A GIS FOR THE MANAGEMENT OF HISTORICAL AND ARCHAEOLOGICAL DATA.

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ABSTRACT

The goal of the European INTERREG IIIB project "Roman Routes in the Mediterranean", coordinated by the Cultural Heritage Safeguard Office of the Aosta Valley (North-West Italy), is to analyse the transformations that have occurred in the Ayas Valley(AO) between the Roman times and middle ages. Six research groups, from different disciplines, have taken part in this project: classical archaeologists, medieval archaeologists, historians and geologists. A tool has been created by our group for the management of the results of the different researches, using GIS technologies for the registration, maintenance, consultation and updating of the data. The achieved experience allows to underline some general rules for the conceptual design of a GIS for the Cultural Heritage documentation and management.

1. INTRODUCTION

The European INTERREG IIIB project "Roman routes in the Mediterranean" has involved fifteen European Regions. The aim was to create a network of several pilot plans on the safeguarding and valorisation of a common historical heritage: the Roman road system.

The working group, coordinated by the Cultural Heritage Safeguard Office of the Aosta Valley, chose the Ayas Valley, as a study area, and the transformation process that occurred in the Roman road system between the Roman times and the Middle Ages, as a historical topic.

Different research groups, with specific skills, took part in this project: classical archaeologists, medieval archaeologists, historians and geologists. Each group carried out studies and analysis using different approaches and various techniques. The collected data was therefore heterogeneous and with different formats, types and aims.

Scientific research was not the only goal of this project. In the guide lines the Project gave particular attention to the spreading of the results to a large number of people (to the public).

A special tool for the management of results obtained from different research groups was created. All the collected data was organised in a GIS, designed for the correct registration, maintenance, consultation and updating of the data. In collaboration with the Cultural Heritage Safeguard Office of the

Figure 1. Example of the different typologies of the collected data.

Aosta Valley, several meetings were organised to analyse the data together with the specialists which had collected them. These meeting permitted the important information and the relationships between the data to be defined.

The two fundamental parts of the GIS were then designed: the database and the geographical base. The design was set up by using an approach that can be considered as a first attempt to define general rules for the implementation of a GIS for the Cultural Heritage. The paper aims to propose a sort of guidelines which can be followed in any GIS for Cultural Heritage design. In order to allow an easy understanding the basic concepts will be explained by using the practical example previously described.

2. DISCIPLINES INVOLVED AND DESIGN CRITERIA

The first step has to define and clarify how the exchange and merging of complex and heterogeneous information, from different specialized analysis, could be obtained.

The GIS structure will be designed paying particular attention to three requirements that are considered to be of fundamental importance by all the involved research groups:

- · to localize all the object in a common reference system
- · to allow a complete access to the source of the data
- · to date each information (dating in fact is very important for the historical disciplines) (Figure 2).

Moreover, as different specialists can be involved in the research work, a metadata structure must be planned to access specific information about who collected the data, what kind of analysis he/she had performed, what sources has been examined.

The metadata structure can be organised by following the general rules defined by ISO (TC211) standards.

In this phase at least the following information, in addition to the previous ones, have to be recorded:

- • the accuracy of the data;
- • the time of the data.

The accuracy (or the quality) of a data can be interpreted as the precision of the collected data or as the reliability that the specialist can assure, in its own opinion, to the acquired data.

In many cases, especially in the domain of Cultural Heritage, information about historical data are usually extracted from documents which are interpreted by the specialist. Each

specialist knows the accuracy of the extracted information, so it is possible to add to each data a general quality parameter.

In case of data coming from measurement techniques (both geometrical and physical) the accuracy parameter can coincide with the statistical accuracy of the collected data.

The recording time of a data is the second important information which allows a correct interpretation: all the data coming from an individual interpretation are influenced by the knowledge acquired till the period of the interpretation, so a correct dating can help the user to understand the meaning of the collected data.

The dataset structure has to be also planned in order to guarantee future integrations and updating and to spread the results of these researches to a large number of people.

3. THE CARTOGRAPHIC SUPPORT

From a theoretical point of view the geographic base of a GIS must be a digital map where all the information have to be inserted as attributes of specific geometric features (points, lines, areas). Raster maps are usually considered as ancillary data able to clarify particular aspects.

But digital maps are not very easy to understand by a not skilled user: the adopted symbology and the selection of the represented elements can be insufficient to fit the real requirements of the wanted GIS

So in a GIS for Cultural Heritage, raster information become in many cases the adequate cartographic support. In fact orthophotos and/or historical maps are usually more easy to understand by the specialists and the users of the GIS for Cultural Heritage management.

The needed geometric entities have to be plotted during the GIS implementation by interpreting the adopted raster maps and are recorded as different layers of the geographical segment of the GIS.

Raster maps (orthophotos and/or historical maps) are usually referred to different reference systems, therefore the first attempt is to transform all raster data in an unique reference system; possibly the UTM-WGS84 have to be used in order to simplify the updating of the new feature generally acquired on the field by a GPS survey.

Figure 2. Database structure

In the Ayas Valley project a CTR (regional map) raster map 1:10000, and a CTR vector map 1:10000 of several areas were available for this study. An orthophoto at 1:10000 scale, and a geological map, were added for the Cartographic part of the GIS.

This set of maps was partial and incomplete for a full use of all the GIS opportunities. It was however considered adequate to start the first step of the research. The adopted management of the cartographic data allows an easy update of more convenient vector maps in the future and a possible sharing of the data with other analogous GIS of the same area.

In fact one of the more attractive goals of the Cultural Heritage documentation is the sharing of the data with other specialists in order to manage in a proper way a modern land planning. GIS could be an useful tool to put together, compare and integrate data coming from different research, using the cartography, as a common base.

4. THE DATABASE

The database design is highly influenced by the nature of the data to be recorded.

Therefore only general rules (e.g. metadata definition, common glossary and a full and understandable documentation) can be stated at the beginning.

The today development of the databases allows the possibility of updating the structure during the time, therefore it is not necessary to design a complete structure from the beginning of the work.

The interdisciplinary character of the data generally managed by a GIS for Cultural Heritage forces a soft approach in order to respect the individualities of the involved specialists. In designing the dataset, particular attention has to be paid to the requirements and needs of the specialists.

Each specialist has to be forced to underline some keywords that can be shared in order to connect the different data coming from each investigation.

These common keywords will allow the query of the database and the merging of all the collected data in order to extract complex information.

In the used example the requirements for a correct collection and selection of data for an accurate historical and archaeological analysis of the Ayas Valley were considered.

4.1 Typology of the data

The contents of the data can be very different, while the typology was more limited.

In our example, most of the data came from bibliographical and documentary researches, and a large part of the data was therefore in text format. The text format class was divided into some subclasses.

Several fields of the database were singled out, where the attributes had a text format, but also a concise set form, constituted by one or few keywords.

In these cases a link to other tables was used, whenever possible, in order to decoding the attributes. In this way the user, for a specific field, can choose from a limited list of attributes.

For example the "Accuracy of Dating" field, in the "Dating" table, allows one to see whether the dating of an object or event refers to one particular year, century or one half of a century, etc. (Figure. 3)

Other fields were designed to give short descriptions of the structures. These fields are in "memo" format and they provide
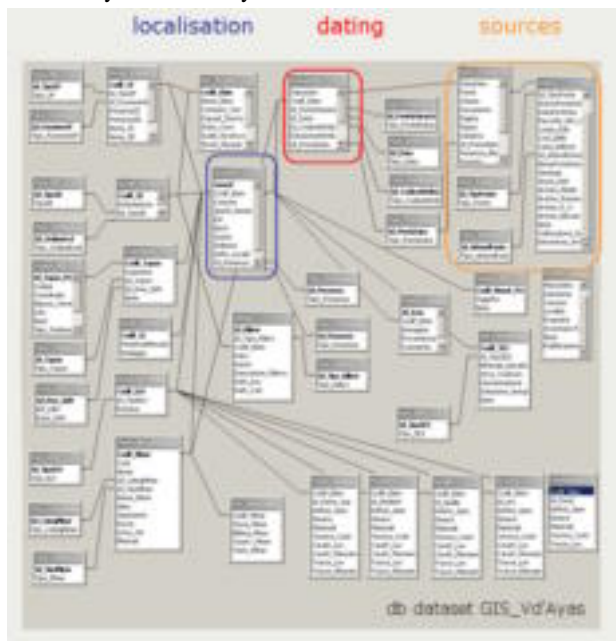
general information on the "historical context", or "description of the area".

These fields can be useful in the GIS technology for the so called "location queries".

Users can query the database by using the location of the object of interest on a map, and then have access to this general information, which was defined by the specialists in order to allow an easy understanding of the object. This approach could be very important for the spreading of the results of these researches to a large number of people.

Another important type of data is the numeric format. The cartographic coordinates and the dating are in fact numeric fields.
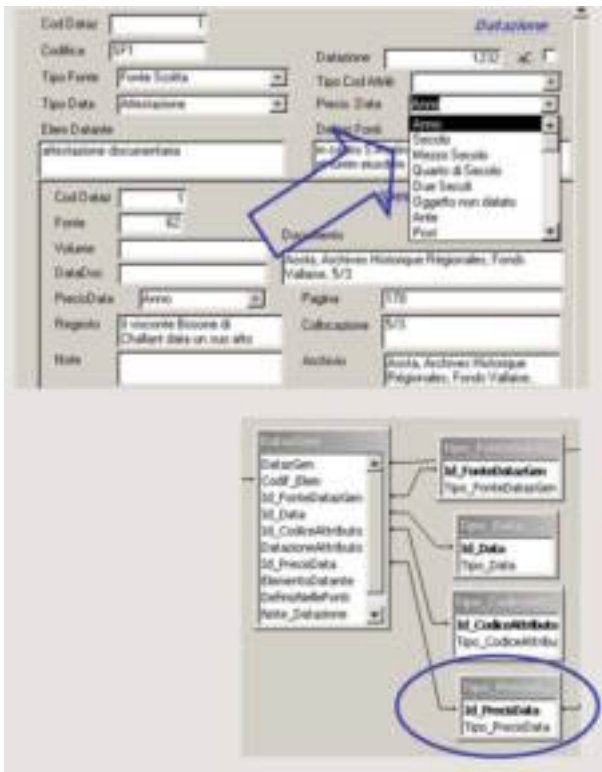

Figure 3. Dating information and "Accuracy of Dating" field.

Finally, there is the large and heterogeneous class of data in image format. The heterogeneity is also due to the contents more than to the file formats. In this case, a table called "Iconographic Catalogue" was created to store information on the date, origin, and authors of each image of a structure, and then there are also hyperlink to the collected images.
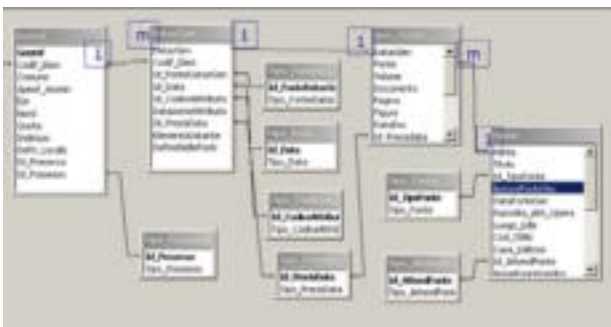

Figure 4. "Dating" and "Sources" Relationship

A table was created for each type of structure included in the census, such as "fortified structures", "ecclesiastic structures",

"settlements", where all the specific attributes about each single structure are collected. Each table is linked, with a "1:1" relation, to the "localisation" table which records the class of data that is common to each structure, such as the cartographic coordinates, position, name..

4.2   Chronology and Sources

Each dating that refers to a structure, usually corresponds to an event or an attribute (for example an attestation, an abandonment, a reconstruction).

Different events can be linked to a structure. The relation between the table "structures" and the table "dating" is a " 1:N" relationship.

Several data that are useful to link the dating to the sources, are collected in the "dating" table, while the attributes of the sources are stored in two other tables.

The "source specification" table is for the specific information about the source (page number, name of the archives, document number), and the table "bibliography" is for more general information (title of the publication, authors…). These two tables were created to allow a correct connection between each piece of information and its specific sources.

The final result is a "1:N" relationship between each table structure and the table "dating", a "1:1" relationship between the table dating and the "source specification" table and then a "N:1" link between the "source specification" and the "source" tables, as shown in Figure 4.

4.3   Surveys

As several research groups were involved in the project and carried out several surveys, a "surveys" table was implemented in the dataset.

This table is directly linked to the tables structures, and it collects data about the authors, type of surveys, year of the survey etc. Using hyperlinks it is possible to access this new data
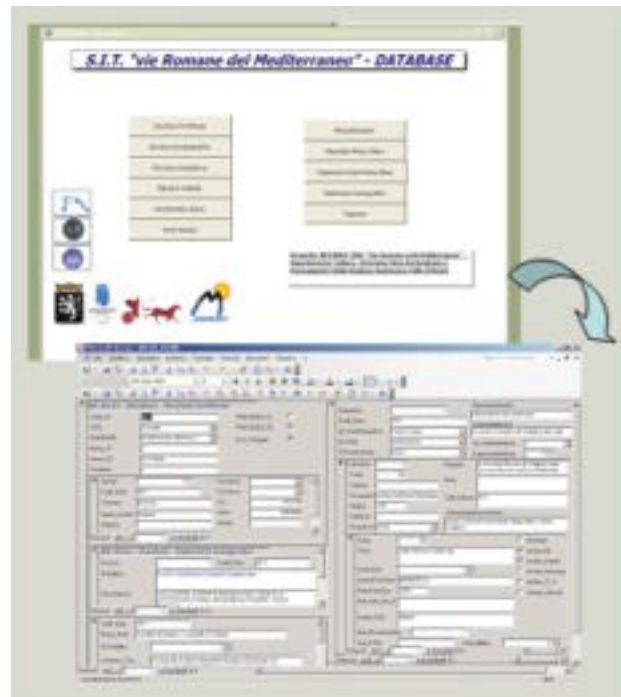

Figure 5. Masks for the input data

4.4   Mask for data input

The data input have to be performed by the specialists themselves in order to guarantee a correct management.
So, user-friendly inputs masks have to be designed considering the different skills of the people involved in the project.
In this way each specialist can insert the data without having to deal with all the complex relationships between the tables, IDs, primary keys, etc. (Figure 5)
The created masks have to accomplish in the best possible way the format used by each specialists during the collection of the data on the field.
In order to guarantee the check of the inserted data the original documents have to be inserted into the database as raster file.

5. G.I.S. PERFORMANCES

One of the main aims of the GIS is to share information between specialists in order to help them in the correct interpretation of the acquired data and, in the future, to obtain an efficient communication of the achieved results.
In fact a GIS allows to perform several spatial analysis which are easy from a technical point of view, and very important and effective for the historical and archaeological study of an area.
The location query, for example, is a simple and direct way of accessing the database, by using the location of the object of interest on a map.
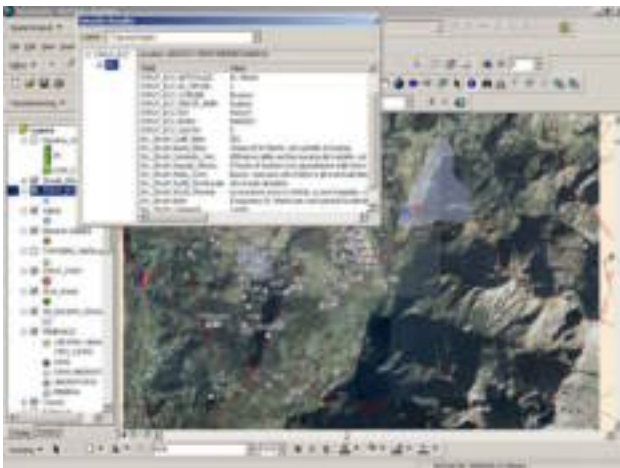

Figure 6. Identify on the San Martin church entity

Figure 7. Information about dating and sources of a structure

Figure 8. Selection by Attributes: gold mines and quarries

Users can access a schedule in which there is a set of collected information. This information has been defined by the specialists in order to allow an easy understanding of the object. Figure 6 shows the data acquired on the Saint Martin Church, inside the castle of Graines; in this case the schedule collects all the data about the location and the description of this structure. It is also possible however to access information about the dating of the structure which was obtained from the bibliography and documents, and the authors of these publications, as shown in Figure 7.
The GIS allows data to be classified using two different selections. The *Selection by Attribute*, and the *Selection by Location*.
The *Selection by Attributes* allows those geometric entities that have the properties asked by the query to be identified. The query can be as simple or complex as the user needs.
The query condition is an instruments that is useful to suggest new interpretations of the data, and sometimes deeper investigations, to the specialists. The selection in figure 8 shows the gold mines and quarries that have been identified in the Ayas Valley.
The *Selection by Location* allows the selection of different entities which are on different layers of the GIS structure. It is therefore possible to carry out the so called spatial analysis. In the foregoing type of query the spatial content is based on the use of georeferenced data, while in the location queries the selection considers the topological link between the layers.
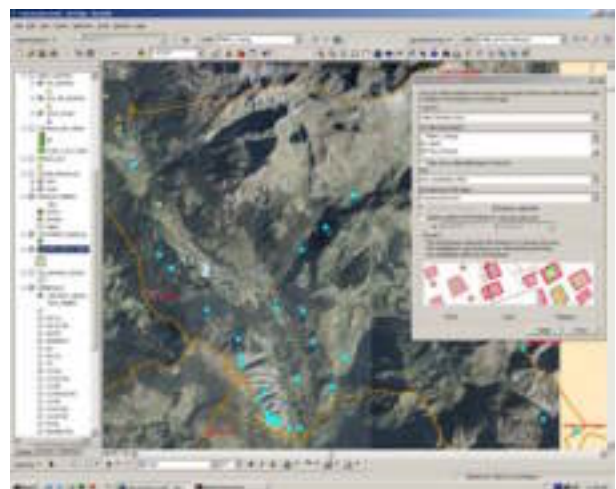

Figure 9. Selection by location, all the entities enclosed in the municipal district of Brusson

Figure 10. Hyperlink to field surveys and their technical reports

The selection can be made through *intersection*, *distance*, *pattern*, *superimposition, etc.*

Figure 9 shows the selection of all the entities (churches, castle, mines, quarries., etc.), that were analysed during the research work enclosed in the municipal district of Brusson.

Another functionality of the GIS is to allow an easy access from the maps to all the collected data surveyed by the involved research groups.

Hyperlinks were structured between the GIS and the field surveys and their technical report (see fig 10).

6. PUBLICATION OF THE GIS

One of the main goals of a GIS for Cultural Heritage documentation is the publication of the results in order to share the knowledge, to allow a correct understanding of the study object and to transmit the achieved results to local administrations in order to plan a correct land management.

These three potential users requires different type of visualisation of the data and no all the acquired data can be understand or be useful.

Therefore, the involved specialists in the GIS implementation have to take care to "translate" their studies in order to fulfil the different user of the GIS.

The "translations" have to be as clear as possible considering the skill of the potential users.

In these cases graphical indexes and visualisation of the query results have to be preferred versus text information.

International literature offers many examples; all the proposed solutions are studied in order to satisfy different purposes and needs and no common rules can be stated.

The only possible general rule in this phase is that the publication of the GIS has to be directly linked to the original database; in this case the updating of the database will perform also the updating of the publication of the GIS itself.

7. CONCLUSIONS

GIS technology for Cultural Heritage documentation is becoming a general adopted methodology.

International experiences shows a large amount of practical examples but not common rules are usually adopted.

The problem can be stated as "each Cultural Heritage object requires an *ad-hoc* approach".

This can be true, but it is necessary to force all the experiences to have at least a common technical approach in order to allow the possibility of sharing information with other studies on the same object and with the specialists which can use the data in order to preserve the Cultural Heritage.

The adopted solutions must be as simple as possible and also economical aspects have to be considered: each solution can be updated and refined in future if an incomplete but correct draft solution has been developed.

Merging data from different disciplines improves the analysis and the historical knowledge of an area, much more than single studies.

In the Valle d'Ayas project a GIS was used as a tool to make the approach to different data obtained from single researches easier.

Analysing the links between each research, the structure of the prominent data were planned and formalized, and then linked to the cartography of the study area, thanks to GIS technology.

A tool designed in this way can increase knowledge on an obsolete landscape, and give a significant aid to historical and archaeological research.

It could also help local administrations for a correct environmental management and an accurate safeguard of the Cultural Heritage

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