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Viminacium amphitheatre, Construction 1 - Merging fragments of a wall painting (photo by Dragana Gavrilović)

CONTENTS / SADRŽAJ

Istraživanja
Research Articles

Pregledi
Review Articles

Izveštaji
Report Articles

Prikazi
Book Reviews

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DIGITAL TOOLS – A NEW ERA IN ARCHAEOLOGY

ABSTRACT

The use of digital technology and digital tools in the research, preservation, and presentation of archaeological heritage is crucial these days. In order to manage resources efficiently, good planning and strategy are necessary. Additionally, in order to plan well, it is necessary to collect, classify, process, and store data. Archaeology, as a science, requires meticulous work on data collection, processing, storage, interpretation, and presentation. A question that is increasingly becoming the focus of all interested parties is the relationship between archaeology and other sciences in terms of exchanging data. The relationship between field archaeology, scientific research, economy, economic development, and spatial and urban planning is mentioned in many works. The main aim of this paper is to promote the need to unify the archaeological documentation used by all interested parties in archaeology, culture, and spatial planning in Serbia and to connect all participants in this process through an information system. Special attention will be paid to the relationship between archaeology, GIS, and spatial planning. An exceptional example of the use of digital tools in archaeology is a map of archaeological sites, which can play a vital role in the coordination of activities in this field.

KEYWORDS: DIGITAL TECHNOLOGY, APPLICATIONS, GIS, DATA, ARCHAEOLOGICAL MAPS, SPATIAL PLANNING.

INTRODUCTION: DIGITISATION OF ARCHAEOLOGICAL DATA IN SERBIA

It is noticeable that in Serbia, a lot of time and effort has been invested in developing a centralised information system for cultural heritage. This includes the digitisation of relevant documents and multimedia data about diverse cultural heritage objects, including archaeological sites, their excavations, and intricate documentation, among others (Kazi *et al.* 2021: 4). Some of the earliest projects in this area in Serbia were carried out in the 1990s, with the PANDORA expert system being the first one in digitisation of archaeological heritage (Mijajlović and Ognjanović 2004: 53; Korać, Ognjanović i Dugandžić 2006).

Of great importance in defining the framework for the use of digital tools in archaeology is the need for a governed process of digitalisation with clear guidelines to cultural institutions on how to preserve digital and digitised heritage and make it available "at the click of a button" (Ognjanović *et al*. 2019: 1). The *Rulebook on the forms, content, and manner of keeping work logs and other documentation that is kept on archaeological excavations and research* (Правилник 2020) gives the

prescription that archaeological documentation should be preserved electronically, using a unique information system, with an aim to "incorporate data and information accessibility for institutions of protection and other state institutions" (*Rulebook on detailed conditions for the digitalization of cultural heritage* (Правилник 2018) (Tapavički-Ilić and Šegan-Radonjić 2021b: 206)). The metadata scheme, as adopted in the previous rulebook (Правилник 2018), needs to be implemented in the information system for cultural heritage documentation management. This process ensures the preservation, presentation, and accessibility of archaeological sites (Ognjanović *et al*. 2019: 1). Information about archaeological sites transmitted using modern digital technologies makes a great contribution to the development of an inclusive society since it has a positive effect on a large number of users, among which are members of the PWD (persons with disabilities) community (Масликовић и Томић 2015).

The same rulebook (Правилник 2018) regulated that all cultural institutions must use information systems. This opened the door to implementing information systems in these institutions and enabling potential connections, networking, the creation of large databases, and data sharing.

INFORMATION SYSTEMS IN SERBIA CONNECTED TO ARCHAEOLOGY

During the last three decades in Serbia, there have been attempts at the creation of various information systems connected to archaeology, such as the Information System for Archaeology (ISA) (1989), the Proposal for the application AGORA BBS (1991), the Archaeological database model proposal (1994), Proposal for the application SUPERBASE for Archaeologists (1999), etc. "However, due to the lack of funding for the equipment, coordinating mechanisms and the lack of experts, as well as the fast development of technology, the suggested solutions were either not accepted or did not last very long" (Šegan-Radonjić, Tapavički-Ilić 2021). ArcheoPackPro! is an information system designed for the entry, processing, and interpretation of digitised archaeological documents (Tasić i Jevremović 2001: 54; Tasić i Jevremović 2003). It was created over the course of six years of fieldwork and used during the excavation of the archaeological site of Vinča, with the aim of enabling archaeological teams to immediately enter and process data collected in the field. This software package was intended for use in two separate processes of archaeological research: field processing and the input of data into documentation; and the processing, analysis, and interpretation of the excavated material (Tasić i Jevremović 2001: 54–55).

Some information systems connected to archaeology currently existing in Serbia are:

- ISNKD - Information system of the immovable cultural property, a web portal run by the Republic Institute for the Protection of Cultural Monuments (ИСНКД);
- GeoSrbija - national GIS web platform, a web-based interactive map with embedded cultural heritage properties, run by the Republic Geodetic Authority (ГеоСрбија) (**Figure 1**);
- IMUS - Unique Information System, application for the museum information system of Serbia, implemented in 78 museums, run by the Historical Museum of Serbia;
- ARHIMUS - a separate piece of software for the digitisation of archaeological field documentation, which works as part of the IMUS owned by the Museum of Vojvodina;
- The Cultural Heritage Browser of Serbia - the first unified browser for cultural heritage search and mapping of monuments and cultural institutions of the Republic of Serbia, initiated by the Ministry of Culture (under redesign).

ARHIMUS

The ARHIMUS software, created in 2017, can be accessed through IMUS. It is a project devoted to the digitisation of archaeological field documentation and is used by the archaeologists in the Museum of Vojvodina. ARHIMUS has not been adopted as official software, although no information system has been declared official in archaeology. It is still in its development phase, with the

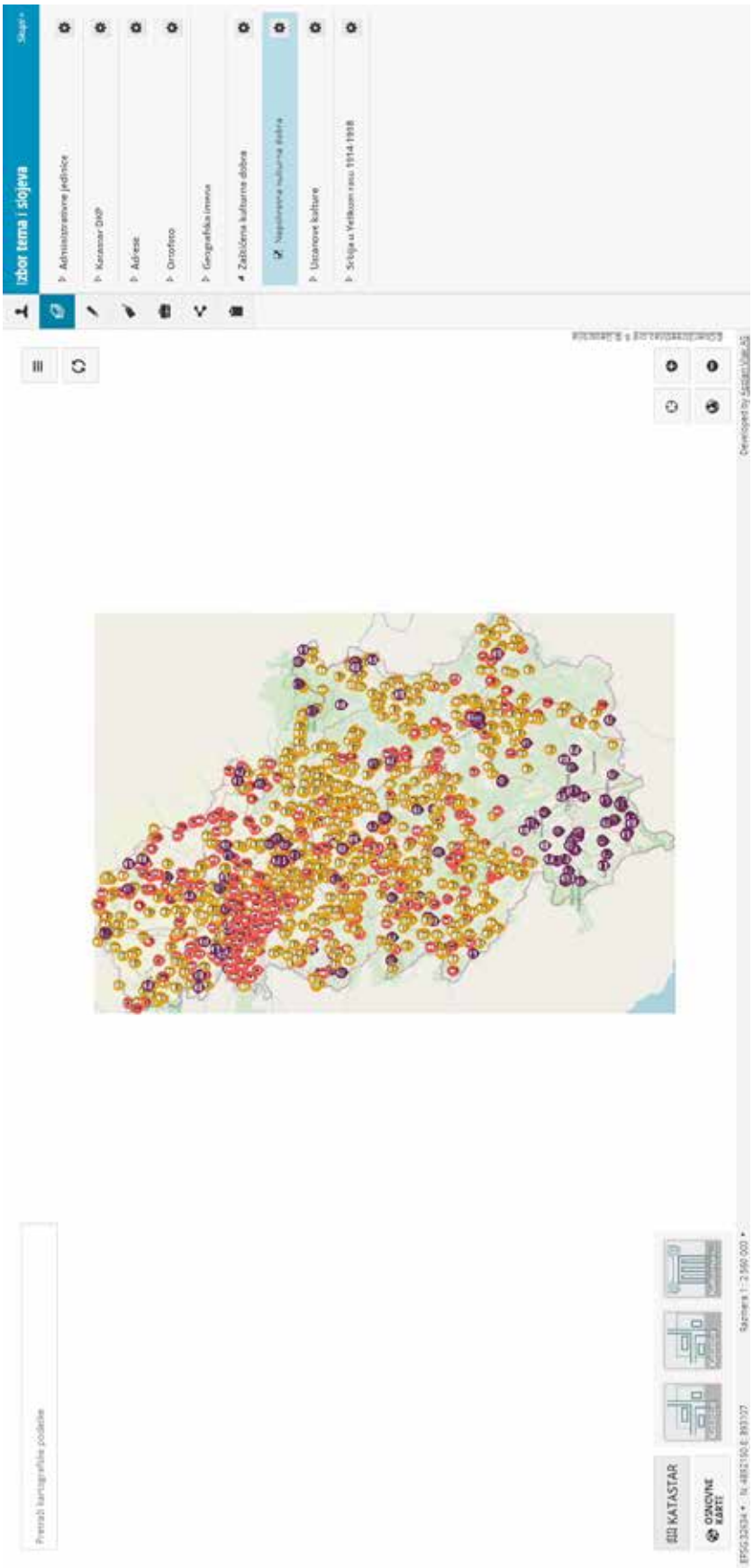

Figure 1. Screenshot of the display of the layer with the locations of the immovable cultural properties, as shown in the web-based interactive map run by the Republic Geodetic Authority (ГеоСрбија).

aim to correlate it properly to the *Rulebook on the forms, content, and manner of keeping work logs and other documentation that is kept on archaeological excavations and research* (Правилник 2020). By incorporating the ARHIMUS application as a module of the IMUS for museums, it is possible to exchange data from all participants in the protection of cultural heritage – archaeologists, curators, and conservators – in the same information system. It is also offers an opportunity to link archaeological field documentation with the main museum inventories, enabling curator-archaeologists to select the most important artifacts of field inventory and immediately include them in the main museum inventory. In such a manner, the processing of museum documentation is faster and easier. Regarding archaeological field documentation, ARHIMUS includes field diaries, levelling diaries, photo diaries with digital photos (**Figure 2**), field inventories and C-cartons with drawings and photos, technical documentation (photogrammetry and drawings of researched objects), and archaeozoological, archaeobotanical, and anthropological (**Figure 3**) reports. In this way, once entered, data becomes available in several ways, which contributes to faster, more efficient, and simpler processing of documentation.

The ARHIMUS creators aimed to reduce the processing time of the entire documentation on archaeological objects (field and main inventory), as well as to simplify the process, leaving experts more time for scientific research work and the interpretation of the past. The plan is to develop a mechanism and measure the performance of the ARHIMUS system as well as the performance of other information systems that are in use in archaeology. All information regarding an archaeological object, from the moment it was found in the field to the moment it became a part of the museum collection, is available in one place.

CONNECTIONS BETWEEN ARCHAEOLOGY, SPATIAL PLANNING AND GIS

Spatial planning is an instrument of public policy. It considers the interaction among policy sectors according to different territorial units; national, regional, and local, across a wide range of policy sectors. It addresses different kinds of problems; economic, social, and environmental, as well as the strengthening of social cohesion and using all possibilities offered by the processes of globalisation and technological innovations. The scope of spatial planning differs greatly from one country to another. However, in nearly all countries spatial planning systems encompass some fundamental functions: spatial planning provides a long or medium-term strategy for territories in pursuit of common objectives, incorporating different perspectives of sectoral policies; spatial planning deals with land use and physical development as a distinct sector of government activity alongside transport, agriculture, environment, etc.; spatial planning can also mean the planning of sectoral policies according to different spatial scales (Đorđević and Dabović 2004: 84).

Administratively, spatial planning is practiced at different levels of government: national, regional, municipal or local. At the local or municipal level, spatial planning, in many cases, centres on land use planning in order to regulate land and property uses (Đorđević and Dabović 2004: 84-85). On the basis of spatial planning, local administrations prepare documents such as detailed spatial regulation plans, which enable the development of industrial zones, free trade zones, duty-free zones, and infrastructure (roads, energy, telecommunications, etc.). It provides good conditions for economic and social development in a regulated environment.

The sudden penetration of natural sciences into archaeology in the middle of the 20th century is the result of the so-called processual or new archaeology as a special and new direction in the theoretical and exact development of archaeology, but also a consequence of the need to adopt new methods that will facilitate the discovery of sites (Stanković Pešterac 2014: 219). Since the beginning of the 1960s, different geophysical methods have been used and adjusted to archaeological needs (Pešterac 2006: 53; Stanković Pešterac 2014: 227). Today, there is no need to speculate on the significance of the role of geosciences in archaeology (Stanković Pešterac 2014: 227). A large number of known sites and the discovery of new ones due to the emergence of new prospecting methods, especially geophysical, which non-invasively obtain precise images of what is hidden under the

Figure 2. Screenshot from ARHIMUS, photo diary, probe photo (accessed by authorised person Natalija Vulikic, on June 22nd 2023).

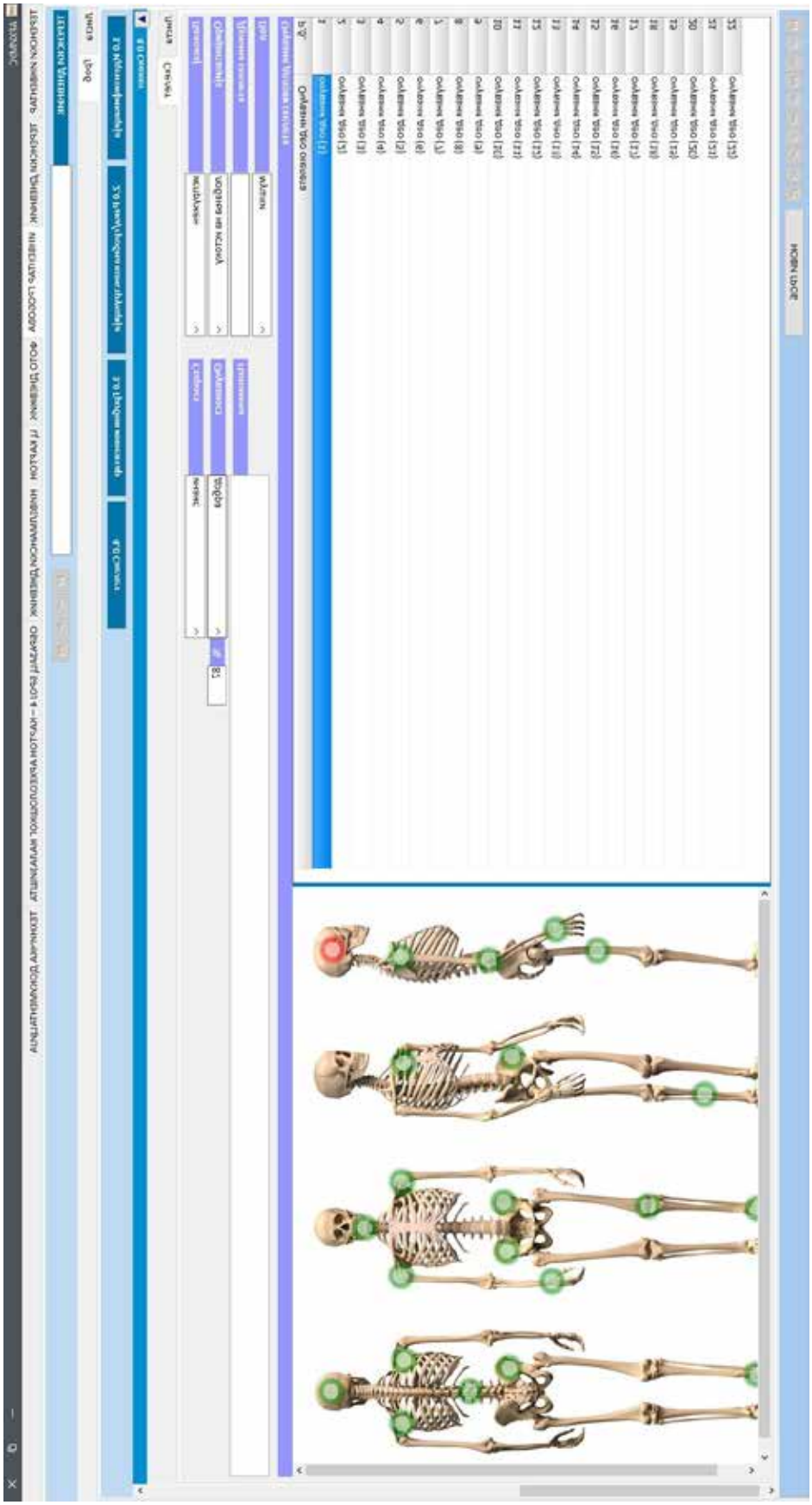

Figure 3. Screenshot from ARHIMUS with a segment for marking the found human skeletons with a description (accessed by authorised person Natalija Vulikić on June 22nd 2023).

earth's deposits, require serious documentation and data processing systems.

The use of GIS in the field of culture and heritage has grown significantly. The reason can be sought in the increase of multidisciplinary studies in this area that use the support of the natural sciences, including geographic information (García *et al.* 2022: 97). The term GIS is not a term that has recently appeared in archaeological studies. It has been present in papers and practice since the 1980s. Despite that, in practice, it was applied ten years later in Europe, in the early 1990s (Scianna and Villa 2011: 337). Since the mid-1990s, GIS has become more connected to other disciplines' work techniques and provided them with support. It was used in the processing and application of satellite images, and in the integration of geophysical survey data with spatial data (Novaković 2003: 155–167). Due to the availability of advanced performance information and communication technology and modern topographic instruments used in geodesy (total stations, GNSS receivers, laser scanners, etc.,) that can collect georeferenced data on the area of archaeological excavations, GIS applications used in archaeology have evolved in parallel (Conolly and Lake 2006: 50–62).

GIS is used in archaeology because it collects data that matches the data needed by archaeologists and allows them adequate research analysis, spatial queries, statistical spatial analysis, different map layers, slope calculation, filtering and overlapping with layers of geology, natural disaster analysis, methods for regional analysis, visibility analysis, export of data for printing and production of publications, collection of metadata, etc. It is a precious source of practical information for archaeologists, whether in scientific research or in practical field work (Conolly and Lake 2006: 68). Therefore, Geographic Information Systems have an increasing role in archaeology, facilitating archaeological analysis and interpretation. This tool stands out as a mechanism for managing archaeological resources. It also plays an important role in the preparation of fieldwork, where advanced analyses are used both for control and model analysis of visibility and intervisibility, as well as GIS assisted three-dimensional modelling (Wheatley 2013: 78).

GIS is also important in the protection of archaeological heritage, particularly in systematic conservation planning (Malaperdas 2021; 1) since it is capable of managing large quantities of graphic and alphanumeric data (Scianna and Villa 2011: 342). The first step in GIS exploitation was to convert information from an analogue to a digital format in order to improve operations and procedures carried out by hand and it was also used as a tool to record and store information. The capability to record, manipulate, and analyse a large amount of diverse geographic and environmental variables appears to be of great interest, as well as the possibility of creating some predictive simulations based on settlement patterns. The integration of archaeological information in urban planning is one of the goals (Scianna and Villa 2011: 342).

Another aspect is the use of data for education. A good example can be found in the research that proposes the use of GIS for motivating students to gain new knowledge of space and the environment, making visual timelines of historical events, etc. (Maldonado López 2012: 42–43; García *et al.* 2022: 93).

We can conclude that GIS is essentially a "grouping of data, procedures, hardware, software, and human resources" (Santovenia Díaz, Tarragó Montalvo and Cañedo Andalia 2009, as referenced in García *et al.* 2022: 93) used to work with geographic data. Therefore, it is not just a database, but a complex tool that has advanced analysis, comparison, and simulation functions. Its use by professional archaeologists leads to faster and better results in archaeological research and enables the application of different methods and techniques when performing archaeological research (García *et al.* 2022: 93, 96).

Archaeological data has a dual nature. It is distributed both in space and time. "A characteristic common to all GIS software is the capacity to manage multi-layer and multi-scale georeferenced geographic data: this potential makes GIS applications ideal for managing archaeological data" (Scianna and Villa 2011: 337). Given that the nature of most archaeological data is very complex and contains a lot of information from the fields of natural sciences and spatial planning, GIS technology has emerged as the most flexible and complete system for analysing the spatial context of archaeological data (Scianna and Villa 2011: 337). Today, geographic information sys-

tems are very present in archaeological research and are increasingly used in the field of protection and management of cultural heritage and archaeological sites. Digital archaeological documentation of excavations as well as digital modelling are becoming integral parts of archaeology. With the development of GIS and the use of ICT in archaeology, new applications in the field of archaeology will appear (Marić 2011: 121).

The development of the National GIS Web platform in Serbia (ГеоСрбија) enables the display, search, analysis, transformation, creation, sharing, and maintenance of geospatial data, resulting in the harmonisation of procedures for obtaining construction permits, preparation of general and detailed urban plans, and communication between cultural institutions, researchers, and the economy. This can contribute to the protection of digitised cultural heritage objects, the long-term preservation of digitised cultural heritage, the creation of new material and additions to existing material, as well as the application of international standards in the process of site search, increasing accessibility to the general public, and data entry.

MAPPING OF ARCHAEOLOGICAL SITES

A good example of the use of digital tools in archaeology is the map of archaeological sites. The creation of the map in its digital form is deemed an urgent matter in Serbia due to its essential role in coordinating the field of archaeology. As far back as 1991, a project for the creation of an Archaeological Map of Serbia was initiated, as a part of the scientific and research work of the Serbian Academy of Arts and Sciences, with the Institute of Archaeology as the responsible institution. Buildings and artifacts in the map were "determined geographically, chronologically, historically and descriptively", and the filled records were accompanied by the topographic maps (Бошковић 1991: 142). Unfortunately, the project was not concluded.

Based on the twenty-year experience and the insight into the documentation of different cultural institutions that deal with archaeological research that the authors of this article have had during their work, we can say that the overall percentage of archaeological sites in Serbia that have been recorded is relatively small compared to their actual number. In some cases, there is no existing documentation for certain sites that have been researched, even though it is prescribed by different laws and rulebooks – the Law on Cultural Property (Закон 1994), the Law on Cultural Heritage (Закон 2021) and the *Rulebook on forms, content, and methods of keeping records of work and other documentation related to the archaeological excavations and research* (Правилник 2020).

Introducing an e-business leads to uniformity and transparency in the work of archaeologists and ultimately leads to visibility and accessibility of extremely rich archaeological heritage. This, in turn, results in a transparent record of archaeological sites, with an emphasis on the risks involved in record transparency, where analysis and statistics can be performed using various tools. Similar projects exist in other countries as well. The authors of this paper had the opportunity to become familiar with a very similar project in the Republic of Slovenia named *From Cloud to Landscape* (From Cloud to Landscape). Slovenia mapped all archaeological sites using Lidar images as the basis, together with other data from involved institutions and field research.

The objectives of the mapping of archaeological sites should be: keeping accurate records of archaeological sites; unification of archaeological field documentation on immovable and movable cultural assets; monitoring the protection of archaeological sites; determination of priorities for archaeological research according to the degree of threat and importance, which achieves efficiency in decision-making and control of spending when financing archaeological works (excavations, reconnaissance, prospecting and publishing); achieving uniformity and transparency in work; and support to the economy (spatial planning, urbanism and construction, environmental protection, tourism, etc.).

Significant attention should be paid to data protection. Not a single piece of information that could damage the integrity and security of the archaeological site should be made publicly available. The map should be an information system for storing unified documentation on archaeological excavations and locations with geo-positioning for the sites that have been declared cultural property and those that are under preliminary pro-

tection. The map needs to contain data about the existing and adopted plans (urban plans; development plans - such as industrial and infrastructure plans; etc.), for specific areas, which contain the measures for the protection of the cultural properties located in those areas, following the current legal regulations. These systems can also enable protection on multiple levels, especially since a cultural property cannot be considered a cultural property in the true sense of the word if proper documentation is not kept on it in a uniform manner (Bojković 2014: 38).

Mapping of archaeological sites should improve digital methods and techniques for the preservation, documentation, and research of the immovable cultural heritage and its presentation. The map should provide a systemic, quality, and uniform approach as well as a contribution to the national and international networking of digitised immovable cultural heritage. Nationally, state authorities should have the opportunity to analyse data, develop strategic plans, and obtain financial support by utilising databases. This would also strengthen the capacity of institutions and individuals and make cooperation between relevant national and regional communities more productive.

CONCLUSION

The cooperation of all interested parties, i.e., state bodies and public institutions, is necessary for the protection and preservation of cultural heritage in any country. The strengthening of heritage protection should be carried out with a special focus on spatial planning optimisation, strengthening the capacity of institutions and individuals to perform the digitalisation process, making a database of all archaeological sites, combating the illicit trafficking of cultural property from, through, and in the region, and promoting its restitution to the country of origin.

Data centralisation is required, considering the presentation of the current situation of the archaeological information systems in Serbia. However, the advancement of centralised and unified data collection and record-keeping on archaeological findings is not possible without unique software for document management. The creation and use of the map of archaeological sites can introduce order into the documentation of archaeological sites and data obtained through different archaeological research (excavation or reconnaissance, that is, prospecting), which indirectly protects this important part of the cultural heritage. It can promote strategic thinking in the preservation of archaeological sites, continuous scientific research work, as well as unhindered economic development in Serbia.

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REZIME

DIGITALNI ALATI – NOVA ERA ARHEOLOGIJE

KLJUČNE REČI: DIGITALNA TEHNOLOGIJA, APLIKACIJE, GIS, PODACI, ARHEOLOŠKE KARTE, PROSTORNO PLANIRANJE.

Upotreba digitalne tehnologije i digitalnih alata u proučavanju, očuvanju i prezentaciji arheološkog nasleđa ključna je u današnje vreme. Da bi se efikasno upravljalo resursima, neophodni su dobro planiranje i strategija, a da bi se dobro planiralo, potrebno je prikupljati, klasifikovati, obraditi i čuvati podatke. Arheologija, kao nauka, zahteva pedantan rad na prikupljanju, obradi, čuvanju i prezentaciji podataka. Pitanje koje je sve više u fokusu svih zainteresovanih strana jeste odnos

arheologije i drugih nauka u pogledu razmene podataka. Odnos arheologije, naučnih istraživanja, privrede, privrednog razvoja, prostornog i urbanističkog planiranja, pominje se u mnogim pisanim radovima. Izuzetan primer upotrebe digitalnih alata u arheologiji Srbije može biti mapa, odnosno karta arheoloških lokaliteta, od suštinske uloge u koordinaciji aktivnosti u oblasti arheologije.

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