Rome Reborn in Google Earth

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Abstract

This paper discusses the development process in building the "Ancient Rome 3D" layer in Google Earth in 2008. The layer contains a 3D model of Rome in A.D. 320, showing more than 7,000 buildings. More than 200 of the better-known buildings and features are marked with information balloons, which have links to external HTML pages that contain descriptions of the objects and a heterogeneous set of on-line resources related to each building or feature. The process was a collaboration between Google Earth software engineers and the University of Virginia.

Keywords: *Google Earth, 3D, historic archaeological models*

1 INTRODUCTION

Rome Reborn[1] is an international project based in the Virtual World Heritage Laboratory (http://vwhl.clas.virginia.edu) at the University of Virginia. The project's ultimate goal is to build 3D digital models that illustrate the urban development of ancient Rome from the first settlement in the late Bronze Age (ca. 1000 B.C.) to the depopulation of the city in the early Middle Ages (ca. A.D. 550). The project, begun in 1996 at University of California, Los Angeles, and moved to the University of Virginia in 2004, is led by Bernard Frischer and represents the collaboration of an international team of archaeologists, architects, modelers, and computer scientists.[2]

In 2007, the first version of the model, Rome Reborn 1.0,[3] was publicly exhibited in Rome at a press conference organized by the mayor at that time, Walter Veltroni. This model (see fig. 1) shows Rome within the Aurelian Walls in the year A.D. 320 when the city was at its peak both in terms of population (estimated to be ca. 1,000,000 people) and urban development.[4]

Rome Reborn 1.0 contains about 7,000 buildings, which for the purposes of the model were divided into Class I and Class II categories. The Class I category is for landmarks and other features that are well-known and for which there is documentary information about their location, function, size, and appearance. Class II covers buildings and features whose existence is documented but whose actual location, appearance, and size are not known (e.g., apartment buildings, single family dwellings, warehouses, and shops). Approximately 250 buildings in the model are marked as Class I, and the remainder belong to Class II.

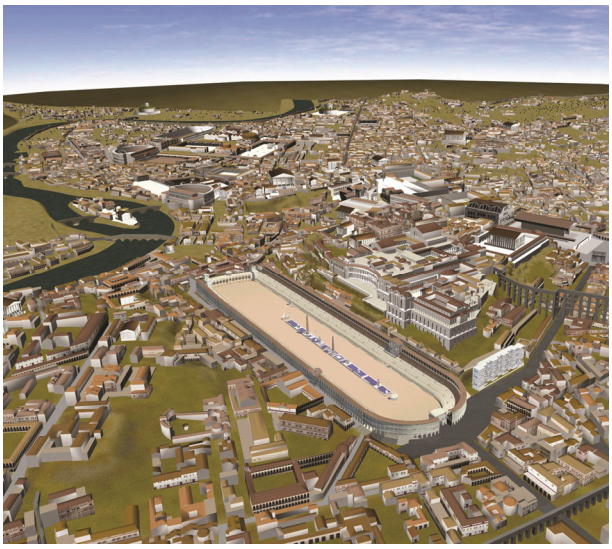

Figure 1. *Rome Reborn 1.0.*

One of Rome Reborn 1.0's major weaknesses was that it could not be run in real time using the Internet. Another problem was that the Class II buildings had limited architectural details, using a library of textures for windows, doors, balconies, etc. that could be attached to the base forms. Since June, 2007, the Rome Reborn group has been actively researching and implementing

[1] www.romereborn.virginia.edu.

[2] For the background and history of the project, see Karen Moltenbrey, "History in the Making. Scholars and Modelers Accurately Re-create Ancient Rome and Make It Accessible via the Internet," *Computer Graphics World* (December 2008): 16–25.

[3] www.romereborn.virginia.edu/rome_1.0.php.

[4] For the city of Rome in the fourth century, see Bertrand Lançon, *Rome in Late Antiquity*, translated by Antonia Nevill (New York: Routledge, 2001) 1–57; John Curran, *Pagan City and Christian Capital. Rome in the Fourth Century* (Oxford: Oxford University Press, 2000) 3–157.

solutions to these two problems. These limits aside, the model was considered a success.[1]

2 ROME REBORN IN GOOGLE EARTH

Soon after the exhibition of Rome Reborn 1.0 in 2007, Google contacted Bernard Frischer and suggested making the model available on Google Earth as a KML version of the model to its Gallery. A layer would be added to the gallery for an upcoming release of Google Earth. By the end of the year, an agreement had been reached, and the Rome Reborn group spent the first ten months of 2008 converting the model to KML format and authoring material for the information balloons and related landing pages. A press conference was held in Rome on November 12, 2008 when the model was put into service on Google Earth, where it is known as "Ancient Rome 3D." Since the release of the model, Google has proved itself enthusiastic about promoting and supporting educational and scholarly uses of the tool.[2] They sponsored a contest for K-12 teachers using the Rome Reborn layer as part of their curriculum[3] and have also promoted its use by non-profits and schools. This is part of Google Earth's more general support for the use of Google Earth by educators, non-profits, and research organization. There are numerous reference guides, best practices, and discussions of other projects available.[4]

Google Earth allows easy creation and placement of accessible, low-resolution, 3D models and it is the most popular and best-supported virtual globe tool. Once installed, the free software allows amateurs and scholars alike to explore ancient Rome, giving the Rome Reborn project much greater dissemination than might otherwise be possible. While KML was approved as an OGC open standard in 2008,[5] as of this writing there are no open source virtual globe applications that can display 3D buildings. NASA's World Wind[6] is open-source and free, but it has limitations when compared against Google Earth.[7] Our main concern at this point about the Google platform is that our model of Rome will only be available as long as Google Earth is willing and able to distribute it.

There were some other potential pitfalls, some of which became apparent only after the project was well along. The interface has limited context for data; a layer shows primarily graphic information (placemarks, terrain, and buildings), but users must click on placemark icons or borders to call up explanations of the data. The information bubbles are also somewhat small, especially if they also contain images and links. More detailed explanation and documentation would need to be placed on landing pages (external HTML pages which are reached by a href link in the information bubble). The 3D buildings in KML are low-resolution, essentially cylinders and rectangles with flat textures, which meant that many details in Rome Reborn 1.0 would not be visible. Corrections or additions to the textual information would be nearly impossible once the layer was released, since the text in the layer would be translated into several languages (Google Earth supports more than twenty languages) and distributed on Google's servers all around the world.

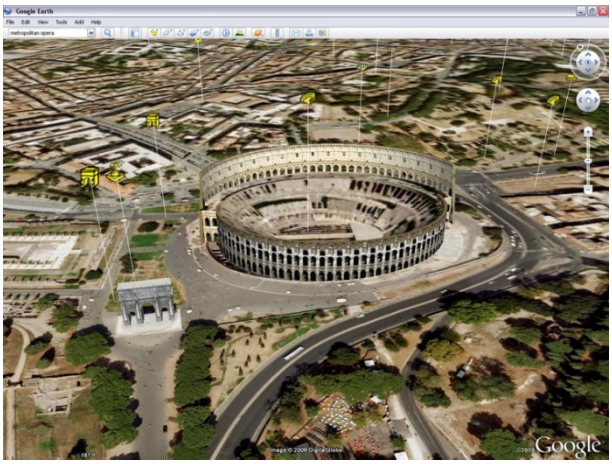

Figure 2. *Screen shot of Google Earth around the Colosseum.*

Furthermore, a user can (and probably normally does) have more than one layer open and can see placemarks and data from several different sources. It may not be clear what data is associated with which layer. For example, figure 2 shows a screenshot of the area around the Colosseum with both the 3D Buildings layer (which shows a collection of 3D models from the Google 3D Warehouse, created by various users) and Ancient Rome 3D layers visible. A user could might reasonably assume that the 3D models of the Colosseum and the Arch of Constantine are part of the Ancient Rome 3D layer, when in fact they are part of the Google 3D Warehouse. This type of confusion can be frustrating for programmers and users.

These issues aside, Google's invitation to publish Rome Reborn 1.0 in Google Earth was very welcome, and Frischer decided to accept and publish Rome Reborn 1.0 as a layer to be called "Ancient Rome 3D." Google

[1] For details, see K. Dylla et al. in this volume (pp. 62–66).

[2] http://google-latlong.blogspot.com/2008/11/roman-history-comes-to-life-in-google.html.

[3] www.google.com/educators/romecontest.html and http:// sketchupdate.blogspot.com/2008/11/when-in-rometeach.html.

[4] http://earth.google.com/outreach/index.html for discussion of non-profits and public benefit organizations that use Google Earth, and http://google-latlong.blogspot.com for more general information about interesting uses of Google Earth.

[5] www.opengeospatial.org/standards/kml.

[6] http://worldwind.arc.nasa.gov/.

[7] For a comparison of Google Earth and World Wind, see http://worldwindcentral.com/wiki/Google_Earth_ comparison.

Earth very generously offered technical support to our team, which Frischer appointed first Dean Abernathy to lead and then (after Abernathy left the university to take a job elsewhere) Chad Keller.[1]

3 CONVERTING THE MODEL

The Rome Reborn 1.0 model was created in MultiGen Creator,[2] a 3D simulation software package. The buildings had complex geometry and relied on a detailed library of textures. MultiGen will export to KML, but since the Rome model was not georeferenced, the model would not export correctly. The Google Earth engineers advised us to convert the model to Sketch-Up and then to turn it over to their team for final processing. While MultiGen's native OpenFlight format cannot be exported directly into Sketch-Up, it can be exported as .3ds files, which Sketch-Up can handle. Unfortunately, in the event, many of the exported .3ds files were damaged (textures and faces were missing).

The Virginia team tried a different approach, and exported the MultiGen files into PolyTrans,[3] a translation and optimization tool for 3D models. PolyTrans converted the model to .3ds, which were then imported into Sketch-Up and sent to the Google team to be optimized (see fig 3).

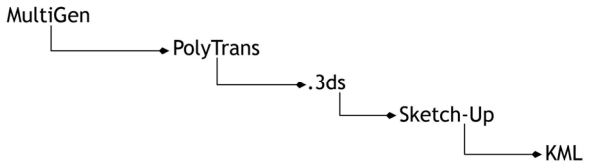

Figure 3. *Workflow for moving the model from MultiGen to KML.*

This four-step conversion of a large 3D model created ample opportunities for problems. One unfortunate side effect was that hitherto-undiscovered errors in the 1.0 model became obvious, so that time which might have been spent fine-turning the Sketch-Up buildings was occupied by fixing these errors. Problems also arose because of the way Google Earth distributes data. As users move through the virtual globe, the Google servers provide a constant stream of data, so that a user does not download geometries and textures until necessary. If a large 3D object is not optimized correctly, however, the data may not be loaded in an efficient and logical order.

In order to ensure that data is distributed as needed, complex buildings and groups of buildings need to be segmented into small chunks. Since there are more than 7,000 buildings in the Rome model, this leads to thousands of KML files. Furthermore, the MultiGen model had a complex hierarchy of objects and textures, but KML 3D buildings are composed from simpler cylinders and rectangles with flat textures. Attempts to reduce the model's complexity created a sort of polygon soup, marked by redundant textures and geometries. There is a limit to the level of complexity that Google Earth (never mind most users' computers) can handle, and the model quickly became unwieldy. The Google Earth engineers spent a great deal of time working on the KML version of the city, but in hindsight, it might have been better to have simply started over again and to have built the model from scratch in Sketch-Up.

Another problem arose from a conflict between the historic and current terrain of Rome. The terrain in and around the city has changed drastically in places over the past 2,000 years, both from natural causes and human intervention, to the point that a recreation of the terrain in A.D. 320 does not easily sit on the modern landscape. After some debate, Google Earth suggested that the historic terrain, and the 3D model, be suspended 40 meters above the ground. This creates an odd cloud-like effect, but it seemed a reasonable solution at the time.

4 THE INFORMATION BALLOONS

Information balloons (which pop up when a user clicks on a placemark) contain text, images, video, Flash videos, and links to external HTML pages. They are often used to provide context for places, buildings, and objects that have placemarks. There is no formal limit on the size of a balloon—the size can be set with CSS or drawn automatically according to the material it contains—but reason dictates that it should not be disportionately large.

Google Earth is used by a wide range of users with wildly varied interests and knowledge. Rather than an all-purpose approach that would suit a general audience, we decided to design for a user who would already be familiar with the city and its basic history. We also decided to offer more than the bare 3D model but instead to offer links to a heterogeneous set of resources about the marked objects. The design for the information balloon (see fig. 4) included identifying graphics, copyright information, explanatory text, a screen shot from the 1.0 model, links to a landing page (an external HTML page with more information about the marked object), and a short description of the marked object's importance, function, and history.

[1]Google Earth offered this support to IATH to help process the Rome Reborn model only. Unfortunately, they are not able to provide this type of assistance to other projects.

[2] www.multigen.com/products/database/creator/.

[3]www.okino.com/conv/conv.htm.

Figure 4. *Design of information balloons.*

To keep the information balloons at a reasonable size, the object descriptions (written primarily by Bernard Frischer) were kept to a few sentences. Ideally, those few sentences would contain intriguing facts that would drive the user to want to know more, but while life in Rome was undoubtedly violent and full of incident, accounts of dramatic events set in specific places survive only sporadically. In lieu of this, the descriptions provide brief summaries of the significance of each marked object. In cases where the description was too long, an ellipsis noted the break and the entire description was provided on the landing page.

At this point, in early 2008, KML supported a limited set of formatting options for balloon content. Since this was going to be part of the Google Earth package, the balloon design also had to be acceptable to Google Earth; the layer needed to conform to Google Earth's standards. Design by committee is always a challenge, but it can be especially tricky when commercial and academic interests are at stake. Google Earth's main interest was to create a good "user experience," meaning that the layer would provide reasonably intuitive cues to the user. The Rome Reborn team's interest was to inform and interest the user, so fortunately both sides were heading in the same direction.

As noted above, Google Earth is released in dozens of languages and the information balloons had to be finished several weeks in advance in order to allow time for Google Earth's team to translate the contents, so there was additional pressure to be sure that the content was correct.

There are placemarks for approximately 250 Class I objects. These objects are located in a fairly small area, only a couple of miles wide. Placemarks are marked by an icon (the default is a yellow pushpin), and having that number of icons in that small a space would create a confusing muddle, especially when viewed from higher up. The solution was to have categories of objects and give each category its own icon. We created six categories and twelve subcategories and designed eighteen icons that would allow users to quickly identify objects (see table 1).

Public Buildings		
	Baths	
	Civic and Military Buildings	
	Commercial Buildings	
	Entertainment Complexes	
Public Spaces		
	Fora	
	Monumental Arches, Columns, Markers, & Statues	
	Obelisks	
	Porticoes	
Private Spaces		
	Gardens	
	Houses & Palaces	
	Tombs & Mausolea	
Infrastructure		
	Aqueducts	
	Bridges	
	Fountains and other Water Features	
	Roads, Streets, & Stairs	
	Walls & Gates	
Hills, Regions, & Geographical Spaces		
Sacred Spaces		

Table 1. *Placemark categories and icons.*

We also wanted users to be able to hide some or all of the categories of placemarks so that they could look at individual placemarks or a category. KML folders allow hierarchal arrangements of placemarks, so we built a nested structure that reflected the categories we had created.

The folder structure also means that users can see a nested list of place names and double-click a name to fly to its location on the map. This allows users to hide placemarks and icons to look at groups or individual placemarks, as in figure 5 where only the Entertainment Complexes placemarks appear. A user could double-click on one of the placemark names listed and fly to that location.

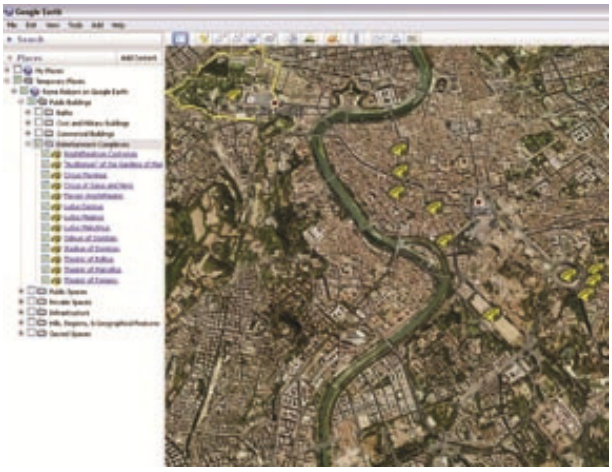

Figure 5. *Hierarchy of objects in Ancient Rome 3D layer.*

5 LANDING PAGES

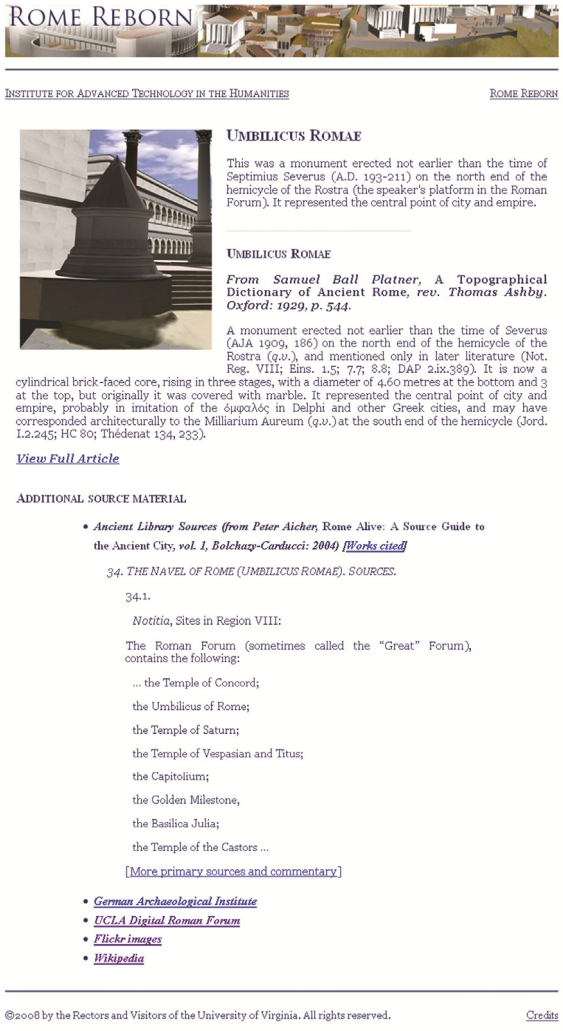

Figure 6. *Sample landing page.*

The landing pages were a more straightforward undertaking, in part because they are external to the Google Earth application (they are on a University of Virginia server) and were designed and built by our team only. They also deliver primarily textual information rather than GIS data and 3D buildings. The visual design was kept simple to focus attention on the content.

The landing pages, which users reach by clicking on the "Learn more" link in the information balloons, contain detailed information about each placemarked object, as well as a heterogeneous set of external resources related to that object. Each page contains a brief description and an article from Platner-Ashby, *A Topographical Dictionary of Ancient Rome.*[1] The external resources cover a range of material, from scholarly to casual. Some objects (e.g., the Flavian Amphitheatre) are better documented than others (such as the Columnae Honorariae), so some landing pages contain more information than others. Figure 6 shows a sample landing page. The sources used are:

- *Rome Alive,*[2] a compilation of original source material keyed to specific locations in Rome, by Peter J. Aicher. We created an HTML version of the text and tagged it to placemarks in the Ancient Rome layer.
- *Aquae Urbis Romae:* The Waters of the City of Rome,[3] an on-line cartographic history of nearly 2800 years of water infrastructure and urban development in Rome, created by Katherine Rinne.
- *The Stanford Digital Forma Urbis Romae Project,*[4] a database of fragments of the Severan Marble Plan.
- The OPAC of the Deutsches Archäologisches Institut,[5] a catalogue of holdings of the research library of the German Archaeological Institute in Rome.
- *UCLA Digital Roman Forum*,[6] a digital model of the Roman Forum in A.D. 400. It was built by the Cultural Virtual Reality Lab between 1997–2003.
- *Flickr*,[7] a photo-sharing application. The link URL contains a query for the object, so the resulting page

[1]Samuel Ball Platner, *A Topographical Dictionary of Ancient Rome*, rev. Thomas Ashby (Oxford: Oxford University Press, 1929).

[2]Peter J. Aicher, *Rome Alive: A Source-Guide to the Ancient City* (Wauconda IL: Bolchazy-Carducci, 2004).

[3]www.iath.virginia.edu/waters/.

[4]http://formaurbis.stanford.edu.

[5]http://opac.dainst.org.

[6]http://dlib.etc.ucla.edu/projects/Forum/.

[7]www.flickr.com.

will contain photos tagged with the name of the object. Contemporary photos showing objects in their current state provide a useful contrast with the 3D recreations. The results are not always directly relevant, since they rely on the accuracy of the tags, but they offer unexpected and often quite beautiful views of buildings and monuments in their current settings.

- *Wikipedia*,[1] which has a surprisingly good collection of pages on Roman topography. There are many well-written and reliable descriptions of famous and less familiar objects.

Doug Ross, a programmer on our team, generated the landing pages from an Excel spreadsheet. The pages are stored on university servers, so updates and additions can be added over time.

Beyond the challenge of assembling the material for the information balloons, there were unexpected difficulties in matching the locations of the placemarks with the 3D buildings. The exact locations of all of the buildings in the model are not known, and even the better known buildings cannot be pinpointed. The team building the 3D model and the team building the information balloons were working with two slightly different sets of latitude and longitude. This problem was only aggravated by the fact that the ancient terrain was floating 40 meters above the ground and the placemark icons sit 75 meters above the ground: it is not always immediately clear which object is marked by which icon.

6 GOING PUBLIC

The entire timeline for this project was influenced by external factors. It was attached to the next release of the Google Earth software, and a press release had to be scheduled several months in advance in Rome's city hall, to be attended by representatives of Google Earth, our team, and Italian officials. Once a date had been agreed upon (a lengthy undertaking), it was nearly impossible to change it. Problems that might have otherwise caused us to postpone the release had to be resolved. Unfortunately, this meant that when Google Earth's engineers ran into last-minute problems with the Ancient Rome layer, they were forced to make some drastic adjustments. The struggle to optimize the model so it would download in reasonable amount of time and would not overwhelm users' computers proved to be a serious problem. The Google Earth team did its best to get rid of redundant texture files and to simplify the files that remained. However, they were not able to take full advantage of all of Google Earth's optimization tools, because the model is suspended above the ground. In order to have a functional version, the layer was split out into parts: the default setting just showed the placemarks, without the hierarchy of folders described above (see fig. 7). While this is probably confusing, it is hoped that the use of the eighteen icons signals the differences between the placemarks.

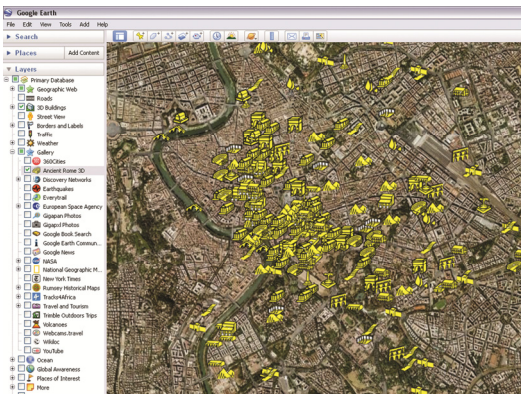

Figure 7. *Screenshot of Ancient Rome 3D layer.*

The information balloons were edited, as shown in figure 8, to include links to download the terrain and buildings in separate steps. This adjustment was necessary to make sure that the entire Google Earth application would open in a reasonable period of time. This is not ideal, but it does work. We lost some of the functionality of our design, but the layer is still useful, informative, and educational.

Figure 8. *Downloading options in Ancient Rome 3D information balloon.*

[1]http://en.wikipedia.org/wiki/Main_Page.

7 CONCLUSIONS

This work took approximately seven months of effort by people on our team and at Google Earth. Technical problems forced us to abandon some key aspects in the design and to deliver the placemarks, terrain, and model in separate steps. With hindsight, we might have been able to execute a simpler and easier approach to the model, which would have allowed us to hold on to the intended interface. And, were we to attempt something on this scale again, we would certainly take a different approach. Sketch-Up is a wonderful tool, but it is not designed to handle complex large models. Indeed, we would advise any project that might consider publishing a large 3D model of a cultural heritage site to make sure that there is an efficient and practical path for 3D data either to migrate to KML or to be built from scratch. It is also important to take the time to consider how the historic terrain may have changed and how that might best be communicated to users.

In spite of the assorted pitfalls outlined in this paper, we are excited by the opportunities that Google Earth offers to cultural heritage research and education. Google Earth is a wonderful tool and an excellent venue for publishing 3D models. In some cases, the best and easiest route will be for the scholar to create his or her own KML files and to publish them on a web site. This allows individual control over the distribution and much more flexibility and precision in the use of the data. In contrast, a project on the scale of Rome Reborn required the active help, cooperation, and (last but not least!) the server resources of Google Earth.

ACKNOWLEDGEMENTS

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