

Florian Hruby*, Irmgard Plank*, Andreas Riedl*

Cartographic heritage as shared experience in virtual space: A digital representation of the earth globe of Gerard Mercator (1541)

Keywords: 3D-facsimile, digital globe, hyperglobe, 3D-visualization, image processing

Summary

The departing point of this paper is the idea that cartographic heritage is cultural heritage. Therefore, but for its own demands as well, cartography faces certain needs to realize this idea. The form of cartographic presentation that should help us to illustrate such a realization shall be the globe. Globes can represent not only cartographic heritage, but the digital state of the art as well. The intended illustration will be done in the framework of a project, which was partly dedicated to the digital transformation in facsimile (facsimilation) of the earth globe of Gerard Mercator of 1541. Tracing this project will help to show one way of a cartographic heritage's administration by digital means. At the end of this way we will see a virtual, three-dimensional facsimile that is interactive accessible and open to the public.

Introduction

Cartographic heritage is cultural heritage

'Digital Technologies in Cartographic Heritage' is the name of a new working group of the International Cartographic Association (ICA). To get acquainted with this young family member of the ICA, a revision in a broad context may be a helpful introduction. For these purposes the second part of the name of this working group can be a fertile starting point, as we can state: Cartographic heritage is cultural heritage. Although this statement is actually self-evident, it assists to answer a fundamental question, that is to say what cartographic heritage is, and why it is meaningful. A general reply after that can be found with the United Nations Educational, Scientific and Cultural Organization (UNESCO). The UNESCO bases its efforts to conserve valuable cultural assets on the identity- and peacemaking character that cultural heritage holds. From those claims accrues a consequence that matters also cartographic concerns "the heritage has to be a shared experience as it offers every human being the opportunity and contentment of self-discovery as another person in that mine of experience as expressed by a culture that is not his own" [URL-01].

For cartography the criteria of accessibility is essential, as it marks a condition to meet the demands that cartography has made for itself, namely to visualize reality i.e. to make reality accessible. The fact that cartographic heritage is generally about historical reality increases not only the relevance of the realization of this basic demand, but also the difficulty. For example, ancient cartographic expressions are precious and often unique and therefore with limited accessibility, if any, but apart from that the special requirements that a representation of historical realities demands from cartography involve arduous efforts. Such requisites arise hence ancient carto-

* University of Vienna, Department for Geography and Regional Research, Cartography and Geoinformation
[florian.hruby@univie.ac.at / irmgard.plank@univie.ac.at / andreas.riedl@univie.ac.at]

graphic products often refer to realities that are contrary to our current geographic knowledge but nevertheless visualizing world views, which have been relevant to the people of a former time and therefore real to their decisions and activities as well.

Making cartographic heritage accessible consequently means then not only to make historical cartographic publications open to the public, which can be achieved e.g. by transforming maps in facsimile (facsimilation), but also to mark a reality that is not in accordance with the present one. That the newly founded working group of the ICA attends to apply digital technologies to cartographic heritage means no more and above all not less than administrating cartographic heritage with tools according to the state of the art.



Figure 1. Pair of globes by Gerard Mercator (Globe Museum, Austrian National Library).

How these twofold claims can be met shall be exemplified below by means of a cooperation-project between the University of Vienna, Department of Geography and Regional Research and the Austrian National Library. This project has been occasioned and realized in the course of the relocation and conceptual reorganization of the worldwide only Globe Museum, which is part of the Austrian National Library. One of the focal points has been a digital facsimilation of the earth globe made by Gerard Mercator in 1541. Together with a celestial globe of 1551 Mercator's earth globe forms a pair of globes that counts to the highlights of the Globe Museum (Fig. 1). To keep this exemplar of cartographic heritage available and open to the public, making it tangible and investigable on a touch-screen was the decided aim.

Bibliographical Comment

The observant reader may have noticed that the topic we are addressing has been already discussed within the scope of two other publications by the authors, namely in Hruby et al. (2005) and Hruby et al. (2006). Therefore it shall be pointed out explicitly in this place what caused the authors to compose another article and where the differences of the present publication are drawn respectively. Two principle reasons can be argued:

On the one hand e-Perimetron provides a quantitative amply framework that allows a more detailed elaboration of the topic. Therefore we can go along the development of the digital facsimile accordingly more extensively and critically. On the other hand the present article makes allowance for the rapid technological progress by including recent developments. In addition it can be taken into account belatedly that the working group on Digital Technologies in Cartographic Heritage provides an adequate scientific home for the introduced project within the ICA – even though this project has been realized before the foundation of this new working group.

Preliminary considerations about facsimiles based on digital globes

The application of digital technologies on cartographic heritage can be two-fold. One method consists on the acquisition of data of a concrete object, while the other relates to the visual representation of this object. Concerning both factors the facsimilation of a globe as a three dimensional (3D) model makes special demands that can be met in various ways.

Preliminary considerations about the acquisition of data of a globe's surface

Regarding the representation of a globe's surface some methods that detect the globe as a 3D-object and translate it directly in a 3D-coordinate system can be distinguished from other procedures that first produce a 2D-map, which serves then as an overlay for the 3D-model of the final facsimile. For the former option of 3D → 3D-data acquisition mainly systems are to be mentioned, which can be summarized under the term “3D-scanner”. For the moment the great shortcoming of these systems is in inaccurate reproductions in respect of the geometry and texture of the globe's surface. Overcoming these deficiencies is a desideratum for the next generations of 3D-scanners anyway. Other possible approaches to a 3D-data acquisition like the use of X-rays or computer tomographies include also the inner structure of an object, which can be of special interest in case of historical globes. 3D → 2D methods in contrast are practiced since decades and have therefore reached an already mature state. The primal focus has been on the exact representation of a globe in the plane, later also with the aim of a facsimilation in form of real and finally digital globes. A critical discussion of the above mentioned methods are to be found with Tomberger (2005), a conclusion at Hruby et al. (2005).

Finally it is to be pointed at external factors, which influence the election of or decision against a certain procedure significantly. A first restriction is often caused by limited funds. Other crucial criteria are the accessibility and availability of the original, which is often well protected under private or public wings and according to its value with none or very limited mobility. Under such circumstances it can be quite difficult or even impossible to realize a situation that allows the operation with a certain device for the data's acquisition.

Preliminary considerations about the representation of historical globes

Concerning the visual representation digital globes have proven to be most suitable to satisfy the general criteria of an appropriate publication of cartographic heritage applied on historical globes. This emerging form of cartographic visualization allows an interactive experience of the original data as well as a comparative reference of this data to a present reality. According to Riedl (2000) digital globes can be further divided into virtual and tactile *hyperglobes* as well as *hologlobes*. This classification describes furthermore the temporal progression of digital globes, where the

category of virtual hyperglobes marks the beginning of a still open-ended development. Virtual hyperglobes are defined as a digital representation of a virtual globe in virtual space Riedl (2000). As yet mainly virtual hyperglobes can be considered as mature technology to made standard practice in the range of cartographic heritage.

However ongoing development of the possibilities of visualization using digital globes gives reason to expect tactile globes to be used in the foreseeable future. Tactile globes are already visualized in real space as a projection on a material sphere. Relevant efforts are being made at the University of Vienna, Department of Geography and Regional Research with a 1.5 m diameter tactile hyperglobe. Currently appropriate software is being developed to establish the presentation's quality and interactivity at a high level that should meet cartographic requirements. Fig. 2 may help to create an impression of the potential of tactile hyperglobes. Still far from a maturity phase are hologlobes that are visualized on a virtual sphere in real space. Nevertheless their potential is conceivable on principle too.



Figure 2. Prototypical visualization on a tactile hyperglobe.

Facsimilation of the earth globe of Gerard Mercator (1541)

With the above mentioned possibilities and aspects we have tried to provide a framework to present an approach to a digital facsimile of the earth globe of Gerard Mercator, which will be explicated below. This approach does not claim to offer the perfect solution to the facsimilation of globes in general but rather an optimum under the given conditions.

These conditions have mainly been set by the Austrian National Library, including the financial responsibility. Accordingly Mercator's globe was not intended to leave the library's premises but rather to be of restricted access as far as possible. Another given criteria was the practical aim of the project, namely an interactive publication of the digital facsimile on a touch-screen, demanding high-quality texture data, which can be investigated on a high level of detail as well as of usability.

Acquisition of the basis data

In terms of the above named conditions the data acquisition was done with a high-resolution digital camera, after deliberating about different possible methods. This approach allowed the Austrian National Library keeping exclusive access to the original globe, as all photos could be taken within the library and by the library's own photographer. Having tested different

parameters, Mercator's globe finally was photographed on 384 pictures under the following conditional instructions:

The photos are geared to the globe's graticule, so that each shoot would cover a sector of about 10 degrees latitude x 15 degrees longitude with four intersections at the corners. As the graticule narrows towards the poles, north- and southwards 70° latitude these photographed sectors have been extended to 10° latitude x 30°. Figure 3 exemplifies this via red marks. The optical axis is best perpendicular to the globe's surface, while all photos should have a central image focal point. High resolution is aspired and realized the present case with: 2560x1920 pixels, Tagged Image File Format.

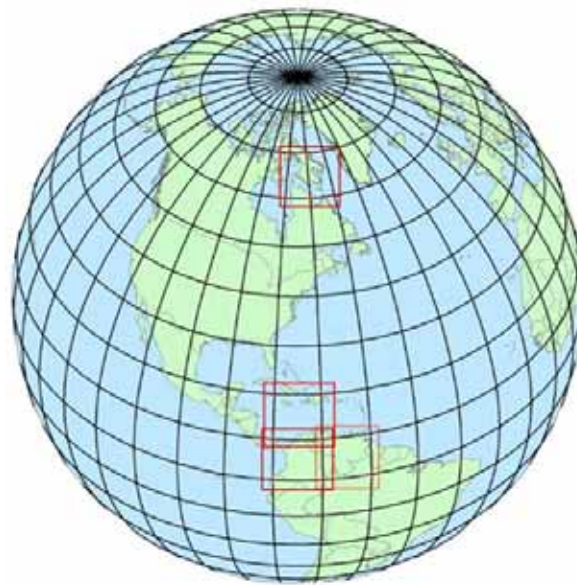


Figure 3. Graticule-based photographing of the original globe. (Plank, 2005)

In addition to the original globe's texture the Austrian National Library submitted another 2D-source, namely a whole set of printed gores that had been reedited by the Royal Library of Belgium in 1875. Implementing this data offered improvements in the readability of the original, so it was digitized as well in high resolution (600 dpi) scans. As these gores were already available in a structured form, each gore was just split up into quarters, to keep the large amount of data manageable during the subsequent data processing.

Basis data processing

As photographing a curved surface comes along with distortions, each photo with its own coordinate system had to be transformed to a reference system, which was done with ERDAS Imagine. The reference file for the transformation was an equidistant cylindrical projection (plate carée). By setting reference points at the graticule's intersections on the photos, latitude and longitude in terms of the target projection could be applied to transform each photo to a rectangular image within a consistent coordinate system. As each processed photo covered 10 degrees latitude x 15 degrees longitude the total number of images increased to 432 consequently. An analogue procedure has been applied to the scanned gores. Figure 4 shows the schematic

process elaborated in ERDAS Imagine, Figure 5 illustrates a set of reference points, exemplified on the basis of a reprinted gore.

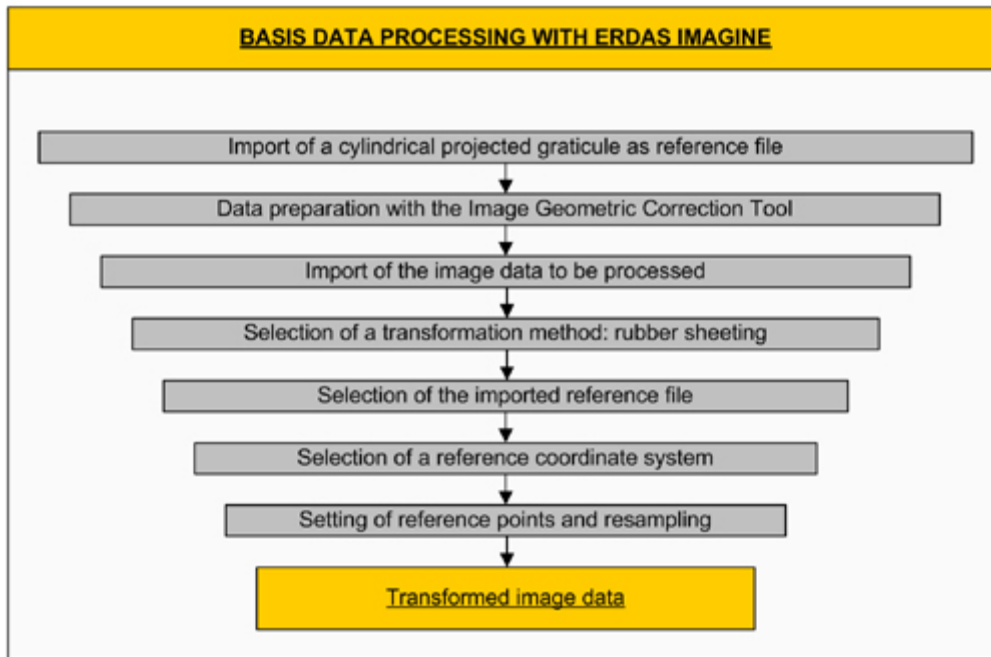


Figure 4. Basic data processing workflow.

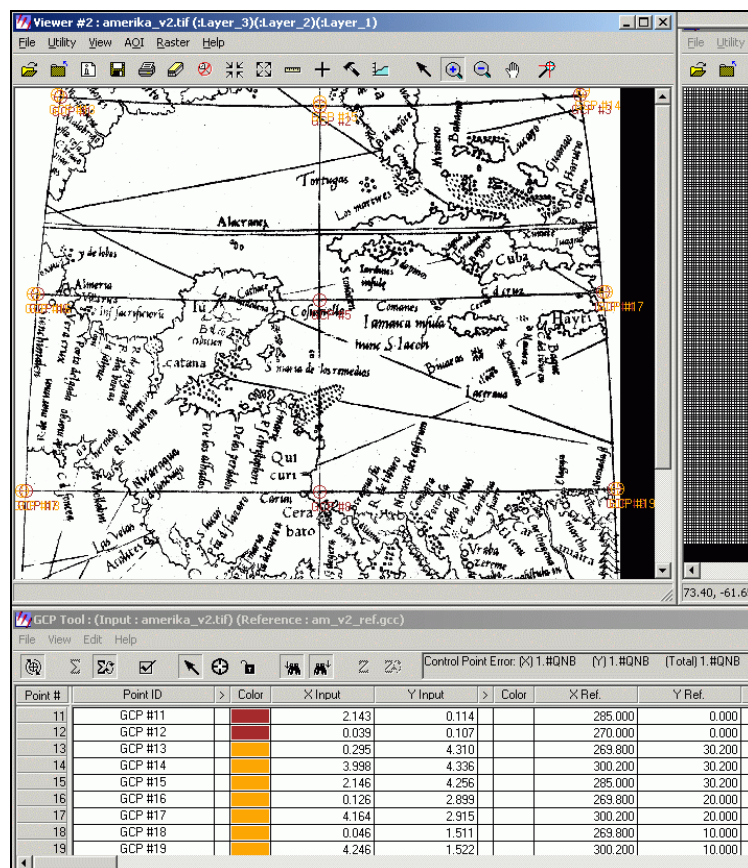


Figure 5. Setting reference points at the graticule's intersections in ERDAS Imagine.

Compiling of the facsimile's overlays

When tessellating the processed photos to one single overlay with Adobe Photoshop, radiometric inadequacies became apparent which had been caused by the lighting conditions during the shooting of the original globe. These deficiencies were corrected for each image to obtain a homogeneous appearance of the globe's overlay. The split sections of the reprinted gores' scans were tessellated in the same way. Figure 6 shows the corresponding workflow.

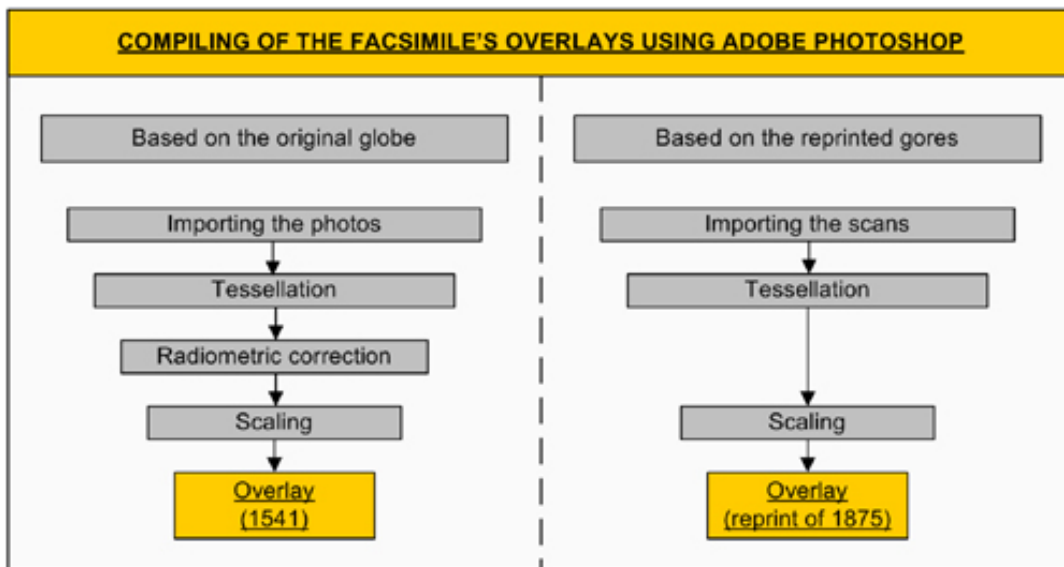


Figure 6. Workflow of the overlays' compilation.

Implementation of current data

As explicated in chapter 1, publications of ancient cartographic products and historical realities require a comparative reference to current geographic data. Therefore the digital facsimile of Mercator's globe was provided with up-to-date vector data, edited with ESRI's ArcGIS software. Figure 7 illustrates the algorithm this data implementation was done with. According to this workflow, vector data of coastlines, major rivers and popular cities has been integrated to the application.

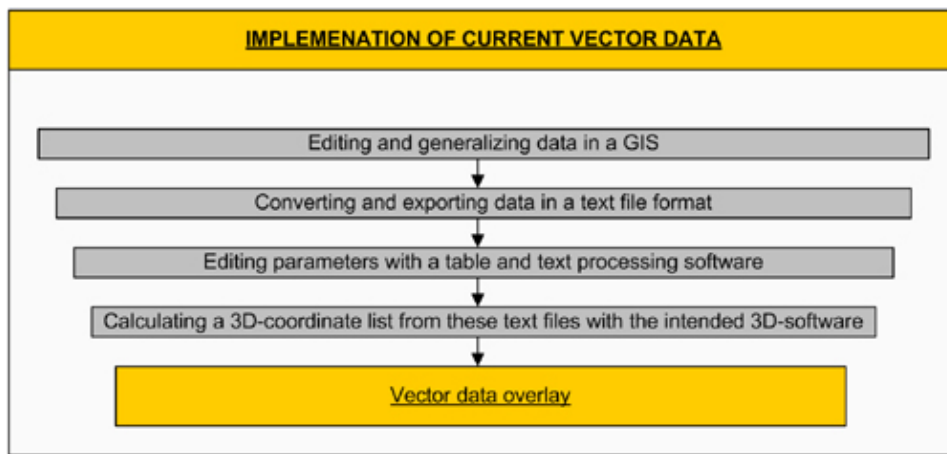


Figure 7. Workflow of vector data's implementation into a 3D-environment.

Composition to a digital facsimile

Finally the edited overlays were integrated to a 3D-model programmed in Macromedia's Director. To meet the demands of this software and accordingly the appropriate data format as well as current hardware's capability, the two overlays were resized to 8192x4096 pixels. With upcoming hardware-generations and rising capacities a stepwise increase of the used image size and resolution can be expected. High-quality texture data is already available anyway. More information about the programming behind the 3D-facsimile of the earth globe of Mercator can be acquired in Henebichler (2005). General information about suitable formats for generating digital 3D-facsimiles can be found in Riedl (2002).

To complete the application and prepare it for a tangible and interactive use, an interface has been designed in consideration of to the target group, i.e. the visitors of the Globe Museum. This user-interface was developed in cooperation with a group of designers to integrate the visual appearance of the project into the corporate design of the Austrian National Library. For more details about the required functions and interactivity for investigating a digital 3D-facsimile see Plank (2005) and Hruby (2005).

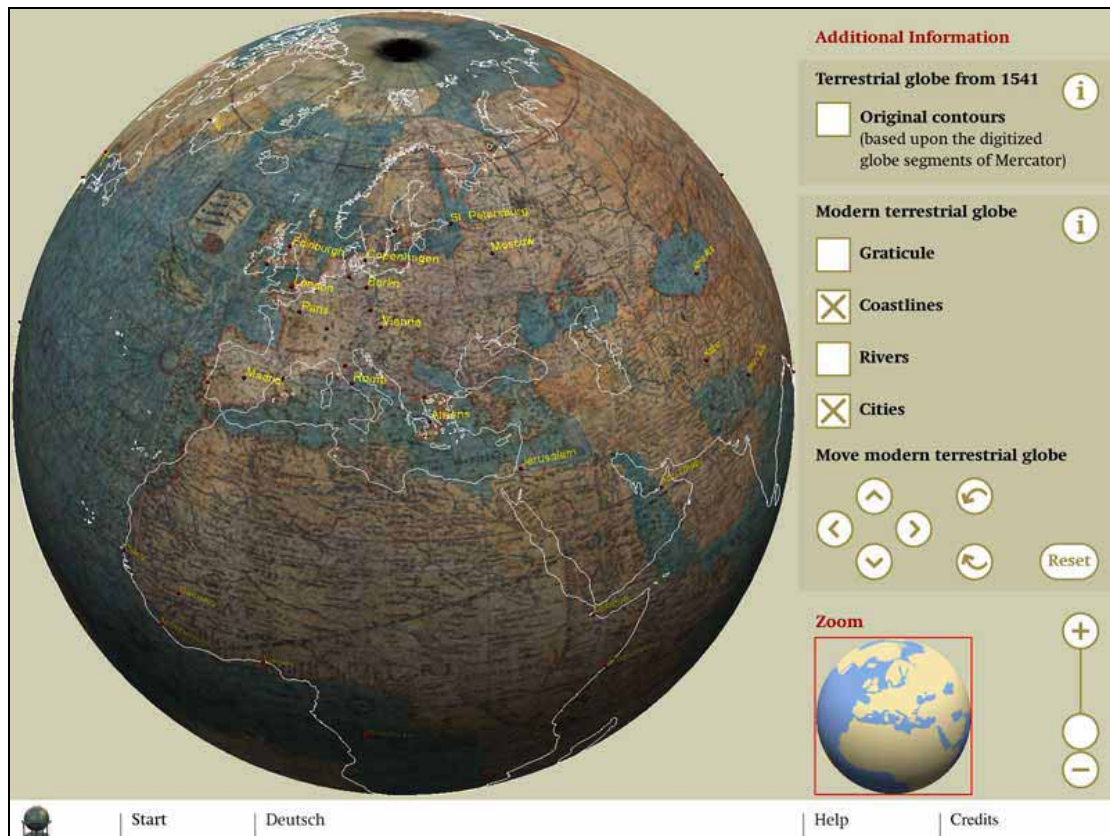


Figure 8. The digital facsimile of Mercator's earth globe in the context of the final application.

Figure 8 shows the virtual facsimile of the earth globe of Gerard Mercator of 1541 as seen on the touch-screened workstation in the Globe Museum. As this outcome is limited to just two dimensions it should be emphasized that the term 3D-facsimile is nevertheless correct. The 3D-model of this facsimile would already allow a 3D-visualization if the display and its technology would do. We have seen above, that this alternative may be realized in the near future.

Discoveries

Whilst exploring the virtual globe and comparing it with the reprinted gores, which show the true historical contents (i.e. the content intended by Gerard Mercator) of the globe, various discrepancies between the two overlays were detected. An explanation to this fact may be, that most of the globes have not been coloured until being bought and therefore after maybe years of storing and already time-worn. Therefore some artists may not have painted or restored these globes properly and without any cartographical knowledge respectively.

That might explain why the Nile Delta flows in mainland while Cyprus is not an island. In fact, the River Nile is labelled “Aegyptos” as for its name in former times. By exploring the historical cities one can also find that many of them are labelled either in their Latin names or in other names used in the 16th century.

Many of the European coastlines are also painted falsely (e.g. see Fig. 9). Spain, France, Great Britain and Denmark show different extents than printed on the globe segments. The same can be told about various islands whose contours are not properly filled with colour. The Sunda Islands for example are merged to fewer but larger islands.



Figure 9. Discoveries: Example of Spain – on the left the original globe; by including the printed gores on the right one can see that the coastlines of Spain are coloured in a wrong extent, mainly in the part of Spain below 40° Northern latitude.

Above all some oceans' labelling varies in comparison of the facsimile with the printed gores. There it looks like the restorers had problems in writing the correct letters. The exploration and comparison of the earth globe with its original segments is not concluded. It will take a long time to find all the differences between the facsimile and the gores but the discoveries made so far are worthy the effort.

A final comment

The Globe Museum has reopened on December 1st in 2005 at its new address, presenting the virtual facsimile of Mercator's globe to the public. Consequently the facsimilation is installed close to the original earth globe and accordingly to celestial globe as well. The concrete arrangement within the museum's premises is shown in Fig. 10.



Figure 10. Pair of globes of Gerard Mercator arranged with a digital facsimilation of the earth globe in the Globe Museum in Vienna.

Finally it should be mentioned that the virtual facsimile is not the only contribution of digital technologies to historical globes in the Globe Museum. Two other applications at different levels of interactivity provide more general information about globes and give historical and technical information on this topic. All these digital applications in the globe museum demonstrate the wide scope of what Fig. 10 illustrated highly accurate: The application of digital technologies in cartographic heritage.

References

- Henebichler, W. (2005). Digitale kartographische Ausdrucksformen im Schulunterricht. Technische Umsetzung eines Hyperglobus mittels Shockwave 3D. Unpublished Master's thesis at the University of Vienna. Vienna: 142.
- Hruby, F., I. Plank, A. Riedl (2005). Potential of Virtual 3D-Facsimiles – Exemplified by the Earth Globe of Gerard Mercator (1541). In: Proceedings, 22nd ICA Cartographic Conference, 2005. A Coruña, Spain.
- Hruby, F., I. Plank, A. Riedl (2006). Das interaktive 3D-Faksimile des Erdglobus von G. Mercator (1541). *Cartographica Helvetica* 33, 11-15.
- Plank, I. (2005). Problematik der Globenbild-Erstellung für virtuelle Globen. Gezeigt anhand der Faksimilierung eines historischen Globus und der Konzeption eines virtuellen Globus für den Schulunterricht. Unpublished Master's thesis at the University of Vienna. Vienna: 120 pp. In digital form, http://www.gis.univie.ac.at/karto/karto-aktiv/dipl/dipl_plank.pdf
- Riedl, A. (2000). Virtuelle Globen in der Geovisualisierung. Untersuchungen zum Einsatz von

Multimediatechniken in der Geokommunikation (mit einem Nachwort “Globenforschung in Österreich” von I. Kretschmer). In: *Wiener Schriften zur Geographie und Kartographie* 13. Vienna: 158.

Riedl, A. (2002). Web3D: Entwicklung, Standards, Formate. *Kartographische Nachrichten* 5/2002. Bonn: Kirschbaum, 214-220.

Tomberger, H. (2005). Der Digitalglobus als Werkzeug für die Globographie. Unpublished Master's thesis at the University of Vienna. Vienna: 97. In digital form,

http://www.gis.univie.ac.at/karto/karto-aktiv/dipl/dipl_tomberger.pdf

[URL-01]

http://portal.unesco.org/culture/en/ev.phpURL_ID=1473&URL_DO=DO_TOPIC&URL_SECTION=201.html

Last review of all URLs on March 28th, 2006.