SPATIAL INFORMATION SYSTEM OF HISTORICAL SITE – PROPOSAL AND REALISATION OF FUNCTIONAL PROTOTYPE

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ABSTRACT:

The development of the methods of spatial data acquisition together with progress in information technologies brings up a question about creation and usage of spatial models and spatial information systems of historical sites and buildings. This paper presents the current state of the "*Live Theatre"* project. The theme of the project is the proposal and realisation of a spatial information system of the baroque theatre of Cesky Krumlov castle (UNESCO site).
The project is divided into three main stages – creation of a 3D model, proposal of a conception of a spatial information system and realisation of a functional prototype. *Spatial data* were acquired by means of photogrammetric and surveying methods. An accurate 3D model was built in CAD system MicroStation and it is a photo-realistic (textured) model. *The proposal of a conception* of a spatial information system was the main result of the author's dissertation. The essential feature of the proposed conception is creation of subsystems targeted on three spheres – management, research and presentation of the site. Functionality of each subsystem is connected with its related sphere; however, they are using the same database. *Realisation of a functional prototype* (with sample data) is a present stage of the project. During this stage we are solving several basic technological topics. Now we are concerned with spatial data, its formats, format conversions (e.g. DGN ⇒ VRML) and its connection to other types of data. After that we will be seeking a convenient technical solution based on network technologies (Internet) and an appropriate layout of data (database). The project is carried out in close co-operation with the administration of Cesky Krumlov castle and some other partners (e.g. Computer Graphic Group, CTU in Prague). This stage of the project will finish in the middle of next year (6/2005).
A functional prototype and information acquired by its testing will become the basis for the final proposal of a complex information system of a historical site. The final proposal and an appropriate technology will be the results of the project. The realisation of a complex spatial information system is expected to follow afterwards. The results would be exploitable for both administrations of sites and for organisations working in the area of presentation of historical sites and creation of multimedia.

1. INTRODUCTION

Progress in information technologies together with the development of methods of geodetic and photogrammetric documentation brings up new possibilities of creation and usage of spatial models of historical sites and buildings. This paper is focused on presentation of the current state of the "*Live Theatre"* project. The main goal of the project is the proposal and realisation of a functional prototype of a spatial information system of a particular historical site. Theoretical foundations of the project were established by the author's dissertation. The dissertation [Hodac 2002] was focused on seeking possible ways from gathering spatial documentation to creation of a spatial information system (IS).

1.1 Background of the project

The theme of information processing is more important today than it was a few years ago. Progress in information technologies and computer technologies is accelerating. Information systems are gradually used in areas, which were up to now a little bit aside of the main interest. Cultural heritage is one of such areas in our country. Apart from the main content of information, localisation and time aspects are getting very important today. There comes a period of movement from IS working with planar data to IS working with space and time. Another movement is connected with the development of network technologies. Information systems are moving from separated offices to the net and Internet. Work with spatial data is closely connected with such science as virtual reality.
The cultural heritage area is now more important also because of its relations to tourist industry. Historical sites, together with nature, belong to the most popular targets both in the Czech Republic (CZ) and abroad. This is again connected with information. If a historical site would like to attract potential visitors, it is necessary to present the site. A perspective way is presentation on the Internet. In this context we can hear terms as virtual tourism, virtual sightseeing and virtual monument or site. The importance of spatial data in this area is slowly growing.

The Laboratory of photogrammetry at the Department of Mapping and Cartography co-operates with the Administration of Cesky Krumlov castle and the Foundation of Baroque Theatre on a project of creation of metrical documentation of the castle´s baroque theatre at Cesky Krumlov. This co-operation has been running since 1996, see [Hodac 2001]. The theatre is primarily documented by the students of geodesy and cartography in their theses. The aim of the first phase of the project is to create new metrical documentation of the theatre in a form of a spatial model. In the second phase, the spatial model will become a core of a spatial information system.

1.2 Motivation and aim of the project

It is not such a big technical problem today to acquire spatial data, to create a spatial model of an arbitrary object e.g. in the area of cultural heritage. The question I met with was: *how to use this model effectively?* Currently, customers demand predominantly 2D form documentation and they do not want spatial data and models. Models are used for one-off purposes e.g. presentation (visualization) or research of a site. Other utilisation of these models is uncertain. It is not so positive because of the volume of work, which was done on creation of the models.

Utilisation of spatial data in spatial IS is one of perspective possibilities. If we are speaking about IS of historical sites it is necessary to ask – *What ideas do owners or administrators of sites have? Do they need IS, do they need spatial data? If yes, what data and for what purposes?* Answers to these questions were the basis for the definition of the aim of this project.

The main aim of this project is: *to find possible ways from gathering spatial documentation to creation of a spatial information system of a historical site.*

2. PHASES OF PROJECT

The project is generally divided into three main stages – creation of a 3D model, proposal of a conception of a spatial information system and realisation of a functional prototype. In this paper, the main focus will be on the second stage. A detailed description of this stage follows.

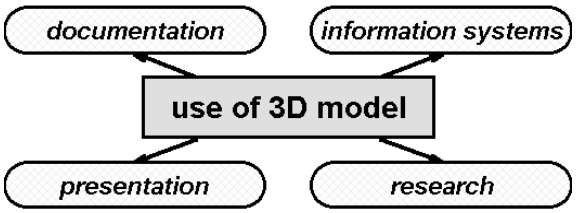

Chart 1. Fields of utilisation of 3D model

Discussions with administrators of sites and also experience coming from professional meetings in the last decade, see e.g. [Santana 2001], were the basis for the definition of basic areas of utilisation of spatial data. Chart 1 describes these areas. The most important areas are – presentation of a site, research of a site and management of a site. In all of these areas we use similar initial data. The methods of processing these data are vary according to user´s requirements.
The course of the second stage of the project was divided into three parts – analytical, synthetic and application.
The main attention in the analytical part was given to two target areas – site management and site presentation. An analysis of current state of data, which are used by administrators of sites, was carried out. The types of operation with these data were also examined. The last part of this analysis dealt with conditions for utilisation of information technologies in the analysed area. Another analysis was focused on the current state of presentations of historical sites on the Internet in the Czech Rep. and abroad. Virtual tourism, virtual sites and tourist industry were essential subjects of this analysis.
The results of the above-mentioned analysis became the basis for proposal of a conception of IS of a historical site in a synthetic part. This proposal works with three main application areas – presentation, research and management of sites.
The application part was also very important. The proposal of a conception of an information system of the castle's baroque theatre at Cesky Krumlov (*"Live Theatre"* project) was created. Primary attention was given to designing schemes of data for each part of IS.

2.1 Analysis – Management of site

The data for this analysis were acquired by inquiry. The questionnaire included questions about the following topics – affordable plan documentation (geometrical data), affordable inventories, tallies (non-geometric data), technical and organisational background. The inquiry was conducted at selected sites (24 sites), which were located in the selected region (southern Bohemia). The main condition for the selection of sites was accessibility for the public. Most of the selected sites were big (e.g. castles) and they were owned by the state.

The result of the inquiry showed that administrations of sites are largely rather small organisations (up to 5 employees). Some of them have a possibility to use services provided by the founder (mainly sites owned by the state). Organisations are equipped with computers only on a basic level and connectivity (to the Internet) is rather insufficient. Utilisation of information technologies is assessed positively by staff of administrations. Unfortunately, reality at administrations is not so good and the use of these technologies is not so widespread. Respondents thought that the main barrier for wider use is finance (low budget).
The quality of existing documentation is assessed as sufficient for current utilisation. A combination of classic (paper) form and digital form of documentation would be optimal according to most respondents.

2.2 Analysis – Presentation of site

Selection of sites (in CZ) was the same as in analysis above. The topics of the analysis were – existence and content of presentation, language of presentation, use of multimedia, services, localisation of presentation and graphical quality.
Approx. 15 foreign presentations and projects were analysed. The main focus was on UK because of its richness of cultural heritage. Other sites or projects were included into selection with consideration of the area of interest – virtual heritage, virtual tourism.

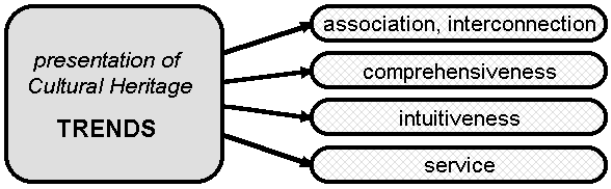

Chart 2. Presentation of Cultural Heritage - trends

The results of the analysis of sites located in CZ showed that we can not speak about virtual tourism today. Most presentations do not use interactive elements and geometrical data (plan, maps, and spatial models). Most of them are static – not living presentations. Complex presentations, which consist of voluminous sets of information, are still sporadic. Connections

to other types of information systems are missing (town, region, republic, tourist industry etc.).
The results of the analysis of presentation of sites abroad brought some interesting information about current trends, see chart 2. These trends have the same background. It is – to facilitate understanding of the significance of cultural heritage to visitors. Complex 3D models of real sites were not included in this particular selection. Interactivity was mainly used in connection with classical form of data (text, photo).

2.3 Proposal of conception of spatial IS of historical site

The proposal of a conception of IS is based on three areas of its utilisation. These areas also determine *subsystems* of IS.
A complex information system including spatial data should comprise subsystems oriented on these areas – ***site management, site research, site presentation.***
Subsystems use the same data set for various purposes. Chart 3 describes the volume of data for each subsystem.

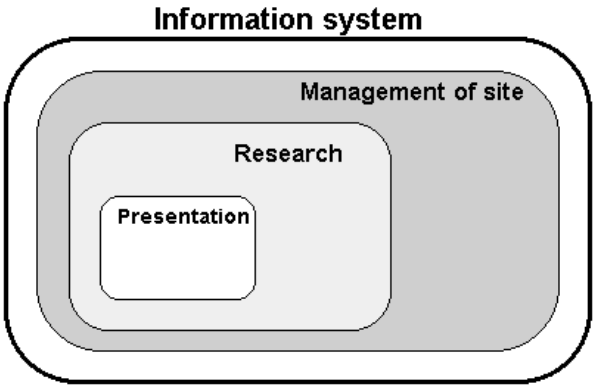

Chart 3. Subsystems of IS of historical site

The results of the analytical part of research were the basis for definition of principal features of an information system of a historical site and its subsystems:

- Subsystem – site management (SM)
  - is intended for management of site, to support decision making process
  - user is administration of site
  - system enables - *update and editing of data; making outputs with use of various types of data; simple spatial analysis etc.*
- Subsystem – site research (SR)
  - is intended for research of site and its funds
  - users are historians, conservationists, restorers, and students
  - system enables – *work with other associated systems; basic analysis of examined data – e.g. modelling; feedback – discussions, publications etc.*
- Subsystem – site presentation (SP)
  - is intended for presentation of site
  - user is potential visitor of site
  - system enables – work *with virtual reality and interaction; work with other associated systems; complete service for visitors etc.*

Each subsystem was further specified in three levels, as is described in chart 4.

User – a future user has a prime impact on the content and form of IS. Users of IS of a historical site are given by area of interest (see subsystems). It is naturally possible that they can use other subsystems (not only one).
Data – subsystems have the same set of original data. The requirements of subsystems are different and therefore the volume and form of accessible data varies, see chart 3.
Functionality – demands on functionality of the whole IS are given by the previous two levels – user and data. Even though the subsystems have the same set of basic functions, each subsystem also needs a specialised function.

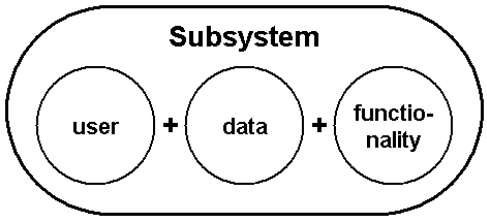

Chart 4. Basic levels of subsystem

2.3.1 Basic conditions for realisation: Apart from the content of IS, fundamental conditions of successful realisation and use of IS were defined. These are:
- utilisation of network technologies,
- low budget for installation,
- low cost of hardware and software,
- simple handling,
- lucidity,
- update of data.

A detailed proposal of technical solution went beyond the topic of this stage of the project. One of possible approaches related to this theme is e.g. a concept of a distributed system. Data does not have to be stored in one central powerful server, but on more servers. Utilisation of this concept could be demonstrated in conditions of public cultural heritage care (in CZ) on a typical relation *administration of site* ⇔ *founder* or *administration of site* ⇔ *network (or fund) administrator*. Chart 5 illustrates this concept.

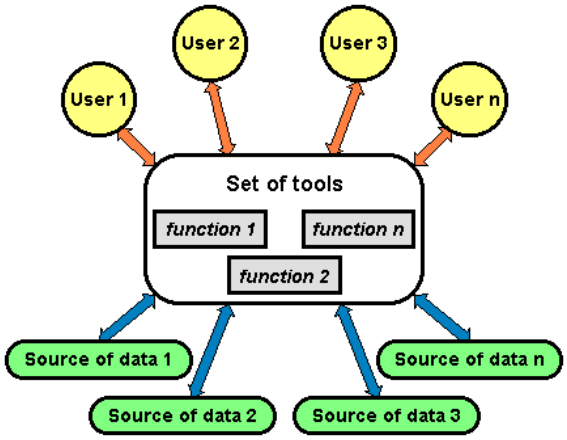

Chart 5. Distributed system

2.4 "Live Theatre" project

A concrete project of IS was designed at the end of this stage. The main goal was – detailed documentation and elaboration of

results of previous phases. "Live Theatre" project arose as a logical result of former activity of students and teachers of the Department of Mapping and Cartography dedicated to the building of baroque theatre at Cesky Krumlov castle (theatre).
Both geometrical and non-geometrical data were available. Subsystems for management, research and presentation of the site were elaborated in more detail in close connection with general results of previous phases. Schemes of selected prototypal data for each subsystem were created. Parameters of technical solution were specified at the end of this phase.

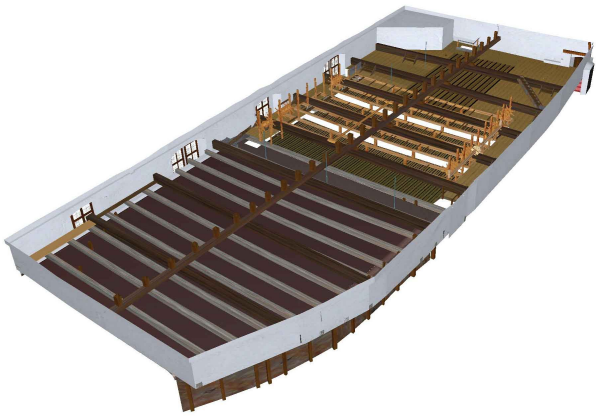

Figure 6. Visualization – upper stage, roping gear

The present state of the castle theatre in Cesky Krumlov is the result of reconstruction of castle´s area in 1765-66. The theatre represents a baroque stage in its mature form. The original theatre fund is preserved in both actual objects such as the building, auditorium, orchestra pit, stage, stage technology, machinery, decorations, costumes, props, lighting technology, fire extinguishers etc., as well as in rich archival documentation such as librettos, scripts, texts, partituras, sheet music, inventories, accounts, iconographic material, and other information on theatre life in the 17th to 19th century. The Krumlov theatre was closed to the public from 1966 to 1997, and after the completion of a large part of the restoration, trial tours of the theatre officially began in September 1997.

2.4.1 Initial sources: Both types of data - geometrical and non-geometrical data were available.

- Geometrical data – it comprises a 3D model of the interior of the theatre. This model was created progressively. Photogrammetric, as well as surveying methods of documentation were used in relation with the type of a documented area. Creation of a 3D model is described in more detail in [Hodac 2001]. CAD system MicroStation was used as a tool for creation of the model. This 3D model is photo-realistic and could be used for visualization and animation purposes. Figure 6 show visualization of the upper stage part of the theatre. The roof and exterior of the theatre are now being documented.

- Non-geometrical data – original wide-ranging theatre funds are gradually restored, recorded and catalogued. The project of digitalisation of the most important funds was completed 2 years ago. Now there is a digital form of "Basic inventory of funds" (BIF) which contains the following funds: costumes and props, decorations, technical and lighting equipment. BIF is based on a card and photo-documentation of each element.

The fund of technical equipment and the fund of decoration (partly) were subjects of metrical documentation, see above. There is no doubt about relevancy of spatial information in these funds.
Additional sources of non-geometric data are – photo-documentation, panoramic videos (see [OIS CK]), videos (rehearsals), collection of sounds (scenic effects), historical plan documentation etc.

For the purposes of IS proposal, the data (non-geometric) of two funds were chosen – fund of technical equipment and fund of decoration.
Fund of decoration – consists of sets of 13 basic stage scenes.
Fund of technical equipment – includes complete original theatre machinery with sliding frames, winches, levers, pulleys, and a movable lighting rack. The floor of the stage is also original, including sliding and removable planks and trap doors.

2.4.2 Proposal of IS: The project of IS of the theatre has a working name "Live Theatre". The objective of the project is – to create a living system, which could be used for recognition of theatre culture in the baroque and more widely to recognise general interrelations of life in the baroque epoch.
The project is realised in close co-operation with The Administration of Cesky Krumlov castle and The Foundation of the Baroque Theatre.

The schemes of data of two fundamental funds were designed for each subsystem. The following topics were further elaborated – user, functionality, data, form and future development of IS.

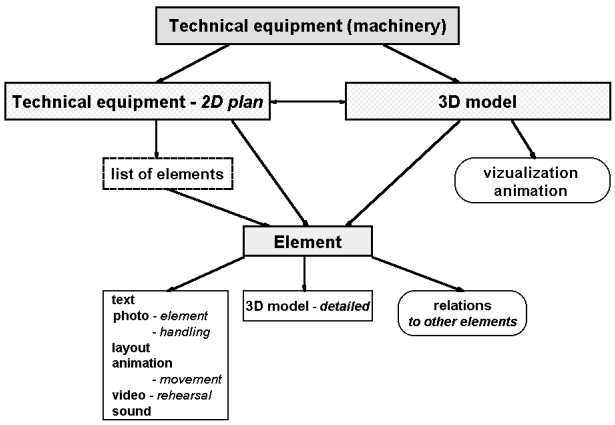

Chart 7. Scheme of data, subsystem – research of site, element of technical equipment

A fundamental segment of the proposed structure of IS is an element. This element is connected with textual, graphical and other information. The existence of an element is given by the existence of a BIF card.
Various possibilities to get information on an element are designed for users. Geometrical data are the basis, see chart 7 and Appendix A. The user can choose a "classical approach" i.e. selection of fund + selection of element on a 2D plan or from a list of elements. Another possibility is "spatial approach" i.e. selection of fund + selection of element inside a 3D model. A straight way – query to database - is also possible.
A combination of all above-mentioned approaches is possible – for example – possibility of switching between 2D and 3D data.

- As for *spatial data*, functions enabling various operations with the 3D model are included in the proposal of IS. The functions allow interactive work with the model (movement in virtual space, identification of elements); work with a detailed model of an element (browse); visualization (making views); viewing animations (walk through, movement of elements, exchange of scenes, interrelations of elements). The baroque theatre is a stable system with a limited number of elements. The demands for editing spatial data will not be so frequent.

- *Non – geometric data* referred to element are constituted by textual information (mainly BIF), photo-documentation (BIF and others), video (rehearsal, panoramic view etc.), sounds, drawings (technical drawing of elements and their relations etc.).

Main features of subsystems:
SM - collects complete set of data from selected funds.
SR - attention is given not only to elements, but especially to their interrelations, dependencies.
SP – its main feature is interactive work with a spatial model, which facilitates intuitive recognition of the site by the user.

2.4.3 Technical solution: The technical solution will be based on the results, which were mentioned in chapter 2.3.1. The requirements for the technical solution could be grouped into three groups – operating, technological, data. The operating group concerns requirements for low budget (hardware and software), easy and intuitive operating. The technological group concerns utilisation of network technology, open source software and convenient database organisation. The data group concerns utilisation of standard data format, metadata, security of data, multilingualism.

2.5 Functional prototype of IS

Realisation of a functional prototype (with sample data, see 2.4.1) is the present stage of the project. During this stage we are gradually solving basic technological topics:
- *spatial data* – formats, conversion, interactivity
- *interconnection* of geometrical and non-geometrical data
- *technical solution* of IS – network, database
- *functional prototype* – realisation, testing

Spatial data: we are now concerned with spatial data, its formats, format conversions and interactive work with this type of data. The existing 3D model is in DGN format. This format is not so convenient for the purposes of proposed IS. Existing formats of spatial data (VRML, VET, and X3D) were analysed and VRML format was selected. VRML is a standard format of spatial data on Internet and experiences with its use are good. Conversion of formats is sometimes very problematic. The 3D model of the theatre is complex and it comprises both the interior and the exterior of the building. Two approaches of conversion are tested – *standard export to dxf* → optimization of dxf (specialised SW) → export to VRML; *export interactively controlled by user* (directly DGN – VRML or DGN – dxf – VRML). The second approach needs creation of a special conversion program. Existing results of conversion are documented in figure 8.
Creation of a set of tools for interactive work with this type of a model is a next step. It will allow e.g. measuring distances, work with layers, selection of elements etc.
Searching for a suitable technological solution will be also the content of the forthcoming steps.

Interconnection of geometrical and non-geometrical data: elements of the VRML model will have direct connection with additional data (see above).
Technical solution of IS: future users will work with IS via the Internet. An appropriate layout of all types of data will have the most important role in the usability of IS.

Functional prototype – realisation, testing: at the end of this stage, a functional prototype of IS will be built on the basis of technologies verified in previous steps and on consideration of its functionality. This prototype will be tested by a sample of future users.

Figure 8. VRML model – lower stage, machinery

Results of project
A functional prototype and information acquired by its testing will become the basis for the final proposal of a complex information system of a historical site. The final proposal and an appropriate technology will be results of the project. The realisation of a complex spatial information system is expected to follow afterwards.

3. CONCLUSIONS

The presented project is focused on a cultural heritage area. The main aim of the project is creation of spatial IS of a particular historical site. The results of single stages of the project could be summarised in several points.

- The analyses were made on a selected sample of historical objects. The theme of the first analysis was current state in the management of the site. A special focus was put on the sources of data and their usage and on potential use of information technologies. The analysis in the field of presentation of cultural heritage sites on the Internet was also done. This was mainly focused on utilization of a 3D model and virtual reality.

- Proposal of a conception of spatial IS was based on information acquired by analyses. Areas of utilization of 3D data (and IS) were defined and IS subsystems were drafted. These are aimed at site management, site research and site presentation. The subsystems have the same set of original data. The basic technical requirement is network technology.

- Conclusions acquired during the previous stages were used in creation of a conception of IS for a specific site - the *baroque theatre at Cesky Krumlov castle*. Selection of an appropriate data set was done and a scheme of data for each subsystem was created. We were also concentrated on functionality of subsystems, bearing in mind work with spatial model and spatial information.

- Realisation of a functional prototype of IS is a current stage of the project. The prime focus is now on conversion of the spatial model format – DGN → VRML. Finally, the prototype will be tested. Acquired results, together with verified technology, will form the basis for creating the final proposal of spatial IS of a historical site.

The contribution of the project is an overall, complex view on the topic. This topic was not solved in CZ so comprehensively. We tried to reflect current trends in spatial information technologies and their application in the area of cultural heritage. These trends are adopted to the conditions of the Czech Republic.

3.1 References

Hodac, J., 2001. Documentation of the Baroque Theatre at Cesky Krumlov Castle, In: *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, Potsdam, Germany, Vol. XXXIV-5/C7, pp.121-125.

Hodac, J., 2002. Proposal of a Conception of a Spatial Information System of a Historical Site. Dissertation, CTU in Prague, CZ. *http://gama.fsv.cvut.cz//~hodac/disertace*

Santana, M., 2001. Virtual Systems and MultiMedia conference, Virtual Heritage Colloquium, „A witness to enhanced realities in virtual heritage: Potentials and limitation", Berkeley, USA. *http://www.virtualheritage.net/news/article.html (6/2002)*

OIS CK. Official information system of Cesky Krumlov Region, *http://www.ckrumlov.cz*

Laboratory of Photogrammetry, *http://gama.fsv.cvut.cz*

3.2 Acknowledgements

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APPENDIX A

Scheme of data, subsystem – site research, element of technical equipment