

Spatial data for large size archaeological projects – an example

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1. Introduction

Archaeology from its very nature is a space and time related science. Therefore, availability of reliable spatial data plays a crucial role in many archaeological projects. Spatial measuring and information technology provides the tools to supply archaeological professionals with the needed information. In the context of large projects special challenges will occur, one of which is the problem of how to establish a ready for use spatial reference frame, which should cover the complete project area while maintaining a consistent quality. Other challenges will arise from the different nature of spatial input data (maps, texts, finds, findings, etc.), which may relate even to very different points in time. All such heterogeneous input data will have to be processed in an appropriate way in order to generate a usable spatiotemporal database.

In the following sections a number of problems occurring in such a context will be addressed by describing a number of spatially related core tasks and solutions developed for a large size archaeological project area in Crimea/Ukraine.

2. About the project

The Project “Byzantine settlements in the Crimean mountains of Ukraine” at the Römisch-Germanisches Zentralmuseum (RGZM) in Mainz mainly concentrates on the two settlements Mangup-Kale and Eski-Kermen (Figure 1). The area covers more than 100 km². The two settlements are situated on the plateaus of limestone-mountains and include a lot of structures of settlements and about 700 man-made caves inside the limestone (Figure 2). The archaeologists are furthermore interested in the landscape, the cemeteries, the churches and the typology of the caves. The part of recording and making available geometric and attribute data within the project is

carried out in close cooperation with the Institute for Spatial Information and Surveying Technology (i3mainz) at Mainz University of Applied Sciences. Beyond the archaeological experts the teams in Crimea incorporated geophysicists, geologists, anthropologists and other experts involved in this project.

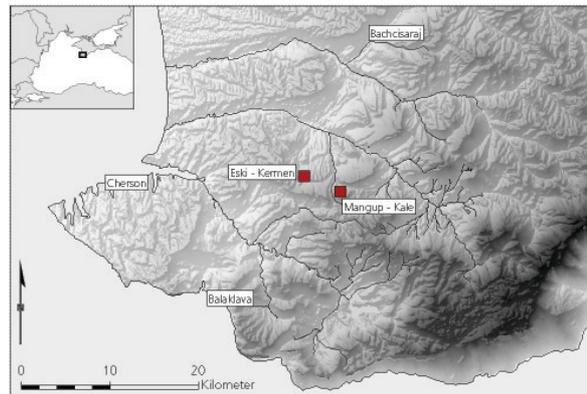


Figure 1: Hill settlements in the focus of the project in the southern Crimean mountains.

Due to the large spatial extent of the project area, the high number of objects to record, the variability of data types and data sources and the status of existent documentations from earlier campaigns it seemed essential to set up a common geometrical reference system. Within this frame all spatial information is recorded and georeferenced using a variety of techniques and methods. The common reference is essential for the combination and combined analysis of data from different sources and disciplines.

For analysing purposes meta-data have to be captured about the different data sources. They contain information about the data, e.g. the source or the geometric accuracy of the data. Geographic

Information Systems (GIS) are effective tools to meet this demand for the geometric documentation of the data. A GIS is a digital information system to document, manage, analyse and present spatial data and the connected attribute data.

3. Data Capture

The process of geometrical data capture can be split into several parts. The basis is the setup of the reference frame. Recording and referencing objects and structures in the field follows and is completed by integrating additional data from various sources. Data coming from other campaigns, sometimes even from past centuries, most often lacks spatial reference.

3.1. Reference Frame

The basis for connecting different spatial data is to setup a well-defined reference system. The area of investigation is more than 100 km² inside the Crimean mountains, in which app. 150 fixed points realise the reference frame.

3.2. Data capture in the field

Dependant on criteria like size, complexity and accessibility of the objects, the most appropriate and efficient equipment was used.



Figure 2: *Artificial cave structures cut in the stone.*

The reference frame was established using geodetic GPS plus total station measurements.

Archaeological field prospection and single object positioning was supported by the use of hand-held GPS receivers. The point accuracy of several meters limits the usage of this method to large-area surveys.

Detailed object information and accurate positions, single structures and reference points were determined by choosing one of the available techniques 3D-scanning (Figure 3), close range photogrammetry and total station.

The level of detail in recording was the result of weighting archaeological interest in structures against expenditure for the survey.

3.3. Integration of additional data

The main task when integrating data from other sources is to find, identify and measure identical or reference points. Most important for the field work in our project was the integration of geophysical measurements performed at the same time and documents of excavations created during the last 15 years. The determination of control points in the field was done mainly by total station measurements.

4. Data Processing

Data processing consists of several steps to be performed with different techniques and tools. Which steps have to be passed depends on the status of the data and on the results to be achieved.

4.1. Processing of raw measurement data

The processing of the geodetic GPS measurements was performed using standard geodetic GPS processing software. The calculated coordinates in combination with the point marks in the field are the reference frame for all further geometric measurements and referencing.

The total station measurements in the field are connected to this frame and are processed into point and attribute data using standard surveyor's software. Additional steps to generate line and polygon representations semi-automatically have been performed using special tools (AUFSCHNAITER, et al. 2008).



Figure 3: *Point cloud from 3D-laserscanner showing the area of Figure 2*

Simple hand-held GPS devices mostly deliver geographic coordinates in the WGS84-System only. In order to combine such coordinates with other data available in different projected coordinate systems, they have to be projected using special local datum parameters of the project area. This projection can be

performed using GIS software or other transformation tools capable of dealing with individual datum parameters.

3D-scanners usually record point clouds in local scanner-centred coordinate systems and are referenced using targets in the point cloud for which coordinates in the project coordinate system have to be provided, either from total station or other measurement.

The results of this first basic processing step are georeferenced data suitable for analysis and visualization, but not yet maps or images ready for publication.

4.2. Further Data Processing Steps

Recorded data from total stations and scanners can be processed into maps and plans. Functionality in GIS is often limited with respect to construction tools, so at this stage using CAD based products instead often is the best choice. Tools for displaying large point clouds inside CAD packages with good performance allow the evaluation of scanner and total station data in the same environment. This proved to be useful for the generation of maps of a large number of plans and sections of caves following self-given standards.

Photogrammetry, in the form of rectified single images or stereo models is used to plot point or vector information in a similar way.

3D-scanner data can also be used for visualization purposes, especially when colour information for the point cloud is present. Video animations and virtual flights allowing various viewpoints and perspectives can be generated easily.

The referencing of spatial data from other sources like geophysical prospection data or antique maps depends on the data type and geometrical quality. Magnetometer data can be shown referenced inside the GIS almost immediately when the measurement in the field is connected to the reference frame and the geophysical software generated appropriate imagery.

Old or antique map data or plans may be more problematic. They can show a landscape situation, which is different from now, so that identical points for referencing are hard to find or identify. If no exact information on datum or projections is available, approximations have to be used. After registration referenced images can be used to extract information in the form of vector or attribute data.

5. Data Products

Various products have been generated for research, analysis and publication purposes for all participating

groups and disciplines in the project. Among these are:

A desktop GIS with topographic maps, elevation models, vector maps, images from geophysical prospection etc. was set up to manage the data, the related attributes and meta-data. Within the GIS, links to additional data like panorama images can be inserted (Figure 4). This basis is used for analysis and generating maps on the one hand. Beyond that thematic or spatial subsets of the system were extracted and distributed together with a GIS-viewer among the project participants.

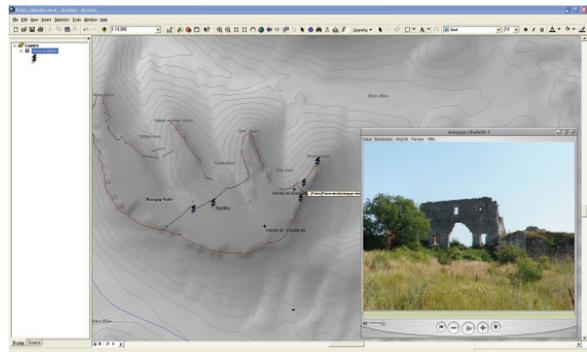


Figure 4: Link to panorama image in GIS.

Some 300 detail plans of about 100 selected artificial caves were generated within a CAD-environment according to a special standard developed in cooperation with architects (Figure 5).

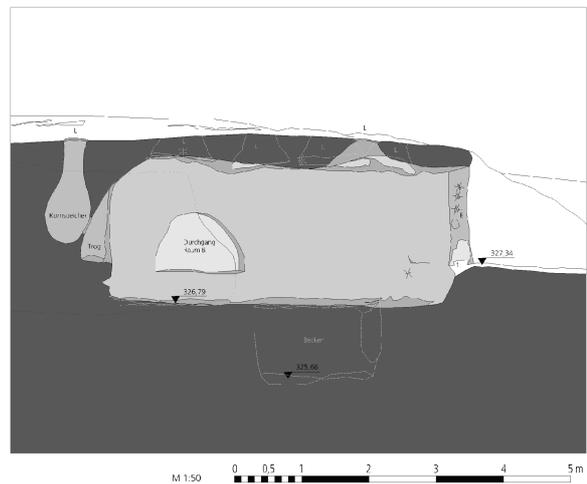


Figure 5: Cross-section of an artificial cave.

The results of archaeological field prospection are visualized in the GIS. Varying thematic maps can easily be generated dependant on the choice and characteristics of the attribute data.

Georeferenced documentations from many campaigns and decades allow for the integrated investigation of structures like the distribution of

graves in extended cemeteries. In our project an overview map and referenced excavation plans from a widespread cemetery in a forest area could be compiled for the archaeological work.

Interactive panorama images in QuickTime or Flash formats and rendered animations from 3D-laserscanner point clouds give vital impressions of the situation in the field. They can be used from single objects or rooms up to parts of the landscape of many km².

Software tools like TruView by Leica allow visualizing 3D point clouds in the web browser and even contain functionalities for simple measurements, which can be performed by any user.

6. Conclusions

This case study may be used as a guideline, which can be adapted to similar projects, in that way helping to develop project-specific processing chains and work plans. Further issues of high concern but not covered in this contribution apply to long-term care of the produced spatiotemporal database including secure archival data storage, to guarantee for re-usability and for retrieval capabilities of the spatial data, to name a few.

7. Outlook

Developments in approaches, user interfaces and data processing routines have the potential to change object-recording processes in the near future. Image based 3D-reconstruction and visualization techniques like Microsoft Photosynth can be used without any specialized and expensive hardware and the need for expert software. Further image based techniques are described at <http://www.c-h-i.org/>.

The setup of reference frames using geodetic GPS may imply problems when the national systems have internal errors resulting in shifting local datum parameters. The introduction of global reference systems into continental frames (ITRF / EUREF) and national reference systems has the potential to ease this task. Using the data of freely available GPS reference stations can support the realisation of highly accurate project reference frames.

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