Integrating Geographic Information Systems and Remote Sensing for Technical Workforce Training at Two-Year Colleges

Geospatial Education Workshop

National Science Foundation
Arlington, VA

August 15-16, 2005

Workshop Outcomes

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with assistance and financial support from

National Council for Geographic Education

National Science Foundation Advanced Technology Education Program

Environmental Systems Research Institute (ESRI)

U.S. Geological Survey Land Remote Sensing Program

National Aeronautics and Space Administration: Landsat Program and Earth Observing System Office

This report was developed by the workshop organizers, Jeannie Allen, Ronald Beck, Osa Brand, Ann Johnson, and Arthur Johnson.

It is based upon work supported by the National Science Foundation (NSF) under grant #0541698; by individual grants from the Environmental Systems Research Institute (ESRI), the U.S. Geological Survey (USGS): Land Remote Sensing Program, the National Aeronautics and Space Administration (NASA): Landsat Program and Earth Observing System Office; and by in-kind contributions from the National Council for Geographic Education (NCGE).

Any opinions, findings and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of NSF, ESRI, USGS, NASA, or NCGE.

National Council for Geographic Education
February, 2006

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Executive Summary

This report examines the outcomes of a workshop held at the National Science Foundation on August 15-16, 2005. Forty-six participants, representing academia, industry, government agencies, professional associations, and special projects met to (1) discuss how geospatial technology training at two-year colleges can address workforce needs and (2) recommend ways to structure and implement effective two-year programs that integrate essential technologies.

The workshop was organized by the National Council for Geographic Education (NCGE); the National Aeronautics and Space Administration (NASA) Landsat Program, the Environmental Systems Research Institute (ESRI) Higher Education Office; and the U.S. Geological Survey (USGS) Land Remote Sensing Program. Financial support was provided by each of these organizations, the NASA Earth Observing System Office, and the National Science Foundation (NSF) Advanced Technology Education Program.

Individual and panel presentations, breakout sessions, and group discussions focused on:

- workforce demand for geospatial technologists
- current geospatial technology training at two-year colleges
- academic and professional initiatives that can guide the development of two-year geospatial technology programs
- ideal program characteristics
- challenges and obstacles to the implementation of two year geospatial technology programs
- implementation strategies and other recommendations

The participants were in agreement that two-year colleges should be able to assume strong roles in training new geospatial technologists and meeting on-the-job training needs of local professionals; that Geographic Information Systems (GIS) and remote sensing are the critical curriculum areas for two-year college geospatial technology programs; that students also need some exposure to global positioning systems (GPS) and photogrammetry; and that the programs should foster problem-solving, project management, and communication skills.

Approximately 400 two-year colleges have GIS courses, but very few offer remote sensing. (GPS is sometimes incorporated into GIS instruction; photogrammetry is rarely offered.) The increasing availability of remote sensing data over the last several years offers students new opportunities to learn valuable problem-solving skills that are readily integrated with GIS and applicable in many workforce domains.

The workshop examined curricular needs and recommended instructional and laboratory resources. Obstacles to establishing effective programs were identified in terms of staffing, financial, and administrative issues; limited student awareness of geospatial career options; and the need for collaboration with local employers. Panel sessions focused on overcoming these obstacles and implementing effective programs by recruiting and training faculty, building internal college support, making and utilizing connections with local businesses and agencies that use geospatial technology, and marketing the programs in local communities and on campus.

This report is available on the NCGE website (http://ncge.org/publications/gew). It will be used by the workshop organizers as the basis for other initiatives that support geospatial education in two-year colleges.

I. Introduction

This report examines the outcomes of a workshop convened at the National Science Foundation, August 15-16, 2005, in order to explore the potential for two-year colleges to meet workforce needs for geospatial technology training.

Geospatial technologies are central to many occupations that focus on land use planning, environmental management, emergency response, homeland security, and a multitude of other fields. Training in these technologies - geographic information systems (GIS), remote sensing, global positioning systems (GPS), and photogrammetry - is acquired on the job, through vendors, and in college/university programs that range from individual courses to advanced upper division and graduate programs. Approximately 400 of the nation's 1,157 two-year colleges offer some instruction in GIS, and 25 offer a GIS Certificate. Many of these GIS programs include some GPS instruction, but very few include remote sensing or photogrammetry.

Two current trends are influencing the potential for geospatial workforce training at two-year colleges. The demand for geospatial skills is increasing so rapidly that workforce needs are not being met. At the same time, recent advances in software, hardware, data acquisition, and data sharing are making geospatial technologies more accessible. Skilled technicians can now perform many aspects of work previously accomplished only by expert professionals. This raises new issues of how to train such technicians, here called technologists. Can two-year colleges provide this training? Can they meet local business and industry needs for on-the-job training?

The workshop was organized by the National Council for Geographic Education (NCGE); the National Aeronautics and Space Administration (NASA) Landsat program; the Environmental Systems Research Institute (ESRI) Higher Education Office; and the U.S. Geological Survey (USGS) Land Remote Sensing Program. Financial support was provided by each of these organizations and also by the NASA Earth Observing System Office and the National Science Foundation (NSF) Advanced Technology Education Program. In addition, NSF provided staff support and rooms for the workshop in its Arlington, Virginia headquarters.

The participants included representatives from academia, industry, government agencies, professional associations, and special projects. Their tasks were to examine how integrated GIS and remote sensing training at two-year colleges can meet workforce needs and to recommend ways of structuring and implementing effective two-year geospatial programs based on these technologies.

This report is based on the workshop presentations and discussions. It is available on the NCGE website (http://ncge.org/publications/gew) to support two-year colleges interested in establishing geospatial technology programs. It will also be used by the workshop organizers as the basis for other initiatives in two-year college geospatial education.

An agenda is attached as Appendix A. Thanks to participant Phillip Davis, it is also available on the Del Mar College website (http://gistech.delmar.edu/geospatial_ws1.htm) in an interactive format that provides access to the presenters' slides.

Photographs were provided by two of the participants, Nancy Hultquist and Demetrio Zourarakis, who graciously allowed the project staff to crop, enlarge and generally compromise the quality of their original photos in order to illustrate the report.

II. Project Team, Participants and Design

The project team included Jeannie Allen, Senior Science Education Specialist, Science Systems and Applications, Inc. for the Landsat program at the NASA-Goddard Laboratory for Hydrospheric and Biospheric Sciences; Ronald Beck, Program Information Specialist, Land Remote Sensing Program, USGS; Osa Brand, Director of Educational Outreach, NCGE; Ann Johnson, Higher Education Manager, ESRI, and Arthur Johnson, Director, Edumetrics. The team members share a mutual interest in geospatial education and workforce needs.

The 46 participants, listed in Appendix B, were invited to the workshop because of their knowledge about the geospatial workforce needs and about GIS and remote sensing education. Participants and project staff represented eleven two-year colleges; seven four-year colleges and universities; seven businesses; four national government agencies; three state and county government agencies; five professional associations; and four institutes and special projects. Several NSF Advanced Technology Education program officers also attended the workshop as observers.

Two pre-workshop studies undertaken by NASA's Landsat Program and ESRI helped define the workshop topics. One consisted of an examination of curricula at selected two-year colleges, in order to determine the kinds of geospatial courses offered. The other was a survey of workforce representatives, academic geographers from two- and four-year institutions, and professional associations who responded to the following questions about the prospects for geospatial training in two-year colleges:

- Is there a workforce need for geospatial technologists trained in two-year colleges?
- If so, can the need be met by integrating GIS and remote sensing instruction?
- What challenges and obstacles would two-year colleges face in creating such programs?

The workshop was designed to encourage as much input as possible from the participants, and to offer formal and informal opportunities for interaction. All of the participants made individual presentations or served as panelists, and all took part in breakout sessions and open discussions. Information was captured in written notes and voice recordings, and the presenters contributed their slides to the Delmar College web page (http://gistech.delmar.edu/geospatial_ws1.htm).

Ann Johnson and Jeannie Allen (left) convene the first group of presenters (right).

III. Workshop Goals

The workshop explored the following topics from the perspectives of geospatial experts in two- and four-year colleges, industry, government, and professional associations:

Workforce Needs: Is there a demand for geospatial technologists with two-year training?
Existing Programs: What kinds of geospatial education programs *are currently* in place at two-year colleges? What educational and professional support is available for two-year programs?
Ideal Programs: What courses and learning resources *should* be in place at two-year colleges in order to meet geospatial workforce needs?
Challenges and Obstacles: Why are the needed education programs and learning resources *not* in place?
Implementation Strategies: What will it take to establish two-year geospatial programs that meet workforce needs?

IV. Outcomes

A. Workforce Needs

(1) What characterizes the geospatial workforce needs?

(a) Growing demand:
The U.S. Department of Labor projected in 2003 that the geospatial industry would have worldwide annual revenues of $30 billion by 2005 ($20 billion in remote sensing and $10 billion in GIS). The only similar estimates for the U.S. have been made by the American Society for Photogrammetry and Remote Sensing (ASPRS; Washington DC). James Plasker, ASPRS Executive Director, discussed the Society's *Ten-Year Remote Sensing Industry Forecast*, published in 2004 and available at http://www.asprs.org/news/forecast/. The authors projected that in 2004 the U.S. remote sensing industry alone would generate more than $3 billion annually and employ more than 175,000 people.


James Plasker

Several participants suggested that the ASPRS figures appear low. Revenue categories can be arbitrary, and employment is difficult to calculate since the U.S. Department of Labor has no job classifications based specifically on remote sensing.

Mr. Plasker indicated that the increasing demand for geospatial skills will provide employment opportunities for graduates of both two- and four-year year programs, especially in the high-growth areas of homeland security, environmental assessment, and infrastructure applications. The demand will accelerate as more businesses, industries, and government agencies understand the capacity of GIS and remote sensing to enhance their operations.

Susan Kalweit, Senior Associate, Booz Allen Hamilton (McLean, VA), quoted Secretary of Labor Elaine Chao as saying, at the September, 2004 announcement of the President's High Growth Job Training Initiative, "The geospatial industry is fast-growing

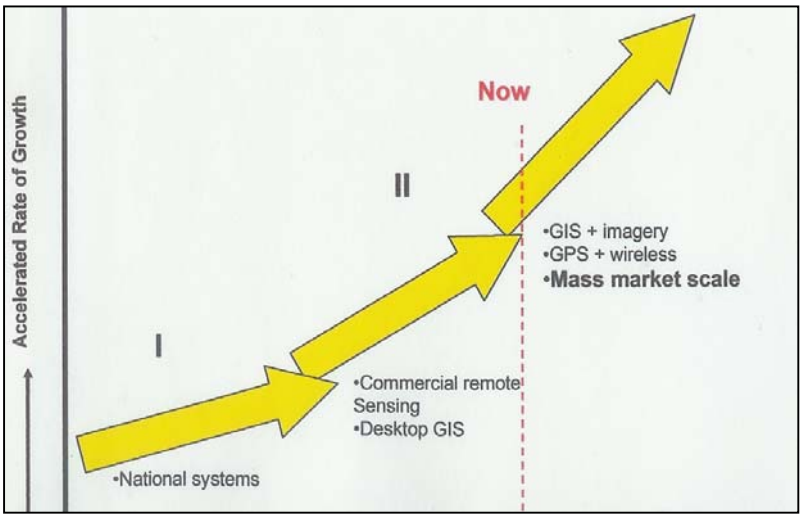
and exciting, and it offers a great deal of job opportunities. The workforce in this industry has doubled in the last four years, and accelerated growth is expected in the years ahead."

Susan Kalweit

Ms. Kalweit showed an illustration, Figure 1, of the impact of three market sectors on the growth of the geospatial industry. Initially, most of the demand for geospatial technologies was in government agencies. As industrial and business markets developed, the commercial demand for both remote sensing products and desktop GIS products resulted in more rapid growth rates.

The recent demand for both GIS and GPS-based desktop consumer products among casual, non-professional users has further accelerated the growth of the geospatial industry. While the mass markets initially focused on GIS and GPS, they now include remote sensing images. New services from Google Earth, for example, offer free satellite images for all parts of the world, and MapQuest now merges maps and satellite images. The mass market will no doubt continue to accelerate at a dramatic rate and have a strong impact on workforce needs for geospatial skills.

Figure 1. Accelerating Growth of the Geospatial Industry



Source: Booz Allen Hamilton, courtesy Susan Kalweit

Kevin Neimond, representing the National Association of Counties (Washington DC), noted that many smaller businesses and local and regional government agencies have been relatively slow to adopt geospatial technology and that the demand will accelerate further as they come on board. The lag in demand is especially apparent at the county level. However, as more and more county agencies are able to demonstrate their utility, geospatial technologies will become essential to effective operations.

The Loudoun County (VA) Office of Mapping and Geographic Information is a well-known model for sophisticated GIS applications. Director Larry Stipek said that remote sensing is, however, not yet integrated into much of the work in his agency's four divisions. Susan Carson Lambert (retired) and Demetrio Zourarakis, representing the Kentucky Division of Geographic Information, Commonwealth Office of Technology (Frankfort, KY), noted that both GIS and remote sensing are underused in their county and state agencies, but that there is considerable interest in on-the-job training. (Their remote sensing workshops in Kentucky are discussed under "Region- and industry-specific needs," below.)

Colleges interested in monitoring state needs for geospatial technology training should be attuned to information compiled by the National States Geographic Information Council (NSGIC). NSGIC monitors state accomplishments in geospatial technology and files an annual state-by-state website report on its website. (www.nsgic.org/states/index.cfm).

Kass Green, President of the Alta Vista Company (Berkeley, CA), stated that the lag in demand will be overcome as geospatial technology becomes "faster, better, cheaper" and easier to use. People can then be hired exclusively for disciplinary expertise and acquire the appropriate geospatial training relatively quickly. Two-year colleges that offer job-related training will have an important role to play.

Ron Beck, Jon Dykstra, Susan Carson Lambert, Kass Greene, Susan Marlow

Richard Wong, representing the Rancho Santiago Community College District (Santa Ana, CA), explained that a recent Geospatial Training and Workforce Needs Assessment has confirmed the lag in demand in both private industry and local government. Conducted by the Community College District and St. Louis Community College (St. Louis, MO) and funded by the U.S. Department of Labor, the needs assessment examined industrial demand for geospatial skills. It surveyed private industries and public agencies, all identified as users or potential users of geospatial technology, in southern California and St. Louis. Of 161 responding organizations, only 48 percent consider geospatial technology to be important to their overall success at present, while 79 percent anticipate that geospatial technology will become much more important to their operations in the near future.

Most of the responding organizations that currently use geospatial technologies require at least a BA/BS degree for jobs involving analysis or application of geospatial data, but a significant number (32 percent) hire applicants with AA/AS degrees for more basic geospatial work.

Thirty-four percent of the organizations do not have enough trained employees to meet their current needs, and 33 percent offer in-house or vendor training. Most said that they would prefer to have employees take courses at two- or four-year colleges.

Ron Beck, Program Information Specialist, Land Remote Sensing Program, U.S. Geological Survey (Reston, VA) explained that the USGS bases hiring decisions on science expertise. Scientists who do not have the necessary geospatial skills acquire training as necessary. In general, the federal government requires four-year or graduate degrees, but two-year colleges can have an important role in training people already employed in the federal workforce.

The workshop participants were in agreement that workforce demands for geospatial skills will continue to grow dramatically. Several expressed concern that much U.S. geospatial work is already done offshore and that relying on foreign expertise to meet the growing demand will result in lost domestic job opportunities. Two-year colleges should be able to help meet the need for less costly geospatial work in the U.S. Kass Green commented that many overseas geospatial technologists, especially in India and China, are well qualified and that U.S. training must aim high in order to be competitive.

Arnold Landvoigt, Geospatial Specialist at the National Security Agency (Washington DC), pointed out that offshore contracting raises security issues. Much of the geospatial work needed by the military cannot be outsourced offshore, so as this demand expands it must be met by the U.S. workforce.

Pamela Lawhead, Director of the University of Mississippi Institute for Advanced Education in Geospatial Sciences (University, MS) saw the growing workforce needs as a tremendous opportunity for two-year colleges. Traditional universities do not realize how intense this workforce demand is becoming, and they seldom have the flexibility to implement responsive programs.

James Plasker pointed out that most people in the geospatial industry received their training primarily in GIS or remote sensing and that few have degrees spanning both fields. Specialists in one area generally seek training in the other as required by their work, in ways that range from on-the-job learning opportunities, to vendor training programs, to college and university courses and workshops, to independent studies. Two-year colleges are often within easy reach for people who need such additional training.

Jon Dykstra, Vice President of EarthSat Corporation (Rockville, MD), offered an example of the demand for geospatial skills in a medium size well-established firm. Earthsat is a consulting firm, founded in 1969, that provides all-source satellite image data acquisition and value added processing for a broad range of commercial and government clients. (see Dr. Dykstra's slides at www.gistech.delmar.edu/geospatial_ws1.htm for examples of EarthSat projects.) The company employs 130 people: 72 GIS and remote sensing specialists; 26 marketing, executive, and support staff; 24 meteorologists; 5 IT professionals, and 3 exploration geologists. Eight of the staff have PhDs, 54 have MS or MA degrees, 56 have BS or BA degrees, and 12, most of whom are support staff, have no degrees.

A large proportion of the employees were in their 20s when they were hired, many of them recent graduates of four-year colleges. None of the current employees have AA degrees, but Dr. Dykstra indicated that he would not hesitate to hire appropriately trained two-year college graduates. Comments from several other business and industry representatives also made it clear that technologists trained at two-year colleges could fill needs in their market sectors.

(b) Rapidly changing requirements:
David Curren, Manpower Analyst, Business Relations Group, Employment and Training Administration (ETA), U.S. Department of Labor, pointed out that that the geospatial workforce needs are highly dynamic and that prospective employees often have difficulty understanding the labor market, knowing where the jobs are, and understanding what skills and competencies are necessary to do those jobs.


David Curren

ETA is helping to shape a flexible and demand-driven Workforce Investment System that addresses these needs. An investment of $15 billion in public workforce resources supports federal, state, and local technical employment training programs and Career Centers across the country that provide information to employers and job-seekers. ETA works with industry and training providers to ensure that the training options are tailored to the changing technical workforce needs.

ETA has also invested over $6 million in grants that directly support the geospatial industry. (For more information, see www.doleta.gov/BRG/Indprof/Geospatial.cfm.) These include community-based job training grants and a new, competitive grant program for training in community and technical colleges.

The grant program is based on partnerships between colleges, businesses, and the Workforce Investment System which ensure that the training meets current industry needs. (The Geospatial Training and Workforce Needs Assessment, described above, is among the projects funded by this program.)

Mr. Curran described the President's High Growth Job Training Initiative as another major federal program that supports industry-education collaboration in order to meet real-time workforce needs. It engages leaders in high-growth industries to help develop workforce solutions that can serve as national models. Two of the projects represented at the workshop, the Geospatial Hub Project and Geospatial 21, were funded under this program.

c) Industry needs related to scale:
James Plasker pointed out that most firms whose primary focus is the geospatial industry are relatively small, with fewer than 100 employees. They provide narrowly defined services, while the larger firms offer a wider range. Most civilian firms provide mapping and engineering applications required by government at local, country, state, and national levels. Small firms cannot easily provide in-house training to meet changing requirements, and they need to rely on appropriate up-to-date training programs for their new hires as well as for existing staff who need to develop new skills.

d) Region- and industry-specific needs:
Several of the participants noted that many geospatial jobs are region- and industry-specific, and that workforce needs will vary accordingly. They recommended that two-year college training reflect such differences in order to meet local and regional workforce needs, both as part of the geospatial curriculum for traditional students and to meet special training needs for members of the workforce.

Susan Carson Lambert and Demetrio Zourarakis offered an example of how state, regional, and local training needs can be met through two-year college workshops. With funding from a NASA grant to the National States Geographic Information Council, they recently offered workshops at four two-year colleges that focused on accessing and applying Kentucky-based remote sensing data. The participants were from state agencies (26%), academic institutions (22%), federal agencies located in Kentucky (13%), county governments, private business, and regional entities (such as regional planning offices, city governments, and nonprofits).

Few had any training in remote sensing or any knowledge of how they could incorporate remote sensing into their work, but in post-workshop surveys 80% of the approximately 100 respondents said that their agencies would benefit by using remote sensing data and technologies, and over 70% expressed interest in taking a remote sensing course.

The workshops pointed out the need for remote sensing training in Kentucky and the value of basing instruction on local and regional applications. The participants said that they were eager to learn because the instruction was relevant to their needs. Those employed in industry and government agencies could see direct applications of Kentucky-based remote sensing data to their work, and the participating schools recognized the relevance of job training based on regional and state needs.

e) Required competencies:

Cyndi Gaudet, Director of the Workplace Learning and Performance Institute, University of Southern Mississippi, discussed the Geospatial Technology Competency Model (GTCM), developed by the NASA-funded National Workforce Development and Education and Training Initiative. The GTCM (Table 1) identifies the roles, competencies, and outputs for the geospatial technology industry as part of a customer-driven workforce development strategy.

The model matches competencies with roles, as opposed to job titles, which can be elusive in the geospatial technology industry, in order to facilitate employee recruitment and selection, performance management, career development, and succession planning. The GTCM was based on research of relevant literature and the participation of a wide range of stakeholders. It identifies:

a) 12 roles that meet the expectations of a specific job or job function: applications development, data acquisition, coordination, data analysis and interpretation, data management, management, marketing, project management, systems analysis, systems management, training, and visualization;

b) 39 competencies, categorized as technical, analytical, business, and interpersonal.

Group discussion focused on additional competencies not listed in the GTCM. In the analytical thinking category, the participants recommended including spatial thinking, critical thinking, and reasoning in multiple dimensions. They also stressed the importance of communication skills and problem-solving abilities that draw on a variety of data sources.

Table 1. Geospatial Competency Model

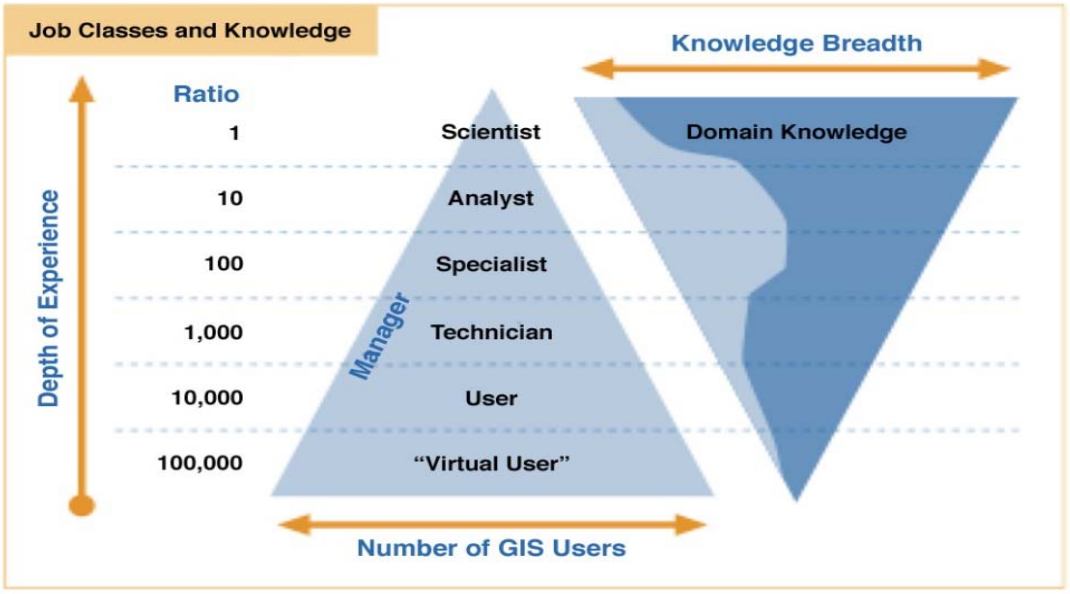
			ROLES											
			Applications Development	Coordination	Data Acquisition	Data Analysis	Data Management	Management	Marketing	Project Management	Systems Analysis	Systems Management	Training	Visualization
COMPETENCIES	Technical	Ability to Assess Relationships Among Geospatial Technologies		●				●	●		●	●	●	●
		Cartography			●	●								●
		Computer Programming Skills	●		●		●				●			●
		Environmental Applications	●			●								●
		GIS Theory and Applications	●			●	●	●		●		●	●	●
		Geology Applications				●								
		Geospatial Data Processing Tools			●	●					●	●	●	●
		Photogrammetry	●		●	●								●
		Remote Sensing Theory and Applications	●		●	●						●		●
		Spatial Information Processing	●		●	●							●	●
		Technical Writing	●	●		●		●	●	●	●	●	●	●
		Technological Literacy	●		●	●	●	●		●	●	●	●	●
		Topology				●								●
	Business	Ability to see the "Big Picture"	●	●			●	●	●		●	●	●	
		Business Understanding		●				●		●				
		Buy-in/Advocacy		●				●	●		●		●	●
		Change Management	●	●		●	●	●	●	●	●	●	●	●
		Cost Benefit Analysis / ROI		●			●	●	●	●		●	●	●
		Ethics Modeling				●		●	●	●		●	●	●
		Industry Understanding	●	●				●	●				●	●
		Legal Understanding		●										
		Organization Understanding		●				●				●		
		Performance Analysis and Evaluation			●			●		●	●	●	●	
		Visioning		●				●	●	●	●	●	●	
	Analytical	Creative Thinking	●	●	●	●	●	●	●	●	●	●	●	●
		Knowledge Management		●		●		●		●		●	●	●
		Model Building Skills	●				●	●				●	●	●
		Problem-Solving Skills	●	●	●	●	●	●	●	●	●	●	●	●
		Research Skill	●			●							●	
		Systems Thinking	●					●			●	●	●	●
	Interpersonal	Coaching		●				●					●	
		Communication	●	●	●	●	●	●	●	●	●	●	●	●
		Conflict Management		●				●		●		●	●	
		Feedback Skills	●	●	●	●	●	●	●	●	●	●	●	●
		Group Process Understanding		●				●		●		●	●	
		Leadership Skills		●			●	●	●	●		●	●	●
		Questioning		●				●	●		●	●	●	
		Relationship Building Skills		●				●	●	●	●	●	●	
		Self-Knowledge/Self-Management		●				●	●		●	●	●	

Cyndi Gaudet, Heather Annulis, and John Carr. "Building the Geospatial Workforce," *URISA Journal*, Vol. 15, No. 1, 2003. p. 29.

(2) What technologist-level work is enabled by the integration of GIS and remote sensing?

Figure 2 was developed by ESRI to explain the relationship between GIS users and the extent of their knowledge and expertise. It also applies to the geospatial industry as a whole. The many informal users need relatively little knowledge of the domain. Within the workforce, knowledge requirements increase with more sophisticated job classifications while the number of people employed at each level decreases. Workshop discussions suggested that geospatial technologists with two-year training are likely to have expertise and knowledge that straddle the technician and specialist categories, and that the current terminology should be expanded to include this category.

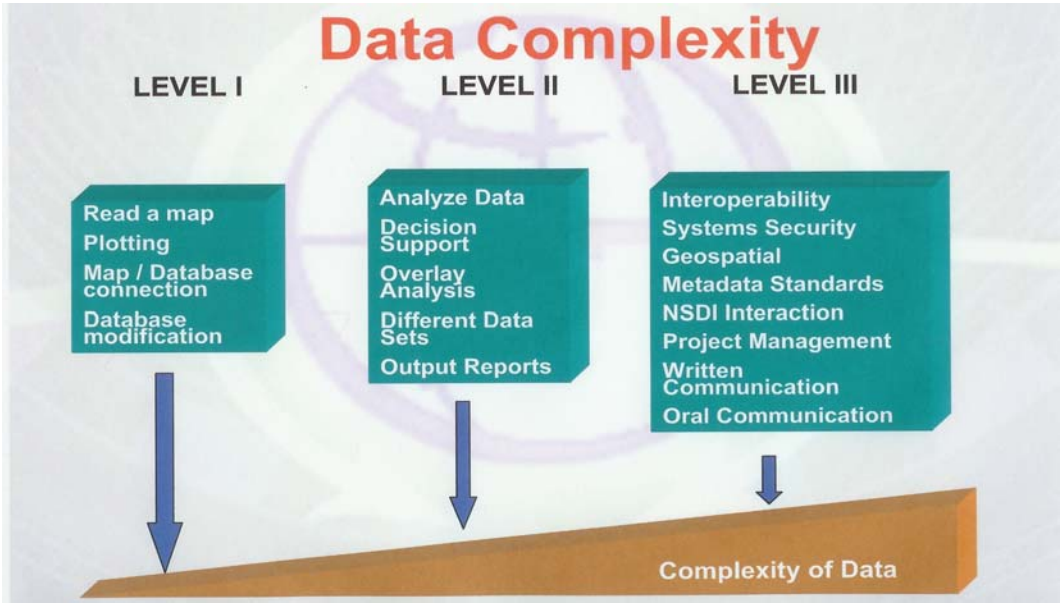
Figure 2. Job Classes, Levels of Expertise, and Breadth of Knowledge



Source: GIS Educator, Summer 2004. p. 2

Susan Marlow, CEO of Smart Data Strategies (Franklin, KY) offered a similar illustration. Figure 3 provides more detail about the kinds of expertise required as data complexity increases along the "depth of experience" continuum. Well-trained technologists should be able to do much of the analytical work in category II (i.e. analyze data from a variety of data sets, provide decision support, and generate output reports) as well as some of the work in category III.

Figure 3. Workforce Expertise and Data Complexity



Source: Smart Data Strategies, courtesy Susan Marlow

The work of geospatial technologists who use both GIS and remote sensing varies widely. In a panel session focused on technologist-level workforce preparation, Stacy Myers (Palm Beach Community College and the South Florida Water Management District, SFWMD) offered an example. SFWMD employs GIS and remote sensing technologists to work on the restoration of the Everglades. They integrate GIS and remote sensing as they identify and map various kinds of land cover/land use and track change over time in satellite images. Basic GIS is an essential tool for working with the satellite images.

Larry Stipek (Loudoun County (VA) Office of Mapping and Geographic Information) added that technologist-level geospatial skills are widely applicable in county agencies that focus on economic development, health, and planning. Such agencies also require an understanding of the major national mapping programs and an ability to work with relevant data sets.

Larry Stipek, Stacy Myers, Arnold Landvoigt, Laura Rocchio, Pamela Bingham

Pamela Bingham (Bingham Consulting Services and Howard University) commented on the interdisciplinary applications of geospatial technology. A very wide variety of jobs are available for well-trained two-year college graduates who can use software tools effectively

and who have an understanding of database development, systems science, computer science, and spatial referencing.

Laura Rocchio (Landsat Support Scientist, NASA-Goddard Space Flight Center) noted that the wide range of jobs makes it difficult for most technologists to receive all the training they need in any given two-year program. New employees usually require additional training tailored to specific job requirements. Two-year programs should therefore ensure that graduates have skills that can be applied in a variety of workforce contexts. Most geospatial technologist jobs require basic remote sensing, GIS skills, and familiarity with current hardware and software. Many require a working knowledge of GPS, basic surveying skills, and/or an understanding of information integration and data fusion. Virtually all jobs require problem-solving skills based on assessing data quality and using multiple data sets. Technologists who have these qualifications are well-prepared for the additional training required in most jobs.

Arnold Landvoigt, Geospatial Specialist at the National Security Agency (NSA), began working for NSA with a community college degree in the 1980s and subsequently earned a four-year degree in Tech Management and Telecommunications. He pointed out that well-prepared geospatial technologists readily advance along various career paths through further training, assuming new and different responsibilities over time both as technologists and in more professional roles. Like most other federal agencies, new NSA hires must now have at least a four-year degree. NSA encourages employees to seek geospatial training in order to keep up with the changing workforce demands. Most of this on-the-job training is in GIS, but the need to educate NSA clients about the potential of remote sensing applications is obvious.

B. Existing Programs

(1) What kinds of geospatial education programs are currently in place at two-year colleges?

The ESRI pre-workshop survey questioned two-year colleges that offer geospatial courses about their curricula. At the same time, a NASA Goddard Space Flight Center intern, Ron Campbell (United Tribes Technical College), examined geospatial programs at the two-year colleges in Virginia, Maryland, and Texas, and all two-year Tribal Colleges. In the data collected by ESRI and NASA, most geospatial course offerings at two-year colleges focus on GIS, often in the context of specific industry needs. GPS instruction is sometimes included in various courses, but remote sensing instruction is uncommon. GIS is also the basis for professional certificates and AA or AS Degrees in geospatial technology. Some programs are campus-based, while others are offered on the Internet. Many colleges provide short courses or workshop opportunities for specific workforce domains (i.e., forestry, first responders, etc.), and training for K-12 and college faculty.

A few two-year colleges do offer more broad-based geospatial curricula, and several of them were represented at the workshop. They offer valuable models for other schools interested in expanding their own GIS-based programs or in establishing new geospatial programs. Brief descriptions follow:

Del Mar College, Corpus Christi, TX (www.delmar.edu; represented by Phillip Davis): Del Mar offers a GIS Certificate and a GIS AA degree. Remote sensing is being integrated into the existing curriculum, largely as a result of this workshop. Among the courses that will include remote sensing are those developed as part of the NSF-funded GIS-Tech project. GIS-Tech

will enable Del Mar to establish a GIS Academy with a broad geospatial curriculum that will serve as a state and national model for both curriculum development and articulation with K-12 education and four-year colleges.

Monterey Peninsula College, Monterey, CA (www.mpc.edu; represented by Deidre Sullivan): The MPC curriculum currently includes Introduction to GIS, PSC, and Cartography; Advanced GIS; Ocean Cartography; and Ocean Data Collection and Visualization. Like Del Mar, the MPC focus has been on GIS applications, but two remote sensing courses are about to be added. MPC offers good models for professional training. Intensive workshops focus on GIS applications in Marine Resource Management and a summer institute focuses on Marine GIS.

Palm Beach Community College, Palm Beach, FL (www.pbcc.edu; represented by Stacy Myers): Environmental GIS/Remote Sensing covers the basic skills of geospatial technology in one course. Students spend a large proportion of their time in the field and in the lab. They learn to use appropriate software and also to work independently on projects that have direct applications for local government agencies or industries. Recent projects include wetland mitigation, wetland change detection, development compliance, land cover classification, and post-classification change detection. Local agencies and industries that hire Palm Beach graduates stress that they value technologists who have learned to apply geospatial skills in environmental contexts.

Gainesville College, Institute for Environmental & Spatial Analysis (IESA), Gainesville, GA (http://www.gc.peachnet.edu/science/gis; represented by Lewis Rogers and Christopher Semerjian): IESA offers a GIS Certificate in Geographic Information Science, which also requires remote sensing skills. The technical instruction draws on content from a number of environmentally-based courses. Articulation agreements with the State University of West Georgia include a four-year dual degree in Applied Environmental Spatial Analysis/Geology. Beginning in 2006, Gainesville will offer a four-year BS program, the first at this community college, in Applied Spatial Analysis.

Lake Land College, Mattoon, IL (lakeland.cc.il.us; represented by Michael Rudibaugh: Lakeland offers an AA diploma in Environmental Conservation & Reclamation, Environmental Protection Technology, Conservation and Vegetation Management Technology, and Wildlife and Fisheries Conservation. It prepares students to work as field specialists where natural systems interact with human ecology and resource development. Emphasis is placed on the field and laboratory skills necessary for work in fisheries, aquatic biology, forestry, parks and other positions related to interactions between people and natural resources. Students have a common first year, after which they specialize in one of the fields. Remote sensing, GIS, and GPS are part of the training during that year.

Pierce College, Woodland Hills, CA (www.piercecollege.edu; represented by Gail Hobbs): Pierce College offers a GIS program with courses that include Introduction to GIS; Beginning GIS Applications; Intermediate GIS Applications; GIS in Science, Business, and Government; and Cartography and Base Map Development (designed to support GIS). Other geospatial courses include Introduction to Global Positioning Systems and Spatial Analysis and Modeling. Internships offer opportunities for students to apply classroom instruction to community-based projects. Remote sensing courses are not yet part of the curriculum. All GIS courses can be taken as geography credits or as GIS credits. Students planning to enter the workforce upon graduation generally prefer GIS credits in order to make their credentials more explicit, while those who transfer to four-year institutions prefer to have geography credits.

Rancho Santiago Community College District, Santa Ana, CA (www.rsccd.org; represented by Richard Wong): The District is integrating geospatial technology, primarily GIS, into existing courses such as surveying, water management, and business. The curriculum guidelines are based on the results of the geospatial needs assessment in southern California and St. Louis, Missouri, discussed on page 5, which was supported by a grant from the Department of Labor. The survey identified local and regional geospatial workforce needs and the specific skills required of key geospatial occupations. This information was the basis for an occupational knowledge and skills matrix, which was correlated with existing and needed courses.

San Diego Mesa College, San Diego, CA (http://geoinfo.sdsu.edu/hightech/noFlashIndex.html; represented by John Johnson): With funding from the NSF Advanced Technology Program, San Diego Mesa College is developing a skills-based GIS certificate program based on core competencies required of GIS technicians entering the workforce. The program will not offer remote sensing training, but will provide a model for articulation of technical courses with both high schools and four-year institutions, through collaboration with San Diego State University and the San Diego City School District.

Cayuga Community College, Institute for the Application of Geospatial Technology (IAGT), Auburn, NY (www.iagt.org; represented by Abu Badruddin): The GIS AA degree program at IAGT integrates remote sensing. (A campus-based MODIS satellite antenna provides data for analysis of both weather and land cover.) Partly supported by NASA, IAGT supports training in applications related to twelve federal government priorities: agricultural efficiency, air quality, aviation, carbon management, coastal management, disaster management, ecosystems, energy forecasting, homeland security, invasive species, public health, and water management.

Jefferson County Community and Technical College, Louisville, KY (www.jefferson.kctcs.edu; represented by Vincent DiNoto): The Geospatial Information Technologist Program offers the same government-priority specializations as Cayuga Community College. The technical courses emphasize GIS, but remote sensing is also integrated. Students are introduced to a variety of career opportunities, including cartography, photogrammetry, surveying, drafting, geography, physical science, computer science, GIS analysis, database administration, and remote sensing.

Ellen Hause

Ellen Hause, American Association of Community Colleges, Washington DC, provided information about two programs that could not be represented at the workshop:

Kirkwood Community College, Cedar Rapids, IA (www.kirkwood.edu): Kirkwood houses the National Center for Agriscience and Technology Education, which provides funding and materials for 17 partner community colleges that have geospatial technology programs and/or courses. A rigorous Model Program of Study outlines the fundamental science, math and technology that is required of the geospatial technology programs. The Center organizes faculty workshops in geospatial technologies with topics ranging from basic awareness of GPS/GIS to advanced spatial analysis. Industry partners, including AgrowKnowledge, ESRI, AgLeader, Deere and Co., support the colleges with software and hardware.

Chemeketa Community College, Salem, OR (www.chemeketa.edu): Chemeketa Community College helped integrate GIS into natural resource education in Oregon's public two-year

colleges by creating a basic skills course for Associate Degrees as well as a GIS Technician Program. Course materials were disseminated to over 260 faculty, and GIS courses are now integrated into most natural resource programs.

Chemeketa also provided mentoring to faculty interested in incorporating GIS/GPS instruction and sponsored eight week-long, hands-on institutes covering basic and advanced skills in GIS & GPS. More than 100 faculty participated in the institutes. While the Chemeketa initiatives have not included remote sensing, they offer a solid model for the development and dissemination of more broadly focused geospatial programs.

(2) What other programs offer support or models for two-year colleges?

University of Southern Mississippi, Geospatial Workforce Development Center (GeoWDC), Long Beach, MS (http://www.geowdc.usm.edu): GeoWDC is part of NASA's National Workforce Development Education and Training Initiative. A customer-driven program designed to meet industry needs for a well-trained geospatial workforce, GeoWDC promotes systemic change in the way students and the incumbent workforce are trained and retrained.

Cyndi Gaudet

Director Cyndi Gaudet described the Geospatial Technology Apprenticeship Program (GTAP) as one model for technologist- level workforce training. A pilot program funded by the Department of Labor, the GTAP is a collaboration among employers and educators to provide on-the-job geospatial training. Participating businesses include many companies involved in the Mississippi Enterprise for Technology at the Stennis Space Center. They employ the apprentices full-time and provide on-the-job mentoring. The apprentices take classes two nights each week. Tuition is covered by the DOL grant, and faculty mentors help them relate their studies to on-the-job learning. Most apprentices plan to become certified as Geospatial Specialists or to complete an Associate's Degree.

Local two-year colleges offer specific GTAP courses at customer-driven times and locations. Certification requires 21 hours of credit, including two elective community college courses and the following required courses: Fundamentals of GIS; Fundamentals of GIS Software; Fundamentals of Remote Sensing; Fundamentals of Database; and Fundamentals of Cartography.

University of Mississippi, Institute for Advanced Education in Geospatial Sciences, University, MS (www.iaegs.com): The IAEGS was funded in 2001 by the NASA Earth Science Division to support geospatial workforce training. Director Pamela Lawhead explained that the IAEGS mission is to develop online courses to support a consistent, high quality, market-driven curriculum in remote sensing, GIS and other related technologies.

Pamela Lawhead

IAGES is developing a library of 30 courses that can be offered by schools across the country. All courses are multi-media intensive. They are designed for a range of markets, including two-year colleges, four-year colleges, universities (graduate and undergraduate levels), businesses, and government agencies.

Course development is funded by grants based on proposals to IAGES. Nine courses are currently available on-line and most others have been completed recently or are near completion. Courses identified as most appropriate for two-year college programs are in italics in Table 2. Institutions may offer any of the available courses by providing a local Professor of Record, purchasing the access, and installing IAEGS virtual portal software locally. The courses use IAEGS software and IAEGS provides tools to monitor student progress.

Table 2: AEGS Curriculum

Courses currently on-line:

Advanced Digital Image Processing	Introduction to Digital Image Processing
Aerial Photographic Interpretation	*Introduction to Geospatial Information Technology*
Decision Support Systems	Orbital Mechanics
Geospatial Data Synthesis and Modeling	Photogrammetry
Information Extraction using Microwave Data	*Remote Sensing and the Environment*

Courses recently completed and near completion:

Advanced Photogrammetry	*Geospatial Primer*
Advanced Sensor Systems & Data Collections	*Remote Sensing of Water*
Agricultural Applications of Remote Sensing	*Remote Sensing Primer Modules*
Artificial Intelligence and Geoprocessing	Sensors and Platforms
Community Growth	Topographic Mapping
Information Extraction Using Multi/Hyper/ Ultra Spectral Data	

Courses in italics are appropriate for two-year college programs.
Source: IAEGS Website

MentorLinks: Advancing Technological Education in Supporting Geospatial Technology at Two-Year Colleges, American Association for Community Colleges, Washington, DC (www.aacc.nche.edu): Funded by the NSF Advanced Technology Education Program, MentorLinks provides mentoring, professional development, technical assistance, and networking opportunities for two year colleges interested in outside expertise to support technical training in the science, technology, engineering, and mathematics (STEM) fields.

Ellen Hause, AACC Senior Program Associate, noted that the following Mentorlinks schools have requested mentors for geospatial technology, primarily GIS: Cape Cod Community College, MA; Lake Land College, IL; Kentucky Community and Technical College System; Flathead Valley Community College, MT; City College of San Francisco, CA; and Springfield Technical Community College, MA. Three of the assigned mentors participated in the workshop at NSF: Gail Hobbs, Mike Rudibaugh, and Vincent DiNoto.

Marguerite Madden

University of Georgia, Center for Remote Sensing and Mapping Science (CRMS), Department of Geography, Athens, GA (http://www.crms.uga.edu): CRMS Director Marguerite Madden represented one of the country's best-known university programs in remote sensing.

While it does not directly support two-year programs interested in remote sensing, the breadth and depth of the CRMS course offerings and its state-of-the-art equipment offer high-end models that can help two-year colleges identify their own goals.

Some of the community-based projects that are described on the CRMS website can also help generate ideas for projects that might be developed on a smaller scale by two-year college geospatial programs.

Table 3: CRMS Geospatial Courses

Air Photo Interpretation
Advanced Photogrammetry
Remote Sensing of Environment
Introduction to GIS
Advanced Remote Sensing with GIS Applications
Computer Cartography and Animation
GIS in Environmental Planning
Applications of GIS in Agriculture
Directed Problems in Remote Sensing and GIS
Spatial Analysis
+60 short courses (CRMS-Georgia Center Cont. Ed.) since 1988, including:
- pc Arc/Info Starter and Advanced Courses (1988-1994)
- Desktop Mapping with SPOT Data (1988-1990)
- Desktop Mapping with Stereo Image Data in Digital Formats (1992)
- GIS for Environmental Applications (2002)
- Image Processing and GIS for Natural Resources Management (1989-1992)
- Integration of GPS, Image Processing and GIS for Resource Management (1996-2004)
- Introduction to Image Processing and GIS (1993-1996)
- Integrating GPS, GIS and Image Processing for Natural Resource Management, 2.5-day Short Course with UGA
- GPS & GIS for Fisheries Resources. Center for Continuing Education 2-day Course, UGA and GDNR
- Liking Lichens: Cooperation with UGA Adult Education, Geography, Geology and State Botanical Gardens, ($160,000 2-year funding from UGA to develop the course.)

Table 4: CRMS Equipment

Servers, Workstations

- Dell Powervault 745N rack-mounted Data server (with Dell PV22S - 4 TB disk array)
- Dell PowerEdge 750 rack-mounted Admin server (500 Gb)
- Dell PowerEdge 750 rack-mounted Web/Ftp server (500 Gb)
- Dell Powervault 745N rack-mounted Backup Server (1 Tb)
- Dell Powervault 745N rack-mounted Off-site Backup Server (1 Tb)
- Dell Powervault 725N rack-mounted Remote Access server (250 Gb)
- 15 Dell Dimension 8400 personal computer workstation (dual-monitor, 3.0 Ghz, 500 Gb)
- Dell Precision 670 MT64 (Visualization and Graphics-optimized) Workstation (dual-processor, dual-monitor, 2Gb Memory, 750 Gb hard disks)
- TabletPC and Compaq iPaq Handheld PC (for GPS/GIS field work)

Network Infrastructure

- Fast Ethernet (100BaseT) network wiring throughout the lab, 3COM 3300 switches and centralized network management.
- Direct connection to University Gigabit fiber optic network and T3 internet link.
- SonicWall Firewall

Peripheral Devices

- Two Epson Expression 836xl large format scanners (800 dpi optical resolution)
- Hewlett Packard Designjet 650c large format color plotter
- Hewlett Packard Designjet 2500cp large format color plotter
- Hewlett Packard Designjet 755cm large format color plotter
- Dell 3000n Color Laser Printer
- Dell 1700n Laser Printers

Survey and Photogrammetric Equipment

- Trimble Pathfinder Pro XRS differential GPS unit with Omnistar/Coast Guard Beacon receiver
- Six Garmin GPS 5 plus several GPS 12 and Etrex handheld GPS receivers
- Digital camera with GPS interface
- Two Hasselblad MKW/E metric cameras for close range photogrammetry
- Laser range finder/digital compass remote positioning system
- Topcon GTS-3 Total Station
- Wild Auto Level
- Bausch & Lomb Zoom Transfer Scope, Zoom 70 and SIS 95 interpretation units

Major Software Packages

- ESRI ArcGIS 9.1 and ArcView 3.3
- Leica-Geosystems Imagine 8.7
- VLS Feature Analyst
- Visual Nature Studio
- eCognition
- R-WEL Desktop Mapping System (DMS)
- Research Systems ENVI
- Aerosys 6.0 for Windows aerotriangulation software
- R2V - Raster to vector conversion
- Golden Software Surfer 8.0
- Adobe Photoshop/Illustrator CS2
- Microsoft Office XP Professional

Karen Edelstein

Conference on Remote Sensing Education (CORSE), Institute for the Application of Geospatial Technology (IAGT), Auburn, NY (www.iagt.org/corse): Karen Edelstein, IAGT Education Coordinator, described CORSE as an annual 5-day intensive summer workshop for K-14 teachers, community educators, and selected students. The workshop offers a basic introduction to remote sensing, GIS, GPS, Digital Elevation Models, 3D and interactive visualization, and scientific modeling. Participants receive hands-on training in ArcView GIS mapping software in a state-of-the-art computer lab.

Workshop topics are keyed to the New York State science standards in order to encourage teachers to incorporate geospatial concepts and skills into earth and environmental science courses. IAGT is housed at Cayuga Community College and collaborates with the college's Associate Degree program in GIS (described in the preceding section).

The Institute for Geographic Information Systems Studies (IGISS), Franklin, TN:
IGISS is a non-profit organization that promotes GIS technology through alliances with schools, businesses, and government agencies. With a $2 million grant from the President's High Growth Training Initiative, IGISS is developing the Geospatial Hub Project in partnership with Central Piedmont and Roane State Community Colleges and Smart Data Strategies (represented at the workshop by Susan Marlow, CEO). Matthew Price, IGISS Director, explained that the Hub project will develop replicable models for:

- a regional infrastructure for on-site and distance-learning at two-year colleges
- professional certification in Land Records and Utilities
- geospatial training, using an apprenticeship approach, in land management and utilities services to unemployed and underemployed workers

David Dibiase

University Consortium for Geographic Information Science (UCGIS), Model Curricula for Geographic Information Science (http://www.ucgis.org): David DiBiase, Chair of the UCGIS Education Committee (and Director of the e-Education Institute at The Pennsylvania State University) explained the work of UCGIS in curriculum development for geospatial education.

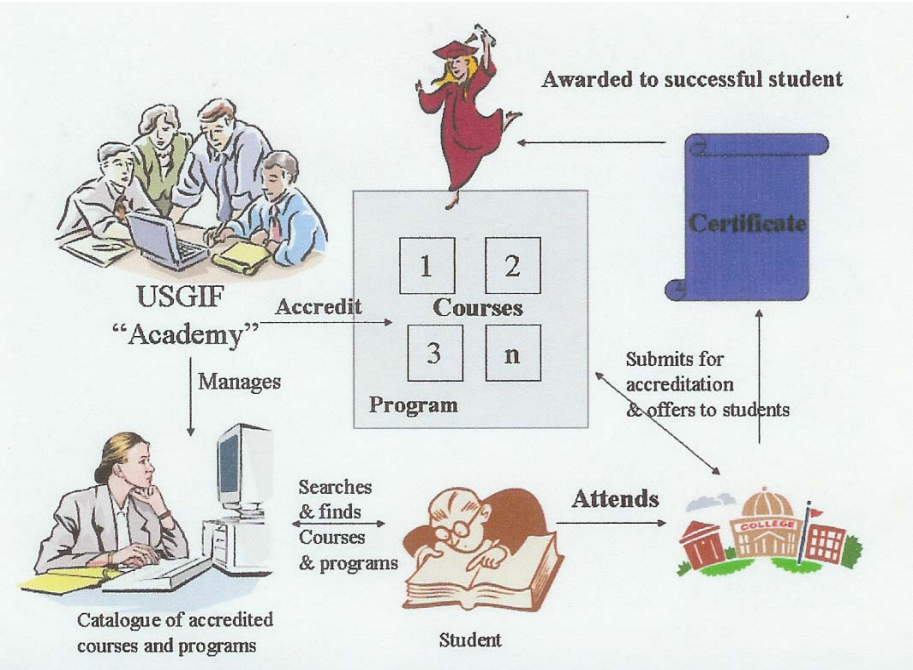
Since 1998, UCGIS has supported an ongoing effort by many scholars to develop a comprehensive Geographic Information Science and Technical (GIS&T) Body of Knowledge. This initiative identifies 10 Knowledge Areas: conceptual foundations, cartography and visualization, data analysis, design aspects, data modeling, data manipulation, geocomputation, geospatial data, and organizational and institutional areas. The UCGIS website describes each Knowledge Area and explains how it is divided into Units that include Topics and specific Learning Objectives.

While the primary purpose in developing of the Body of Knowledge was to aid in the development of academic curricula for GIS&T, it can also help establish a basis for professional certification; program accreditation; articulation agreements among two-year and four-year institutions; comparisons of educational programs; employee recruiting and selection; and continuing professional development.

UCGIS will publish the first edition of the GIS&T Body of Knowledge during the summer of 2006. The guidelines will continue to be refined, and a second edition is scheduled for publication in 2010.

U.S. Geospatial Intelligence Foundation (USGIF) Academy (www.usgif.org): USGIF brings together many disciplines and public and private organizations with a common interest in geospatial intelligence to exchange ideas and best practices and to support the geospatial industry. An important current educational initiative is the development of an Academy that will accredit programs for Geospatial Intelligence Analysts. Figure 4, provided by Susan Kalweit, illustrates the UGIF accreditation guidelines. Educational institutions may submit information about geospatial intelligence courses, and the Academy will accredit those which meet its qualifications. A USGIF catalog will list accredited courses and programs.

Figure 4. UCGIF Curriculum Guidelines and an Accreditation Process for a Geospatial Intelligence Certificate



Source: Booz Allen Hamilton, Courtesy Susan Kalweit

NativeView would have been represented at the workshop, but for an unforeseen cancellation. A consortium of Tribal Colleges, NativeView works to integrate geospatial technology, education, culture and research through programs at Tribal College campuses. Driven by Tribal needs, the initiative is a self-empowering mechanism to put tools, training, knowledge and other resources into the hands of Tribal Colleges in ways that are culturally and scientifically appropriate. NativeView affirms the colleges' vision of creating a more prosperous future for Tribal people and enhancing Tribal quality of life. NativeView is supported by many partners including Tribal, State and Federal agencies.

Other sources of support and models for two-year geospatial programs:
Curriculum developers at two-year colleges will also be interested in the work of several organizations that were not represented at the workshop:

- National Center for Geographic Information and Analysis (NCGIA), Core Curricula in GIScience (www.ncgia.ucsb.edu)
- Remote Sensing Core Curriculum, sponsored by the International Center for Remote Sensing Education (ICRSE), NASA, and ASPRS (http://www.umbc.edu/rscc)
- Geospatial Information and Technology Association (GITA) (wwww.gita.org)

C. Ideal Programs

In five different breakout sessions, the participants identified the characteristics of ideal two-year college geospatial education programs.

1. Geospatial training should include:
   - basic GIS and remote sensing; data formats (raster, vector, etc.); database use; image processing; sensors and platforms; image interpretation; data development
   - discipline-related applications so that students become familiar with how and why to use remote sensing in their chosen fields
   - basic geospatial concepts and project-based applications of those concepts
   - skills related to data acquisition and data quality control, so that students learn to identify data that is appropriate for different kinds of problems
   - basic cartography and visualization
   - a basic understanding of how photogrammetry and surveying work
   - valid, highly structured internship opportunities based on true partnerships with industry and specifically focused on geospatial technology
   - portfolio development that is representative of the students' work as they move through the program
   - applications of local data, to make it easier for students to relate to the topics and also to enhance local employment opportunities

2. Even if individual programs emphasize single workforce domains, they should introduce students to a broad range of geospatial technology applications, including forestry, agriculture, land use planning, homeland security, environmental sciences, etc. in order to broaden their career horizons.

3. Geospatial programs should foster skills in communication, technical writing, problem-solving, project management, and customer service.

4. Students from underrepresented populations should be encouraged and supported through mentoring, scholarships, relevant internships and other workforce-related opportunities, and contact with professional role models.

Mike Rudibaugh (left) and Vince DiNoto (right) report on a break-out session. Moderator Art Johnson is on the far right.

A subsequent group discussion identified the following laboratory needs:

- computers with adequate memory, CD and DVD burners; USB ports
- high resolution monitors
- fast video cards; flashdrives
- Internet access for downloads, administrative privileges
- large scale color printer; large scale drum scanner; large scale/large format plotter
- data projectors; overhead projectors
- WiFi
- stereoscopes
- door monitors
- GPS units
- Cameras; camera with built-in GPS unit (automatically creates a shape file)
- GIS software; state level site licenses & institutional commitment to maintain them
- access to remote sensing data and images at a variety of scales, including local.
- supply budget; IT and systems support
- good adjustable lighting; comfortable furniture
- large storage area and dedicated student storage

C. Challenges and Obstacles: Why are the needed geospatial education programs and learning resources *not* in place?

This issue was addressed by panelists Gail Hobbs (Pierce College, Woodland Hills, CA), John Johnson (San Diego Mesa College, San Diego, CA), Phillip Davis (Del Mar College, Corpus Christi, TX), Caroline Teich (American Association of Community Colleges, Washington DC), Robert Ridky, US Geological Survey, Reston, VA), Abu Badruddin (Cayuga Community College, Auburn, NY), and Richard Wong (Rancho Santiago Community College District, Santa Ana, CA).

Gail Hobbs, John Johnson, Caroline Teich, Abu Badruddin, Phil Davis, Richard Wong
Robert Ridky participated in this panel but was not present for the photograph.

They identified the main challenges and obstacles as:

Academic:

- lack of trained faculty. Nationwide, relatively few two-year college faculty are prepared to teach geospatial technology in ways that meet workforce needs. Schools that do offer geospatial instruction tend to focus on GIS, and their ability to hire additional faculty with expertise in other technologies is often limited.
- student assumptions that remote sensing and GIS are technically difficult to master. Of the geospatial technologies, only GPS is familiar to them from informal contexts.
- uncertain position of geospatial technology in the curriculum. Geospatial technology programs can be considered either academic or vocational. This can raise questions about whether they should count for credit toward AS/AA degrees. It can also raise uncertainty about appropriate faculty qualifications.
- inadequate curriculum materials. Two-year programs need curriculum materials that are not readily available: exercises related to various disciplines and exercises that can be localized to the community or region by using available data.
- disparate student needs. Traditional students typically have no background in geospatial technology while members of the workforce who seek additional training often have considerable prior experience.

Financial:

- high levels of funding for dedicated computer facilities (high end computers with adequate speed, memory, and graphics), printers, plotters, and other equipment such as GPS handheld devices, cameras, etc.) and for maintaining and updating equipment and software
- high costs of acquiring and managing remote sensing data (high-end data sets, servers, and network capabilities)

Administrative:

- uncertain position of geospatial technology in the two-year college structure. GIS and remote sensing are integrative technologies that can be applied in many disciplines. Colleges often have difficulties determining whether multi-, trans-, and cross-disciplinary programs should stand alone or be part of a specific curriculum.
- articulation issues. Geospatial courses are offered as 100 and 200 level courses in two-year colleges and generally only as upper level courses in four-year institutions. As a result, students cannot count on transferring credits for GIS and remote sensing courses to four-year institutions. Articulation can also refer to formal links between two-year colleges and K-12 education. Outreach from geospatial programs to local high schools would help recruit students, since the current lack of pre-college exposure means that few students enter two-year colleges actively seeking geospatial training.

Other:

- lack of understanding by college administrators, students, and many employers of the potential of GIS and remote sensing to enhance decision-making.

A discussion that followed this panel focused on the need for K-12 articulation with respect to geospatial education. Several participants expressed concern that students completing high school not only lack geospatial literacy but also lack the academic background necessary to succeed in solid two-year geospatial programs. Robert Ridky, USGS Director of Education, noted that only about six percent of American high school students currently take earth science (compared with 28 percent in 1969). Many graduates also have poor skills in mathematics and in the other sciences that underlie geospatial technology.

Pamela Lawhead suggested that two-year colleges consider in-service teacher education programs that support the integration of geospatial technology into various high school subjects, with geospatial skills keyed to the appropriate national standards. Initiatives targeted for pre-college students should focus on high-interest areas. USGIF outreach to grades 7-12 students, for example, includes promoting Geospatial Intelligence as an exciting career path. James Plasker suggested drawing on appropriate electronic games to interest young students in geospatial tooling. He noted that the gaming industry is actually looking to remote sensing and GIS for new tools.

A recent report by the National Research Council of the National Academies, *Learning to Think Spatially* (National Academies Press, 2006 and www.nap.edu) addresses the need for geospatial literacy in K-12 education. Several participants recommended this study as an excellent resource for K-12 outreach efforts in geospatial education.

E. Implementation Strategies

Two panel sessions discussed strategies for implementing two-year geospatial programs in ways that meet workforce needs and the needs of students with varied backgrounds and goals (initial job training, preparation for further education, professional skills development, etc.). Panelists included Mike Rudibaugh (Lake Land College, Mattoon, IL), Vince DiNoto, (Jefferson County Technical College, Louisville, KY); Deidre Sullivan (Monterey Peninsula College, Monterey, CA), Matt Price (Institute for GIS Studies, Franklin, TN), Lewis Rogers, (Gainesville College, Gainesville, GA), Gino Guzzardo (Geospatial 21 Project, Los Angeles, CA), Jongwon Lee and Ivan Chung (Association of American Geographers, Washington DC),

Demetrio Zourarakis (Commonwealth Office of Technology, Frankfort, KY), Wendy Mitteager (SUNY Oneonta, Oneonta, NY and NCGE Remote Sensing Task Force); Nancy Hultquist (Central Washington University, Ellensburg, WA and NCGE Remote Sensing Task Force), and Allan Falconer (George Mason University, Fairfax, VA).

Mike Rudibaugh, Vince DiNoto, Deidre Sullivan, Matt Price, Lewis Rogers, Gino Guzzardo

Jongwon Lee, Ivan Chung, Demetrio Zourarakis, Wendy Mitteager, Nancy Hultquist, Allan Falconer

Their recommendations addressed the challenges and obstacles identified above:

Academic:

- Hire well-qualified new faculty whenever possible; train existing faculty through workshops and courses at other institutions and/or via distance-learning.
- If the needs cannot be met by full-time faculty, hire adjuncts. Faculty or graduate students from nearby universities may be able to meet instructional needs and help with articulation issues. Professionals from local businesses, industries, and government agencies who can serve as adjunct faculty may also be able to help with internships and job placement for graduates.
- Base the program on a solid curriculum and strong curriculum materials. Seek advice from experts. Examine other programs for models that can be adapted.
- Develop problem-based pedagogy approaches. Have students work with local data.
- Recruit students from the local workforce. Schedule evening and weekend classes, and offer courses and workshops targeted to their needs (firefighters, police force, city and county planners, K-12 educators, etc.). Offer courses in small modules and offer them live at job-sites, live in class, online, or a combination of online and live. Permit students who take enough modules to combine them for full course credit.
- Offer certification. Ensure that all geospatial courses can be credited toward certificates, and that certificates can be counted toward the Applied Science degree.

Financial:

- Develop detailed budget justifications for the college administrators.
- Establish an Advisory Council of industry, business, and education partners who can provide professional advice/services at no cost. They can help develop curricula, mentor faculty, market the program, provide student or faculty internships with a local project focus, and enable access to local data. Local professionals may also be able to help with grant applications for program support.
- Identify and work with local industries and agencies that use geospatial technologies: conduct needs assessments and offer to provide services/products; negotiate student internships; attend relevant meetings to assess changing markets.

Administrative:

- Develop articulation agreements with four-year institutions whenever possible.
- Build internal support by developing a thorough knowledge of other college departments. Promote the program in ways that support them. Encourage other faculty to send students to your program. Establish on-campus user groups.
- Find champions within the administration. Produce small GIS/remote sensing products that meet the needs of senior administrators to build their understanding of geospatial technology.

Other:

- Develop and market college-based services to the community to generate awareness of geospatial technology. Consider a wide variety of uses and needs, such as land use planning, emergency services, homeland security, health care planning, economic development, utilities planning, etc.
- Market the program to the community. Include information about job potential, income levels, career paths, and career and life-style satisfaction. Specific marketing initiatives can include:
  - radio spots, news releases, brochures
  - high school recruiting through student workshops and targeted newsletters
  - special events for the annual GIS/Remote Sensing Day
  - local-needs workshops for policemen, firefighters, first responders, realtors, etc.
  - notices of courses/programs/events to former students
  - outreach to 4H, Boys and Girls Clubs, Scouts, etc.

V. Summary of Key Recommendations

The workshop participants were in agreement that two-year colleges can assume an important role in addressing geospatial workforce needs by preparing new technologists and providing needed training for people already employed. Existing GIS programs that are expanded to include remote sensing can both meet workforce needs and serve as models for schools interested in establishing new geospatial programs based on the integration of these technologies. Key recommendations for institutions that are interested in expanding or developing geospatial programs include:

Faculty training:

The lack of qualified faculty was identified as a critical problem. Most two-year colleges that are interested in developing geospatial programs will rely in large part on existing faculty, usually in geography or environmental science programs. A national-level initiative to train such faculty in GIS and remote sensing would help to resolve this problem.

Curriculum:

- Make GIS and remote sensing the primary content and skill areas for both traditional students and students seeking on-the-job training. Incorporate enough exposure to other geospatial technologies so that students have a basic familiarity with cartography, photogrammetry, GPS, and surveying.
- Design courses that help students develop skills in the use of automated support systems, geospatial software and hardware and remote sensing data.
- Design courses that help students develop spatial thinking skills, problem-solving skills using multiple data sets; project management capabilities; and technical writing abilities.
- Require students to develop portfolios as important representations of their work. This will serve them well when they look for jobs.
- Make internships critical components of the program. They help the students understand content and develop skills while connecting them with potential employers.
- Teach students to apply geospatial technology to various workforce domains and to local business/industry/government agency needs in order to enhance their understanding of potential career opportunities.

Funding, enrollments, and community outreach:

- Maximize administrative support by providing detailed budget justifications.
- Work with local businesses, industries, and agencies to establish a school-to-work pipeline that will attract students and grow the program.
- Conduct local needs assessments and develop relationships with the organizations that need geospatial work. Inform local employers about ways in which geospatial technology can enhance their decision-making capabilities. Offer services through small projects.
- Increase enrollment by providing workshops and flexible, modular classes that meet specific training needs of local industries and government agencies. Schedule them on-site at appropriate times or on-line, according to need.
- Market the program to local/regional industries and agencies, to the high schools, and on campus to raise interest among potential students.
- Seek support for faculty training through grants, partnerships, etc.
- Seek external support for acquiring and maintaining remote sensing data, servers, and network capabilities.
- Establish a Regional Advisory Council of industry, business, and education partners for no-cost expert advice on curriculum development, internships, marketing, etc.

Administrative and faculty support:

- Market the program to administrators and faculty. Explain the job opportunities and the benefits of a geospatial technology program to the students and the college;
- Develop a knowledge of other departments and disciplines and of how they could benefit from your program; produce small projects for them and for key administrators that demonstrate your program's capabilities;
- Provide campus-based services to local industries and government agencies;
- Ensure that geospatial technology faculty are well-trained, experienced, and strong spokespersons for geospatial technology and for your program;
- Seek articulation agreements with four-year institutions and with local high schools.

VI. Next Steps

The workshop generated considerable discussion about the need for national-level efforts to support geospatial technology training in two-year colleges. Such initiatives should: l

- inform both colleges and potential employers about the roles that geospatial technologists can play in the workforce
- provide guidance for two-year colleges interested in establishing geospatial technology programs
- support faculty training

These issues will be addressed in future initiatives by the project staff and many of the participants.

VII. Epilogue

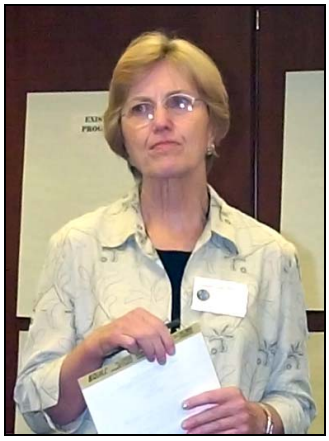
We began this project believing that the workforce needs geospatial technologists and that two-year colleges might be able to provide appropriate training, especially in the areas of GIS and remote sensing. These opinions were brought home with the events surrounding Hurricanes Katrina and Rita. Local government agencies did not have enough trained personnel to access and use the available spatial information, including the real-time remote sensing images necessary to assess the damage to many homes, business, and neighborhoods. Nor did they have the expertise to use GIS effectively for search and rescue operations, establish evacuation routes, find appropriate locations for shelters, or identify the boundaries necessary for assessing property losses and for supporting rebuilding efforts.

We could generate a long list of needs that could have been met by a geospatially literate cadre of authorities and by a general population who had access to GIS and remote sensing data and the ability to interpret it. Our nation used geospatial technology in the aftermath of 9-11 and uses it to track and manage fires in California, but broad applications are still limited. The general lack of awareness of this technology and of its utility, especially in times of natural disasters, should be addressed in all educational systems.

Jeannie Allen (left), Science Systems and Applications, Inc., NASA-Goddard Landsat program; Ann Johnson (right), ESRI

Art Johnson, Edumetrics

Ronald Beck, Land Remote Sensing Program, USGS



Osa Brand, NCGE

National Science Foundation building atrium

Group concentration during a panel presentation….

Kass Green, Alta Vista Company

Chris Semerjian, Gainesville College

Jon Dykstra,
Earth Satellite Corporation

Gino Guzzardo,
Geospatial 21

Kevin Neimond,
National Association of Counties

Stacy Meyers , Palm Beach Community College and Jeannie Allen, Project staff

Carolyn Teich, AACC, has the floor.

James Plasker, ASPRS and Jongwon Lee, AAG

Robert Ridky, USGS

Foreground, l to r: Art Johnson, project staff; Gail Hobbs, Pierce College; Pamela Bingham, Bingham Consulting Services and Howard University

National Science Foundation entrance

APPENDIX A: Workshop Agenda

Monday, August 15, 2005
8:00-8:20 a.m. Continental Breakfast

8:20-9:00 am. Welcome, Introductions, Workshop Goals, Workshop Procedures
Osa Brand, Educational Outreach Director, National Council for Geographic Education
Ann Johnson, Higher Education Manager, Environmental Systems Research Institute (ESRI)
Jeannie Allen, Senior Science Education Specialist, Science Systems and Applications, Inc. at NASA Goddard Space Flight Center
Art Johnson, Director, Edumetrics

9:00-9:30 a.m. GIS-Remote Sensing Applications: Examples from Government. 10 minute presentations:
National Government: **Ron Beck**, Program Information Specialist, Land Remote Sensing Program, United States Geological Survey
State Government: **Susan Carson Lambert**, Geographer, recently retired from Kentucky state government
County Government: **Kevin Neimond**, County Government GIS Program, National Association of Counties

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9:35-10:05 a.m. GIS-Remote Sensing Applications: Examples from Industry. 10 minute presentations:
Kass Green, President, The Alta Vista Company
Jon Dykstra, Vice President, Digital Imaging
Susan Marlow, CEO, Smart Data Strategies

10:05-10:20 a.m. Discussion of GIS-Remote Sensing Applications
Ann Johnson, Facilitator

10:20-10:35 a.m. BREAK

10:35-11:05 a.m. Workforce Needs
Current and projected geospatial workforce needs. 10 minute presentations:
David Curren, Manpower Analyst, Business Relations Group, Employment and Training Administration, U.S. Department of Labor
James Plasker, Executive Director, American Society of Photogrammetry and Remote Sensing
Susan Kalweit, Senior Associate, Booz-Allen Hamilton

11:10-12:00 a.m. Workforce Needs, continued
Which GIS-remote sensing workforce needs can be addressed in two-year programs?
Impromptu Panel of Experts/Discussion: **Ann Johnson**, facilitator
Robert Ridky, National Education Coordinator, U.S. Geological Survey
Larry Stipek, Director, Loudoun County Office of Mapping and Geographic Information
Pamela Bingham, CEO, Bingham Consulting Services; faculty, Howard University
Arnold Landvoigt, Geospatial Specialist, National Security Agency
Laura Rocchio, Landsat Support Scientist, NASA Goddard Space Flight Center

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12:00-12:45 p.m. Discussion-Based Lunch: Current status of geospatial education: What are the trends?

12:45 –1:00 p.m. Ideas Generated During Lunch
Ann Johnson, facilitator

1:00-1:45 p.m. Current Status of Geospatial Education: Implications for Two-Year Colleges
10 minute presentations:

Ellen Hause, Senior Program Associate, American Association of Community Colleges
Cyndi Gaudet, Director, Workplace Learning and Performance Institute, University of Southern Mississippi
David DiBiase, Chairperson, University Consortium for Geographic Information Science, Education Committee; Director, e-Education Institute, Penn State University
Marguerite Madden, Director, Center for Remote Sensing and Mapping Science, Department of Geography, University of Georgia; Vice President, American Society of Photogrammetry and Remote Sensing

1:50-3:00 p.m. Programs Currently in Place for Remote Sensing Training in Two-Year Colleges
10 minute presentations:

T. M. Bull Bennett, Science Coordinator, North Dakota Assn. of Tribal Colleges
Pamela Lawhead, Director, Institute for Advanced Education in GeoSpatial Sciences, University of Mississippi, two-year college outreach programs.
Karen Edelstein, Education Coordinator, Institute for the Application of Geospatial Technology and Conference on Remote Sensing Education
Abu Badruddin, Associate Professor, Cayuga Community College
Chris Semerjian, Director, Spatial Analysis Laboratory, Gainesville Community College
Stacy Meyers, Professor, Palm Beach Community College

3:00-3:15 p.m. BREAK

3:15-4:00 p.m. Ideal GIS-Remote Sensing Programs at Two-Year Colleges

What kinds of two-year programs will meet the workforce needs for GIS-remote sensing training?

Breakout sessions:

1. What technologies should be addressed? What courses should be included? What should be the role of internships?
2. How can GIS-remote sensing programs meet the different needs of students seeking AA degrees, students planning to transfer to four-year institutions, and professionals who need to enhance their skills?
3. Is it feasible for two-year colleges to offer GIS-remote sensing certificates? If so, what coursework, other experiences, and skills should they represent?
4. Which content areas can best be addressed in GIS-remote sensing programs in two-year colleges? To what extent should instruction be grounded in content?
5. What special needs must be addressed by two-year programs that want to interest underrepresented students in GIS-remote sensing careers?

4:00-4:40 p.m. Break-Out Session Reports, 5 minutes each. Group Discussion
Art Johnson, facilitator

4:40-5:00 p.m. Summary of the Day's Discussions; Wrap-Up
Jeannie Allen

5:00 p.m. Adjourn

Tuesday, August 16, 2005
8:00-8:30 a.m. Continental Breakfast

8:30-9:15 a.m. Challenges and Obstacles
What challenges/obstacles must be overcome for two-year colleges interested in offering GIS-remote sensing programs? Impromptu Panel of Experts/Discussion. **Ann Johnson**, Facilitator
Gail Hobbs, Faculty, Pierce College (CA)
John Johnson, Faculty, San Diego Mesa College (CA)
Phillip Davis, Faculty, DelMar College (FL)
Caroline Teich, Sr. Program Associate, American Association of Community Colleges (Washington DC)
Abu Badruddin, Faculty, Cayuga Community College (NY)
Richard Wong, Faculty, Rancho Santiago Community College (CA)

9:15-10:30 a.m. Implementation Strategies
What strategies can be developed to implement two-year GIS-remote sensing programs?
Impromptu Panel of Experts/Discussion. **Art Johnson**, facilitator
Mike Rudibaugh, Faculty, Lake Land College (IL)
Vince DiNoto, Faculty, Jefferson County Technical College (KY)
Matt Price, Executive Director, Institute for GIS Studies (KY)
Lewis Rogers, Faculty, Gainesville College (GA)
Gino Guzzardo, Program Director, Geospatial 21 (CA)
Deidre Sullivan, Faculty, Monterey Peninsula College (CA)

10:30-10:45 a.m. BREAK

10:45-11:30 a.m. Implementation Strategies, continued
What kinds of training will enable GIS instructors to integrate remote sensing?
Impromptu Panel of Experts/Discussion. **Ann Johnson**, facilitator
Nancy Hultquist, Faculty, Central Washington University (WA)
Wendy Mitteager, Faculty, SUNY Oneonta (NY)
Jongwon Lee, Educational Fellow, Association of American Geographers (Washington, DC)
Ivan Cheung, Director, Geoscience Program. Association of American Geographers (Washington, DC)
Demetrio Zourarakis, Remote Sensing/GIS Analyst, Commonwealth Office of Technology (KY)
Allan Falconer, Chair, Geography Department, George Mason University (VA)

11:30-12:00 p.m. Implementation Strategies, continued
Wish-list for courses, hardware, data, facilities. Discussion. **Ann Johnson**, **Ron Beck**, facilitators

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12:00-12:45 p.m. Discussion-Based Lunch
Recruiting strategies for employers, members of the workforce, prospective students (high school and two-year college). What works?

12:45-1:15 p.m. Ideas Generated During Lunch
Art Johnson, facilitator

1:15-1:45 p.m. Walk-Around Review of/Additions to Poster Comments

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1:45-2:45 p.m. Summary and Review, **Jeannie Allen.** Post-Workshop Report and Feedback Mechanisms; Next Steps, **Osa Brand**

2:45 p.m. Adjourn

APPENDIX B: Geospatial Education Workshop Participants

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