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Virtual Representation of Archaeological Excavation and Surroundings Using Topographical Techniques, for The Purpose of Assisting Museums with the Presentation of Archaeological Information.

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Abstract. This paper presents the results of the investigation being carried out by the Landscape and Archaeology Research Group of the Polytechnic University of Madrid. The principal aim is the creation of three-dimensional pattern of archaeological sites and their surroundings, while maintaining the accuracy afforded by traditional cartographic documents. The prototypes are developed by linking the archaeological sites to national and international geodesic networks, and the creation of an enclosing grid that makes it possible to express any type of topographical work or archaeological details using a system of standard co-ordinates. Thereafter the more detailed data from the site is analysed, in an attempt to achieve sufficient quality of data that will allow the creation of maps at a scale of 1:100 of the surroundings, and 1:50 maps of the excavations. In this phase the latest methodologies and instrumentation are tested (GPS in RTK, laser total stations, etc.) as well as sensitivity analyses under extreme conditions. In-situ data representing the topography of the site and surroundings has been obtained, bi- and three-dimensional "cartographic documents" have been developed from DTM and hyper-realistic virtual representations of the excavation. Finally multimedia prototypes have been designed using special software, which enables the entire archaeological phenomenon to be integrated within the cultural heritage. This paper presents the models developed for the Sharjah Project (UAE), in the archaeological sites of Jebel Buhais and Mleiha.

Keywords. cartography, archaeology, 3D models.

1 Introduction

The Landscape and Archaeology Investigation Group of Madrid Polytechnic University was founded in 1996, aiming in the development of new means of co-operation between the sciences of cartography and archaeology, applying the latest engineering technology. A dual line of investigation was followed.

In the first place the intention was to provide basic archaeological maps at different scales that could be used as supporting information by multi-disciplinary teams participating in the excavation, providing documents for the scientific analysis of both traditional and digital maps.

On the other hand the intention was to produce cartographic documents that will assist in the development of material, in hard copies for static displays, or in digital format for dynamic simulations. I such a way as to provide museums with a means to market all of the above.

In both cases our main objective is to maintain the topography, the geometric layout, below the presentation but always accessible, and in this way expend the field of application of both disciplines.

We are working within the terms of the agreement established with the Department of Culture and Information of Sharjah Emirates, and in close collaboration with the Museum of Archaeology, developing models and prototypes. We also rely on the support of the *Colegio Oficial de Ingenieros Técnicos en Topografía* and the participation of companies operating in this sector.

In this report the results presented were obtained in the course of the project described above, from the work carried out by the Investigation Group.

In dealing with the existing cartography, we can draw attention to the following report:

Digitalisation of the cartography of the Emirate of Sharjah. Creation of a topographical map at a scale of 1/50.000 and a map locating the archaeological sites and places of historical interest with internet link. -Ricardo Lobo, Gerardo Mellado y Natalia Hernandez-.

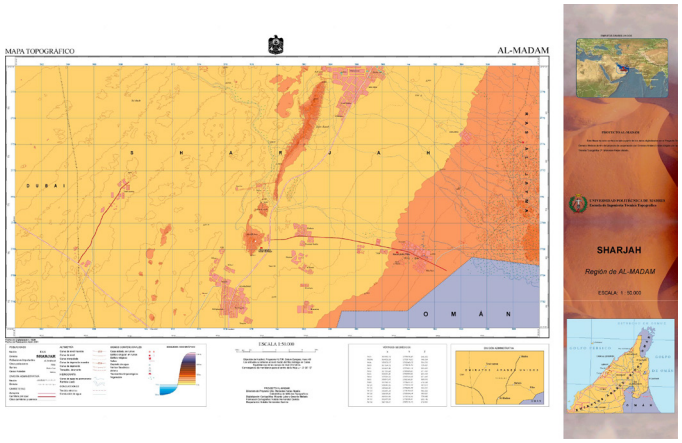
This cartographic work was carried out in the Al-Madam region of Emirate of Sharjah in the U.A.E. The main objective was to provide means of managing information to obtain cartographic documents that can assist specialist participating in international archaeological investigation projects, which was made possible by a strong political investment on the part of the Department of Culture and Information of the Emirate.

The original documentation provided by the Department of Culture and Information consisted of 8 maps measuring 0,80 m x 3,20 m in UTM projection, at a scale of 1/6.250. This documentation, of English origin, was dated in 1992. From the digitalisation of the maps mentioned previously topographical maps of the Al-Madam region were obtained at a scale of 1/ 50.000 . In this map archaeological sites were located using co-ordinates from the survey points and observed using GPS techniques from the 1997 survey .

Later this document was manipulated using Freehand 9 software, from which the following was obtained.

As part of this project a map was also created that identified archaeological sites in the Emirates as well as sites of

historical-cultural interest in the city of Sharjah, and in particular the archaeological Museum. The dates used for the creation of this map come from digital images from the Emirate of Sharjah Atlas, in situ photographs as well as other information obtained through the Internet, and tourist information, literature from the country itself and the Emirates Embassy in Spain. The Sharjah tourist map included 3D images of buildings of historical-cultural interest as well as other images that enhanced the presentation and converted it into a more user friendly document. This document was created in digital format which allows a much greater flexibility for updating and offers an opportunity to work with the map in a much more efficient manner.



Another project along the same lines is:

Creation and updating of existing cartographic documents and multimedia maps of Emirate of Sharjah. -Elena Ledesma, Sonia Acosta-

In order to carry out this work it was necessary to visit the Emirate of Sharjah where relevant information related to the work could be gathered and checked., with the objective of information dissemination for archaeological and tourism purposes, in both paper and multimedia formats.

The hard copy format consists of a brochure with a theme map of the city of Sharjah in which different museums are identified with supporting information relating to the country and the Emirate of Sharjah.

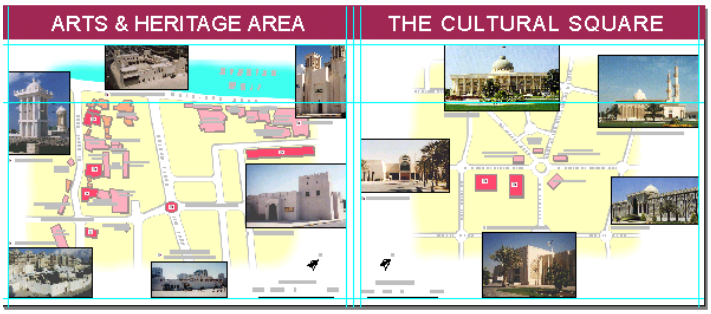
The creation of the map came about through a long process which started with the calculation of the area of the zone to be represented, the scale, the projection, and other interrelated data that depended on the purpose of the map. Once these parameters were defined the cartographic process started, with generalised procedure, in which the work of the cartographer was to select only those data that would guide the reader to a good interpretation. This is a long process that could not be defined by mathematical rules, given that the grid scale of the map depended on the level of information to be shown, and therefor the level of generalisation. Once the map had been scanned the co-ordinate information was added, using an information source compatible with computer, which could be manually digitalised using Freehand 9, a program that allows screen digitalisation. The tourist brochure was completed using text annotation, which gave a more complete picture of the city of Sharjah. For the selection of the final composition a number of different models were used as well as the development of a number of prototypes.

The resulting brochure includes pages such as the following:

Another means of representing the archaeological and tourist information is through the use of multimedia technology. Its introduction in museums assumes that visitors are interested in learning and experimenting, both of which, require active participation. The project includes the development of multimedia prototypes that would familiarise us with the UAE, giving a general overview of the country. We propose that a journey through the Emirate of Sharjah is demonstrated from East to West. One would get to know Sharjah as a cultural and commercial city with a great number of museums and historic sites that reflect the life and culture of the people. And on the East Coast we will get to know interesting cities such as Dibba, Kalba y Khorfakkan.

For the development of the multimedia presentation *Director 7* software programme was used, the treatment of the photos and screens was done with *PhotoShop 5,* and the plans and symbols with *Freehand 8*.

The large number of the archaeological sites that exist in the Emirate has provided the means to discover the roots and culture of the civilisation in more depth.

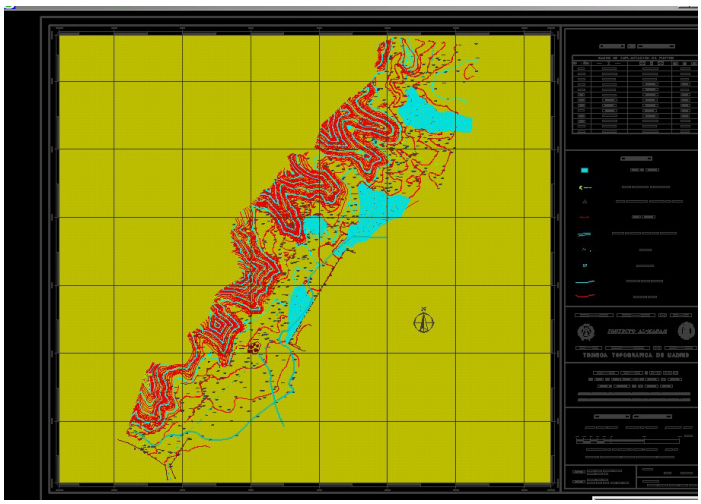


All of the above demonstrates how cartography is enhanced using new technology and incorporating new means of communications, the Internet and multimedia technologies and how all of these enrich the possibilities.

Following along these general lines we demonstrate the search for new cartographic systems for the archaeological sites and theirs surroundings by mean of the following three reports:

1) Topographical map at scale 1 /1.000 of the Jebel Buhais Area in the Emirate of Sharjah (UAE) and the creation of the

Digital Terrain Model (DTM). -Roberto Hernandez, Alberto González-.



The area chosen to carry out this project was an important archaeological site in Jebel Buhais. The topography of the zone is a decisive factor for the location of this site. We can describe Jebel Buhais as a small mountain range which block the advance of the Rub-al-Khali desert.

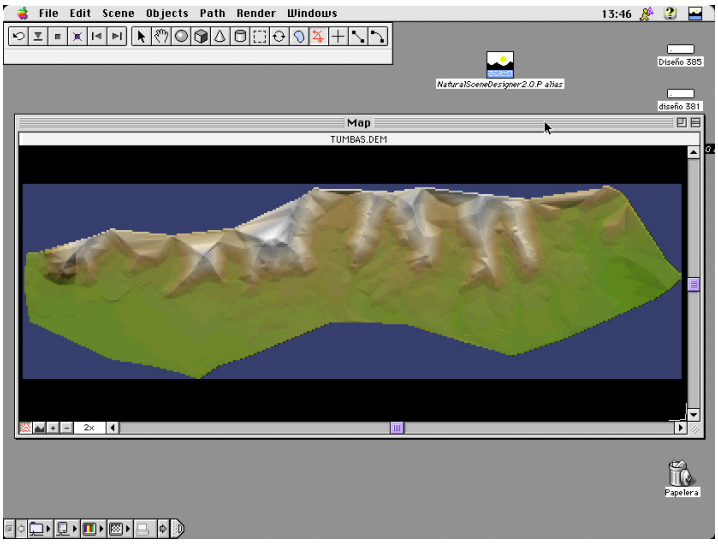
The shape of the Jebel Buhais, on the side shielded from the desert sands has been used since time immemorial as a communication route. This site was chosen for development, as is demonstrated by the archaeological remains. The great number of tombs encountered here leads us to believe that Jebel Buhais is a sacred place and burial ground for more that just the people using the caravan route and the few that lived there. To date more that 80 tombs have been found in the area, some of which were communal graves. The excavation work continues today. The data collection work was done in February 2000, with a TC 1000 total-station and accessories. In addition to the survey points that describe the topography of the terrain, each grave was also marked so that it could be shown later with a symbol on the map. The graves dates back to different times varying from the Iron Age to the Islamic era.

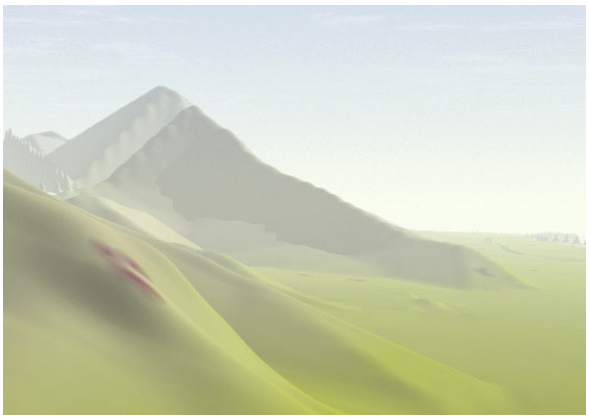
The setting out of the basic grid was done with GPS equipment in such way that one fixed point was first chosen. In later survey work that point was taken as a reference point, used to measure co-ordinate increments in x, y, z. The grid consisted of 13 points in segment 40 of the UTM projection, and the reference ellipsoid WGS84 was used.

The data collected after each day of work was transferred to the computer and treated with the calculation program *TOPCAL,* such

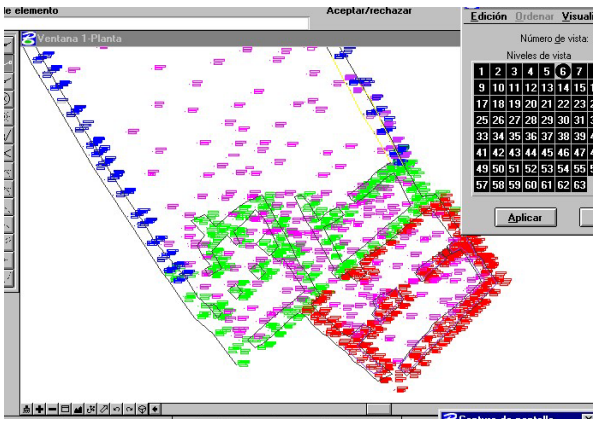
that the corresponding scatter of points could be observed with the drawing program, which in this case was *Microstation*. By obtaining the scatter of points for each zone it was possible to create contours with the program *INRAIL*.

The project was completed with the creation of the DTM with the help of *Natural Scene Design* software. For this it was necessary to create a triangular mesh and convert it into a raster image with the program *MDTOP*. Using this program it was possible to navigate the whole archaeological area as well as capture images from any perspective**.**





2) Topographical representation of Al-Madam 31 Sector and creation of three-dimensional model. -Berta Dominguez, Mirem Bartolome-.



The aim of this work, which was carried out in the Al-Madam 31 Area, was the creation of a 3D model for the local construction of the Jebel Buhais site and surrounding area. This type of representation of an object is very attractive due to its realism which enables one to easily visit the site in three-dimensions, while at the same time providing accurate information due to the way in which the model is created.

The topographical fieldwork consists of the following two phases:

- The installation of a grid from which the entire area could be seen.

- The topographical map of the construction, the hill on which it is located and the surrounding survey points.

The fieldwork is complemented with photographs showing the details of walls and floor, which allow us to introduce texture later in the digital model. In the same way 360 degrees panoramic photographs were taken to introduce them as background in the model.

The existence of previous topographical grids which encompassed the whole zone of Jebel Buhais simplified the installation of the grid required for this work, given that two of the first points were adequately positioned to allow visibility, and it was only necessary to locate two more points. This was done in such a way that the whole zone was visible from one of these four points.

A Wild totalstation TC 1000 was used for the topographical work, with which horizontal and vertical angles and geometric distances from each visible points were measured. The data that was automatically stored in the REC module was loaded into the instrument, which was later transferred to the computer.

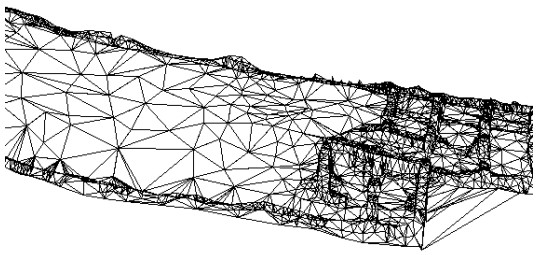
The process for the measurement of the points which define the archaeological sites had to be accompanied by clear and detailed sketches. After considering the use of plan sketches it was decided to use perspective drawing on which the points defining the upper and lower wall profiles could be marked with different colours for better interpretation.

Once the points were measured and their positions calculated, a *dxf* file was created giving all points with corresponding number and level.

The *dxf* files were imported using CAD *Microstation* and the data was separated with different levels and colours, in such way that later when mistakes were detected, it was possible to separate that series of data. The different points defining the upper and lower outlines were then joined, as well as the vertical lines. In this manner the floor of the archaeological building was defined as well as the 3D structural outlines.

Using the scatter of points and the connected outlines a triangulated model of the site could be obtained with the DTM program MDTOP, introducing the outlines as rupture lines. In this way a triangular mesh was created which was based on the field survey points.

The triangular mesh was separated into smaller triangular meshes according to the geometry of the walls, in such a way that it was possible to apply the textures correctly.



Once the mesh was separated into different layers using *AutoCAD*, the file was reconfigured in order to use *3D Studio Max* program.

In order to obtain more regular surfaces the different meshes were smoothed so that the intermediate triangles rounded the angles. In order to achieve a more realistic representation, materials were created data using photography taken on site to apply to the different surfaces as textures. Using *PhotoShop* the illumination, brightness, contrast and other parameters were modified to achieve a more regular appearance. In the same way a hemisphere was created which surrounded the model and on which the images developed from the 3D panoramic photograph were applied given the following virtual representation.

3) Creation of a virtual model of the archaeological remains C2, in the Mleiha area of the Emirate of Sharjah. -Fernando García, Raquel González-.

Using the same methodology as before but in order to capture a wider area surrounding the remains, we created a map of the tomb and surroundings using RTK (Real Time Kinematics) GPS methods.

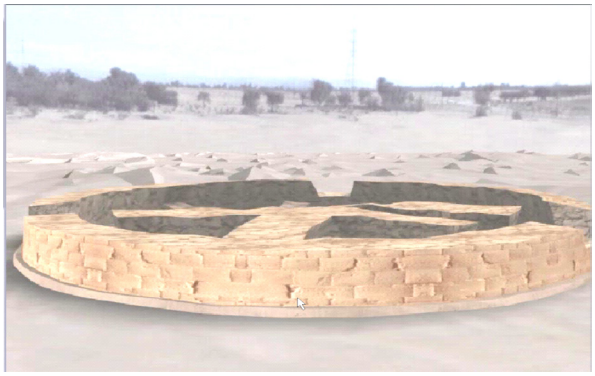
For this purpose 3 GPS 500 Leica receptors were used, equipped with radio-modems, a rigid tripod, two staff and flexometer.

The GPS equipment comprised of the following:

- Receptor SR530 dual frequency RTK.
- GEB121 Batería Camcorder, large.
- Antenna AT502 de dual frequency.
- Terminal TR500 for the GPS receiver.
- Radio-Modem Satellite 2AS+Antena.

And the co-ordinates were obtained at the same time as the survey with a precision of 1cm+1ppm.

The manner in which the GPS work was carried out in real time, was to use a stationary (fixed) GPS for reference, for which the co-ordinates were known based on a specific reference system, and two mobile GPS receivers. The real time methodology is based on ambiguity determinations, at the same time as the readings are taken. Once the receiver, which is located at a fixed reference point, has identified ambiguities, co-ordinates of points on the map are taken, by calculating the required base lines.



If the number of satellites above the horizon and their constellation geometry is favourable, the reference receiver fixes ambiguities in a few minutes. Once this has been done, the calculation of co-ordinates for the remaining points is virtually instantaneous.

The communication between the reference receiver and the mobile receivers, is made possible by radio modems with a range of 5 km between receivers. In order to avoid communication problems, we raised the reference receiver antenna, with the help of staff to a height of 2 m.

The precision of the co-ordinates of the points taken is in the order of 1 cm.

The Leica GPS 500 receivers in real time, allow introduction of the points with a code and specific layer, e.g. A tree can be entered as layer 20 and code “tree”. For this purpose a list of codes is created for each of the planimetric details to be mapped in the zone. This provides a simple aid for converting the data into DXF format, which allows one to store a number of layers.

Once the different scatters of points has been obtained, one with the points defining the building and the other defining the terrain, the points measured were joined as rupture lines to from the model. This process was carried out with the help of sketch models, with the TOPCAL topographical calculation model, which enables one to join the points by their number. It was decided to do it this way because there already were a number of detailed sketches on which was specified in which category each points belonged (upper lines defining the tombs, as well as terrain linear elements).

The development of the model was done in two phases, on the one hand the model for the tomb, and on the other the terrain on which it is found. This work was carried out using the GEOPAK digital programming models which are part of the Microstation suite of programs. This program was chosen because it is easy to use and produces reliable results.

This program allows are to import DXF files in which we have points for different levels and rupture lines. To begin with a triangulation is generated, which can be used to make contours, profile calculations, measure volumes of excavations, check altitudes from the file data or generate a uniform three dimensional mesh. Them, from a regular scatter of points, a triangulation was done to produce a digital model of the walls and floor of the tomb. These models were entered into the 3Dstudio program to obtain the final image.

2 Conclusion

Through the work of the Archaeological Investigation Group we have tried to apply new technologies to archaeology. We would like to retain compatibility between different forms of data, to promote the dissemination of data. In doing so, by means of digital models, we have developed the reference terrain into a 3D model, without sacrificing the possibility of obtaining traditional cartographic documents.

At present we are working in introducing interactivity into the spatial modelling, and also record the evolution of the excavation work in the dissemination techniques.

Our Investigation Group has developed from an engineering background and therefore we lack understanding of the precise archaeological requirements. We have attempted to resolve a certain archaeological problem, but we don’t know to what degree we have achieved this objective, or if it addresses current archaeological needs.