

REPORT ON THE CENTER FOR SPATIAL STUDIES

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1. Background

The Center for Spatial Studies, also known as `spatial@ucsb`, was established in July 2007 with three years of funding from the Executive Vice-Chancellor. This report describes the center's activities and achievements to date.

The vision of a Center for Spatial Studies was developed by a special committee that met in the first few months of 2007 with a mandate to consider the state of spatial thinking, data, and tools across the campus. The committee recommended the establishment of a center whose primary objective would be to develop spatial thinking as an approach to scholarship, supporting its use across the entire range of disciplines at UCSB.

Spatial thinking has become increasingly relevant over the past few years, driven by a number of factors:

- the increasing familiarity with spatial perspectives among our students, acquired through exposure to video games, movies, and many other forms of spatial information;
- the increasing availability of spatial technologies, including Web services that emphasize maps, tools for designing and manipulating images and video, GPS navigation systems, and spatially oriented applications in 3G phones;
- an increasing awareness that spatial thinking is not given sufficient emphasis in traditional education, despite the massive attention given to the development of other forms of intelligence, including verbal and mathematical thinking; and
- research in spatial cognition that shows the importance of spatial intelligence as a predictor of student success in science and engineering.

The center is also intended to capitalize on existing strengths at UCSB, and to enhance their public image. Numerous centers, programs, and courses touch on spatial thinking, and many of these activities are widely recognized nationally and internationally, but until the creation of the Center for Spatial Studies UCSB lacked a centripetal unit that could bring these disparate strengths under a single umbrella.

The center was funded for three years beginning in July 2007. It has three staff: a Program Director (Don Janelle), a half-time Administrative Coordinator (Karen Doehner), Computer and Network Technician (Guylene Gadal). In addition the budget allows for two graduate student researchers.

This report is divided into sections detailing the center's activities in 1) services, 2) curriculum development, and 3) research and funding. Section 5 summarizes progress to date and discusses future options. Publications and presentations about the center's activities are listed in the final section.

2. Services

The center has been designed to provide a number of services to the academic community at UCSB. These include the development of labs and working space where access can be provided to cutting-edge hardware, data, and software tools; the creation of a consulting service and seminar series; community outreach; housing for visitors; international summer workshops; and a conference series. All of these have helped to enrich the resources at UCSB for spatially enabled research, and have contributed to the development of a strong interdisciplinary thread of spatial studies.

2.1 Renovations

Shortly after the establishment of the center three spaces were renovated: Phelps 3510/12, which serves as the center's primary space, Ellison 2616, and Ellison 3625. Phelps 3510/12 had served since 1989 as the UCSB site of the National Center for Geographic Information and Analysis, the subject of a major NSF award. NCGIA still exists as a collaboration between the University of Maine, SUNY Buffalo, and UCSB, under a memorandum of understanding; its activities have now been subsumed under the Center for Spatial Studies. Phelps 3510/12 was stripped, and new offices and workspace were installed, together with a conference space, a large electronic wall display, new servers, and new workstations. The renovation successfully transformed what had become a crowded space into very convenient workstations for students and an ideal environment conducive to the activities of the center.

Some months later Ellison 2616, which had previously served as a graduate lounge for the Department of Geography, was renovated into a 16-seat computing lab with high-end workstations. This lab is designated for use by graduate students and faculty for center-related activities by graduate students and faculty, and for the international workshops that the center offers each summer. It also houses the help-desk activities of the center.

Ellison 3625 was also transformed into a workspace for graduate students working on research projects in the area of transportation, and named the Geotrans Lab. It accommodates a large center research project on the LA ports (funded by US DOT), as well as research projects directed by Kostas Goulias.

All of these facilities benefit from the UCSB site license for ESRI software, for which UCSB receives a significant discount. The cost of the site license has been shared for many years between the various user groups on campus. In addition strong links have been established with the Map and Imagery Laboratory, a major repository of spatial data, and with other groups on campus that manage substantial data resources, including MSI, Facilities Management, and CCBER. The center has chosen this approach of building partnerships as a better alternative to developing its own data-center functions.

2.2 Seminar series

The center has made special efforts to bring together faculty and student researchers from across the campus to exchange ideas and methodologies about spatial thinking and spatial analysis. These include the *ThinkSpatial Brown-bag Forum* and the *Graduate Student Forums*.

The ThinkSpatial series (beginning in December 2007) has included 33 noontime presentations, featuring UCSB faculty and graduate students from the departments of Art, Computer Science, Geography, Mathematics, Psychology, the Bren School, and the Neuroscience Research Institute, as well as visitors from the Los Alamos National Laboratory,

the U.S. Geological Survey, and from the universities of Auckland, Bremen, Ohio State, Redlands, Seoul, Temple, Washington, and Wollongong, and from CSU Northridge. These sessions have averaged more than 20 attendees per session, with some attracting as many as 40.

The Graduate Student Forum features student-organized events, drawing on student participants who have come from Anthropology, the Bren School, Computer Science, Earth Science, Geography, Media Arts, Political Science, and Psychology. These sessions have included the *Spatial Technology Lunch Discussions* (one per academic quarter for student discussion and interdisciplinary collaboration on spatial research themes) and the *Spatial Technology Coding Circle*. The latter events have focused on applications of the Python language, the PostGIS database management system, the Geoserver data server, and the OpenLayers visualization service, and have examined generic problems with the goal of learning about various technologies and practicing their integration. *Spatial Lightning Talks* are a recent addition to the Graduate Student Forum series, featuring about ten compressed talks on spatial topics over a lunch period.

The Center has also collaborated with other units on campus in both advertising and sponsoring speakers for special events. These have included:

- With the Department of History (Feb 2009): Jennifer S. Light (Departments of Communication, History, and Sociology, Northwestern University), speaking on “Taking Games Seriously.”
- The 10th Annual Dangermond Lecture (May 2009): Shashi Shekhar (Computer Science, University of Minnesota) speaking on “Evacuation Route Planning: Novel Spatio-temporal Network Models and Algorithms.”
- The Department of Geography Colloquium (Feb 2010): Susan Cutter (Hazards and Vulnerability Research Institute, University of South Carolina), speaking on “Disaster Resilience and Vulnerability: What to Measure, How to Measure, Why Measure?”

2.3 Consulting service

The center moved quickly to establish a regular consulting service, offering advice to the campus community on the use of spatial data and tools. This has evolved into a weekly event with a broad base of interested users, including faculty, graduate students, and undergraduates. It is staffed by graduate research assistants. Many of the topics concern standard GIS client software, but there is increasing interest in Web programming and server software, and in tools such as Google Earth.

Since the consultation program began in 2008, support requests have ranged from simple cartographic design advice to complex, multistep spatial information modeling. The following are a sample of projects and departmental affiliations that have received technical support from the spatial@ucsb help desk:

- Inventorying food preparation sites of California prehistoric peoples (Department of Anthropology)
- Mapping California farm labor (Department of Anthropology)
- Modeling harvest pattern change following the creation of a marine preserve (Bren School)

- Assessing crime patterns near various categories of media distribution sites (Department of Communication)
- Routing police patrols to disrupt gang activity (Department of Economics)
- Mapping Asian communication infrastructure (Department of Film and Media Studies)
- Delineating information flows for disaster mapping (Department of Geography)
- Analyzing transportation networks and socioeconomic factors on access to education in a developing nation (Department of Geography)
- Identifying dangerous bridges with respect to pedestrian traffic (Department of Political Science)
- Assessing cartographic arrangement against spatial cognition (Department of Psychology), and
- Prescribing maintenance schedules for campus road, parking lot, and paths by quantitatively modeling condition (Design and Construction Services)

2.4 Community outreach

While the primary orientation of the center has been towards the campus, several activities have focused on outreach and relations with the local community. The center's official launch event, in May 2008, was publicized widely, and included two general-interest keynotes:

- Shoreh Elhami, co-founder of GISCorps, a group sponsored by the Urban and Regional Information Systems Association that provides volunteer experts in GIS and related tools to disaster relief efforts; and
- Jack Dangermond, President and co-owner of ESRI, the leading supplier of GIS software located in Redlands, CA.

The event also included a poster display featuring the work of UCSB students and faculty, and projects in the local community. Many of the approximately 250 attendees were able to tour the Four Eyes Lab and the Allosphere, both UCSB facilities with strong spatial orientation.

In June 2009 a similar event (spatial@ucsb.local09) was sponsored by the center to continue the momentum of local outreach established by the launch, and a third (spatial@ucsb.local10) is planned for June 2010. These events give UCSB undergraduates an excellent opportunity to display and discuss their work, and are co-sponsored with the Channel Islands GIS group, a collaboration among GIS users in Santa Barbara and Ventura Counties. For the 2010 event we plan to feature the Allosphere again, as well as the Map and Imagery Laboratory.

The four fires that have impacted the Santa Barbara area in the past three years have provided another opportunity for initiatives that emphasize the use of spatial data and tools in emergency management. During the Jesusita Fire a Web site co-organized by one of the center's graduate students, Alan Glennon, provided up-to-the-minute maps and fire status reports, culled from a multitude of online sources. Recently the center has sponsored a visit from Susan Cutter, a professor of geography at the University of South Carolina and an expert on the assessment of social vulnerability to hazards. A series of meetings has been held with local officials and locally based Direct Relief International, with the objective of developing a local project to map social vulnerability in Santa Barbara County.

2.5 Visitors

The center has hosted several productive visits over the past three years:

- Xiaohua Tong, Tongji University, Shanghai. An expert in the application of statistical methods to the modeling of uncertainty and error in spatial data, Tong visited for the 2008–2009 academic year and worked with Goodchild and graduate student Linna Li on problems associated with the conflation of spatial datasets.
- Kun Lee, University of Seoul. A professor of Urban Sociology, Lee spent a year-long sabbatical as a visiting scholar (2007–2008). He spent his time at spatial@ucsb learning to apply GIS to his research interests, which include survey methodology, census studies, and the labor market.
- Miguel Gómez, Universidad Complutense de Madrid. He collaborated with Professor Stuart Sweeney in the project “Intra-urban industrial location under institutional and accessibility constraints” from 2009–2010, analyzing and separating the factors that explain the location decision of an industrial establishment, and attempting to identify the existence of spatial interaction or clusters. The analysis will be applied to the highly industrialized Madrid region of Spain.
- Arnold Bregt, Professor of Geo-information Science, Wageningen University, The Netherlands, will spend part of a sabbatical year with the center, starting in July 2010. His interests concern research on spatial data infrastructure (SDI) and agent-based modelling. At UCSB he will focus more on human–space interactions, geo-sensor networks, and voluntary geographic information within an SDI context.

Although the space available in Phelps 3510/12 is limited, the center recently received an additional allocation of space for visitors on the 4th floor of Ellison Hall. This will allow us to increase the rate at which we accept visitors.

2.6 International summer workshops

For the past two decades UCSB has gained a reputation as a home for workshops offered to senior graduate students and junior faculty during the summer months on a variety of spatial topics. The tradition began with NCGIA and the Varenus Project in the 1990s, and continued with the CSISS and SPACE projects. In 2005 we received two years of funding from the National Institute of Child Health and Human Development for two years of week-long residential workshops aimed at the current cohort of young demographers and population scientists, and in 2008 were successful in proposing five further years of more advanced workshops on topics in spatial analysis. These workshops have traditionally been substantially oversubscribed, and have been unusually successful at attracting graduate students and junior faculty from minority-serving institutions. In 2010 UCSB will host two workshops, one focused on geographically weighted regression and the other on spatial pattern analysis. Participants come from a broad range of disciplines, including demography, epidemiology, the social sciences, and the health sciences. A limited number of positions in the workshops have been filled by participants from UCSB, most recently from the Bren School, Economics, Marine Science, and Sociology. The workshops have also provided instructional experiences for Geography graduate students, who work as teaching assistants.

2.7 Conference series

Another longstanding spatial tradition at UCSB has been the Specialist Meeting, originating in

1988. These meetings convene 30-40 researchers from around the world to discuss the state of the art in a cutting-edge topic, and to formulate a community research agenda. Almost 50 such meetings have been held, with a variety of funding sources including NSF. In December 2007 shortly after the establishment of the center we organized a specialist meeting on Volunteered Geographic Information, coining the term and beginning a research tradition that has now gathered significant momentum. Two such meetings were held in 2008, one (the International Symposium on Geographic Information Science) to mark the 20th anniversary of the funding of the National Center for Geographic Information and Analysis (NCGIA) at UCSB in 1988, and the second (Spatial Thinking in Science and Design) to explore the relationship between fundamental spatial concepts in GIS on the one hand, and the design disciplines on the other. This second meeting was funded by ESRI, and reflects a very active interest on the part of that company in what is being called *geodesign*, or the use of spatial tools and data to provide a scientific basis for landscape architecture, urban planning, and related design activities. That meeting led to a full-scale conference organized and hosted by ESRI in January 2010.

Another specialist meeting is in the planning stages for December 2010, on the topic of spatial and temporal constraints on network interactions. This topic is attracting significant interest in the intelligence community, and seeks to reconcile two opposing views: the traditional spatial view that distance is a significant constraint on interaction, and the contemporary view that the Internet has obliterated such effects. The center will organize the meeting in collaboration with Kathleen Carley's group of networking theorists at Carnegie Mellon University.

3. Curriculum development

One of the center's goals is to increase student access to courses and instructional materials that build spatial intelligence. Efforts since the establishment of the center have focused on the UCSB undergraduate curriculum; on building interdisciplinary strength at the graduate level; on outreach to the K-12 curriculum; and on creating extensive online resources.

3.1 Undergraduate curriculum

Shortly after the establishment of the center Janelle began an effort to discover interest in spatial topics across UCSB, by identifying centers, faculty, and courses that reflected substantial interest in the core concepts of a spatial perspective. He met with numerous faculty and examined course descriptions, and developed an inventory that eventually included more than 130 courses at the undergraduate upper-division level from 26 departments and programs, and nearly 200 faculty from outside the Department of Geography with research and teaching interests in aspects of spatial scholarship.

If spatial thinking is a malleable and universally relevant form of intelligence, then the obvious location for it in the curriculum is in the General Education program. But GenEd requirements are widely recognized to be the result of decades of demand from numerous directions on campus, and the process of adding to them has proved to be politically fraught. Consultation with various administrators and faculty led to the conclusion that the most appropriate target should be a minor, so Janelle has invested a large amount of effort over the past two years in developing a proposed program, titled *Spatial Studies*. It includes three tracks, reflecting three different contexts: *Spatial Thinking*, *Space and Place*, and *Spatial Science*.

Spatial Thinking emphasizes spatial cognition and reasoning associated with problem solving and representation, and applications of both elementary and complex reasoning processes in

different domains of human activity and knowledge development. This focus represents a concentration on the science of spatial learning at individual and societal levels, and on the mental associations that facilitate learning about and functioning within human and natural environments.

Space and Place builds on courses that apply spatial reasoning and visualization in the humanities. Examples include creative and aesthetic renderings (*e.g.*, stories, visualizations, sounds, and fine arts), the design of lived-in environments that reflect and accommodate human values and activities, the documentation and assessment of affinity to sense of place and region, and communication through use of spatial metaphor and spatialized languages.

Spatial Science emphasizes the analysis and visualization of information, featuring courses that build methodological and technological competencies for documenting space–time patterns and processes about phenomena in the physical world as well as about behavior and its consequences in the human world. In the design disciplines (including some branches of engineering) the focus is on problem solving and product development that frequently entails the (re)arrangement of spatial entities and documentation of the consequences thereof.

The proposal for the Spatial Studies minor is complete, with support from all relevant departments, and will be submitted through the campus reviewing agencies shortly.

3.2 Graduate curriculum

Even at the graduate level it is easy to point to areas where students lack the kinds of critical spatial thinking skills that are needed to make effective use of today’s spatial tools, and to conduct research in areas that make extensive use of data and models that are embedded in space and time. A multidisciplinary PhD emphasis would be an excellent way of addressing this gap, by training a cohort of students with a stronger set of critical spatial thinking skills. Accordingly the center submitted two proposals to NSF in 2009, both aimed at providing graduate fellowships and at the eventual target of a multidisciplinary PhD emphasis.

One proposal was targeted at NSF’s GK-12 program, and follows a successful program at UCSB that is now winding down. GK-12 provides graduate fellowships for students interested in working in K–12 classrooms. It was the only UCSB submission for the 2009 competition, so was not subject to a campus review. The proposal received a “highly recommended for funding” rating from its NSF panel, with two Excellent and three Very Good, but did not make the funding cut. The criticisms were minor and can easily be addressed. Several submissions were proposed in the 2010 competition, so there will have to be a selection process in the Office of Research.

The second proposal was targeted at NSF’s IGERT program. It was one of three selected to go forward from UCSB in the 2009 competition, and the preproposal was the only one of these selected by NSF for a full proposal. The full proposal was declined, but the reviews and panel summary were very encouraging, so a new preproposal is being prepared for the 2010 competition, and has been selected as one of four to go forward from UCSB.

3.3 K–12 initiatives

The center’s interest in spatial intelligence spans the entire educational spectrum, but as with undergraduate education it is difficult to find room for it in a crowded curriculum. A project funded by the US Fish and Wildlife Service has allowed us to explore the introduction of spatial concepts into the Grade 6 earth science curriculum. Two middle schools, one in Guadalupe and

the other in Ventura, were selected based on the interests of teachers, and a research assistant (Josh Bader) worked with them over 15 months to develop teaching materials. Simple concepts such as mapping using GPS, identification of plant species, and topographic elevation were explored in what turned out to be a highly successful program. The program formed the nucleus for the almost-successful GK-12 proposal described in the previous section.

3.4 Online resources

One of the center's significant contributions has been the development of extensive online resources. The main spatial.ucsb.edu site, maintained by a full-time webmaster, provides a wealth of information on the center and its programs, draws attention to events, allows users to see powerpoint and video recordings of presentations, and includes extensive educational resources. In addition the center has developed teachspatial.org as a substantial collection of materials relating to fundamental spatial concepts. Much of this work has been completed by graduate student Karl Grossner.

Spatial concepts range from very simple ideas acquired in early childhood, such as location, distance, and direction, to far more sophisticated and abstract concepts that are often not acquired at all, not even by people with advanced degrees. This latter category includes the two defining characteristics of spatial data—spatial dependence and spatial heterogeneity—and their significance for the statistical analysis of natural experiments.

We began this effort by organizing a small workshop in the summer of 2008 in collaboration with the University of Redlands, where Diana Sinton has been tasked with introducing spatial thinking as a persistent theme across the entire university. We invited people from around the US and Canada who have thought deeply about spatial concepts and the development of spatial intelligence. Out of that meeting came a call for a collection of Web resources that would invite contributions from interested academics.

The development of teachspatial.org was envisioned as occurring in three phases. In the first, the literatures of numerous disciplines would be mined to identify a set of spatial concepts, and these would be made available online with references to original sources. To date we have identified 186, mostly from the literatures of geography, cognitive psychology, landscape architecture, and urban planning. Phase Two is now under way, and consists of the construction of assorted indices and ordinations of the basic set, allowing users to approach the resource from a range of perspectives. Beyond simple alphabetical indexing, we are identifying part-whole relationships, cases of semantic similarity where the same or similar concepts have different names in different disciplines, groupings based on loosely defined categories, and links to state and national curriculum standards. Phase Three will develop instructional materials based on the concepts, and will also look at whether the concepts can be used as the basis of new, more intuitive, and more coherent user interfaces to spatial technology.

We have also developed relationships with a number of similarly motivated efforts around the world. The SPLINT project at the Universities of Leicester, Nottingham, and London in the UK is also developing online materials, while the Spatial Intelligence and Learning Center, a collaboration between Temple University, Northwestern University, and the University of Chicago, is funded by NSF as a Science of Learning Center.

4. Research and funding

Mention has already been made of two externally funded projects: the work on Grade 6 funded

by the US Fish and Wildlife Service, and the international summer workshops funded by NICHD. The proposals for graduate funding to GK-12 and IGERT have also been discussed. This section details other sources of external funding that have been developed by the center. Table 1 presents a summary of center funding from all sources.

4.1 Endowed chair

The center has worked closely with UCSB development staff since its inception. ESRI, the leading developer of ESRI software, has had close relationships with UCSB for the past 30 years and has provided substantial funding for research, conferences and workshops, and student support. In December 2009 the owners, Jack and Laura Dangermond, announced their intention to fund an endowed chair at UCSB. Goodchild was selected as the first holder of the chair.

4.2 US DOT ports project

Funded by the US Department of Transportation's Research and Innovative Technology Administration, this project is concerned with improving the efficiency of the trucking operation to and from the Ports of Los Angeles and Long Beach. It is led by Goodchild with Richard Church as co-PI, and with Val Noronha as project manager. Currently approximately 200 trucks are being tracked in and out of the port on a 5-second sampling interval using GPS, and the results provide a real-time database of the movement of a large sample of the roughly 8,000 trucks that move shipping containers in the L.A. Basin. Work by Church and the project's subcontractors has focused on improving the efficiency of the operation, and reducing its air pollution, by optimizing truck routing, minimizing queueing time at the port, and optimizing the handling of containers in the port. The project is currently under a no-cost extension that ends in June 2010, and employs two graduate students at UCSB.

4.3 National Geospatial-Intelligence Agency

The NGA's Academic Research Program is currently funding two projects at the center. The first, with PI Goodchild and co-PI Phaedon Kyriakidis, is examining the application of geostatistical techniques to spatio-temporal data. It is developing new methods of interpolation that use both spatial and temporal evidence, and is also defining confidence limits on the detection of change in temporal sequences of imagery. The project is in its third year of funding, and a no-cost extension will be requested to take the project into 2010–11. Graduate student Guofeng Cao is currently employed on the project and will finish his PhD in 2010.

The second project was funded in 2009 for two years and optional additional years, with Goodchild as PI and Martin Raubal as co-PI. It focuses on conflation, or the merging of geospatial data sets from disparate sources. The conflation problem is especially current in GIScience because of the rapid proliferation of data sources on the Web. Two graduate students are currently employed on the project: Linna Li (Geography) and Ben Adams (Computer Science).

4.4 NSF and Army Research Office: VGI

The topic of volunteered geographic information (VGI) is currently the focus of two awards, from the NSF Geography and Spatial Sciences program and from the Army Research Office. Both awards were made in 2009 for three years with Goodchild as PI. VGI is the geospatial form of user-generated content, and raises numerous research questions: who contributes, about what, and what assurances lead to confidence in the results? The NSF project is collaborative with colleagues at the University of Washington and Ohio State University. In Santa Barbara, the four recent fire emergencies have provided an excellent case study of the creation and use of VGI in

time-critical situations. Three undergraduates were employed on the research in the summer of 2009, and graduate student Darren Hardy (Bren) is currently researching the geospatial content of Wikipedia.

4.5 Minerals Management Service

In 2009 the center was awarded a small grant from the Camarillo office of the MMS to develop their geospatial data resources for the Federal part of the coastal zone. The project involves the creation of metadata, cleaning of existing data, and identification of new data sources. The center is collaborating with the Marine Science Institute and is employing graduate student Gargi Chaudhuri (Geography) on the project.

4.6 UC Multicampus Research Programs and Initiatives

In 2009 the center participated in two submissions to the MRPI program, one jointly with UCLA and UC Merced on community sensing and mapping, and the other jointly with UC Riverside on the development of a spatially disaggregated model of the economy, transportation, and land use in the LA Basin. The latter was successful and funded for five years beginning in January 2010. The UCR PI is Richard Arnott, an economist, and Goodchild is the UCSB PI. UCSB’s part of the project concerns the construction of a GIS database, and the development of Web services that allow access to the model’s forecasts. A full-time Specialist is being hired at UCSB.

4.7 NSF: SEEK

This project to study the spatial skills of Alzheimer’s patients was originally proposed by Reg Golledge before his death. It is being directed by Goodchild and Dan Montello, and funds post-doc Andrea Nuernberger.

Funding agency	Title	Start and end	Award
US Department of Transportation	MeTrIS: Metropolitan transportation information system applying space-based technologies for freight congestion mitigation	8/7/07 to 6/30/10	\$1,995,329
National Geospatial-Intelligence Agency	A geospatial framework for data analysis and modeling across multiple spatial and temporal scales	8/7/07 to 8/6/10	\$450,000
National Institute for Child Health and Human Development	Advanced spatial analysis training program for population scientists (subaward from Pennsylvania State University)	6/3/08 to 5/31/10	\$183,592 to UCSB
Minerals Management Service	GIS research	9/24/09 to 8/15/10	\$60,000
National Geospatial-Intelligence	Geospatial feature conflation: conceptual, statistical, and optimization approaches	10/16/09 to 10/15/11	\$288,548

Agency			
National Science Foundation	Development and assessment of self-assessed scales for everyday environmental knowledge (SEEK)	9/1/09 to 2/29/12	\$200,000
Army Research Office	User-generated terrain information	6/15/09 to 6/14/12	\$237,392
National Science Foundation	Collaborative research: a GIScience approach for assessing the quality, potential applications, and impacts of volunteered geographic information	6/1/09 to 11/30/12	\$149,454
UC Office of the President	Virtual co-laboratory for policy analysis in Greater LA (subaward from UC Riverside)	1/1/10 to 12/31/14	\$630,730 to UCSB

6. Publications

The following items published since the inception of the center are directly relevant to its work:

- Y. Liu, Q.H. Guo, J. Wieczorek, and M.F. Goodchild (2010) Positioning localities based on spatial assertions. *International Journal of Geographical Information Science* 23(11–12): 1471–1502.
- M.F. Goodchild, and D.G. Janelle (2010) Toward critical spatial thinking in the social sciences and humanities. *GeoJournal* 75(1): 3–13.
- M.F. Goodchild (2009) Geographic information systems and science: today and tomorrow. *Procedia Earth and Planetary Science* (Proceedings of the 6th International Conference on Mining Science and Technology) 1: 1037–1043.
- M.F. Goodchild (2009) Geographic information systems and science: today and tomorrow. *Annals of GIS* 15(1): 3–9.
- N. Schuurman (2009) An interview with Michael Goodchild: GIScience and social reordering in the new millennium. *The Information Society: An International Journal* 25(5): 360–363.
- D.G. Janelle, S.R. Hespanha, F.M. Goodchild, and M.F. Goodchild (2009) Workshops and national dissemination of geographic analysis in the social sciences: the CSISS experience in the USA. *Journal of Geography in Higher Education* 33 (Supplement 1): S88–S103.
- M.F. Goodchild (2009) What problem? Spatial autocorrelation and geographic information science. *Geographical Analysis* 41(4): 411–417.
- M.F. Goodchild (2009) The quality of geospatial context. In K. Rothermel, D. Fritsch, W. Blochinger, and F. Dürr, editors, *Quality of Context: First International Workshop, QuaCon 2009*, Stuttgart, Germany. Lecture Notes in Computer Science 5786, pp. 15–24. Berlin: Springer.
- E. Pultar, M. Raubal, T.J. Cova, and M.F. Goodchild (2009) Dynamic GIS case studies: wildfire evacuation and volunteered geographic information. *Transactions in GIS* 13 (Supplement 1): 85–104.
- D.G. Janelle and M.F. Goodchild (2009) Location across disciplines: reflections on the CSISS experience. In H.J. Scholten, R. van de Velde, and N. van Manen, editors, *Geospatial Technology and the Role of Location in Science*, pp. 15–29. Amsterdam: Springer Netherlands.
- M.F. Goodchild (2009) 029 GIScience and Systems; 034 GIS and Cartography; 438 First Law of Geography; 503 Quantitative Methodologies; 553 Uncertainty. In R. Kitchin and M. Thrift, editors, *International Encyclopedia of Human Geography*. New York: Springer.
- M.F. Goodchild (2009) Modeling the earth: A short history. In M. Dodge, R. Kitchin, and C. Perkins, editors, *Rethinking Maps: New Frontiers in Cartographic Theory*, pp. 83–96. New York: Routledge.
- M.F. Goodchild (2009) Virtual geographic environments as collective constructions. In H. Lin and M. Batty, editors, *Virtual Geographic Environments*, pp. 15–24. Beijing: Science Press.
- M.F. Goodchild (2009) Location-based services. In M. Madden, editor, *Handbook of Geographic Information Systems*, pp. 779–786. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.

- P.A. Longley, M.F. Goodchild, D.J. Maguire, and D.W. Rhind (2009) Geographic information science. In M. Madden, editor, *Handbook of Geographic Information Systems*, pp. 19–24. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.
- S.R. Hespanha, F.M. Goodchild, and D.G. Janelle (2009) Spatial thinking in the undergraduate social science classroom. *Journal of Geography in Higher Education* 33 (Supplement 1): S17–S27.
- M.F. Goodchild (2009) Challenges in spatial analysis. In A.S. Fotheringham and P.A. Rogerson, editors, *The SAGE Handbook of Spatial Analysis*, pp. 465–480. Los Angeles: SAGE.
- M.F. Goodchild (2009) Neogeography and the nature of geographic expertise. *Journal of Location Based Services* 3(2): 82–96.
- M.F. Goodchild, J.-X. Zhang, and P. Kyriakidis (2009) Discriminant models of uncertainty in nominal fields. *Transactions in GIS* 13(1): 7–23.
- E. Pultar, M. Raubal, and M. Goodchild (2008) GEDMWA: Geospatial Exploratory Data Mining Web Agent. In W. Aref, M. Mokbel, H. Samet, M. Schneider, C. Shahabi, and O. Wolfson, editors, *16th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (ACM GIS 2008), Irvine, CA, USA*, pp. 499–502.
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- M.F. Goodchild (2007) Recognition of GIS critical. *GIM International* 21(4).
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6. Presentations

The following presentations have described the work of the center to audiences worldwide.

6.1 Presentations by Goodchild

- “Spatial by Design: Understanding the Special Role of GIS.” Keynote, GeoDesign Summit, Redlands, January 2010.
- “Geographical Information Systems and Science: Today and Tomorrow.” Opening keynote, Workshop on GIS Technology and Applications, Indian Institute of Technology, Bombay, December 2009.
- “Uncertainty in Geographical Information.” Workshop on GIS Technology and Applications, Indian Institute of Technology, Bombay, December 2009.
- “The Changing Face of GIS.” Michigan State University, October 2009.
- “The Changing Face of GIS.” Capital Normal University, Beijing, October 2009.
- “Geographic Information Systems and Science: Today and Tomorrow.” Keynote Address, International Conference on Mining Science and Technology, Xuzhou, October 2009.
- “The Changing Face of GIS.” Keynote Address, International Conference on Mining Science and Technology, Xuzhou, October 2009.
- “Virtual Geographic Environments as Collective Constructions.” Wuhan University, October 2009.
- “Enabling Analysis in Space and Time.” Opening Keynote, International Symposium on Spatial Analysis, Spatio-Temporal Data Modeling and Data Mining (ISSA 2009), Wuhan, October.
- “The Changing Face of GIS.” Keynote Address, GIS in the Humanities and Social Sciences 2009, Taipei, October.

- “Enabling Analysis in Space and Time.” Opening Keynote, Conference on “The Dynamics of Space-Time Use: Measurement, Patterns, and Consequences.” Ohio State University, October 2009.
- “The Changing Face of GIS.” Institute for Remote Sensing Applications, Chinese Academy of Sciences, Beijing, September 2009.
- “Digital Earth: A Decadal Assessment.” Sixth International Symposium on Digital Earth, Beijing, September 2009.
- “The Changing Face of GIS.” Opening Keynote, 17th International Conference on Geoinformatics, George Mason University, August 2009.
- “The Quality of Geospatial Context.” First International Workshop on Quality of Context (QuaCon 2009), Stuttgart, June 2009.
- “California Reality and Nova Scotia Dreaming.” Tech Social, Nova Scotia Community College, Middleton, June 2009.
- “The Changing Face of GIS.” Geomatics Atlantic, Wolfville, Nova Scotia, June 2009.
- “Formalizing Place in Geographic Information Systems.” Conference on Place, Health and Equity, University of Washington, May 2009.
- “Geographic Information Systems and Science: Today and Tomorrow.” University of California, Merced, April 2009.
- “Citizens as Sensors: The World of Volunteered Geography.” GeoJournal Plenary Lecture, Association of American Geographers, Las Vegas, March 2009.
- “Business Opportunities in the Evolving Geoweb.” University of Mary Washington, March 2009.
- “SDI: Now What?” Institut Cartografic de Catalunya, Barcelona, February 2009.
- “The Geospatial Web: A State of the Art Report.” INPE, Sao Jose dos Campos, Brazil, February 2009.
- “Geographic Information Systems and Science: Today and Tomorrow.” University of Minnesota, January 2009.
- “Citizens as Sensors: Web 2.0 and the World of Volunteered Geography.” University of Western Ontario, December 2008.
- “Geography and Geospatial Science: Today and Tomorrow.” Centers for Disease Control and Prevention, Atlanta, December 2008.
- “Citizens as Sensors: Volunteered Geographic Information.” World University Network Virtual Seminar in NeoGeography, December 2008.
- “Geographic Information in the World of Web 2.0.” Borchert Lecture, University of Minnesota, November 2008.
- “Simulation, Modeling, and Digital Earth: Status and Prospects.” Digital Earth Summit on Geoinformatics: Tools for Global Change Research. Potsdam, November 2008.
- “Spatial@ucsb: Perspectives for Teaching and Research.” National Geographic Society, November 2008.
- “GIS and GIScience: Today and Tomorrow.” Chinese Academy of Sciences, Beijing; Sichuan University, Chengdu; Chinese Academy of Sciences, Lanzhou; Chinese Academy of Sciences, Urumqi; Wuhan University; October 2008.

- “Fundamental Spatial Concepts.” Wuhan University, October 2008.
- “A Geostatistical Framework for Geospatial Data Analysis and Modeling across Multiple Spatial and Temporal Scales.” NGA Academic Research Program conference, Washington DC, September 2008.
- “Virtual Geographic Environments as Collective Constructions.” Keynote Address, International Workshop on Indoor Spatial Awareness, Seoul, August 2008.
- “Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management.” Special Lecture, Korean Research Institute for Human Settlements, Seoul, August 2008.
- “The Geospatial Web: A State of the Art Report.” Keynote Address, IEEE Conference on Semantic Computing, Santa Clara, August 2008.
- “Top Down or Bottom Up: Geographic Data Production and Web 2.0.” Keynote Address, GeoWeb 2008, Vancouver, July.
- “Assertion and Authority: User-Generated Geographic Content.” Keynote Address, GI-Forum 2008, Salzburg, July.
- “Authority and Assertion: The Science of User-Generated Geographic Content.” Colloquium for Andrew U. Frank's 60th Birthday, Vienna University of Technology, June 2008.
- “Spatial Accuracy 2.0.” Keynote Address, Eighth International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Shanghai, June 2008.
- “Representation of Geospatial Futures.” National University of Ireland, Maynooth, May 2008.
- “GIS 101.” Isoscapes Conference, Santa Barbara, April 2008.
- “The Future of GIS and Geospatial Technology in Our Changing World.” Oak Ridge National Laboratory and the University of Tennessee, March 2008.
- “SKling for GIScience.” First Annual Conference on Spatial Knowledge and Intelligence, Fernie, BC, February 2008.
- “GIS Frontiers in Transportation.” University of California Transportation Center annual student conference, UC Santa Barbara, January 2008.
- “Virtual Geographic Environments as Collective Constructions.” Opening keynote, International Conference on Developments in Visualization and Virtual Environments in Geographic Information Science, Chinese University of Hong Kong, January 2008.
- “The Global Positioning System: Where Are We Now?” Ventura College, November 2007.
- “Citizens as Sensors: The World of Volunteered Geography.” Festival International de Géographie, St-Dié-des-Vosges, France, October 2007; Minghi Distinguished Lecture, University of South Carolina, February 2008; ESRI, March 2008.
- “Geographic Information Science for Sustainability.” Conference on Geographical Concepts in the Academy: Sustainability, GIS, and the World, Clark University, September 2007.
- “Transportation and GIScience.” Transportation Research Board, Washington, September 2007.
- “GIS, Map Accuracy, and Statistics.” Joint Statistical Meetings, Salt Lake City, August 2007.
- “Towards User-Centric Description of Data Quality.” Technical University of Munich, July 2008.
- “Culture in Place: New Geospatial Tools for the Humanities.” University of California, Los Angeles, May 2008.

- “Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management.” University of Mary Washington, October 2007.
- “Fundamental Spatial Concepts.” ESRI, May 2008.
- “The Case for Space.” Curtin University, November 2007; Temple University, November 2007; Ryerson University, November 2007.
- “The Spatial Web: Visions for a Geospatial World.” Los Angeles County Health Department, February 2008.
- “Representation and Computation of Geographic Dynamics.” Keynote, 13th European Community GI and GIS Workshop, Porto, July 2007; Curtin University, November 2007.
- “The Spatial Web: Visions for a Geographically Enabled World.” Willamette University, September 2007; University of Mary Washington, October 2007; Charles Drew University, October 2007; Curtin University, November 2007.
- “A Brief History of Geospatial Data Modeling.” University of Nebraska, Lincoln, April 2008.

6.2 Presentations by Janelle

- “The Education Challenge for Building a Nation of Spatial Thinkers.” Workforce Panel, University Consortium for Geographic Information Science, UCGIS Winter Meeting, Washington, DC, February 2010.
- “Spatio-Temporal Approaches to Understanding Human Behaviour and Social Organization, GIS in the Humanities and Social Sciences.” International Conference 2009, Taipei, Taiwan, October 2009.
- “Spatial Perspectives on Analysis for Curriculum Enhancement in the Social Sciences.” Special Session on Spatially Integrated Social Science, Association of American Geographers, Las Vegas NV, March 2009.
- “Perspectives on Time Geography and Space-time Tracking at Individual and Ecological Levels.” The Three G’s (GPS, GIS and Genes) Environment Interaction Research Workshop, University of California, San Diego, San Diego CA. February 2009.
- Three presentations: (1) “Spatio-temporal approaches in the social and behavioral sciences,” (2) “Perspectives on time-space convergence, (3) “Spatial concepts and spatial reasoning in the social sciences,” Australian Research Council Research Network on Spatially Integrated Social Science (ARCRNSISS), Summer School for Research Higher Degree Students. University of Queensland, Brisbane, Australia, February 2009.
- “spatial@ucsb and spatial concepts in undergraduate education.” Specialist Meeting on Spatial Concepts in GIS and Design, Santa Barbara, December 2008. (with Karl Grossner).
- “A Spatial Literacy Initiative for Undergraduate Education at UCSB.” ThinkSpatial Brown-bag Forum, University of California, Santa Barbara, October 2008. (with Michael Goodchild)
- “Spatial Literacy, Geographical Information Technologies, and Solutions to Societal Problems.” Board of Directors of UCSB Alumni Association, Santa Barbara CA, October 2008. (with V Noronha, R Church, and J Sopher).
- “Spatial Concepts and Spatial Reasoning in the Social Sciences.” International Workshop on Spatial Cognition and Learning, Freiburg, Germany, September 2008.
- “SPACE (Spatial Perspectives on Analysis for Curriculum Enhancement)” Poster, 2008. Course Curriculum and Laboratory Improvement (CCLI) PI Conference, sponsored by the National

Science Foundation (NSF) Division of Undergraduate Education (DUE) and the American Association for the Advancement of Science (AAAS), Washington, D.C., August 2008.

“Location across Disciplines: Reflections on the CSISS Experience.” Symposium on Geo-ICT and Location within Science, Vrij Universiteit, Amsterdam, September 2007.

“Perspectives on the Time Geography of Cities.” The Catholic University of Salvador, Salvador, Brazil. August 2007.

“Spatially Integrated Social Science.” The Federal University of Bahia, Salvador, Brazil, August 2007.

“Perspectives on Time-space Convergence.” The Catholic University of Minas Gerais, Belo-Horizonte, Brazil, August 2007.