Digitization of Old Maps and Possible On-line Tools for Their Use

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Abstract Old maps are one of the most important historical sources. Today's modern methods of digitization for on-line access allow much more than just making copies of old maps for viewing. Is it possible to fully exploit the potential of old maps as cartographic works with all of their specific properties. The various tools and services for digitized old maps are shown in this chapter. Thanks to georeferencing of this digitized images of old maps followed by layering associated with opacity can be effectively compared the contents of the different maps between themselves. For these purposes are important on-line tools for georeferencing of raster images of old maps. Important are also on-line tools for display of georeferenced maps in 3D view on digital terrain model. On-line tools of new generation can do also automatized processing of georeferenced raster images of digitized old maps. These are e.g. searching for occurrences of map symbols, classification of digitized old maps, automatized extracting of texts etc. In addition to the above, this chapter also deals with the requirements for proper digitization of old maps. Reported are mainly requirements for the preservation cartographic properties of old maps. Special attention is paid to the preservation of positional accuracy of drawing on old maps during their digitization.

Keywords Old maps · Digitizing · Georeferencing · Map services · Chartae-Antiquae.cz

1 Introduction

Old maps, plans, atlases and globes are certainly part of our cultural heritage. They are part of our history, they illustrate the situation at the time of their creation and complement other historical sources. They are also an important proof of the skill, knowledge and artistic excellence of our ancestors (Fig. 1).

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H. Kremers (ed.), *Digital Cultural Heritage*,
https://doi.org/10.1007/978-3-030-15200-0_22

The process of creating the maps is, in contrast to other historical documents, specific works. From the cartographic point of view, the oldest view maps are considered to be pictures or sketches rather than real maps. However, since the early 18th century, maps began to be created based on accurate geodetic measurements and mathematically defined cartographic displays. From such maps, it was possible to precisely measure lengths, determine directions and calculate the areas. It should be noted that each map has its accuracy based on the mapping method used, the instrumentation and the scale used. Maps, plans and globes are therefore works that have their cartographic properties. Only by knowing these features is it possible to extract all of their information potential from them.

The need to digitize and access these archive materials does not need to be emphasized. In view of their importance as historical sources, the old maps are increasingly of interest to researchers. This naturally increases the effort to use them with modern methods, especially digital ones. However, mere digitization and subsequent free online access to view old maps is not enough for users. There are requirements to preserve and exploit the full potential of old maps as cartographic works with all their specific properties. And that's not all. Users are increasingly asking for value added, which will allow them to work better with digitized old maps and gain more information than is possible in their classical use of paper maps.

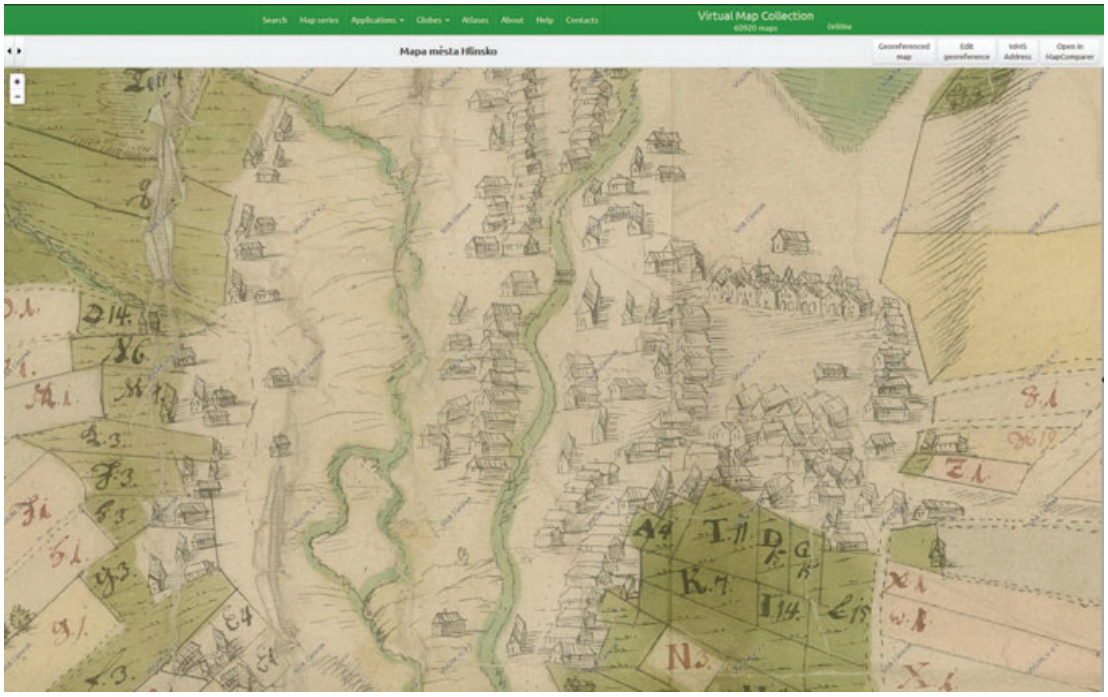

Fig. 1 Part of the manuscript map of Hlinsko town from 1731, State Regional Archives in Zámrsk, http://www.chartae-antiquae.cz/maps/19248

2 Basic User Requirements for Digitized Old Maps

The first basic user requirement is clearly the free online availability of digitized old maps. For simple maps viewing, it is enough to provide raster images of the maps in a suitable zoomable way that will be fast enough on common internet lines and allow basic image manipulation such as zooming or scrolling. This kind of use will surely satisfy, for example, the provision of old maps through Zoomify.

However, among the basic requirements of users, the requirement for preserving all cartographic properties of old maps can also be included. Of course, when it comes to real maps with such features and not mere sketches without any scale and cartographic projection. In order to preserve their cartographic properties, the digitized raster images of the old maps must be georeferenced, i.e. placed in the coordinate system taking into account their cartographic projection used. Georeferencing problems will not be dealt with in detail in this text, because it is a relatively demanding operation in which it is necessary to adhere to a number of rules based on the theory of mathematical cartography and elastic transformations. The correct methodological procedure for precise georeferencing of a larger map set is given e.g. at [1]. But important is that when a georeferenced map is made available, the user can directly measure the lengths, directions, areas, coordinates, etc. in the web application on the monitor screen. The digitized map thus remains its cartographic properties.

3 Values Added of Digitized Maps

If digitization of old maps is achieved and resulting georeferenced raster images are provided in an appropriate standardized online way, it is natural that users want to work the most efficiently with them. They expect some value added compared to the original paper map, which allows them to make better use of these digitized data than before. Here are examples of such value added.

3.1 Finding and Displaying Suitable Maps Available Online

The most basic requirement is to have a tool for finding and displaying the required maps provided on-line from as many sources as possible, such as map collections of archives, libraries or museums. A user (researcher, explorer, etc.) interested in, for example, a specific area in a specific time period and looking for maps displaying this area within a certain scale, inserts this data into the search tool. For example, the area can be defined by a range of coordinates, or defined on an underlying map. The result will be a list of the corresponding maps provided by individual libraries, etc., including meta-information about them and links for their display. Application for

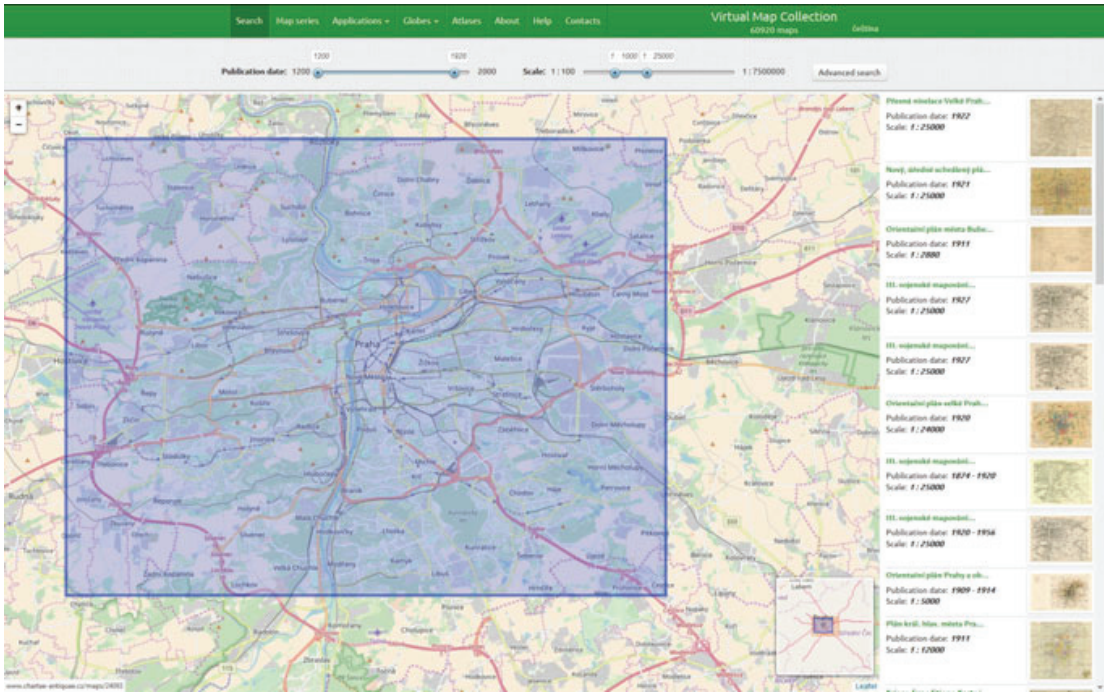

Fig. 2 Geographic Search on Virtual Map Collection Chartae-Antiquae.cz [5]

viewing maps in the form of non-georeferenced raster image then allows to browse maps swiftly pan and zoom to the smallest detail. Users will certainly appreciate it, especially for large maps.

This task is called geographic search of maps and has been in the forefront of interest of a number of institutions in recent years. There have been made several webapplications to solve it. For example, it can be list CartoMundi [2], Cartesius-Portal [3], geographic search in the Moll's map collection [4], or geographic search of maps in Virtual Map Collection Chartae-Antiquae.cz [5] (Fig. 2).

3.2 The Ability to Compare the Situation on a Map

The ability to compare the situation on old maps on-line can be a very high value added of the digitized maps compared to the original paper maps. It allows to lay two different maps on the monitor side by side, no matter where their original paper maps are. In addition, even when viewing maps in Zoomify, it is easy to compare maps of different scales. Of course, only in proportion to the scale differences and the generalization of compared maps.

But much more useful is the ability to compare maps by layering them together with transparency or overlay. It will also help to reveal even minor changes in the drawing of situation, such as the course of communications or the extent of water or forest areas, etc. The user can compare maps of different time periods, different scales, and different cartographic projections, which come from different map collec-

tions. This, however, assumes that the maps will be georeferenced and provided in a standardized way so that they can be used uniformly in map applications, regardless of who is their provider. There are more standards for map services there. However, the Open Geospatial Consortium (OGC) Web Map Service (WMS) [6] and the Open Source Geospatial Foundation (OSGeo) Tile Map Service (TMS) [7, 8] appear to be the most widespread and most suitable for providing raster map data.

These services, in addition to common single maps, are mainly used to publish important map sets (multi-sheet maps), which are more useful to georeferencing. In the case of larger map sets with a larger number of sheets, it is also necessary to perform so-called mosaicing, i.e. the binding of individual digitized map sheets in one seamless raster. Technically, of course, it is not necessary to create one huge file of raster format with all map sheets, but it is necessary to ensure that the respective tiles (separate parts of the raster on which the file is divided) are georeferenced and composingable. During the mosaic process, other problems arise and need to be addressed. Especially because individual paper map sheets are affected by paper collision. After scanning map sheets is necessary to remove the paper collision and then merge the sheets with the respect to the cartographic projection used.

As an example of a good practice for such on-line comparison of maps, can be mentioned the MapComparer web application on the chartae-antiquae.cz portal. Maps can be compared in this application in two ways. The first is to compare maps in one large map window. In this window, the maps are inserted and displayed each in the individual layers, and the transparency tool can be used for comparing of their contents. In MapComparer is possible easily to compare any maps found in the portal database (about 64,000 maps). Likewise, any other map provided by WMS, Zoomify, or as a custom raster image from your PC can be added. Using the slider bar, the layers can be made more transparent and mutually compared (Fig. 3).

When comparing more than two maps, this method is less practical and unclear for the user. MapComparer is therefore provided with a maps view feature in two or up to four map windows. Different maps can be inserted into each window and compared they visually at a glance. Zooming and scrolling the map in one window synchronously scrolls all the maps in the other windows. The user still compares the same area at the same scale in all the windows. To each window, multiple maps can be placed using multiple layers that can be turned on or off, or to regulate their transparency. It is therefore possible to compare e.g. 10 maps at the same time, both visually and ensuring transparency.

Several map sets are preset in the application that are most used to track changes on old maps. However, the user can attach other maps to the application that are provided to anyone via WMS, such as e.g. cadastral maps, geological maps, maps of archaeological sites, etc. To the map window, the user can also upload maps that are not provided by WMS, but are displayed on the site via the Zoomify application and/or the maps that has stored on its computer. Such maps are not georeferenced and must be managed separately in the application. It is important to emphasize that for the use of all these functionalities the user needs only an Internet browser and does not need any own GIS or specialized software.

3.3 *Online Georeferencing of Zoomify Old Map Images*

To use more advanced tools e.g. such as mentioned in the previous paragraph maps are required to be georeferenced. The proper georeference in the form of the elastic transformation of the raster image is usually done using the control (identical) points given both in the old map and in the underlying map.

For easy and fast georeferencing of raster map images provided in Zoomify format, is possible to use, for example, an online application on the chartae-antiquae.cz portal. After entering an internet address of the map at zoomify format, its accessibility check is performed and a custom application window for georeferencing open—see Fig. 4. Here is an old map, which is supposed to be georeferenced and an underlying map. On both maps, a number of control points will be marked successively, and then a custom transformation is made to show the georeferenced old map. Control points can be interactively added or deleted in the areas where they are needed. The application instantly converts the transformation to the resulting georeferenced map. This makes it easy to achieve the desired positional accuracy of georeferencing in the whole area of the map. The final result of georeferencing is a WMS link where is possible to view the original zoomify map in georeferenced form. This link can also be used to display the resulting georeferenced map in the user's GIS systems.

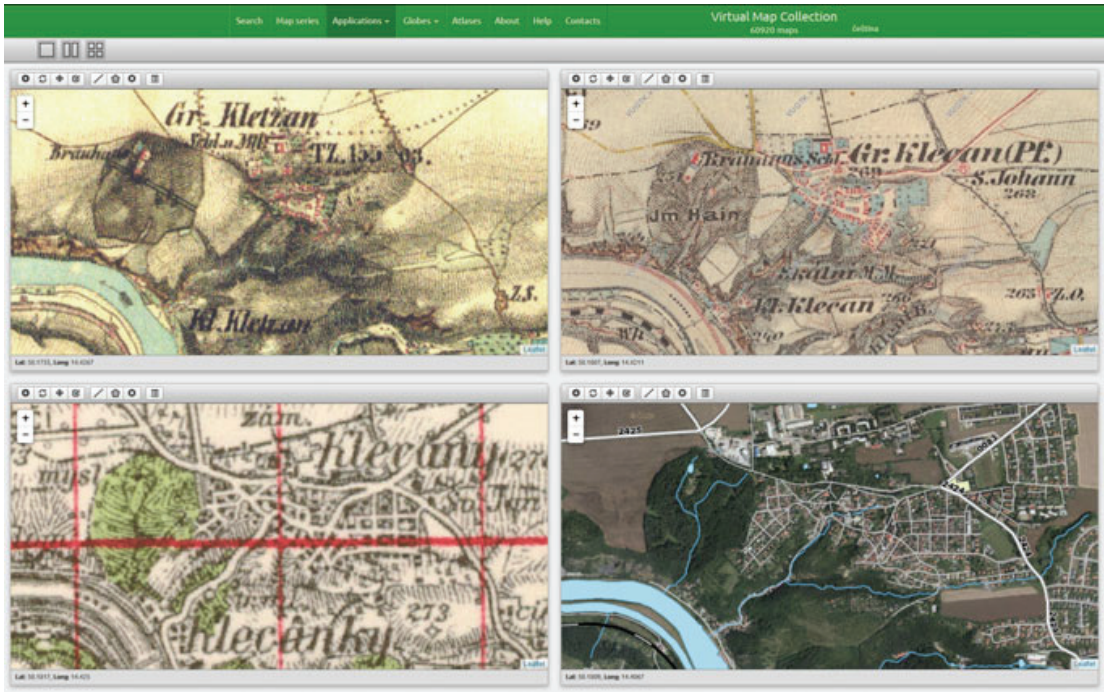

Fig. 3 MapComparer, web application on the chartae-antiquae.cz

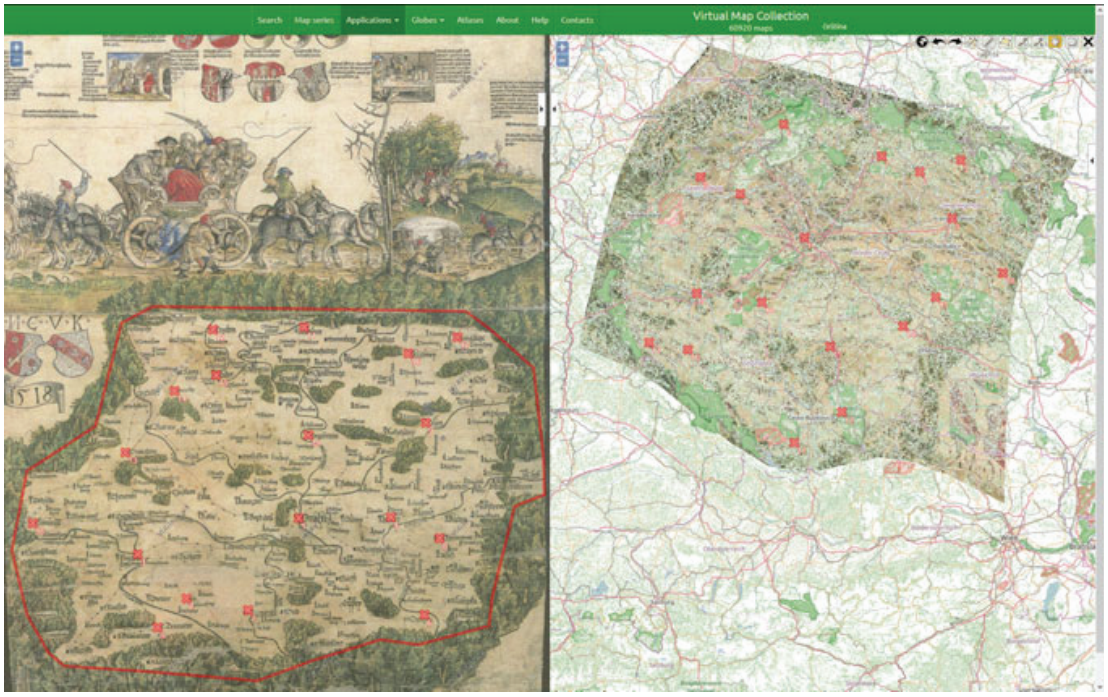

Fig. 4 Online application for georeferencing of zoomify old maps on the chartae-antiquae.cz

3.4 Viewing of Georeferenced Map on a 3D Map

If old maps are already georeferenced and provided in a standardized way, we can start using more sophisticated services with value added. One of these is to display a georeferenced map on a 3D map. Again, chartae-antiquae.cz serves as an example of good practice. The "3D Visualization of Digitized Maps" application allows to view any maps provided in the WMS or TMS format on a 3D map (3D model). The Cesium library, which uses WebGl, is used to view the 3D map, so viewing is not possible on older web browsers. The resulting 3D map model, can be moved, rotated, tilted, zoomed in or out, and can be changed the direction of the light by setting the time. An example of a map view in a 3D model is shown in Fig. 5.

For both applications (georeferencing and 3D view), detailed helps for their use are available. Again, it is important to emphasize that for the use of all these functionalities the user needs only a web browser and does not need any own GIS or specialized software.

3.5 Automatic Detection of Map Symbols

Another significant value added can be, in general, automatic search and recognition of objects in raster images of digitized old maps. A particular useful application can be, for example, the search for map symbols/markers on the map. With some degree

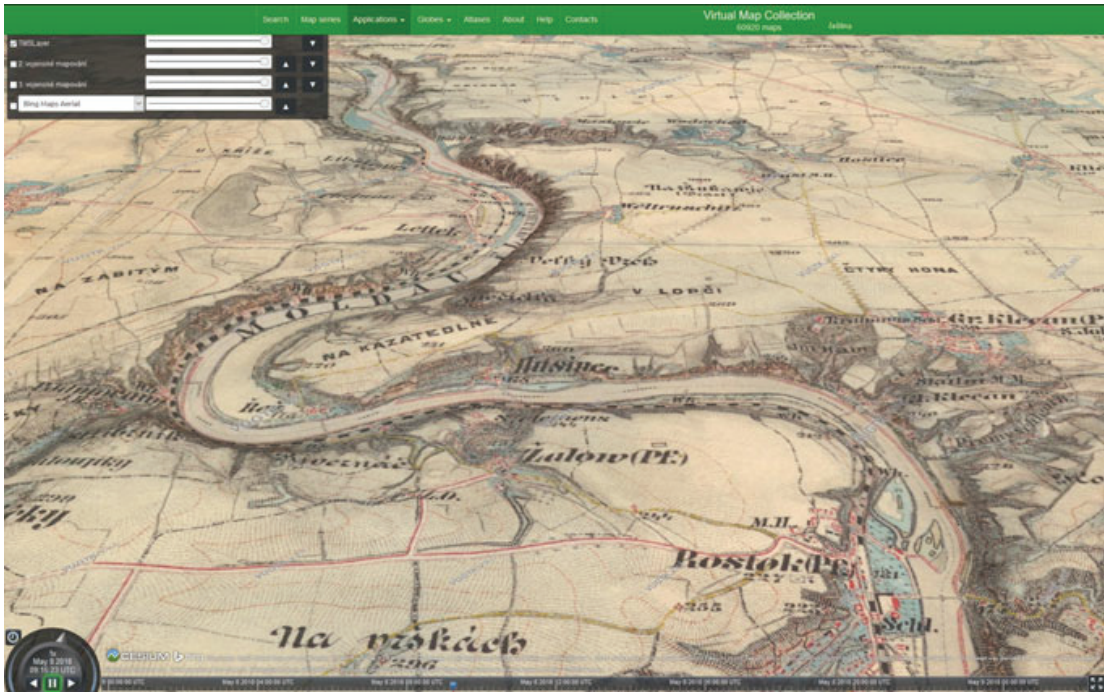

Fig. 5 Online application for viewing of georeferenced old map on a 3D map on the chartae-antiquae.cz

of probability, you can search for objects such as map symbols. The significance of this option increases with large maps with many map sheets. Such map sets are in the same cartographic projection, with the same expression of the Earth's surface, the same map symbols, and the same colours used. Therefore, the existence of an online tool available to solve this task can be very useful to all researchers.

For example, the chartae-antiquae.cz portal implements a map symbols search application in special maps of III. Military survey (1: 75,000). These maps have many map symbols. However, these are not user-friendly maps thanks to a very dense drawing including hachures. For a quick search, a special application has been created, where the map symbols are already automatically searched by machine recognition of objects in a raster image. It is sufficient for the user to tick the relevant map symbol in the branding key, and on the selected map sheet these symbols are immediately highlighted—see Fig. 6.

3.6 Possibility to Use Digitized Maps in User Map Applications

This value added seems to be the most fundamental of all of the above—especially for its generality and versatility. If digitized old maps, respectively their raster images, will be provided in a georeferenced form in a standardized way (WMS and/or TMS

Fig. 6 Online application for automatic detection of map symbols on the chartae-antiquae.cz

format), than it will allow individual users to create their own applications using this provided data for own special purposes.

The spectrum of users of old maps is huge and it is possible to use old maps in almost all fields of human activity. Therefore, it is not possible to cover all user needs in advance and create appropriate tools for them. It will be much more efficient and promising if the old maps will be available to users in a standardized way. At the same time, standardized way of availability will allow the use of their cartographic properties. It is then just on users to ensure optimal use of provided data in their own applications for their own needs and at their own expense.

4 Basic Requirements for Digitizing Old Maps

Here are just a few principles that should be respected, given their importance and the facts above.

4.1 The Accuracy of the Scan of Old Maps in Terms of Their Position

Scanning of old maps created based on cartographic projections must be done in a way that allows them to preserve their cartographic properties. The most important is to

achieve the highest positioning accuracy of individual pixels in the raster image. This can only be done by using accurate cartometric scanners, whose positional accuracy will be regularly checked (attested). In this control measurement, the testing scanner usually takes a raster image of the control grid on non-shrink material (e.g. plastic astralon film). The raster image is then evaluated in terms of positional accuracy. From experience, the mean coordinate error at the point of the grid points should be less than 0.10 mm. The maximum offset at position should be less than 0.30 mm. For more information about testing the accuracy of scanners see e.g. [9].

4.2 Scanning Parameters

The optical resolution of the scanner should be at least 400 dpi in both directions. However, the optical resolution 600 dpi is recommended, optimal is 800 dpi. A 400 dpi resolution is enough only to view old maps on the monitor. For the use of more sophisticated services, such as automated search and object recognition in raster images of digitized maps, a minimum resolution of 600 dpi is required. As well as for georeferencing process of maps should be at least 600 dpi resolution, because the elastic transform raster distortion occurs each pixel raster image.

To maintain colour fidelity, scanning should be performed in a colour gamut of at least 24 bits, including an ICC (International Color Consortium) profile [10], which has been approved as an ISO 15076-1:2005 international standard (Image technology colour management—Architecture, profile format and data structure) [11]. This colour profile characterizes the colour gamut (reachable area of colour in a certain colour space) and the properties of the reproduction device or media. The information can then be used to accurately reproduce or display colours on a printer, monitor, plotter, or other device. ICC profiles are mainly used in DTP applications where they are used to convert between RGB and CMYK colour spaces and to ensure colour matching when reproducing colours.

5 Conclusion

It can be said that today to clients of archives, libraries and other map collections, where old maps are kept, the availability of these old maps online is not enough. They require more than just viewing old maps on the monitor. To users is necessary to provide some value added that will allow them to use of digitized old maps better than is the using of original paper maps. However, this can be achieved only with the proper digitization and the appropriate way of providing old maps on the Internet.

Examples of several such value added show where possibilities of using old maps by digital methods are going. At the same time, there are listed some basic principles that need to be complied when digitizing old maps. At the same time, managers and owners of map collections can be strongly encouraged to digitize their old maps

according to these guidelines so as not to lose their cartographic properties. Furthermore, to provide digitized old maps in a standardized way (preferably WMS/TMS) to enable this data to use in user's map applications.

In conclusion: the future life of old maps is to shift their understanding from nice pictures (artefacts) to an online service available.

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