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III Encuentro PRECOM³OS DESAFÍOS de la CONSERVACIÓN PREVENTIVA Seminario para estudiantes doctorales, expertos y gestores de sitios patrimoniales.

UNIVERSIDAD DE CUENCA
desde 1867

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3(4)D data models and their opportunity for relevant heritage analyses under a preventive conservation approach

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ABSTRACT

Preservation of cultural heritage is progressively linked to regular maintenance and a continuous monitoring; both activities will define what is known as preventive conservation. This paper discusses the design of a conceptual model for a heritage monitoring system as a support to preventive conservation practices in World Heritage Properties. With respect to these properties the design of the proposed system starts by the choice of a data model, which is determined by different requirements. In heritage conservation, these requests are based on the values and attributes of analyzed elements. They will allow to the system the act of measuring change in the state, number or values presence. Within this framework, a conceptual model is proposed, showing how values and characteristics of heritage elements can be translated into **data requirements,** how these data requirements define a **data model,** how this data model determines the database to finally established , how the **database** determines the best choice for a Geographic Information System (**GIS**).

The paper was illustrated for building blocks in Cuenca and it gives an insight into requirements and potentials of a heritage monitoring system able to combine complex information in spatial reference system valuable to public administration (site managers) for more informed decision making and management strategies. For Cuenca and other world heritage sites, the link made between technology (databases + GIS) and heritage requirements has the objective to overcome the existing gaps and to promote a more nimble heritage management.

1. INTRODUCTION:

Preventive conservation in cultural heritage aims to avoid or mitigate the damages to a heritage property by understanding its risks and harmonizing the responsibility among actors and involved stakeholders. It also promotes maintenance as a preservation strategy based on continuous monitoring of the heritage site[1].

Since the Athens Charter (ICOMOS 1931) and continuing with the Venice Charter (ICOMOS 1964), the Burra Charter (ICOMOS 1999), and the World Heritage Convention (UNESCO 1972); different maintenance and monitoring reflections were taken place. But it is only until 1992 when the World Heritage Committee deserved special attention to heritage management procedures. Different measures to strength the control, follow up the changes over time and establish successful management strategies has been the aim for organisms such as General Committee, Advisory Bodies and the States Parties. However, with the increase of officially listed heritage sites, these properties are still facing a number of threats due to a number of risks, generated by agents of deterioration, which result in (negative) consequences for heritage properties, increasing the probability to affect its values[2].

In response to before mentioned, inscription procedures and listing requirements have been reviewed. But special attention was taken in heritage management procedures which were translated into processes for a reactive monitoring and periodic monitoring. From this perspective, in Latin America, different heritage sites worked on two Periodic Reports processes but from its experience it is clear that in spite of the importance of the writing of Periodic Reports, World Heritage sites lack monitoring instruments; which could allow them to trigger control measures to prevent, correct or mitigate problems in a preventive conservation approach[3].

This is where monitoring systems play a relevant role. According to professional practice and heritage literature Tony Walton (2003) states, monitoring systems are digital repositories which look at changes on different elements (site, building block, heritage building, etc) over a given period of time.

The Preventive Conservation Approach

As defined by ACI (1996), preventive conservation aims to "mitigate deterioration and damage to cultural property through the formulation and implementation of policies and procedures"[4]. This concept is relevant to the long term protection of our heritage. But as it was mentioned before, it is not a new concept; it was noted by the Charter of Athens (International Congress of Architects and Technicians of Historic Monuments 1931) and followed by other international charters. Nowadays a number of countries have been shifting from restoration towards a system of regular maintenance to protect their monuments and buildings. Supporting this co-called proactive protection of cultural heritage. The PRECOMOS network and the UNESCO Chair for preventive conservation, maintenance and monitoring have been established at different universities, which include the vlir project World Heritage City Preservation Management vlirCPM at the University of Cuenca. The current methodology based on PRECOMOS regarding the application of Preventive Conservation to Cultural Heritage (ICOMOS 2003)[1]. It aims to avoid the causes of damage; implement a monitoring system which could get an early detection of the symptoms of damage; and control it. As it is shown in figure 1, there are four steps for the preventive conservation processes namely: analysis, diagnosis, therapy and control. 1) Analysis gives the description of the state of conservation defined by: heritage values, damages, etc. 2) During the diagnosis stage the condition assessment is linked to the risk analysis towards 3) therapy, which proposes possible mitigation actions and later allowing 4) the control of the efficiency of the actions or mitigations proposed.

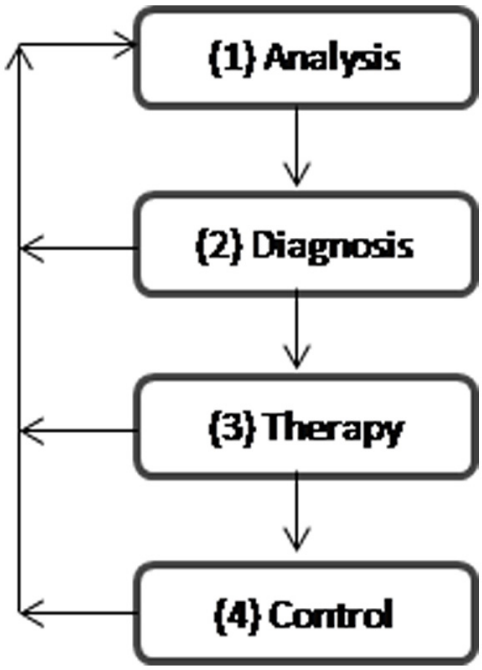

Fig. 01. Scheme ICOMOS Charter – Principles for the Analysis, Conservation and Structural restoration of Architectural Heritage (ICOMOS 2003).

Preventive Conservation presents advantages as well as challenges. It keeps the intervention to the cultural heritage at a minimum ensuring the integrity of the sites. In December 2011, within the framework of the project vlir***CPM*** an important maintenance campaign took place in Susudel, a small parish of Oña in Azuay Province (vlir***CPM***, 2011). This plan was called: "Campaña de mantenimiento emergente de edificaciones patrimoniales". Nowadays, it constitutes a successful history concerning to concrete preventive conservation actions. From the close experience with this program, it had been important to understand the basic information needed before the implementation of any plan under a preventive conservation perspective. Here both qualitative and quantitative data (state of conservation, risks, heritage values, attributes, etc) are essential for further and planned analysis. It opens a possibility to authorities to take informed decisions and standardize certain management procedures.

Management of World Heritage properties and Monitoring System

Part of proposed management procedures are giving by heritage organisms such as the World Heritage Committee. It confirmed and enhances the link that must exist between the maintenance of the Outstanding Universal Value (OUV) of a property and its management over time. Reactive monitoring and periodic reporting had been seen as part of these management mechanisms that could enables the Committee to assess if a property retains or not it's OUV. But from the experience of the Historic Centre of Quito and Cuenca there is an unclear definition of heritage values and its incorporation into management objectives. Crucial elements that are tackle on this paper and which also have constituted basic requirements for Susudel and definitely for the development of the heritage monitoring system in Cuenca.

The heritage monitoring system is based on the design of a conceptual model, which starts by the choice of a data model, determined by specific requirements: what should be monitored?, which are the allowed thresholds for a change on values?. In order to give an answer to the stated questions, monitoring indicators had been established.

Data requirements

Monitoring indicators

For several years different indicators had been used for analysing the performance of environmental, social, economic, etc. However, in the specific case of conserving heritage sites, the use of indicators is very new[5].The first attempt to develop a set of indicators of the state of conservation of urban sites took place between 1998-1999, but it was not only until 2007 when the World Heritage Centre (UNESCO) defined which conservation indicators should be measured. Those indicators are: i) indicators of pressure (threats to the asset), ii) those of state (universal values, authenticity and integrity), iii) those of response (management and public asset), and indicators for the state of conservation.[3]

In Latin America it is evident that a lot of work has to be done to fulfill all mentioned categories. However for historical city center of Cuenca the difficulty resides on a clear definition and the link between values to attributes to indicators. Therefore, the proposed monitoring system will be focused first on indicators linked to their OUV.

A step by step approach

For many reasons, it is undesirable to seek universal application of standard criteria. No exact criteria can ever accurately describe all the values of every heritage ensemble. Attempt to unify all values fail[6]. Therefore, different meetings with stakeholders had been taken place within the framework of the project vlirCPM. The last reunion has the aim to establish consensus about heritage values and attributes in the building block scale.

Stakeholders - Building consensus

When a value assessment needs to be done, it could be easier to do by oneself, or just bring in an expert who does it all. However, the end result will be much less viable, reliable and sustainable. Engaging the stakeholders increases considerably the chances of preserving the multiplicity (tangible and intangible) of values of an ensemble. In line with this statement and from the vlirCPM experience; the recognition of more “soundless” stakeholders

(common citizens, who most of the times are outside of social and political structures) is fundamental in any conservation process. In any case it is necessary to find appropriate means to communicate and engage them.

In order to accomplish the traced objective the Delphi technique was recognized and used as the strategy to gather opinions, from different stakeholders, about heritage values and attributes.

The Delphi technique

The Delphi technique has been characterized as a popular consensus building strategy among experts on an uncertain issue[6]. This technique can efficiently accomplish tasks about ill-defined and highly complex issues. Its application consists of three stages: a) identifying the important issues by asking qualified experts with a sufficient research background; b) proving and opportunity to reconsider and modify their answers by re-circulating opinions a few times; and 3) proposing potential from the final consultation phase[7]. Under a preventive conservation approach, the Delphi technique is used for deriving mutual agreement trough a feedback process within a multidisciplinary group. Kim Chang-Jun, 2010, states that "the reliability of an evaluation group is essential for organizing persuasive categorizations"; therefore in this paper, the value definition was validated by a universe group consisting of 15 executors who are local authorities, governmental institutions, citizens, neighbors of El Vado sector and part of the team of vlir***CPM*** project who have enough experience in value assessment and heritage conservation. As seen in figure 2, the mutual opinions of executors and experts have been adjusted by three Delphi rounds, and from the feedback process has identified 14 heritage values and 25 attributes at the building block level.

Selection of factors to monitor values and attributes

Once the values and attributes were recognized, a summary table was developed in order to select relevant "indicators of change" as the main support to develop of the conceptual model (bases for the GIS based monitoring system). The table below (Table 1) was the proposed template to gather these indicators.

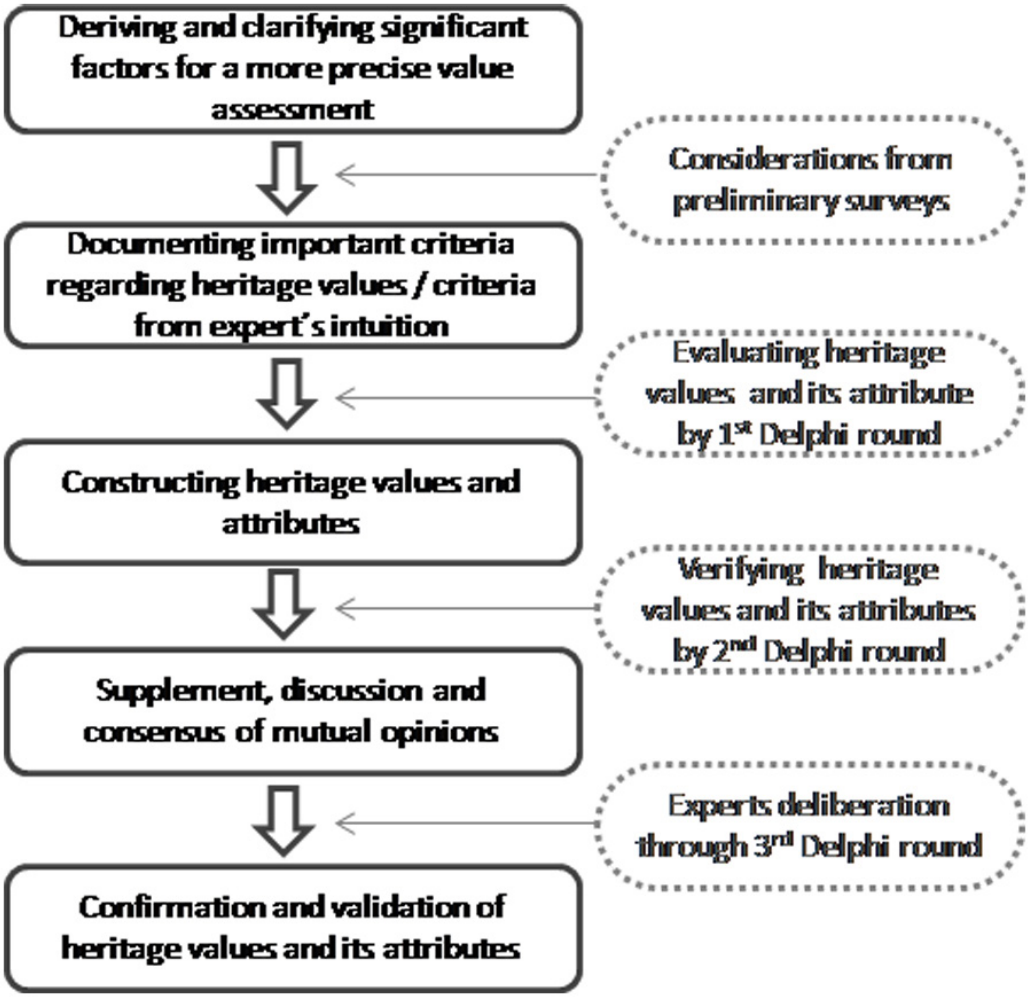

Fig. 02: Value and attribute identification process by the Delphi technique.
Source: the author, January 2012.

- Value(s): in this field heritage values were defined based on official documents (nomination file, ICOMOS evaluation, Retrospective inventory and the Nara Grid) and afterwards validated with the stakeholders.
- Attributes: key features (material characteristics on which significance resides).
- Agents of change: related with agents of deterioration (document used in Petra, source Prof. Koen Van Balen[8]).
- Indicator of change: key features that evidence change.
- Action indicator: action that could "balance" the presence of disturbances or agents of deterioration.
- Thresholds (time-space): dynamics for the analysis where two, two and a half or third dimension are important. This field indicates the limits for an accepted change.
- Type of analysis: the data analysis that could be: none dimension, two dimension, two and half dimension or related to the third dimension.

The following table show selected values that will support the analysis on two and half dimension or the third dimension:

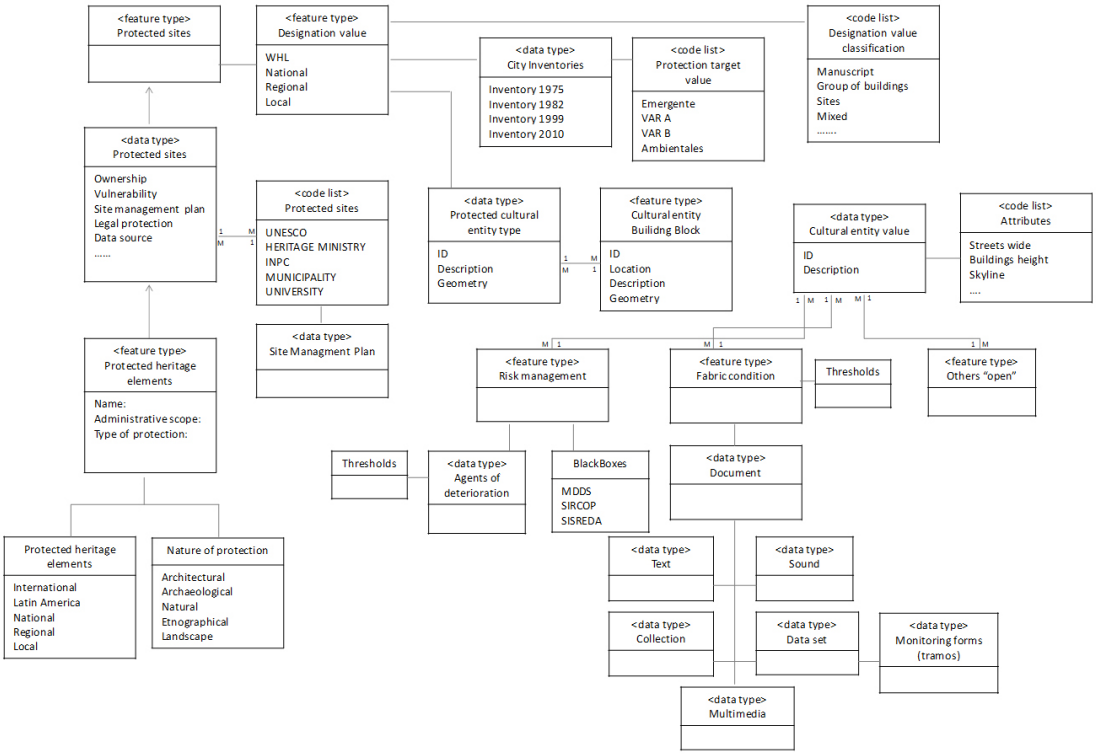

Table 1: Proposed template to gather monitoring indicators.
Source: The author, September 2011.

2. Heritage Monitoring System

The development of the monitoring system for Cuenca pretends to become a management support tool for heritage conservation.

2.1 Data model

A data model is a set of constructs for describing and representing selected aspects of the real world in a computer. Difficult choices have to be made about what things are modeled in a GIS and how they are represented. Because different types of people use GIS for different purposes, and the phenomena these people study have different characteristics, there is no single type of all-encompassing GIS data model that is best for all circumstances. Therefore the decisions about the type of data model to be adopted are vital to the success of a GIS project[9].

Values	Attributes	Agent(s) of Change	Indicator of change	Action Indicator	Thresholds for the indicators (time-space)	Type of analysis
The building blocks, shape the space perception in the historic city. It is expressed through its own scale. The urban and natural landscape is still clear and consistent, specialized and susceptible to interpretation.	-Max. height of the building block stretch. - Sky-line from the historic centre to the surroundings.	-Dissociation -(In)Direct impact from human activities or development on the fabric.	-Heights of the buildings -Width of the streets -Inscription boundaries -Buffer zone boundaries	-Building block stretch survey (Total station, terrestrial photography). -Landscape survey:Annual report	-Buildings not higher than 3 floors (aprox. 9-10m.).No more than two buildings placed in a radio of 25m. -Width of streets no less than 6 meters -Size of the WHS in hectars (max. - min.) -Size of the Buffer zone in hectars (max. - min.)	- Calculate the slope between the skyline and heigh of the buildings. - Calculate the distance between the building (línea de fábrica) and the pathway. Repeat the procedure with the street pattern. - From key visual points and within the buffer zone; calculate the slope between the skyline and heigh of the buildings. Check if the historic skyline is kept.

Table 2: Determination of monitoring indicators at the building block level.
Source: The author, February 2012.

In light to the previous mentioned, the heritage monitoring system was designed considering the requirements of Cuenca as a world heritage site but from a generic perspective that could embrace all kind of heritage spatial data and extendable to future requirements. The system will allow the possibility to query, maintain but fundamentally it will follow heritage values up and clearly determine changes that could threaten them. It means that the development of the conceptual model started by identifying heritage values, which were translated into attributes as the main elements that need to be monitor through time. Conceptual blocks and interrelationships were settled depending on the information that is relevant or could show changes on studied elements.

2.2 Structure of the data model

The development of the data model for the heritage monitoring system has three main, interconnected conceptual blocks in the schema: fabric condition, risk management, and "other factors", a subdivision that will enable different ways of extending the model depending on the nature of the implementation.

- The legal part is concerned about the legal protection of what could be considered of heritage value. This main class conveys on a set of elements for all Protected Heritage Places.
- The cultural part is established to define the heritage entity to be analyzed, such as building blocks, heritage monuments, constitutive elements, etc. This part of the model will record all aspects that give the state of "heritage" to the elements. For the pre-condition of the system, as a tool for monitoring actions, the heritage values and its attributes are identified and structured.

- The monitoring part is a set of classes designed to record "clue information" from the real world entities and which could allow a close and continuous observation.

2.3 Main elements in the model.

The proposed class diagram is set up from protected heritage elements, which in this case establish the building block as the territorial unit to be studied. Then, the model revolves around three main classes that organize its structure. These classes are.

- Protected heritage element; it gathers information about it geometry, the legal and documents (Dossier, Retrospective Inventories, Evaluations, etc), the institution responsible for the management, the scope of the legal protection (buffer zones)[10]. It constitutes an elementary enumeration of legal and management elements that might be extended in time.
- Protected cultural entity, defines the scale of work to the real world phenomena that is being studied. The studied entity will delineate data requirements.
- Monitoring entity is the key feature within the monitoring system. It is subdivided in three other entities which will reinforce the concept of the system. This monitoring criteria (elements) was established by WHC/UNESCO 2007[11], and reviewed by Silvio Mendez in 2009[5].

o The risk management part constitutes a "clue block" within the preventive conservation concept. The system will take information from other existing programs such as MDDS or S.I.R.Co.P. Interconnections with external "black boxes" intended to have a more efficient system rather than duplicate concepts.

o The fabric condition, aims to understand the state of conservation of the heritage element (attribute) through records of different types of documents.

o Finally, during the development of the monitoring system there are different factors that are also important for change identification such as: economical, social, political issues. However, the system will not develop them for this study; the block "other factors" will function as an open or extendable element for future consolidation.

2.4 Third and fourth dimensions on the Data Model

Paul A. Longley (2010) states: "Geographic analysis is only as good as the geographic database on which it is based, and a geographic database is only as good as the geographic data model from which it is derived".[9] With this statement the geographic data modeling starts with a clear definition of the project goals, it continues with users' identification and data requirements to move forward with the logical and physical models. Following the same logic and once the proposed monitoring system has been delineated as a support tool for heritage management; the elements (attributes) that will be monitored and its relationships have been identified and showed on the class diagram (Fig.3). The data requirements fit also on what the system has proposed. At this stage and regarding the data requirements, it is important to state that currently, the geographic information systems (GIS) provide a means to create and analyze models of real world in two-dimensions (2d) (GIS) and 2.5-dimensions (2.5d)(GIS). The three-dimensional (3d) applications to represent relationships and properties with 3d spatial variation are being tested in different fields. With this perspective, the present research states requirements for the 2d data but it will also try to overcome the deficiency

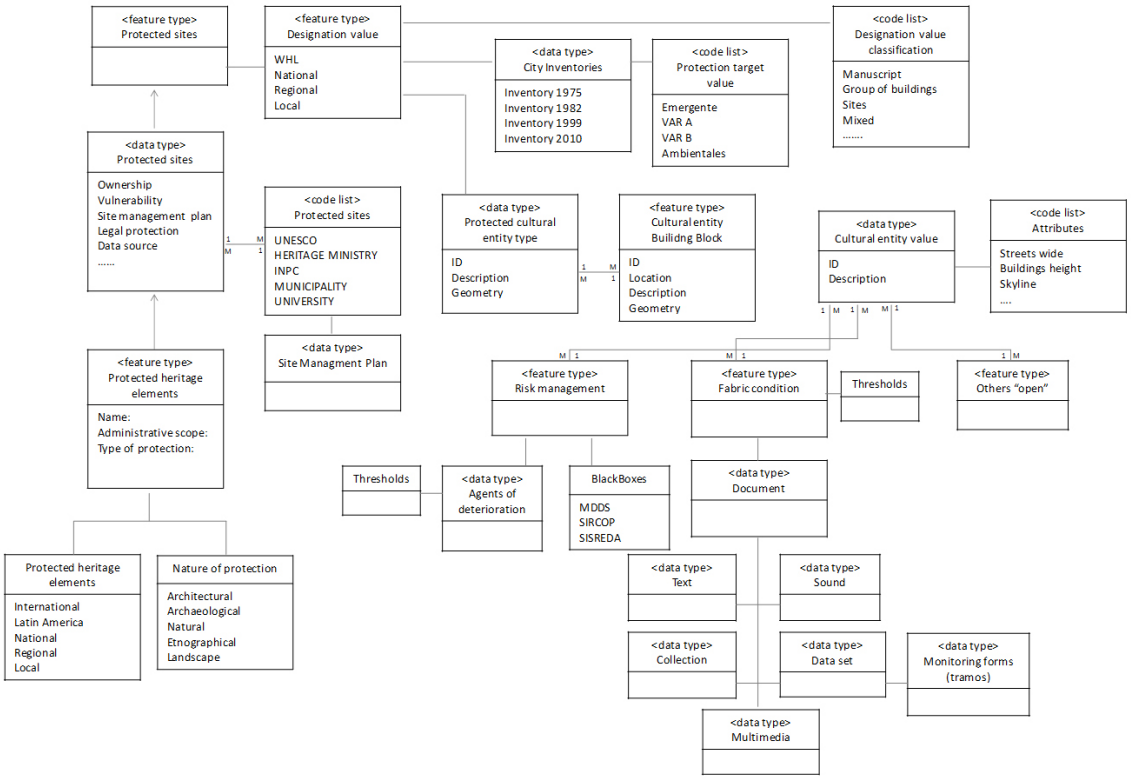

Fig. 03: Cultural Heritage Monitoring Schema. Class Diagram for the proposed Monitoring System.
Source: The author, March 2012.

time-space and to provide a general framework for a 3D data requirement, as an opportunity for relevant heritage analysis under the preventive conservation approach.

Different attempts to include spatial relationships on heritage databases are taking place (Leano, V.A., 2011)[12]. Singular studies, classified the objects according to the change of their spatial position or shape in time. For the particularities of the proposed monitoring system, three models were selected to express changes in time: i) change on their spatial position, ii) reshaping object and iii) attribute change. See figure 4 (a)(b).

3. Future research

Further work and small tests will lead to some adjustments to the diagrams, their behavior and the type of interaction between them. As part of the system requirements, the more suitable 3D data model will be established in order to find the best solution for the conservation questions (reality-model) which involve the third and fourth dimensions. This data model(s) will determine the database to finally establish the best choice for a Geographic Information System (GIS).

4. Conclusion and Discussion

The preventive conservation approach applied to the use of 3D-4D data models opens the possibility to perform relevant heritage analysis and consequently to a better manage and monitor of heritage values. The case study, the world heritage site of Cuenca, showed on one hand, that the heritage data for a better OUV management has a direct implication on monitoring procedures. Based on these arguments, monitoring indicators had been identified as clue information for the system. These indicators aspire to be an important input for two OUV management phases:

1) *Nomination phase:* from the experience related to the recognition of monitoring indicators, the nomination file could be improved by means of collecting heritage data that can assist State Parties with the preparation of the nomination dossier by guiding them to complete this baseline information

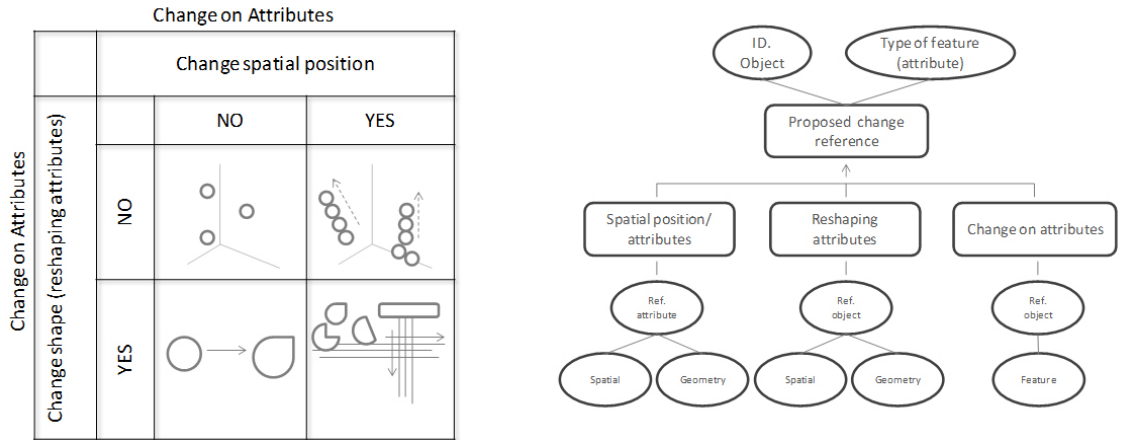

Fig. 4a: Spatio-Temporal classification for the monitoring system. Source: Leano, V.A.: Fr.En.C.I.S.: A Spatio-Temporal Framework for Cultural Heritage Data Visualization and Exploration. 7th Reasoning Web Summer School, Galway, 23-27 August 2011, March 2012.

and to further establish an ad-hoc monitoring system for the management of the World Heritage properties.

2) *Protection phase:* within an established monitoring process, the preparation of periodic reports should be the occasion to review and confirm the World Heritage values in an integrated monitoring system, improving the ability to share documentation (interoperability) and promoting international collaboration.

On the other hand, the development of 3D and 4D data models generates a number of challenges to overcome such the application and test of different models to find the most suitable solution for the conservation questions (reality-model.

To conclude, the research would like to emphasize that it is vital for a heritage site to establish a monitoring process, which should start from the identification of elements that are valuable for the site and therefore need to be conserved over time. The type of analysis and the technical tool to be used are important but secondary aspects of the process. It means such a tool (GIS) could only assist in making the process more efficient and systematic but the recognition of what is definitely important and needed to be preserved is a fundamental task for all stakeholders.

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