MOBILE COMPUTING IN ARCHAEOLOGICAL PROSPECTION

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1 Introduction: the disjunction between laboratory and fieldwork

We should emphasise that from the second half of the 1990s, when in Siena as in the rest Italy we began to use Geographic Information System for the management and analysis of archaeological data, we have felt a progressive schism between work in the laboratory and work in the field. While the availability of advanced technologies has been rapidly growing, activities in the field have continued to make use of instruments and methodologies developed in the 1970s. The problems arising from this situation are mainly inherent in the collection of data that lack the accuracy required by GIS, or which rely work to a different kind of rational logic and the unavailability in the field of the large amount of data stored in the desktop GIS.

2 Field walking survey

The processes of field walking survey represent a good example to discuss some of these problems. It has to be recognized that an important influence on the value of the data that we collect is the methodological process that we apply in the field and the possibility of georeferencing monuments or artifacts scatters with an acceptable degree of accuracy. A first real improvement, as is well known, came with the introduction of GPS measurement. Our own first experience in the use of GPS was strictly related to the mapping of artifact scatters and archaeological structures during field survey. We soon realized that GPS technology could be applied in the field for numerous tasks, such as the mapping of special finds, photo-locations, Quick Time Virtual Reality, movie sequences, shovel tests, tracking the actual path and distance between researchers during field-walking and monitoring the movement of artefacts scatters etc (CAMPANA, FRANCOVICH 2003).

Furthermore GPS not only permits the mapping of points, lines and areas but also allows us to navigate on site on the basis of geographic coordinates exported from our laboratory-based GIS systems. Navigation with the support of a GPS represents an extremely useful tool in many archaeological applications. For instance in relationship with air photo anomalies a methodological problem that we encountered before the introduction of GPS technology was the problem of accurately identifying on the ground features previously identified on one kind of imagery or another. This difficulty was particularly acute in situations of limited visibility (wooded areas, vineyards, olive groves etc.) or in the absence of identifiable artifacts or structures. The main limitation of the traditional GPS device for navigation is related to the interface and the non-availability of raster data as background to the locational information. Nevertheless GPS represented the first device that was able to reduce the disjunction between the real world and its digital representation in our GIS systems. A significant improvement come with the PDA computer and mobile GIS (RYAN *et alii* 1999; RYAN, VAN LEUSEN, 2002; CRAIG 2000). During the work on the archaeological map of Siena, we started by using a PDA on which we had installed the corresponding versions of the software used in the laboratory: ArcPad 6 as graphical interface with the geographical data and FileMaker Mobile as Data Base. This system has proved itself to be totally satisfactory, with important increases in flexibility and efficiency and with an accuracy as close as 30 cm after real-time differential correction. We are able now to load into the PDA all the GIS data that we require and therefore to take into the field a range of information that was formerly accessible only in the laboratory. Specifically, the main applications, and the resulting improvements to research in the field can be summarized as follows:

- Real time access to a large selection of the information stored in the data base and GIS.
- Capacity to integrate topographical, thematic and historical maps, aerial photographs, satellite imagery and geophysical data.
- Quick, easy and accurate navigation to any target whose coordinates are known through the interaction of GPS point with the raster and vector data in the background.
- Opportunity to make direct and accurate real-time comparisons between past survey data and the actual situation observed in the field, for instance in monitoring changes of land-use or the movement of artefact scatters etc.
- Capacity to compile the documentation directly in digital format in the field, giving significant savings of time through the use of software for the transfer to the server of data collected in the field.
- Availability of a device that “connects” real landscapes (the material world as observed at a precise moment in time) with the digital representation of the past and present countryside.

But what we would really like to emphasize is that the technological merging between PDA and GPS devices goes far beyond the level of increased fieldwork efficiency, in at last making possible the systematic application of strategies and methodologies developed in the past but applied only rarely up till now because of the excessive amount of time involved in their use (ORTON 2000). One may think here, for instance, of some practices tested in the early eighties for field survey and the collection of artifacts, such as the georeferencing of every single object or the collection of artifacts within predefined grids, etc. With regard to the creation of a survey grid, in the case of the simple GPS instrument topographical recording has certainly become quicker in comparison with Total Station survey, but there still remains the need for physical construction of the survey grid, generally involving posts fixed into the ground at the corners of each cell. This is time-consuming and requires the researcher to carry all the tools and materials necessary for the physical construction of the grid. During a recent survey the systematic use in the field of our mobile GIS has convinced us that it is possible to develop an entirely new solution for the collection of artifacts within a predefined grid. In the laboratory GIS we generated vector grids in shapefile format of the areas to be surveyed, using three different sample

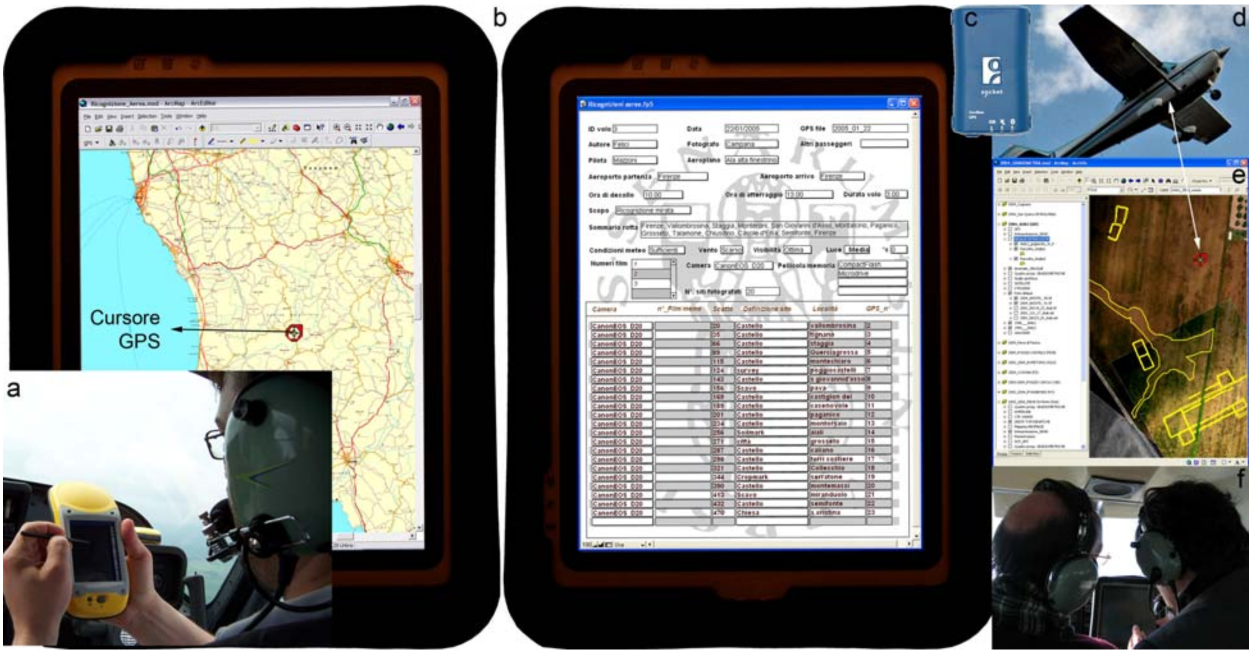
1-PDA mobile GIS at work: grid collection without the need to build a physical grid moving directly to surface collection

intervals of 5, 10 and 20 meters. Every cell of the "virtual" grid was allocated an identifier. After transformation of the projection system from local grid to UTM we loaded the data into the PDA. This allowed us to work in the field without the need to build a real grid. The merging between the digital grid visualized in the PDA and the real-time position of the DGPS allowed us to move directly to surface collection, without the need to carry with us all of the tools and other equipment needed for the construction of a physical grid. The contribution to field-walking survey of this technological solution has not just been in the reduction of working time or the avoidance of conflict with land-owners but, more importantly, in the capacity each time we find a new site to choose the best strategy for collecting artifacts at this particular location. Moreover in field-walking survey we often need to replicate collection in different years or at different seasons of the year. The PDA allows us to go back into the field and repeat surface collection in precisely the same cells, without the effort of rebuilding a physical grid in exactly the same position.

3 Aerial Archaeology

During aerial survey in 2004 we developed a mobile GIS system for information-recording and navigation. Despite significant gains in both areas the PDA and its related software still displayed certain limitation. Most notably, the 3.5-

inch screen proved too small for the geographical scale in which we were working and aircraft-vibration made the instrument difficult to use. Another problem lay in the use of a self-contained PDA unit. The need to operate in a high-wing aircraft meant that the structure of the cockpit impeded reception of the satellite signals, forcing the user into an unnatural and uncomfortable forward-leaning posture. An external aerial would have provided a solution but would also have involved cables in the cockpit which might have hindered the operation of aerial photography. The Tablet, by contrast with the PDA, is a genuine computer with a large memory, using the Windows XP operating system. This makes it possible to install in it the same software that is used in the laboratory, and to carry similarly large quantities of data. We have now developed a system based on ArcEditor (ESRI) and a small relational database, originally structured through FileMaker but now being transferred to Access. The idea of the system is to give the archaeologist, in flight, a wide range of technical cartography and orthophotography while at the same time acting as an instrument for the georeferencing and archiving of the collected data (DBMS). The mobile GIS also contains the routes flown in previous years, the reference-points and rectified plans of all of the sites recorded during earlier oblique air photography, as well as through vertical photography, satellite imagery, gradiometry, field-survey, technical literature and documentary



2-PDA and Tablet PC at work in the air.

sources. This constitutes a far richer, more flexible and up-to-date aid than traditional flight report forms and paper-based maps (CAMPANA 2005).

While this is still ‘work in progress’ three significant aspects have emerged during the first stage of use in the air. The capacity to take a PC into the air, in addition to satisfying the primary needs of survey and navigation, also provides an instrument that can be used in a variety of other ways. For example, aerial archaeologists are making ever greater use of digital cameras and the Tablet can be used to download data if the camera’s memory becomes full. Also, in cases where the quality of the recorded image is of prime importance (for instance in the recording of historical monuments or excavations in progress), the results can be downloaded and examined on-screen in real time. It is also possible to install software such as Jeppesen Flitestar, giving access to aeronautical maps and assisting route planning. A second consideration is that of writing. Unlike the PDA, the Tablet has a system for the recognition of writing, which means that it is possible to make entries in lists and tables with Tablet’s own pen, just as one would with an ordinary biro. In addition to facilitating work in an environment which (we must not forget) is subject to constant movement and disturbance, this allows us to record both ‘standardized’ and ‘free-form’ information. It is practically impossible to do this with a traditional digital keypad, even less so in the air than on the ground. To assist this process the database has been provided with pre-defined lists and terms. The data are entered field-by-field, selecting predetermined terms from the various menus. One has to choose the option which is closest to the item being recorded, an operation which naturally carries with it some risk of ‘forcing the issue’. A final consideration lies in the inherent difficulty and intensity of aerial work. Following the route, reading and interpreting the landscape below, keeping cameras and other equipment under control so as to arrive at the next target with the right lens already in place, making sure that there are enough exposures still available, checking the lighting-conditions, writing detailed flight reports and site records – these are just some of the many tasks that need to be done. And to be done correctly they require considerable experience. We feel that equipment of the type we have described will significantly aid the archaeologist’s work in the air, simplifying navigation as well as the recording of (and access to) information in ways which will allow the archaeologist to give more attention to the landscape below.

4 Geophysical survey

This last part of our paper is very much a work in progress. The need to acquire large-scale geophysical data has led us to look at ways of making field-operations more efficient. Our first problem lay in the need for some methods, to establish reference grids at various stages in the collection of the field measurement. The proper construction of a grid ensures the complete and consistent coverage of the site and improves the topographical accuracy of the survey data. However, the use of grids and the subsequent processes of establishing the relationship between the grids and the collected data, result in at least two disadvantages: a significant increase in the time taken for the work, and the need for a larger number of people in the field. There is now available on the market at least a limited range of GPS systems for the georeferencing of individual field-measurement. While such a system can reduce the time taken for field-operations it does not do away with the problem of ensuring complete and consistent coverage of the site. For this it is essential to have in the field a reference system consisting of grid-corners and (in general) metrical references both along the x axis and along each profile (the y axis). Leaving aside problems of magnetic interference with certain instruments (in particular with magnetometers and gradiometers) one solution which we have been working on consists of integrating the normal processes of GPS survey with those of GPS navigation. The basic principle is the same as that developed for the collection of surface material within 'virtual' grids, discussed above in the section on field-survey. In this case, however, in addition to the creation in the laboratory's GIS of the grids required for the site survey, one can also create (still on the desktop PC) the individual profiles (at predetermined spacing of 2m, 1m, 0.50m, 0.25m etc). Once the grids and profiles have been transferred to the DGPS the field operations consist simply of following the profiles on the display while at the same time taking the geophysical measurements. By using a topographical GPS unit that has been configured to carry out the differential correction in real time (by radio-modem or GSM net connection to a base-station within 30 km of the site) the margins of error are reduced to very low levels. The system makes it possible to arrive at the site and immediately start taking measurements. The process of data-collection in the field is reduced to the periodic checking of the instrument's measurement values or settings and the navigation along the predetermined profiles, for which it is possible to use either a simple data logger, a PDA or a Tablet PC. The use of a Tablet PC seems to us a particularly interesting solution since it provides potential support for many other operations. For instance it permits the downloading of the geophysical data on completion of each grid square, its rapid cleaning (for example through an Excel macro), the georeferencing of the results and the inputting of images into the mobile GIS. It will also allow, at a later stage, for the precise re-location through GPS navigation of any geophysical or other anomalies which could produce enhanced information through the application of other methods or instruments.

5 Conclusion

In general we believe that giving more attention to the process of data collection, and in particular to the contribution that new technology can make in the process of fieldwork, provides one of the best ways of achieving a real improvement in the acquisition of new data for our GIS systems and consequently in the type and quality of the analyses which we can then carry out. In our experience the integration of PDA or Tablet PC and GPS devices represents for archaeologists an extremely powerful combination, capable of transforming the practice, quality and power of work in the field in much the same way as happened more than 15 years ago with the advent of desktop personal computers in the laboratory. Moreover, this new development goes a long way towards restoring the link between active work in the field and the management and analysis of heritage data in the laboratory.

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