



# Harvard Revisited: Geography's Return as GIS

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## **Center for Geographic Analysis at Harvard University – Operational Model, Achievements and Perspectives**

### **Establishment of the Center**

Geographic information systems (GIS) technology is valuable to many disciplines. It provides a framework for organizing our knowledge geographically. It reveals patterns, relationships and processes, broadens our knowledge and deepens our understanding. It helps us conceptualize, represent and communicate ideas, reconstruct history, illustrate the present, or plan for the future. In order to harness the benefits of GIS, many universities have established GIS centers.

There are two common models of GIS centers in universities. One is department based, such as the three National Centers for Geographic Analysis (NCGA), the GeoPlan Center at the University of Florida, and the Environmental Resources Spatial Analysis Center (ERSAC) at the University of Minnesota. Departments hosting GIS centers include geography, urban planning, and forestry, among others. The other common model of university GIS centers is library based, or library joined with university IT services. Examples are abundant, such as Stanford University, Yale University, MIT, or Rice University.

Prior to 2006, Harvard University had both models. The Graduate School of Design had been offering GIS course modules as part of its curriculum and spatial analysis support by its IT staff. Meanwhile, the Harvard College Library Map Collection also had GIS staff offering spatial data and GIS support to users across the university. However, Harvard faculty and administrators felt that much more needed to be done to meet future demand for geographic analysis.

To the degree that a department based center is focused on serving the hosting department or school it may have few resources left for the rest of the university. A library based center serving the entire university may be limited in its service by the operational conventions of libraries. To overcome these limitations, Harvard University established the Center for Geographic Analysis (CGA) in 2006. The CGA works with both the School of Design and the Map Library, but it has a broader mandate.

At its inception, the CGA was designed to focus on research and education in the field of spatial analysis and geographic information. The Center's goal has been to work with entities across the university to strengthen university-wide GIS infrastructure and services; provide a common platform for the integration of spatial data from diverse sources and knowledge from multiple disciplines; enable scholarly research that would use, improve or study geospatial analysis techniques; and improve the ability to teach GIS and spatial analysis at all levels across the university. This paper briefly reviews the Center's 3-year accomplishments and development trajectory.

### **Research services**

#### ***Help desk***

CGA staff offers two physical help desks, one on the main campus; the other on the Longwood medical campus. Both provide a weekly walk-in or scheduled service to anyone with a Harvard University ID. Professors may come to ask questions about where to find data for their research projects, students may come to see a demo on how to do certain spatial analysis, post-docs or research fellows may come to discuss which software package is most suitable to include in their grant proposals. Those who can't come at the pre-scheduled time may email to schedule a one-on-one session. Many use the CGA virtual help desk which guarantees a response to an email or phone call within 24 hours. The number of help desk users has been steadily growing, with a monthly average of about 10 in 2006, 20 in 2007, 40 in 2008 and 60 in the first half of 2009.

### ***Consultation***

Many faculty members require more dedicated service than a help desk session. Often CGA staff is invited to attend a project team meeting, review their project plan, examine collected data, and offer advice on how to incorporate geographic analysis into their project at various levels. Such consultation can be a one-time, half-day effort or a series of 1-2 hour sessions over several months. Like the help desk service, such consultation is provided free of charge.

### ***Project work***

When the demand for CGA staff time goes beyond a few hours, the work is managed as a "project". CGA staff will fill out a one-page project specification, documenting the required work, estimated work time, planned deliverable product, deadlines and foreseeable risks and alternative approaches. The scope also indicates the amount of service, charged at a flat rate of \$75/hour. Work will start when the user approves this project specification. Modifications to this document may be made at any time during the project life span when both parties agree to the changes. When work is completed, CGA staff will send the user an invoice accordingly. For users who don't have enough funding to cover such service charges, CGA offers discount at various levels. The objective is to offer the most needed service for all, but also to educate users about actual cost of such services, and prioritize CGA staff time to guarantee deadlines for those who have sufficient funding.

### ***Contract management***

It is not unusual for a project to require some labor-intensive work, such as massive digitizing of paper maps, repetitive georeferencing of scanned image tiles, or specialized code programming. Such work is outsourced to external service providers. CGA maintains a list of such companies with competitive rates. CGA staff translates research project demands into technical service requirements, negotiate service terms, manage the contract, and perform QA/QC of the deliverables. Products of such contract services are submitted to the Harvard Geospatial Library or the GeoTools portal for sharing according to the nature of the product and the usage permission of the source materials.

### ***Grant proposals***

After the initial consultation, researchers may invite the CGA as a collaborator for their project in the grant proposal writing phase. CGA staff may write a section of the proposal, or provide a letter of support and other required contents. In such cases, CGA service charges will be included in the project budget.

### ***Teaching and training***

Before the establishment of the CGA, there were a couple of courses in the Graduate School of Design and the Department of Anthropology which had GIS modules. The CGA injected both credit courses and non-credit training programs which are open to all in the University.

### ***For-credit courses***

Through the Department of Government, a full time GIS preceptor offers credit courses to students in the Faculty of Arts and Sciences, the School of Engineering and Applied Sciences, the Harvard School of Public Health, and the Harvard Medical School. About 50 undergraduate students and 85 graduate students have taken these courses since 2006. Six undergraduate students received thesis guidance from the GIS preceptor. CGA staff also added GIS courses through the Harvard Extension School. Available GIS courses in the current school year can be found at this website: <http://gis.harvard.edu/icb/icb.do?keyword=k235&pageid=icb.page189847>

### ***Non-credit training series***

CGA staff also offers non-credit training series that is free and open to everybody with a Harvard University ID. These training sessions are two to four hours long, combining short lectures with several hands-on exercises, aimed at giving students a conceptual introduction and some

practical skills in geographic analysis. Topics are demand driven and have been expanding every year (<http://gis.harvard.edu/icb/icb.do?keyword=k235&pageid=icb.page189848>).

### ***Annual thematic workshop***

It has become a tradition for the CGA to host a one day conference every spring. These annual thematic workshops are free and open to all Harvard affiliates with others accommodated as seating is available. The topic is determined by the CGA Technical Advisory Committee, and the event logistics are supported by the Institute for Quantitative Social Science. Some of these workshops were co-sponsored with other Harvard organizations such as the Harvard University Center for the Environment and the Harvard Museum of Comparative Zoology. Presentations on these workshops are made available online for the public (<http://gis.harvard.edu/icb/icb.do?keyword=k235&pageid=icb.page148866>).

### ***Summer GIS institute***

In the summer of 2009, the CGA introduced a new training program called the Harvard GIS Institute. This is a two-week intensive training session mainly designed for graduate students and research fellows at Harvard. It includes not only lectures and lab exercises but also guest speakers introducing application cases in various disciplines, tours to GIS related facilities on campus, student selected projects using GIS, and a one-day mini-conference for the students to present their work. Registration demand significantly exceeded capacity for the summer session. It will be offered again in January of 2010 as an over-flow session, and most likely be repeated every summer, if not every winter too, in future years.

### **Infrastructure support**

#### ***Site license***

The CGA took over responsibility for administering the university site licenses under agreements with Environmental Systems Research Institute Inc. (ESRI) and Leica Geosystems. It has since adjusted the GIS site license portfolio, added ArcGIS Business Analyst, Data Interoperability, Idrisi and Google Earth Pro. The floating licenses are served out from one central server but backed up by several departmental servers. The single use licenses are administered through a standardized procedure with verification of user IDs and signed statement of understanding of the license restrictions. The cumulative usage of the ESRI licenses averages more than 10,000 hours per month, and about 150 copies of single use ArcGIS student licenses were distributed in 2008.

#### ***Online data library***

The Harvard Geospatial Library (HGL) is a web based searchable catalog developed and maintained by the Harvard University Library (<http://hgl.harvard.edu>). It contains many kinds of geospatial data, from global elevation information to building footprints to scanned and georeferenced historic maps for cities around the world. Data can be searched by location, subject, author or date, and most of the data can be displayed on screen or downloaded. It includes items from the Harvard Map Collection, data created by the CGA and a selection of records from the Dataverse Network (DVN) at the Harvard Institute for Quantitative Social Science. In addition to contributing data contents, CGA staff are also actively involved in the redesign of the system's user interface, promotion of its usage among Harvard users, and improvement of its interoperability with other Harvard systems such as DVN and AfricaMap.

#### ***Hosting of web GIS services***

As web mapping technologies have matured, an increasing proportion of service projects designed and completed by CGA staff have resulted in web based services. A list of such services can be found at this website: <http://gis.harvard.edu/icb/icb.do?keyword=k235&pageid=icb.page222549>. Some of these services run on the ArcGIS Server platform (e.g. The Fall of the Roman Empire, Chinese Earthquake Web Map), others on Google Map API applications (e.g. The Surgical Safety Web Map, Geographic Location Finder), yet

others are run on a specially developed geoportal (such as AfricaMap). Even though most of these applications were developed for Harvard researchers in other departments or schools, many of them don't have the infrastructure and expertise to host and maintain such services without long term support from the CGA. The web GIS hosting service from the CGA has turned out to be welcome and cost effective way to fill this niche.

### ***GPS and plotting equipments***

CGA maintains a series of GPS devices of different accuracy levels and functional specifications. They can be checked out on a first-come first-served basis by people with a Harvard affiliation. CGA staff also publishes best practice guidelines for their field usage and post data processing. In addition, the CGA provides large format map and poster plotting services on a 42" HP DesignJet Z6100 plotter to any Harvard ID holder. The usage is fee based mainly for material cost recovery. It is much cheaper than commercial services of similar kinds.

### ***Computer labs on both campuses***

There are 11 computer labs in several schools on both the main campus and the Longwood medical campus that have GIS software installed, and the number is growing. CGA staff provides periodical upgrade media and consultation to these lab managers.

### ***Community building***

#### ***Newsletter and website***

The CGA newsletter is published monthly to a listserv of over 1000 subscribers. The listserv is open to the public for self subscription. The newsletters are also published on the CGA website with a complete archive of all issues. The CGA website (<http://gis.harvard.edu>) has 57 pages displaying 135 live topics. Many of the topics are updated daily. There were on average more than 800 unique visitors per week in 2008. 3500+ users from 51 countries downloaded materials from the CGA website in 2008.

#### ***Student award***

The Howard T. Fisher Prize for Excellence in Geographic Information Science was established in 1999 to promote and reward student work in GIS, from both undergraduate and graduate students at Harvard University, with an endowment from Jack Dangermond (MLA 1969), President of ESRI. Howard Taylor Fisher, geographer and mathematical cartographer, founded the Laboratory for Computer Graphics and Spatial Analysis (LCGSA) at the Harvard University Graduate School of Design (GSD) in 1965 where he developed the synegraphic mapping system (SYMAP). Currently, the prize is jointly sponsored by the CGA and the GSD. Each academic year, CGA invites faculty or staff members from three or more schools within the University to form the annual H.T. Fisher Prize Award Review Committee. The Review Committee administers the award process for the year.

#### ***Technical seminars***

Jointly with the co-chairs of the Harvard ABCD-GIS group, CGA introduces topics and guest speakers for geospatial technical seminars to the Harvard GIS community on a regular basis. Most CGA staff has also served as a speaker at this forum. The seminars are open to the public, and generally held at noon on the 3<sup>rd</sup> Wednesday of the month.

#### ***Technical information exchange***

CGA staff constantly monitors geospatial technology development trends, new products, new titles, new events and new data sources. Information is shared with the public through blogs, conference reports, hardware/software/data service evaluations, code sharing, etc. carried on both the newsletters and the websites.

## **Collaboration promotion**

### ***Cross disciplinary connections***

The CGA's operational model has had a much-appreciated byproduct in a highly decentralized university: cross-disciplinary and cross-school connections. People from all parts of the university come to CGA for assistance in finding data, making maps, selecting analytical tools, receiving training, etc. Through broad user contacts, CGA staff often finds themselves in a unique position to help make cross disciplinary connections for scholars. An epidemiologist from the Harvard School of Public Health might be looking for the same census data as a political scientist from the Harvard Kennedy School of Government studying violence; and an entomologist from the Harvard Museum of Comparative Zoology may be interested in building the same digital elevation model and hydrologic network as a historian or archaeologist studying ancient trade routes. Through the CGA, some of them became aware of other's work in the same region of the world, made contacts to each other, shared base data and local data sources, coordinated equipment usage (such as GPS), and some even found other's work inspiring to their own research.

### ***Institutional Membership***

Representing Harvard University, the CGA manages institutional memberships in geospatial technology and academic organizations such as the Open Geospatial Consortium, Inc. (OGC) and the University Consortium for Geographic Information Science (UCGIS).

### ***Visiting scholars and student interns***

Since its establishment, the CGA has housed over a dozen visiting scholars and student interns. Coming from diverse background and research interests, each has contributed to the CGA operation in a unique way: lecturing on their research projects using GIS, participating in CGA service projects, conducting individual research and producing technology documentation in the CGA's shared technical document archive, developing geospatial tools or designed geodatabases to enhance a module of a CGA system. Through these activities, they also received GIS training, technical help, review comments and other input from CGA staff and other scholars and interns at the CGA. The close interaction in this extended CGA community benefits all participants academically and technically.

### **Combining “research with GIS” and “research on GIS”**

When the CGA was established in 2006, its primary focus was to support research and teaching with GIS, which means using mature GIS technology to enhance research and teaching of all subjects, rather than research on geographic information science itself. However, in doing so, we have found that even though mature GIS technology is far from being utilized at its full potential, there are cases when proven technology falls short in solving a particular problem or providing a particular service. Such unmet needs push the envelopment of geographic information science itself, and inevitably lead us into the research on GIS.

One such challenge is the need for a system that is publicly accessible, simple to use for non-technical scholars, fast in search and mapping speed, and rich in geographic content. Finding no exiting tool or system that met this requirement, the CGA has made a particular effort to develop a geoportal, known in its current incarnation as the AfricaMap system.

### ***AfricaMap***

AfricaMap is an open source, web-based mapping framework designed to make data on Africa easier to discover and explore. While currently focused on Africa, the technology can be used to organize information for any region of the world, large or small. The system is designed to support very large quantities of data and very rapid and unstructured search, as well as cartographic quality display of multiple layers. The system leverages the vast holdings of the Harvard Map Collection and other sources inside and outside Harvard and attempts to use location as a framework to organize and display research projects and actual data, so that

researchers can click on a particular location and find information and data from all recorded projects which describe that geographic location, across disciplines. More information is available from the About tab on <http://africamap.harvard.edu>.

Since the beta version release in November of 2008, the CGA has received many requests to clone the system to other parts of the world. Several of these requests are currently under construction, including a Boston Research Map, a Vermont Geological Map, an East Asian Map, and a Harvard Forest Map.

### ***Medieval European Civilization***

Another challenge has been to completely avoid system development while making web based mapping an integral part of a series of courses in Harvard's Department of History. The goal is to let students visualize historical places, monuments, excavations, relief and vegetation of the late Roman Empire. Students use the web map to zoom in, click on a site and see all related information about the place, including listening to the instructor's tour of the monument, site, or excavation, as well as viewing all digital resources, especially photos. This project provides the first high quality digital maps of the Roman Empire and Medieval Europe which are suitable for continuous improvement and adaptation in teaching and research worldwide. The website below shows just a small portion of what the students use in the classroom, the content of which was developed over several years: <http://cga2.cga.harvard.edu:8399/Roman/>. Even though the performance of this off-the-shelf system still needs improvement, the underlining geodatabase design addressed a number of unconventional issues such as the life span of historical objects and events, uncertainty and nonstandard time definitions, and the verification and consolidation of multi-source scholarly inputs.

### ***China Historical GIS***

Similarly, the China Historical GIS project (<http://www.fas.harvard.edu/~chgis/>) is another example of GIS supporting humanities, which not only applied mature GIS database and mapping technologies to historical data, but also touched on some thorny spatial-temporal modeling issues, such as representing hierarchical relationships of historical administrative units whose polygonal boundaries were never defined or not known, or retrofitting historical population distribution to a finer scale based on modeled natural, economical and social environment over the historical landscape.

These projects, often started as an application of existing GIS technology, eventually contribute to the geographic information science in many ways. Unlike stable business operations in the industrial or public sectors, academic research in any discipline constantly explores new approaches, new analytical means, and new viewing angles to very diverse objects and processes. They present a strong demand and ample testing cases for the study of new scientific methodology. The CGA is uniquely positioned at the crossing point of research with GIS and research on GIS. It is firmly based on the former, with much potential to grow in the later.

### ***Future Perspectives***

From early 2006 to mid 2009, the CGA has doubled its staff size and quadrupled its office space. Looking into the future, the physical growth of the Center may be slow in terms of staff, budget or space, but its service scope and research topics will continue to evolve rapidly. The principle is to effectively respond to demands from the user community.

Based on the input from the faculty steering committee, the technical advisory committee and the general users, the CGA plans to continue on its current course, which includes expanding in areas most demanded by the users, such as improving and expanding the AfricaMap framework to more regions and use cases, and extending the GIS Institute to a broader audience, eventual including undergraduate students.