

The use of GIS for studying cultural heritage and historical urban landscape: the case of Perm and Usolie (Russia)

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Abstract: Perm and Usolie are cities in the territory of Perm region (Russia) which hold a rich cultural heritage. The historic urban planning of these cities is threatened due to anthropogenic and natural factors. Geographic Information Systems (GIS) are an excellent tool for operating archival geospatial sources, dating back to the 18th – beginning 20th centuries. With the cooperation of the Department of Ancient and Medieval History of Russia at Perm State Humanitarian Pedagogical University and the Department of Cartography and Geoinformatics at Perm State University, geospatial models that contain information of monuments of history, architecture and urban planning in according to the national cultural heritage register of Russia were developed. Processing of cartographic sources through GIS allowed visualizing the lost historical buildings and to combine information about all objects of cultural heritage. It provides the management of historical data in the preservation of cultural heritage and development of urban-planning regulations.

Key words: cultural heritage objects, GIS, geodatabase, cartographic sources.

El uso del SIG para estudiar el patrimonio cultural y el paisaje urbano histórico: el caso de Perm y Usolie (Rusia)

Resumen: Perm y Usolie son ciudades en el territorio de la región de Perm (Rusia), que posee un rico patrimonio cultural. Debido a factores antropogénicos y naturales, la planificación urbana histórica de estas ciudades y su patrimonio cultural se ven amenazados con una pérdida. Los sistemas de Información Geográfica (SIG) son una excelente herramienta para el tratamiento de las fuentes documentales geoespaciales, del siglo XVIII a principios del siglo XX. Se realizaron modelos geoinformáticos con la colaboración del departamento de Historia Antigua y Medieval Rusa de la Universidad Perm State Humanitarian Pedagogical University y el departamento de Cartografía y Geoinformática de la Perm State University. Estos modelos contienen información de monumentos históricos, arquitectura y planes urbanísticos de acuerdo con el Registro de Patrimonio Cultural de Rusia. El procesado de fuentes cartográficas a través de SIG ayuda a visualizar los edificios históricos perdidos y a combinar información sobre todos los objetos del patrimonio cultural. Proporciona el uso efectivo de datos históricos en la preservación del patrimonio cultural y la elaboración de planes urbanísticos.

Palabras clave: objetos del patrimonio cultural, SIG, geodatabase, fuentes cartográficas.

Introduction

Perm and Usolie are cities located on the Middle Urals (Russia, Perm region). The cities have rich historical and cultural heritage whose definition herein used of the Federal Law «On the objects of cultural heritage (monuments of culture and history)» (Law 73-FZ). According to this law, the objects of cultural heritage are «objects of immovable property ... were created as a result of historical events». These objects are valuable «from the point of view of history, archeology, architecture, urban planning, art, science and technology, aesthetic, ethnological or anthropological, social culture» and are

evidence of epochs and civilizations, original sources of information about the culture origin and development.

Usolie was founded in 1606 as a village around new Stroganoffs salt production and received official status of the city in 1918 (after the nationalization of patrimonial estates). There are more than 40 objects of cultural heritage on the territory of the historical center of the city. Objects were built in a variety of architectural styles – from baroque to eclecticism. Due to the construction of the Kama hydroelectric station in the 1950s, the historic part of the city was flooded and buildings, which were built in the 18th – beginning 20th centuries, no longer

used in accordance with the original purpose. Presently the flooding part of the city is in the doldrums and in need of developing a strategy for the conservation/restoration of cultural heritage. It must be highlighted that Usolie's cultural heritage was not the object of special investigations. Several times Usolie appeared in the catalogs of cultural heritage's objects of the Perm region. As a rule, such publications do not contain information about all Usolie monuments but only outstanding monuments of Baroque and Classicism, which received of the cultural heritage of Federal Importance (Shatrov 1976; Kiselev and Yakina 2011). The rest of monuments, which are important urban objects, unfairly remained outside researchers' field of attention. Vladimir Kostochkin (1988: 113-154) had been studying of the cultural heritage of the several historic settlements in the Urals. He had published a short essay about the history of Usolie in which he highlighted the events that influenced on the history of Usolie urban planning development (especially fires) and described outstanding architectural monuments of Usolie. Grigoriy Golovchanskiy is the first researcher who has been attempted to describe the urban development of Usolie in the context of the city's history from the foundation until 1917 (Golovchanskiy and Melnichuk 2005: 95-99, 150-159, 186-201).

The history of Perm began in 1723 when Egoshikhinskiy copper smelting plant was founded at the place of the modern city. Settlement around the copper plant was converted in the regional capital and renamed in 1781. Nowadays Perm is the center of the Perm region. There are more than 300 monuments and ensembles mostly dated to the pre-revolutionary period (before 1917) in Perm. During the last decades, the city center has been actively constructed, but the designers and developers do not always take into account the peculiarities of the historical urban development of the city, resulting in clashing elements appearing in the center of the city.

Researches devoted to Perm, primarily, highlighting the problems of the city foundation, urban planning and building development of the city. A soviet researcher of the Urals cities Leonid Iofa had concluded that Perm profitable «combines the water connection with the capital cities and closer the mining and metallurgical districts of the Urals», which determined the development of settlements (Iofa 1951: 235). Alexandr Terekhin has studied the formation of the architectural and historical environment of Perm and in consequence of archival research, revealed previously unknown city maps (Terekhin 1980). Presently, Pavel Korchagin has been researching the history and urban planning development of Yegoshikha-Perm. He underlined the need to create an archaeological map of the city at the level of the General Plan, the Project detailed planning or development separate quarters. It is based on the conclusion that «in the course of [archaeological] investigations revealed quite a number objects of the 18th century, with the result that appeared the prerequisites for georeferencing to modern

topographic of maps the first centuries». (Korchagin et al 2000: 72). Perm historical and cultural heritage also appeared in the catalogs of cultural heritage's objects, but because of a large number of monuments, the information about them was presented very briefly (Shatrov 1976; Kiselev and Yakina 2011).

Further studying of the historical and cultural heritage of Usolie and Perm, including the use of digital documentation, is necessary for developing strategies for the conservation of cultural heritage in circumstances of urban planning development.

Methods and methodology

The principal sources for studying the historical and architectural environment of Perm and Usolie are maps and plans of the cities, therefore, geographic information systems (GIS) are an invaluable instrument for processing geospatial data. Using the opportunities GIS and geoinformation mapping allows to obtain a new product including new historical information in the processing of historical archive sources. GIS-technologies as part of GIS do not only allow to work with maps and text materials, but also visualize them in readable form.

Using GIS-technologies applied to the study of cultural heritage was formed as an interdisciplinary field of research. In the last decades, GIS is used as a tool for monitoring and management of cultural heritage for their protection. The group of researchers from the Cyprus University of Technology and the Institute for Mediterranean Studies using GIS as a non-destructive and cost-effective method to assess risks for cultural heritage in Paphos (Cyprus) for predicting the future development of the present hazards (Agapiou et al 2015: 230-239). The database, based on a Geographic Information System (GIS), was created by Spanish researchers. As a result, a catalog of traditional rural buildings in the province of Almeria (Andalusia, Spain) was compiled to facilitate the management of cultural heritage by public organizations or individuals for their reuse and restoration (Cano et al 2013: 34-47). In one of the chapters of «Visitor Management: Case Studies from World Heritage Sites» Katie Evans and Lindsay Fielding had discussed ways in which GIS might be used to achieve management objectives related to the protection of the Giza Plateau from the environmental damage caused by the development of tourism (Evans and Fielding 1998: 82-99). The research team from Jordan showed the results of a study carried out to evaluate the effect of the modern urbanization process in the degradation and loss heritage of the city of Irbid using spatial analysis through GIS (Al-Kheder et al 2009: 81-92).

Urban history is one of the most developed research directions with the use of GIS, besides many aspects of urban history are associated with cultural heritage. Anne Kelly Knowles has been allocated the application of GIS

in scientific practice in several areas, including empirical research on the history and to visualize past landscapes and the changing morphology of built environments (Knowles 2008: 8). Loren Siebert's historical GIS of Tokyo is a good example of studying urban history. In the result of research has been created of the digital atlas of the city, where the researcher presents various aspects of the city's history, including data on the physical landscape, administrative boundaries, information on the growth of the road and rail networks, information on land ownership, etcetera (Siebert 2000: 537-574).

As an example of the implementation of GIS-technologies for the study of cultural heritage it is worth to mention the only project of its kind in the region: «Historical and Cultural Heritage of Perm Region», which has been implemented by the Center for Geographic Information Systems and Technology and the Laboratory historical and political Informatics of PSU from 2013. The project provides an access to the data of cultural heritage and expects to use it for research projects without harming the physical integrity of the objects (Kornienko et al 2015: 124-132). The biggest advantage of the project «Historical and Cultural Heritage of Perm Region» that it includes information about almost all objects of cultural heritage of the region, is also its disadvantage because large amounts of information are difficult to work on the study of the local area. Due to the fact that in small area the region has a large number of monuments, some of them do not appear on the map of the project without any additional search in the database (Istoriko-kul'turnoe nasledie Permskogo kraja, 2013-2014).

Evgeniy Kolbovsky has formulated general principles of organization and technology of cultural landscapes' information support, which are relevant for the current research because created projects are associated with historical data (Kolbovsky et al 2012: 224-231). The present research was the implementation of the licensed software ArcGIS 10.2 (ESRI). For the correct work with spatial data needs a common coordinate system, accordingly, all historical maps were brought to coordinate system WGS 1984 Web Mercator Auxiliary Sphere. For the substrate used photographs of different spatial resolution: the territory of Usolie archives «PSU Space Monitoring Center»: LandSat (spatial resolution of 30 m, 2001), Spot-6 (natural colors, the spatial resolution of 1.6 m, 2014); Perm – WorldView-2 (spatial resolution of 0.5 m, 2010) and the base maps of resource ArcGIS Online.

The geospatial models - «Architectural and historical environment of Perm» and «Cultural and historical heritage of Usolie» - were created with the collaboration of the Department of Ancient and Medieval history of Russia at Perm State Humanitarian Pedagogical University and the Department of Cartography and Geoinformatics at Perm State University. At the same time, we had been working on the study of urban planning development of Usolie and Perm.

The developing of each geospatial model took place in several stages. First, the quality cartographic materials were selected and scanned. Cartographic and iconographic materials dated the 18th – beginning 20th centuries from the funds of national and regional archival repositories were used in the preparation of projects. Among which the Russian State Archive of Ancient Acts, the Russian State Historical Archive, the State Archive of the Sverdlovsk region, the State Archive of the Perm Region, History and Art Museum of Berezniki, the Solikamsk local history museum and Usolie historical and architectural museum. Methodological sides for the analysis of urban plans were developed by Pavel Korchagin (2006: 7-27).

The following stage was the georeferencing of each cartographic source to the modern topographic base and bringing them into a single coordinate system (WGS 1984 Web Mercator Auxiliary Sphere). The final stages of the work were the digitization of maps and plans and creation on their basis of the geodatabases. Creating the geodatabase is an important stage in the work because it allows you to work with large arrays of data. The geodatabase is necessary for structuring available positional and attribute data, which facilitates to work with them. Raster and vector map layers were attributed to positional information. In turn, the raster map layers were divided into cartographic materials and data of the Earth remote sensing, which were used as supporting material for digitization, georeferencing and identification of objects. Vector map layers represent digitized maps, which include the information of the following classes of objects recorded in the geodatabase:

- borders of the city and urban sprawl;
- existing brick and significant wooden buildings at the time of the map or plan;
- built-up and planned for building quarters;
- water bodies (rivers, streams, ponds);
- communication (roads, pipelines, tram and railway);
- infrastructure (bridges, dams, locations of fire hydrants, etc.).

Attribute data contains comprehensive information obtained from historical cartographic sources and represents tabular information, which is the basis of geographical objects, allowing to visualize and analyze data. Geodatabase allows creating attachments, which store the detailed information (non-geographic) about the objects of cultural heritage. By clicking on the object user can view necessary information in the pdf-document.

Results and discussion

The result of the investigation was the development of two geospatial models, which contain information about the planning and urban development of the Usolie and Perm in the 18th – beginning of the 20th century. In the attachments of geodatabases gathered information about

all the Perm and Usolie objects of cultural heritage, dated the 18th – beginning 20th centuries (Bushmakina et al, in press). The attachments include public information from the national cultural heritage register of Russia: the name of the object, its address, the date of construction, reconstruction and/or dates associated with historical events, the category of historical and cultural importance and type of cultural heritage's object. Moreover, the attachments represent archival and modern photographs of monuments, a suggestion of the architects or builders (if known), a brief historical information, architectural description of objects and drawing or building project [Figure 1].

Geodatabases allow storing the information in an orderly manner, to produce accounting and systematization of cultural heritage's objects and to implement spatial monitoring. It is possible to use query to search, do samplings on the set parameters and analyze the requested information, which is important in view of the annual change in the number of cultural heritage's objects under the government protection (annually in the Perm region, especially in Perm, several buildings are revealed as objects of cultural heritage, and some lost objects, which impossible to recover, removed from state accounting and government protection). These samplings can be helpful for research purposes or in the practical activities of the executive power authorized in the sphere of cultural heritage protection.

It is important to point out that GIS-technologies allow to study the heritage of cities in their integrity and diversity, not only the cultural heritage's objects, but also the historical and architectural environment: the existing system of verticals and spatial relations, the main streets and squares, the cultural landscape and the natural environment. Through the using archival maps and plans which were brought out to the modern topographic base, we have recreated the urban development of Perm [Figure 2] and Usolie [Figure 3]. Through the imposition of the archival cartographic sources, we have been able to identify new information which not shown in writing sources. We have recorded borders of the city and urban sprawl, network of water bodies, changes dimensions of existing buildings and add information about the history of the building of cultural heritage (monuments and ensembles).

Integration of historical maps and plans in GIS has allowed localizing the borders of the cities, historical building line of the 18th – beginning the 20th centuries, the density of development, highlighting the historical city center (in the case of Perm - the drift of the center) and separate functional zones, belonging residential estate. Correlation of archaeological data with historical maps makes it possible to analyze and confirm the accuracy of the information contained in archive documents.

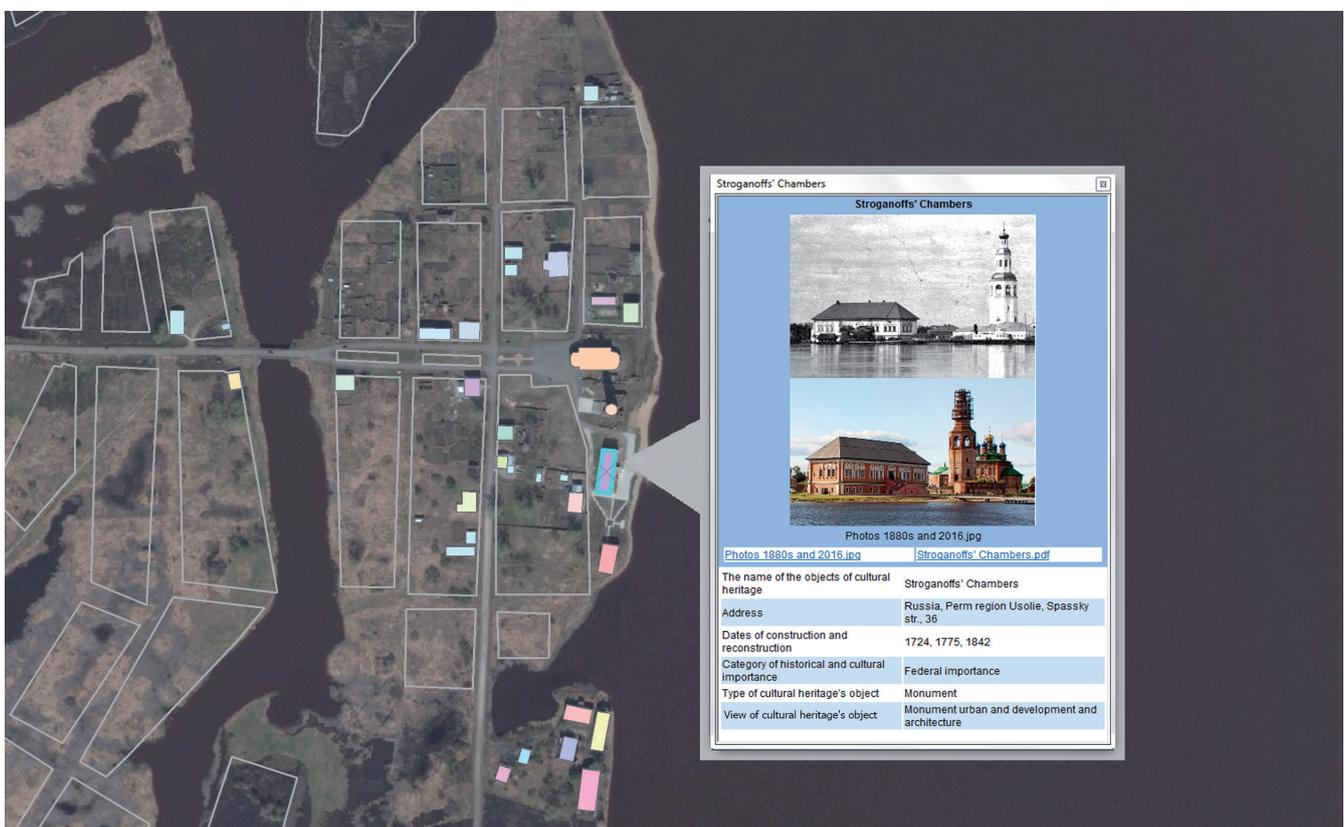


Figure 1. - Example of the attachment from geospatial model «Cultural and historical heritage of Usolie» (screenshot). Image owners – Maria K. Dmitrieva, Yuliya V. Bushmakina.

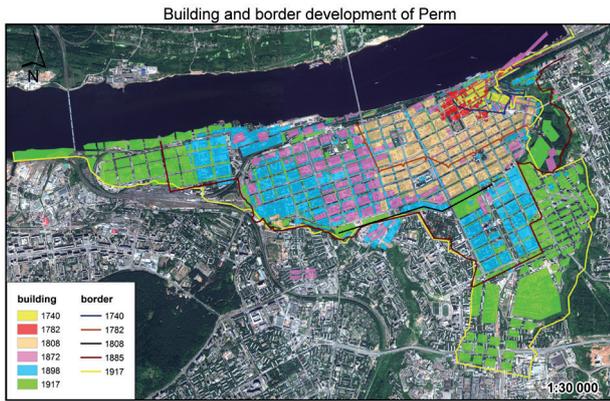


Figure 2.- Map of administrative boundary and quarterly network development in Perm. This figure was first published in 5th International Conference Youth in Conservation of Cultural Heritage YOCOCU 2016 Congress Book, published in relation of the conference YOCOCU 2016, organized by Museo Reina Sofía's Department of Conservation-Restoration, Fundación Museo Reina Sofía, YOCOCU (Youth in Conservation of Cultural Heritage) Association and the Institute of Geosciences (CSIC-UCM), which took place from September 21th to 23th, 2016. Image owners – Maria V. Gogoleva, Polina A. Balyberdina.

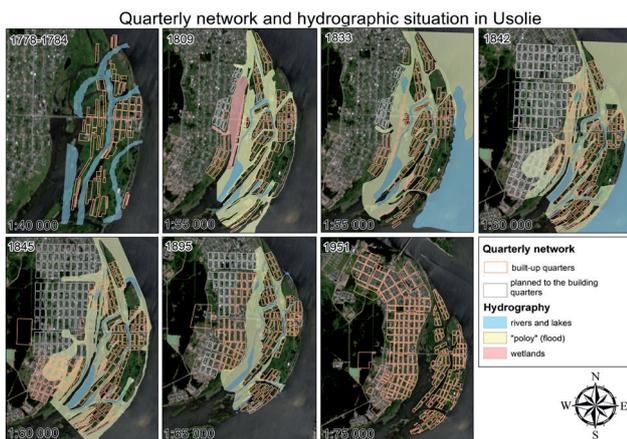


Figure 3.- Map of quarterly network reconstruction and hydrographic situation in Usolie in the 18th – the first half of the 20th century. Image owners – Maria K. Dmitrieva, Yuliya V. Bushmakina.

Correlation archival plans for «Project of quarters» and plans reflecting real urban development of the cities has provided an opportunity to identify divergences from the original plans (cemetery placement closer to the line of building) plans and the experience of failed planning decisions that eventually had to be rejected (the placement in Usolie of shops along the bridge and building quarters at flood). Availability of such information now helps to weed out failing urban planning and design decisions.

Moreover, through the use of GIS we have received qualitatively new information, especially in a changing cultural landscape because of the active channel processes and anthropogenic factors. For example, major of natural water bodies in Perm (except for the Kama river) are small (Egoshikha, Medvedka, Danilikha, Svetlaya), most

of them were backfilled or enclosed in underground drainpipes. Mapping their channels would eliminate the technical excesses even at the design stage of buildings and constructions [Figure 4]. Integration archival maps and modern topographic proved useful for fixed changing coastline of the Kama and the location of the oxbow lakes in boundaries of Usolie by reason of channel processes before commissioning of the Kama hydroelectric station. Drawing of water and transport networks, communication networks, which appeared at the turn of the 19-20th centuries on the relief, demonstrates conditionality of their historical location. Finally, by means the archival cartographic sources are integrated to the modern topographic were refined construction periods, historical functions of many monuments of industrial architecture, including those from which only the foundations remain. Thus, the analysis plans of Perm and Usolie with application

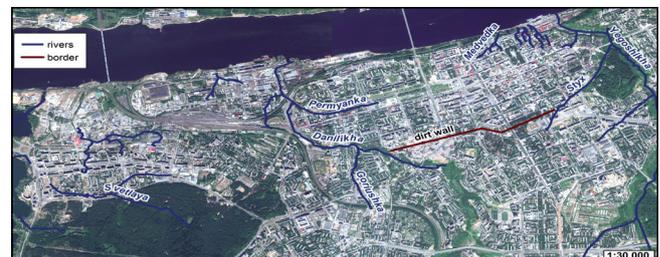


Figure 4.- Bodies of water in Perm filled or enclosed in underground sewer. Image owners – Maria V. Gogoleva, Polina A. Balyberdina.

geoinformation methods has revealed features of the folding urban planning, define the boundaries of spread of building, identify patterns of folding of historical and architectural environment of the cities that will be useful for the study of the socio-economic subjects its history. Besides, the GIS-projects managed to bring together all information about the cultural heritage (monuments of history, architecture, and urban planning) of historical cities that allows implement spatial analysis and monitoring of cultural heritage, predict potential risks on the basis of the information included in the geodatabase. The application of digitized maps facilitates the use of historic cartographic sources in solving various historical and architectural problems of applied quality, given the plethora of information contained in archival maps and plans. Therefore, the use of GIS projects with drawings, photographs, and other historical data is valuable to the restoration monuments and conservation of the historic environment.

Conclusions

The GIS-technologies as a method of digital documentation are an excellent tool not only for visualization but also for studying cultural heritage and history of urban planning development, providing new opportunities for historical research. Using GIS for studying historical and cultural heritage provided an opportunity to confirm or refute the established historiography judgments concerning the

urban development of Usole and Perm. The information obtained as a result of developing GIS project can be applied in practice. Digital data can be used to work with objects of cultural heritage (to carry out their spatial analysis, monitoring and accounting), in conducting archaeological research, the study and teaching of regional history. The correlation of geospatial models and modern buildings might be using in the development or correction of the urban-planning regulations.

The work on the projects for creation the architectural and historical models of cities Usole and Perm will continue. It is planned to add in geospatial models data about the architectural environment of the 20th century given the development of Soviet construction, including information about the monuments of constructivism and Stalin's empire, the cultural heritage of the settlements included in Perm in this period.

Acknowledgments

We express our deep appreciation to Pavel Korchagin for proofreading manuscript, valuable advice and comments.

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