André Novak*, Volodymyr Ostash**

Digitizing Historical Maps and their presentation in Online Map Collections

Keywords: historical maps, online map collections, libraries, preserving maps, digitizing maps

Summary: As technical tools and methods emerged, maps started to be created digitally. Besides this, analogue maps were digitized to preserve them and make them accessible more widely. The approach changed through the years, beginning with microformat media and now with mobile applications. By this, technical and methodical issues from previous projects and current map preservation challenges must be taken in mind to successfully finish a digitizing project and provide the maps via an online platform. One important factor for that is georeferencing, which allows users to easily use maps in their GIS-software and compare different maps. Many digitized maps are provided online for free on different websites. In the last years, an unthinkable number of maps was made available online. They are provided by libraries, scientific institutions or by private projects. Their ways in presenting the maps differ, as libraries take a more storaging and describing approach, while other institutions take the maps as the main item of interest. Though maps carry spatial information, they are not always georeferenced, and even if they are available online for free, it makes it therefore difficult to use them for spatial analysis or presentational purpose.

Introduction

The rise of new advances in technology of map-making and -preserving leads to increased interest in archived cartographic materials such as maps, plans and other objects of historical value. Works of this art constitute an exceptional source of cognitive material and an important basis for further planning. They belong to one of the most precious treasures of libraries and due to their big historical and aesthetical value, the cartographic heritage needs to be preserved. Moreover, common digital approaches need to find their use cases for this matter.

The following questions are important to consider regarding this topic: Why should we save maps and how do we convert them into digital formats and make them available online? Why should we digitize, georeference and replicate them? How are these maps presented to potential users and what are the advantages and disadvantages of "Online Map Collections"?

In this work, the development of digital approaches in cartographic heritage and some of the most important online map collections and their main features will be presented.

History of Modern Cartography

The history of cartography can be divided into four areas, with each of them representing main differences to modern cartography (cf. Jelfs, Cartwright and Pupedis 2014: 2ff):

- The Historical area, where cartographers had to solely rely on analogue approaches, without implementing any digital technologies and where they had to use their own techniques in order to create suitable products for their customers or aims.

* University of Vienna, Austria [andre.novak@univie.ac.at]
** University of Vienna, Austria

- The "start" of technology (1960s), indicates the area, where technological progress started and new products were developed. "The discovery of electronic capabilities made a new dimension in map production accessible: Not only were most of the design techniques transferred to digital platforms, but also the possibility to deal with huge amounts of data that can hardly be analysed by a single person […]" (Henning 2016: 3) allowed scientists to look at the data from another perspective. It would not be wrong to constitute that the process of preserving the cartographic heritage started, even if very slowly, during this time.
- The era of technological advancement (1990s), where cartography and particularly Geographic Information Systems (GIS) became widely used and spatial information like geodata became easier to access. Programmes were more user friendly, even though they still relied on command-line entries. This was the area where people felt the rising need of geographic systems that co-occurred with technological advances.
- The era of modern technology and methods (2000s), in which almost all people interact with cartographic products on a daily basis. The use of the internet, location based- and web mapping-services has greatly enhanced our productivity, and when GIS originally was thought to be used only by professionals, it has, however, landed in the public domain, allowing anyone to create their own products.

Development of Approaches for Preserving Data

The evolution of digital approaches to preserve the cartographic heritage occurred together with the advances in cartography. The use of computers and optical storage media is now widespread in almost all historical map libraries and museums. To access maps, users do not have to physically open drawers anymore, but can simply click on their computer mouse, for example in different online map collections (see chapter "Online Map Collections"), that have been designed and created to preserve and view cartographic heritage. This development contains the following periods (cf. Cartwright 2011: 3ff):

– In the 1970s and 1980s, map data was stored on microformat media.

– The use of videodisks started in 1979, where the content was created in any available programming languages (for example Turbo Pascal), so users could control laser readers with specific commands, to show desired frames of maps. Video laserdiscs were even standardized by NATO and used by other countries in their National Defence Departments mappings. In Australia, several disks were produced in collaboration with States archival photographic collections, and later digitized (see chapter "Digitizing of Cartographic Heritage") to preserve them in digital format.

– In 1982, the first CD-ROM was presented and maps stored on CD-ROMs became additions to different exhibitions. Since this type of medium had a lot more storage available, bigger and more detailed maps could be transferred and viewed on any kind of computers. CD-ROM also represents the adaption of maps to current time.

– The use of the Internet, Web 2.0, and making online maps collections and library collections available, made cartography even more ubiquitous in modern society. Spatially indexed information together with digitally and georeferenced cartographic material can be viewed and examined within the blink of an eye. First online collections were text overloaded and contained basically only scanned, hyperlinked images. Modern web designers learned from previous mistakes and provide much better performance, client- and server- based. Online collections constitute an important role in preserving cartographic heritage for future generations and make maps available for a broader

range of users. They can be viewed not only on desktop devices, but are also mostly adjusted to mobile devices, so that users can view their location on historical maps on the fly.
According to Cartwright (2011), mobile applications were most recently developed, as mentioned in the previous paragraph. Mobile applications and devices "[…] enable [the] usage of digital information during mobility. In combination with wireless networks, the devices can be connected to the Internet (the mobile Internet), offering even more flexibility and instant information access." (Reichenbacher 2005: 1311). In this case historical map applications are of great importance, as they allow users to lay ancient maps over modern ones and navigate through space with help of Location Based Services (LBS).

Cartographic Developments Based on Digital Approaches

Jobst and Gartner (2011) describe several latest developments in the modern cartography, which are based on digital approaches. They start with geovisualisation, which contributes to the understanding of complex geospatial concepts, based on computer graphics. Then comes web mapping, which describes the delivering of maps using internet technologies and mobile applications. Geospatial Web Map Services (WMS) render static images based on client's request and send them to user. Location Based Services (LBS) use the geographical position of the device (GPS) and provide information, which is based on the current location, using mostly mobile devices. Volunteered geography and neo-geography describe public access and creation of geospatial data.

Why are Maps Worth Preserving?

Maps have been collected for more than 2000 years. They "[…] are a source of information not only about a modern state and condition of the environment, but also about its past. Early maps contain various kinds of historical information and present it on many levels" (Nieścioruk 2013: 2). This shows that maps are a carrier of the past and help to understand how the earth and normal life has been centuries ago.
Maps "[…] are able to translate a three-dimensional reality onto a two-dimensional surface. They display spatial relationships between components, i.e., their positions relative to each other, and also describe an area visually; they reveal the presence of features and characterise them. No other source can provide the user with a view of a territory and its attributes together." (Kent 1998: 3)
Converting analogue maps into digital forms can result in discovering new insights about the past. It ensures that the information will be preserved and accessible for a much longer time, compared to analogue approaches. Digitizing of analogue spatial data also ensures an easier dissemination and professional research.

Technical Issues of Provision of Maps Online

Jobst and Gartner (2011) also classify 5 main components (content, format, application, device and storage) in digital cartography, which assure sustainable preservation and build a solid fundament for cartographic heritage.
In Figure 1, we can see the heritage depth on the left and on the right the digitalization grade is shown.

The heritage depth begins with storage, which is a crucial player in terms of cartographic heritage. If the storage cannot be ensured, all the other four elements will not find their application. "*As soon as an element can be accessed in future, it can be called heritage. "(*Jobst and Gartner 2011: 69)

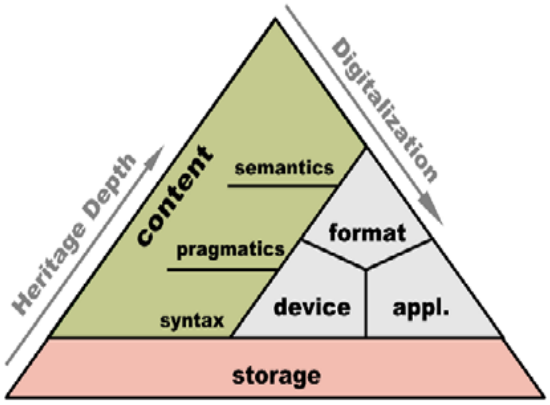

Figure 1: Conceptual cartographic heritage architecture (Jobst and Gartner,2011)

The next major player is the content of cartographic application. The importance of this element lies in the fact that without a proper selection of cartographic information and its representing techniques, the danger lies in the possibility that the topic will not be understood in the future and thus remain unusable.

The format allows the implementation of the application. Jobst and Gartner (2011) define two important type formats for this matter: "ASCII" and "Binary". While the second one can only be read by machines, "ASCII" provides much more protection due to its readability for humans.

The application is used to read format structure and translate it in various ways (sound, virtual reality etc.). For proper archiving it is advised to use Open-Source-Initiatives, because the source code can freely be accessed and the product can be adjusted to personal needs. While using proprietary applications, steps have to be well documented and it has to offer an API (Application Programming Interface) for further development.

The final important content of cartographic heritage is the device, which assures communication and information transfer between humans and computers. If the interface will not be available in future, the application cannot be executed and thus the preservation will fail.

The digitalization side begins in most cases with analogue media like paper maps and starts with storing techniques backwards to the heritage depth (see Figure 2). It is important to say that digitizing indicates digitalising. The first one converts analogue data into digital form and the second uses technology to adjust data to the modern developments. The cartographic heritage can only be preserved by using them both.

Digitizing of Cartographic Heritage

Stachoň (2011) describes digitizing as one of the most progressive ways to preserve old cartographic products. It belongs to one of three main ways of preserving maps: photocopying, microfilming and digitizing. (cf. Ngulube (2003), cited in Stachoň 2011: 259) Nowadays, most of the maps are digitized by scanning. This procedure has a lot of advantages, as it is a low-cost technique and does not require a lot of resources.

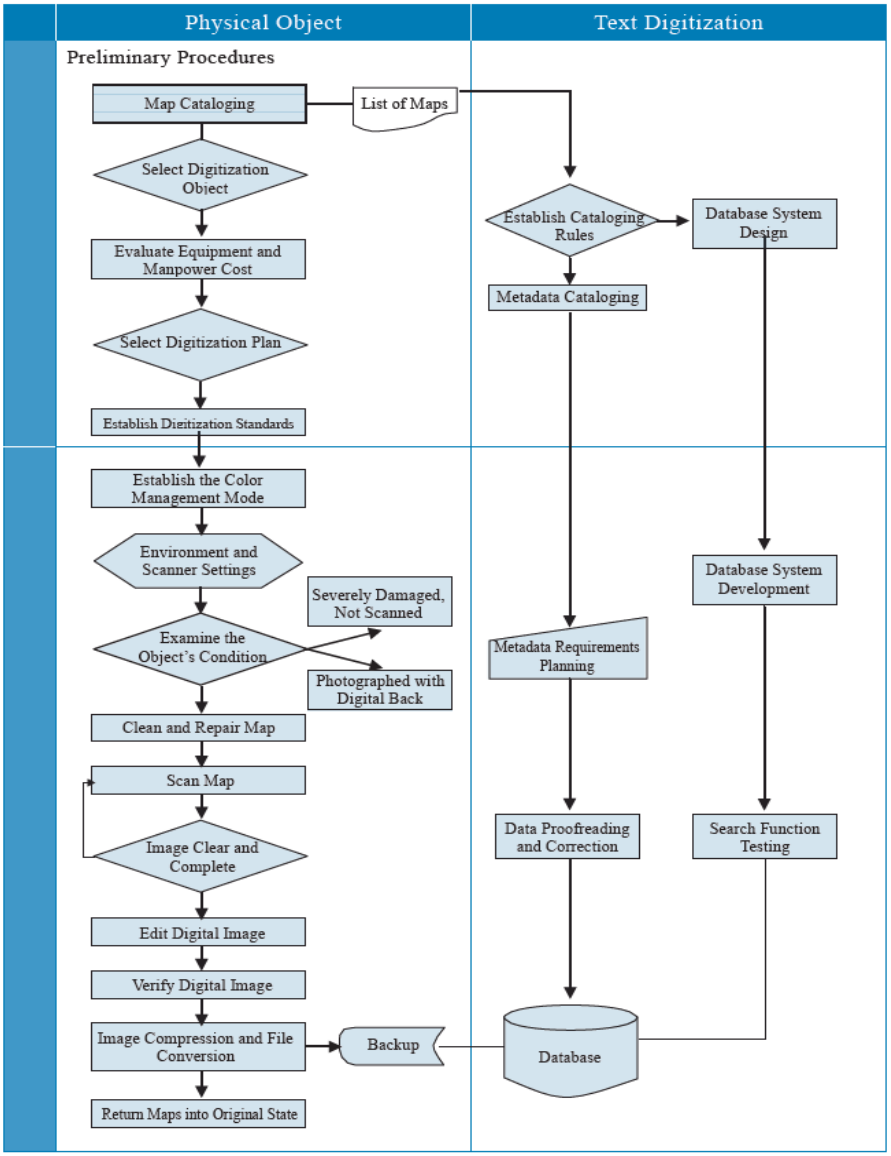

Figure 2: Workflow of digitizing (cf. Fang-Chich, Tzu-Ying und Yen-Hung 2011)

The process of digitizing maps can be divided into three categories (cf. Fang-Chich, Tzu-Ying and Yen-Hung 2011: 13ff):

- Preliminary procedures. In this part, the condition of digitization objects has to be examined, available procedures and cost effectiveness evaluated and digitization specifications and workflow standards established.
- Object digitization procedures, where the colour management mode, scanning procedures, digital image editing and backup management have to be defined.
- Metadata and Database establishment, where it is important to set the necessary metadata, cataloging and establish a database for saving the results.

Looking at available cartographic materials for digitizing, three main types by Stachoň (2011) can be established: map sheets, globes and atlases. Each of them has to be treated differently.

A digitizing workflow can be seen at Figure 2. Flatbeaned scanners (A4 or A3 format) are mostly used for the digitization of old maps. The larger the format, the more expensive it would be conducting this workflow. It is also important to treat the map carefully to prevent damage.

Based on purposes of image files, they are divided by Fang-Chich, Tzu-Ying and Yen-Hung (2011) in three levels:

- Permanent preservation with the highest possible image resolution.
- Commercial purposes which are provided for example for printing and must meet the printing requirements.
- Browsing, images that are used by browsers and online displays.

One must choose a digital file format taking into account that it can be preserved and opened by future devices. Fang-Chich, Tzu-Ying and Yen-Hung (2011) came to conclusion that the TIFF format is the best for long-term preservation because it supports both the CMYK colour mode and LZW lossless compression method. However, for online libraries or map collections, JPEG or GIF formats are more suitable because of their small size.

The resolution refers to the number of pixels represented or captured in a unit length. Scanning of cartographic products is mostly in the range of 400-1000 dpi, but modern scanners can dissolve more than 9600 dpi. Stachoň (2011) also stated that conventionally scanned documents in Czech libraries feature about 100-600 dpi and recommended 400 dpi for map archiving purposes, due to the fact that the images are then mostly comparable to the original. However, he also says that doubling the resolution leads to quadrupling of the file size, which can be a negative side-effect. For browsing purposes or online collections, a lower resolution, like 72 dpi, may be sufficient.

In most cases, the 24-bit colour mode, called true colour can be used for preservation. For browsing purposes or online maps, however, 8-bit indexed colours are more suitable.

The final important step is the setting of metadata, as it provides additional information to each stored item, and accelerates the search algorithms. Stachoň (2011) names ISO, Dublin Core and METS metadata profile and choses Dublin Core metadata profile, which contains 15 basic elements which seem to be more suitable for map archiving.

Worth mentioning is also georeferencing technique, that allows to convert scanned maps from pixel coordinates into a projected coordinate system. It "puts" the map onto its place in the world, allows better overlaying and geospatial analysis.

Digitizing maps and making them available online is vitally important for maps which are in a poor shape and cannot be viewed by many users in reality. Also, for people who do not have the opportunity to view maps in reality due to their spatial distance to the place where the map can be accessed, this opens the chance to view maps from all around the planet.

The next chapter will provide some additional insights in the actual use of preserved cartographic items and show that the bridge between analogue and digital maps has been successfully constructed by using of the named digital approaches and map digitizing.

Online Map Collections

There are many different map collections available online. Some of them are collections which only represent maps from one country. (see chapter "A Vision of Britain Through Time") Others have a more global approach because they represent maps from all around the world. (see chapter "David Rumsey Map Collection")

Users expect to find the maps they need online and with easy access. This presents libraries and other institutions with problems because they must adapt their trusted process of borrowing maps from libraries or viewing them at these institutions. The maps now must be digitized and if possible

georeferenced for user-friendly viewing. (cf. Buckley 2019: 1; Southall and Přidal 2012: 73) Libraries and other scientific or federal institutions worldwide have launched or already completed projects to digitize their map collections and make them available online.
Below, different selected online map collections will be presented and compared regarding their advantages and disadvantages. The following examples cover only a small part of online map collections. However, these are widely used and recognized and show how different institutions use/apply different approaches to achieve the same goal.

David Rumsey Map Collection

The Website "David Rumsey Map Collection" (cf. Cartography Associates 2020) is an online map collection which contains nearly 90,000 maps. It is hosted by "Cartography Associates" and their president David Rumsey. This company is specialising in digital publishing.
Users can download or buy prints of these maps. The maps are represented in different ways. There are applications for viewing the maps with a basemap and the maps can also be viewed in "Google Earth" or "Google Maps".
There is also the opportunity to be part of the project as it is possible to georeference maps via the "Georeferencer v4" application. Users can georeference randomly represented maps to contribute to the project. This can be seen as crowdsourcing, *"[…] the practice of using contributions from a large online community to undertake a specific task […]"*. (Terras 2016: 420) In scientific research, financial capital and skilled workforce are often hard to come by. So, any help in fulfilling the huge amount of work to digitize 10,000s of maps is appreciated.
Lafreniere, et al. (2019) successfully showed the possibilities of public participation in Geography/Cartography in their "Historical GIS"-project. They used the help of the public via websites to help them digitizing information about buildings from maps. They reached over 250,000 classifications. To keep volunteers interested, it is important to set incentives like showing the results of their work or "gamification", so that the task is not too complicated. (cf. Holley 2010)
In the "David Rumsey Map Collection", this is achieved by detailed explanations and an intuitive way to georeferenced the old maps. The results are then showed on the website at "Recently Georeferenced Maps". (cf. Cartography Associates 2020)
For signed-in users (for free) it is possible to obtain access to the georeferenced maps by a WMTS-Service or to download it as a "GeoTIFF"-File. As stated in chapter "Cartographic Developments Based on Digital Approaches", this is important because only georeferenced maps can be used in GIS to visualize them spatially or use them for analysis.
The website has a lot of available maps and users can access them in many ways. Because of these different ways and the structure of the website, it is difficult for new users to find their way around the website and get the maps in the format they want.

Old Maps Online

As part of the Great Britain Historical GIS Project, the website "Old Maps Online" (cf. University of Portsmouth n.d.) represents maps from the 18th century to today. Maps from different sources (e.g. USGS, University of Prague, British Library, Hong Kong Historic Maps, …) can be viewed there. There is also a short description including information such as the age, the creator and the size of the map. The website links directly to the source websites where the maps can be viewed in detail and downloaded. If users want to view or download the map, they have to do it via the source

website. It therefore depends on these websites if the maps are available georeferenced or simply as pictures.
The maps can also be viewed via an app for iOS and android named "Old Maps Online: A Touch of History". As Cartwright (2011) mentioned, this leads to simplified access and thus increased use of the map collection, especially for non-experts who want to look at old maps. The application also features location-based map retrieval.
One big advantage of this website is that you can find maps from different sources there. It is one hub on which it is possible to view maps from many different sources and compare them. The incredible amount of nearly 500,000 available maps allows anyone find what they need. (cf. South-all and Přidal 2012: 73ff)

World Digital Library and Library of Congress

Like many other libraries, the "Library of Congress" in the USA (cf. Library of Congress n.d.) has a large collection of digitized items. As maps are mostly part of national collections, some of these libraries also made their map collections available online. The "Library of Congress" has one of the largest map collections worldwide with more than five million maps, but only a small percentage of their maps has been made online accessible. Therefore, the information about the maps is listed in great detail, so that the respective maps can be found easily. Metadata such as creation date, language or the physical description allows the user to view the maps from a librarian´s perspective. One problem is that the maps are only available as pictures which are not georeferenced. So, if users want to deal spatially with one of these maps, they need to georeference it themselves.

Examples from Austria: "Sammlung Woldan" and "UB-Maps"

In Austria, there are also examples of online map collections. One is the "Sammlung Woldan" (Austrian Academy of Sciences n.d.) which is the asset of an Austrian jurist managed by the "Austrian Academy of Sciences. Beside different geographic works, it contains over 300 maps from the 15th century onwards covering not only Austria but also different parts of the world and provides detailed descriptions of them. The maps can be downloaded as normal images or georeferenced. There are also globes available. This project shows that not only libraries want to make their map collections online available. One example is the "David Rumsey Map Collection". (see chapter "David Rumsey Map Collection") Private collections are a rich source of old maps and if scientific institutions, such as the "Austrian Academy of Science", make their collections online available, scientists and other people who are interested can benefit from it.
The library of the "Department of Geography and Regional Research" of the "University of Vienna" has also launched a project to digitize its map inventory. The "UB-Maps" are available on two websites and via the university-wide search engine for publications, which is called "u:search". It holds maps from 1656 onwards which cover mainly Europe and in particular Austria and the area of the former Danube Monarchy. It holds over 10,000 map sheets. Maps can be downloaded not only by students or university staff but also by interested people. The maps are not yet georeferenced, but it is part of the project to make them available georeferenced as well. (cf. University of Vienna, Library and Archive Services n.d.) This would be important because especially students and scientists need digitized maps georeferenced to work on projects successfully and efficiently.

A Vision of Britain Through Time

The website „A Vision of Britain Through Time" (cf. University of Portsmouth 2017), which is also a part of the "Great Britain National Historical GIS", is a prime example of a "Historical GIS"-website. With utilising the advantages of Web 2.0 and further developments, it connects the availability of maps, statistical data and geolocated travel writing. (see chapter "History of Modern Cartography") Their data has been available freely from the beginning of the 19th century onwards. National maps (topographical, boundary, land use) from the "Ordnance Survey", the "British War Office" and other institutions are accessible via download after answering a short questionnaire about who you are and why you want to download the maps. The maps are not georeferenced but bounding box coordinates are given, which makes georeferencing easier.
By combining the availability of maps and other related information, a deeper understanding of past centuries is made simple. Users will acquire a deeper understanding about what they want to know.

Historical GIS

As these maps are represented online, we should make the connection to the term "Historical GIS", which is part of the "Digital Humanities"-movement. This *"[…] refers to new modes of scholarship and institutional units for collaborative, transdisciplinary, and computationally engaged research, teaching, and publication."* (Burdick 2012: 122) In "Historical GIS"-research, GIS-methods and -approaches are applied to historical research. This application can bring new understandings to the field of historical research, if not only GIS are used for presentation but also for analysis. (cf. Gregory and Ell 2007)
Part of this evolving field is the development of "National Historical GIS". These are platforms which are databases which hold historically relevant spatial data from a country. They are mostly presented via a website, e.g. "A Vision of Britain Through Time "(cf. University of Portsmouth 2017) Different types of data, such as statistical datasets or maps are available for download. (Gregory and Ell 2007: 186ff)
Such "Historical GIS"-projects are important not only for geographers or cartographers. Historians too can use these spatial relevant resources of the past to use them in their scientific work. (cf. Presner and Shepard 2016: 205ff)

Comparison of Online Collections

There are many different online map collections available. The ones described above cover only a small part of all available but are representative for them. These are now going to be compared. (see Table 1) There are scientific or private projects or libraries which want to make their collection online available. They all share the same goal: Making historical maps easily accessible online.
These projects have different numbers of maps available. The libraries or scientific institutions digitized their own collections (around 1,000 to 10,000, sometimes up to over a million), only the website "Old Maps Online" combines different sources of maps and held a lot more maps.
The maps available are from different centuries. While the website "A Vision of Britain Through Time" (University of Portsmouth 2017) is specialized on the time from the beginning of the 19th century onwards, other projects present maps from earlier times (from 12th/13th century or the beginning of the renaissance), even though maps have existed for over 5,000 years.

All maps are available in standard picture formats such as "PNG" or "JPEG". Only a small number of websites offer maps in georeferenced formats like "GeoTIFF". (see chapter "Digitizing of Cartographic Heritage") As maps are representing a part of the earth, it is important if they are digitized to make them available georeferenced, so that users can use them in their GIS-Software as well. The comparison of the presented website (see Table 1) shows that libraries do not provide georeferenced maps, while in projects the maps can be downloaded georeferenced. This points out that libraries are not very much aware of this important topic.
Connected to this, "Geographical Searching" is relevant. This means that by zooming or panning on a webmap, collections are filtered to those maps which are available for the presented area. This important feature is available for most of the projects. It is user-friendly and helps non-specialists to easily find the information they need.

Website	**Link**	**Number of Maps Available**	**Period**	**Coverage**	**Geographical Searching**	**Download Format**	**Download of Georeferenced Maps**
David Rumsey Map Collection	davidrumsey.com	approx. 90,000	1223-today	worldwide	yes	JPEG, GeoTiff, WMTS-Service	yes (not all maps)
Old Maps Online	oldmapsonline.org	498,907	17th century-2005	worldwide	yes	no (via linked websites)	no (differs at linked websites)
World Digital Library/Library of Congress	wdl.org loc.gov	1,059/55,506	12th century-1994	worldwide	yes	PNG, JPEG, GIF, TIFF	no
Sammlung Woldan	sammlung.woldan.oeaw.ac.at	576	1485-1930	worldwide	yes	JPEG, GeoTiff	yes
UB-Maps	goobi-viewer.univie.ac.at/viewer/sammlungen/karten phaidra.univie.ac.at/view/o:423816	>10,000	1656-1978	mainly Austria and Danube Monarchy, Europe	no	PDF, JPEG	no
A Vision of Britian Through Times	visionofbritain.org.uk	approx. 2,180	1801-1958	mainly United Kingdom, Ireland, Europe	yes	JPEG	no (boundary box coordinates are given)

Table 1: Summary Online Map Collections (sources: Austrian Academy of Sciences n.d.; Cartography Associates 2020; Library of Congress n.d.; University of Portsmouth n.d.; University of Portsmouth 2017; University of Vienna, Library and Archive Services n.d.)

Conclusion

In modern time it has become much easier to obtain different cartographic material and conduct analysis on it. The bridge to that purpose has been constructed during several epochs and shows a development from analogue to digital form. We went from saving the data on a microfiche, with an extremely low storage capacity, to mobile devices which allow us to constantly access millions of

geospatial datasets. *"Users perhaps now take for granted that they can immediately access historical cartographic products, […] however, much innovative research and development in the application of technology to storing and delivering cartographic artefacts has taken place"* (cf. Cartwright 2011: 3ff).

A conceptual cartographic heritage architecture, considering the latest developments in cartography and technology, has also been shown by Jobst and Gartner (2011). They also state, that *"a possible cartographic heritage of the future is built today. Each digital cartographic application that will be accessible in future times creates cartographic heritage of the future" (*Jobst and Gartner 2011: 74*).*

To efficiently preserve and use this heritage, Stachoň (2011) described a possible way of digitizing analogue maps and converting them into digital form/formats. He stated that many things must be considered before doing it: Beginning with accessing the status of the original material and ending with metadata setting. He also says that "*further development of (geo)information technologies such as increase of available disk space, memory, and processor frequency can be expected. Therefore, it is necessary to recommend lossless data compression and the use of higher scanning resolution for archiving usage"* (Stachoň 2011: 270).

Applying these findings, there are many different "Online Map Collections". All of them found different ways to present their rich heritage to users. Some followed the way libraries made their collections available online and others took a GIS-based way. As these collections were made for different purposes and by different institutions, their structure and type of availability varies greatly. Some collections have only a small number of maps available, but others hold an almost infinite amount. All their content can be downloaded for free, which is related to "Open Data". Citizens should get free access to information, in this case maps, of their local institutions. Not only they, but also students and scientists, can very much profit from this.

As maps represent the world in different scales and ways, the information they hold is always spatially relevant. Thus, it is important that digitized maps are always also georeferenced. This could be done by the person who downloads a picture of a map, but not all users are experts in this field. If acknowledged institutions take on this task, it is a lot easier for users to work with the maps and benefit from the usage.

Historic maps carry much information about the past. This information should be made accessible to as many people as possible in a straightforward way. This will lead to new findings and easier scientific research and education.

References

Austrian Academy of Sciences (Ed.) (n.d.). Sammlung Woldan Kartenportal. www.sammlung.woldan.oeaw.ac.at (11.11.2020).

Buckley, A. R. (2019). *Sharing Collections of Historical Maps Online*. In: Abstracts of the ICA, 31.

Burdick, A. (2012). *Digital Humanities*. Cambridge, MA.

Cartography Associates (Ed.) (2020). David Rumsey Map Collection. www.davidrumsey.com (11.11.2020).

Cartwright, W. (2011). *Structural Aspects for the Digital Cartographic Heritage*. In: Jobst (Ed.). Preservation in digital cartography. Heidelberg, 3–24.

Fang-Chich, L., Tzu-Ying, L. and Yen-Hung, L. (2011). *Maps and GIS Digitization Procedure Guideline*. In: International Collaboration and Promotion of Taiwan e-Learning and Digital Archives Program, 8–84.

Gregory, I. and Ell, P. S. (2007). *Historical GIS. Technologies, methodologies, and scholarship*. Cambridge, New York.

Henning, B. (2016). *Mapping Practices in a Digital World*. In: ONSRUD (Ed.). Advancing Geographic Information Science. Needham, 153–168.

Holley, R. (2010). *Crowdsourcing. How and Why Should Libraries Do It?.* In: D-Lib Magazine 16.3-4.

Jelfs, L., Cartwright, W. and Pupedis, G. (2014). *Considering innovations in cartography and changes in geographic representation methods*. In: Geospatial Science Research.

Jobst, M. and Gartner, G. (2011). *Structural Aspects for the Digital Cartographic Heritage*. In: Jobst (Ed.). Preservation in digital cartography. - Heidelberg, 57–76.

Kent, A. J. (1998). *The Value of Historical Maps: Art, Accuracy and Society*. Dissertation number 4299.

Lafreniere, D., Weidner, L., Trepal, D., Scarlett, S. F., Arnold, J., Pastel, R. and Williams, R. (2019). *Public participatory historical GIS*. In: Historical Methods: A Journal of Quantitative and Interdisciplinary History, 132–149.

Library of Congress (Ed.) (n.d.). World Digital Library. www.wdl.org (11.11.2020).

Nieścioruk, K. (2013). *Cartographic source materials and cartographic method of research in the past environment analyses*. In: Bulletin of Geography. Socio-economic Series, 81–95.

Presner, T. and Shepard, D. (2016). *Mapping the Geospatial Turn*. In: Unsworth; Siemens und Schreibman (Ed.). A new companion to digital humanities. - Chichester, West Sussex, UK, Malden, MA, USA, 201–212.

Reichenbacher, T. (2005). *Adaptive Methods for Mobile Cartography. - Mapping approaches into a changing world*. A Coruña, 1311–1321.

Southall, H. and Přidal, P. (2012). *Old Maps Online: Enabling global access to historical mapping*. In: e-Perimetron, 73–81.

Stachoň, Z. (2011). *Issues of Digitization in Archiving Processes*. In: Jobst (Ed.). Preservation in digital cartography. Heidelberg, 257–272.

Terras, M. (2016). *Crowdsourcing in the Digital Humanities*. In: Unsworth; Siemens und Schreibman (Ed.). A new companion to digital humanities. Chichester, West Sussex, UK, Malden, MA, USA, 420–438.

University of Portsmouth (Ed.) (n.d.). Old Maps Online. http://www.oldmapsonline.org/ (11.11.2020).

University of Portsmouth (Ed.) (2017). A Vision of Britian Through Time. www.visionofbritain.org.uk (11.11.2020).

University of Vienna, Library and Archive Services (Ed.) (n.d.). UB-Maps. https://goobiviewer.univie.ac.at/viewer/sammlungen/karten/ (16.11.2020)