The MHS system as an active tool for the preventive conservation of cultural heritage

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ABSTRACT: The MHS project (Monitoring Heritage System) is designed as a monitoring system adapted to historical and artistic heritage that has been implemented and tested since 2005 by the Heritage Conservation department of the Santa María la Real Foundation- Center of Romanesque Studies (FSMLR). The system has been developed to measure, record, evaluate and control various crucial and influential parameters in the conservation of heritage monuments in order to ensure sustainable management and optimal maintenance of the building as well as all the elements housed within. To date, the project has become a system of reference in the cultural sector, a powerful tool to efficiently control the status of historic preservation in real time, thanks to an innovative system of sensors that transmit data wirelessly. This leads to intelligent management and dynamic results.

1 THE NEED FOR THE MHS SYSTEM

It is clear that there is a continuous need for preservation and maintenance of historical heritage. However, the huge amount of heritage is overwhelming and has gone beyond the capabilities of traditional management, which normally goes into action once significant deterioration is detected. Such "curative" types of interventions are very costly and unfortunately, it may be too late to reverse the damage already done.

It is imperative, therefore, to change this action model and to have the ability to anticipate the deterioration, to have the information needed to assess the status of each building, painting or sculpture at any given moment, and to do so sustainably. The operational viability to meet this need is subject inexorably to process automation and the application of new technologies.

The MHS system is a direct consequence of the practical need to develop functional equipment that monitors the status of heritage conservation in real time, is adapted to specific needs, is easy to install and maintain, is invisible to the eye of any visitor and at the same time is economical and efficient. Furthermore, the infrastructure required to implement the system allows a number of other features to be managed remotely from a single control center: energy consumption, ambient and structural parameters, dissemination (lighting scenes, video projection, audio guide, etc.), visitor control (automatic opening doors) or safety. To manage these elements, an identical configuration of equipment in all scenarios is required.

2 DESCRIPTION OF THE MHS SYSTEM

The MHS system has been developed as a tool to control, environmental, structural, and security parameters in movable and immovable goods. It has two objectives: to implement a methodology of preventive conservation in heritage monuments and also to generate a system and an infrastructure that permits sustainable and integral management.

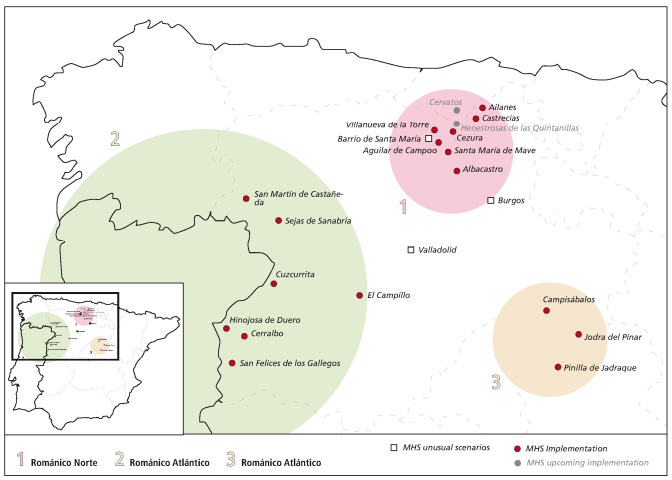

Figure 1. Location of MHS implementations in Spain.

Currently, the MHS system is installed in 21 heritage monuments in Spain (Fig. 1). In all the cases, the system has been implemented according to what was published in the VII International AR&PA Congress (Chiriac, M. et al. 2010), following the different stages:

- Previous investigation
- Installation and activation
- Research and parameter control
- Maintenance

2.1 *Equipment*

The system consists of both hardware, which includes the necessary equipment for measurement, reception, transmission and data storage, as well as computer applications or a software package that provides the user interface (Fig. 2). The configuration is set with the following components:

- A "*smart" control center* that processes all the information received from all the heritage buildings under the supervision of a specialist. It will consist of:
  a. *Server*. It receives data from central nodes in each historic building.
  b. *Database*. It stores the historical data.
- An *infrastructure of sensors* in each historic building will collect real-time measurements of parameters with different physical, chemical, mechanical, and security frequencies as well as the amount of usage. These sensors are connected to *local nodes* which periodically transmit the data to the respective central node using ZigBee technology. A *central node* in each historic building will collect all the information received by the wireless sensor infrastructure. In turn, the central nodes are connected through the available infrastructure with the "smart" control center.
- A *platform for the collection and storage of data* from the sensors manages all the matters relating to the sensors, their status, reception of the measurements originating from the sensors, sending "commands" or orders to the actuators or sensors, the storage and indexing of measurements in appropriate databases, and the implementation of reporting mechanisms for applications that are assigned to specific events or sensors.
- A set of *user interfaces* allows the possibility to access and configure the various components and obtain the information reported by the system.

Following recent developments in the MHS system, the central node is comprised of a coordinator node, an industrial computer and a GSM device for sending data. The local nodes have been designed and optimized by the FSMLR basing its development on the use of a

minimum circuit optimized for specific needs, without unnecessary ancillaries such as USB, LEDs, interface elements, expansion or input / output, yielding a device with the following features:

- ATMEGA 1281V with 8MHz frequency with external or internal ceramic antenna
- AT86RF212 Transceiver
- Radio Frequency 900MHz
- JTAG connector for external programming
- Communication with I2C sensors
- Digital inputs and outputs for actuators
- Power Source with industrial batteries -3.6V
- ABS Protection box with ventilation for sensors
- Digital sensors like SHT25 from the Sensirion brand

The local nodes collect the information from the sensors and transmit to the coordinator node directly or via an intermediate node configured as a router connected to the electrical grid. The data received by the coordinator is interpreted by a software application, which stores them in a BBDD or text file and sends it to the control center via the Internet, M2M or SMS. The goal of the Control Center is to process information either automatically or by means of a software tool based on preset protocols or by customizing it using a specialist to recognize and analyze the information.

For most rural buildings the cheapest variant is the M2M but this method is not feasible in areas with poor GSM coverage. In these cases, the communication via SMS is the most suitable. An example of this particular circumstance takes place in some of the churches involved in the Atlantic Romanesque Plan. Although they are located in Spanish territory, they are close to Portugal and get more of an intense signal from the neighboring country, making communication with the national phone lines inoperative. Similarly nationwide telephone companies vary depending on geographic location, this not only effects data transmission but it would also be extremely costly to contract several different telephone companies.

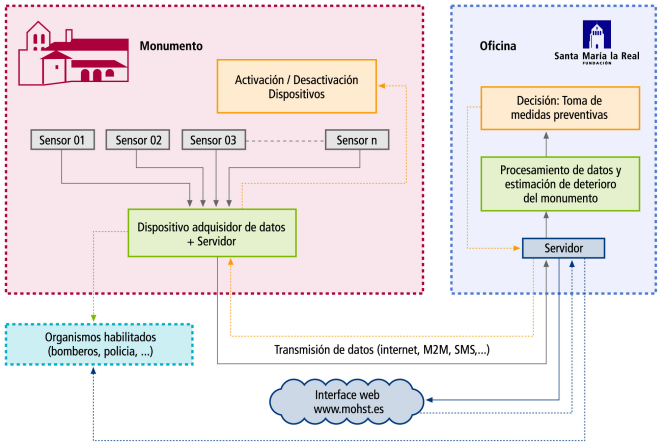

Figure 2. MHS operating generic scheme for a single building.

2.2 *The MHS system as a diagnostic tool*

Currently, data received in the Control Center is analyzed by technical specialists for each scenario individually. Incrementally, there is a plan to develop a tool to process the information automatically, estimate the damage that the assets may have under certain short term and long term conditions, trigger automation to stabilize parameters or recommend specific corrective actions. Thus, the objective is to develop software based on the implementation of mathematical algorithms developed by Statistical Process Control (SPC) and Pattern Recognition in collaboration with the University of Valladolid and the University of Salamanca.

In relation to the study and analysis of environmental parameters, we are currently

collaborating with the University of Madrid in order to use the data collected by the humidity and temperature sensors of the MHS system as a diagnostic tool for moisture in historic buildings. The data provided by the monitoring must be framed within a diagnostic protocol to be meaningful, (García-Morales, S. et al. 2012), and that there are one or more underlying questions behind monitoring. The monitoring itself is not a diagnostic tool. Therefore, in the implementation of the MHS system hygrothermal inspection is being used, developed in said diagnostic protocol to provide the necessary background information to reach the pre-diagnosis, which may require monitoring of the heritage building.

2.3 *The MHS system as a comprehensive heritage management tool*

The MHS project goes beyond just being a mere heritage monitoring system focused on preventive conservation. We believe that the technical structure proposed in the MHS system can be a powerful, effective, and comprehensive heritage management tool.

The functionality of the system depends on operating centrally around three fields of action for effective and efficient management of the assets: *knowledge*, *conservation* and *use* (López, E. 2012). The useful information collected by the system, along with other processes, substantially facilitates decision making by technicians and institutions with horizontal economic control.

By customizing the equipment needed for each section or activity and integrating the corresponding software module, a tool can be coordinated to adapt to the needs of each manager. 6 different and complementary modules relative to critical sections are proposed to meet the needs that can converge in the current management activities in the field of heritage: cataloging, conservation, safety, resource efficiency, distribution and visit control. The conservation module considers the bulk of the complex section of preventive conservation, specific maintenance actions and recommendations on actions needed in restoration.

The FSMLR gives the end user access to data via the website www.mohst.es or via custom software installed in the client´s computer.

3 CONCLUSIONS

MHS is a quality and secure monitoring system that provides understanding of the monitored building as well as the data needed to establish the optimal times to execute conservation action before the damage is irreparable.

To this we must add that monitoring should be framed in a diagnostic protocol to obtain data that serves to achieve an accurate diagnosis. Additionally, for the MHS system to be complete, the involvement of specialists in different disciplines (architects, pathologists, historians, engineers etc.) is critical. These specialists should participate in the various stages of system implementation.

The FSMLR has verified and implemented the MHS system successfully in a large number of heritage scenarios. Today we can state that the MHS system has become a reference in the sector of heritage in Spain.

4 REFERENCES

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