Reports on National Historical GIS Projects

The U.S. National Historical Geographic Information System

Over the past twenty years, there has been a rapid growth in the area of geographic information systems (GIS) and the related creation of spatially addressable data sets. Much spatial data are related to population statistics, including the U.S. Bureau of the Census' TIGER files (geocoded street and enumeration-unit files that allow for spatial analysis and mapping). GIS has significantly broadened the scope of questions that can be asked with geospatial data, and has popularised the use of mapping techniques for the display of spatial information. GIS has facilitated the increased use of geodemographic analysis, including geomarketing and many forms of population analysis, by providing powerful means of analysing the wealth of population data that are now spatially referenced. Examples of these methods include the assessment of environmental justice and racism at multiple spatial scales (regional, urban, community); the calculation of segregation indices, and identification of areas of concentrated poverty; and the development of neighborhood indicators, including a multitude of economic and social measures based on population data. All of these kinds of analyses are based on applying GIS methods to census data.

Increasingly, researchers are attempting to use the census geographic base files for geodemographic analyses. For instance, after the 1990 U.S. census, it was possible to document the changes in geodemographics between 1980 and 1990 using the 1990 TIGER files. A common application was mapping the change in minority populations between the two periods. However, researchers are constrained mostly to two or three decades of temporal analysis with the availability of only post-1970 digital files. The development of digital geographic base files for the period 1940 to 1990 would allow a more detailed analysis of population change, at much finer levels of resolution (especially tract level), for most urban areas. Many potential research projects/application areas would benefit from the availability of such boundary files. Unfortunately, there is no complete set of digital census boundary files for the United States. For instance, comprehensive tract-level files simply do not exist other than for a very short time period.

The National Historical Geographic Information System (NHGIS), a five-year project funded by the National Science Foundation, will result in a comprehensive U.S. census database—at the census tract and county

levels—for both geographical and attribute data from 1790 to 2000. Technological change presents an unprecedented opportunity to make these data readily available for social science research. Bringing the complete census within reach of social scientists will unlock the potential of two centuries of data collection, and will stimulate research in economics, history, sociology, geography, and other fields.

In addition to creating a comprehensive spatio-temporal database, the NHGIS project will enable scholars to perform robust spatio-temporal analysis of census data, such as comparing census data with different enumeration boundaries through areal interpolation procedures that will be provided. The project consists of three major components: data and documentation, mapping, and data access.

- The data and documentation component gathers all extant machine-readable census summary data; fills holes in the surviving machine-readable data through data entry of paper census tabulations; harmonizes the formats and documentation of all files; and produces standardized electronic documentation according to the recently developed Data Documentation Initiative (DDI) specification for metadata standards.
- The mapping component creates consistent historical electronic boundary files for tracts, counties, and larger geographic units such as states.
- The data-access component creates a powerful, but user-friendly, Web-based browser and extraction system, based on the new DDI metadata standard. The system provides public access free of charge to both documentation and data, and presents results in the form of tables or maps.

The process of reconstructing census-tract boundaries begins with the Census 2000 TIGER files as the base. From these files, tracts for both 2000 and 1990 can be directly obtained. The 1992 TIGER files (updated after the 1990 census) provide the 1980 tract boundaries. For earlier decades, the tract-level boundaries are created backwards in time from scanned paper census maps to the first decade that a city was tracted which, for many cities in the eastern United States, dates to 1910. The enumeration unit of analysis for this tract work is the county, that is, tracts are scanned and processed together at the county level. When complete, boundary files and a significant amount of census statistical data will be processed for all census tracts and county units. As of the 2000 census, the entire United States had been tracted. County boundaries are based on tract boundaries where possible. For rural areas after 1910 and all areas before 1910. county boundaries are created backward in time, reflecting changes recorded in historical maps and other sources. NHGIS plans to create county boundaries for every county that was enumerated in a U.S. census. More than one-fifth of present-day states will have county data available from the first census, 1790 to the most recent census in 2000.

A significant part of the project involves the creation of several versions of the database corresponding to the different scales included in the NHGIS. This requires developing systematic and robust procedures for geographic generalization. The first component of this work involves determining which scales will best meet the needs of potential users. Will users require detailed metropolitan-level data, or more generalized county-level data for a multistate analysis? Our preliminary work has identified three scales as potentially most useful: one at 1:150,000 for detailed tract-level mapping; one at 1:400,000 for county-level mapping, and one at 1:1,000,000 for regional and national mapping. Current research is focusing on the exact methods of generalization to be applied, the potential measurements that are needed to ascertain both the selection of the algorithms, and the determination of tolerance levels. A final consideration is the Web-based delivery of multiscale geographical data.

The NHGIS is being developed at the University of Minnesota's Population Center. By 2005, researchers expect to have completed almost all census-tract editing. This work includes producing county-level boundary files containing the census tracts for each of the years for which tracts existed. Focus has now turned to comparing the completed files with the census data and making any necessary modifications prior to their release. The project began releasing test versions of the census data in late 2004, with modifications to the test files continuing as necessary. The final release of all tract and county-level data is scheduled for July 2006.

NHGIS Resources Online

• National Historical GIS online: http://www.nhgis.org

—Robert B. McMaster and Pétra Noble
University of Minnesota

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The Great Britain Historical GIS

Work on what was to become the Great Britain Historical GIS (GBHGIS) began in 1994 when Ian Gregory teamed up with Humphrey Southall at Queen Mary, University of London. In previous research with David Gilbert, Southall had created a large database of nineteenth-century demographic statistics. This consisted of census data published every ten years, vital registration statistics from the *Registrar General's Annual Reports* and *Decennial Supplements*, Poor Law statistics from the Returns of the Poor Law and Local Government Board usually published bi-annually, and an assortment of other data published at a variety of dates. Their initial aim was to create a GIS holding the changing boundaries of the administrative units to which these data referred.

Early in the project an architecture was developed whereby changes to administrative boundaries were stored in ArcInfo using "date-stamps" such that when a user specified a particular date, accurate to the day, the system would retrieve the actual boundaries in existence on that day and assemble them into an ArcInfo coverage. The ArcInfo coverages contained place-names that enabled them to link to the statistical data which also contained place-names and were stored in an Oracle relational database management system. Gazetteers were used to handle historical changes and variations in the spellings of place-names.

Building on this highly flexible architecture, the project was expanded to store the changing boundaries of all of the major administrative units of Great Britain from the early nineteenth century until 1974. Data for the post-1974 period were not included as these were already available in digital form. At the same time the Centre for Data Digitisation and Analysis at the Queen's University, Belfast (see separate report on Ireland) was added to the project to create a comprehensive statistical database of tables that recur in nineteenth and twentieth century census and vital registration statistics—data to populate the GIS. This project was completed for England and Wales in 2000 at around the time when Gregory and Southall moved to the University of Portsmouth. Scotland has been added subsequently. The data are freely available to the academic community. The boundary data can be extracted from the UKBorders units of EDINA at the Data Library, University of Edinburgh while the statistical data are available as the Great Britain Historical Database (GBHDB) from the Arts and Humanities Data Service, History (see URLs below). Unfortunately, users currently have to extract the spatial and attribute data separately and rejoin them themselves.

In recent years, the work of the key members of the original project has diverged. Ell's work is covered later in this volume. Southall's main emphasis has been on creating a website to disseminate information about British localities to a wide audience. This work has been funded by the New Opportunities Fund. At its core is a statistical database on individual places taken from the GBHGIS some of which has been simplistically interpolated (re-districted) onto a standard administrative geography to allow comparisons over time. Additional information includes textual data on places taken from both gazetteers such as the *Imperial Gazetteer from the 1870s* and Frederic A. Youngs *Guides to the Local Administrative Units of England*, and contemporary accounts of places such as those written by Daniel Defoe, Cecilia Fiennes, and William Cobbett. Creating this system in a way that can be easily disseminated over the Internet has involved redesigning the architecture of the system so that all of the data are primarily held in Oracle. Content from this system is increasingly being made available over the Internet through the "Vision of Britain through Time" website.

Gregory's main emphasis has been on developing analytical approaches to using the information within the GBHGIS and similar systems. Early

work, including collaborations with Southall and others, explored a variety of topics including changing migration patterns over time and changing patterns of poverty in England and Wales over the twentieth century. Work on poverty has been taken further to explore causal relationships between living conditions and health inequalities although these studies have a primarily statistical rather than geographical emphasis. Gregory's recent work has focused on how data from multiple dates can be interpolated onto a single administrative geography to allow them to be compared over time. Key to this is the ability to perform the interpolation as accurately as possible but also to explicitly handle the error that the results of any interpolation inevitably contain. Further work has concentrated on techniques for analyzing both the geographical and temporal nature of data contained in a national historical GIS. In particular, this has focused on the potential of geographically weighted regression building on the analysis presented in *Mapping the Great Irish Famine* by Kennedy et al. (1999).

A second aspect to Gregory's work has been in establishing how GIS can best be used within historical research. To this end he has written *A Place in History: A Guide to Using GIS in Historical Research* (Oxbow, 2002 and online [see URL below]), which includes an extensive bibliography of historical GIS scholarship. He and Paul Ell are currently writing a monograph titled *GIS for Historical Research* that will provide a more extensive overview of the field and its methods.

GBHGIS Resources Online

- Boundary data: http://www.edina.ac.uk/ukborders.
- Demographic data: http://hds.essex.ac.uk/studybrowse (then go to "GBHD Online").
- Vision of Britain through Time: http://www.visionofbritain.org.uk. See also: http://www.gbhgis.org.
- Ian N. Gregory, *A Place in History: A Guide to Using GIS in Historical Research*: http://hds.essex.ac.uk/g2gp/gis/index.asp.

—Ian N. Gregory
Centre for Data Digitisation and Analysis, Queen's University, Belfast

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A Historical GIS for Ireland

The Centre for Data Digitisation and Analysis (CDDA) at the Queen's University, Belfast has a long-standing interest in the computerization, visualization, and statistical analysis of large numeric, spatially referenced historical databases. The Centre has, for example, digitized most of the recurrent statistics contained in the Irish Census from 1821 to 1971, as-

sisted in the development of the Great Britain Historical GIS (see separate report on Great Britain); provided historical census data for that project; digitized the 1676 Compton Census, and worked on a range of historical-statistical data for Wales. Hence, the Centre is well placed to develop an Irish Historical GIS.

A number of factors explain why an Irish GIS would be of significant value. Ireland is simply little mapped. Even within historical geography and subjects that have been exhaustively analyzed using both quantitative and qualitative sources, Irish historians have rarely visualized or analyzed spatial relations. The Irish Potato Famine is a case in point. Scholars have produced detailed, lengthy books on a quantitative analysis of the Famine without a single map. The absence of maps is all the most striking because historical arguments about the Famine are essential spatial, such as that the Famine was worst in the west of Ireland and not as bad in Ulster. The recent atlas by CDDA and associates, *Mapping the Great Irish Famine* (1999) (using computer cartography rather than GIS) demonstrates that across a whole host of different measures, from demography to housing quality, religion, and language, there was a clear spatial dynamic. In other words, important research debates could be addressed by a national GIS.

This is even more the case for topics for which CDDA already holds a large amount of spatially referenced data for Ireland in electronic format. The Database of Irish Historical Statistics contains more than 32 million data values of census and related sources, all referenced by place-name and geographical location. These census data are far more comprehensive than for many other countries. Early Irish censuses go beyond head counts. They include information on the Irish language, literacy levels, religion, housing, emigration, and agriculture. Other datasets include crime statistics, health data, and civil registration information. Thus for Ireland, a rich set of data are already available for a GIS.

Further, Ireland's administrative geography lends itself to the development of a historical GIS. As in other countries, administrative units changed over time and generally do not nest one within another. Poor Law Union boundaries, for example, cross-county boundaries, and the number of Unions changed from, for example, 130 in 1840 to 163 by 1851. However, the smallest administrative unit, the townland, *does* nest within all higher-level units, both civil and ecclesiastical, and from 1861, the census records the administrative provenance of each townland. Moreover, townland boundaries rarely changed, and when they did they normally divided with no change to the outer boundary. Townlands are small, averaging about 200 acres; they total over 62,000 units. Digitization of these polygons would be a major task but justified, as from this all other units could be created.

The digitization of townland boundaries is not required however, thanks to a network of collaborators CDDA has built who are assisting in this area and others. Ordnance Survey Northern Ireland, the national mapping agency,

has agreed to allow CDDA to use their modern townland boundary coverage free of charge for educational purposes. CDDA has the straight-forward task of time-enabling these 1970s boundaries. Other key alliances have been formed with local museums, the School of Geography at Queen's University, and the Northern Ireland Statistical Research Agency—each providing unique expertise or sets of data for the Irish GIS.

Finally, the Irish project is learning from the experiences of the pioneers of national historical GIS development. Unlike the Great Britain Historical GIS, the Centre is not digitizing multiple administrative boundaries—it is starting with the most recent, accurate, detailed boundaries and working back in time. This avoids the problem of inaccurately overlaying coterminous boundaries that appear not to match as they have been digitized from different, imperfect sources. Because of the nature of Ireland's administrative geography, nor will different coverages for different administrative units be created, as all units will be built from the townlands. CDDA is not re-digitizing existing electronic data, namely the boundary data coming from the Ordnance Survey and recent socioeconomic data from the Northern Ireland Statistical Research Agency, considerably reducing costs as a result. Furthermore, in collaboration with the Electronic Cultural Atlas Initiative (see separate report) and the School of Archaeology at the University of Sydney, we are adapting TimeMap—a free, easy-to-use geospatial browser that enables researchers to use the data without having to learn GIS software.

To date, the Centre has the bulk of the attribute data in digital format and the modern boundary data available. Scholarly research so far has identified the need to begin mapping Ireland's past and the potential of spatial analytical techniques (see Ell and Gregory, this volume). The geospatial browser is well developed. Over the next few months, work to time-enable the townland coverage will begin together with the computerization of the locational attribute data. Each stage in this process is linked to a range of substantive research outputs. CDDA is creating a major research resource and will also be at the forefront of scholarship using the resource.

CDDA Resources Online

- CDDA online: http://www.qub.ac.uk/cdda

—Paul S. Ell
Centre for Data Digitisation and Analysis, Queen's University, Belfast

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The Belgium Historical GIS

Since 1990 a historical database of Belgian municipalities has been under construction at the Department of Modern History at Ghent Uni-

versity. Historical demographic and economic statistics at the level of municipalities for the period 1800-1961 have been systematically collected. Hundreds of historical maps have been digitized, representing the territorial structure of Belgium for the period 1800-2000. Recently, a sophisticated historical geographical information system and a website have been developed to make these maps and data accessible to the public.

The main goal of the project is to build a historical GIS that links the historical data to territorial units and enables users to map and analyze the data through time. To handle the evolution of hierarchical territorial units (such as municipalities, cantons, and arrondissemental districts) within a historical geographical database, four dimensions have to be integrated—geographical (longitude/latitude) coordinates, descriptive attribute data (such as population figures or place-names), hierarchic relations between different territorial units (which municipality is part of which district), and time. These components are subject to continuous change—boundaries, hierarchical relations, and attribute data evolve simultaneously and independently from each other. It is clear that this complex situation cannot be described within a simple table-linked-to-map-system. To reconstruct territorial evolutions within an HGIS, advanced methods such as the method of least common geometry have been applied.

The Belgium HISGIS is based on three modules:

- *Module 1*: A map of least common geometry, containing all historical boundaries of Belgian municipalities for each census year between 1800 and 1963 and for the present-day situation as of 2003. The map is stored in one single map layer, as an ArcView shapefile, in Belgian Lambert 72 map projection. This is a flexible storage system for geometric data, which contains all polygons representing every historical municipality down to the smallest units. Each polygon has been time-stamped. By linking historical data to this map the boundaries of municipalities, valid only for a particular moment in time, can be extracted from this map.

  In comparison to systems based on simple tables linked to different historical maps (snapshots in time), the most important advantages of the method of least common geometry are:

  - The geometry of the map can be easily updated, and each boundary exists only in one map and not in hundreds of different historical maps; and
  - Evolutions of attribute data (for example, population densities) of territorial units can be interpolated through time, even if the names, shapes, and areas of territorial units have been changed.

- *Module 2*: A spatio-temporal relational database-management system, powered by Microsoft Access XP, containing all information of the evolution of the historical territorial units, their composition and the

historical attribute data, linked to the territorial units and to the map of least common geometry. Thanks to the hierarchical structure of Belgian administrative units, the map of the municipality boundaries also can be used to reconstruct territorial units at a higher level, such as departments and districts, since districts are assembled of different municipalities and departments consist of different districts.

The database contains the following information:

- The name of each Belgian municipality since 1800.
- A linktable for the composition of each department between 1800 and 1963: districts in each department.
- A linktable for the composition of Belgian districts between 1800 and 1963: municipalities per district.
- A linktable for the composition of the Belgian cantons (juridical and electoral) between 1800 and 1965: municipalities per canton.
- Dates marking the creation and abolition of each department, district, electoral canton, and juridical canton since 1800.
- The number of inhabitants for each census year between 1800 and 2001.
- Data on land use in 1834 per municipality: area per land use category.
- Selected municipal data on agriculture (province of Antwerp, 1846), industry and employment (province of Eastern Flanders, 1846, 1880, 1896, 1910).

- *Module 3*: Since September 2003 a website has been created, making all data accessible via the Internet. The maps on this website are snapshots in time: each map is valid for a certain moment in time (December 31 of each census year). Data linked to these maps can be visualized and analyzed interactively. The system is free and open to the public. The map browser of our website is powered by "CommonGIS," which is a shareware program, developed and provided by the German Fraunhofer Institute. Users of our website do not need to install additional software on their local PCs; CommonGIS will be started on our server whenever the user sends a request to consult a particular map.

From 2005 onwards, the information system of the Belgium HGIS will be used and developed further to compile a Historical Atlas of Belgium, 1800-2000. This atlas will be based on a large collection of statistical municipal datasets and will visualize the country's main demographic and economic transitions in a large set of interactive maps. The digital atlas will also be available in print (including texts analyzing the main historical trends).

The HGIS is explained in greater length in M. De Moor and T. Wiedemann, "The Historical Geographical Information System of Bel-

gium," *History and Computing* 3:1 (2001): 69-96. The system provided the empirical basis for S. Vrielinck's three-volume study, *De territoriale indeling van België 1795-1963* [The territorial division of Belgium] (Universitaire Pers Leuven, 2000).

Belgium HGIS Resources Online

• Belgium HGIS online: http://www.flwi.ugent.be/hisgis/

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—Eric VanHaute
Ghent University

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Towards a Historical Geographic Information System for the Netherlands (HGIN)

As this issue goes to press, the History Department of the Netherlands Institute for Scientific Information Services (NIWI) in Amsterdam is in the process of digitizing all Dutch historical censuses (1795-1971). Within a few years, they will be accessible for statistical research. In order to add a geographical component to these census statistics, the NIWI recently has started a complementary project called Historical Geographic Information System for the Netherlands (HGIN).

The HGIN project is not the first of its kind in the Netherlands. Two pioneer projects, "Kartofoot" and "NLKAART," will be integrated into the HGIN project. The Kartofoot project, which started in the 1960s, was the first historical mapping system for the Netherlands. From a map of the 1856 municipal division of the Netherlands, E.W. Hofstee constructed the "Kartofoot," a giant jigsaw puzzle of over 1,000 pieces, in which every piece represented a different municipality. With ten differently shaded copies for every municipality, he was able to construct choropleth maps for all kinds of variables. As soon as an assistant finished the puzzle according to Hofstee's instructions, a photograph was made which was ready for publication (see Figure 1).

The main problem with Hofstee's map was that it only represented the municipal division of the Netherlands in 1856. However, every year, municipalities merged or boundaries changed. As a consequence, the total number of municipalities in the Netherlands fell from more than 1,200 in 1830 to about 600 in 1990. In order to draw a correct municipal map of the Netherlands for every moment in time between 1830 and 1990, 280 different maps are needed instead of the one Hofstee created. Hofstee more or less solved the problem by recalculating or interpolating the original statistics. In so doing, he managed to use his 1856 map for data from the start of the nineteenth until the beginning of the twentieth century.
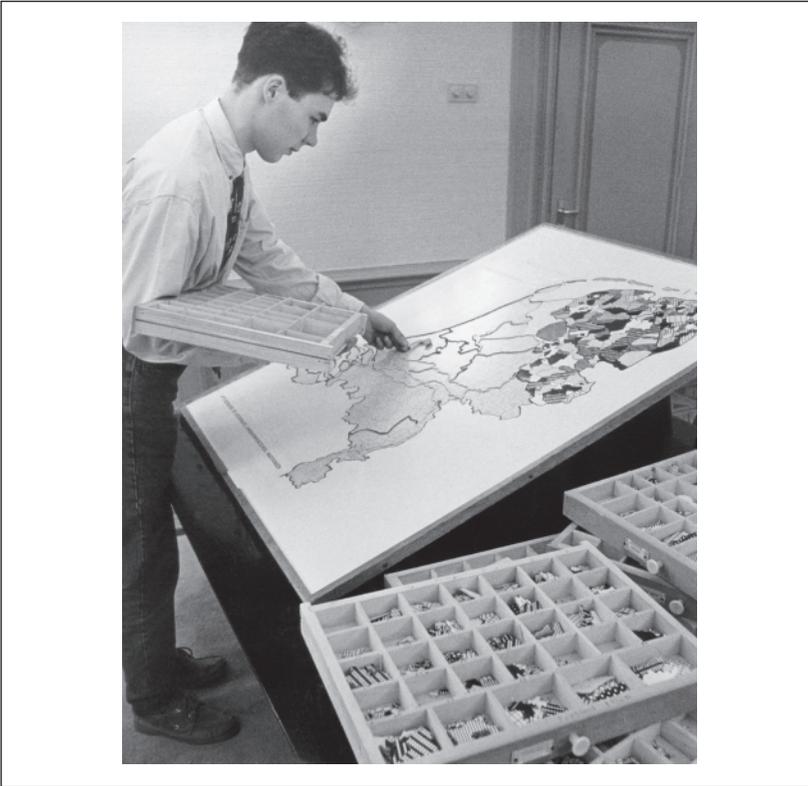
Figure 1. Putting the Kartofoot together: Hofstee's assistant at work, mid 1960s. Photo by W.F.J. de Jonge.

The second pioneer project, NLKAART, was initiated by Onno Boonstra. This project, which started in the mid 1980s, aimed to solve Hofstee's problem using computer technology. Boonstra's system consisted of just two tables in a relational database. The first table identified the municipality and the time period in which each municipality existed in a specific form, the second table contained the coordinates of that specific form. Because the NLKAART system ran in SAS using SAS/Graph to create the maps, a few lines of programming sufficed to retrieve municipalities with the correct boundaries for a given date, combine them with relevant statistical data, and put them into a historically accurate map. Initially, NLKAART covered 150 years, 1830-1980. In the late 1990s, the system was extended to the earliest period for which data on municipal boundaries is available in the Netherlands, 1811-1990. There also was a partial conversion from SAS to MapInfo.

The current HGIN-project aims at four general results:

- *Conversion of NLKAART.* HGIN aims to convert the full NLKAART system into municipal map layers for a genuine historical GIS.

- *Adding data*. Because NLKAART's database only consists of the bare historical maps, one has to enter his or her own data into them to create a thematic map. HGIN will incorporate data from different sources, beginning with digitized census data. A gazetteer that links place-names with relevant historical information and aggregated units will be created.

- *Adding depth*. HGIN will take NLKAART two steps further in geographical depth by digitizing *wijken* (neighborhoods) and *buurten* (blocks). Census data are available for this level of geographical detail for the years 1849 to 1971. For the most recent census years (1960 and 1971), the available sources are very good and very detailed. The existing sources for the census years between 1930 and 1956 are less well preserved, but they should still facilitate the creation of map layers for the entire country. The sources for the years before 1930 are very scattered. A pilot project will research the possibility of finding and digitizing the necessary information for about thirty municipalities back to 1849. The results of this pilot will be evaluated to see if it is possible (technically and financially) to recreate the sub-municipal boundaries of all Dutch municipalities for the census years between 1849 and 1930.

- *Distribution through WWW*. The HGIN project aims to distribute maps and (census) data over the Internet. Different GIS servers will be tested before a choice is made.

The first results of HGIN will be available in 2006.

HGIN Resources Online

- HGIN home: http://www.niwi.knaw.nl/nl/geschiedenis/projecten/toon (in Dutch)

—Luuk Schreven, Onno Boonstra, and Peter Doorn
Netherlands Institute for Scientific
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HGIS Germany: An Information System on German States and Territories from 1820 to 1914

This project grew out of an interest in the construction of digital historical maps of the development of German and European states. Such maps, arranged in thematic strands and combined in series covering important benchmark years, have been placed on a mapserver that is already in operation at the Institute of European History (IEG) at Mainz, an

independent research institute loosely connected with Mainz University. However, map series can only show a limited amount of information for selected dates at fixed scales, and it is generally not possible to attach a large variety of thematic data such as statistical or general historical information to them. A GIS solution, using an ArcGIS platform, was therefore designed in order to cover this gap, which, in a sense, then led to a new project, "HGIS Germany," now being developed by the IEG in conjunction with the Institute for Spatial Information and Surveying Technology (i3mainz) at Fachhochschule Mainz, University of Applied Sciences. The project team is headed by Andreas Kunz (IEG) and Wolfgang Boehler (i3mainz). Major funding for an initial three-year phase has been secured from the Krupp Foundation of Essen, Germany.

HGIS Germany will be an historical information system focused on the development of Germany's states and territories during the nineteenth century. Powered by a GIS engine, it will enable the user to select specific territorial units— such as states, provinces, and districts—and explore their "life histories" over a period of 100 years. At the core of the system are data on changes in the spatial development of the units under investigation, basically the forty-one states comprising the German Confederation of 1815 and their successor states up to 1914. All boundary changes that occurred between and within these states (to the level of the governmental district—*Regierungsbezirk*) will be recorded in the GIS database on a yearly basis, creating a complete record of area changes for even the smallest of the German states or "statelets" at the time—of which there were quite a few prior to unification in 1871. Moreover, the design of the database and its input make it possible to display administrative linkages of the nearly 500 areas that comprised the German Confederation in 1820. This is done in a hierarchical fashion, providing a foundation for a comprehensive administrative history of Germany that will be far more flexible and more easily accessed than existing print histories.

Besides the spatial development of territories, the information system will offer additional geographical and contextual information related to the units, such as the name and location of the seats of government, the attachment of units to supra-national bodies such as customs unions, or whether an area was ruled by more than one state as a so-called "condominium." Moreover, special attention has been given to the recording of some 140 very small enclaves and exclaves, all of which can be accessed through the database in conjunction with some 130 administrative divisions of the 41 German states. At present, this data exists for 1820, but eventually such information will be provided on an annual basis from 1820 up to 1914.

The information system will serve as a platform for historical statistics as well. Numerical data will be integrated directly into the GIS database, so that scholars can use the data in statistical calculations or to generate thematic maps. Naturally, within a project of limited financial re-

sources only selected data and limited functionalities can initially be placed at the disposal of the user. Initially, the system will include figures on population, textile production (to 1850), the production of iron and steel (as of 1850), the mining of coal and iron ore (as of 1850), and—in the realm of socio-political history—on the ruling families of the German monarchical states. The data on population and production will, if possible, be made available at the lowest territorial level now used in the system, that is, for governmental districts. Finally, multimedia presentations on each state, as well as on administrative units and special territories, will soon be available from the project website. The presentations contain explanatory texts and visual documents such as historical maps, manuscript documents, images, tables, and graphs. The objects in these presentations will be integrated at the upper query level, as will the maps on the IEG mapserver.

HGIS Germany will become available as an Internet-based system. A prototype may be available as early as the fall of 2005. It will be accessible both through the IEG and the i3mainz websites. We may also create a more expert-oriented version, which would be available on demand through academic and/or institutional channels for all members of the growing historical GIS community.

HGIS Germany Resources Online

- Development of German and European states: http://www.ieg-maps.uni-mainz.de.
- HGIS Germany: Will be accessible through http:www://inst-euro-history.uni-mainz.de and http://www.i3mainz.de.

—Andreas Kunz, Institute of European History Mainz
—Wolfgang Boehler, University of Applied Sciences Mainz

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Historical GIS Initiative in Russia

Russian archives contain hundreds of thousands of large and medium-scale maps and related manuscripts describing administrative boundaries and the nature and economy of the country on a very detailed level. They belong to military surveys, surveys of forests, and estate plans from the eighteenth to the twentieth centuries. Every historian uses them to study localities. A wide spectrum of statistical data on nature, land use, population, economy, culture, and social life was gathered, processed, and stored by the government with the data's affiliation to the relevant administrative division and place-names. The demand for such data now comes from a broader scientific community, including political scientists, geographers,

economists, ecologists, and linguists. Meeting all the needs of detailed, countrywide research based on these materials still exceeds human power.

There have been few attempts in Russia to integrate spatially referenced historical data. The main obstacles have been (1) the incompatibility of maps from different periods due to various scales, coordinate systems, projections, and mapping technology; (2) the difficulty of dealing with the great variety of textual data that can be spatially referenced; (3) changes over time in administrative boundaries; (4) variability in spelling of place-names; and (5) low accessibility of cartographic materials. There are many historical maps of Russia, but they are scattered between archives; there is not enough information about their availability; and, not long ago, the majority of them were classified ("top secret"), whatever their age and scale, and so out of reach to researchers. The reforms of the last fifteen years opened archives and map collections for research. But still maps are scattered between different archives, making them difficult to study, and statistical data are usually kept separately from maps.

The main purpose of our initiative is to provide an overview of the network of Russian administrative boundaries and place-names from 1775 up to 1920. The starting date is the year of the administrative reform of Catherine II that concluded the long period of modernization of administrative control over the regions. The principle task is to create an accessible electronic reference system that allows one to view administrative boundaries at the local level (*uezd* and *volost*) and their temporal dynamics, and to determine the past and present administrative affiliation of an area or village. We aim to build a system that will be easy for researchers to use and that will be compatible with the most common GIS software.

We consider compiling the framework of Russian administrative boundaries and place-names to be the decisive step to applying digital methods in Russian historical geography. This work will provide the academic community with the spatial data and technological framework for the analysis of their own spatially related data. It will also provide a framework that other researchers may use to create their own digital maps and data. Though all these goals are too ambitious to be fulfilled within a single project, starting the whole initiative may have a very broad promotional influence on the state of research.

The initiative is now in a pilot phase. All information on the current activities can be found at the project website (see the URL at the end of this article). Up to this point, the most work has been done compiling lists of historical maps in archives, including the Russian State Archive for Military History, the Archive of the Foreign Policy of Russian Empire, the Russian State Archive of Ancient Documents, the Cartographic Department of the Russian State library, the library of the Russian Geographical Society, and other repositories. The information gathered during the study was included in the online bibliography devoted to Russian historical ge-

ography and a set of scanned historical maps presented in a small Internet-gallery (listed at the end of this article).

In 2003-2004, we conducted two small projects on the construction of a georeferenced gazetteer of historical place-names, which we consider to be the integral part of historical GIS. The first one was conducted in collaboration with the Harvard Yenching Institute. We analyzed old maps of western China, created in the second half of the nineteenth century by Russian military surveyors, agents, and travelers of the Russian Geographical Society. Though this project did not cover the territory of Russia, it enabled us to work out technological approaches for processing, standardizing, and integrating Russian historical data on the global level. We digitized maps of various scales and dates, extracted historical information, and built several geo-referenced datasets of historical place-names. These datasets, together with a catalogue of cartographic sources from Russian archives, formed the Russian contribution to the China Historical GIS (see CHGIS report).

Another project focused on the territory of Petersburg *gubernia* (the northwest of European Russia) and is being conducted in collaboration with the Center for Environmental and Technological History of the European University at St. Petersburg. The general goal is to reconstruct the spatial development of fisheries in the eastern part of the Baltic since the sixteenth century in order to understand the main changes in the Baltic ecosystem. The usage of fishery statistics from Russian cadastres for the sixteenth to the nineteenth century required knowing the exact geographical location of many ancient fishery sites. Our contribution is the geo-referenced historical gazetteer of place-names, digitized from old Russian maps for the Russian section of the Baltic sea coast. By the end of the project we plan to publish materials on the World Wide Web.

As we continue to develop the Russian HGIS, we are strongly interested in any possible contribution from and collaboration with the academic community worldwide. We want to build on the momentum created by the main initiator of historical GIS activities in Russia, our colleague and friend Alexei Karimov, whom we lost in a car accident in February 2004. As a historical geographer, he foresaw the great prospects for developing historical GIS in Russia and its potential usefulness to the scientific community. He contributed a lot to the detailed study of the historical cartographic sources being kept in Russian archives. His personal pages on the Web represent his contributions to, and his vision for, a historical GIS of Russia.

Russian HGIS Resources Online

- Russian HGIS home: http://www.ihst.ru/personal/imerz/bound/bounds.htm. This site includes a bibliography of Russian historical geography in Russian (imerz/bound/biblio.htm).

- Web gallery of historical maps: http://195.19.12.125/personal/krm/work/collection/collection.htm
- Russian section of China Historical GIS: http://www.fas.harvard.edu/~chgis/data/rus_geo/
- Alexei Karimov pages: http://www.ihst.ru/personal/krm/Karimov_pages.htm

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China Historical GIS

The China Historical Geographic Information System (CHGIS) project began in 2001 and the basic work is scheduled to be completed in 2006. Its main object is to create the authoritative common base GIS for Chinese history from the inception of a unified bureaucratic empire in 222 BC to the end of the dynastic period in 1911 AD. In the future, the GIS can be extended in time—forward to the present and backward to early history—and spatial detail can be added. It is an open-ended platform, which can be used as the basis for the digital representation of many kinds of spatial and temporal data.

The geographical core of CHGIS is a comprehensive digital compilation of administrative units and human settlements, all of which have been georeferenced and documented at each stage of their historical development. This is possible over the span of more than 2,000 years because of the government's long tradition of conducting land surveys and household registration, holding censuses, and compiling national administrative geographies. In addition, for the last thousand years of Chinese history in particular, CHGIS aims to include cities and towns outside of the administrative seats of county and prefectural government to enable study of urban, economic, and cultural development that are not adequately recorded in government sources. By the eleventh century the population had reached about 100 million. The state apparatus did not expand with the increase in population and it was no longer able to control the ownership and distribution of land or to limit commerce to official markets. The extraordinary increase in commercial activity outside of state control brought with it unprecedented urbanization and new commercial networks. The fact that market towns might grow larger than the county seats under whose administration they fell points to the need for the GIS to recognize both economic networks and administrative structures.

Tracing the development of non-administrative towns is made possible by the appearance in the twelfth century of a new kind of historical source—the local gazetteer (*difang zhi*)—which compiled place-specific

information about settlements in the county, religious establishments, schools, population, villages and towns, tax quotas, arable land, crops, names and dates of civil service degree holders, and more. Many included maps. Over 8,000 such gazetteers are extant.

The point of creating a base GIS for Chinese history is to make it possible for users to map their data—whether population reports, tax quotas, military garrisons, or religious institutions—onto historically accurate administrative and settlement geographies. By downloading the base GIS, researchers can join their own datasets to it and create new data layers appropriate to their projects. They can analyze the CHGIS data, test hypotheses about spatial relationships, generate historical maps for research, teaching, and publication, and—because CHGIS provides an internationally available and authoritative platform—share their data with others. By the end of 2004 continuous time series for seven of the eighteen core provinces were completed and made available through CHGIS v.3.

At the same time, CHGIS serves two other functions.

- It is an *historical gazetteer*. Researchers can use CHGIS to find information about a specific place, to see when it existed, where it was, where it belonged in the administrative hierarchy, and what historical documentation exists for these findings. This means that almost any place-name found in historical texts can be accurately located. The CHGIS search engine, which functions as the primary historical gazetteer server, is a free, Web-based utility that currently receives between 20,000 - 50,000 search requests per month.
- It is an *electronic atlas*. Because CHGIS has adopted a "continuous time series" approach—that is, it traces all known boundary and settlement changes over time, so that users are free to decide which moment or moments they wish to view—it may be used it as a source of maps of the known administrative structure and settlements of China for any year between 222 BC and 1911 AD. Users can do this for themselves, generating maps as they need them, or they may consult and download sample maps from the series of maps based on CHGIS data.

The core content of CHGIS is being created by China's primary national center for historical geography, the Center for Historical Geography at Fudan University in Shanghai. Many of the scholars there who were involved in the authoritative, multi-volume reference work, the *Historical Atlas of China* (*Zhongguo lishi ditu ji*, 1982–1987), are now conducting new, more detailed and precise research for the CHGIS project. CHGIS goes beyond the atlas in providing a continuous time series rather than particular moments in time; it takes into account far more primary sources and modern research; it specifies relationships to the administrative hierarchy; it provides exact longitude and latitude coordinates; it provides beginning and ending dates for all historical places; and it includes source notes. The completed work will supercede any existing historical

administrative geography of China in terms of temporal range, spatial accuracy, and documentation of sources.

The source notes linked to the spatial objects and administrative and settlement data in the GIS are of particular importance and cannot be found in any printed historical atlas. They consist of extracts from the historical sources used to determine administrative changes, point locations, and boundaries. Historical texts, with bibliographic citations, are quoted directly from primary and secondary sources in Chinese and are accompanied by commentaries in which the editors provide written justifications for their choices. In this way the core research being done to create the database is exposed to the users for their reference.

All CHGIS place-name records are compiled in English transliterations (Pinyin) and Chinese characters (both simplified and traditional). In addition to these primary records, the CHGIS data model allows for variant place-names. Currently the database contains place-name records in several vernacular scripts: Chinese, Japanese, Russian (Cyrillic); and several romanized forms: Pinyin, Wade-Giles, and Non-standard Variants. We are working on expanding the entry of vernacular equivalent names in Tibetan and Mongolian. In this way, the CHGIS database functions as a multilingual historical gazetteer, easily expanded to include any vernacular script input in Unicode UTF-8 character set encoding.

The raw datasets of CHGIS are made freely available to the public for unlimited and unrestricted non-commercial use in two of the most widely used standard GIS data formats: ESRI shapefiles and MapInfo tables. CHGIS data is mounted on the Harvard University and Fudan University servers, where it can be browsed, searched, mapped, and downloaded using ordinary Internet browsers without any additional software clients or plug-ins. In the United States, all CHGIS data will remain permanently available through the Harvard Geospatial Library. As electronic formats change, it will be migrated to new formats.

CHGIS Resources Online

- Harvard University: http://www.fas.harvard.edu/~chgis
- Fudan University: http://yugong.fudan.edu.cn/chgis

—Peter Bol, Harvard University
—Jianxiong Ge, Center for Historical Geography, Fudan University

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HGIS Project of Korean Culture

Since August 2002, Korea University's Institute of Korean Culture (IKC) has carried out a project named the *Electronic Cultural Atlas of Chosun*

Korea (ECA-CK). The research team consists of thirty professors and thirty graduate students in the fields of geography, history, philosophy, literature, and folklore. The culture that was developed during the Chosun dynasty (1392-1910) became the foundation for the culture of modern Korea. This project is aimed at transferring the various cultural phenomena of the Chosun dynasty into digitized information and then transforming this information into maps. We hope that the GIS database that is the basis for the ECA-CK will provide a new research methodology for the study of culture throughout the Chosun period.

The present state of development of the ECA-CK can be summarized in three parts. First, the basic framework for the project has been developed. The unit forming the atlas' geographical framework is the county (*GunHyun*), beginning with the 330 counties that served as administrative districts of the original Chosun dynasty. The culture of the Chosun dynasty has been classified into twenty subjects, and temporal and spatial classification standards have been set. Second, the databases and thematic maps on the twenty subjects, including population, agricultural land, roads, temples, paintings, food, markets, traditional music, and games, have been or are nearly completed. Third, through comparison and analysis of the collected data, several studies of historical continuity and change in the culture of the Chosun dynasty have been conducted.

The framework for the ECA-CK is composed of a three-dimensional search structure that is broken down into various time, place, and subject-related categories. Users can obtain the desired information by choosing an entry from each of these three categories. Currently, the time and place categories are limited only to topics related to Chosun dynasty and Korea. However, the basic principle of this project is to eventually extend the time range from the ancient to present time and also to expand the spatial range to include other territories related to Korean history in various periods.

Although the objectives of this project are quite simple, there remain many tasks that still need to be carried out as well as many limitations that need to be overcome in the future. First, one of the main objectives behind the development of ECA-CK is to provide researchers with a scientific database of reliable information. It is a delicate process to select texts and to design the database, partly because we have attempted to keep the contents of the database as simple as possible so that it is accessible even to the general reader. Second, there is an urgent need to translate the information contained in the database into English so that the project can serve a larger audience. Third, Internet capabilities also must be developed. The eventual objective for ECA-CK is to make all the information available on the Internet. We hope to achieve this by the summer of 2005.

The two-year period of funding for the development of ECA-CK is rapidly coming to a close. Over the last two years, the researchers associated with this project have published the results of their studies in various academic journals. They are now preparing to present a second round of

papers in their respective fields. These researchers have also introduced the results of their studies in international academic conferences such as the Computer Applications in Archaeology conference held in Vienna in April 2003, the Pacific Neighborhood Consortium conference held in Bangkok in November 2003, the Electronic Cultural Atlas Initiative (ECAI) meeting held at the University of California at Berkeley in May 2003, and at academic conferences hosted by IKC. Their major findings have been published in *Korean Cultural Studies* 38. A joint international workshop was held on May 20, 2004, with members of Berkeley's East Asian Library, the Japanese Historical Maps research project, and the China Historical GIS team. In addition to having the achievements of ECA-CK made available on the Internet, other studies that have made use of our electronic cultural atlas will be published in book form or as a compilation of materials.

The research team also is planning to carry out a three-year research project designed to establish databases for a comprehensive gazetteer, the topography of South Korea, and the geography of traditional folk music, fables, and beliefs. We recognize the necessity for constructing electronic cultural maps of other regions. It is our hope that in addition to our project, we can someday participate in the development of electronic cultural maps of East Asia. Lastly, it is our fervent hope that other researchers and institutes will share our interest in this project and provide us with valuable expertise.

South Korea HGIS Resources Online

• Research articles based on ECA-CK are available at http:// ikc.korea.ac.kr/culture/ culture_start.htm.

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HGIS of Print Culture in Canada

Since 1997, we have been exploring ways to visualize and understand the development of print culture, a multifaceted and complex social phenomenon. Print culture embraces the circuit of textual communication (whether manuscript, print, or electronic) from creation, or authorship, through production and dissemination to reception by users and readers. This circuit involves the printed texts themselves and all the participants in the circuit, coupled with the social, political and economic factors that produce them. Our long-term goal is to use GIS and associated mapping as a framework for exploring and visualizing the variables of print-culture

history in ways that approach more holistic perspectives than are otherwise possible. Towards that end, we have received funding to develop Canadian data for a model HGIS project as part of a major grant from the Social Sciences and Humanities Research Council of Canada for the project, *A History of the Book in Canada / Histoire du livre et de l'imprimé au Canada*. Several national book history projects are currently underway, but the Canadian project is the first to have an HGIS component. Our focus is on nineteenth-century data as modern Canada developed during that century.

Print-culture historians, such as George L. Parker, have long affirmed the crucial role of such factors as religion, education, and ethnicity in local and regional patterns of print culture. We are examining these roles using standard sources of data such as censuses, and visualizing them locally and regionally within a GIS environment, in order to make comparisons across both space and time. Two pilot studies aided us in designing the HGIS. The first, completed in 1998, used census records for counties in nineteenth-century England. The second, completed in 2003, used aggregate late-twentieth-century Canadian census data.

Our work at Dalhousie University and the University of Regina has focused on the development of a national database of the printing and allied trades. The Canadian Book Trade and Library Index (CBTLI) includes more than 13,000 records relating to individuals and organizations active in the trades in the nineteenth century. Seven thousand of those records were extracted from the 1881 Canadian census. We will add data from other historical censuses as they become available. Other records have been created from town and regional directories and from newspaper advertisements and notices, mainly from the late-nineteenth century. Each record within the CBTLI can contain up to forty-five fields which include biographical and business information in addition to fifteen fields devoted to geographic information down to the street and building level, whenever this is known.

Our achievements to date include snapshots of historical data within our GIS. We have analyzed the religious adherence and ethnicity of members of the Canadian book trade as compared to the general population and have considered the spatial range of locations with book trade activities in relation to known transportation routes. We and our research assistants have presented the results of our work at conferences and workshops in Canada, the United States, and Europe to audiences representing many scholarly disciplines. Our current analyses concentrate on comparisons between Nova Scotia, a well-established province of Canada by the 1880s, and Manitoba, which was a newly acquired, sparsely populated territory at that time. Time series for fuller temporal analyses will be developed as we expand the historical range of the CBTLI.

In the future, we will work collaboratively with other projects developing book trade indexes (BTI) that aim to incorporate GIS. The British

and Australasian BTI projects both plan to use GIS. We are active participants in international conferences related to print culture such as the Society for the History of Authorship, Reading, and Publishing (SHARP). Our collaborative aims are to produce research resources that will permit scholars to search and visualize spatial and temporal patterns related to print culture. Within Canada, we are developing links with other projects such as the Montreal HGIS, "Montréal: L'avenir du Passé." As many geographies of print changed over time due to immigration, government settlement initiatives, mandatory schooling (introduced in Canada in 1870), changes in printing technology, methods and technologies of transportation, and urbanization, we plan to develop additional GIS databases relating to these variables. While our GIS work at present is housed at a limited-access site, we plan to make it, and all of its eventual accompanying datasets, available to scholars internationally.

History of Print Culture Online Resources

- Canadian book trade and library index: http://www.dal.ca/hbic-hlic
- British book trade index: http://www.bbti.bham.ac.uk

—Fiona A. Black and Bertrum H. MacDonald
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The Electronic Cultural Atlas Initiative

The Electronic Cultural Atlas Initiative (ECAI) was founded in 1997, when Lewis Lancaster, professor of Buddhist Studies at the University of California, Berkeley, was researching the transmission and transformation of the Buddhist canon as the religion spread throughout Asia. He recognized that a written description of this process, even with map images, would not do justice to the complex geographical, cultural, political, and economic contexts within which it occurred. He convened colleagues to propose the collaborative development of a digital cultural atlas that would incorporate not only research about Buddhism, but also other information that could be located in time and place, about trade, politics, ecology, historical events, and heritage sites. ECAI emerged from these conversations.

In subsequent discussions, Lancaster and his collaborators decided that the atlas should not be conceived as a static publication. Rather, the initiative could capitalize on developments in GIS and networked search and retrieval technologies. The cultural atlas would be an ever-evolving collection of content with a spatial component. A central catalog of metadata would link to datasets maintained and updated by their cre-

ators. Users would create customized maps incorporating data from many sources; scholars would share spatial data over the Web.

When ECAI was founded, existing GIS software posed difficulties for humanists, museum curators, and others with limited technological expertise who wished to represent continuous historical change in boundaries, settlements, hydrological features, or routes of travel. ECAI supported the University of Sydney's TimeMap Project to develop the metadata clearinghouse, map-authoring software, and time-enabled map browser required by the ECAI community. TimeMap is a system for customizing and displaying historical-spatial data. The TimeMap Java Web-mapping applet incorporates an interactive timeline slider bar and on-screen animation. These tools allow users to filter data so that the map displays only the information about a specified time period, making it possible to show spatial change over time. The map browser also includes the capacity to create hyperlinks to texts, images, databases, and other non-spatial data. TimeMap Windows software makes it possible to create projects for the World Wide Web by combining raster base maps and database layers from multiple sources, filtering and rendering data, and creating the necessary metadata. The TimeMap Java applet and windows software are freely downloadable for personal and educational use.

The ECAI clearinghouse is integrated with the TimeMap system. It currently contains over 800 datasets and authored interactive maps. It is also linked to over 1,500 georeferenced images of historical maps from the David Rumsey Map Collection. Users can assemble customized maps by selecting multiple datasets from many sources. There are no access restrictions to the ECAI clearinghouse. However, individual data owners may choose to password-protect their own data. In addition to the clearinghouse, ECAI has created electronic publications and atlases, with objects on interactive maps linked to websites incorporating databases of images and library resources, text, and links to related projects. A showcase achievement is the Cultural Atlas of Iraq, recently selected as Featured Collection by *D-LIB Magazine*. Other ECAI atlases and publications focus on the Persian Sasanian Empire; ivory and bone carvings from Afghanistan; Austronesian languages of the Pacific; French and Spanish missions in North America; recent scholarship on Southeast Asia; travelers and empires of the Silk Road; and Daoist sacred geography in Sichuan. Many of these are accessible from the ECAI website.

The initiative is not only a system for organizing and disseminating geographic and historical information. ECAI also promotes the development of digitized geospatial and temporal information for history and the humanities, and engages in research on issues pertaining to time-variant and multilingual spatial information about culture. To promote geospatial research and publication in the humanities, ECAI has sponsored two international conferences per year since 1998. In addition, a number of workshops, ranging from four hours to one week in length, have offered

training in relevant software and methodologies. ECAI affiliates and staff have delivered papers at many digital library, history, and geography conferences. ECAI has co-sponsored specialist meetings on topics ranging from grid computing to virtual reality. In April 2004, ECAI launched an H-NET sponsored e-mail discussion list for people interested in cultural atlases and geospatial studies in the humanities. Articles about ECAI have appeared in *Past Time, Past Place: GIS for History*; *Central Asian Studies Review*; *D-LIB*; *History and Computing*, and numerous conference proceedings.

Digital cultural atlases are an emerging genre. The software, standards, and good practices needed to create spatial data, map visualizations, and Web-based atlases, and to network and share them on the Internet, are still developing. Digital gazetteer development is a particularly important area. Gazetteers are databases that index information about named places. They can be used as reference works that associate places with many names through time and in different languages, georeference named places, and provide summary information about a place, such as its feature type (county, school, river), and position in an administrative hierarchy. Gazetteers can also link place-names to textual sources and to library catalogues and other kinds of databases that can be searched by place-name. Finally, gazetteers are the basis for historical geographical information systems that include rich documentation in addition to map visualization. ECAI has been funded by the National Science Foundation to develop standards and good practices for historical and multilingual gazetteers, and by the Institute of Museum and Library Studies to network gazetteers with library catalogues.

The Religious Atlas of China and the Himalayas is ECAI's newest research and development project. Begun in January 2004 with funding from the Henry Luce Foundation, it will be based on multilingual historical gazetteers about Chinese religious geography. Collaborators in Asia, Europe, and North America are combing reference works and primary sources for spatial information about temples, mountains, pilgrimage routes, Islamic mosques, Buddhist kingdoms, Christian missionary schools, and other religious places. The Religious Atlas is projected for completion in 2007.

ECAI Resources Online

- ECAI home: http://www.ecai.org. This site includes links to the Cultural Atlas of Iraq (ecai.org/iraq), the Religious Atlas of China and the Himalayas (ecai.org/chinareligion), and the gazetteer projects (ecai.org/projects/gazetteer).
- TimeMap Project: http://www.timemap.net.
- ECAI Clearinghouse: http://ecaimaps.berkeley.edu/clearinghouse.
- David Rumsey Map Collection: http://www.davidrumsey.org.
- Discussion list on cultural atlases and geospatial studies in the humanities: http://www.h-net.org/~ecai.

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