations they belong to and the persons who will carry out the proposed activities)*

4.1 – Participants

(Spyros Apostolos)

NMR Laboratory, Chemistry Department, University of Crete (NMRL, DeC, UoC)

Organisation description

The University of Crete (UoC) is a young public educational institution committed to excellence in research and teaching. UoC has been included in the Times Higher Education 100-Under-50 (universities operating for less than 50 years) for the last three consecutive years, occupying position 48th for 2014, and in 2012 it was awarded the "HR Excellence in Research" logo by the European Commission. Established in 1973, the University accepted its first students in 1977-78. It now has 16 Departments in 5 Schools (Philosophy, Education, Social, Economic & Political Sciences, Sciences & Engineering, and Medicine) as well as a number of affiliated research-oriented institutions, including the Skinakas Observatory, the Natural History Museum, and the University General Hospital. Currently, over 16000 undergraduates and 2500 postgraduate students are registered here. They are educated by an outward looking academic faculty of around 500 members, supported by adjunct lecturers, post-doctoral researchers, laboratory support staff and instructors, as well as around 300 technical and administrative support staff.

The Department of Chemistry (DeC) of UoC was established in 1985 emphasizing both research and teaching. The ascending success of DeC is primarily due to the high level of pioneering research work conducted by its faculty members and its remarkable ability to incorporate new and exciting findings into the teaching and laboratory curricula. The increasing collaboration of the Department with Industry and Public Sector for implementation of knowledge gained through research, constitutes a potent driving force for seeking excellence in research and teaching. Complementary to the research strength of the DeC is the close collaboration developed with Research and Production Sectors of the National and International Industry over the years. In the front line of such a collaboration between DeC and Industry are three legally independent research entities established by DeC and the Senate of UoC in 1997. Amongst these is the Nuclear Magnetic Resonance Laboratory (NMRL).

The NMR laboratory represents a dynamic and coherent research unit that uses multinuclear, multidimensional NMR spectroscopy as an efficient tool for the characterization of organic compounds and performs cutting-edge research in analytical chemistry, cultural heritage materials analysis and food science. NMRL has developed novel NMR methodologies for the characterization of a wide variety of original works of art (paintigs, wall paintings, modern art installations, whole artefacts), and materials that are relevant to cultural heritage, such as drying oils, natural resins, varnishes, waxes, polymeric consolidants, natural and synthetic dyes, pigments, etc. NMRL members have written several research articles and and book chapters dealing with cultural heritage materials analysis, and has attracted numerous citations, demonstrating the

international appeal of this research, and establishing NMRL as one of the world leaders in the analytical chemistry of cultural heritage materialsby NMR spectroscopy. Members of NMRL have educated undergraduate and graduate students in NMR spectroscopy, conferring 11 Ph.D., 20 M.Sc. degrees, and over 40 diploma theses to graduate students.

Significant infrastructure

DeC has recently moved into a new purpose-built building at the University's new campus that provides ample laboratory space and hosts its excellent instrumentation facilities (a number of LC-MS, GC-MS, MALDI-TOF, X-Ray, FTIR-Raman, and other instruments), obtained through competitive national and international grants. Moreover, the Computing Centre of DeC staffed by capable personnel assists effectively the computational work of the academic staff of the Department.

In particular, NMRL is equipped by two spectrometers: A Bruker Avance III operating at 500 MHz for proton and a Bruker DPX-300 operating at 300 MHz for proton. NMRL is also using the latest NMR-related software for spectral analysis of NMR data, including TopSpin, ChenomX, Statistica and SIMCA.

Dr. Apostolos Spyros is currently an Assistant professor of Analytical Chemistry of the University of Crete, M.Sc. (1993) and Ph.D, (1996), University of Crete. He has published 47 research articles in international peer-reviewed scientific journals (including four invited reviews), one book chapter, and one book. He participated in 48 international and national conferences. He is a reviewer for 16 leading scientific journals, including Analytical Chemistry, Journal of Agricultural and Food Chemistry and Biomacromolecules. Prof. Spyros is overseeing the NMR facility of the University of Crete since 2000, and he is leading a newly established (2007) research group focusing on the development of analytical NMR spectroscopy methodologies for the characterization of cultural heritage materials, and the analysis of biomolecules in chemistry, environmental and food sciences. He is currently the supervisor of 4 Ph.D. and 3 M.Sc. students. Citations: 855, h-index: 19. (March 2015, Thompson-ISI)

«Egg yolk identification and aging in mixed paint binding media by NMR spectroscopy»
S. Sfakianaki, E. Kouloumpi, D. Anglos, and A. Spyros, Magn. Reson. Chem. 2015, 53, 22.

«NMR spectroscopy analysis of polyester resins as contemporary art materials».
A. Spyros, U. Knuutinen in Impact of the Indoor Environment on the Preservation of our Moveable Heritage, Havermans, J., Adriaens, M., Thickett, D., Strlic, M., Fassina, V. and Rabin, I. (Eds), Nardini Editore, 2013. (Book chapter)

«Analysis and aging of unsaturated polyester resins in contemporary art installations by NMR spectroscopy»
G. Stamatakis, U. Knuutinen, K. Laitinen, A. Spyros, Anal. Bioanal. Chem., 2010, 398, 3203.

«Studies of organic paint binders by NMR spectroscopy».
A. Spyros, D. Anglos, Appl. Phys. A, 2006, 83, 705.

«Study of aging in oil paintings by 1D and 2D NMR spectroscopy».
A. Spyros, D. Anglos, Anal. Chem., 2004, 76, 4929.

(Spyros Apostolos)

- A description of the legal entity and its main tasks, with an explanation of how its profile matches the tasks in the proposal;
- a curriculum vitae or description of the profile of the persons, including their gender, who will be primarily responsible for carrying out the proposed research and/or innovation activities;
- a list of up to 5 relevant publications, and/or products, services (including widely-used datasets or software), or other achievements relevant to the call content;
- a list of up to 5 relevant previous projects or activities, connected to the subject of this proposal;
- a description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work;
- any other supporting documents specified in the work programme for this call.

(Arroyo) The University of Seville is an institution that provides the public service of superior education by means of studies, teaching, and research, as well as the generation, development and diffusion of knowledge to serve citizens and society.
Department of Chemical and Environmental Engineering is a research group of the High Technical School of Engineers (ETSI) of the University of Seville (US), DIQA-ETSI-US.
In the environment sector, DIQA-ETSI-US's activities are centered on:

1. CO_2 Capture and Sequestration
2. Waste Analysis and Evaluation
3. Protection and Inspection Processes
4. Hydrometallurgy
5. Conservation of historical heritage: the historical heritage is a resource of great importance. Due to human activity (pollution, traffic, use of historic buildings, public works) deterioration has advanced very rapidly in the last 50 years, so it has become necessary to implement measures to correct these negative effects. The group interest focus on reducing this deterioration, conducting research related to: 1) physical chemistry and mechanics of materials (stone, mortar, brick) and their conservation status characterization, using non-destructive testing techniques physical; 2) investigation of the deterioration factors (climate, air pollution, use of the building) and 3) evaluation of materials and products treatment (strengtheners, water repellents, restoration mortars) with assays that determine their effectiveness, compatibility with original material and its resistance to accelerated ageing (http://departamento.us.es/diqaus/investigacion/lineas-de-investigacion/patrimonio-historico/) **(Arroyo)**

(Arroyo)
Curriculum vitae;

ADMINISTRATIVE DATA	
Organisation legal name	University of Seville
Organisation short name	US
Country	Spain
PIC number	999862518
STATUS	
Type of organization	Research organization/Non-profit organization
KEY PERSONNEL INVOLVED IN THE PROJECT	
Name	**Rosario Villegas Sánchez**
Email	**rvillegas@etsi.us.es**
Short CV	Rosario Villegas Sánchez is an Associated Professor at the department of Chemical and Environmental Engineering, since 1983. She has received her M.Sc. degrees in Industrial Engineering at the Faculty of Engineering of the University of Seville, Spain, in 1982 and her Ph.D. in Chemical Engineering at DIQA in 1989. Her main research interest during all her professional career has been in conservation of historical heritage: evaluation of treatments for restoration works and application of non-destructive techniques. She has collaborated widely in conservation projects of important cultural objects.
Family name	**Fátima Arroyo Torralvo**
Email	**fatimarroyo@etsi.us.es**
Short CV	Associated Professor at the department of Chemical and Environmental Engineering, since 2001. She has received her M.Sc. degrees in Industrial Engineering at the University of Seville in 2001 and her Ph.D. in Chemical Engineering at DIQA in 2007. Her research interests, in addition to educational issues in the Chemical and Environmental Engineering field, are focused on conservation of historical heritage and industrial waste valorization. She has authored publications and technical papers in these topic areas.
Family name	**Luis F.Vilches Arenas**
Email	**luisvilches@etsi.us.es**
Short CV	Luis F. Vilches is an Associated Professor at the department of Chemical and Environmental Engineering, since 1995. He has received his M.Sc. degrees in Industrial Engineering at the School of Engineering of the University of Seville, Spain in 1991 and his Ph.D. in Chemical Engineering at DIQA in 2000. In recent years his main research interest has been in waste water treatment and recycling of

	industrial by-products.
Family name	**Yolanda Luna Galiano**
Email	**yluna@etsi.us.es**
Short CV	Yolanda Luna is an Associated Professor at the Chemical and Environmental Engineering since 2003. He has received his M. Sc. Degrees in Industrial Engineering at the School of Engineering of the Universitiy of Seville, Spain, in 2001. Her main research is focused on the industrial solid waste engineering: waste treatment (stabilization/solidification of solid waste with hazardous metals) and recycling and valorization of industrial by-products (geopolymers field), where she has published some papers.

Publications;

- Arroyo Torralvo, Fátima, Alcalde Moreno, Manuel, Villegas Sánchez, Rosario: Effect of the Diameter and Colour of Colorimeter Aperture Reducing Templates on Colour Coordinate Measurements. *En: Materiales de Construcción*. 2008. Vol. 58. Núm. 291. Pp. 99-109.
- Robador Gonzalez, Maria Dolores, Arroyo Torralvo, Fátima, Perez Rodriguez, Jose Luis: Study and Restoration of the Seville City Hall Façade. *En: Construction and Building Materials*. 2014. Vol. 53. Pp. 370-380.
- Rosario Villegas and Fatima Arroyo. The cathedral of *Jerez* De La Frontera (Cádiz, Spain): Stone degradation and conservation Journal of Cultural Heritage DOI: 10.1016/j.culher.2012.10.023h
- F.J. Alejandre, V. Flores-Ales, R. Villegas, J. Garcia-Heras, E. Moron. Estimation of Portland cement mortar compressive strength using microcores. *Influence* of shape and size. Construction and Building Materials 55 (2014) 359-364.
- R. Villegas, C. Nuñez, F.J. Alejandre, F.J. Blasco. Technical studies for the restoration of the Inmaculate Conception monument, Seville. Science and Technology *for* the Conservation of Cultural Heritage, Taylor & Francis Group, 2013, 337-340. ISBN 978-1-138-00009-4 http://www.crcpress.com/product/isbn/9781138000094

Previous projects;

- Characterization of Materials (Opus caementicium, Masonry and surperficial deposits), factors and indicators of alteration and study of the effectiveness of conservation treatments to the Roman Theatre in Cadiz. (2339/0233).2014-15
- Study of Consolidating treatments for Macael marble and plaster by “in situ” tests in the Alhambra. (1983/0233)2013-14.
- Agreement between the bishopric of Asidonia - Jerez and AICIA for the study of the Cathedral of Jerez de la Frontera (ES-1148/2013) for the study of Nuestra Señora de la Antigua Torrealhaquime Church (ES-1149/2013) for the study of the Minor Basilica of Nuestra Señora de la Caridad Coronada in Sanlucar de Barrameda (ES-1151/2013).
- Preventing damage by crystallization of sodium carbonate in stone material heritage. Call for March 1, 2014 for financial aid "Campus of International Excellence PatrimoniiUN10" for programs of international research on cultural and natural heritage. 2014-15.
- Impact of urban atmospheric aerosol paints / *polychromy* of architectural monuments (semi)open. Predicting changes and preventive conservation. AERIMPACT (2013-15) CGL 2012-30729.

Infrastructure and/or any major items of technical equipment, relevant to the proposed work;

- Climatic Chamber
- Surface area and porosity analyzer, micromeritics ASAP 2020
- Agilent Technologies 5100 ICP-OES
- Thermogravimetric analysis, METTLER TOLEDO TGA/SDTA 851
- Universal Testing Machine, TINIUS-Olsen
- Mercury Porosimeter, micromeritics AutoPORE IV
- Colorimeter Minolta CR210
- Ultrasonic tester, SteinKamp BP-5
- Measurement of Adherence, Neurtek KN-10
- XRD, Bruker D8 Advance A25
- FRX, Panalytical AXIOS: EDAX, Eagle III

- Scanning electron microscopy, Philips XL-30. Jeol 6460 LV

(Arroyo)

(Paladini 3) *The legal entity*

The Institute of Structure of Matter (ISM) of the Italian CNR consists of about 120 researchers, and associated academics, including chemists, physicists, biologists. It also has a scientific unit at Elettra, the Synchrotron Radiation Laboratory in Trieste (Italy), where CNR-ISM runs three beamlines. The mission of CNR-ISM covers different aspects of the physical and chemical sciences exploiting both experimental and theoretical advanced approaches. Its activities find applications in areas such as energy, environment, biological systems, electronic and magnetic devices, and cultural heritage. The institute's activities range from theoretical modelling to development of prototypal devices. This is achieved via the study of the processes, the preparation and functionalization of materials, and the characterization of their structural and electronic properties with novel instrumentation and methodologies.

In particular the research activity is organized according to the following areas: laser-matter interaction and laser spectroscopies; chemistry and physics of functional materials (e.g. nanostructured, organic inorganic, magnetic materials, semiconductors); materials and devices for energy conversion from renewable sources; structural and surface diagnostic techniques; dynamics of atomic and molecular systems in gaseous phase and at the gas-surface interface; development of methodologies and instrumentation for Synchrotron and Free Electron Lasers.

Every year, the groups of the Institute host and tutor several graduate and PhD students both Italian and foreign. CNR-ISM with its facilities and outstanding research activities which result in a high publication rate (ca. 100 papers per year, about 10 of them in journal with IF>6) provides an inspiring and stimulating environment for young scientists.

The longstanding experience of CNR-ISM staff in energy and time resolved laser spectroscopies will be crucial for the achievement of the objectives of the project. In particular, CNR-ISM laboratories are equipped with different laser systems, providing tunable radiation in the UV-vis-IR, with pulse duration from few ns down to 100 fs. In the frame of the EuroFEL project a new laser laboratory has been recently developed at CNR-ISM, which will provide shorter laser pulses (ca. 30 fs).

The ability of the CNR-ISM to build experimental set-up and to develop in house analysis and acquisition software will be instrumental to the realization and implementation of portable spectrometers. Free access to mechanical and electronic workshops will be also provided by CNR-ISM.

Participants (to be completed)

1 senior researcher, 3 researchers, 1 technologist, 3/4 technicians.

A list of up to 5 publication on peer reviewed international journals.

1. A. Paladini, F. Toschi, F. Colosi, G. Rubino, P. Santoro, "Stratigraphic investigation of wall painting fragments from Roman villas of the Sabina area", Applied Physics A, 2015, 118 (1), 131-138. DOI: 10.1007/s00339-014-8815-3.
2. F. Toschi, A. Paladini, F. Colosi, P. Cafarelli, V. Valentini, M. Falconieri, S. Gagliardi, P. Santoro, "A multi-technique approach for the characterization of Roman mural paintings", Applied Surface Science, 2013, 284, 291-296. DOI: 10.1016/j.apsusc.2013.07.096
3. A. De Giacomo, M. Dell'Aglio, O. De Pascale, R. Gaudiuso, A. Santagata, R. Teghil, "Laser Induced Breakdown spectroscopy methodology for the analysis of copper-based alloys used in ancient artworks", Spectrochimica acta. Part B, 2008, 63, 585-890. DOI : 10.1016/j.sab.2008.03.006
4. A. Santagata, A. De Giacomo, O. De Pascale, M. Dell'Aglio, R. Teghil, A. De Bonis, M. Corrente, G.P. Parisi, S. Orlando, "Femtosecond/Nanosecond dual-pulse orthogonal geometry plasma plume reheating for compositional analysis of ancient copper-based-alloy artworks", Journal of physics. Conference series, 2007, 59, 585-890. DOI: 10.1088/1742-6596/59/1/125
5. V. Lazic, R. Fantoni, F. Colao, A. Santagata, A.Morone, V. Spizzichino, "Quantitative laser induced breakdown spectroscopy analysis of ancient marbles and corrections for the variability of plasma parameters and of ablation rate", Journal of analytical atomic spectrometry, 2004, 19(4), 429-436. DOI: 10.1039/b315606k

Projects (to be completed)

- Progetto Premiale 2012 SM@RTINFRA-SSHCH "Infrastrutture integrate intelligenti per l'ecosistema dei dati delle scienze sociali, umane e del patrimonio culturale". Coordinators of ISM Unit: Elisabetta Agostinelli, Alessandra Paladini. MIUR Funding: 15.000 Euro.

- Collaboration Agreement with other CNR institutes working on Cultural Heritage in the Rome Research area, i.e. ISMA, ITABC, ICVBC. The agreement is aimed at the study, conservation and valorisation of the roman villas and artefacts of the *Sabina tiberina* area. Starting from 2015.
- National Program (PON) "TECSIS- Tecnologie diagnostiche e Sistemi intelligenti per lo sviluppo di parchi archeologici del Sud Italia". Partecipation to the WP: Pulitura ottica di superfici con diagnostica on-line e modellizzazione. Starting from 20-09-2002.

Infrastructure and/or any major items of technical equipment, relevant to the proposed work;
-Raman spectrometer; single and dual-pulse Laser Induced Breakdown Spectroscopy (LIBS) at nanosecond or femtosecond time scale; nanosecond and femtosecond tunable laser systems; UV-vis spectrophotometer; FTIR; optical microscope; SEM; x-ray diffractometer.
Instruments for the acquisition of geographical and topographical data: pulsed total station, GPS analysis (if necessary), software for the analysis of graphical data.
(Paladini 3)

(Fiadeiro)
- Paulo Torrão Fiadeiro (researcher responsible) – Departamento de Física da Faculdade de Ciências;
- António Manuel Gonçalves Pinheiro (researcher) – Departamento de Física e Centro de Óptica da Faculdade de Ciências;
- Maria Manuela Areias da Costa Pereira de Sousa (researcher) – Departamento de Informática da Faculdade de Engenharias;
- João Nuno Oliveira Cruz (operational technician) – Centro de Óptica da Faculdade de Ciências.

- Grant research for a team member with a BSc degree in the field;
- Grant research for a team member with a MSc degree in the field;
- Grant research for a team member with a PhD degree in the field.

(Fiadeiro)

4.2 – Third parties involved in the Project

No third parties involved in this project

5 – Ethics and Security

5.1 – Ethics

There is no ethics issue in the ethical issue table in the Administrative Proposal Form of RESTORA, Part A.

5.2 – Security

The activities or results of this project do not raise security issues.