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RECONNAISSANCE, HISTORICAL-GEOGRAPHY AND TOPONYMY RESEARCH OF TOPLICA "LAND" WITH IMAGE MODELING [*]

Abstract: Project *New technologies and reconnaissance and historical- geography and toponymy research of Toplica "land"* aims to research the territory of the Toplica land, making the list of all localities dating between prehistory to the 16th century. Some of those are known archeological sites with material remains, and the others devastated throughout the history and witnessed today only by local tradition or toponymy. Both detailed reconnaissance and historical- geography research are conducted through extensive terrain examinations. Besides listing of localities, research team is working on gathering and sorting toponymical information. New information will profoundly extend and expand the understanding of this region. Simultaneously, new technologies used within this project would broaden the classic way of researching and thus supplement it with a new element - a possibility of making a precise map of all localities and cultural- historical monuments. All localities, known as well as unknown and undefined, will be mapped and their locations will be presented by the positions gathered from GPS. In addition, localities will be presented in a digital form through numerous photographs and films.

For the purpose of the project, two packets were tested: Photoshop and Photosynth, both on the material collected at localities of Toplica land. Testing Photoshop and Photosynth produced impression that Photoshop is more complex for using (with its numerous functions). It is good in image analysis and processing. Photosynth, on the other hand, has created very good 3D effect with its geometric topology of the pictures. Photosynth makes dynamic photos/videos, and allows exploring of places, objects, and events in detail unlike any other media; therefore, it is useful for archeological heritage, as well as all tangible (material) heritage.

Key words: Historical Geography, Toponymy, Toplica region, Object Reconstruction, Image Modeling

Toplica "land". Previous research and today`s conditions

Toplica "land" is located in the south of Serbia, in the region of the central Balkans. At some point of time, it probably included also the territory known as *župa* Reke (Pusta reka). The name of the whole area originates from the name of the river, Toplica, which runs through this region. According to archeological research done so far, appropriate geographic conditions and natural wealth predetermined inhabitation of Toplica as early as in prehistoric times. In antique period, it was under Roman authority. In the time of the Byzantine Empire, the Slavs who named it Toplica populated it. It was considered a Serbian main land as early as in Stefan Nemanja`s times and it was a part of Nemanja`s appanage (*udeone oblasti*). In the 15th century, it was given to the Turks as a dowry of Mara Branković.[1]

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[1] Р. Ђук, *Царица Мара*, ИЧ (1978–1979) 53-97; *Историја Српског народа* I, Београд 1981; II, Београд 1982 (by registry); М. Спремић, *Деспот Ђурађ Бранковић и његово доба*, Београд 1994 (by registry); *Куршумлија кроз векове*. Зборник радова са научног скупа 13–14. октобар 1995. Пролом Бања. – Београд, Историјски институт САНУ ; Куршумлија, Туристичка организација општине Куршумлија, 1996. (especially the papers of G. Tomović, M. Janković and O. Zirojević, with the reference to the older bibliography); М. Благоје-

The research of Toplica done up until today was mainly directed towards specific parts of the territory such as settlements or monuments of a particular importance to a historic or cultural point of view, or archeological localities which contained numerous material remains. Recently, National Museum in Prokuplje integrated in its activities a number of archeological examinations and a partial reconnaissance of certain districts.[2] Localities related to neolith and antics are better explored whilst middle ages and early ottoman era have been almost completely neglected. Nevertheless, detailed historical-geography reconnaissance and gathering toponymy of the entire Toplica "land", has not been done yet. In addition, researches done before the Digital (Information) Age are not followed up by the application of new technologies,

Historical-geography research of Toplica is extremely important for it holds the key to understanding the past and the life of the territory itself, and therefore leads to improved perception and appreciation of the history of the Serbian people in the parent-regions. Terrains and toponymy examinations would fill out gaps created through the lack of sources. For Toplica to be thoroughly and meticulously examined, and its plane adequately reconnaissance, marked, established and digitized, it is necessary to choose a multidisciplinary approach. Participation of not only humanistic arts and sciences such as history and archeology, but also natural sciences such as geography and new information science is the only way.[3]

This cooperation between history, geography, mathematics, computer appliance and informational technologies, participating in one historical research, as it is in the case of Toplica "land", became a new project named *New technologies and reconnaissance, historical-*geography *and toponymy research of Toplica "land"*.[4]

вић, Жупе Реке и Дендра (δενδρα) Јована Кинама, ЗРВИ 35 (1996) 197–212; *Међународни научни скуп Стефан Немања – Свети Симеон Мироточиви - историја и предање*, Септембар 1996, Београд : САНУ, 2000 (especially the papers of J. Kalić and S. Ćirković with the reference to the older bibliography); Т. Живковић, *Синови Завидини*, Зборник МС за историју 73 (2006) 7-25; Ј. Кузмановић – Цветковић, *Прокупље, град светог Прокопија*, 2006. М. Јоцић, *Древно Прокупље*, Прокупље 2007; *Митска Топлица* (Митолошки зборник ; 20), Рача : Центар за митолошке студије Србије, 2009 (Лапово : Колор прес) (especially the papers of J. Kuzmanović Cvetković and Ž. Andrejić with the reference to the older bibliography). About some towns and market places in Toplica, see: *Лексикон градова и тргова српских средњовековних земаља: према писаним изворима* (група аутора), Завод за уџбенике, Београд 2010. See also next note.

[2] Д. Шљивар, Ј. Кузмановић-Цветковић, *Плочник код Прокупља, насеље винчанске културе,* Гласник Српског археолошког друштва 13 (1997) 103-113. Web adress: http://scindeks-clanci.nb.rs/data/pdf/0352-5678/1997/0352-56789713103S.pdf; Д. Шљивар, Ј. Кузмановић-Цветковић, *Плочник код Прокупља, истраживања у 1997,* Гласник Српског археолошког друштва 14 (1998) 79-85. Web adress: http://scindeks-clanci.nb.rs/data/pdf/0352-5678/1998/0352-56789814079S.pdf. About construction of archeological park Pločnik, see: Beta 13/06/2010. 20:18 | Prokuplje, Danas.rs http://www.danas.rs/danasrs/srbija/hronika-/obustavljena_izgradnja_arheoloskog_nalazista_plocnik.73.html?news_id=192649 (Date of last access: 16. 06. 2010.) Also by now, it looks like that world's oldest Copper Age settlement found at Plocnik by J. Kuzmanović Cvetković and her team. See: Archaeology Daily News, November 15, 2010, http://www.archaeologydaily.com-/news/201011155551/Worlds-oldest-Copper-Age-settlement-found-at-Plocnik.html.

[3] About humanities (especially history) multidicsiplinary approach and new technologies: A. Fostikov-S. Mandić, "*New categories of historical sources: e-mail and forum. Internet communacation and history*", *Pregled NCD*, 10 (2007), 40–41; Beograd, 2007; Slobodan Mandić, *Kompjuterizacija i istoriografija: 1995-2005*, Beograd: Istorijski arhiv Beograda, 2008. Today, this cooperation between humanities, computers and information science, is also known by a more precisely title *Digital Humanities*.

[4] In 2002, the first project about digitization of this region entitled *Sacral object of Toplica region* started by Ž. Mijajlović, A. Valjarević and A. Simonović. In the mean time, it grows up and became project *Archeological and sacral objects of Toplica region* 2008, a part of the general project *Application of information technologies in the digitization of scientific and cultural heritage.* About project and its development, see: Ž. Mijajlović, *Project: Sacral object of Toplica* http://www.ncd.matf.bg.ac.rs/?page=projects&lang=sr&file=sakralni.HTM; Ž. Mijajlović, M. Milovanović, A. Valjarević, D. Radovanović, A. Simonović, *Digitization of Cultural Heritage of*

Goals, tasks and research program stages

As above mentioned this project aims to research the territory of the Toplica land, making the list of all localities, those with material remains dating between prehistory to the 16th century, as well as ones devastated throughout the history and witnessed today only by local tradition or toponymy.

At the same time, new technologies used within this project will broaden the classic way of researching and supplement it with a new element - a possibility of making a precise map of all localities and cultural- historical monuments. This will enable profound understanding of their synergy in a historical context. All localities, known as well as unknown and undefined, will be mapped and their locations will be precisely[5] presented by the positions gathered from GPS. In addition, localities will be presented in a digital form through numerous photographs, video material, etc. GIS base of this region would easily use information on localities positioned and digitally processed in such a manner.[6]

Once completed, general reconnaissance and listing of localities and toponyms, and their digitization, administered in such manner, would not have to be repeated. In the future, all newly discovered information could simply be added to the already existing base. Multidisciplinary regional exploration such as this one should become a standard.

Nature of this research indicates that the whole project should be conducted in separate but parallel stages:

A – Preparation stage:
1. Fabrication of a detailed research program for each expedition
2. Study of existing sources and literature

B – Terrain exploration:
1. Terrain reconnaissance (field survey)
2. Historical-geography terrain research
3. Gathering of toponyms in the area
4. GPS Applications
5. Education of the younger researchers in the field of the terrain`s survey methodology

C – Assembling results:

Toplica Region in Serbia, http://seedi.ncd.org.rs/events/SEEDI2010_BookOfAbstracts.pdf p. 23 and the presentation
http://seedi.ncd.org.rs/events/SEEDI2010_presentations/May19/%5B21%5D%20Z.%20Mijajlovic,%20M.%20Milovanovic,%20A.%20Valjarevic,%20D.%20Radovanovic,%20A.%20Simonovic%20-%20Digitization%20of%20cultural%20heritage%20of%20Toplica%20region%20in%20Serbia/PRESENTATION%20Digitization%20of%20Cultural%20Heritage%20of%20Toplica%20Region%20in%20Serbia.pdf. The cooperation between the two projects, one about *reconnaissance, historical- geography and toponymy research of Toplica "land"* and the second about *Digitization of Cultural Heritage of Toplica Region* was established in the second half of 2008. First preliminary research of this area was done in August, same year. In August 2009. the project started and the first team for reconnaissance, historical- geography and toponymy research was on terrain. This project is being led by prof Siniša Mišić, Faculty of Philosophy – University of Belgrade and prof Žarko Mijajlović, Faculty of Mathematics- University of Belgrade.

[5] The usual description of the site e.g: by tradition the remains of the church/fortress/.. are situated about 2 or 3 km near/south of the/…village X on/under/.. the hill Y in the forest. Without precise coordinates, or the some sort of a guide-person who was on the site before, it is very hard to find any remains, especially since they usually lay under thick vegetation for a minimum of a few years, sometimes few decades.

[6] Some digital forms forms presented in this paper are described in more detail by S. Janićijević and some of them by: Ž. Mijajlović, M. Milovanović, A. Valjarević, D. Radovanović, A. Simonović, *Digitization of Cultural Heritage of Toplica Region in Serbia,* http://seedi.ncd.org.rs/events/SEEDI2010_BookOfAbstracts.pdf; A. Pejović (*О резултатима неких пројеката дигитализације у Србији*) http://ncd.org.rs/ncd_sr/Events-/NCDBeograd2010/BookOfAbstracts.pdf, p. 24.

1. Systematization, classification, data processing, digitization
2. Research results report
3. Establishment of relevant base
4. Creating maps
5. GIS and HGIS (Historical Geographic Information System)

Use and application of the research

This research will facilitate the creation of the historical map of Toplica[7], therefore of Serbia, which will be of considerable importance and value not only to historical science but also in a cultural, political and touristic domain.[8]

Data gathered through research and digitization of localities will allow better comprehension of the history of Toplica. At the same time number of younger researchers aiming to continue and improve their education through not only gathering and handling the information but also through practical work at the location, necessary for their further scientific development, will be incorporated into the project.

Beside the great value to the narrow scientific circle, such an exploration will make it possible for the wider public to be acquainted with the history of Toplica "land", and will find its application in the education of the future researchers of the local history and region. In addition, the data could be used as groundwork for a regional database, which would have to contain exactly such historical data and facts as well as toponyms or find its application in the future touristic development of the region.

Taking photos of the site and image modeling application

New technologies could provide numerous ways of observing and reconstructing the past in a digital form. One of those is a making High Definition digital photographs of the site like localities or material remains e.g. churches, figurine … Today there is a growing demand for the modeling of the tangible heritage, as mentioned above, for computer visualization and documentation purposes. HD photography presents a generous data source and at the same time is the most convenient recording mode on site. A photograph is a high-density container of information. It carries radiometric information and can provide range values as well. In terms of computer vision, structure from motion is a process to find the correspondence between images. Features must be tracked from one image to the next.

Here we will try to present some image modeling applications, which could be interesting for use in digitized heritage, especially when you wish to create a crude 3D model of the researchable topic for the start. First, we must explain what techniques were used as a testing method in our project of Toplica "land". It is not new technology method; it was Photoshop test where we modeled particular photos of various localities. The test was done in CS3 version.[9]

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[7] About HGIS, see: *The Historical-Geographical Information Systems (HGIS) Research Network* http://www.hgis.org.uk/index.htm, Page Last Updated: 12/06/10 (Date of last access: 16. 06. 2010.).
[8] About digitization, its importance and value: Ž. Mijajlović, *Application of information technologies in digitization of scientific and cultural heritage,* http://ncd.org.rs/ncd_sr/Events/NCDBeograd2010/BookOfAbstracts.pdf, p. 16–17.
[9] The Photoshop is today standard for image modeling and the test by Stefana Janićijević carried out during work on the projects: *Archeological and sacral objects of Toplica region* and in general project *Application of information technologies in the digitization of scientific and cultural heritage.* About others techniques applied on research material including digital restoration see above note six.

We used several utilities. First, we changed the image size because photographs were too large for further analysis, storing, preserving and digitizing. The file size of an image is the digital size of the image file, measured in kilobytes (KB), megabytes (MB), or gigabytes (GB). We created our photos having 500 KB-2 MB), as the file size is proportional to the pixel dimensions of the image. Images with more pixels may produce more detail at a given printed size, but they require more disk space to store and may prove time-consuming to edit and print. We keep in mind that in this process the image resolution becomes a compromise between image qualities and file size. As we prepared images for the web online media[10], we needed to compromise between displayed image qualities and file size. We used Save for web & Devices box applications to preview optimized images with different file attributes.

After that procedure, the Free Transform application is the next step. With it, we did the main part of rotating, scaling, skewing, distorting and perspective manipulating. On some photographs, we had to use the Lens Correction filter for fixing common lens flaws such as barrel and pincushion distortion, vignette, and chromatic aberration. The filter works with 8-bits and 16-bits-per-channel images only. It can also be used to rotate an image or fix the image perspective distortion caused by vertical or horizontal camera tilt. The filter's image grid makes these adjustments easier and more accurate than using the Transform command. Additional functions were color design, like bitmap mode, multichannel mode and grayscale mode. We converted a bitmap mode image into a grayscale mode image in order to edit it better. This process lets us generate multiple shades of gray from an image scanned on a 1-bit scanner. After this effect, we tried to achieve different blending mode types, such as opacity effect, darken, color burn, linear, lighten, saturation, hue, luminosity and brightness. With Hue and Saturation application, we adjusted hue, saturation and brightness of a specific color component in an image. This command was good for fine-tuning colors in a CMYK image. In some cases, where needed, we did color dynamic brush option and created a noise gradient. These possibilities were functional for improving details, such as highlights, shadows, tonalities and picture atmosphere. There were no 3D layouts or video presentation for us to use.

Microsoft offers another relatively new tool for photo browsing, Photosynth,[11] which we also used for testing Toplica"land" photographs[12] with intention to use it in future parallel with Photoshop for the research practice and digitization.

The software *Photosynth*, is designed as an image browser for objects, documented by internet imagery. The user navigates through a bundle of images representing the object. A smooth transition from one photo to the next is leading to the impression of a 3D model. Photo positions are known as well as a point cloud emerged from the registration process.

Photosynth acquires photos, combines them together, and restructures a 3D scene out of them in which anyone can view and move around in. It is different from static photos and videos, and this program allocates and explores details of places, objects, and events. In simple terms, it seeks a group of photos of the same scene or object and automatically unites them into one big interactive 3D viewing experience, which could be shared with anyone on the web. However, if you want to reach a result such as brilliant, you will need a huge collection of photographs.[13]

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[10] The general one of main ideas of the digitization is wide availability of digitized material, especially through online media and for that purpose, most photographs must be resized.

[11] Based on the research on *Photo Tourism* from the University of Washington and Microsoft Research: http://phototour.cs.washington.edu/ and http://photosynth.net/Background.aspx (last accessed to both sites: 23. 06. 2010.)

[12] The test of this software was done on few sets of photographs crated for this project, see above note no. 4.

[13] In this case, you need somebody from the team to stay on the site or have in some cases at least one photographer in the team, but it is not always possible. Limit of the angle between photos should be no more than 25

The program involves the analysis of multiple photographs taken of the same area. Each photograph is processed using an interest point detection and matching algorithm developed by Microsoft Research which is similar in function to UBC's Scale-invariant feature transform. This process identifies specific features, for example the corner of a window frame or a door handle. Features in one photograph are then compared to and matched with the same features in the other photographs. Thus, photographs of the same areas are identified. By analyzing the position of matching features within each photograph, the program can identify which photographs belong on which side of others. By analyzing subtle differences in the relationships between the features (angle, distance, etc.), the program identifies the 3D position of each feature, as well as the position and angle at which each photograph was taken. This process is known scientifically as Bundle adjustment and is commonly used in the field of photogrammetry.[14]

The second part involves the display of and navigation through the 3D point cloud of features identified in the first step. This is done with the publicly downloadable Photosynth viewer. The viewer resides on a client computer and maintains a connection to a server from their original vantage point. It incorporates DeepZoom technology Microsoft obtained through its acquisition of Seadragon in January 2006. The Seadragon technology enables smooth zooming into the high-resolution photographs without downloading them to the user's machine.

Photosynth has several negative issues like computer processes inspection of immense amounts data, which implies several negative sides of the program: upload speed is providing a blurred picture at first (at the standard of 2 Mbit/s). If the flow rate is less, time is getting extensive. Since the presentation is only on line, a user needs to have Internet connection and the format of saving is unknown. This implies that importing/exporting of a document is not possible. This also implies that the risk for the data protection is very high, while upload of data has been produced only on a Microsoft server, and no data does on a private hard disc is unsafe. If a user needs to create panorama view or realistic 3D model, it is necessary to prepare very high number of photographs, with a lot of similar details so the navigation could work properly. In a description block there is no specify explanation for every photo, but only for the whole group. In addition, for using of this software you need lot of time if your Internet connection is slow or computers configuration is under the recommended.[15]

Comparative analysis of the software packages:

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degrees - at least 15 photos per full rotation. However, this could be a cheap way creating a rude/simple model for use. If the detail reconnaissance of some site even done, it is usually done later, when other teams, by some other archeological or preservation teams.

[14] Use of calibrated cameras and manual operating seems to be a disadvantage of photogrammetry. Computer vision methods target to the use of non-calibrated cameras and very automatic model reconstruction approximating the object geometry by triangular surface meshes, textured with image data.

[15] E.g. Upload has been running about 30 minutes, for 18 photographs, resolution of pictures was 3000x2000 px and 512 Kbit/s. Optimal dimension of the photos would be 1024x768 px. Testing of the Photosynth was at the computer with 2GB memory and processor with 1,6GHz. About recommended configuration, see http://photosynth.net/faq.aspx#q14(last accessed: 23. 06. 2010.)

Photoshop	**Photosynth**
Very famous and very useful for image processing	Analyzes digital photographs and generates a three-dimensional model of the photos and a point cloud of a photographed object
Large graphic design software	It is not assigned for graphics design
Quite many tools, filters and palette for image editing	Very simple for client users, without any complex tools
It is capable for making desired changes in images (program has many add-on and plug-ins plus additional tools for creation and editing of the images. One can draw, fill-in the colors, cut, paste, add special effects, etc in the images with Adobe Photoshop, retouching of the pictures, color changing…)	It is not capable to change pictures or to do any interventions on. It is utilized for previewing any panoramas, objects and artifacts, and it is very well for observing from any angle or distance. So, any panorama could be analyzed from all sides and points.
It is capable to create panorama with options File > Automate > Photomerge	Panorama is creating with options Create the profile > Sign in > Create your Synth > Upload photos
It uses a interpolation algorithm (bilinear interpolation, cubic interpolation) algorithm	Photographs are processed using an interest point detection and matching algorithm developed by Microsoft Research which is similar in function to UBC's Scale-invariant feature transform. Process is called Bundle adjustmen. Second step is incorporation of DeepZoom technology which Microsoft obtained through its acquisition of Seadragon. The Seadragon technology enables smooth zooming into the high-resolution photographs without downloading them to the user's machine. At the end, it enables a user to, among other things; see any of the photographs from their original vantage point.
There is no 3d effect	There is 3d effect

Image 1 Fresco painting in church dedicated to Saint George,
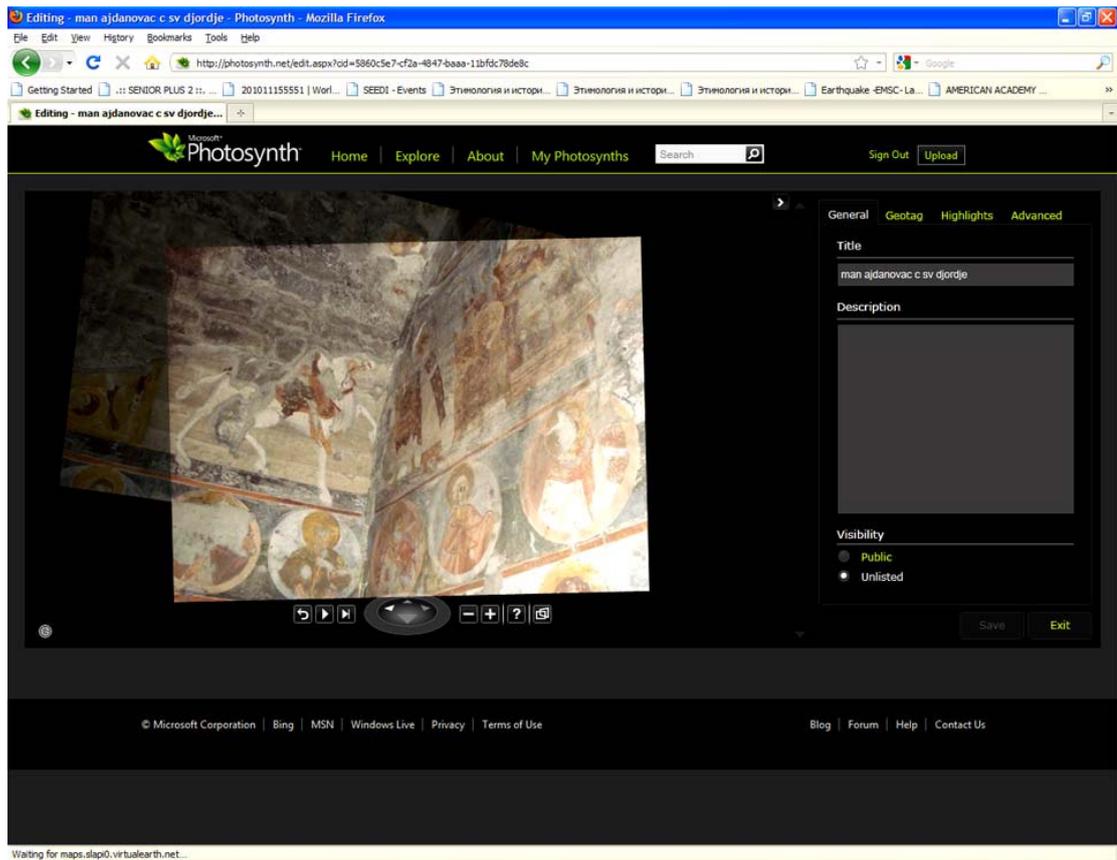Monastery Ajdanovac. Photo by A. Fostikov

Image 2: Fresco painting look in Photosynth

ПРЕПОЗНАВАЊЕ, ИСТОРИЈСКО-ГЕОГРАФСКО И ТОПОНОМАСТИЧКО ИСТРАЖИВАЊЕ „ЗЕМЉЕ" ТОПЛИЦЕ С ПРИМЕНОМ МОДЕЛОВАЊА СЛИКА

Пројекат „Нове технологије и рекогносцирање и историјско географско и топономастичко истраживање "земље" Топлице истржује територију земље Топлице од праисторије до 16. века, са циљем да се попишу сви локалитети, како они са материјалним остацима тако и они који су током претходних столећа дева-стирани и о којима данас сведочи само локална традиција или топонимија. Детаљно рекогносцирање и историјско географско истраживање биће спроведено кроз теренска испитивања која су веома значајна за употпуњавање знања о одређеној области и историјској епоси услед чињенице да су извори за раније периоде историје често веома оскудни. Осим пописа локалитета истраживачка екипа ће радити и на скупљању и пописивању топонимије. Тиме ће бити скупљен један број нових историјских чињеница, којих нема у историјским изворима што би продубило и проширило сазнања о прошлости овог простора. Истовремено у оквиру пројекта биће примењене и нове технологије са циљем да се до сада класично истраживање прошири и обогати новим елементом који ће омогућити стварање прецизне карте свих локалитета и културно историјских споменика, а самим тим и сагледавање њихових односа у историј-ском контексту. Сви локалитети како познати, тако и непознати и недефинисани биће уцртани на карте и њихове локације биће представљене на основу позиција добијених путем ГПС-а. Локалитети ће такође бити представљени у дигиталној форми кроз бројне фотографије и филмове. Овако позиционирани и дигитално обрађени локалитети ће моћи да се користе и за базу ГИС-а ове области.

Нове технологије пружају бројне могућности за опажање и реконструкцију прошлости кроз дигиталну форму. Многи web сервиси креирају 3-дим слику од фотографија – користе фотографије, комбинују их заједно и моделују 3д сцену од њих, тако да свако може да прегледа и да се креће у томе. Креирају се динамичне фотографије/видео записи, и дозвољава се истраживање детаља сцене, објеката, догађаја и места као ни у једном другом медију. Такви сервиси корисни су за археолошко наслеђе, као и за сваку врсту материјалног наслеђа.

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www.MeshLab.com *Homepage of MeshLab mesh processing software*
photosynth.net *Mirosoft Photosynth Network*
photoshop.net *Adobe Photoshop network*

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