COBRA Project: a successful technology transfer and scientific divulgation method

ENEA opens its labs to improve cooperation with SMEs and CH Institutions

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The main objective of CO.B.RA Project is to develop and disseminate methods, technologies and advanced tools for the conservation of Cultural Heritage (CH), based on the application of radiation and enabling technologies.

Fig. 1 - Church of San Costanzo in Ronciglione: a detail first and after laser cleaning.

ENEA leads the project as the only institution funded by the Lazio Region to carry out all the activities which started on July the 21st 2015 and will end on December the 20th 2017.
The laboratories involved are dislocated in the Lazio Region ENEA (Frascati and Casaccia) research centres and in Rome Headquarters (STUDI unit); the former belong to 3 Departments:

- Energy Technologies Department
- Fusion and Technology for Nuclear Safety and Security Department
- Territorial and Production Systems Sustainability Department.

The results obtained by COBRA project include: diagnostic activities on sites, prevention of natural and human hazard, new way of fruition CH, performed upon specific intervention requests by stakeholders. Instruments and technologies have been adjusted to the solicitations of end-users, technology transfer demonstrators have been realized and put at disposal of Small and Medium Enterprises (SMEs). The implementation of ICT facilities made easier conserving the acquired data and exchanging the obtained results.
The effectiveness of COBRA has been demonstrated through the results obtained during the experimental campaigns carried out in these sites:

1. Church of Costanzo Martire in Ronciglione: Laser spectroscopic diagnostics and Laser Cleaning on frescoes by Cavalier D'Arpino atelier.
2. Forum Traiani Museum: 3D reconstruction of marble frieze pieces by structured light scanner and photogrammetric relief; Laser cleaning of stone fragments.
3. Roman Domus Valeriorum archeologic site: laser spectroscopic characterization and laser cleaning of frescoes fragments.
4. Bell Tower of the Cathedral and Theatre in Rieti: Structural monitoring by fiber optic sensors.
5. Priscilla Catacombs in Rome: 3D photogrammetry and 3D reconstruction and image processing with SfM technique; 2D / 3D laser imaging of frescoes.
7. Temple of Minerva Medica in Rome: Dynamic structural characterization of the monument monitoring structural risk caused by environmental vibrations; non-destructive investigations.
8. Saint Alexander Catacombs in Rome: Compositional and structural characterization of two frescoes; Photogrammetry; Thermography; vibrometry.
9. Etruscan Necropolis in Tarquinia: Acquisition of the 3D color model by laser scanning and photogrammetry; Laser spectroscopic characterizations of painted walls.
10. Etruscan Necropolis in Veio: acquisition of 3D model by Photogrammetry; Spectroscopic characterization of painted walls; Non-destructive testing application.
11. National Museum of Musical Instruments in Rome: Radiography of wooden historical instruments.
12. Roman National Museum in Rome (Altemps Palace): study of the state of conservation and renaissance restoration works on three roman sculptural groups.
13. Museum of Sarcophagi - San Sebastian Catacombs: laser spectroscopic characterization of Orantorum Sarcophagus prior to a restoration campaign.
14. Aurelian Walls Museum in Rome: data collection via high resolution laser scanner in the guard tower where hardly observable historical inscriptions and graffiti are located.

In this article the methodological instruments used into the project in order to create a new "shared space" - both real and virtual - where Research Organizations, Cultural Institutions and SMEs cold better comprehend and work with each other, are described. Within this shared space, from now on it should be easier to:

- create a common language that combines scientific, technological and humanistic knowledge with the craftsmanship and application expertise;
- meet needs of each other, interacting directly on site, before and during the restoration activities, in order to better plan the intervention and to adapt technologies to suit some specific needs.

In details, the benefits of creating this "shared space" are:

- for SMEs: increasing the supply of innovative technology tools; updating internal skills, by training on the job; accessing laboratories, in order to use instruments which may be expensive or unique, often made available only by public research organizations such as ENEA is.
- For CH Institutions: increasing the methods to investigate artworks through the use of technologies for diagnostic measures; improving the monitoring of the state of monuments “health” in order to prevent risks; reducing maintenance costs thanks to planning focused restoration, due to diagnostic measurements available; access to a long-term repository of row and post-processed data about all the restorations carried out; updating promotional strategies for CH.
- For Research Organizations: approaching CH by working directly on artworks and monuments with restorers: only in this way it is possible to learn about the pragmatic lacks and necessities expressed by both Institutions and SMEs working on sites; testing-phase conduced on site, to develop more effective tools; simplify technologies by creating user-friendly tools (Demonstrators) that meet the capabilities and skills of restorers and experts.

The shared space is formed by:

1. Project Website
2. Demonstrators
3. Open Labs
4. Cloud and Data Storage
5. Focus Group.

It is important to stress the complementarity of these various tools, which firstly provide access to knowledge and information at different levels of details.
Project Website
The website www.cobra.enea.it achieves the aim to provide, with a synthetic and informative language, a valid support to the knowledge about demonstrator's tools and technologies developed in ENEA's laboratories, as well as about the results of their applications. It addresses not only the project end-user (SMEs) and stakeholders (CH Institutions), but also a wide-ranging public. It has been developed using the Content Management System (CMS) open-source Plone, since it has been used for years in ENEA, and also because it allows us to manage the ongoing updating of contents via web.
In the process of designing its main architecture, to define the main areas issues, all the information about the main characteristics of labs involved have been collected by interviewing the ENEA experts researchers and technicians. In order to simplify the scientific contents, the experts were asked to fill a form with fixed fields with specific but brief information about how labs and technologies work.
Therefore, the “National Confederation of Crafts and Small and Medium Enterprises (C.N.A)” was asked to evaluate these laboratories' forms. Thanks to the feedback received from C.N.A., the contents and the website areas have been set up to meet the suggestions collected by SMEs: first focusing on the application and usefulness of tools, and then linking a contact person to email directly.
During the first project workshop, the level of interest of SMEs to the service of ICT provide by ENEA have been surveyed by a questionnaire. The most SMEs had expressed interest to an easy access to information, first of all about instruments and services available. Therefore, even the website's contents have been editing to satisfy these requests.
This website has managed to fill an ENEA internal communication gap, creating a single web point to access the most of technologies and skills on CH in Latium Region.
The website section Laboratories was structured as follows:

- Laboratories for diagnostic investigation;
- Laboratories for the structural characterization and protection from natural hazards;
- Laboratories for the materials and surface's treatment.

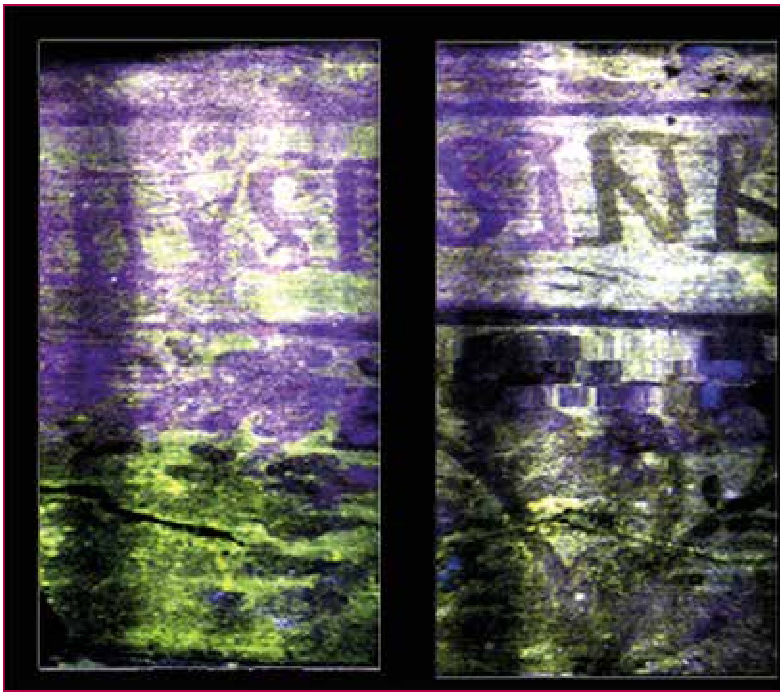

Fig. 2 - Catacombs of Sant'Alessandro in Rome: laser induced fluorescence (LIF) on an inscription.

Fig. 3 - Priscilla catacombs in Rome: 3D model of the Greek Chapel.

To better describe activities and results two additional sections have been created:

- Interventions: includes forms filled with information about all the campaigns of measures carried on CH, which have been also highlighted on a multimedia map implemented using Web GIS Application.

- Demonstrators: includes forms about technical characteristics of some instruments developed in the project and designed to be used by SMEs on sites. These forms describe also the demonstrarors' innovative functions, situated in laboratories available to SMEs.

Between the site's main sections - Laboratories, Interventions and Demonstrators - there is a close connection, which is pointed out by the numerous internal reference links. In order to explain better Demonstrators' functioning and applications, some available Tutorial's videos have been produced.
The offer of instruments by enterprises collaborating with some labs, is in the section about the Showroom: a staged room (inside Frascati Research Centre) where laser systems are made available of SMEs for laser cleaning texts and experiments. In order to make easier the cooperation with SMEs, a "request for action" form has been designed and it is available on the website Home Page: filling out this, the SMEs and CH Institutions located in Lazio Region can ask ENEA to cooperate on a specific intervention.
For foreign public relevant pages have been translated in English.

Fig. 4 - Mercati di Traiano - Museum of Imperial Forums in Rome: 3D reconstruction of the Sphinx Frieze by structured light scanner.

DEMONSTRATORS

User-friendly prototypes have been implemented during the project in order to be used by SMEs' restorers and technicians. New functionality, applicability and usability are the main features of these instruments. In some case, Demonstrators are manufactured for specific actions which need new and mobile instruments, easier to be used than the most advanced technologies already available at ENEA. In other case, fixed tools available only in labs, have been customized to fit the most common way-of-working for CH professionals. The companies interested to test them and to learn their functions can contact directly the developers.
List of Demonstrators:

1. COBRAKIN: 360 degree and 3D real-time video for monitoring and surveillance of internal environments (e.g.: museums)
2. SPRITZ: Terahertz Imaging Spectrometer, for morphological and chemical characterization
3. Dynamic and structural monitoring by optical fiber sensors FBG
4. J-SYSTEM SMART - optical fiber sensors integrated into structural elements for permanent monitoring
5. CALIFFO: Laser induced fluorescence measurements
6. PIXE: Particle Induced X-ray Emission, based on proton accelerator
7. LIRA: Laser Induced Breakdown Spectroscopy and RAMAN Spectroscopy Integrated System
8. LINAC: LINear Accelerator for volume treatments to remove biodegradation and organisms on the first layers of artefacts (paper, canvas and wood).
9. SAGACE: Software for Algorithms for Management, Statistical Analysis, Comparison and Elaboration of spectrographic data in image format.
10. DREAM: Multiple Excite Raman Demonstrator.
11. Demonstrator of handling and transportation of art works.
12. Demonstrator of tests on vibrating table.

OPEN LABS

Since some ENEA labs are not usually open to everybody, due to safety and security matters, another goal of the project has been to make possible sharing of technologies and remote fruition of experiments. Thus, a network of webcams has been supplied into the labs to allow video and data streaming on the web. Moreover, the integration between streaming and archiving systems will allow everyone to see experiments in a delayed time.
Structural Dynamic, numerical Simulation qualification tests and vibration Control - DySCO is the first example in Italy of Virtual Lab for remotely shared experimental tests on a network platform consisting of two large scale oleo dynamic seismic tables and two electro dynamic shakers. Within COBRA project a 3DVision system was recently updated with new NIR cameras and ICT tools were integrated to improve data sharing and streaming by the Cloud E3S.(Mongelli, 2016).
Cloud E3S ENEA Staging Storage Sharing System
E3S is a Staging Storage Sharing System for Data Handling in a multisite laboratories and organizations designed by ENEA ICT experts, in order to meet the needs of researchers, technicians and specialists working on CH. In large organizations the laboratory experiments produce a huge amount of data and their processing and storage management are a challenging issue. Cloud architectures are exploited for storage solutions and data sharing as well, in order to realize a collaborative worldwide distributed platform. Whilst large experimental facilities manage themselves ICT resources such as: compute, networking and storage, small experimental laboratories are demanding more and more resources for their

own scientific instruments aided by data acquisition and control systems, especially in terms of storage and sharing/publishing data solutions. E3S system has been developed over the ENEA GRID infrastructure using Own-Cloud as architectural component for file syncing and sharing. E3S provides a homogeneous platform able to store and share heterogeneous data produced by many different laboratories geographically spread on several sites and working on collaborative tasks. The systems for CH diagnostic include computer aided instruments, producing a huge amount of raw data that need post-processing analysis. The different diagnostic instruments generate a large variety of data, spanning from slow time-series to high frequencies sampling, to 2D and 3D scans and so on. Experiments are often carried out on the CH site and the data acquisition systems are remotely controlled. The structure of the raw and post-processed data of all diagnostic instruments has thus a high complexity, and designing a common data model for an uniform data access is not a convenient strategy. A solution was designed in order to hide the data structure complexity allowing users to store data in local staging areas and synchronize there with distributed filesystems for worldwide sharing. In this way the data integrity is guaranteed, whereas the security is provided by the single-signed on authentication/authorisation system that includes also the Access Control List for storage areas (Iannone, 2017, pp. 1-3).

Access via data-sharing by authorized external users through the cloud-sharing system is guaranteed by the middleware node, accessible from any location. The E3S interface allows the data manager to define the data sharing policies in a simple and secure way. This architecture fits well with the CH needs, where the results of the experiments have to be shared - in a safe way - with a number of different subjects: authorities, restorers, students, etc. The actual data repository over time can also be threatened by the rapid obsolescence of technologies. To overcome this future problem the data have to be accompanied by metadata about format, acquisition equipment and software used in post-processing. These solutions include also physical backup strategies and proper disaster recovery procedures (Calosso, 2016, pp. 24-29).

REFERENCE SCENARIO

THEMATIC AREAS	SCENARIO 1 TECHNOLOGICAL ACCELERATION POLICIES	SCENARIO 2 TECHNICAL TRANSFER POLICIES	SCENARIO 3 INNOVATION DRIVERS ENTERPRISES	SCENARIO 4 COMPANY NETWORKS
Development and management policies sector	Main solutions from the public sector	Main solutions from the public sector	Main solutions from the private sector	Main solutions from the private sector
Economy and market	PA subsidies and rewards in the most innovative technology announcements.	PA subsidies to create business networks and to access technologies at low cost.	Companies fund research and get technological innovation.	Companies aggregate in competitive multiservice networks.
Innovation and technology transfer	Technological innovation key role. Public research speeds up.	the public sector helps strategic organization of knowledge and skills	Technological innovation key role. Private research speeds up.	Strategic organization of knowledge and skills made by companies.
Impact on PAs and companies	The most innovative companies remain on the market; small non-specialized operators disappear. PA invests in upgrading and training specialists.	Business networks become industry lobby. PA defines new professional figures.	More forward-looking companies innovate and operate on a global scale. PA adjusts to progress.	Companies adjust to technological innovation as needed. PA more receptive to innovation.

FOCUS GROUP

Since the project is addressed to implement different ways to engage technical collaboration with regional end-users, meetings were held using the Focus Group (FG) approach. During three FG meetings the actors of the CH chain have been given the opportunities to face and discuss altogether specific issues about the use of technology.

The FG methodology is based on interactions, focused on a given subject, between selected groups of people, by interviews aimed at an in-depth exploration of opinions, motivations and attitudes, highlighting the elements of convergence. It is a very common technique used in social research, usefull to have an overview of a given situation in a short time and with low investment.

Through COBRA FG it has been possible to identify problems and barriers to the development of a successful technology transfer process, looking for their causes and then plan actions for overcoming them. In fact, the analysis of opinions has been aimed, in one hand, at comprehending the level of acceptance of the new technologies already established and, on the other hand, at exploring what are the new tools that CH operators really need.

Stakeholders operating on Lazio Region have been pre-selected to participate to FG Cobra from the following lists:

- National Institute for Conservation and Restoration (ISCR)
- Italian Restorers Association (ARI)

Fig. 5 - Roman National Museum: Two Demonstrators during measurements on sculptures: imaging system and line scanning system.

- Italian Association for Architectural, Artistic and Urban Restoration (ASSORESTAURO)
- National Anti-Corruption Authority (ANAC)
- The list of enterprises available on the website “Lazio Futouring” of the Technological District for Cultural Heritage and Activities of Latium Region.

THE FIRST FG

An investigation on existing and potentials networks of SMEs and other relevant stakeholders in CH was conducted. Thus, it was possible to analyse dynamics that can affect the transfer of technological innovation.

Because of one of the FG's success requirements concerns the presence of well-informed participants, before the FG two project workshops were organized: the 1st workshop main purpose was to present the project aims; the 2nd was about the preliminary results of activities carried on artworks. Before and during these workshops a survey was done to better know who were the end-users and the stakeholders, in order to subdivide FG participants into three homogeneous groups:

1. ICT companies, fruition, valorisation and technical
2. Restoration and construction companies
3. CH Institutions and Research.

Each group worked with the help of a facilitator and with the support of some ENEA experts involved in the project. In the 1st phase each participant was asked to illustrate the role and weight the technologies currently have in his work. Therefore, the advantages and obstacles perceived about the use of technology were talked about. Then, the results of the work made by each group was shared with all the other 2 groups with brief presentations.

The 2nd phase started with the presentation, made by ENEA experts, about:

1. Diagnostic analysis aimed at treatment of materials and surfaces
2. Structural characterization and preservation by natural hazards
3. Fruition of 3D models and digital data storage.

The participants were divided into 3 groups focused on these 3 research areas. First the "concrete" interest in these areas, and then the barriers that the specialists could encounter using the related tools and technologies were highlighted. The debate was very useful, since relevant clarifications were provided by ENEA.

Finally, all the participants were asked to suggest some solutions for an efficient technology transfer strategy: creation of a database; easy access to application experiences; a greater adaptability of equipment to various contexts of use; a stronger support for training about upgraded tools and a real valuation by public administration (PA) of technological instruments in use.

THE SECOND FG

It has focused on the definition of a scenario shared between participants at a regional scale, in order to define a future technology transfer common strategy. The methodology used was the “Planning Scenario”: a strategic method that organizations use to make their long-term plans flexible. It allows us to imagine what might happen to be ready to face or address problems and variations. It does not concern the prediction of the future but rather intends to describe what is most likely to happen based on the status quo assessment. It allows us to associate specific problems with those who have the responsibility to resolve them. It is the only method of participation officially recognized by the European Commission with a registered trademark: European Awareness Workshop Scenario, EASW®.

Few days before the FG, some Reference Scenarios were preliminarily proposed at all the invited participants:

At the beginning, participants were divided into 2 groups, each of whom were asked to imagine being in 2027 and to assume that through the COBRA project the technical-scientific outcomes have been successfully transferred to Lazio Region's SMEs, enhancing their ability to compete. Each group discussed about what strategies have been activated and by whom, for economy, market, innovation and technology transfer. Finally, the participants were able to elaborate their specific scenario for the medium to long term, with actions and indicating who can take the responsibility to promote their realization.

THE THIRD FG

The Logical Framework Approach (LFA) methodology was used in order to identify the priorities to be implemented in a scenario which was shared with all the operators. LFA was developed in the second half of the 60's by the US Agency of International Development to improve the planning and evaluation system of projects. It is currently widely adopted by the EU Commission for the identification of strategies and projects within the Community.

The LFA method involves two phases:

1. SWOT analysis of the present situation: a strategic planning tool used to evaluate strengths, weaknesses, opportunities and threats, based on which it is possible to imagine how the situation could develop in the future.
2. Plan of actions necessary to achieve future goals, to ensure the feasibility and sustainability of the scenario. In this phase, the European Awareness Workshop Scenario (EASW) method is used to find an agreement between stakeholders.

The work, articulated in 2 groups, was based on the results and, above all, on the scenarios already shared in the second FG. Each group worked on 2 strategies:

- Group A
  Strategy 1: Support for the aggregation process of operators;
  Strategy 2: Promoting innovation and technology access by SMEs.
- Group B
  Strategy 3: Increased investment and demand for "highly qualified" interventions with high technological know-how;
  Strategy 4: Create a DB; training specialists with a multidisciplinary approach.

Then, for each strategy were identified general objectives (long-term benefits for CH and society), specific objectives and the activities, through which the strategy will be implemented by actors, and also the beneficiaries.

Finally, each strategy was shared with both groups. It is important to emphasize that the shared scenario is at the base of the synthetic document "Acts on strategic and shared actions for innovation and technology transfer in the cultural heritage sector of Latium Region". This document may support the Region in drafting new funding calls for projects on "Technologies for CH".

CONCLUSIONS

The project is concluded, thus, we are able to say that all its goals have been achieved thanks to the technology transfer methods and scientific divulgation instruments used. In particular, into the “shared space”, both real and virtual, which has been created, even after the end of COBRA, it will be easier:

- The interaction between SMEs, Research Organizations and CH Institutions, in order to better plan different interventions on monuments and artworks
- The development of specific scientific skills and new and more efficient technologies for CH
- The construction of a bigger network made up of labs integrating interdisciplinary skills and tools, that has to be opened to enterprises, researchers and public institutions, for instance within the new DTC of Latium Region.

Meanwhile the ENEA labs are becoming an hub for, on one hand, the institutions which need much specific and high level interventions and, on the other and, for the SMEs which are not strong enough to make research by themselves.
In conclusion, the method used to create this “shared space” could be easily reused and replied also in other local and national contests, even with different historical and CH conservation issues.

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ABSTRACT

THE ARTICLE DESCRIBES THE TECHNOLOGY TRANSFER METHODS AND SCIENTIFIC DIVULGATION INSTRUMENTS THROUGH WHICH COBRA PROJECT HAS ACHIEVED ITS MAIN GOAL: THE DIFFUSION AND TRANSFER TO SMES, OPERATING IN THE FIELD OF CULTURAL HERITAGE INTO THE LAZIO REGION, OF ENEA TECHNOLOGIES AND SKILLS AVAILABLE IN THE LABORATORIES AT THE REGIONAL RESEARCH CENTRES, BY DEVELOPING ALSO SPECIFIC INSTRUMENTS. MOST OF THESE INSTRUMENTS HAVE ALREADY BEEN APPLIED WITH SUCCESS IN INTERVENTIONS ON DIFFERENT TYPES OF ARTWORKS, SUCH AS ARCHAEOLOGICAL SITES AND FRESCOS.

KEYWORDS

TECHNOLOGY TRANSFER; OPEN LABS; CLOUD; FOCUS GROUP

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