

NEH Application Cover Sheet

Digital Humanities Start-Up Grants

PROJECT DIRECTOR

Dr. Patricia Seed
 Professor of History
 259 Krieger Hall
 University of California, Irvine
 Department of History
 Irvine, CA 92697-3275
 UNITED STATES

E-mail: seed5@uci.edu
Phone(W): (949) 824-8223
Phone(H):
Fax: (949) 824-2865

Field of Expertise: History

INSTITUTION

The Regents Of The University Of California
 Irvine, CA

APPLICATION INFORMATION

Title: *The Development Of Mapping: Portuguese Cartography And Coastal Africa, 1434-1504*

Grant Period: From 4/2007 to 3/2008

Field of Project: Renaissance Studies

Description of Project: Digital technology applied to a historically significant collection of maps will not only allow collective display, but will create a research resource enabling entirely new modes of scholarly investigation. New knowledge can be gained through use of GIS software. The project is significant to many humanistic fields and will be openly available to scholars and teachers.

BUDGET

Outright Request	\$29,997.00	Cost Sharing	
Matching Request		Total Budget	\$29,997.00
Total NEH	\$29,997.00		

GRANT ADMINISTRATOR

Ms. Monique Munoz
 Contract and Grant Officer, ORA
 Office Of Research Administration
 300 University Tower
 Irvine, CA 92697-7600
 UNITED STATES

E-mail: monique.munoz@rgs.uci.edu
Phone(W): (949) 824 8634
Fax: (949) 824-2094

STATEMENT OF SIGNIFICANCE AND IMPACT

The Development of Mapping: Portuguese Cartography and Coastal Africa, 1434-1504

The process of swiftly and accurately mapping unknown coastlines was developed during Portuguese voyages along the western and southern coasts of Africa in the 15th century. How Portuguese mapmakers learned to join discrete sections of coastline into a single map with highly accurate distance and direction has long remained a mystery. During thousands of years of sailing the Mediterranean, equivalent levels of accuracy were never reached; the first explorations of an unknown coastline produced this new result. Cartography scholars know very little about one of the most important moments in the history of mapping: the period during which mapmakers learned to make large charts to scale.

This knowledge has been inaccessible in part because of the far-flung present-day location of the maps themselves. Amassing the collection has taken more than a decade because no single library or archive has more than a handful of the surviving maps. One scholar has accumulated and digitized this collection of approximately 100 surviving nautical charts of Africa's coast between 1434 and 1504, by single-handedly visiting various corners of the United States, the national libraries of France and England, small city and university libraries and archives throughout Italy, France, and Spain, the Vatican, and state and municipal libraries and archives in Germany.

Digital technology applied to this historically significant collection of maps will not only allow collective display, but will create a research resource enabling entirely new modes of scholarly investigation. GIS software applied to various data sets will allow researchers to identify features of the maps, learn about locations of 15th-century Africans, and analyze advances in cartography. Identification of map features has proven difficult due to instable nomenclature—the result of new European discovery, colonization and independence—and to environmental change. The Geonames database from the U.S. National Intelligence and Imagery Agency provides the contemporary and sometimes the historical names of thousands of communities in each of the countries of western and southern Africa, as well as precise contemporary latitude and longitude. Identified historical names linked to modern ones allows mapping of the 15th-century people and places to contemporary coastal points. In those cases where Geonames data is insufficient, adding hydrographic and digital elevation models to identify rivers and hills, along with vegetation data, is very useful, both for identification and for analysis of environmental conditions of 15th-century African communities. This technology will reveal new historical information about Africa's coastal people prior to extended contact with Europeans, providing a baseline against which the subsequent impact of environmental change and the slave trade can be compared.

Cartographical analysis will benefit tremendously from this new resource. The various maps in the collection can be analyzed in chronological order, allowing comparative measurement of scale, distance, and direction to reveal gradual improvements in navigational map-making accuracy. Combining this information with data on time-lag between the return of ships from each voyage and the appearance of the nautical chart of the region will enable identification of when the map-making process became swift and precise.

Adding more data sets and annotation in combination with GIS software will make this research and teaching resource still more robust. Cartographical analysis can be improved by presenting the maps with dynamically changeable mathematical formulas, rather than as fixed objects. These, in addition to developing the most useful and user-friendly search tools, are the primary goals for future development of the collection, for which we will apply for additional funding.

This project will provide a valuable open-access resource to many fields of the humanities, enabling new knowledge and new teaching tools. It will also serve as a model for other digital humanities projects, illuminating possibilities for georeferenced humanistic information of many varieties and the user interfaces necessary for humanistic research and teaching.

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List of Participants

Seed, Patricia

Professor of History, University of California Irvine

Goldberg, David Theo

Director, University of California Humanities Research Institute

Diaz, German

GIS specialist, Rice University

Roemhild, Simone

database consultant

Graduate Students,

UC Irvine and Rice University

Programmer analyst,

To be named

NARRATIVE

The Development of Mapping: Portuguese Cartography and Coastal Africa, 1434-1504

Enhancing the humanities through the use of emerging technologies

Between Columbus' first preliminary sketches of the Caribbean in 1493 and the final agreement between Spain and Portugal over the division of the world (1529), nearly the entire eastern seaboard of the Americas was mapped, giving it a profile recognizable even today. These swiftly developed continental outlines provided the Americas a visual signature that immediately became identified with the continents, lending credibility to their very existence. But contrary to common assumption, the process of swiftly producing cartographic coastlines neither originated with the discovery of the New World nor did it first occur there. Techniques for quickly mapping unknown coastlines were actually developed earlier, during Portuguese voyages along the western and southern coasts of Africa during the previous century. This discovery was made by the director of our digital project, Patricia Seed. Our project seeks to fill in the last piece of the puzzle: not when or where, which we now know—but *how* Portuguese mapmakers learned to join discretely described sections into a single map with highly accurate distance and direction. This has long remained a mystery. The digital humanities can help to solve it.

In the history of mapping we know astonishingly little about one of its most important moments—the period during which mapmakers learned to make large charts to scale. In 1434 maps of Africa covered only its northern (Mediterranean) coast and tiny slivers along the east and west coasts. No sketch depicted the majority of the coastline: the outline of Africa south of the Sahara on the west or of the Red Sea in the east. Conjectures about the continent abounded: one group of scholars speculated that to the south, Africa consisted of a solid mass of land, ending somewhere near what we now know as Antarctica; others guessed that a body of water—“the encircling ocean”—lay somewhere to the very south, again in the vicinity of present-day

Antarctica.¹ Then, between 1434 and 1499, Portuguese navigators found the reality that lay beyond those two corners—a cone-shaped continent—surrounded on all sides by seas.

Exploration of this unknown coast led to an explosion of mapmaking. Since navigators needed to know the direction in which to travel—and how far they needed to go—these mapmakers tried to establish the direction and distance between any set of locations along the coast accurately. While such charts had long been available for the Mediterranean,² few had managed to accurately combine both direction and distance (with the latter usually imperfectly rendered). Furthermore, the Mediterranean had been sailed for several thousand years. How did Portuguese cartographers achieve such accuracy now, especially when Africa had never been circumnavigated before?

This much is known: to sail around this water-circumscribed continent, Portuguese pilots developed an entirely new repertoire of sailing techniques, beginning with Gil Eanes' rounding the promontory called "The Bulging Cape" (Cape Bojador) in what is presently Western Sahara³ and ending with the invention of the nautical astrolabe in 1497. During the same time period, information to construct maps of these areas was carefully assembled. As Portuguese ships traveled, designated individuals on board made note of the natural landscape—beaches, groves of trees, dunes, and hilltops—sketching the height and shape of these features as seen from the deck of a ship.⁴ Each profile would allow subsequent expeditions to verify their location by seeing if the contours of the land matched up with what they could see. This technique remains part of

¹ Encircling originates with the Egyptians and the Babylonians; the land mass idea comes from the Greeks, especially Ptolemy.

² Tony Cambell, "Portolan Charts from the Late Thirteenth Century to 1500," in Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean ed. J.B. Harley and David Woodward. Chicago: University of Chicago Press, 1987, 371-463.

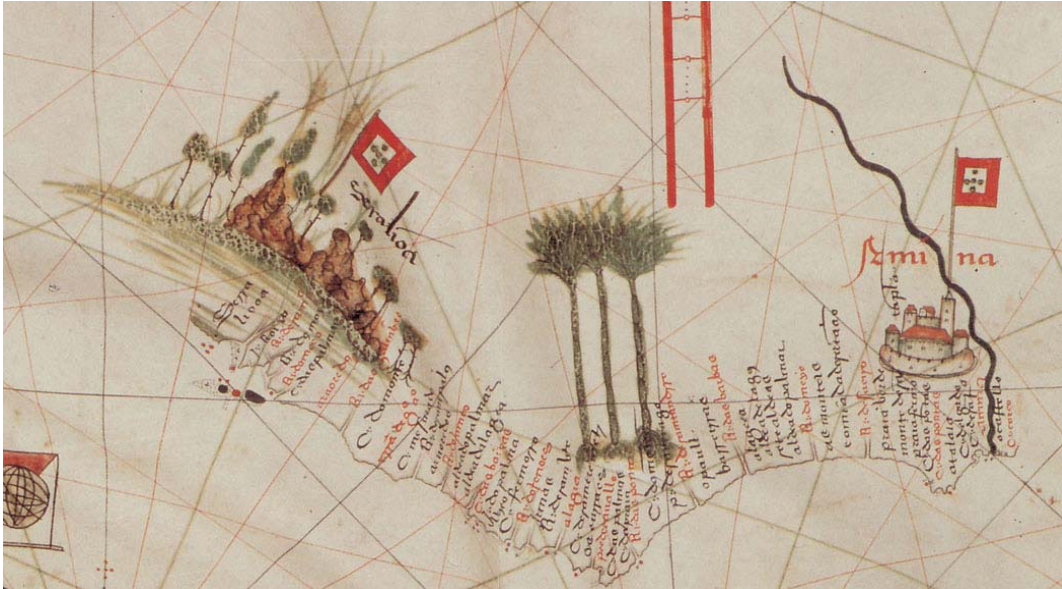
³ Patricia Seed, "Navigating the Mid-Atlantic, Or What Gil Eannes Achieved," in Jorge Cañizares and Eric Seeman, eds. *The Atlantic in Global History, 1500-2000* (Prentice-Hall, 2006), 77-89.

⁴ Duarte Pacheco Pereira's, *O Esmeraldo Situ Orbis* contains many of the original fifteenth-century sketches of the African coast from southern Morocco to Gabon. The only English translation by George Kimble is very poor. (London : Printed for the Hakluyt Society, 1937.).

modern sailing instructions around the world.⁵ In addition to the profiles, the outlines of bays, capes, peninsulas, islands, and river deltas were also sketched, and distances between these features were measured. Thus these men outlined the coastline in separate segments, noting the direction in addition to the distance between features of each section of coast. Slice by slice, trip by trip, a wealth of information was accumulated about the coasts of Africa. Back in Lisbon, professional mapmakers combined the information from each of these slices into successively larger maps, uniting ever longer stretches of Africa's coast into a single chart. Eventually they drew a unified outline managing to accurately map Africa's 16,000 mile coastline.

Analysis of these cartographical advances has been hindered in part because of the dispersed present-day location of both the preliminary sketches and the maps themselves. Having never been brought together in a single book or online publication, they remain strewn across dozens of libraries and archives in the United States and Western Europe. Amassing the collection has taken more than a decade because no single library or archive has more than a handful of the surviving maps. The Bibliothèque National in Paris holds the single largest collection, and the British Library the second largest. But the rest of the maps, including many crucial to the study, remain scattered all over the United States and Europe—often with a given library holding only a single item of interest. Project director Patricia Seed, history professor at UC Irvine, has for the past ten years been accumulating this collection of approximately 100 digital copies, photographs, or slides of the surviving nautical charts of Africa's coast from the years between 1434 and 1504, by single-handedly visiting various corners of the United States, the national libraries of France and England, small city and university libraries and archives throughout Italy, France, and Spain, the Vatican, and state and municipal libraries and archives in Germany.

⁵ See the contemporary navigational publications entitled Sailing Directions Enroute produced by the National Imagery and Mapping Agency and, published by the U.S. Government Printing Office.



Portion of large nautical chart of 15th-century coastal Africa; Portuguese.

This project will bring these maps together for the first time, which itself constitutes a significant resource for research on historical cartography. Humanities scholars studying, e.g., fifteenth century European navigation and exploration, early contact between Europeans and Africans, or the beginnings of European trade in African slaves will also find this collection extremely valuable to their work. The project will not only provide online collective display of these maps, however, but will create a research resource enabling entirely new modes of scholarly investigation. In addition to presenting the map collection, we are taking advantage of Geographic Information Systems (GIS) software and applying this technology to the maps in conjunction with a several databases.⁶ GIS technology provides an earlier look at west and southern Africa than we have had before, making it possible to see exactly where these people resided—for many at the time of their first contact with Europeans. Extant fifteenth-century narrative sources are sparse and geographic indications in these narratives vague. Making these maps available in geo-referenced form will provide students of African history with an invaluable

⁶ The digital humanities are beginning in some cases to utilize GIS, which captures, tags, and displays geographically referenced information, allowing geographical analysis that is usually used for applied scientific or utilitarian purposes (population health, mapquest) rather than historical research.

source of information to compare against later developments along Africa's western and southern coasts, not only revealing new historical data about Africa's coastal people prior to extended contact with Europeans, but providing a baseline against which the subsequent impact of environmental change and the slave trade can be compared. The application of GIS will also enable new knowledge about early cartography that could not otherwise be discovered. (*See Methods section below for a description of how GIS enables these developments.*)

History and duration of project

The project director began collecting the nautical maps ten years ago in the course of her research on 15th century Portuguese navigation. She discovered GIS as a solution seven years ago (1999), while analyzing a 1517 nautical map from the Huntington Library for her "Latitude" website (see below). In trying to disassemble the map in pieces to discover its method of construction, she used the method of visual matching of the continuity of coastline sections. This necessitated having three separate individuals verify the visual matches. Dissatisfied with purely visual identification techniques, she turned to GIS, and began using it to design her own maps for publication that same year. These appeared in *American Pentimento: The Pursuit of Riches and the Invention of "Indians"* (U of Minnesota P, 2001; Winner, 2003 Prize in Atlantic History).

By 2003, we had created a basic process for analyzing the development of African coastline charts. We published the first example of these procedures in the ESRI conference proceedings for 2004.⁷ Two maps are now fully georeferenced and analyzed, with historical names, modern names, modern locations, latitude/longitude positions, scale, error measurements, and some ethnographic data. A third map is partly analyzed: georeferenced with error measurements, but no name identification. Thirty-five more maps are ready for analysis, with test digitization done on two-thirds and a preliminary survey of names done on four.

⁷ "Rewriting the History of Nautical Cartography," (with German Díaz) Conference Proceedings, ESRI Higher Education Conference 2004

We developed the techniques of digital restoration in 2004 so that damaged historical maps could be sufficiently restored for electronic analysis. Our findings were published by the Institute of Electrical and Electronic Engineers' Digital Libraries group in December 2005.⁸

The project director's considerable experience in web design and programming will be put to use in developing the resource for online use. She has created a major internationally recognized website on the history of Portuguese navigation in the fifteenth century, titled "Latitude: The Art and Science of Fifteenth Century Navigation." Since 1999, its home page has remained in the top five Google responses for the word "latitude," and in China, where Yahoo surpasses Google, it is the number one site for the same word. Several of its interior pages also remain the top answers for their subjects—including "terrestrial magnetism," "Agulhas current," "Maggiolo map," and "Polynesian navigation." The site has been incorporated into educational CDs in Scotland, South Africa, and Poland, and has garnered dozens of awards and recognition from science as well as humanities organizations. It receives millions of hits annually. The site was designed and coded entirely by Seed, including layout, graphic design, hand-coding HTML, javascript, and, more recently, CSS2. Feedback about the site has provided Seed with solid knowledge of the strategies that work in designing a website with broad appeal.

The University of California Humanities Research Institute (UCHRI), a supporter and collaborator of the project, is well-versed in sustainability issues and administratively committed to the perpetuity and dissemination of digital resources. UCHRI intends to support development of current and future phases of the project. We will consider a variety of non-exclusive options to assure duration of the project:

- preservation at the San Diego Supercomputer Center (SDSC), a leadership national cyberinfrastructure Center of the National Science Foundation which

⁸ "Electronic Restoration: Eliminating the Ravages of Time on Historical Maps," with German Díaz in E.A. Fox et al. (Eds.): ICADL 2005, LNCS 3815 (Heidelberg Berlin: Springer-Verlag 2005), pp. 100 – 108. Originally presented at Institute of Electrical and Electronic Engineers, Conference on Digital Libraries, Bangkok, 2005.

focuses on data-oriented computational science applications. UCHRI frequently partners with SDSC on digital humanities projects. Archiving at SDSC means inherently that all digital files will be replicated at least three times and preserved.

- preservation in UCHRI's HASS grid.
- preservation at the California Digital Library Digital Preservation Repository.

UCHRI recognizes acutely the difficulty in maintaining digital resources and making them consistently accessible to user communities. It is for this very reason that UCHRI Director David Theo Goldberg co-founded the HASTAC (Humanities, Arts, Science, and Technology Advanced Collaboratory) consortium. The HASS (Humanities, Arts, Social Sciences) Grid, developed and deployed by UCHRI, is designed to meet sustainability challenges by using a networked storage system for electronic content at each University of California site.

Staff

Patricia Seed, Professor of History, University of California Irvine
Project Director
50% time, contributed

David Theo Goldberg, Director, University of California Humanities Research Institute
Institutional Collaborator
10% time, contributed

German Diaz, GIS specialist, Rice University
Intimate knowledge of project; has worked with it since inception to develop GIS analysis methods
30% time, not funded by this proposal

Simone Roemhild, database consultant
Intimate knowledge of database needs of project
30% time, not funded by this proposal

Graduate students, UC Irvine and Rice University
Prepare maps for analysis
25% time, not funded by this proposal

Programmer analyst, to be named
Will develop best methods for user interface as more data sets are added, specific to needs of humanities scholars and teachers, to enable start-up phase of online version of project

20% time

Methods

Analysis involves combining an unusual set of software programs—Erdas’s *Imagine* for digitally restoring the originals,⁹ Illustrator or AutoCad for creating scalable vector versions of the originals for the analysis of segments, ArcMap for georeferencing the digitized maps, vegetation, elevation and hydrographic databases, and the NIMA’s Geonames server for defining contemporary names and locations.

The first step of understanding when and how large scale nautical charts emerged required the project director to assemble nearly all the extant charts of the western and southern coasts of Africa in one place. In order to compare maps, she first had to identify landscape features, names of capes, towns, and people listed along the coast. This has proven difficult due to instable nomenclature—the result of new European discovery, colonization and independence—and to environmental change. The process of identification began over a hundred years ago when Nordenskiöld began to decipher some of the names on about 15 of these charts. Other scholars followed and in some cases, tried to identify a modern location using latitude and longitude. However, the most recent such list appeared more than fifty years ago—before the independence of African nations—and the removal of many former colonial names.

The Geonames database from the U.S. National Intelligence and Imagery Agency gives us vastly improved precision by providing the contemporary and sometimes the historical names of thousands of communities in each of the countries of western and southern Africa. Even if both names are not provided, having all the names of nearby places in a large surrounding area allows us to see which place is the most likely modern equivalent of the older name. Geonames data also includes precise contemporary latitude and longitude, which means that all the locations

⁹ “Electronic Restoration: Eliminating the Ravages of Time on Historical Maps,” with German Díaz in E.A. Fox et al. (Eds.): ICADL 2005, LNCS 3815 (Heidelberg Berlin: Springer-Verlag 2005), pp. 100 – 108.

can be easily imported into a map using GIS software. When the identified historical names are linked to their modern ones, we can then map the fifteenth-century people and places to contemporary points along Africa's western and southern coasts.

For approximately sixty percent of the people and places, the geonames provide sufficient information to map historical people and places. When the modern equivalents of historical names are not immediately apparent, other features of GIS often help identify the location. Adding two other GIS databases—the site of rivers and hills (hydrographic and digital elevation models) along the coast—has proven particularly useful. On the fifteenth-century maps, places and peoples are sometimes placed on one side of the mouth of a river or on one side of a small hill. River locations have proved particularly helpful, because these fifteenth-century charts usually carefully mapped the locations of inlets and rivers along the shoreline. Adding a final layer of data—vegetation—allows us to look at the countryside surrounding these people and places. Matched with fifteenth-century indications of heavily forested regions, we can also form an idea about the process of desertification and deforestation. In a relatively few number of cases, the vegetation model suggests one reason why a fifteenth-century coastal people would have moved from the coast to the more heavily forested interior. The information on African people and locations can easily be delivered from ArcMap to the relatively fast and easy map delivery software package ArcIMS, resulting in a earlier look at west and southern Africa than contemporary scholars have ever had.

This identification process, significant in itself, serves also as the first step for our next goal: analysis of the history of coastal charting. After locating and georeferencing (connecting the historical names to contemporary locations), the contours of the original maps are transformed into scalable vector graphics via Illustrator or AutoCad. Each drawn coastal segment is then rasterized and matched against the corresponding segment of the modern coast. Laying the traced segments of the fifteenth-century map atop a modern one allows us to see exactly how close the historical chart comes to the contemporary one. We can then measure and compare the

differences in scale, distance, and direction between the two and even measure the degree and direction of the error.¹⁰ By repeating the process, over multiple maps and segments, we can measure the gradual improvements in accuracy in navigational map-making over the course of the fifteenth century. Looking at the time lag between the return of ships from each of the voyages and the appearance of the nautical chart of the region, we will also be able to identify the time at which nautical chart making became an increasingly swift and precise process.

We would next like to improve upon the existing visualization programs through customized programming. The most popular programs—ArcIMS and Mr. Sid—treat maps as fixed objects that allow viewers to zoom in on features or overlay them other equally fixed maps. None of these allow viewers to dynamically alter the mathematical formulae used to create a map and then see the results. For example, changing the formula for determining latitude from a secant to a logarithmic function alters the way in which northern and southern latitudes appear. Similarly, changing the calculations employed to create a projection also produces significant visual alterations in the basic shape of continents. As historians of the scientific era of cartography can attest, the importance of mathematical changes to the end result—i.e., the historic maps themselves—is considerable.

We will solicit feedback on the start-up phase (the initial website) through UCHRI channels. The project will be featured at UCHRI meetings and seminars on the digital humanities. Participants will visit the site and use the resource. A survey eliciting specific responses that produce useful information for the project director and staff will be distributed and thorough response encouraged.

Final Product and Dissemination

¹⁰ For an example of such an overlay see the illustrations from Gracioso Benincasa's 1468 map of West Africa in "Rewriting the History of Nautical Cartography," (with German Díaz) ESRI [Higher Education Conference Proceedings](#), 2004, figure

Our ultimate goal is to provide humanities researchers with a complete collection of these beautiful 15th century maps annotated with GIS-referenced information, a resource allowing them for the first time to identify features of these maps, gain new knowledge about locations and environments of 15th-century Africans, and analyze historical advances in cartography.

To date we have disseminated information about the project through publication of the techniques we have developed in the relevant disciplinary publications. The aim of the start-up project is to display the information on mapmaking and the fifteenth-century African coasts in an open access website. Eventually, the entire set of maps and the information linked to them will be assembled into a database that will allow people to ask for information on a particular group of people across all of the analyzed maps. Information will be retrieved from the databases using a standard computer language (Structure Query Language) and delivered to the website using the scripts available with open source Python.

We will work with our programmer analyst and SDSC to further increase functionality and to develop the user interface for optimal benefit to humanistic scholars. Visualization and display can be improved, advancing cartographical analysis as a result of presenting the maps with dynamically changeable mathematical formulas, rather than as fixed objects. More data fields and data sets will be added. UCHRI will host meetings of leading scholars in the relevant fields to determine which data sets, data fields, and annotations will be most useful to researchers and teachers. The NEH start-up grant will fund digitization of the remaining maps, programming for user interface and some increased functionality, bringing the project online. Ongoing preliminary analysis and preparation of the maps, as well as additional improvements (e.g., additional data set possibilities as advised by meetings of experts), will be funded by other sources.

We anticipate going online with some of the maps by the conclusion of the grant term. Functionality of the resource will be regularly improved with added datasets and more beneficial

user features. More maps will be added to the site as the preliminary analytical work on them is completed.

The project will be announced through UCHRI's network of 7000+ contacts and featured at its meetings and seminars on digital humanities. We also plan to present the project at relevant professional association meetings (American Historical Association, African Studies Association, Society for the History of Technology, etc.)

Work Plan

The first stage of presenting this collection in an open source environment involves making each individually analyzed map available using the relatively simple ArcIMS program from GIS publisher ESRI. We have already secured copyright permission from the British Library, Yale's Beineke Collection, and several Italian provincial libraries. Should we be unable to secure reproduction rights for other maps, we can use the vector images that we created from the original with our identification of places and people along the coast.

Four years of experience and two publications on the process of analyzing these maps has afforded a realistic understanding of what can and cannot be accomplished during a year. Furthermore it has provided an existing network of student assistants, GIS specialists, and data design consultants with whom we have already worked and who are both interested and enthusiastic about the project. Some of the students who have worked on the project are architectural graduate students at Rice University. These students are particularly valuable because the Architecture School demands a fairly sophisticated knowledge of GIS. In addition, these students are also familiar with the drafting and display software used in these projects (AutoCad and Illustrator). As a result, they need very little training to be able to work on these maps. They also seem to enjoy the work, because when they graduate, they tend to recommend the jobs to their friends.

The most efficient way to divide the work among the graduate students is to have three students—each working on a different segment of the African coast starting with the first section mapped by the Portuguese. The assignments are then divided according to the number of maps available for each segment. The first smallest segment (including the largest number of maps) runs from Bojador in present-day Western Sahara to Dakar, Senegal. The second segment runs from Dakar to Elmina in present-day Ghana. The third segment runs from Elmina to Sofala, just south of Beira in present-day Mozambique.

Working 10 hours a week, three graduate students can identify places and peoples, trace the coastlines, and georeference the names and coasts of a single map in approximately six weeks, thus creating five web-ready images per student over the course of 40 weeks. Having them all work on the African coast together allows discussion of names that have proven hard to identify on any given map. In the past this has proven especially helpful when names have been smeared—usually by water.

While the students are talented and hard-working, the GIS software frequently presents unexpected conundrums. For example, a recent problem involved trying to set the GIS map to a perfectly round sphere. The manual says that you can make this change easily, but in fact, as the GIS specialist found out after several hours that three intermediate steps (described nowhere in the literature) are required to set it to a perfect sphere. That instance merely showed us that not surprisingly very few people working with GIS are trying to reproduce the fifteenth and sixteenth-century assumptions of the earth as a perfectly round sphere. Having German Díaz, an experienced GIS consultant, is essential for the successful mapping of these fifteenth-century objects. Furthermore, he has collaborated on several already published technical papers providing solutions to some of the issues raised by working with historical maps.

The graduate students should be able to place the map images on the web via ArcIMS, so that pictures of the maps (or their outlines) will be available not long after the work is completed. However, in order to allow other individuals to ask questions of the information about each of

these maps, we will need to develop a user interface and prototype database of the names and web based query of the geographic places and names of communities on the map. The programmer analyst funded by the NEH start-up grant will design this interface working with database consultant Simone Roemhild, who is familiar with the project. The larger database and more sophisticated visually based searches will be developed with SDSC.

The project director will be analyzing the three largest and most complicated maps of Africa: Jorge Aguiar's 1492 map, the 1502 Cantino map, and the 1504 Pedro Reinel map. These maps represent the first complete images of the entire African continent. Analysis of the first map is nearly complete, while the second and third provide the earliest examples of the transfer of this technology to the New World.