APPLICATION OF A GIS FOR THE ACCESSIBILITY OF ARCHAEOLOGICAL SITES BY VISITORS WITH DISABILITY AND VISITORS WITH REDUCED MOBILITY

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ABSTRACT:

Over the last years, most developed countries take more and more serious concern in providing easy access to their historic monuments and archaeological sites. At European level, a social policy, which supports initiatives and projects related to reception aspects of people with reduced mobility (PRM), e.g. senior citizens, and people with disability (PwD), e.g. wheel-chair users, has already been launched.
This paper describes the design of a special Geographic Information System (GIS) called "AccAeS" (ACCessibility on archAEological Sites), which will improve accessibility conditions of archaeological sites. As an application area the archaeological site at Philippi, Greece, has been chosen. Besides appropriate data acquisition and recording, the information is managed in such ways, so as to guarantee the 100% functioning of the chain of accessibility during a visit of a cultural site. The appropriate geometric recording of the sites and the development of the special GIS aim to serve the decision-making process and in conclusion, to improve the accessibility of all cultural resources for visitors with reduced mobility and visitors with disability.

1. INTRODUCTION

During the last couple of decades, a world-wide understanding has risen, that people with reduced mobility (PRM), include pregnancy, responsibility for small children, old age, etc, and especially people with disability (PwD) have the same rights to equally participate in social activities. A wide definition of "disability" can be: "a physical impairment which has a substantial and long-term adverse effect on a person's ability to carry out normal day-to-day activities (HMSO, 1995); the most common case is the wheel-chair users (taking into consideration a narrow definition). The understanding and attitude of society towards disabled people has developed from one of denial of their existence to a recognition of the myriad of ways in which society itself has created both the physical and social barriers which disadvantage them (Imrie and Hall, 2001).

Today, accessibility and freedom of choice are considered as basic human rights and people with disability may face particular challenges regarding these rights. The continuously growing participation of PRM and PwD in all domains of cultural life has become one of the most critical factors for the determination of relevant guidelines both at national and international levels. On a European level, there is official recognition that the historic environment makes a significant contribution to the cultural, social and economic well-being of people, that is to their quality of life, education and enjoyment; it provides a unique source of information and livelihood and is a powerful generator of wealth and prosperity, particularly within the tourism industry (English Heritage, 2005). Specific European and national directives support policies and implementation strategies, which require special provisions to be made to ensure equality of access for PwD and PRM, e.g. guidelines for Universal Design.

The participation of PRM and PwD in cultural activities, unlike other social activities, has a special characteristic related to the restrictions caused by the nature of the cultural environment, that is the topology of the archaeological site, the constructions, etc. Questions arise though related to the type and size of interventions that must or can be done so that PwD will have the same accessibility rights. Should the historical environment be adapted to reflect the visitor rights of those for whom the historic environment presents physical barriers? Is it acceptable to have "alternatives" for disabled people instead of preserving the "original" environment for future generations?

2. ACCESSIBILITY OF ARCHAEOLOGICAL SITES

There is an obvious need for balance between access rights and conservation of the archaeological sites, which demands the development of the relevant access legislation and technical standards. Barrier-free access is one of the most significant key-elements. Barriers exist at various levels, such as:

- organisational issues, such as lack of staff or lack of support for access improvements
- physical issues, such as lack of accessible signage and information, narrow paths and entrances, loose or uneven path surfaces, steep slopes and long distances, steps, lack of seating and shelter, luck of accessible toilets and baby changing facilities
- intellectual issues, e.g., complex or text-only information
- social and cultural issues, e.g., publicity does not promote access, inaccessible website, lack of information shared with local community etc
- financial issues, such as charges for activities, like guided tours, cost of travelling to and from a site.

In order to grant accessibility to cultural environments, activities on two levels need to take place:

- public awareness needs to be risen as far as cultural heritage is concerned, so that the public interest will start at younger ages and
- necessary infrastructure needs to be provided, in order to guarantee accessibility to all population groups.

Tools appropriate for planning better access are very important. The development of a special Geographic Information System (GIS), which combines various types of information (2D or 3D graphical, raster, textural etc), will improve accessibility conditions for PRM and PwD in cultural environments, and can

be such a tool. The goal is to find a way to more easily facilitate comfortable and safe mobility and to inform on accessible and safe ways providing personalised guidance information for every user. GIS technology offers the appropriate solutions to such a multi-parameter problem, making good use of all types of information, while it provides for a further development of the system. Relevant proposals, for accessibility in built environments, were made (Vozikis, 2005), based on the so-called "chain of accessibility" (Business & Disability, 2007). This means that every link of the access-chain needs to be intact, otherwise no accessibility can be guaranteed; e.g., pavement networks, public transport stops, means of public transportation, curb cuts, hand railings, special parking lots for wheelchair users, even pavement surfaces, sufficient lighting, information in Braille. The final intention is to offer every user the possibility to create queries and to have the GIS find the best possible solution to reach the target, according to the tourist's personal criteria of autonomy.

The parameters of such a special GIS are shown below, regarding the improvement of accessibility conditions of archaeological sites, as well as results derived from a pilot application for the archaeological site of Philippi in Northern Greece, one of the largest and most significant historical sites of the country. These were developed in the frameworks of a research project entitled "ACCessibility on archAEological Sites (AccAeS)".

3. A SPECIAL GIS FOR "AccAeS" PROJECT

The most common fields of application in GIS are the disaster mapping, land management, navigation domain (e.g. car driving navigation systems), incident locating, monitoring and state-of-the-art decision-making applications. Its use in the domain of tourism is reduced to the provision of online information for visitors about archaeological sites and monuments (digital tourist guides), studies dealing with the restoration and upgrading of them, hotel booking and other tourist relevant informative sources. Although the use of GIS in archaeological applications has been developed significantly in the last years though, it mostly focuses on the creation of systems, which provide in-situ information for tourists, and on specified studies, such as for the regeneration of archaeological sites or for restoring monuments (Ioannidis et al, 2004).

The idea of using a GIS for the functioning of the chain of accessibility, during tourist visits in archaeological sites, is new. The development of a special GIS, including the appropriate 3D geometric recording of the sites, aim to serve the decision-making process and to improve the accessibility of all cultural resources for visitors PRM and PwD. The third dimension in this system, and consequently the development of 3D GIS, is of great importance (archaeological sites usually have rough relief).

The possibility for users to ask route questions and be answered appropriately is considered the most important value of "AccAeS" project: every visitor with disability and visitor with reduced mobility has her/his own special criteria, which have to be fulfilled in order to reach the target destination in a safe and autonomous way. This personalized criteria distinction is of major importance, as on the one hand, the kinds of obstacles, which the person with reduced mobility has to avoid are not considered prohibitive for the person with visual impairment. On the other hand, obstacles of a certain height will definitely cause problems to the person with visual impairment, but such obstacles may not have been considered when searching for a route for the wheelchair user. Thus, the possibility of creating queries and of choosing the most appropriate route according to personal mobility criteria is considered to be one of the most important facets in such a system.

The aim of the Information System of "AccAeS" is to provide accurate and up-dated information, to enable users to define their own preferences, as well as to offer the 'best possible solution' to any kind of queries. The query values of "AccAeS include for instance:

- reaching the archaeological site: best route with means of public transportation, etc.
- reaching the accessible entrance: fewest crosswalks from parking area, most traffic lights, etc.
- cost: cheapest way of arrival, entrance price reductions for PwD, etc.
- distance: shortest route on foot/ by car, etc.
- outdoor orientation: best signed way on foot/ by car, etc.
- archaeological site visit: accessible paths, possibility of round-walks, overview plans of service's location, supportive construction elements, etc.
- route description: route with most trees/under shelters, route to most important spots, etc.
- supportive equipment: sitting possibilities, drinking water fountains, etc.
- visitor's facilities: accessible WC, museum, souvenir shop, cafeteria, etc.

4. PROJECT'S PHASES

The project "AccAeS" consists of four work phases, which are presented below.

4.1 First Phase: Parameters identification

The first phase refers to the identification of parameters and the definition of all required criteria and relevant factors for an autonomous, easy, safe and barrier-free visit of archaeological sites by visitors with disability and visitors with reduced mobility. This parameterization is based on the listing and categorization of all significant architectural parameters (according to national and international universal design standards, as well as the real needs according to interviews with persons with disability), which enable or hinder PwD and PRM to reach a target on a cultural site on their own. The determined parameters were inserted into the data base of the GIS.

The specific parameters were divided into the following nine categories:

- General Site Information
- Approach Route
- Approach Route Facilities
- Outdoor Parking and (Dis-) Embarkation Space
- Main Entrance Access
- Accessible Main Entrance
- Security Exits
- Horizontal Circulation (Corridors)
- WC Facilities
- Other Site Services (Counters, Drinking Water Fountains, Rest Areas, etc).

Table 1 shows, by example, the parameters which were selected for the category "Horizontal Circulation".

Stairs from accessible entrance to corridor?	Yes	No		
How many steps?	Nr:		Height:	Width:
Is corridor accessible with other means: ramp /stairlift ?	Yes	No	Existing means	
Corridor width (>1,30m)?	Yes	No	Width:	
Corridor height (>2,20m)?	Yes	No	Height:	
Corridor inclination (<6%)?	Yes	No	Incl.:	
Corridor surface continuous,	cont	Yes	No (description)	
smooth, non-slippery?	n-slip	Yes	No (description)	
Space for wheelchair turning	beg	Yes	No	
cycle at corridor's beginning,	mid	Yes	No	
end, middle? (r=1,50m)	end	Yes	No	
Handrails on both sides?	Yes	No		
Handrails in 0.7/0.9m height?	Yes	No		
Signs height (<1,40m)?	Yes	No	Height:	
Information in Braille?	Yes	No	Description	
Obstacles in corridor?	Yes	No	Description	
Lighting?	Yes	No	Existing means	

Table 1. Parameters for the category "Horizontal Circulation"

4.2 Second Phase: Geometric recording

The second phase of "AccAeS" concerns the data collection and processing of the geometric information, which is needed for the 3D GIS structure. It includes the update and completion of all existing material (surveying and architectural plans, aerial and terrestrial images of the site, etc) and the integration of new data, using field surveys, photogrammetric techniques or terrestrial laser scanning. The modern methods for geometric documentation of monuments provide a variety of choices, according to the topography of the area, the object and the users' demands in terms of costs, details, and accuracy (Ioannidis and Georgopoulos, 2007).

The necessary products include the Digital Terrain Model (DTM) of the archaeological site and the surrounding area, the road network of the broader area with the points of interest, e.g. entrances, ticket boot, museum, important spots for the visit of the archaeological site. In areas of the archaeological site, where routes for PRM and PwD are planned to be made, the demands for accuracy and details of the geometric recording are very high, similar to those of the construction plans (at scales of 1:20 – 1:100); for the rest areas the accuracy demands are much lower, e.g., at scales of 1:200 – 1:1,000. Ortho-images, at scales of 1:500-1:1,000, are usually the plans of the broader area; high resolution satellite images or aerial photos of medium scale used for the production of these ortho-images.

4.3 Third Phase: Qualitative information

The project's third phase includes the detailed in-situ observation and criteria recording of all necessary qualitative information, such as:

- the arrival/ departure area (parking space, nearest bus stop, entrance/ exit of the archaeological site, ticket counter, etc)
- points of interest inside the archaeological site (historic monuments, buildings, museum, drinking water fountains, souvenir shop, toilets, etc)
- points for emergency cases in the wider region (doctor's office, pharmacy, police station, phone boots, etc)
- names and numbering of roads, etc.

The recording of all these data sets is made with special emphasis on the pre-defined parameters and with consideration of universal design guidelines.

4.4 Fourth Phase: GIS development

The fourth phase of "AccAeS" consists of the development of the GIS and refers to the correlation of the two information groups (geometric and qualitative data) by integrating it into the GIS. Therefore, proper filing and saving of all gathered geographic information (e.g. geometry of an object and its 3-dimensional location in space) and non-geographic information (e.g. description of features and object attributes) is necessary, in order to have the tool answer to users' queries. With this facility in place, every user will have the opportunity to enter her/his personal criteria and get the best possible access/route solution.

The analysis and documentation of the results provide conclusions about the practical benefits and gives the possibility for making proposals on the applicability of the proposed system. The appropriate geometric recording of archaeological sites and the development of the special 3D GIS aim to serve the decision-making process and to improve the accessibility of all cultural resources for visitors with reduced mobility and visitors with disability.

5. PILOT APPLICATION OF "AccAeS"

For a pilot application of "AccAeS" project the archaeological site of Philippi, in Greece, was selected to be the most appropriate; the main criteria of its selection are:

- It consist one of the most important archaeological sites of Greece, but is comparatively less known and visited.
- The area of the site is large and, in most parts, it is not easily accessible by PRM and PwD. Accessibility problems are caused by the area topography (ground inclination), the height differences between the historic monuments and the contemporary technical interventions (such as the construction of a road through the site).
- Historical and archaeological information and geometric recording data were available from older studies, compiled by members of the research group.

Figure 1. 3D view of the archaeological site of Philippi and the surrounding area (source: Google Earth)

5.1 Historical information and description of the site

The archaeological site of Philippi is situated in northern Greece, 17 km to the northwest of the city of Kavala, at the foot of the mountain Pangeon. The first city (named Krenides) was founded by Attic colonists, at the spot where the Thracians exploited gold mines. Around 350 BC, this ancient city was

fortified by Philip II from Macedonia, and therefore was named after him. In Roman times (42 BC), the area of Philippi became well known, due to the victories of Antonius and Octavius against Caesar's murderers Brutus and Cassius in the city's surroundings.

Furthermore, the visit of the Apostle Paul has remained in history, as it was here that he founded the first Christian village on European territory and because he was kept in prison. From the city's zenith in the 10th century AC, when it was the bishop's residence, there are the remains of Byzantine basilicas. The city's decadence starts with the intrusion of the Franks, in the 12th century. However, the fortification walls remained until the end of the Byzantine Empire.

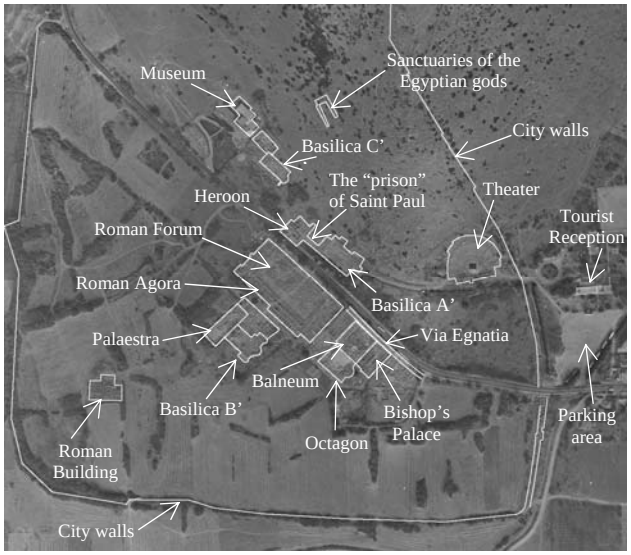

Figure 2. Orthophoto of the archaeological site of Philippi showing the most important spots during a visit

The area surrounded by the fortification walls is approximately 65 he, up to the pick of the hill where an Acropolis is (Figure 1); the archaeological excavations cover an area of almost 7 he (Figure 2), but they are cut into two due to the crossing National Highway from Kavala to Drama. This road is positioned approximately parallel to the ancient "Via Egnatia", an important historic avenue, which linked the Dirrachion and Byzantium for a length of more than 1,000 Roman miles.

Figure 3. The Roman ruins and the Basilica B', at the southern part of the archaeological site

So, the visit of the archaeological site is separated into two parts. In the southern part, the excavations are gathered nearby. The most interesting monuments, these that should be accessible by the PRM and PwD, are:

- remains of the Roman Forum, Agora and Palaistra (2nd century AC), with height difference of 4.5-7 m to the street level (Figure 3)
- the Basilica B', from the Old-Christian times (6th century AC), with height difference of -6 m to the street level
- the octagon Sanctuary with mosaics with height difference of -3.5 m to the street level; at the same area there are, also, the remains of the Bishop's Palace, and a Balneum (baths) from the 2nd century AC
- parts of Via Egnatia.

The northern part of the archaeological site is accessible by car; there are two parking areas, one at the eastern end of the site, close to the recently built cafeteria (tourists reception) and one at the western end, close to the local archaeological Museum. The most interesting monuments in this area are:

- the Greek theatre (with a height difference of approximately 6 m between the orchestra and the nearby parking area), dating back to the 4th century BC, but having been adapted and changed several times during the Roman period. This theatre is still used as a performance area for open-air festivals during the summer period
- the Basilica A', from the Old-Christian times (5th–6th century AC), with height difference of 5.5 m to the street level, and a Roman Heroon, which start from the level of the road and reaches a relative height of +5 m
- the Basilica C', 4th-6th century AC, next to the Museum.

Figure 4. The ancient Theatre, at the northern part of the site

5.2 Geometric recording of the site

The first tree phases of the project were made mostly in parallel; it was an interactive procedure, by using the conclusions derived during the compilation of one phase for the completion of the other phases. From the process it was concluded that the successful operation of the developing system depends, to a great extent, on the right choices for the geometric recording and documentation of the site.

The spatial infrastructure of the GIS was based on the use of the existing material and the collection and editing of new data. The existing information was:

- aerial photos for photogrammetric processing, taken in 1994 at a scale of 1:6,000 and low altitude photos taken by balloon, at 20-50m height above the ground, mainly for documentation purposes (Figure 5)
- excavation and architectural plans of monuments, at scales of 1:20-1:100 and general use 2D topographic diagrams of the site and the surrounding area at a medium scale.

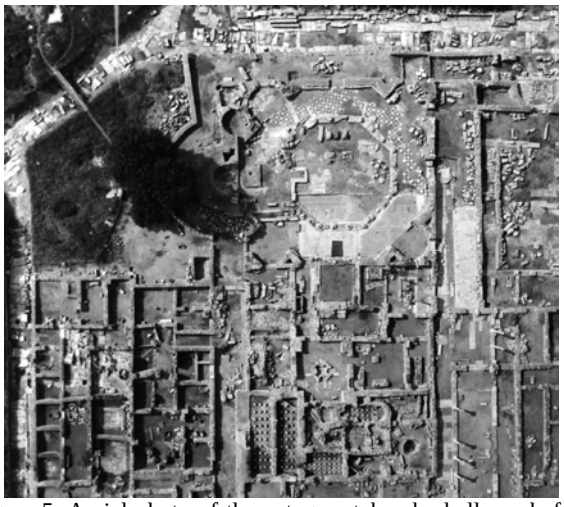

Figure 5. Aerial photo of the octagon, taken by balloon, before it was covered by a shelter

For the update of these data, the acquisition of new information and the creation of the necessary GIS coverage, the following were done (or are still under development):

- field surveys, such as the measurement of the control points for the photogrammetric stereo-restitution, terrestrial images and laser scans acquisition at particular locations and of particular monuments
- data processing and combined use of various types of data, for DTM extraction and orthophoto production of the archaeological site and the surrounding area (Figure 9), detailed restitutions and intersections of the ground and the excavation areas at selected zones (of existing and proposed routes, points of interest, etc), 3D models at particular locations of the site (for the extraction of horizontal intersections and, also, to check the visibility along the routes at particular heights above the ground).

5.3 Proposed routes for PRM and PwD

The main issues for the determination of the structure and operation of the GIS, are:

- the definition of the structure of the data base, using the final parameters, which are identified during the first phase of the project, and
- the efficiency control of the system, through its actual use by persons with reduced mobility.

Figure 6. Existing routes within the archaeological site (top: at the southern part, bottom: at the northern part) easily accessible by PRM and PwD

Figure 7. The current connection of the northern and southern part of the archaeological site (left) and the other entrances of the southern part (right)

A significant portion of this study was the allocation and the selection of the routes which would or must be available for the PRM and PwD when visiting the archaeological site. In the site there are areas and routes which have no accessibility problem (Figure 6); yet the following should be improved:

- the difficulty in visiting the southern part of the site, which today is inaccessible by PRM and PwD, since there is no parking area nearby and the existing three entrances from the road requiring the use of stairways (Figure 7)
- the significant height differences between the monuments in the northern part of the site and the frequent existence of stairs (Figure 8) or the steep inclinations of the visitor's routes.

The combined used of the data derived from the three first phases of the project (parameters-technical specifications, geometric recording, in-situ investigation) led to the determination of access points, parking areas and routes, which connect and approach all the important monuments of the site and are accessible by PRM and PwD. The important objectives ware to avoid the need for construction or other interventions which would affect the shape of the archaeological site and, simultaneously, to achieve a low cost solution (e.g., using small wooden bridges, fills or smoothening of the ground between the monuments, etc). Figure 9 gives a general impression of these proposed routes, parking areas, as well as current height differences along the routes.

Figure 8. Locations with height differences, scattered within the archaeological site

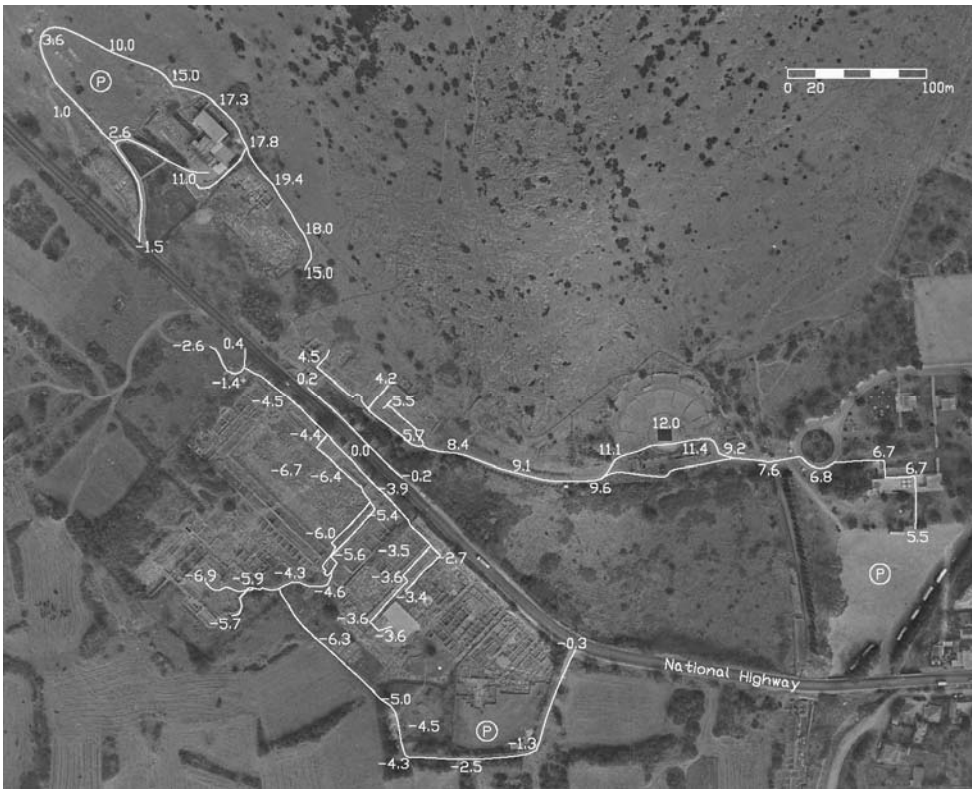

Figure 9. The proposed routes and existing height differences at the most important monuments of the archaeological site of Philippi.

6. CONCLUSIONS

So far, products of geometric recording have been used for the documentation of individual monuments and archaeological sites. The integration of such products into a special 3D GIS for identifying accessible routes in areas of cultural heritage for visitors with disability and visitors with reduced mobility is an innovative initiative. An important issue is the parameterization of the existing technical specifications for similar aspects at European level and their integration into the data base of the system. The development of "AccAeS" project and the pilot application on the archaeological site of Philippi have shown, that it can be a reliable tool for the improvement of the existing situation.

Yet, physical access improvements to enable tourists with disabilities to visit archaeological sites and historic environments are a compromise because of the strength of conservation interests. Questions remain as to whether intellectual access, such as audio-visual presentations and virtual tours, is an acceptable substitute for physical presence.

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