MULTIMEDIA GUIDE IN ARCHAEOLOGICAL SITES BY GIS-GPS TECHNIQUES, POCKETPCS AND POCKET GPSs

A. Scianna *, B. Villa **, A. Ammoscato **, R. Corsale**

* C.N.R. DAST - Dipartimento di Rappresentazione – Università di Palermo, viale delle Scienze c/o Facoltà di Ingegneria, 90128 Palermo, Italy – e-mail: scianna@dirap.unipa.it
** Dipartimento di Rappresentazione – Università di Palermo, viale delle Scienze c/o Facoltà di Ingegneria, 90128 Palermo, Italy – e-mail: bevilla@unipa.it

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ABSTRACT:

Archaeology is one of the sectors that can benefit by new surveying techniques (i.e. those ones related to the use of *GPS*) for the representation and the management of an archaeological site. Another aspect of the archaeological sector that can take advantage from the use of both *GPS* and *GIS* instruments is guided visits of archaeological sites. Today, during visits in museums, visitors often use some electronic equipments as sound players, special headsets or personal computers equipped with multimedia applications. All this is possible because archaeological goods are in a relatively small covered area, where there are also people that can help the visitor at every time. On the opposite, about visiting open archaeological sites, some other problems or needs come out connected to the big dimension of the area, to the scattered distribution of archaeological goods and to meteorological conditions. So enjoying the site with traditional electronics equipment become impossible. On the contrary both *Pocket GPS*s and *PocketPC*s, connected together, may be very useful if used for multimedia guided visits of archaeological sites. This paper treats of the creation of a *GIS* multimedia guide running on *PocketPC* connected to a *Pocket GPS* by the *Bluetooth* interface, developed with *Enhanced Visual Basic*®. The system is in the testing stage in some archaeological sites in Sicily.

1. INTRODUCTION

Sicily has always been, due to its geographical position, land of conquest and occupation for peoples interested to control the Mediterranean sea. The invasions left many examples of urban structures and buildings; the remains are sometimes embedded in the cities, but very often they are sited in the countryside.
Since the beginning of 19th century, many excavation campaigns have brought to light interesting archaeological sites that are the witness of ancient people who lived in Sicily.
Archaeological goods are public property under the control of a Regional Office for Cultural Goods (*Soprintendenza Regionale ai Beni Culturali*) which has given the support for the development of this research.
Archaeological sites are also a good tourist resource to promote Sicily Region and therefore an important economic resource. So it is a primary action to build information infrastructures to enjoy this goods through a visit on site or virtual tour.
The main goal of the research project is the creation of multimedia guides to support tourist's visit of archaeological sites in Sicily.
The goal is achieved through the use of *pocketPc* and *Pocket GPS* and a software application by which is possible to define in real time position of visitors in an open archaeological site, and to give them, also in automatic way, the information on goods of visited areas.
For the different archaeological sites in Sicily, general maps at large scale (1:2000) and surveys at very large scale (1:20 for detailed architectural representation) are often available. Usually only traditional instruments are used in surveying activities and a digital map doesn't exist or it is never used as base map. Even in the better situations, only a scanned raster map is available. Besides *GIS* or *WEB-GIS* technologies are rarely used in the archaeological sector.
So in order to develop the research, it has been necessary to start with base operations as like creating suitable maps for the specific aim.
The research project is organized into four main stages:

1. Investigations on typological and dimensional features of archaeological sites in order to establish needs and hence the suitable equipments to carry out the project;
2. tests on pocket *GPS*s in order to choose the areas for the experimentation, collection and/or creation of a medium scale base maps suitable to aims;
3. collection of historical and typological information, design and construction of a *GIS* for chosen sites;
4. construction of an application for navigation in the archaeological site (the multimedia guide).

The satisfaction of proposed aims is also due to the evolution of *GIS* and *GPS* instruments. During last years, some important changes are introduced in the *GPS* field so to make possible the development of this research: the elimination of SA error by U.S.A. Army and the activation of *WAAS-EGNOS* differential correction system, that is of primary importance for the use of *pocket GPS* in the shown experimentation.

2. PRELIMINARY EXPERIMENTATION ON TEST AREAS

In the early stage of research development, some tests have been carried out in the campus area of University of Palermo, to validate some ideas assumed as basis for the entire process.
In order to check the possibilities of the use of pocket GPS instruments, many measurements and observations has been made on different kinds of predefined paths, according to the

possible configurations of really existing paths of visitors in archaeological areas.

The experimentation regarded:

1. accuracy measurement along a path;
2. precision measurement going along the same path many times;
3. stability of measurements over a fixed station point;
4. influences on measurement by external factors as presence of trees, buildings, etc.

All the tests were carried out referring to high accuracy measurements made with a *GPS* in static way.

The check of the results were made according to U.S. National Standard of Spatial Data Accuracy.

During the tests, the operator went along the test path at a moderate walking speed, simulating the same behaviour as going around in an archaeological site.

The test path is composed by straight and curve elements (these last ones with a radius of 3 meters) and, along the path, some check points has been defined, surveyed by a *GPS* with a static method.

So, after these operations, it has been verified that the use of *GPS* is suitable for open sites also with dispersed trees, and then it has been started a second stage of tests in two archaeological areas (Solunto, Monte Jato) carrying out both a cinematic survey and a static survey (this last in order to define some reference points).

3. TYPOLOGIES STUDIES ABOUT ARCHAEOLOGICAL AREAS

Starting the research, a deep investigation on dimensional and distributive features of many archaeological sites in Sicily has been carried out, in order to set the methodology and the procedure to developing the project.
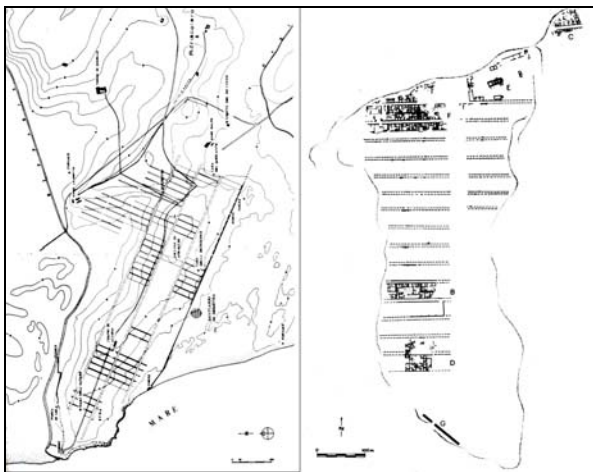

Fig. 1 – Examples of orthogonal streets plan of archaeological sites of Camarina and Hymera

The analysis of every site, the emerging observations comparing the different sites each other and also with Greek models permitted to extrapolate the grammar and the syntax of urban Hellenistic architecture.

Through this activity it was possible to define the typological structure of archaeological cities in Sicily, that is resumed as follow.

The urban plan is characterized by an orthogonal grid, that characterizes Hellenistic urban planning also known like *hippodamian*, from the name of architect *Hyppodamus of Miletus* (Fig. 1).

The hierarchical layout of the plan is organized in main longitudinal streets, large from 6 to 10 meters, intersecting in an orthogonal direction secondary streets, large from 3 to 6 meters, concurring to form rectangular blocks, 28-40x60-190 meters, (Fig. 2).
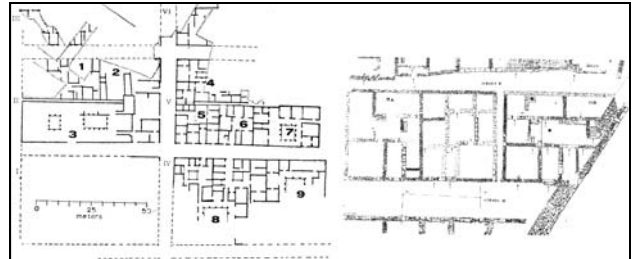

Fig. 2 – Detailed layout of archaeological sites of Morgantina and Heraclea Minoa

The *acropolis*, the holy space that hosts main temples, is situated in the upper part of the city, and it is characterized by its own city walls and by a spatial layout that includes buildings and big open areas (Fig. 3).
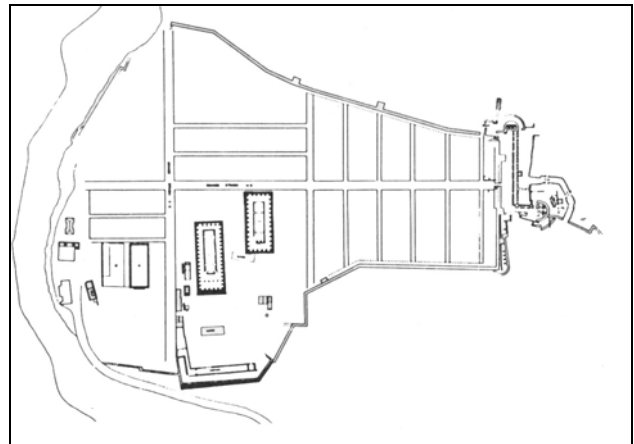

Fig. 3 – The *acropolis* of Selinunte

The public space constitutes the nucleus of these urban plans; inside it, there is the *agorà*, usually delimited by arcades, the *bouleuterion* (building including a semicircular *cavea* for meetings of local senate), the theatre, the *gymnasium,* the *thermae*, etc. (Fig. 4). All the buildings, in this area, were assigned to people services: sometimes they had small dimensions, and were integrated by wide and articulated open spaces.

According to previously exposed considerations, it is possible to say that the exploration (seen as visitor moving) can be of two types:

1. paths along the orthogonal streets, and hence in long and thin spatial areas;
2. paths without constraints in sacred areas and in public spaces.

Besides the verification of applicative potentiality of the integrated *GPS-GIS*, for navigational purposes in archaeological sites, must be developed starting from the limit situation, represented by minimum and maximum width (3-10 m) of streets of whatever urban plan; in this case it is necessary to use instruments with a positional accuracy within 1 meter (about).

A first test has been carried out in the archaeological site of *Solunto* (near Palermo). The activities were aimed to survey the site with GPS instruments in order to correctly georeference the available raster map.
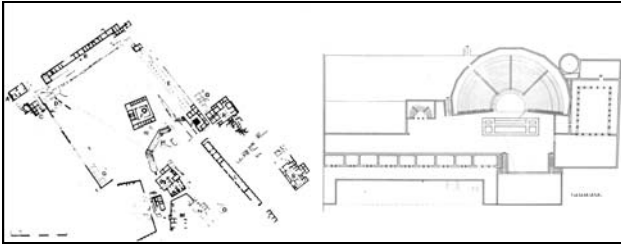
Fig. 4 – Public area in the archaeological sites of Morgantina and Solunto.

Initially a static survey has been performed with dual frequency receivers and differential post processing error correction, choosing some clearly visible points, both on the maps and orthophotos at a scale of 1:10000.

Five points (distributed in the area at regular distance) has been surveyed stopping on every points for 30 minutes.

The survey has been carried out with 3 dual frequency receivers (Topcon mod. Legacy-E-GGD), one of which positioned over a point of known coordinates and the others over the surveyed points of the archaeological site.

So it was possible to obtain both the relative position and the absolute position of surveyed points, in UTM-WGS84 system.

In order to test the two pocket GPS receivers, the survey, carried out by these ones, has been exported in shape format and superimposed to georeferenced map.

The two pocket *GPS*s used in this experimentation are:
- a Magellan Sportrack Map;
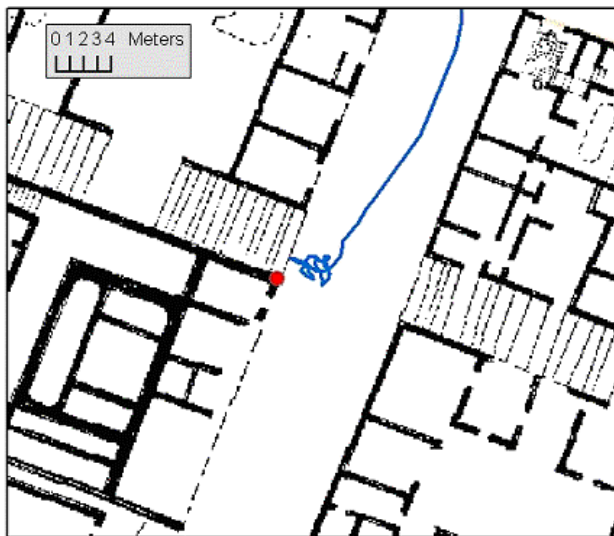- a Bluetooth EMTAC GPS with Sirf II LP chip

Fig. 5 – Positional variation relating to a fixed point

The following considerations come out from this comparison:
1. the starting time of EGNOS differential correction is about of 10-15 minutes;
2. usually only signal from the IOR Egnos satellite is always received; signal from AOR satellite is not constant;
3. the *GPS* receivers show good positioning accuracy going along a straight path;
4. when the surveyor stands on a point, the received position varies within a circle of 2.5 meters, but the first position, received when the surveyor stops, seems to be the best (Fig. 5);

5. tracks saved in the memory of the receivers are characterized by a positioning accuracy varying from 1 m and 3.5 m with a similar precision.

Generally, this kind of accuracy makes these instruments suitable for fruition of an archaeological area of this typology, but the *pocket GPS*s tested show a different behaviour probably due to different *GPS* chips used (Fig. 6).
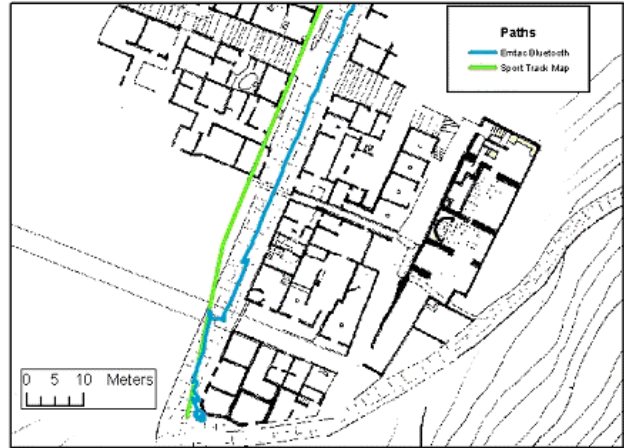

Fig. 6 – Comparison of paths surveyed with the two pocket GPS receivers used for the experimentation
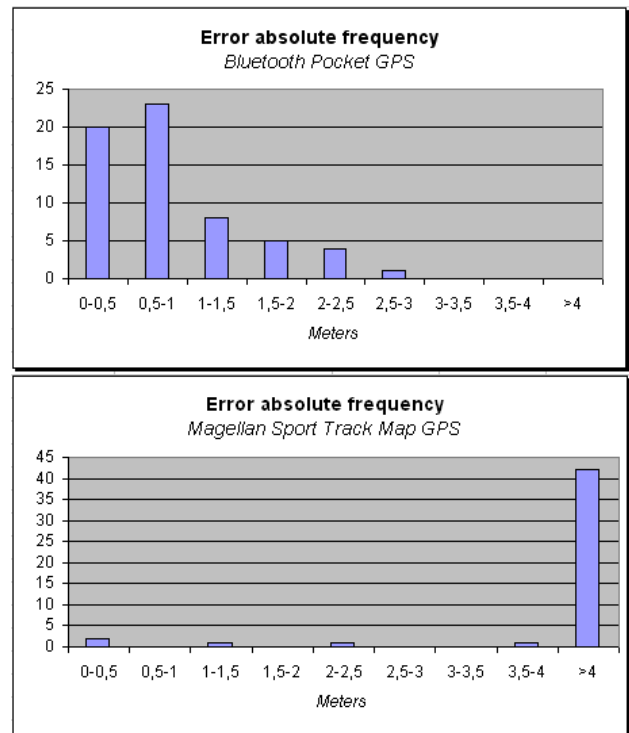

Fig. 7 – Absolute error frequency along the path

With reference to figures, it is possible to say that the Bluetooth EMTAC GPS with SirF Star II LP performs better than Magellan Sport Track Map (Fig. 7); actually the EMTAC is the most suitable instruments for the aims proposed. the Bluetooth EMTAC GPS performs well also in complex paths as that of Fig. 8.

But obviously, it is necessary to produce extensive tests to find all pocket *GPS* suitable for this kind of use.

Fig. 8 – A complex path surveyed by BT-GPS EMTAC

Another activity, that engaged the research group, was the creation of geographical database to use in the *pocketPc*, with the aim to integrate geographical information with multimedia information.

This activity has been carried out referring to *Solunto* layout (the same considerations may be done for other sites with hippodamian plan).
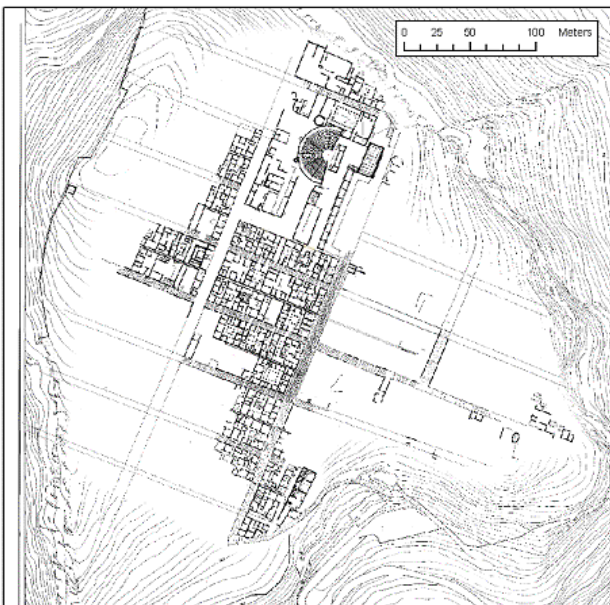

Fig. 9 – The general plan of Solunto

Solunto, that gained in the 4th century B.C. the layout as today seen, was built on the east side of *Catalfano Mountain* looking the sea, in an area strongly sloping towards East direction, from an altitude of 230 m to an altitude of 150 m above sea level.

The layout of *Solunto* is defined by main streets going from N-E to S-W (large 6.50-8.00 meters) intersecting less important street (large 3.00-5.80 meters), this last ones oriented about the maximum sloping, and so consisting very often in stairs (Fig. 9 and Fig. 10).

The blocks, defined by this layout, have a rectangular shape of 40x80 m about, organized in different levels, with smaller side looking towards main streets.

Going along main street it is possible to see (in ordered sequence):

1. a little block hosting thermal baths;
2. residential blocks, whose houses become more important going towards public area (atriums and arcades);
3. public area where are the remains of sacred buildings, of *agorà*, of a theatre, of a little *bouleuterion*, of a *gymnasium* and of a collective tank.

Fig. 10 – The layout of Solunto

Probably, in the area over the theatre – where many un-identified structures exist – would be the *acropolis* .

An area with buildings of mixed typology (houses and craftsmen shops), is located next to a street over the main street and parallel to this last.

The navigation on each archaeological site, by the multimedia navigation software, requires the creation of a *GIS* for every site.

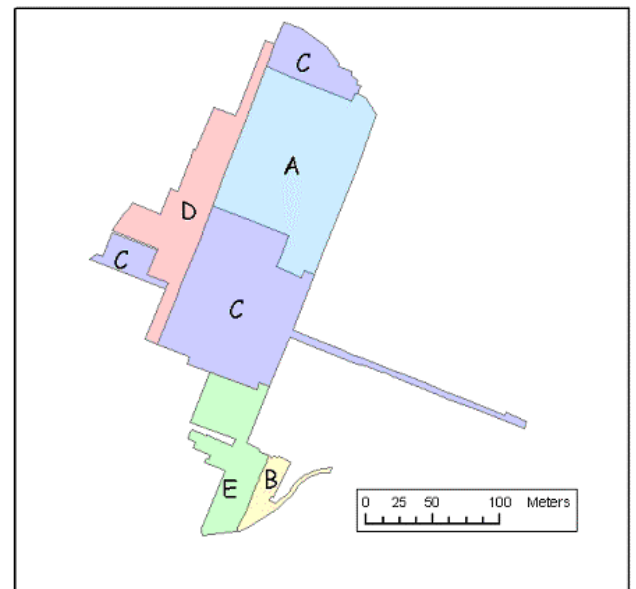The *GIS* data, of Solunto site, where organized in a hierarchical way about levels, themes and classes.

Fig. 11 – The main areas of Solunto

On the basis of the study carried out, the site has been divided in five main areas (Fig. 11):

A) public area;
B) thermal baths area;
C) wealthy people houses;
D) craftsmen blocks;
E) popular houses blocks.

Geographical objects are grouped into 3 classes (Fig. 12):
1. public and craftsmen buildings (sacred buildings, stoà, gymnasium, thermal baths, public services buildings and infrastructures);
2. residential buildings (building units characterized by decorative, functional and typological features);
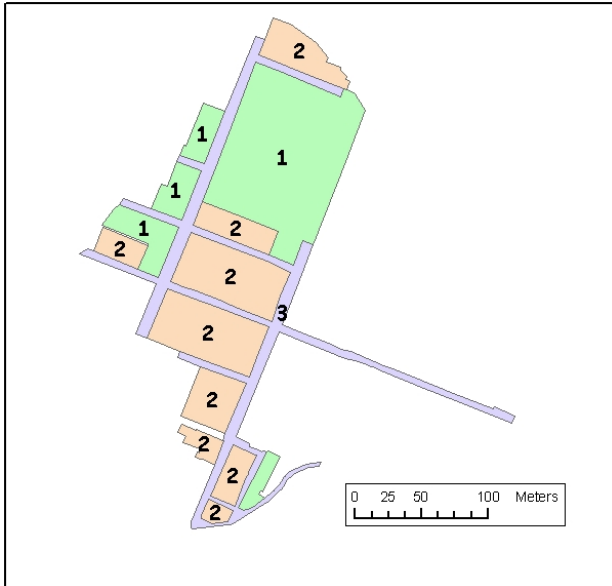3. streets (main and secondary constituting the layout of the city).

Fig. 12 – Classes of geographical objects

Streets layout is hierarchical relevant as it is the connection element between other areas (all other features).

The information relating to the upper enumerated areas are connected, in the database, to streets that are crossed from.

Every street is mainly defined by a code and a name (that was attributed by archaeologists or public owner).

The code is constituted by two couple of integers numbers, the first specify the theme, the second the class, so the whole code field exists in a domain of integer numbers.

Every class comprises the set of different parts in which a street is divided, so every part constitutes recognizing element of the areas that are crossed by.

A code is associated to every part of these.

Public and private buildings, and their open spaces, constitute geographical elements which are connected with specific information, regarding building reference types, spatial distributive features, the presence of decorative elements (mosaics, frescoes and other artistic elements), the type of use, the stages of constructions (deriving from specific archaeological studies), etc.

All this entities are defined by a code and a name.

Also in this case the code is constituted by two couple of numbers: the first specifying the theme (01 – public buildings and services, 02 – residential buildings), the second specifying the class. In order to better describe each building, it also exists a database with room data coded by a couple of numbers.

The definition of the structure of information system is finalized to facilitate the information management, during the navigation, through the software .

4. POCKETARCHEONAV – THE MULTIMEDIA GUIDE

The multimedia guide has been realized using Enhanced Visual Basic® for Pocket PC 2002 and MapInfo MapX Mobile SDK®.

MapX Mobile SDK gives the application all the base functions to manage base maps and the geodatabase.

So the Pocket ArcheoNav has got the main functions of a geographic client to query the database and to change the thematic representation of geographical objects (the features).

The support for managing *GPS* data was written, by the research group, in order to manage the data received by *GPS* units.

After the launch and map loading, the application goes in moving map state when the *GPS* button is pressed.

When the visitor goes around and enter into any feature area, the software performs a simple calculation to check if the visitor has never been in this area, and in affirmative case the guide message starts. To be sure that a point is really inside an feature area, a subroutine has been written that may calculate both the average value on a predefined number of points, received by the *GPS* unit, or the percentage of a predefined number of point that fall inside the feature area. The most suitable way to estimate the visitor position is through the second method: the position is given good if the 80% of 5 points are inside a feature, but the percentage value or the number of points may be changed.

The PocketPc used for the experimentation is a HP IPAQ 5450 with 64 MB of RAM (Arm Xscale processor), equipped with an expansion memory SD card of 256 MB. The speed of the processor is of main importance for this kind of application.
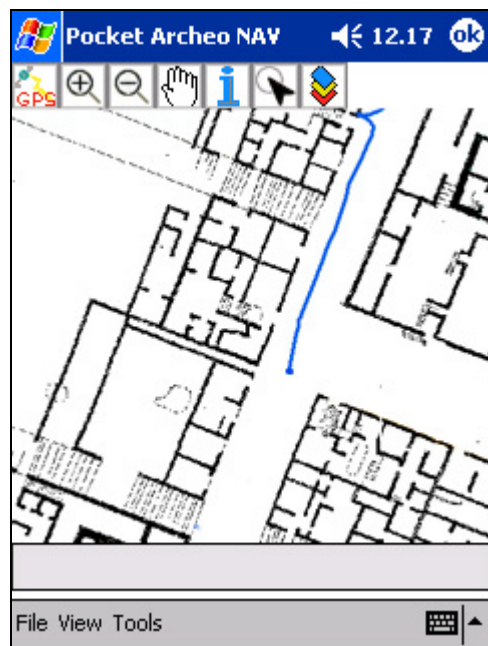

Fig. 13 – The main screen of the software application

The geodatabase is built using ArcGIS® then exported in MapInfo® by which is created the MapInfo geoset, that is also supported by MapX Mobile SDK®.

Sound data files are converted in MP3 format to save space.

The database has a minimal dimension and structure in order to save memory and to improve the execution speed of the application.

Every point is received, by the *GPS*, in geographical coordinates in WGS84 datum and is converted by a subroutine

in plane coordinates in UTM-WGS84 format. No other type of conversion is performed in order to minimize errors.

For this reason, all the maps, as previously said, are georeferenced in the UTM-WGS84 system through an accurate *GPS* survey.

In moving map state (Fig. 13) the application also show the position of the visitor on the screen, moreover an option permits to visualize labels relating to each feature area of some interest.

5. CONCLUSIONS

The application still requires a period of test to make it more user friendly. The buttons on pocket PC can be used to perform some simple actions as starting the navigation, re-launching the instructions about an area or stopping the message.

Today, the test on the use of the software application, showed here, is carried out in the archaeological site of Monte Jato.

But there are some important activities to carry out :

- to realize of an open *GIS* support for managing the geodatabase.
- to carry out some other tests on many other *GPS* systems (of bluetooth type or applied to a pocketPC by a jacket), checking the accuracy of positioning in relation to the chip used to build them, also looking for the less expensive *GPSs*.
- to better investigate the possibility to standardize the description of archaeological sites by *GIS*, also for the virtual fruition through a *WEB-GIS* system.

The global aim is to extend the use of the system to all open archaeological sites of Sicily.

REFERENCES AND SELECTED BIBLIOGRAPHY

Atzeni P., Ceri S., Paraboschi S., Torlone R., 1999. *Basi di dati*. McGraw-Hill, Milano.

Coarelli F., Torelli M., 1988. *Guide archeologiche Laterza - Sicilia*. Laterza, Bari.

Coppa M., 1981. *Storia dell'urbanistica, Le età ellenistich*e, Officina edizioni, Roma.

Forte M., 2002. *I sistemi informativi geografici in archeologia*, MondoGis s.r.l., Roma.

Hell V., Hell H., 1988. *Turchia*, Edizioni Futuro, Verona.

Kennedy M., 1996. *The Global Positioning System and GIS: An introduction*. Ann Arbor Press, Chelsea, Michigan.

Leick, Alfred, 1995. *GPS Satellite surveying.* John Wiley & sons, Inc., New York.

Many authors, 2003. *Solunto Zona archelogica*. PI.GI.EMME, Palermo, Italia.

Many authors, 2003. "Open GIS specifications". http://www.opengis.org/specs/?page=specs (accessed 30 Mar. 2004).

Many authors, 2004. "The Egnos System". http://www.esa.int/esaNA/egnos.html (accessed 15 Apr. 2004).

"MapX Mobile®: Developer's Guide", MapInfo Corporation, Troy, NY.

Martin R., 1980. *Architettura Greca*, Electa Edizioni, Milano.

Ray S., 1987. *L'architettura dell'occidente*, La Nuova Italia Scientifica, Roma.

Pausania, 1991 *Viaggio in Grecia*, Rizzoli libri s.p.a., Milano.