

SURVEY PROCEDURE AND ARCHAEOLOGICAL G.I.S DATA BASE FOR THE MIEVEAL MINE OF ROCCA SAN SILVESTRO

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ABSTRACT:

This paper concerns some results produced following a scientific line planned for the integration of several survey techniques implementing a simple methodological approach to harmonize the scientific contributions for the study of territory. Geographic information systems are nowadays a necessary instrument for the organization, management and analysis of survey data and recently some experiences promoted by the D.I.C. of the University of Florence have supplied the opportunity to estimate some aspects inherent the integration of different methodologies. Since 1985 Arch. L. Ippolito (D.I.C. University of Firenze) in collaboration with Prof. R. Parenti (Dipartimento di Archeologia e storia delle Arti di Siena) have promoted a first research plan in order to support complex survey operations programmed for the documentation of archaeological excavation in the Rocca San Silvestro area. In more recent times some new research lines, based on the reading of the territory and its archaeological heritage, were added and conventional topographic, aerial & close range photogrammetric surveys were implemented with image elaborations and digital photogrammetric survey with light aircraft. Extrusions and 3D differential data plot correlations were then programmed in some case of study and elaborations data were then specially formatted for the designed archaeological G.I.S.

1. INTRODUCTION TO THE PROBLEM

Actually, any researcher or any territorial planner agree on the importance to effectuate territorial surveys and to accede at others already been done, for understanding and putting in evidence the evolutive aspects. The territory information, like are presented at the date of the execution of a survey, are various and complicated stratifications because their constitutive reasons made in the ancient periods are partially lost. The researcher that observes today the territory find himself in the difficulty to understand evolutive dynamics from signs hardly set into credible developing models. A territory taken in its globality is so charged in information that a tentative of studying it needs a preliminary representation of its informative contents. Without creating a merit hierarchy for the various research instruments, is obvious that their integration can provide a reflection and modification element for the orientations of the same research. If our point of view is valid for the survey and the interpretation of the excavated objects, is more valid for informations that a territory did not revealed yet. In fact, how distinguish in the study the false traces from those with a historical value? How can we effectuate a correct interpretation without a direct verification? Starting from this reflection, we tried to trace a methodological process for the integration of the different territory investigations. This process is structured in a way that can be integrated with experiences already existing, and can be compatible with the management instrument of the public administrations.

1.1 The territory and the survey

Commonly the term territory have different meanings and it is used with different ways depending on the context in which it is inserted. The etymology of this word derives from the Latin *territorium* that means everything directly related to earth. What is interesting however is that the term "territory" is also connected with other words like *ager*, *regio* and *finis*, that refer directly to a colonized part of a land and inhabited by men or to environments inserted in a structure of a society where people have already started to do some modifications. In other words, in the connotation of territory we always have two semantics

tendencies; the first related to all that we can call "natural" dynamics and the second is the continuous human will actions on these dynamics. Because we need to face the relations between the territory, its survey and its restitution, the first query presented is to try to have a general idea of what we intend to express when we talk about territory. Due to the extreme complexity and variety of this word, and for not founding ourselves in the temptation of putting an absolute definition that surely results useless for our investigation, it is useful mention some definitions that differ from different disciplines structured for describing the territory. Definition of territory:

"part of land with considerable extent...that contains beside the mainland delimited by boundaries, the subsoil, the internal waters, the territorial sea waters, the atmospheric space above them"

*"the term territory define a land extant inhabited by a human community that adapted it by time to its vital need and auto representation, making it different from other lands and very often unique. We can add that it makes part of the territory when it is urban and rural, but not only this because it is also part when it is not urban or rural when it is forest or woods or beach on the sea borders of rivers and lakes, sky boundaries. In others words it makes part of the territory all the empty space if we consider that the full space is the economical one." ***

*"the maximum hierarchic category of organisms of the anthropic space that contain all the possible hierarchy grades from urbanism to common objects designs." **

The invariant element in all these definitions is the valency of superior limit that the territory assumes in its relation with the actions of man. This characteristic permits us to say that inside the territorial scale all the other possible hierarchy grades that

* s.v. "territorio" DEVOTO G., OLI G., (1990), *Dizionario della lingua italiana*, Firenze, Le Monier, pp. 1971

** Cfr DE CARLO G., *Lettura e progetto del territorio* "in lettura e progetto del territorio, Maggioli editore p.8

* Cfr CATALDI G. (1977), *per una scienza del territorio*, Uniedit Firenze, pp. 31

contribute to form the territory are included. It results clear that inside a territory we can make an infinite kind of readings; in a time we can read a define phenomenon as it is a single unity, and at the same time we can read the same phenomenon as a part of a whole complex. The extreme complexity of this structure lead to the difficulty of finding a reference model.

As precisely defined by Tozzi** (Tozzi, M. Harari, 1984, 17), *“il suolo conserva, senza distinzione le tracce delle differenti fasi della storia umana e pare volere superare arbitrarie e tradizionali partizioni... .. cui gli studiosi abitualmente ricorrono per fini pratici”*.

“the soil conserve, without distinctions the traces of the different phases of the human story and seems that wants to exceed arbitrary and traditional divisions... .. that studios usually apply for their practical objectives.”

Bringing to an end his reasoning, Tozzi affirm that the readability of a soil varies a bit in relation of the signs fixed by men or in relation of the transformation process done on the environment by people themselves or by the nature. Therefore a fundamental problem is put down; how to succeed to treat the data of a territory. Also the general difficult differentiation of the traces present in an environment is an other element to add at the difficulty of reading the soil. If we consider in fact the territory as a palimpsest, where the effects of anthropization are conserved as a result of a sort of a cumulative process, the actual reading of the traces can be enough for caring on a study. If the processes of anthropization were cumulative processes we could read them with a stratigraphy reading putting in evidence the homogeneous phases. This kind of reading, integrated with historical sources, can lead to absolute historical reconstructions. This can be possible if the structure of a territory does not endure significant variations during time. However as known, in this kind of scenes, continuous dynamical processes that alternate not only the appearance of the territory but also its constitutive organization are always in action. In this case it results that it is fundamental to try to understand the natural tendencies presented during time as the other made by man.

We always need, in fact, to consider the duality of territorial processes; the natural ones that accompany from always the slow physical modification of the soil in a part, and the others made by human that leave more evident modifications and very often more unexpected and less clear modifications if not found in their respective historical period.

1.2 I The transformation process of the territorial organism: Permanence and Variations

If we consider a cognitive framework that can be determinate of a territory, we have as a principal difficulty of outlining significant connections in an appearance that results often in a very fragmentary. The general undifferentiation of traces leads the operations, that should decode the informative context, to take in consideration very often every single case by itself without considering it in a larger context for interpreting its significant and value. The introduction of a refer to the territory as to an organism can help to face the study the relation that runs between the single peculiarity and the hole taken as one unique element. This kind of confrontation can be moreover very efficient for the possible synthetic framework that we can get in relation with the anthropize action.

In the definition of organism, it results central its property of *conserve and reintegrate its own aspect and constitution, and to*

*reproduce it**** in definitive the possibility of evolution and transformation during time of its own structure until it modifies and creates a new organism. In an analogue way we can identify in the territory, in the various orders it took during time, the duplicate valency of an evolution state of the same organism or even the genealogy tree that conserves the story of a continuous genesis that leads a new organism to replace the precedent.

That permits us to introduce the notion of transformation of a structure seen from a part as its own growing in time and from an other part as its permanent heredity in the variations that lead to a new structure. From transformation as a dynamic process, the territory, at a certain date, put in evidence some phenomenon that are called respectively territorial *Permanence* and *Variation*. It likewise results necessary not only identify on a range of detail the situations that constitute essential concepts or that acquire in the hole process of transformation the permanency valence, but also know to attribute a correct value and significant to the surveyed traces.

In the comparison of two situations, chronologically non concomitant, series of indications on happened tendencies or to happen can surely emerge. These indications are necessary for working the recognition of the traces and their value. It is obvious that the only base where we can effectuate our synchronic and complete research is the territory in its aspect as we have it actually. On an other hand the necessity of comparison impose a certain level of knowledge of the previous situations of a state that was and isn't anymore. As mentioned already, the transformations are accompanied documents regarding the structure of the territory or some of its characteristics during a precise historic period.

We can evidence two principal lines for a first differentiation o the informative context that can be used for understanding the variations and the permanencies. In a first place the territory itself: the undifferentiated, the environment where it can be effectuated different readings and representations made for limit the structure, the going processes or the permanence of the effects of processes that are already exhausted.

In second place all that is related to representation and description of previous evolutive statuses. In this typology we have over all the hole cartography, maps, and surveys that report a territorial representation with precise dates, even if it is only used on site form survey purposes, aerophotogrammetric copies, photogrammetric copies, monographies and the entire survey process used to realize these cartographies.

The main role in this process of survey and the critical comparison between the survey of the traces and the survey of the state that these traced are related, results clear.

2. THE SURVEY OF THE PERMANENCIES AND THE TERRITORY VARIATION

The element that determine and characterize the operative phases of survey results essentially the structure of orography of the zone where the permanencies are situated. Naturally for the multiplicity of cases that can be presented, it is difficult to define a global an unique procedure. Every survey operation needs in fact an analyse of its own particularities and the organization of specific and consequent operations on site. We can divide the multitude of the cases in two main groups using as a classification parameter the survey operations that can be achieved on remote-sensing data. On the remote-sensing data,

** Cfr TOZZI P., HARARI M. (1984), *Eraclea Veneta: Immagini di una città sepolta*, Parma, CGR editore, p.17

*** s.v. *“organismo”*, Devoto G., Oli G., (1990), *“Dizionario della lingua italiana”*, Firenze, Le Monier, pp.1291

that are all the images that can be taken from any platform,

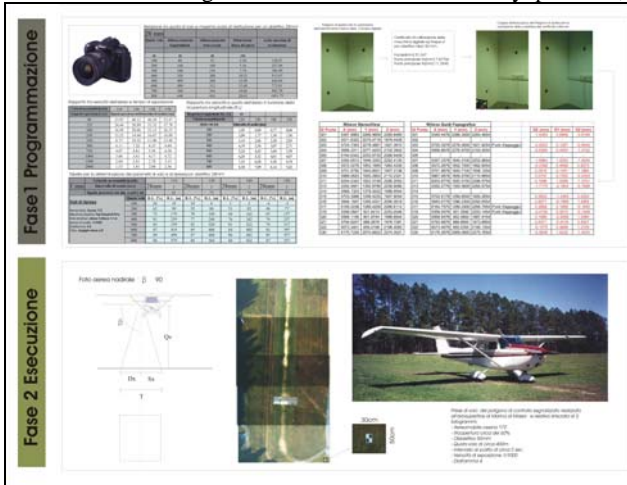


Figure 1. Diagram of aerial survey from light aircraft measurements can be effectuated with one single image or many images taken of the same scene. Our reference will be directly photogrammetric e stereophotogrammetric survey process.

We can so identify two main parallel process. The first related to permanencies situated on plain orographic landscape, and the second related to articulated and complex orographic landscape. We have identified two specific cases inside the experimental zone in which we have tested survey methodologies. These applications can be notated as real referent process for future surveys, the post excavations control, and prognostic phase useful for the planning of the site operations.

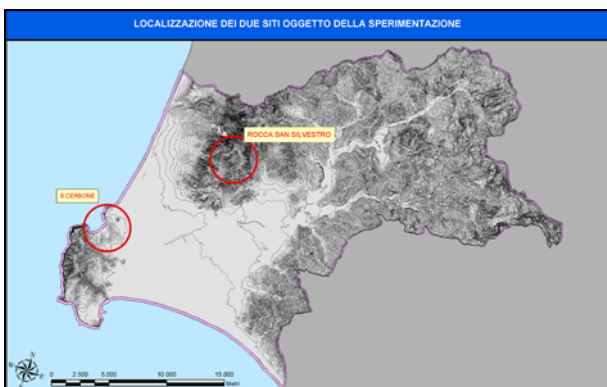


Figure 2. sites localization

These two specific cases (Fig.1) are the excavation of Rocca San Silvestro, situated in the Campigliese hills and the Necropolis of San Cerbone situated in plains of Baratti Golf and Piombino promontory (both on Tuscany coast). These two site are a good example for studying traces in both plain orographic landscape and complex orographic landscape. However it is obvious precise that these two sites had been studied on the archaeological level and excavated during the previous years. The part of the archives that interests us are the zenithal aerial photos made for cartography purposes that conserve the pre-excavation morphology. The first operation done was the retrieval of zenithal images of the two sites and the execution of flights with light aircraft* for having the actual sites situations.

* the aerial survey from light aircraft are developed into an previous reaserch published in Atti Conferenza Nazionale Asita 2002 *Geomatica Per L'ambiente, Il Territorio E Il Patrimonio Culturale Perugia, 5 - 8 Novembre 2002 "Sperimentazione di una metodologia di rilievo aerofotogrammetrico e fotointerpretativo da aeromobile*

The procedures for effectuating the comparison on the design level between aspected design and reality of permanence can be done with the photogrammetry in the case of the plain orography and with stereophotogrammetry analogical and digital in the case of complex orography. In consequence, the design of operations follows two different organizations that we are going to develop separately.

2.1 The example of complex orography: Rocca San Silvestro Site

Rocca San Silvestro site was the center of an extensive archaeological excavation during the eighties and the nineties, what brought to light the almost whole installation.

The following flights were retrieved in the Regione Toscana.

- flight EIRA 1975/76, folder N°68 stripe 71/a photogramm 243-244-245 altitude 2000m
- flight CGR 1982 folder N°216 stripe 103 photogramm 525-526 altitude 1100m
- flight SCAME 1984 folder N°266 stripe 11 photogramm 5270-5269 altitude 2000m
- flight TA 1994 folder N°500 stripe 19 photogramm 327-328 altitude 1050m
- flight done may del 2002 with Cesna 172 at altitude 600m
- flight done September del 2004 with Cesna 172 at altitude 800m

The aerial stereofotogrammetric copies dating before the excavations were subjected to analytic design with a stereorestitutore digicart of Galileo Siscam (Fig.1)III.9.1.-8, III.9.1.-9, III.9.1.-10, III.9.1.-11, III.9.1.-12, III.9.1.-13).

The copies made with the light aircraft were subjected to digital design with Micro-Map Software.

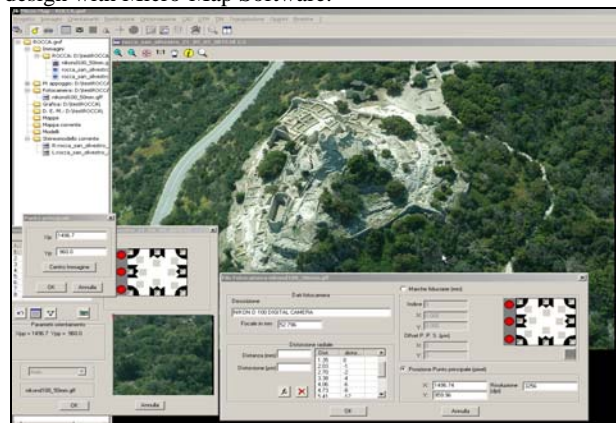


Figure 3. medieval mine of rocca san silvestro stereo-model in micromap software

The historical situations and the evolution of the excavation were design by line representation for the whole area of the site. For doing orientation operations of the copies, some visible elements were individualized on these copies and on the site that are actually permanent. These elements were topographically surveyed. In the case of the copies representing the situation of the site before the excavations, the survey was done on the formation of the vegetable covering. The comparison between the orography before the excavations operations and the one after them. The comparison between the orography previous to the excavations and the one following the excavations had put in evidence many interesting aspects. We have observed moreover, that the parts where the vegetable covering results poor or missing correspond to parts

leggero con l'ausilio di macchine digitali e restituzione digitale". autori: Prof.Fausto Sacerdote, Dott.Ivan Chiaverini, Lorenzo Bianchini, Fabrizio Costantino Daniele Ostuni Mauro Del Sette

of the site where the excavations had brought to light important mural structures or portions of extended pavements.

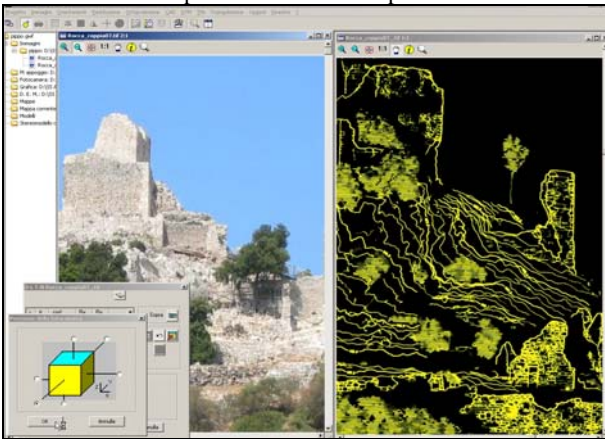


Figure 4. medieval mine of rocca san silvestro close range digital photogrammetric surveys

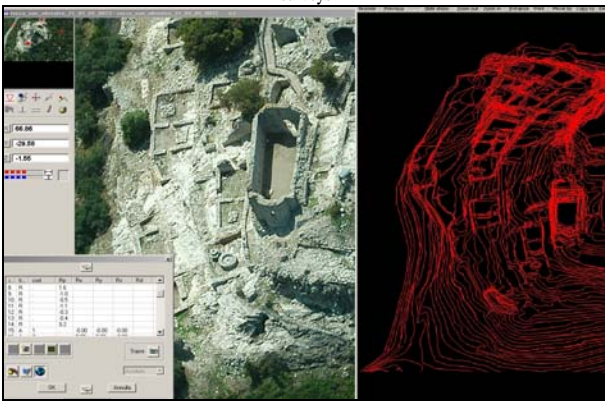


Figure 5. medieval mine of rocca san silvestro aerial digital photogrammetric surveys

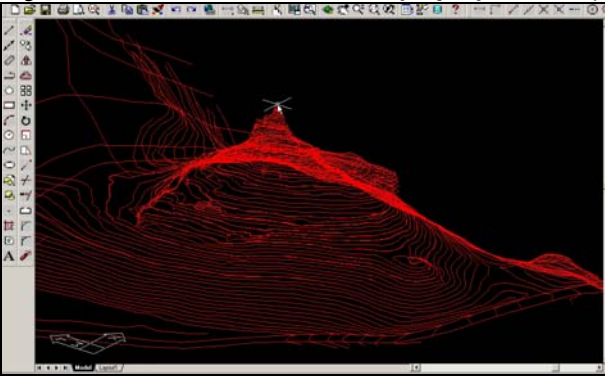


Figure 6. medieval mine of rocca san silvestro before excavation contours

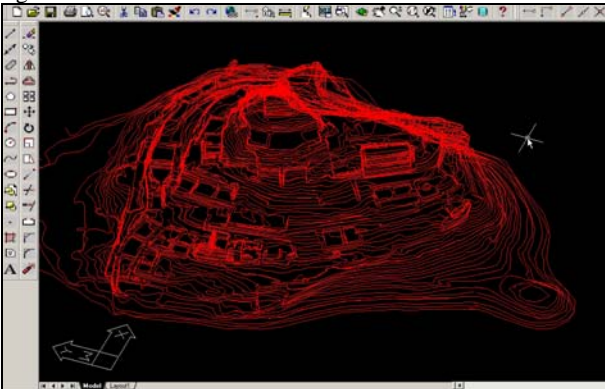


Figure 7. medieval mine of rocca san silvestro after excavation contours
A more complete vision and a more direct comparison can only be executed by the observations on the stereorestitutore. A superficial model of the ground was made for trying to make the

survey more representative and to put in evidence the filtered aspects of contours design. The model was obtained by the application of the aerial photographs taken in low altitude on TIN. Naturally the whole surveyed material was archived in GIS programme.

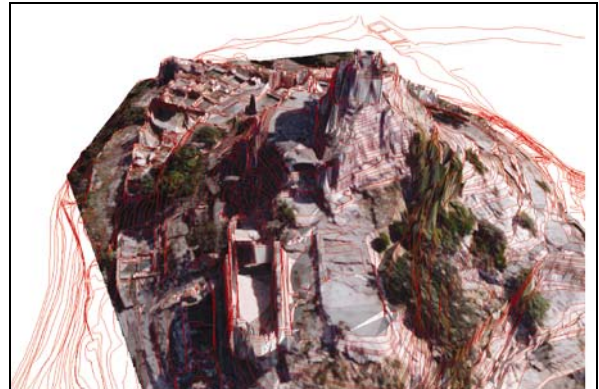


Figure 8. medieval mine of rocca san silvestro particular of church

2.2 The example of plain orography: the Site of San Cerbone Necropolis.

The site that actually makes part of the archaeological park of Baratti, Populonia, seems to have a very complex excavation story. The part of the site that interest us, in fact, is limited by the necropolis surface that face directly Baratti golf.

In this case fotogrammetric procedures that have reported aproximatively the orographic state of the territorial surface to a plain were executed. This procedure provoke without doubts, in the precision of the survey, the introduction of errors in the differences of the studied zone respect to the ortho-rectification plane. All of this can be compatible with the survey objectives, as we verified later on, only when the slope of the territory results not very high. For the approach of the problem we have used the aero-photographic covers of the flights made in the forties, the RAF flights and the more recent aero-photographs taken for the cartographic production of Tuscany and its districts.

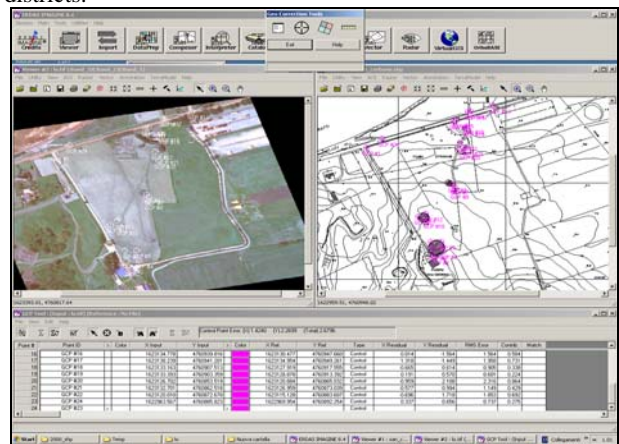


Figure 16. Site of San Cerbone Necropolis ortho-rectification
The first operation executed is the ortho-rectification, and the georeferencing of the zenithal air photos on the district cartography (scale1:2000)

This operation had brought us the situation of the site on different time periods. The second step for the comparison with actual situation of the site was the execution of flights for taking oblique photographs of the zone. For the evolving of the operations we took photographs at large scale that show the whole survey area and detailed photographs for the singular evidences.

The design operation had, at this point, followed a double route. As a first phase the oblique photographs of the entire area were ortho-rectified having as a ortho-rectification coordinate elements recognizable in both photos and cartographies. On the second phase the detailed photos were ortho-rectified extrapolating the ortho-rectification coordinates of the general photos already worked. This double passage has its reasons in two parts. On the first part because of the impossibility of finding in cartography points recognizable in detailed oblique photo. On the other part in the possibility of making a better geometric resolution in the photos of details than on the general one



Figure 16. Site of San Cerbone Necropolis

3. THE MANAGEMENT SYSTEM FOR THE SURVAYED INFORMATION AND THIER CONNECTION WITH OTHER REASERCH SOURCES

The initial purpose is to create a system that can be used on a hand as an active research instrument, and on the other hand as a component on which the responsible of the custody of the historical-archaeological heritage, can have the possibility to effectuate analysis. A bound of instruments was created or used for this purpose. We have in fact, adopted as a computerized territorial instrument a GIS as the Arcview-Arcgis that is the standard instrument used by the public administration for the management of the territory. On the other side we had to impose the management of the data exchange between GIS and DBMS for the recording of the archaeological data.

In the first step the sources that can have an importance for the creation of the methodological process have been valuated. They belonged to different typologies, from the existing cartography as the zenith and oblique aerial photography to the satellite images and archaeological sites documentations. Trying to make accessible the informations taken from different historical periods, to integrate methods of investigation and representation already consolidated in older periods, and to obtain more quickly a quantity of data having various nature and informative contribution, seem a possible way to make a critical comparison between the various sources.

Starting from this first analyse, the need to construct one working instrument that can globally manage the various typology of these data and permit their comparison is brought to light.

We have structured in Arcview-Arcgis an extension that permit the charging, the management inside the GIS and the dialog with other DBMS of the data.

Anybody that worked with Arcview-Arcgis surely knows the problematic connected to the allocation of the process of the theme and the extreme fragility of maintaining the projects.

The major difficulties are how to give back the GIS the various information and to make the data organization the more flexible and the growable possible.

Concerning the data representation in the GIS, we have made two principal classes of different representation: One that

contains the data that the informatics contribute have the possibility to be represented directly trough a cartographical projection; to which belong almost all the cartography and the elaborations that render the georefer images. The other that contains all the other sources in which the informatics contribute cannot be represented as a geometrical shape or from which we do not want, for a beneficial valuation cost, to execute a georeferencing. This is the case of the bibliographical sources of documentation, of site and of the images with a high grade of redundant

Concerning the organization of the data structure, and the charging of the information, a main difficulty comes from the natural division of the informatics support category.

In the data treatment, the raster and the vectorial formats have different starting points, problematics and solutions. We do not enter now into the specific questions that took us to valuate one format convenience respect to the other. Our system that we structured have the possibility to loading both the formats trough the same interface that present the choice of the interested format.

This objective was realized trough the division of the data organization of some thematic folder grouped by homogeneous classes (structured in analyse phase of the source, ex: cartographical net, historical cartography, technique, thematic, three-dimensional representation).

The name of the folder and the process of collocation of thematic class to which the folder belong, have been associated to a separated list directly connected to the interface of the own charge of every thematic class. Having made the procedures with algorithms based on list composition, a growable thematic class or a new sub-group of a specific class at the system is automatically executed once added the name of the class to the list of the class or the name of the sub-group to the list of sub-groups. This together with the choice of the data charging through the comparison between the geographic position that interest the research and the one of own various data, and the selection of the data type to charge trough comparison with a part of its folder address, permitted a quick management in comparison phase of various sources.

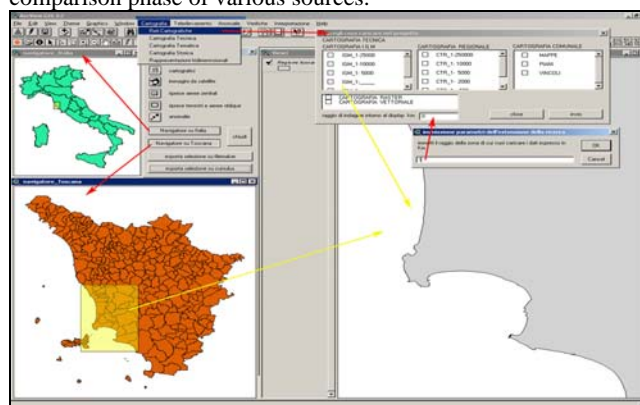


Figure 17. surveying data management system

In fact the work directory stabilized and one the extension charged the thematic classes of data charging are visualized trough the menu bar and the key of management instrument. the part of our interest is individualized on video by a navigator. Once the limit of investigation respect to the visualization of the scheme is indicated, it can simply be able to ask the charging of all the information that are present in this specific area if respect at the actual situation one of the data changes or grove, the refreshing operation consist on determinate to which thematic and sub-class the data are re-conducted for positioning the file in the corresponding folder. This has permitted once the work directory is established by a defied structure, to eliminate

the principal lack in the rigidity of managing the projects in Arcview-Arcgis.

This is valid to any type of data and support. For making the management system an effective instrument of research, we had to ask ourselves about the way of working in both data representation classes.

For the first class, for which belong the data referable to a cartographical projection, the passage was very natural. The same representation by icon represent at the same time the hole basic cartographic shape and the information itself. So once the charging effectuated, the visualisation in Arcview-Arcgis allows having the direct access to the information.

More complex was the determination to the best shape for the access at data not referable to a cartographical projection or those who was for a working economic reason did not wanted to treat with those of the first class. The complexity resulted from the fact to integrate the GIS with DBMS externs and at the same time to think about the necessities that the instrument could offer in both phases search and consulting.

The solution that we experienced was a multiple approach to the access of data based on various and in part parallel sub-procedures. These sub-procedures in phase of structuring were made second the type of investigation in which they will serve. In this way two principal lines are divided. The case of transversal photos and their interpretations can help to explain the differences between both sub-procedure. The first part from necessity of comparison and interpretation a single photogram at the same time and in which the interest is turned to understand the real potential for archaeological motives.

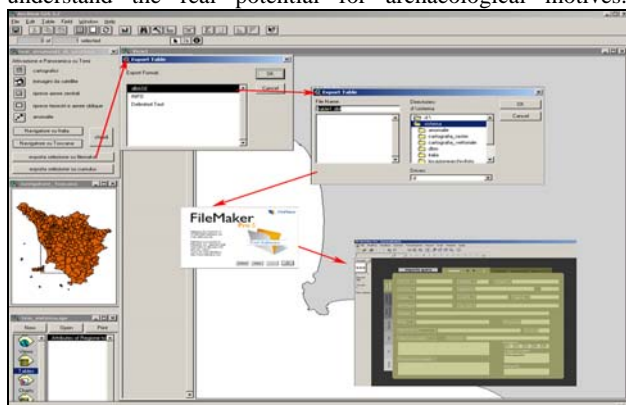


Figure 18. surveying data management system connected to extern archaeological Db

There are georeferenced the information trough the geographical localisation of conventional graphic signs organized in themes connected to extern DBMS. For doing this, a biunique connection was structured held to the definition of a identified field in GIS collocated to the ID sites already registered and with which generate the TUPLE of the relation. At this point, once effectuated the choice of a single photogram or of a whole photogram to analyse as single unity for the research, we can export directly and visualize the choice from Cumulus or Filemaker. For Filemaker, the process effectuates a choice from the totality of the files individuating those that interest us, and from those that is possible accede to a whole series of information specified from a single photogram or from relational refreshing. The exportation to Cumulus results effectuated in the same way with the passage of the division of exportation in more than one phrase due to the constitutive limits of the program. This operation can be effectuated with a processing pseudo-dynamic but our choice was to offer the possibility to save the exportations on a hard-disk in a way to obtain at the end of an investigation the trace of type documentation that was consulted.

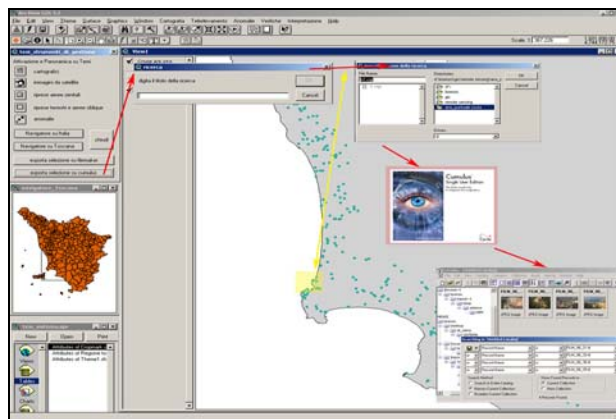


Figure 19. surveying data management system connected to extern images data base

The second is turned to compare some of abundance images of the same subject with which we can effectuate a first analyse and classification. From a part the must to visualize all the photos was necessary and from the other part a strategy for optimise the work is to be found. It was chosen to report into significant themes (ex: the GPS traces of the flight rout or the documentation of the same anomaly) the information associated with conventional graphic signs trough a suitable command. We can accede at the activation of the link on every singular georeferencing shape that make the access to the associated information directly from the chosen shape. Once the first image is opened, we have the possibility to vision also those appertaining at its thematic class. This happen through the charging of a program associated at the type of format in which the information is codified.

4. CONCLUSION

The present paper based on the reading of the territory and its archaeological heritage, with conventional topographic, aerial & close range photogrammetric surveys with image elaborations and digital photogrammetric survey with light aircraft 3d model conducts to the importance of the construction of a closely integrated system between survey and data management and GIS applications. Showing the importance of an active reflection about the possibility that a synergy of various methods and instruments can give to the description of the actual state of the territory is the first step for understanding the historical and archaeological heritage with the future territorial planning.

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