GIS AS A TOOL FOR THE CONTINUOUS DOCUMENTATION: FROM THE RESTORATION OF THE HOLY SHROUD CHAPEL IN TURIN TO A COMPLETE MANAGEMENT SYSTEM

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WG II

KEY WORDS: GIS, Documentation, Restoration, CH Management, Open Source

ABSTRACT:

On April 12th 1997 a fire completely destroyed the Holy Shroud Chapel in Turin. The Chapel designed by Guarino Guarini in 1667 is now under restoration.
During the first seven years a big documentation process has been promoted by the Italian Ministry of Cultural Affairs in order to correctly plan restoration both of the structural and decorative parts.
To manage the big amount of collected data a special WebGIS, completely based on Open Source solutions, has been implemented. The data have been inserted in a geo-referenced geometric model of the Chapel. All the specialists involved in restoration used these data by making queries and analysis on the database. The WebGIS, named AGR, was completed in 2005.
The paper proposes a possible integration of AGR by collecting useful data from structural and decorative restoration works able to build up a complete knowledge system to support the following phases of management and maintenance.
Structural elements with their mechanical properties after the restoration will be recorded and all the materials and techniques used for the restoration will be saved in order to give to the future managers the possibility to monitor the stability of the structure also considering the seismic attitude of the site.
A specific monitoring system will be placed and all the sensors will send the "day by day" information to the GIS in order to point out possible critical conditions which need rapid interventions in order to guarantee safety conditions for the structure itself and for visitors. The inner surface of the Chapel has been subdivided into more than 5000 elements. Each of them will require different restoration approaches. Decorative restoration will be documented in order to know the materials used to rebuild every element. These information will help the managers to correctly plan the maintenance activities and future heavy restoration works. The selection, organization, recording and management of the data will be developed by following the suggestions coming from RecorDIM initiative and will formed a step forward to a complete documentation activity for Cultural Heritage.

1. INTRODUCTION

The Holy Shroud Chapel in Turin is part of a residence of the Royal House of Savoy (UNESCO list) designed by Guarino Guarini. Residences of the Royal House of Savoy in and around Turin represent a comprehensive overview of European monumental architecture in the 17th and 18th centuries, using style, dimensions, and space to illustrate in an exceptional way the prevailing doctrine of absolute monarchy in material terms.
Using a circular shape Guarini interpreted in a new way this idea subdividing the perimeter of a circle into 9 sectors. The three basic arches support three spherical sectors (not the usual 4 of the baroque architecture) each of them supporting two big windows (see figure 1). This idea has been repeated six times defining a system of 36 arches which define six exagons. The space is closed by a 12 tip star. The Guarini's idea is based on mathematical concepts by using multiples of the number 3 which represent, for Christians, the Trinity of God. Therefore the main intention of the architect was the spiritual elevation of the people who will visit the Chapel.

Figure 1. The three main arches of the Chapel

On April 1997 a fire completely destroyed the Chapel. First interventions were realized in order to ensure the structural stability of the Chapel but in a short time a lot of efforts were directed to design and plan a complete documentation project able to support the structural and decorative restorations.

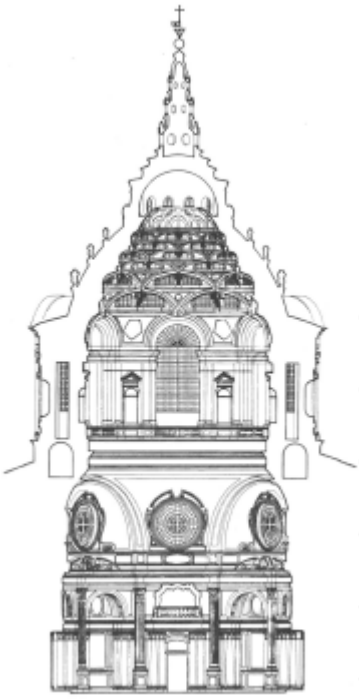

Figure 2. The holy Shroud Chapel structure

Figure 3. The Holy Shroud Chapel before and during the fire

Figure 4. Metallic scaffolds used to ensure the structural stability

The documentation project was developed by applying the rules and the recommendations of the RecorDIM initiative (2002-2007) supported by Getty Foundation and CIPA. A specific GIS based on Open Source platform was built-up and used to define and manage the basic information useful for the restoration planning.

2. THE DOCUMENTATION OF THE HOLY SHROUD CHAPEL

"*Heritage information - the activity and products of recording, documenting, and managing the information of cultural heritage places - should be not only an integral part of every conservation project but also an activity that continues long after the intervention is completed. It is the basis for the monitoring, management, and routine maintenance of a site and provides a way to transmit knowledge about heritage places to future generations.*" [Letellier, 2007]

These words were at the beginning of the RecorDIM initiative promoted by the Getty Foundation and CIPA and were at the basis for all the development of the documentation project of the Holy Shroud Chapel.

The main topics of the RecorDIM platforms which were used are the integration of different skills in a complex documentation project, the use of a GIS platform to manage the information coming from different fields and to build-up a complete knowledge useful to understand in a proper way the object. This knowledge is essential first of all for a correct restoration, but in a second time all the information will made possible to form a consistent management system after the restoration actions.

A complete selection of the measurements (both geometric and physical) was performed by a team of expert coordinated by a conservator which will follow all the phases of the interventions. The idea that only a correct set of data defined in a coherent coordinate system will allow the complete understanding of the structure and a correct planning of the restorations to be realized forced the idea to provide first of all a complete 3D metric survey with different accuracies considering the different use of the geometric information (from structural understanding up to the restoration of the decorative elements).

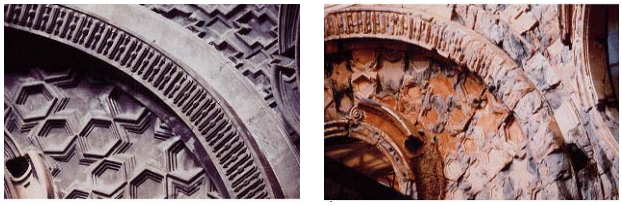

Figure 5. Decorative elements before and after the fire

2.1 The basic element of documentation

The first attempt of a correct documentation project is to individuate the basic element of the documentation or, in other words, the smallest part of the object which can collect useful information from all the involved disciplines.

Historical studies, considering the Guarini's architectural ideas, allow to considering as the basic element for the documentation a small portion of the decorative inner surface of the Chapel named "concio".

These basic elements forms also the fundamental parts of the structural model of the whole Chapel.

Considering this result, the object was subdivided into 5450 basic element (see figure 6.).

2.2 Geometric and physical investigations. First analysis.

All the analysis performed during the first years was recorded and documented for each basic element:

- geometric survey

- photographic survey
- direct disease recording
- chemical analysis
- geophysical analysis
- structural analysis

Figure 6. Basic elements (*concio*) of a portion of the Chapel

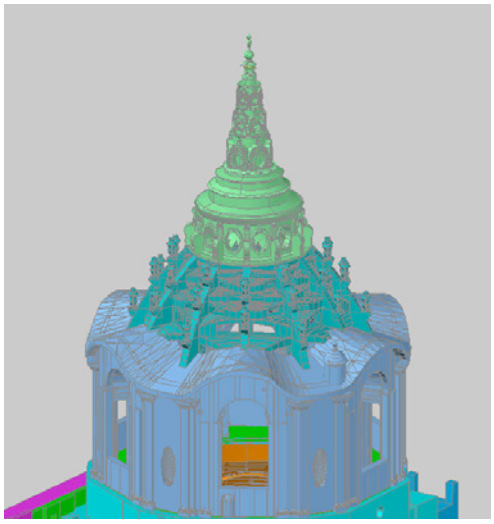

Figure 7. View of the 3D geometric model

All the obtained results were inserted in a database able to show the results both for each of the basic elements and for groups of them.
By inquiring the database the users can visualize a report for each basic element (see figure 8).
During the fire a lot of fragments of the decorative surface fall down on the basement of the Chapel: each of the useful fragments were than surveyed and classified and, when possible, connected to the corresponding basic element. A special data structure for each finding has been realized in order to allow a possible use of the fragments during the restoration phase.
For each basic element experts assigned different scores concerning the degree of deterioration, the structural function, structural risk coefficient able to point out different levels of damages occurred to the Chapel, percentage of the decorations completely destroyed and other useful information. All these indexes were decided by the documentation team in order to finalise the collection of information to a consistent set of information useful for the restoration planning activities.

2.1 The GIS for the use and the dissemination of the results

The big amount of data to be managed, the number of experts involved during the data collection and for the restoration planning were the main reasons which forced the documentation team to plan a specific GIS for the collection and management of the data.

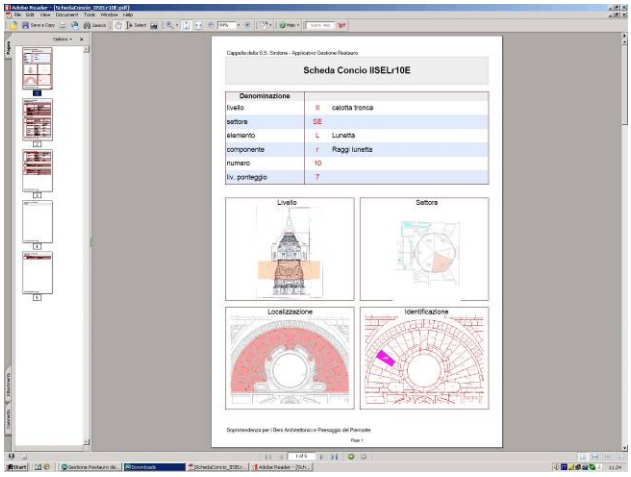

Figure 8. Report of a basic element organized in a *pdf* file

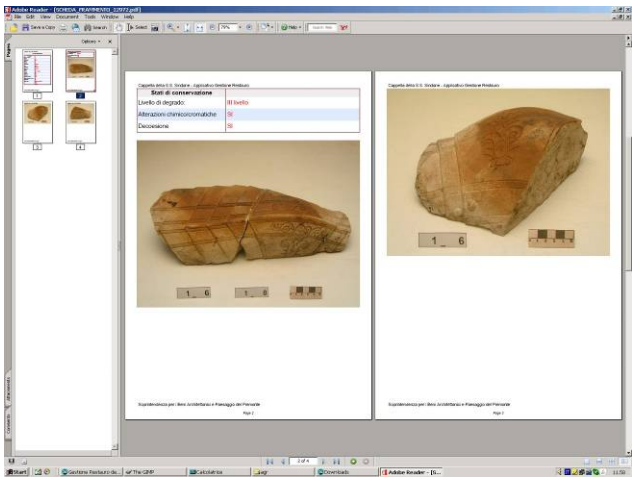

Figure 9. Report of a fragment related to a specific basic element organized in a *pdf* file

Following the RecorDIM statements a complete Open Source approach was adopted for the development of the AGR platform. In addition a WEB approach was chosen in order to concentrate the data storage in a unique server and to allow different access to the experts: some of them can modify (edit and update) the data and other can just see and inquire the database.
The used DBMS is the Postgres intergrated by the PostGIS tools and the MapServer graphic tools have been adopted as basic graphic platform of the application.
The database organisation was carefully designed in order to connect all the useful information and a specific “query builder” was implemented in order to simplify the direct inquiry of the database by the specialists usually not expert in database management.

The AGR has been conceived as a hierarchical structure where all the accesses and use of the data have to be allowed by a unique responsible in order to avoid improper use and input.
The following figures show some of the basic inquiries realized by the restores during the planning of the interventions.
Figure 10 shows the multiple (orange) and single (red) stone cracking over a portion of the Chapel.

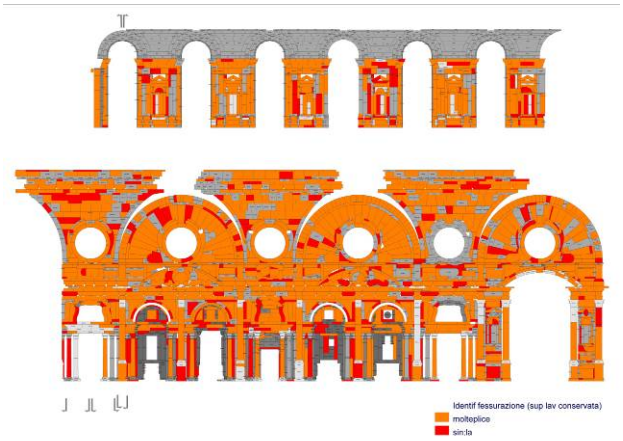

Figure 10. Stone cracking

Figure 11 shows the different percentages of the decorative losses over a portion of the inner surface of the Chapel.

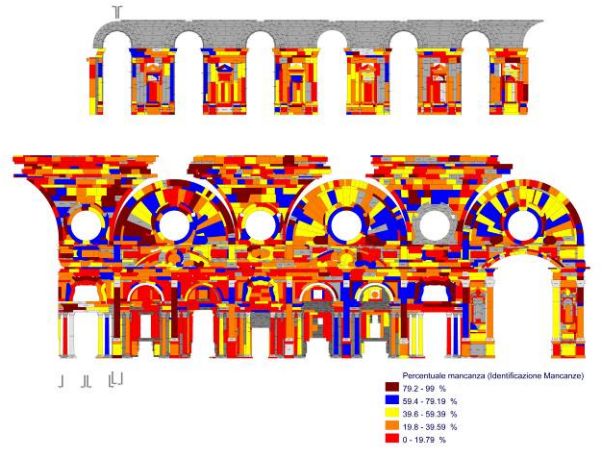

Figure 11. Percentages of decoration losses

3. THE RESTORATION DESIGN

During the planning of the restoration interventions the data acquired for each basic element were used to subdivide them into 4 different classes of actions:

- basic elements restored *in situ* by using epoxy resins;
- basic elements partially removed and consolidated *in situ*;
- basic elements completely removed and consolidates in a laboratory;
- basic elements completely modelled by using new stones.

The AGR WebGIS helps the designers into the selection of the basic elements to be classified in the four mentioned classes and during the computation of the volumes to be treated. In particular economic evaluations, essential in order to properly invite tenders for a contract, have been executed only thanks to the AGR structure and its query facilities.

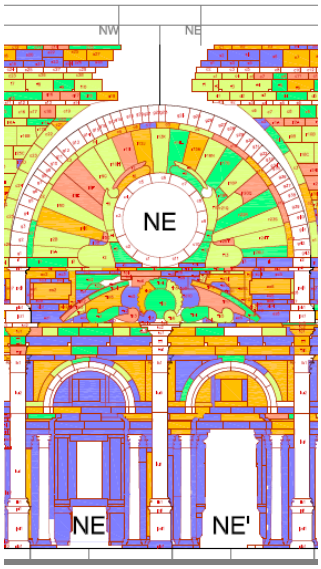

Figure 12. Extract from the restoration design drawings: classification of basic elements considering the type of restoration automatically produced as result of a query to the database

Each foreseen action on a basic element has been recorded into the specific database portion of the basic element itself and these information will form the documentation of the realized actions.
During the execution every change in the procedure will be recorded in order to build-up an updated database able to give to the future managers of the Chapel all the information useful for a correct maintenance policy.

Figure 13. Detail of a *in-situ* consolidation and restoration

4. MONITORING SYSTEM IMPLEMENTATION

The documentation project cannot be limited to the restoration planning. Following the RecorDIM statements and suggestions the Holy Shroud Chapel GIS has been designed in order to be able, after the restoration interventions, to support ordinary and extraordinary maintenance planning and actions.
"*Monitoring has become one of the key issues in conservation management. The party in charge of a region, a site, or a single building needs to know where risks exist, what is causing the changes, whether visible problems of decay are active, how fast these problems advance, and how urgent it is to intervene. These questions can be answered by comparing the present situation with reliable records produced in the past. Monitoring intended as a process of measuring change through regular inspections and the production of sequential, repeatable*

records is an important management tool, as it allows us to recognize problems at an early stage and to forestall larger interventions through small-scale repair and maintenance." [Letellier, 2007].
The risks related to the Chapel after the restoration will be the seismic sensibility of the site, the possible displacements of basic elements of the structure due to natural phenomena, the deterioration or the reconstructed elements.
In order to monitor the whole structure during its life a complex system has been designed able to allow a detailed and continuous check both using automatic sensors and manual inspections.
The first monitoring system will be placed during the complete substitution of more than 1000 basic elements which collaborate to the structural stability of the Chapel. During this phase the metallic structure placed just after the fire in 1997 will support the whole complex.

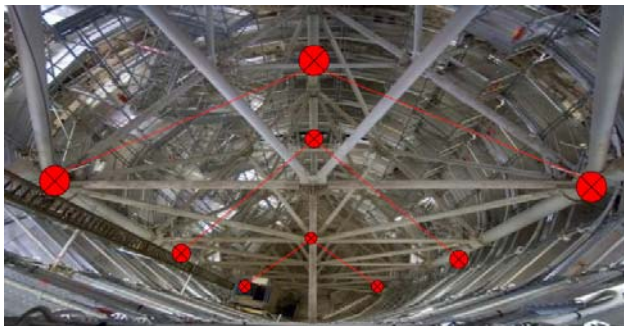

Figure 14. Electronic sensors placed on the metallic structure to monitor the structural stability during the restoration

The sensor will transmit the monitoring data directly to the AGR and the experts will be able to control and check the movements of the structure during the different phases. These information will permit a real control of the structure during the restoration and will allow quick and effective intervention when accidental mechanical actions will interest the object.
After the restoration a permanent monitoring system will be placed in order to allow a correct movement and deformation check of the Chapel and than an affordable management system of the maintenance and security.
Each basic element will be provided by means of RFID (Radio Frequency IDentification) sensors able to transmit to a receiver the ID number of the basic element: the same ID number used inside the GIS from the beginning of the documentation project.

Figure 15. RFID sensors placed on basic elements for their automatic identification

Qualified technicians will directly check the basic elements automatically identified thanks to the RFID system: a direct connection with the GIS will allow a direct reading of all the acquired data (damage analysis before the restoration, restoration actions planned and realized, previous inspections, etc.) and a real time recording of the results of the new inspection.
In order to check dynamical effects on the structure 35 MEMS (Micro Electro-Mechanical Systems) will be placed and more than 100 sensors based on a Plastic Optical Fiber technology useful to check the deformation of the structure.

Figure 16. MEMS accelerometer sensors placed to monitor the dynamic of the structure

Figure 17. POF sensor placed to check the deformations

These two last sensors will transmit the information directly to the GIS and an automatic procedure will send the data to the responsible of the monitoring system.
The transmission of the data from and toward the AGR system will be guarantee by means of wireless communication net.

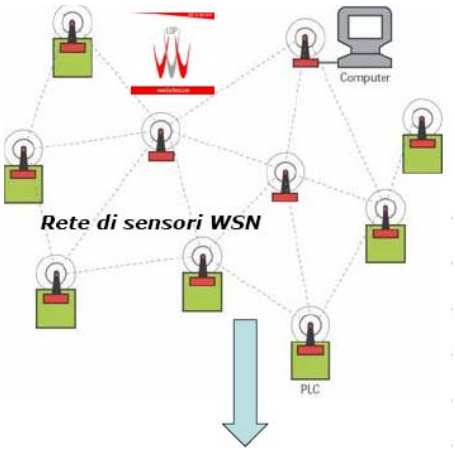

Figure 18. The Wireless communication system

5. CONCLUSIONS AND FUTURE DEVELOPMENTS

The AGR, the WEBGIS system for the documentation management of the Holy Shroud Chapel in Turin, is a system able to manage all the data acquired for the restoration of the structure and of the decorative apparatus, all the restoration interventions and in future also the monitoring system.
The system is based on Open Source platforms both for the DBMS and geometric management of the information.
The systems is strictly controlled by a System Manager who can decide accesses and use of the information.
The structural monitoring system furnishes to the system some information about the movements and deformations of the structure in order to alert in case of danger.
All the solutions provided by AGR have been reached following the ideas and the statements developed during last 5 years by RecorDIM initiative; especially multidisciplinary approaches to the documentation have been followed up in order to reach the best solutions for each documentation aspects.
The choice of an Open Source platform will allow to share the basic tools with other similar documentation projects: this was the aim of the Ministry of Cultural Affairs offices when decided to establish the project.
The AGR system is also a repository for all the knowledge about the Holy Shroud Chapel and can be used as a source from where it is possible to recover all the information useful to build up effective communication systems for different skilled and unskilled users.
Actually all the studies executed from 1997 up to now have been recorded not only in a database structure but also collected as reports in digital forms.
RecorDIM initiative represented for this particular project a good starting point and a continuous reference: the solutions provided by RecorDIM specialists allowed an high customisation level especially useful for Cultural Heritage documentation.

6. ACKNOWLEDGEMENTS

Arch. Mirella Macera, Holy Shroud Chapel documentation and restoration responsible.
LACHESI (spin-off of the Politecnico di Torino) designer of the monitoring sensors.

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