THE PAMPA OF NASCA – DEVELOPMENT OF A MULTIMEDIA GIS

Prof. Bernd TEICHERT and Christiane RICHTER, Germany

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ABSTRACT

The Nasca Lines and geoglyphs are one of the best known archaeological sites in South America, indeed the world. These large biomorph figures, long straight lines, and various geometric shapes were drawn on the surface of the desert near the town of Nasca beginning over two millennia ago. In 1995 the UNESCO added this area to the World Heritage List. The unanswered question that has historically aroused the most attention is: "Why were they created?"

About 20 theories are current amongst scientists and pseudo-scientists but even today nobody is able to provide a comprehensive and scientifically provable answer to this question. One of the major theories deals with astronomical phenomena. In order to prove this astronomical theory a special research project was started by the department of surveying and cartography of the University of Applied Sciences in Dresden, Germany.

The initial steps were the development of a special datamodel and the creation of a regional Digital Terrain Model (DTM). In September 2000 the photogrammetric data processing of the Nasca block (about 150 images) was started. This includes aerial triangulation, local DTM- generation, the extraction of lines and geoglyphs and the generation of ortho-images. Parallel to that the development of an astronomical approach was started.

The presentation includes theoretical as well as practical aspects. We report about the current stage of the project. Especially, the datamodel and the astronomical concept will be explained in detail. In the practical part we will demonstrate some analyses and special animations using our GIS.

Remarks: A quite similar article was presented at the International Workshop on Recreating the Past ~ Visualization and Animation of Cultural Heritage ~ in Ayutthaya, Thailand, 26 February- 1 March 2001. This workshop was organized by ISPRS Com. V.

1. INTRODUCTION

In the south of Peru near the town Nasca between the Pacific Ocean and the imposing Andes extends a desert plateau called the "Pampa of Nasca", scene of a peculiar art gallery. An area of several hundred square kilometers is covered with large figures, geoglyphs and lines drawn in the rock strewn desert. Scientists attribute most of these drawings to the golden ages of the Indian "Nasca" culture (-200 - 800 AD.). Some

figures measure over 200 m in length and the lines run up to 9 km. That's why they can only be properly viewed by eyes that are high in the sky.

The traces were caused by removing the darker (oxidized) gravel of the desert's surface to expose the lighter (unoxidized) surface below. It is remarkable how these mysterious tracings have remained intact for so many centuries. This is due to a special geographic and climatic situation, which is unique to the Peruvian coast.

For the last 50 years this archaeological site had been heavily damaged by human beings. The on-going destruction will hopefully stop now because UNESCO added this area to the World Heritage List in February 1995. In order to help to protect and preserve the historical drawings a special project has been set up by the University of Applied Sciences in Dresden.

2. MAJOR THEORIES

The question that has historically aroused the most attention is "Why were these drawings created?". Many theories are current amongst the scientists but even today nobody knows which theory is the right one. Here we have to distinguish between the popular literature and some serious scientific explanations. Nevertheless professional scholars generally believe that we do not have to pay attention to what popular literature has to say about these phenomena. A very good overview is given by (Aveni, 1990); he divided all the explanations into five distinct classes:

1. Calendar and Astronomy
2. Geometry
3. Agriculture and Irrigation
4. Movement or Communication, including Walking, Running and Dancing
5. Artistic Expression

In our opinion the first class of those theories is doubtless of major importance. Paul Kosok called the Pampa of Nasca "The Largest Astronomy Book in the World". Unfortunately he never undertook a systematic survey of the lines for astronomical orientation. Late in 1941, Maria Reiche, a Dresden-born scientist followed his ideas and investigated the lines and the geoglyphs for more than 40 years and she found many lines and also geoglyphs which give evidence for astronomical orientations, (Reiche, 1993).

Other scientists also tried to figure out the relationship with astronomy. The first seeming systematic approach was done by Hawkins in 1969, (Morrison, 1978). He concluded that the lines showed no solar, lunar, planetary, or stellar preference and that they "as a whole cannot be explained as astronomical nor are they calendric". Because of his special way of investigation several criticisms can be made and therefore the negative results cannot be regarded as the final word on any astronomical hypothesis for the origin of the lines.

A much better study was done by Aveni (Aveni, 1990). He concluded: "In sum, then, were we to reformulate a hypothesis most consistent with the data, it would be a hybrid of the walking, the agricultural, and the astronomical hypotheses."

3. PROJECT DESCRIPTION

To give an answer about the mysteries of Nasca, it would be important to have an interdisciplinary team of experts from disciplines like Geodesy, Archaeology, Astronomy, Agriculture, Irrigation, Ethnography, Iconography, Ceramics and Culture. Our primarily interest within this research project is the astronomical question in order to find evidence of the astronomical theory. Since we still believe that some of the lines and geoglyphs can be explained as astronomical or calendric, a computer simulation and animation will be developed as well. Last but not least the development of a special datamodel incorporating all the different aspects of the various disciplines by using a commercial GIS helps to solve those problems best.

3.1 Astronomical approach

One of the main parts of our project is the examination of the astronomical theory. Therefore the following components were defined:

- Generation of a regional DTM
- Photogrammetric aerial triangulation and topographic data acquisition incl. a local DTM
- Tacheometric and GPS measurements
- Determination of the two angles -azimuth and altitude- of lines, (areas and geoglyphs)
- Computation of the position of stars, planets, the sun and the moon during the Nasca-period
- Examination of the correlation between the azimuth and altitude of the lines with the computed ones of the celestial bodies
- Examination of the conformity of the celestial constellations of stars with the geoglyphs

3.1.1 Regional DTM of Nasca

A digital terrain model (DTM) of the whole area had been worked out by digitizing contour lines and single points by using existing topographical maps. The DTM was generated with the software "SCOP" (Schiefer, 1998).

3.1.2 Photogrammetric data capture

The only practical solution to capture the geographical information of this area to a adequate accuracy will be a photogrammetric approach. Therefore the aerial photos (1:10 000) of the two photoflight missions in May 1997 and May 1998 are used; for more information see Grün et. al. (Grün, 2000). The aerial triangulation has already started and we expect to have the results by the end of February. After having solved the triangulation, the lines, geoglyphs and topographic data as well as data to generate the local DTM´s will be captured and automatically stored into the database. From the most interesting sites of the Pampa digital ortho-images will be generated. Zeiss (P3, Phocus, Phodis and BINGO) instruments and software are used.

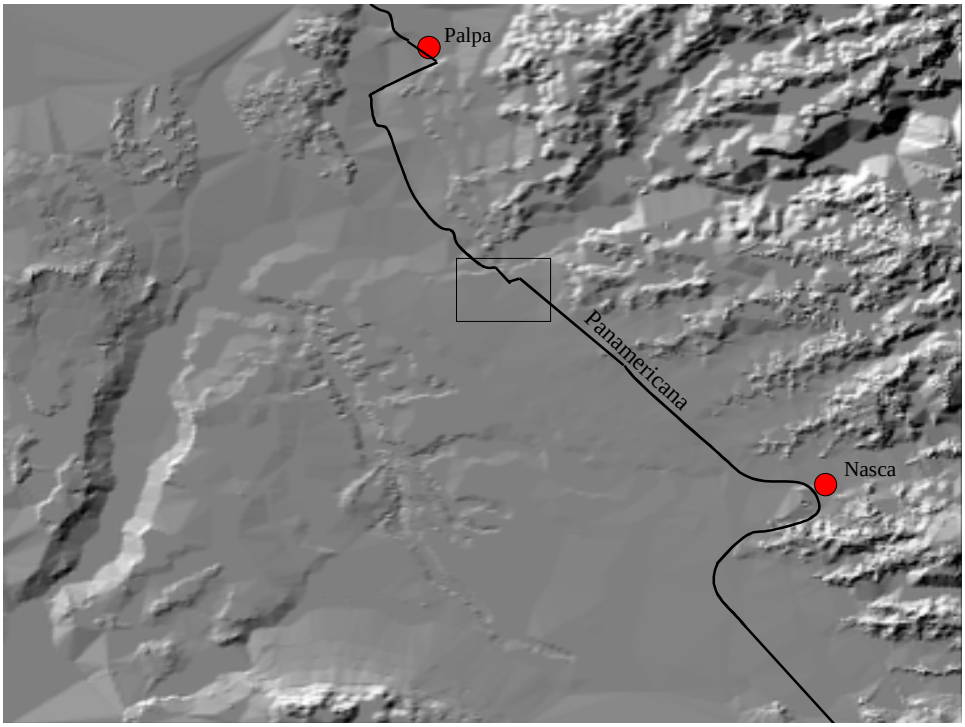

Figure 1. The computed regional DTM of Nasca and surroundings.

3.1.3 Tacheometric and GPS measurements

In July and August 1996 fieldwork was done by members and students of the University of Applied Sciences Dresden. Nine of the well known geoglyphs had been captured by tacheometric measurements and 19 line centers by GPS.

These geoglyphs as well as the line centers have been transformed into the Peruvian coordinate system (UTM Zone 18) via control points. Unfortunately the control points for the photoflights had been measured at a different epoch than the ones used in our fieldwork; so we need to transform all the coordinates into one common system.

Figure 2. GPS measurements (1996) at the Pampa of Nasca

3.1.4 Determination of azimuth and altitude of the lines

In order to test whether the ancient lines in the desert near Nasca show a preference for the directions of the sun, moon, planets, brighter stars, or whether the lines show any deliberate alignment with a center of some ancient pattern of stars a fully automatic procedure (software program) has to be developed. Once we have the accurate geometry of the lines in our database, the azimuth and the altitude will be computed and stored as attributes. For these computations the local horizontal system of each line is used. The astronomical azimuth of the lines can be derived from the well known equations. For the computation of the altitude the regional DTM is needed because this angle is dependent on the surrounding landscape. These two angles of each line determine the

astronomical direction within the local horizontal system of a possible rise or set of a celestial body.

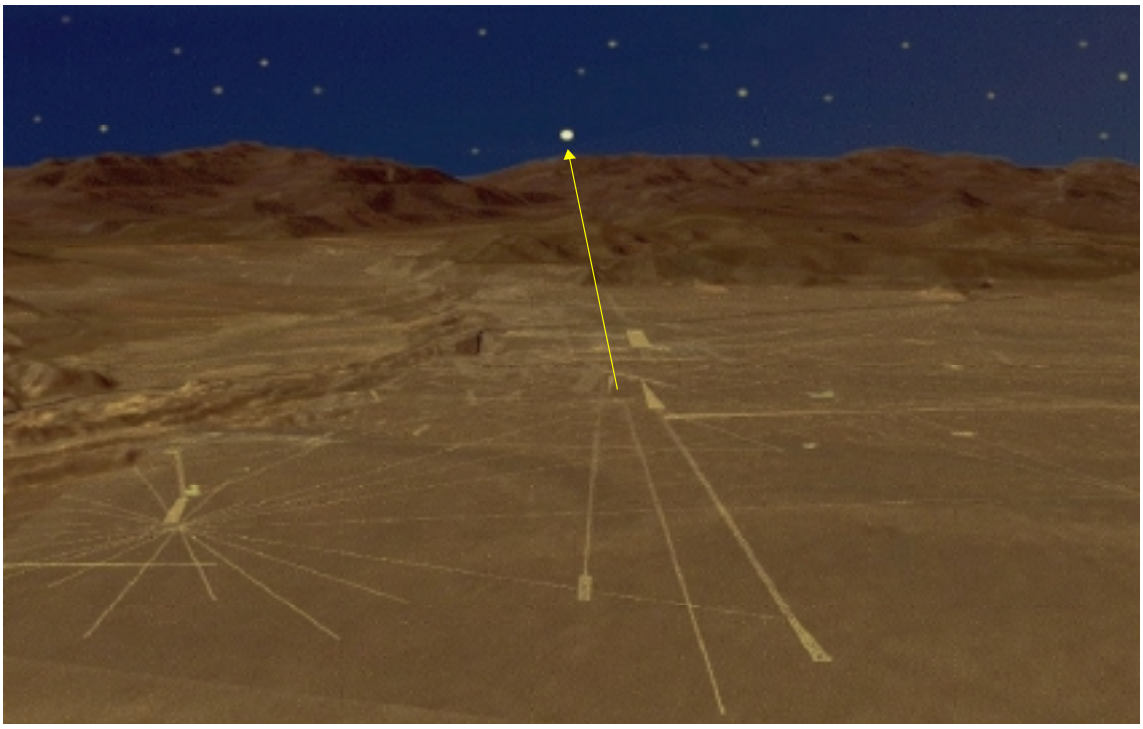

Figure 3. Computer simulation: Screenshot incl. the DTM, lines, geoglyphs and celestial bodies

3.1.5 Position of stars, planets, the sun and the moon

The astronomical directions (azimuth and altitude) of the celestial bodies in the local horizontal system can be derived from the FK5-star-catalog and the JPL- Ephemerides. All the necessary transformations in between the different astronomical coordinate systems are well known and need not be described here. Low-cost-systems are also under investigation.

3.1.6 Correlation and conformity with celestial bodies

To examine the correlation between the azimuth and altitude of the lines with the computed ones of the celestial bodies the following procedure is under development:

- The altitude of lines is derived from the DTM- software "SCOP" and afterwards stored in the GIS- database "Topobase".
- Geographical coordinates (longitude and latitude) of the reference point of the line as well as the azimuth and altitude are stored in the GIS- database.
- The astronomical directions of stars, planets, the sun and the moon are computed for each relevant line in the period of the "Nasca-time" and compared with the data stored in the GIS-database.

The examination of the conformity of the celestial constellations of stars with the geoglyphs (figure 5) is planned.

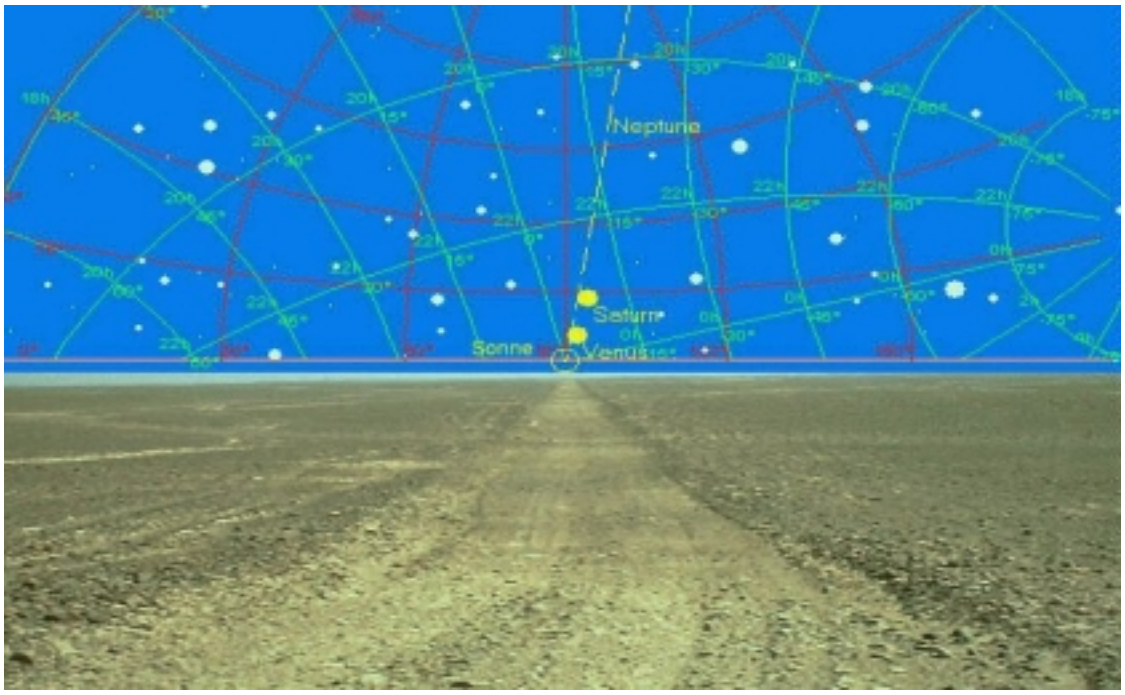

Figure 4. Correlation between the azimuth and altitude of a line with the computed ones of the celestial bodies (Schiebold, 1997)

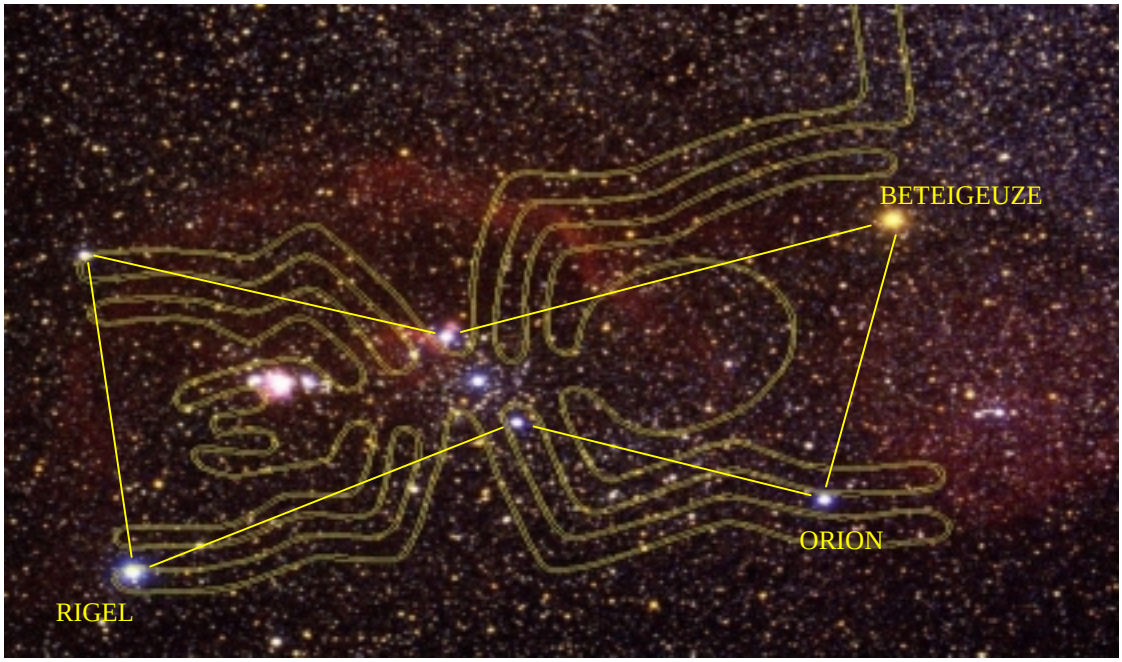

Figure 5. Conformity of the celestial constellations of stars (e.g. the Orion) with the geoglyphs (e.g. the spider)

3.2 Computer Simulation and Animation

Another objective is the computer simulation and animation which finally will lead to a Multimedia-GIS. The simulation will show all the movements of the celestial bodies in relation to the virtual landscape of the area; this task is not yet under development. The idea is shown in figure 4.
The animation ends in a video sequence, a virtual flight over the Pampa of Nasca. A screenshot is shown in figure 6.

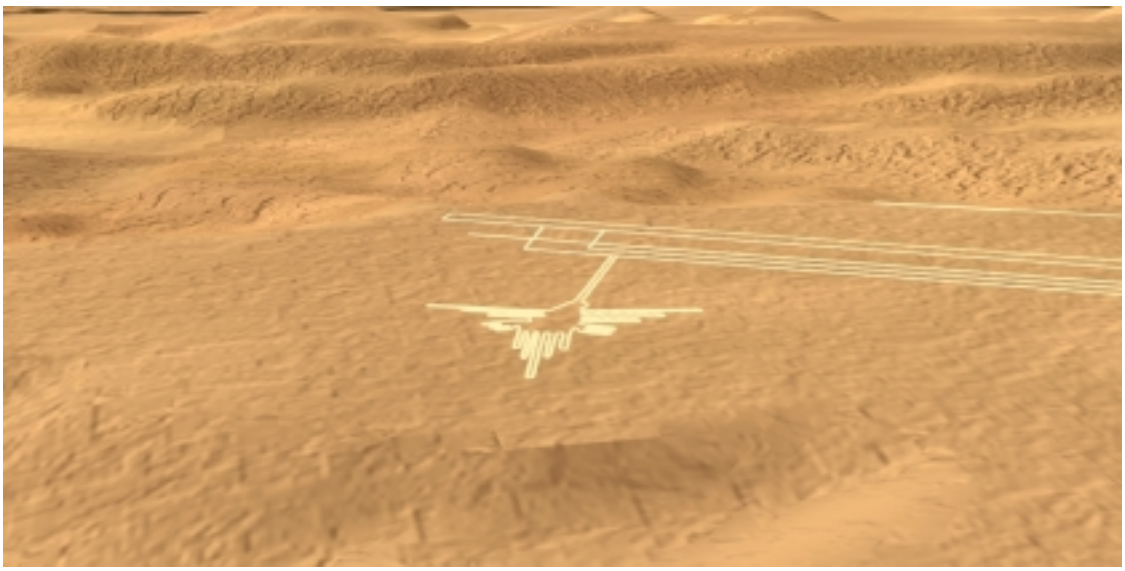

Figure 6. Screenshot of the virtual flight over the Humming bird

3.3 The Nasca datamodel

There is a need for a very special datamodel which includes the geometry and attribute data. All the necessary information about the lines, geoglyphs, areas, archaeology, astronomy etc. will be captured and stored into our GIS "Topobase", which includes Oracle 8i spatial and Autodesk products (Map 2000 and Mapguide).

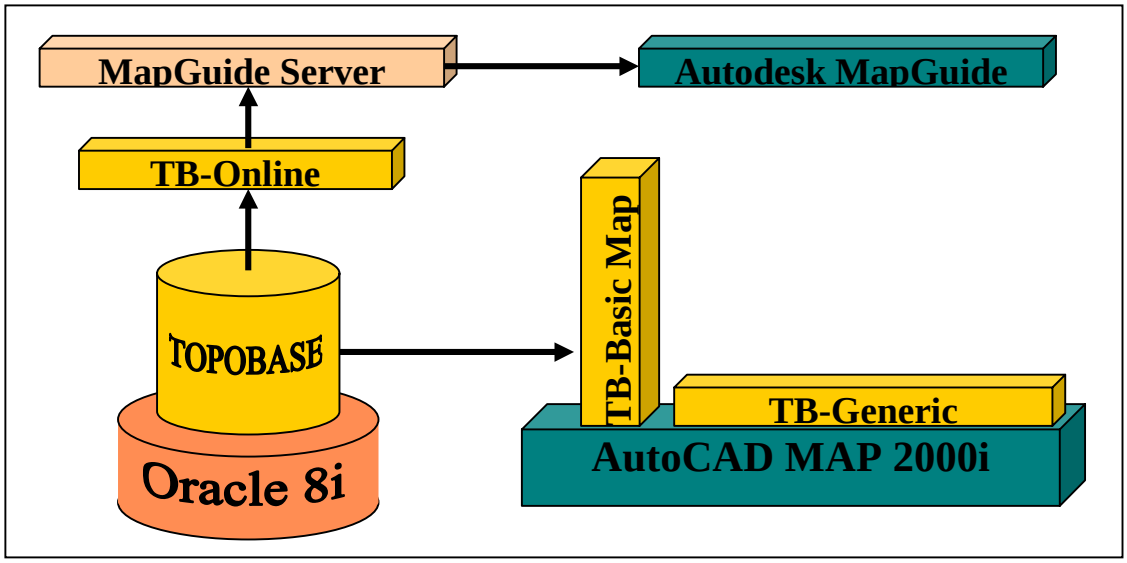

Figure 7. Configuration of the GIS "Topobase"

The development of a spatio-temporal GIS would be necessary but its beyond of our scope. An intermediate state of the highly dynamic datamodel is shown in figure 8 in terms of an ER- Diagram.

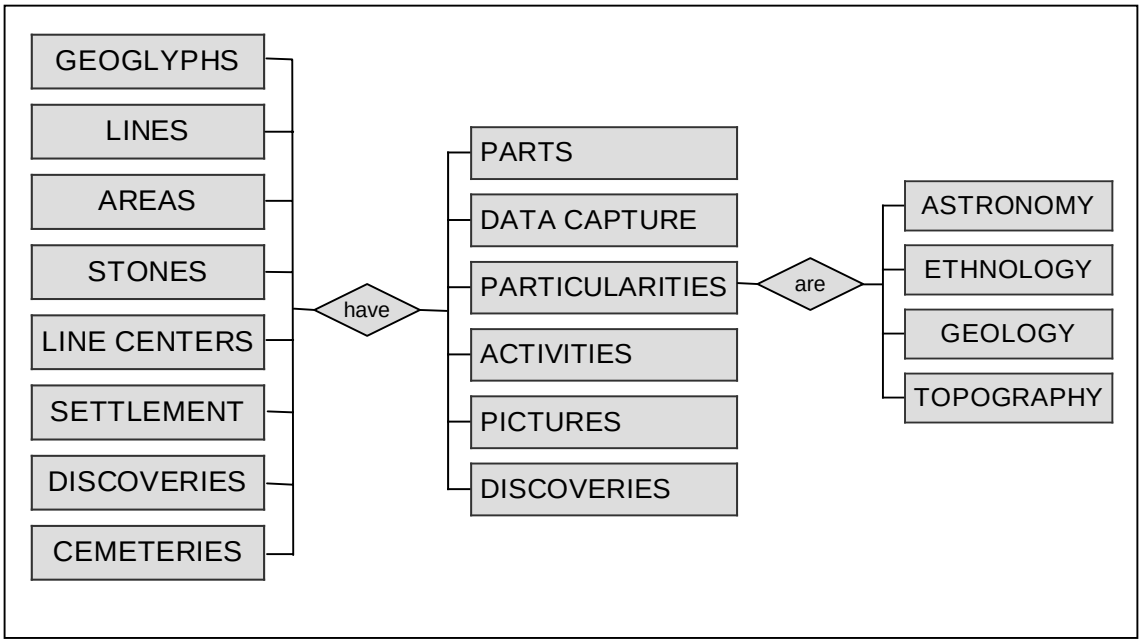

Figure 8. Entity Relationship-Diagram

The following data are already stored in the GIS-database respectively in SCOP:

- Geometry and attributive data of nine famous geoglyphs, some lines, 19 line centers and major settlements, roads and rivers.
- Scanned aerial and ceramic prints and the regional DTM of the whole area.
- The registration of the description of objects (name, age, kind and percentage of destruction, date and kind of data capture, etc.) is an ongoing process.

Figure 9 shows a screenshot of the implemented Nasca-GIS. There are two main windows: the graphical (AutoCAD Map 2000i) and the alphanumerical one (TB-Generic). Taking the monkey as an example: The first window gives the geometrical information and the second window shows the attributes. This window includes all tables of the Entity Relationship-Diagram in figure 8. The ceramic in the little window is one of the discoveries of the monkey.

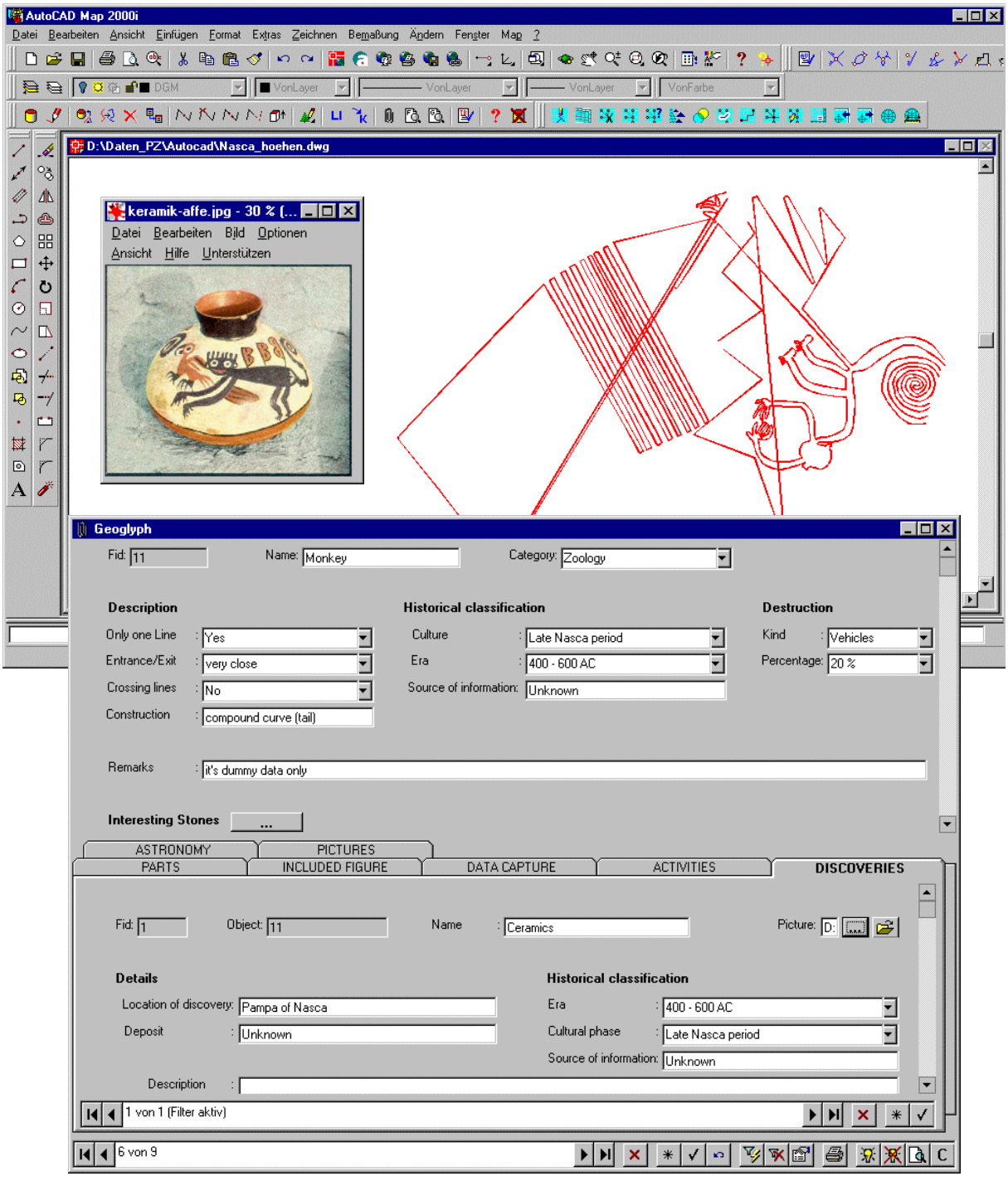

Figure 9. Screenshot of the Nasca-GIS

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CONTACT

Prof. Bernd Teichert and Christiane Richter
Hochschule für Technik und Wirtschaft Dresden (FH)
University of Applied Sciences
Department of Surveying and Cartography
Friedrich-List-Platz 1
D-01069 Dresden
GERMANY
Tel. + 49 351 462 3179
Fax + 49 351 462 2191
E-mail: teichert@htw-dresden.de or crichter@htw-dresden.de

BIOGRAPHICAL NOTE

Prof. Dr. **Bernd Teichert**
MSc. and Ph.D. at the University of Bonn, Germany
Employment
German Volunteer in two Projects of the FAO and WHO in Nepal/Asia.
Research Fellow in Digital Image Processing and Remote Sensing, TU Berlin.
Developing Engineer and Product Manager for GIS- Applications in Switzerland.
Teaching Experience
Lecturer (1980–1985) for Astronomical and Physical Geodesy, Satellite Geodesy and Gravimetry at the Technical University of Berlin.
Since 1993 Professor for Photogrammetry, Remote Sensing and Geoinformatics at the University of Applied Sciences, Dresden, Department of Surveying and Cartography.
Membership
DVW – Deutscher Verein für Vermessungswesen (German Association of Surveying)
Chairman of the Working Group 3 - "Geoinformatics and Cartography"
National Delegate of the DVW for Commission 3 of FIG
Chairman of the FIG Com. 3 Working Group 3.2 "Spatial Data Infrastructure"
DGPF – Deutsche Gesellschaft für Photogrammetrie und Fernerkundung
(German Society for Photogrammetry and Remote Sensing)

Dipl.-Ing. (FH) **Christiane Richter**
Dipl.-Ing. at the University of Applied Sciences Dresden, Germany
Employment
Surveyor at the land registry
Since 1994 Laboratory Engineer for Surveying, Geoinformatics and Landmanagement at the University of Applied Sciences Dresden, Department of Surveying and Cartography.
Membership
DVW – Deutscher Verein für Vermessungswesen (German Association of Surveying)