**Developing and Sustaining**

**Geospatial Programs in Community Colleges**

**Best Practices Series**

**GeoTech Center**

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**Overview**

This paper begins with a brief historical perspective on the use of GIS and geospatial technology in education with a focus on community college programs. It outlines the components that help introduce and create a geospatial program and identifies the key players and resources needed to help build a strong, sustainable program or expand an existing program. Topics include methods for developing a course, certificate or degree program, tools to help build a curriculum and suggestions on how to spread the use of geospatial technology across the campus. Links to resources from other best practices documents created by partners of the GeoTech Center provide details on creating articulation agreements, and ways to have geospatial courses recognized as fulfilling General Education requirements appropriate for use in community colleges. Appendix A includes recommendation for setting up a geospatial computer lab or providing software access via remote desktop access as well as resources needed for field data collection. Many of the suggestions are also appropriate for four-year university programs.

**Historical Context and Growth of Geospatial Technology**

In a little more than a decade, Geographic Information Systems (GIS) has gone from an obscure, difficult to use technology available only to graduate students with access to high end workstations to a technology that can be used by students in many disciplines at all levels of education. GIS is also the power behind many consumer products that the public has begun to rely on such as in car navigation systems and online virtual worlds. This paper will broaden the context to include not just GIS, but other geospatial technologies. The term geospatial technology (GST) as used in this paper encompasses GIS, remote sensing, global positioning systems (GPS), Location Based Services (LBS) and mobile technology as well as online web mapping applications and other emerging technologies. GST is often also seen as a profession (GIS Certification Institute <http://www.gisci.org/>) or an occupation (http://online.onetcenter.org/link/summary/15-1099.06) or as an essential tool in many other professions, such as surveying. This is why there has been such a rapid growth of GST in education and why there are so many disciplines interested in using it in their program or creating specialized GST programs or departments. This growth has been aided by lower cost, yet more powerful computer hardware, easier access to abundant data through the Web, and the development of easier-to-use software. It is also because of the rapidly expanding use of GST by government, business, industry and the general public. The Department of Labor, in a study of the geospatial industry carried out by the Association of American Geographers (AAG) and Geospatial Information & Technology Association (GITA) settled on this definition ((<http://www.aag.org/giwis/>) of the geospatial industry:

“The geospatial industry acquires, integrates, manages, analyzes, maps, distributes, and uses geographic, temporal and spatial information and knowledge. The industry includes basic and applied research, technology development, education, and applications to address the planning, decision-making, and operational needs of people and organizations of all types.”

Government is using the technology to make better, faster, more cost effective decisions and then using web-based mapping visualizations to make those decisions more transparent to the public. Utility companies, first responders, healthcare professionals, and transportation and logistics organizations are just a few of the many users of the technology ([www.esri.com/industries](http://www.esri.com/industries)). With the pressing need for energy conservation and the development of practices that support sustainability, GST is helping to foster understanding and develop innovative solutions to address local to global problems. Campus administrators are also learning of the power of geospatial technology for the business of education including campus mapping, facilities management, marketing and outreach, student tracking and campus security.

Another aspect of the growth of the use of GIS in education is the National Research Council report on *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum.* The report suggests that thinking spatially is an essential tool for the workforce and should be incorporated into existing courses and programs. The report also suggests that GIS may help in the effort to increase spatial thinking skills in students. Many colleges and universities are using GST as a catalyst for creative thought and problem-solving skills and to facilitate spatial reasoning that supports higher levels of learning among students.

Because GST can be used in so many ways, it is often difficult to reach a consensus of just where to include it on a campus. The searchable “Find a Program” online database at Esri, a leading developer and vendor of GIS software, includes information about more than 558 GIS programs (http://edcommunity.esri.com/universityprograms/). A quick review of the list of programs reveals just how diverse the departments are that offer GIS. While geography is the most common department, agriculture, forestry, engineering, geomantics and computer science are just a few examples of the departments in which GIS or other geospatial technologies are taught. GIS and geospatial technology are used as a teaching tool in many disciplines, a tool for analysis of geospatial data in many disciplines and as a discipline and research area (GIScience) in its own right.

While this rapid growth has presented educators with exciting challenges and opportunities, it has also added logistical, administrative, pedagogical, and curriculum demands that must be considered when implementing a program. The suggestions included in this paper are intended to support educators, researchers, and administrators at colleges in developing a successful and sustainable geospatial program and help spread the use of the technology across their campus. The paper includes resources to help locate or develop appropriate curriculum, describes procedures and methods for planning and maintaining a geospatial program (including hardware, software, faculty training, and laboratory needs), and provides links to other resources helpful for long-term management and maintenance of a program. These suggestions were compiled from a variety of resources including conversations and recommendations from educators that have successfully developed and maintained a program as part of Johnson’s work at Esri ([www.esri.com/highered](http://www.esri.com/highered)) and by both authors though work on state (California Workforce Development, C3GIS.net) and National Science Foundation grants focused on GIS (National Geospatial Technology Center of Excellence (GeoTech Center) DUE #0801893) and remote sensing (Integrated Geospatial Education and Technology Training (iGETT) DUE #0703185).

**Developing a Geospatial Program**

The process of developing a geospatial program, whether it is a course, certificate, degree program or the across campus use of the technology has many elements in common with the development of a geospatial project at a small city. They all share the need to have a “plan of action” and the necessary personnel, processes and facilities to carry out that plan for the specific audience that will benefit from that plan. For community colleges, the audience may be quite varied and include traditional students seeking a two year degree or transfer to a university or they may be working and unemployed professionals seeking new skills to find a job, advance in their profession or move to a new career. Where a program resides in a community college is also varied with some programs in academic disciplines, some in Career and Technical Education (CTE) and others in both academic and CTE. For more details about this topic, see the December 2011 issue of the URISA Journal article “Spatial Education at U.S. Community Colleges: Background Challenges and Opportunities. Johnson 2010. .

Some of the elements needed to carry out a plan and develop a program include:

* Someone with a *Vision*
* Someone with *Power*
* An Implementation and Sustainability Plan
* An Advisory Committee
* Facilities (lab with needed resources and internet access)
* Hardware (computers, printers, network access, servers, field equipment, etc.)
* Software (GIS, remote sensing, MS Office, Ghost, Deep Freeze, etc.)
* Curriculum and related resources (course syllabi, curriculum, program structure, teaching materials, texts, lab manuals)
* Data Faculty and staff able to teach GST
* IT Support

Each of the above elements will be discussed with specific recommendations within the body or in an Appendix to this document.

**The Vision**

Most programs start with a person that has a *vision* of what they want to do with GIS and may or may not include other geospatial technologies at their institution. This visionary may be inspired by what they see in the workplace or in their discipline that leads them to believe that this technology is essential for their students to be able to understand and use to be successful – either in a course or a career. These visionaries are also often “lifelong learners” themselves and see learning to use the technology as an interesting and rewarding challenge. If their vision is just to add a module to a course, the needed resources and challenges may be minor and accomplished without too much difficulty – as long as they have ready access to computers, the Web and materials (lesson, data, software). If their vision is to start a new course or program, they will need many more resources and processes in place. Our advice is to “start slow and THINK BIG.” That is, test the water with a module, but have in mind a longer term plan to investigate the needs, resources and timeline needed for a program. The vision has to accompanied by a statement of purpose and a collaboration between stakeholders who share that purpose. Getting the seed planted involves a structured join of resources to begin, improve and continue the program. Essential resources are college information technology, college discipline instructors, employers and GIS professional advisors.

**The Power**

While the visionary may be able to put many of the needed resources in place for a module or even a course, they must have someone that shares their vision and has the power on campus to make it happen if they want to develop a program. Generally the “power” person sees the value of the technology and becomes an advocate for the geospatial program development. Generally, this person is not interested in learning the technology themselves or dealing with the details of curriculum development and teaching within a program, but are enablers that have access to resources including funding, facilities and curriculum development support. They are an important force to help support new and growing programs as well as provide continuing support to expand programs across a campus. The influence of GIS on college courses is incremental. A surging thrust of ambition at the beginning can be lost when there is not a corresponding acceptance. Because community colleges conduct their business through committees, the influence of GIS needs to be a gradual, studied campaign that embraces college instruction needs. A steady conversion of potential GIS adopters within the college will facilitate the studied discussions that lead to supportive administrative, budgetary and implementation decisions.

**Which Approach – Top Down or Bottom Up?**

Sometimes the visionary is not a faculty member, but an administrator who has heard about GIS and other geospatial technologies and wants a program to be included in their college, division or department. This is often referred to as a “Top Down” approach whereby they (administration) recommend and support setting up a program and the faculty in their school or department are directed to, learn to use the technology, create the program and offer the new program.

Sometimes it is a faculty member who hears about the technology, wants to learn to use and teach (or teach using) the technology in their courses and continues on to promote it on campus. This is a “Bottom Up” approach where the faculty member takes on the tasks to build a program and works to get approval from the administration. The easiest approach for success is a two pronged approach – a visionary from the faculty who wants to learn and incorporate the technology and a person with power and funding (the administrator) who sees the value and bigger picture of promoting the technology. This team then works together to form a larger “advisory committee” and carry out the other tasks to put a program in place.

A third critical influence is Outside-In. The GST’s productive merits are its ability to produce students with skills that enhance their participation in the economy. Employers are a critical influence on the formulation and sustainability of the program since they know what the student must possess to win and successfully perform employment. If business participates in the program formulation and helps guide program acceptance, then college administration and college staff have confidence that what they are doing within the GST offerings meets economic needs outside the college. The influence of business outside the college brings critical material and financial resources to the college GST program.

This is especially true for the administrative use of GST at a college. While some colleges are using GST in administration, most institutions make little use of the technology. More work needs to be done to document the process and best practices to effectively use GST for administrative purposes. This aspect of geospatial use on campus is changing rapidly with the awareness of the technology created by Google Earth and other web and server sites used by cities, states and federal agencies. The Community College of San Francisco has developed a Campus Map for use by all students, students with disabilities and Facilities Management (http://c3gis.net/udp.cfm?i=24). The National Geospatial Technology Center of Excellence (GeoTech Center) is using GST to create awareness of GST programs on its web page ([www.geotechcenter.org](http://www.geotechcenter.org)) with an interactive National Community College Geospatial Technology Program Map.

**Planning Phase**

A well carried out planning phase is vital to the ultimate success of a GST program. The planning phase should include a Needs Assessment and Resource Assessment that clearly defines the program goals and objectives as well as identifies the existing resources and overall college infrastructure and support for a geospatial program. The plan should include methods for creating awareness of the new program as well as a timeline for accomplishing the stated goals and objectives. It should also clearly identify the costs and benefits of the program to encourage those with the needed funding sources to allocate those funds. A Logic Model can be useful as it illustrates how the needed Inputs and Activities produce the Outputs and short to long term Outcomes in a simple to understand, one page format. A Logic Model displays the sequence of actions that describe what the program or project is and will do (www.unex.edu/ces/pdande/evaluation/evallogicmodel.html). Figure 1 is a template for creating a Logic Model with links to resources for creating your own Model (NSF ATE: <http://evalu-ate.org/app/webroot/files/uploads/logic_model_template.ppt> ). Additional templates and resources can be found at the University of Wisconsin, extension site <http://www.uwex.edu/ces/pdande/evaluation/evallogicmodel.html>



Figure 1 – Logic Model Template

Figure 2 is an example of a GST Program Development Logic Model that can be modified to fit the needs and requirements of a college. This example assumes that Short-Term Outcomes will be achieved in one to two years, Mid-Term in two to five years and Long-Term in more than 5 years.



Figure 2 – Example of a GST Program Logic Model

**Establishing Goals and Objectives**

The goals and objectives of the program will dictate the extent of the Needs Assessment – with more limited assessment for a module or course to an in depth assessment for a certificate or degree program or across campus use of geospatial technology in administration. A Needs Assessment can help foster cooperation and communication among departments toward a set of common goals and link current programs to future campus wide activities. In addition, it serves as a learning tool for potential users by describing what geospatial technology is and how it can benefit their department. Without a complete Needs Assessment, it is possible that individual departments might already be using the technology..

If the initial goal is limited to using geospatial technology as part of an existing course, then planning may be carried out more informally by the instructor wishing to add the technology. If the goal is to establish a long term plan with the objective of creating courses, certificate or degree programs, then the Needs Assessment and Resource Assessment should be more extensive.

**Adding a Module to a Course**

If the goal is to add a module to an existing course the Needs Assessment and Resource Assessment may be combined into one document. It may be as simple as learning what type of software, hardware, data and teaching resources (exercises and lessons) may already be available on campus and adding the activity to the course syllabi. A primary consideration is whether the module will be limited to a discussion and demonstration of geospatial technology or actual hands on use. If it is to be a hands on activity, then access to hardware (computers) and the Internet will be required. Software may be limited to free, browser based applications, or free software that must be downloaded and installed, or software that must be purchased and installed in a laboratory. If the long term goal is to set up a course or program, it may be that this initial offering uses simple awareness techniques but can lead to more advanced software use in the future. Several free options exist for browser based modules such as Google Earth, Esri’s ArcGIS Explorer, Bing Maps. Please see Appendix A for more information about what resources are needed for laboratory or field work.

**Adding a Course, Certificate, or Degree Program**

An initial step for a more extensive program should include the formation of an Advisory Committee. This should be a task of the individuals providing the vision and power to develop a new program. An Advisory Committee can include representatives from the college, local government agencies, school systems; industry and business that help provide a broad perspective on the goals for a geospatial program as well as what is needed to effectively offer such a program. This is particularly important if the primary audience is the local user community or graduates of the college that wish to stay in the region surrounding the college. Other subcommittees may need to be formed from time to time to deal with specific tasks. One of these may be a "technical committee" that has specific expertise in technical aspects of the program while another committee may be formed that specifically addresses the curriculum needs. Some of the responsibilities and decisions the Advisory Committee can assist with include:

* Identifying the goals and objectives of the program
* Conduct a GST faculty seminar. In the session show what GST is and how it is useful. Show some of the ways it can be implemented. Show what students can learn. Show how it fits into the business world. Bring speakers from the outside who can help your audience share the vision inside.
* Needs Assessment
	+ Determining program needs (facilities, hardware, staff, software, data)
	+ Determining local users need for geospatial training
	+ Determining what other programs at other educational institutions may impact (compete with) the program
* Resource Assessment
	+ Determining available resources of the institution
	+ Determining what equipment and facilities exist
	+ Determining what faculty and support staff exist
	+ Determining available funding and possible grants
* Helping to designing curriculum to meet identified needs using GTCM, DACUMS and assessment tools from GeoTech
* Maintaining a realistic timetable and goals
* Helping establishing an advertising and marketing campaign
* Helping identify funding and possible grants to support the program
* Supporting a coordinator or manager for the program

Members of the Advisory Committee should rotate every two to three years to include representatives from other local businesses, industries, educational institutions, and government agencies as well as representatives from different campus departments and administrative units. This will generate new energy, enthusiasm, and ideas for long-term success of the GST program. Alternatively, a larger advisory (10-12) committee will allow for longer tenure and a more varied input from government, private industry and education (4-year transfer universities). The advisory committee should include recent graduates of similar programs to understand how the college preparation influenced their work. This helps insure the direction of the program is grounded in functional performance.

*The Needs Assessment*: A thorough Needs Assessment should be conducted. As used in this document, the Needs Assessment provides not only the justification for starting a program and identifies the audience, but also includes identifying what resources are required. The Needs Assessment should address the following questions:

1. What are the program mission, goals, and objectives including:
* Will the program offer modules within courses, courses within existing degree programs, a certificate or degree program, or a mix of these offerings?
* Who are the potential audience for the program - faculty, staff, administration and/or traditional or working professional students
	+ what are their needs (occasional use, set class times per semester, free access at all times, restricted access to data)?
* If there is to be a dedicated geospatial lab facility?
	+ Who should be the manager of the facility?
	+ How will lab setup, development and support be handled for the lab?
	+ What equipment will be needed (printers, plotters, computers, servers, GPS, cameras, see Appendix A)?
	+ Are desks, chairs and a projector available or will they need to be acquired?
	+ How will consumables be replenished (paper, ink, etc.) – who pays for these?
	+ How will software, computer, and facility security be provided?
	+ Will a Center or lab facility be open or restricted to particular users at set times?
	+ Will the computers be networked or stand-alone?
	+ How will the use of the Internet and student/faculty project storage be handled?
* If the program must share a lab facility, how will access and scheduling of courses be handled, what is the compatibility of software programs for the different offerings held in the shared facility and how will data access and student project storage be accommodated?
* If a separate Center or facility is set up, how will it be funded?
* How will software and hardware upgrades and maintenance be funded?
* While initial programs may not need a centralized and shared database, how will a central database for data and student projects be developed and managed?
	+ How will it be protected?
	+ How will users access it and how will it be updated and maintained?
* What type of technical support exists on campus and how will technical support be provided to the Center, dedicated lab facility or shared lab?
* If it is Distance Education program, how will students access software, data and lectures?
1. Determination of what academic programs on campus could be using geospatial technology;
2. Determination of what administrative activities could use geospatial technology
3. Market analysis – is there a need for this type of program. What other programs in the region may offer support or compete for students?

*The Resource Assessment:* Often, faculty do not know what resources may already be available or what programs using GST already exist on campus. Other departments may have acquired hardware, software or other resources that they may be willing to share. Using the findings from the Needs Assessment, that identified what is required for a program, the Resource Assessment helps define what the college already has in place to support a geospatial program and it identifies what may need to be acquired. The Resource Assessment should determine:

* What courses or programs on campus may already have or use geospatial technology;
* What facilities (rooms, labs, etc) are already available;
* What hardware already exists and is it adequate for use in a geospatial program;
* What software may be available and what is the cost to access that software;
* What IT support may already be in place;
* What curriculum exists that may be used to support geospatial technology;
* What administrative tasks are already using GST or could use geospatial technology more effectively;
* What kind of database is being used on campus and how can a new program use that resources available from such use such as Oracle or other software?

*College Policies*: The college will have specific steps that must be followed if a new course or program is to be created. The Advisory Committee should be informed as to the rules and policies regarding starting a new course or program and follow the guidelines so that all steps are completed in a timely manner. In a multi-campus college district, there may also be policies about program content and offerings that must be followed. Another consideration is whether the course or program will be housed in an academic or Career and Technical Education (CTE) or a combination of the two types of programs. This may impact the requirements for faculty and staff education and qualifications as well as the number of hours or credits needed for a program.

The answers to these questions will impact the goals for the program and the physical design, priorities, and access policies of the GST facility. For example, if a certificate program is offered, there may be a need for evening access for professionals as opposed to a program strictly designed for lecture and teaching of on campus traditional students. The physical layout of the lab facility must take into consideration the type of use of the facility. If it is primarily a teaching lab, desk and computer arrangement must take into account the line of sight and distance from the projection screen for students and instructors to view computer demonstrations. If the facility is to be multipurpose where many different activities and groups will be using the lab, the flexibility to reconfigure the lab to meet varying needs may be advisable (see Appendix A: GST Facility Requirements). A multipurpose facility will also require more security

*Program Curriculum:* What to teach and how to teach it are two important questions that must be addressed. The specific answers also depend on the outcomes from other sections in the Planning Phase especially the Needs and Resources Assessments. Here again, it depends on the goal of the plan. If it is just adding a module to an existing course the topics to be covered will often be dictated by the host course and discipline. If it is a “gateway” course that provides students with an awareness of the technology and leads them to take additional GST courses, the content may be focused on helping students develop spatial thinking skills. If it is to serve the working professional and lead to increasing their conceptual and technical skills, it should include topics that address workforce needs. While there have been many efforts to provide guidance on content for programs (AJohnson, 2010), the Department of Labor (DOL) approved a Geospatial Technology Competency Model (GTCM) in July, 2010. The GTCM was built upon the work of these earlier efforts (AJohnson, 2010) and provides a detailed structure that outlines the skills and competencies needed by the GST industry (<http://www.careeronestop.org/competencymodel/pyramid.aspx?GEO=Y>). The GeoTech Center has created a Program Self-Assessment Tool, based on the GTCM, (<http://www.geotechcenter.org/Projects/Research-Projects/Geospatial-Technology-Competency-Model-GTCM2/GTCM-Program-Self-Assessment-Tool>) that can be used to develop curriculum for courses and build certificate or degree programs. This Self-Assessment tool can also be used to evaluate existing courses and programs. The GeoTech Center has also carried out DACUM events for GIS Technicians and is in the process of carrying out DACUM events for Remote Sensing Technicians. DACUM stands for Developing A Curriculum and is a formal job analysis technique which brings together expert workers to describe or define the duties and tasks required by their jobs or occupations. Outcomes from multiple DACUM events have been combined into Meta-DACUM documents that can also be used to help determine the needed content for GST courses and programs that focus on GIS Technicians or Remote Sensing Technicians (See URISA Journal “What GIS Technicians Do: Synthesis of Jobs Analysis. JJohnson, 2010). The Meta-DACUM for GIS Technicians is available from the GeoTech web site (<http://www.geotechcenter.org/Resources/Publications/GIS-Technician-MetaDACUM-Analysis-Report> )

*Program content and length:* A recent article in the *Inside Higher Education* online journal(<http://www.insidehighered.com/news/2010/12/07/certificate>) reported on a study (<http://www.completecollege.org/path_forward/certificates_count_release/>) that suggests industry finds certificate programs of moderate (longer-term) length (one year of study) are most effective in providing the workforce with the needed depth, rigor and breath than shorter-term programs. Industry has also indicated that programs should include real world problem solving opportunities with capstone projects and internships as part of the requirements. Sample curriculum is available from the GeoTech web site (http://geotechcenter.org) and Esri Education Community web site (<http://www.esri.com/industries/university/programs/gisprogs.html>). In general, a certificate of 18 to 30 units should provide students with ample opportunity to learn to:

* Understand and use GST concepts at an Introductory Level (see GTCM and Meta-DACUMs)
* Use GST software and hardware,
* Use spatial analysis techniques to solve real-world problems,
* Create, manage and store databases and metadata using GST best practices.
* Use cartographic principles for presenting visualizations (maps) about analysis outcomes appropriate to the audience
* Modify a software application using a scripting language (introductory level programming)
* Collect field data using GPS and integrate into a GIS database and project.
* Work effectively in a GST environment (capstone project or internship or both) including ability use effective oral and written communication principles

If a degree program is part of the goal of the plan, the above content suggestions for certificate program can serve as the GST core with additional courses added depending on the discipline or knowledge area of the degree program.

It should be stressed that not all incoming students may need or desire a degree. This is particularly true with working professionals that may already possess a Bachelor, Master or even a Ph.D with several too many years of working experience. This student population may be seeking a place to learn GST for their current position or move to a new career path. Thus, it is advisable that all students taking a “gateway” or introductory course complete a standardized survey assessing their needs and reasons for taking the initial course as well as testing their entering GST skill level. This test can be used to support a success matrix for programs where students successfully move up a career path, but do not complete a typical course sequence leading to a certificate or degree. Repeating this survey and test in later courses will allow faulty to access how much students have learned and any changes they have made in their career pathway after starting the program. If possible, graduates of the program should also be contacted to see if they feel the curriculum provided them with the needed skills and asked to make recommendations for changes to improve the program.

As to “how to teach” a course or program and what type of delivery should be used (face to face, online, or hybrid), the most important consideration is to provide ample hands on application of the concepts, tools and analysis possible using real-world applications and data by an engaged and dedicated teacher (Yanow, 2011). Integration of lectures into hands on laboratory activities based on solid foundational concepts, such as map projections and coordinate systems, helps students learn to problem solve and develop critical thinking skills. Industry stresses that student project work and internships that provide them real world, hands on experience and include oral and communication skills are essential.

*Market Analysis Both Within and Outside the College*: Prior to establishing your GST program, it is important to conduct a benchmark analysis of your competition both within and outside the college, including documenting the need for such a program. As to competition, it is important to determine who will be potential users and if there is a competing program. Oftentimes developing a close relationship or collaboration with other programs may enhance your program and benefit students and defuse any problems regarding competition. Some questions that should be addressed include:

* Are there any local or regional colleges or universities that have established GST programs?
* What are their goals?
* Who are their users?
* Are there other departments on campus with GST facilities?
* How many individual groups are using GST?
* What other disciplines and departments can benefit from a GST facility?
* What kinds of distance education programs (at your institution or other institutions) may aide or compete with your program?

To analyze the need for such a facility or program, supporting documentation should be gathered that includes any local, regional, or national workforce needs including job descriptions, salary surveys, or other documentation from a GST-related professional organization that demonstrate the need for education or training in GST. Many of these resources or links to resources can be found on the GeoTech Center web site (<http://geotechcenter.org>).

*Data and Database Planning*: GIS is highly dependent on data access and accessibility. While a central data repository is not needed for modules or initial course offerings, it does become important as programs increase in size, spread across campus or are used for administrative purposes. This is as true for educational programs in GIS as it is in industry whereby initial projects may not need a central database, but it becomes a necessity as its use by many entities within an organization becomes a reality. A GST center or lab facility must include a plan for securing, maintaining, and managing a data and geospatial databases for educational and research purposes. This is also vitally important for the administrative use of GST. The first step in planning the database is finding and utilizing the appropriate data that will support the objectives and function of the facility.

A survey should be performed to analyze and inventory available data and to identify potential sources of data. A master data list should then be compiled. The task of developing the GIS database should be the responsibility of all interested departments. The database eventually will become a college wide resource that is created and managed according to the objectives and purpose established in the needs assessment. As data needs and sources are identified and acquired, expansion of the database becomes an important consideration. Be sure to plan for expansion with adequate server storage space and backups and ways to protect the security of the database must be an important consideration.

*Types of Data*: The types of data needed for the program is an important consideration. There are many types of data that can be utilized by a GIS, and each type has its own unique potential for contributing to the goals and objectives established in the needs assessment. GIS software often comes with base data sets that can serve as a starting point for many types of projects. This data can be shared on the campus, but each data set includes metadata about the allowed uses of the data and this should be verified before use outside of the educational setting. How this data is shared is also dependent on the type of program the institution wishes to develop. In the simplest case, data sets may be saved on individual computers. A much more common method would be to store them on a shared drive on a server that is accessible from a teaching lab. Students or faculty would then access the needed data sets and store them locally. For enterprise or across campus use, this becomes much more of an issue of access, security and versioning. Administrative use for marketing or facilities management will require additional security and a system for accessing or updating any data.

Various data types include mapped data, which includes published maps that may be already digitized into a vector data structure; attribute data tables, which are available from many organizations and agencies and can readily be input into a GIS; and image data, which includes remotely sensed images in the form of aerial photographs to satellite data. Many of these images can be displayed in a GIS, but for analysis purposes, these images need to be georeferenced or rectified so they can be overlaid on similarly georeferenced images or data. Imagery and derivative products of raster based analysis can require large amounts of storage. Lidar data also is becoming much more available, but also requires a large amount of storage space. This should be taken into account when planning database storage and maintenance. New software options by Esri and others may be used to store, manage and access image data more efficiently. Other types of data that should be considered for the GIS database include scanned images or pictures, hard-copy maps, digital orthophotography, and digital elevation models (DEM). Data sets that are used for administrative purposes should have clearly defined access rights, versioning control and use restrictions. This is particularly important for infrastructure data and student or alumni data sets. A backup system should also be instituted with off-site backup of data bases in case of a major natural or man-made disaster affecting the data storage facility.

*Finding and Acquiring Data*: Significant data sets are available from local, state, and federal agencies either free of charge or at reasonable costs. Two agencies that store large amounts of geographic data for the United States include the U.S. Geological Survey (USGS) and the Census Bureau. The USGS supplies free vector and raster data which are national in coverage while the Census Bureau supplies free demographic data. Other government entities such as the National Oceanic and Atmospheric Agency (NOAA) acquire, store and distribute data.

A complete list of government sources can be accessed over the Internet (see geotechcenter.org for more links to data). Another wealth of geographic data can be found at Esri's ArcGIS Online. Private data firms also house useful geographic data usually developed for a local government. These firms can be contacted individually by the institution to determine if there is educational use pricing available. Many states also have data clearing houses (i.e., PASDA for Pennsylvania, TNRIS for Texas, etc.). Some states have state-level GIS departments that may work with the institution to access data. Remote sensing data may be accessed from state, federal or private data repositories including USGS Global Visualization site (http://glovis.usgs.gov) Some remote sensing data is free (Landsat) or low cost for education, but generally the higher the resolution and the more current the data, the higher the cost. Contact should be made with remote sensing imagery vendors to learn what options exist for educational use. Local regions or towns may have recent, high resolution aerial surveys including LiDAR and other data that they may be willing to share with educators. Commercial data vendors may also be willing to share data with educators or reduce costs significantly for educational purposes. Be sure to check use restrictions as the vendor may not include the use of data or software for administrative uses.

*College Support Structure*: It is a wise investment of time to establish a college support structure that will help to ensure the long-term success of a GST program. In many public and private institutions, financial support for start-up costs is available via interdepartmental grants or grants from state or federal agencies. These grants are helpful for short-term benefits, but without administrative support and commitments, facilities may become vulnerable in the long term. Administrators often assume that facilities are self-sustaining with little required upkeep or need for ongoing funding. If at all possible, obtain a financial commitment from the administration by clearly identifying the benefits and sources of revenue that can be obtained from developing the GST program. Securing annual line-item budget support from the college would be the ideal situation. If the facility is expected to become self-supporting, strategies for creating revenue should be carefully evaluated especially in regard to software license restrictions. In all cases, attempts should be made to familiarize deans, department chairs, and other administrators with GST and the benefits it brings to the campus. These benefits include academic excellence programs, but the use by administrators should also be emphasized. Tours of the facility, software demonstrations, and mini workshops to give administrators a chance to use the facility first hand can help achieve this goal. Having the GST center serve as the campus mapping center with students actively involved in creation and maintenance of this resource including a web site for the campus can provide added support for funding of the facility. If the facility is intended to be used by various departments, there must be a fair distribution of financial support that is contributed by each participating department. However, the management and oversight of the process should be clearly defined and can be counter to the spread of geospatial technology across a campus. This very difficult and time-consuming process for cost recover can be eliminated if financial support can come from the institution's administrative body rather than multiple or single academic departments. On some campuses, the funding is available through student fees that support software and IT or are part of the library system is supported centrally by the campus. Housing the GST center as part of the library system has many advantages and has been successful for many long term programs. See also the section below on Sustainability for additional recommendations.

*Program Funding:* Assuming there is a positive consensus among college administration and faculty from one or more departments in establishing a GIS program, the next major step is securing the necessary funds to purchase equipment, software, and support personnel. Both internal and external sources of funding should be explored. Internal funding may be available through college grants, capital equipment funds, or laboratory fees. External funding can be obtained through private and federal grants, contracts, and donations. Sharing resources (lab facilities, hardware, software and IT support) with other departments and disciplines (computer science, information technology, graphic design) can help defer some funding needs as you launch a program.

Implementation Phase

Once the planning phase is complete and the outcomes from the Needs and Resource Assessment are available, work should begin on the creation of an Implementation Plan. This Plan should include:

* Overview of the Program Plan with goals, objectives and activities
* Updated GST Program Logic Model
* “Program Organization” chart outlining roles and responsibilities including who will continue to lead the effort and support the program and any adjustments to the Advisory Committee
* Timeline of Tasks for Implementation including:
	+ acquiring needed resources (hardware, software and facilities)
	+ steering documents through college administrative approval process

 for course/program offerings

* Budget – funding to start program
* Curriculum for course(s) and program content based on the advice from the Advisory Committee and using the latest curriculum guidelines (GTCM Program Self-Assessment Tool and DACUMs) available from the GeoTech Center.
* Marketing and Outreach plan and activities including creation and distribution of brochures or other marketing resources
* Faculty and IT support identified and training provided.

Sustainability Phase

Once a program has been launched, the longer-term outcomes should include plans for expanding and sustaining the program. The GeoTech Center has identified ways to help promote long term sustainability and has created several best practices documents (<http://geotechcenter.org>) to help in this effort. There are also articles that address some of these issues in the December 2010 issue of the URISA Journal (<http://urisa.org/files/URISA%20Journal%20Vol.22%20Issue%202.pdf>) and on the bibliography at the Esri Education Community web site (<http://edcommunity.esri.com> ).

Some of the ways to support program sustainability include:

* Creating articulation between the college and high schools and universities (<http://www.geotechcenter.org/Featured-Items/Supporting-Your-Program>) to increase the pipeline of students interested in GST;
* Having gateway or introductory GST courses approved for General Education (GE) status (see URISA Journal, Enhancing General Education with Geographic Information Science and Spatial Literacy, Tsou and Yanow, 2010);
* Increasing the number of disciplines that include a GST option by working with other departments and disciplines to create and add a module demonstrating use of GST in their discipline or by including the gateway or GE course in their program (spread GST use across the campus);
* Creating certificate programs that help working professionals acquire technical or conceptual skills leading to successfully passing technical (industry) or professional certification examinations;
* Promote and support use of GST by administration. This can include use for marketing and outreach, facilities management, campus security and campus mapping; and
* Survey outgoing and former students to improve program quality and build reputation for successful preparation of students for the workforce.

Promoting the use of GST by administration has several advantages in helping sustain programs. In a time of budget constraints, GST can help administration make better decisions and save money. This can be through better marketing and outreach such as those practiced by Tacoma Community College <http://www.esri.com/library/casestudies/tacoma.pdf>, projects to better map and manage campus facilities by the Community College of San Francisco (CCSF) (<http://www.esri.com/news/arcnews/spring10articles/taking-efficiency.html>), or by saving energy and creating a green campus such as the efforts at Pomona College (Winter issue of ArcNews). Reliance of administration on the use of GST software and data can lead to the administration covering the cost of those resources and alleviate the need for individual departments to fund those resources. Students can also get practical hands on experience by working on administrative projects and community based projects providing awareness of the GST program and promoting it to other students.

Conclusion

It remains a challenge to successfully build, implement, support and expand a geospatial program at a community college. Inevitably, questions arise concerning the importance of geospatial technology in academic and CTE programs; for example, how to successfully develop a curriculum, where to find funding to support the facility, who will teach the courses, what technology is needed to stay at the cutting edge, how to fund a program, how to work with IT staff and many others.

There is no doubt that the impact and demand for geospatial technology will continue to experience tremendous growth in the educational sector over the next decade. Progress continues to be made toward determining the most effective and efficient pedagogical methods to enhance geographic problem-solving and spatial reasoning skills. GIScience has helped to facilitate these skills by providing students with a real-world interface between the technology and the content in a variety of subject areas. It is the GeoTech Center’s goal to continue to support educators and community college geospatial technology programs to increase the quantity, quality and diversity of the geospatial workforce.