Defining and Communicating Geospatial Industry Workforce Demand

PHASE I REPORT

Defining And Communicating Geospatial Technology Industry Workforce Demand

I. INTRODUCTION & BACKGROUND

The President's High Growth Job Training Initiative

This Presidential initiative is a strategic effort to prepare workers to take advantage of new job opportunities in high growth, high demand and economically vital sectors of the American economy. The program is sponsored by the U.S. Department of Labor's Employment & Training Administration (DOL-ETA). Fourteen targeted industries have been selected and three, including Geospatial Technology, have been identified as important emerging high growth industries.

Important Emerging High Growth Industries

Biotechnology
Geospatial Technology
Nanotechnology

Targeted High Growth Industries

Advanced Manufacturing	Health care
Automotive	Homeland Security
Biotechnology	Hospitality
Construction	Information technology
Energy	Nanotechnology
Financial services	Retail
Geospatial Technology	Transportation

Source: http://www.doleta.gov/BRG/JobTrainInitiative/

DOL-ETA has sponsored substantial initiatives, including six grants totaling nearly $6.4 million, in an effort to define the nature, industry, growth, and workforce requirements of the geospatial industry. Jennifer McNally, Director of DOL-ETA's Business Relations Group, provided some insight regarding selection of geospatial as a high growth industry. Speaking at this project's October roundtable, she said that the origins were in the nation's reaction to 9/11 and the need to develop national disaster response capabilities, with the accompanying philosophy that community planning should be based on geospatial skills.

Overall Project Objectives

This DOL-ETA-funded one-year project is titled "Defining and Communicating Geospatial Industry Workforce Need." The objectives are:

1. To define the diverse geospatial industry components, characteristics, and skills required to fill geospatial occupations, so that schools and One-stops can understand them and provide the necessary training;
2. To develop an effective and compelling public outreach program and informational materials about those industry components for distribution through existing DOL-supported education and information channels, to address the lack of public awareness of geospatial technologies and their applications, and to make a better connection between the geospatial industry and diverse populations of potential workers;
3. To pilot and demonstrate experimentally a new and innovative tool by which to provide current location-based industry worker demand information correlated with educational and workforce opportunities;
4. To pilot and demonstrate a specific application of these new outreach materials and geospatial intelligence information tools and methodology in a particular geographic area to better align educational, employment, and economic development programs with employers' labor needs.

Objectives of This Report

The aim of this report is to describe the project's Phase I efforts to collect information and build consensus among stakeholders and industry leaders with respect to the current and future trends of the geospatial industry and its workforce demand. The specific objectives are:

1. To summarize our collective impressions of the two thought-leader roundtables held in Washington, D.C. on October 6th 2005 and January 27th 2006;
2. To summarize responses to an online feedback mechanism, which collected responses during the months between the two roundtables;
3. To present additional information and approaches to build consensus about industry definition, market segmentation, workforce demands, and challenges in meeting the demands;
4. To seek feedback from a large group of stakeholders regarding the critical issues broadly defined above.

II. DEFINING THE GEOSPATIAL TECHNOLOGY INDUSTRY

Refining an Existing Definition

Although there is no consensus on a definition of the geospatial technology industry, the one developed by the Geospatial Workforce Development Center of the University of Southern Mississippi has been well crafted and is frequently used. This definition of the geospatial technology industry is:

> ***"an information technology field of practice that acquires, manages, interprets, integrates, displays, analyzes, or otherwise uses data focusing on the geographic, temporal, and spatial context. It also includes development and life-cycle management of information technology tools to support the above."***

The above definition was constructed for the purpose of developing a geospatial workforce competency model. "A definition was written by industry stakeholders early in the process to ensure participants answered questions from the same industry perspective. Research participants included those whose primary expertise and experience was remote sensing, as well as those with primary expertise and experience in GIS. Initial focus group discussions focused on the differences between remote sensing and GIS workforce requirements. However, during focus group session activities, participants recognized and determined that the workforce requirements were not remote sensing- or GIS-specific, but rather represented a broader industry domain they labeled geospatial technology (Gaudet et al. 2004, p. 24)"

Building upon a lively discussion at the first thought-leader round table event held in Washington, D.C. on October 6, 2005, we presented three additional definitions written with different perspectives to our participants and other stakeholders via the online feedback mechanism (see http://www.aag.org/roundtable/feedback/feedback.html). We received seventy-nine responses from participants and stakeholders within the United States. Fifty-three percent of respondents were affiliated with private or public companies, 23% with educational institutions, 18% with government agencies, and 6% with non-profit organizations. Table 1 shows the definitions, their sources, and results.

Table 1: Responses to Geospatial Industry Definitions

Definition	Results
1. The geospatial technology industry is an information technology field of practice that acquires, manages, interprets, integrates, displays, analyzes, or otherwise uses data focusing on the geographic, temporal, and spatial context. It also includes the development and life-cycle management of information technology tools to support the above. *[Geospatial Workforce Development Center of the University of Southern Mississippi developed this definition and has been posted on the DOL site]*	38%
2. The geospatial technology industry is concerned with the design, development, implementation and use of geographic information systems technologies. GIS technologies include a wide array of technologies, such as GIS software, global positioning systems (GPS), location-based services (LBS), mobile GIS, remote sensing, and Web GIS. *[written by Professor Mei-Po Kwan, Ohio State University's Distinguished Professor of Geography and the chairperson of AAG GIS & Science Special Group]*	23%
3. The broad domain of geographic information science & technology (GI S&T) represents a body of knowledge that focuses in an analytic fashion upon various aspects of spatial and spatio-temporal information and therefore constitutes, in some of its aspects, a science. In other aspects, where the focus is largely upon the utilization of GIScience to attain solutions to real-world problems, it has more of an engineering flavor with attention being given to both the creation and use of complex tools that embody the concepts of GIScience. The focus of GIS&T education is concepts and methods for geographic problem solving in a computation environment. *[Strawman Report prepared and published by UCGIS in 2003]*	24%
4. The geospatial industry engages, at a variety of spatial scales, in the acquisition, integration, analysis, visualization, management and distribution of data having an explicit spatial and temporal context. A critical component of the industry involves the design, construction and testing of both hardware and software tools to support these activities. Because of the highly technical nature of the industry it is essential to include in any definition those organizations and individuals in the higher education community who are engaged in relevant instructional activities. *[written by Dr. Duane Marble of the Castereagh Enterprises, Inc. and published in ArcNews Winter 2005/2006 edition]*	15%

Detailed comments submitted by respondents can be found in the summary report titled *Summary Report for Geospatial Industry Online Feedback Responses 2006*, co-written by Ivan Cheung and Beth Schempler of the AAG (see http://www.aag.org/roundtable/).

Selected general comments from the online feedback mechanism include:

too much focus on GIS as a technology rather than as an enabler to improve business performance

need to include importance of dissemination, such as Google is doing

need to include the importance of location as an enabler for other applications

need to capture the growing importance of geospatial in enterprise workflow and integration, web and other consumer services, and communications infrastructures

include the simple word "mapping" into the definition

include those organizations and individuals in the higher education community who are engaged in relevant instructional activities

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Using the results from the online feedback mechanism, we asked participants in the second roundtable, working in seven breakout groups, to refine and improve the first definition by integrating ideas, principles, and concepts from the other three definitions. Seven definitions were crafted and presented for a lively town-hall style discussion. This discussion focused on making the definition appeal to people who don't know the industry and on trying to make the definition more clear and succinct. Follow-on sentences could be added to the definition for more specific applications of the technology.

Seven definitions suggested by roundtable workgroups

The geospatial technology industry acquires, manages, interprets, integrates, displays, analyzes or otherwise uses data focusing on the geographic, temporal and spatial context for decision support.

The geospatial industry produces knowledge, products and services that acquire manage. Geospatial technology is a scientific industry that promotes the acquisition, management, integration, analysis and display of maps, GIS, databases and imagery.

The geospatial industry produces, manages and uses geographic data to help people make decisions. Geospatial professionals work in government, business, and academic in diverse specializations from environmental management to national defense.

The geospatial industry is a field of practices that acquires, manages, interprets, integrates, displays, analyzes, enables or otherwise uses data, science, engineering and technology focusing on the geographic temporal and spatial context.

The geospatial industry is a field of practice that acquires, manages, interprets, integrates, displays, analyzes and disseminates information based on geographic, temporal and spatial knowledge. The field includes basic and applied research, technology development and integration to satisfy business, government, general public and educational needs.

The geospatial technology industry acquires, manages, interprets, integrates, displays, analyzes, locates and defines the relationship among geographical features in time and space.

The geospatial industry is a field of practice that is concern with the research, development, and application of spatial and temporal information and technologies (e.g. GIS, GPS, RS and others).

Based on an evaluation of the seven breakout group definitions, comments obtained from the online feedback mechanism, and discussions at the second round table event, the following definition is recommended for adoption by the Department of Labor.

Recommended Definition

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.

III. GEOSPATIAL MARKET SEGMENTATION

Defining the market is difficult given the current lack of record-keeping for this emerging industry. The term "geospatial" or related terms do not appear in the 2002 version of the North American Industry Classification System (NAICS) or in the revisions that have been adopted for the 2007 version. The only specific codes that appear relevant are 54136, Geophysical Surveying and Mapping and 54137, Surveying and Mapping (other than geophysical). There is very little source material in terms of understanding the industry, let alone dividing it into segments. Furthermore, Marble (2005) points out in his ArcNews Winter 2005/2006 article that "we are not even in a position to select a limited number of NAICS codes and attempt to call the result 'geospatial' since our activities touch upon so many different NAICS codes."

There are potentially many ways to segment the geospatial industry. All have merits and disadvantages, but the critical issue for this project is to determine what would work best for collecting data about geospatial workforce demand. The following methods may be useful.

Method 1:

Divide by technology sectors/components (modified from approach taken by ASPRS)

Working definitions of these technologies are provided for reference purposes.

- Geographic Information Systems (GIS)

  Geographic information systems (GIS) are automated systems used to capture, edit, store, manipulate, analyze and display a variety of spatial data. A GIS has three major components: a data base, a spatial analysis and modeling capability, and a means for graphic display. [ACSM]
- Remote Sensing

  Remote sensing refers to the observation and collection of data without the sensor being in physical contact with the object being studied, such as the study of the Earth from distant vantage points, via satellite or aircraft. [ASPRS]
- Surveying & GPS

  A *surveyor* is a professional person with the academic qualifications and technical expertise to conduct one or more of the following activities: to determine, measure and represent land, three-dimensional objects, point-fields and trajectories; to assemble and interpret land and geographically related information; to use that information for the planning and efficient administration of the land, the sea and any structures thereon; and, to conduct research into the above practices and to develop them. [FIG, International Federation of Surveyors]

Global Positioning Systems (GPS) is a geospatial technology that enables a portable hand-held device to provide a precise location almost anywhere on the earth by processing signals with a constellation of satellites. [ASPRS]

- Mapping & Cartography

  Cartography is concerned with all aspects of the mapping process. It has artistic, scientific and technical dimensions. It includes the gathering, storage, retrieval, evaluation, and visualization of geographic information. It also includes the abstraction or generalization of data to suit the mapping scale, purpose and audience. [ACSM]

- Computer Aided Design (CAD)

  Computer Aided Design (CAD) is a computer-based system to support technically precise object and layout designs, such as architecture and engineering design applications of structures and other man-made facilities. [ASPRS]

- 3-D Imaging & Other Visualization Tools

  3-D imaging and other visualization tools provide the ability to display geospatial and other data in a computer environment that permits interactive examination and analysis of parameters, real-time display of monitoring information, simulations and other advanced technology.

- Information Technology (IT)

  The *information technology* industry includes such products and services as software, telecommunications, wireless, Internet, hardware, peripherals, and computer and data services. [U.S. Bureau of Labor Statistics (BLS), Career Guide to Industries 2004-05]

Method 2:

Divide by vertical markets (market analysis approach)

GITA divides the geospatial arena into six unique types of end users (vertical markets) in its annual Geospatial Technology Report. These sectors are electric, gas, water and wastewater, pipeline, telecommunications and public sector. Public sector participation in the survey supplying data to the report provides the largest response of the six industry types, representing 37% of all participants and exceeding participation of gas and electric utilities combined.

Another way to classify geospatial technology end users is into categories of traditional image analysts, traditional GIS users, users from other disciplines, mainstream business PC users and consumer and non-technical business users. The first two categories have predominantly specialized technical skills in handling geospatial information, while the users in the other categories have predominant expertise in their own subject matter areas and use geospatial technologies to enhance their business processes. Users in the latter three categories may have a wide range of geospatial technical expertise, ranging from very sophisticated to minimal capabilities.

Method 3:

Application/end user matrix (Adopted from Lo & Yeung 2002)

		Major Users						
		Government	Military	Education	Business	Non-Profit	Utility	General Public
Major Application Areas	Land & Resource Management							
	Environment							
	Census							
	Market Analysis							
	Surveying & Mapping							
	Engineering							
	Public Health							
	Health Services							
	Utility							
	Transportation							
	Facility Management							
	Geographic Data Browsing							
	Defense & Intelligence							
	Humanitarian							
	Emergency							

[Adopted & modified from Lo & Yeung, 2002, Figure 1.4, page 6]

Analysis of the feedback mechanism showed 47% preferred Method 1, 47% preferred Method 2, and 6% preferred Method 3.

Selected general comments from the online feedback mechanism include:

Our discipline would be better categorized by the cross-cutting core set of knowledge that is required by all practitioners, having to do with coordinate reference systems, geodesy, error analysis, data models.

Combine the segmentation of Definition 1 with that of application groups, as employees need to have background knowledge and experience in the type of data they will be using.

GIS is the core technology and emphasis, while the other technologies are contributors or enhancements, such as GPS.

(see http://www.aag.org/roundtable/)

Discussions at the second roundtable focused on the need to use some combination of the first two methods, as a single best segmentation approach could not be agreed upon. There was a general preference for Method 1 as the lowest common denominator and a collection of expertise, but there was consensus that segmentation needs to be done via a matrix approach.

Representative comments from the second roundtable follow.

- Given that employers are the source of jobs, they must first establish what competencies they require and then job seekers must relate to those needs.

- One approach to segmentation would be to start with the first method and evolve to the second. Currently the geospatial work force is very linear. With evolution, employer demands become more focused. From the worker's perspective, they could start with technical skills required and see how that evolves into a career path. Technology skills (GIS Technician) would be the first focus and industry sector would come later.

- Given the cross disciplinary nature of the industry, in many cases there is a need to look at the core job first (engineering or design background) and use GIS as support tool.

- There was a suggestion of using neither method, rather making a modification to divide by fields of practice, i.e., user domains such as telecom, transportation, geo intelligence, business intelligence, educational, water. This would be more useful for students and educational institutions.

- Another description provides three methods of categorization: Technology (applications, web development, database, software), Industry (utility, health, education, business intelligence), and Theory (cartography, geography).

The matrix proposed by the ASPRS/NASA Ten-Year Forecast provides a useful illustration of the use of a multi-dimensional matrix for market segmentation (Figure 1).

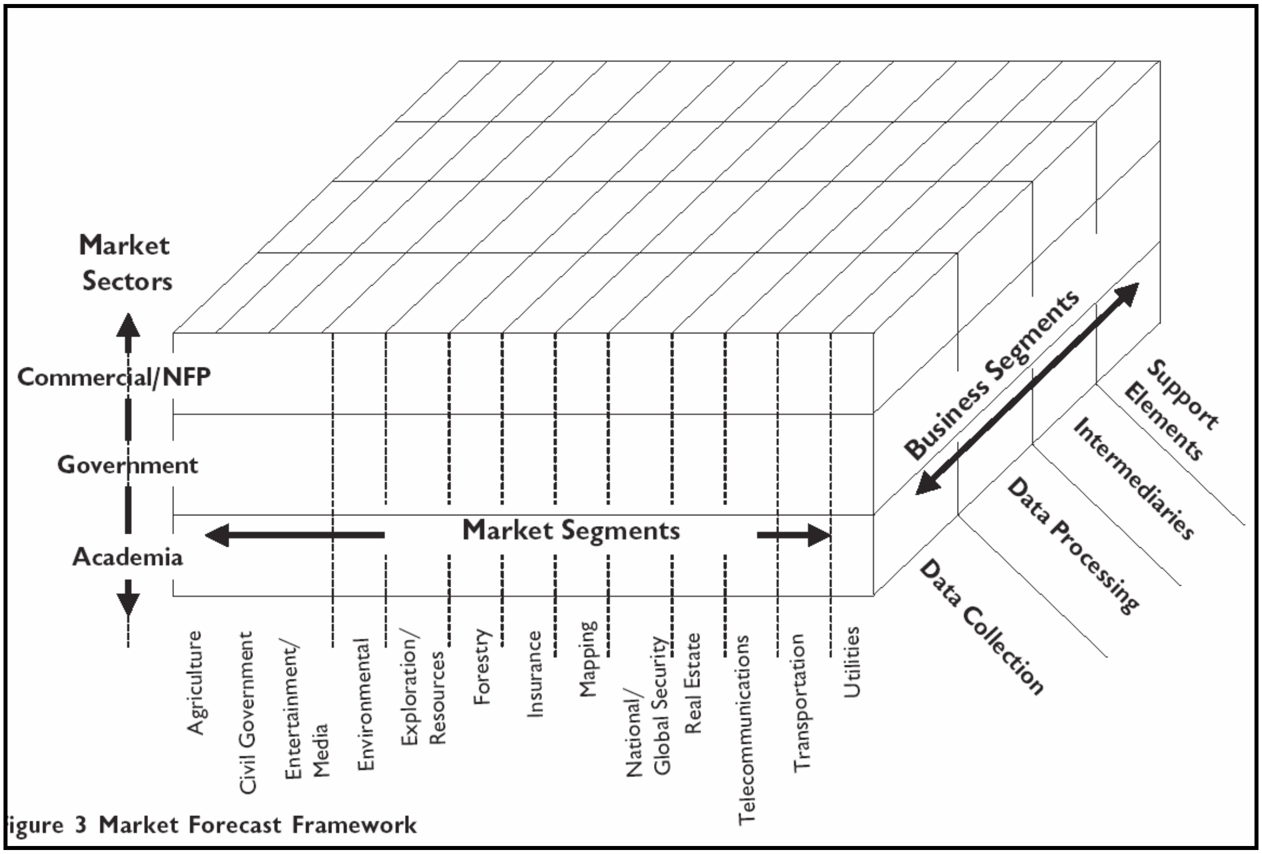


Figure 1: An Example of Market Segmentation.
Source: ASPRS (January 2004), page 20, Figure 3

Recommended Market Segmentation Approach

Based on all of the discussions and feedback to date, the recommendation for market segmentation is to use a matrix, segmenting first by technology skills and second by industry type. This approach to segmentation will provide the greatest flexibility for inclusion of geospatial skills in a diverse range of professions and will accommodate new job functionality and skills and the technology continues to develop.

IV. GEOSPATIAL TECHNOLOGY INDUSTRY WORKFORCE NEEDS

The Need for a Systematic Approach to Collect Geospatial Workforce Demand Information:

Gewin (2004) reported that 26% of NASA's most highly trained "geotech" staff will retire in the next decade yet the National Geospatial Intelligence Agency is expected to need 7,000 people trained in GIS in the next three years. On one hand these figures point to a bright future for those who want to enter the geospatial technology profession. On the other hand, this high workforce demand poses tremendous challenges to the geospatial technology industry and educational organizations. One goal of this project is to assess workforce needs across the United States, beginning at the state level. To do so, we must equip ourselves with a better system for collecting data about geospatial workforce needs.

The 2000 Standard Occupational Classification (SOC) system is used by Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data (http://www.bls.gov/soc/home.htm). All workers are classified into one of over 820 occupations according to their occupational definition. To facilitate classification, occupations are combined to form 23 major groups, 96 minor groups, and 449 broad occupations. Each broad occupation includes detailed occupation(s) requiring similar job duties, skills, education, or experience. Traditionally, especially for well established and mature industries, the SOC system provides the basis for workforce demand projections. Unfortunately, for emerging industries the SOC system is inadequate for capturing the growth in workforce demand.

Very few codes (17-1021: Cartographers & Photogrammetrists; 17-1022: Surveyors; 17-3031: Surveying & Mapping Technicians) are directly related to geospatial technology. These three occupations are projected by BLS to grow by about 16,000 jobs between 2002 and 2012. To make use of the BLS SOC system, we must establish a method to link common geospatial job titles to these occupational titles and consider petitioning for appropriate new SOCs to be added.

Figure 2 shows that 90% of feedback mechanism respondents agreed that BLS should update or add new SOCs to reflect the emergence of new or additional geospatial technology professions. If the respondents are segmented by type of organization, the response remains positive. It is interesting to note that no respondent from the government sector (local, state, and federal) disagrees with the need to update or add new SOCs.

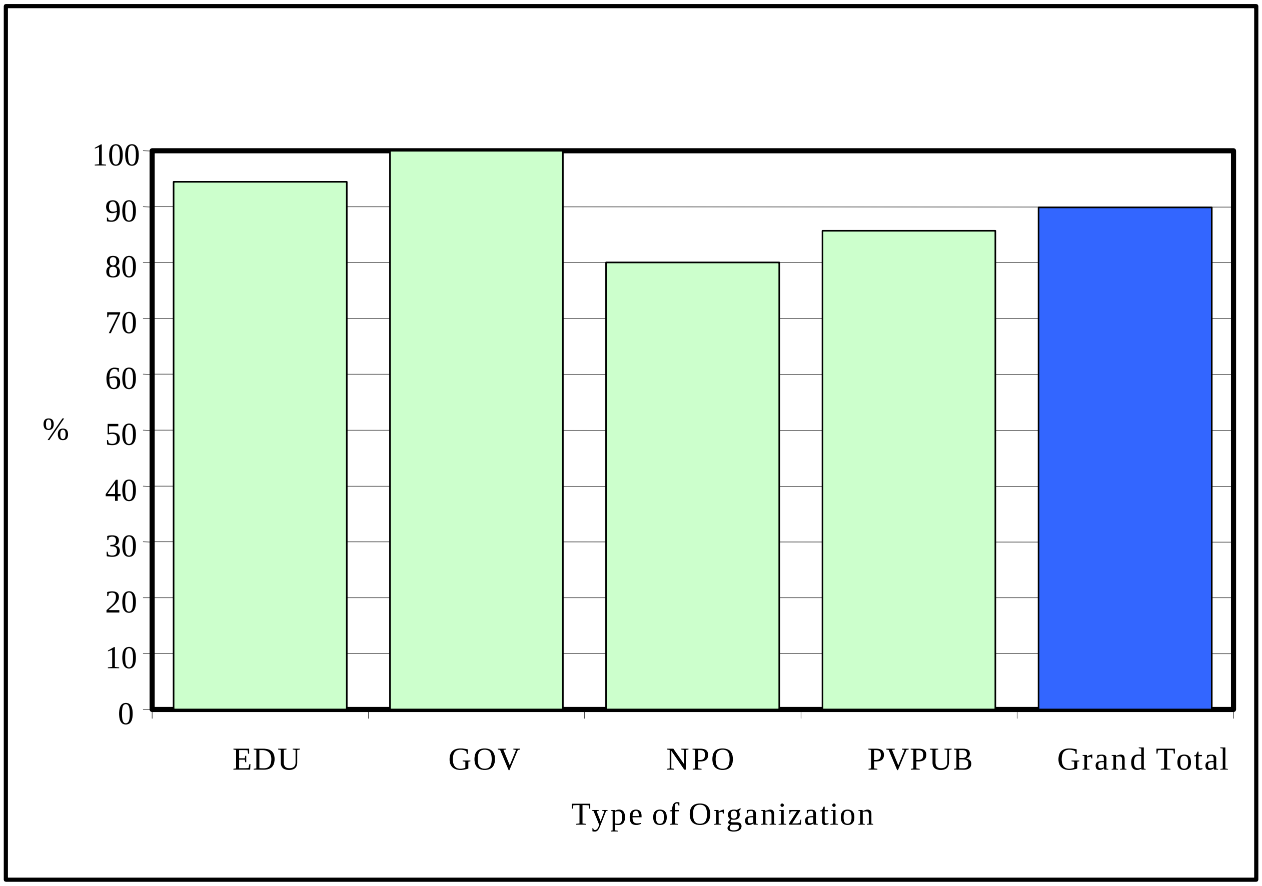


Figure 2: Respondents suggesting BLS update or add new SOCs

Pamela Frugoli of the DOL-ETA Business Relations Group spoke at the second roundtable to introduce the topic of SOC categories. She reported that the last changes in SOCs were released with the 2000 Census. There is a current effort to revise codes for 2008 as well as for the 2010 Census. Addition of new codes must be tempered by the need to preserve historical continuity in the codes; otherwise excessive change in the time series data will make it difficult to project labor statistics. Every industry wants to add more, which is not realistic. Aggregated categories containing more specific occupations would be easiest to maintain. A call for SOCs will soon be released in the Federal Register and there will be 60 days to submit recommendations for occupations.

Frugoli's comments regarding SOC criteria include the followings:

Are the data collectable?

Is this a title anyone would write on a Census form or that an employer would use to describe their employees?

Is the size of the occupation large enough to find a statistically significant number of workers in a survey of households or business establishments?

Is the occupation concentrated in certain industries?

Commonly Used Job Titles

In the online feedback mechanism, we asked respondents to list three commonly used geospatial job titles they would recommend adding to the SOC system. The result is a collection of 184 varied job titles which were analyzed for frequency of mention by category. Analysis methodology and complete results can be found in Appendix A.

General analysis found that the most commonly mentioned job titles, in order, were: GIS Technician, GIS Analyst, GIS Specialist, GIS Manager, Geospatial Analyst, Program Manager, and Geospatial Technician. Separate analysis of the first portion of job titles showed, in order, the following descriptors: GIS, geospatial, geographic information, and spatial. Separate analysis of the second portion of job titles resulted in grouping into general categories of Analyst, Technician, Specialist, Manager, and Software Developer.

The conclusion of the analysis is that the majority of jobs mentioned would fall under the following categories: GIS/Geospatial Analyst; GIS/Geospatial Technician; GIS/Geospatial Specialist; GIS/Geospatial Manager; GIS/Geospatial Developer.

Other relevant studies of geospatial job descriptions include:

- URISA "Model Job Descriptions for GIS Professionals", published in 2000, identified six special categories based on job responsibility: **Mangers**; Coordinators; **Specialists**; **Programmers**; **Analysts**; **Technicians**.

- ESRI's "GIS Educator", published in summer of 2004, also uses similar job classes in its discussion of the relationship between GIS users and the extent of their knowledge and expertise. The job classes include: Scientist, **Analyst**, **Specialist**, **Technician**, User, and Virtual User. The above classes are arranged in descending order, indicating that Scientist has the widest knowledge breadth and deepest experience. **Manager** is a special class that can range from the User to Specialist levels of breadth and depth.
- As documented earlier, the GITA/AAG team also conducted a study using job advertisements posted on internet job sites. Results of this study are presented in Appendix B.

Recommendations

Our participants and stakeholders strongly believe that it is vital for the Department of Labor to consider adding new Standard Occupation Classification codes to reflect the emergence of geospatial professionals. Based upon the analysis of the online feedback mechanism, as well as the research of other associations' studies, we recommend the submission of the following four occupations. GIS/Geospatial Analyst and GIS/Geospatial Technician should be added as new SOCs, similar in structure to Surveyor and Surveying Technician. GIS/Geospatial Manager and GIS/Geospatial Developer should be added as new geospatial categories to existing technical management and software development SOCs.

Recommended Additional Occupational Titles

To be added as new SOCs:
- GIS/Geospatial Analyst
- GIS/Geospatial Technician

To be added as a geospatial categories to existing SOCs:
- GIS/Geospatial Manager
- GIS/Geospatial Developer

Projecting Growth in Geospatial Workforce Needs

It is challenging to project geospatial workforce needs at the national level, let alone to make an accurate geographic distribution. For this reason, GITA is developing methodology for its Denver pilot project to determine industry workforce demand at the level of a metropolitan area. Collecting the data requires labor intensive phone and email surveys and results will always be incomplete, but we are uncovering a great deal of information about workforce demand in one metropolitan area. It is our intent to document the methodology and results of these surveys as part of the Denver pilot in hopes that other metropolitan areas and workforce boards will be able to extend the methodology for their areas.

The Association of American Geographers (AAG) has identified occupations (by SOC) that are related to geospatial education and training. A committee of experts identified 146 relevant occupations (See Appendix C). It is important to note that not all of these occupations are directly related to the geospatial technology industry. However, as the geospatial industry is cross-cutting, these 146 occupations provide a broad view of how the technology is integrated into many occupations.

There are only three SOC occupations that can be directly linked to common job titles in the geospatial technology industry. These titles include Cartographers & Photogrammetrists (17-1021), Surveyors (17-1022), and Surveying and Mapping Technicians (17-3031). These three occupations are projected by BLS to grow by about 16,000 jobs between 2002 and 2012.

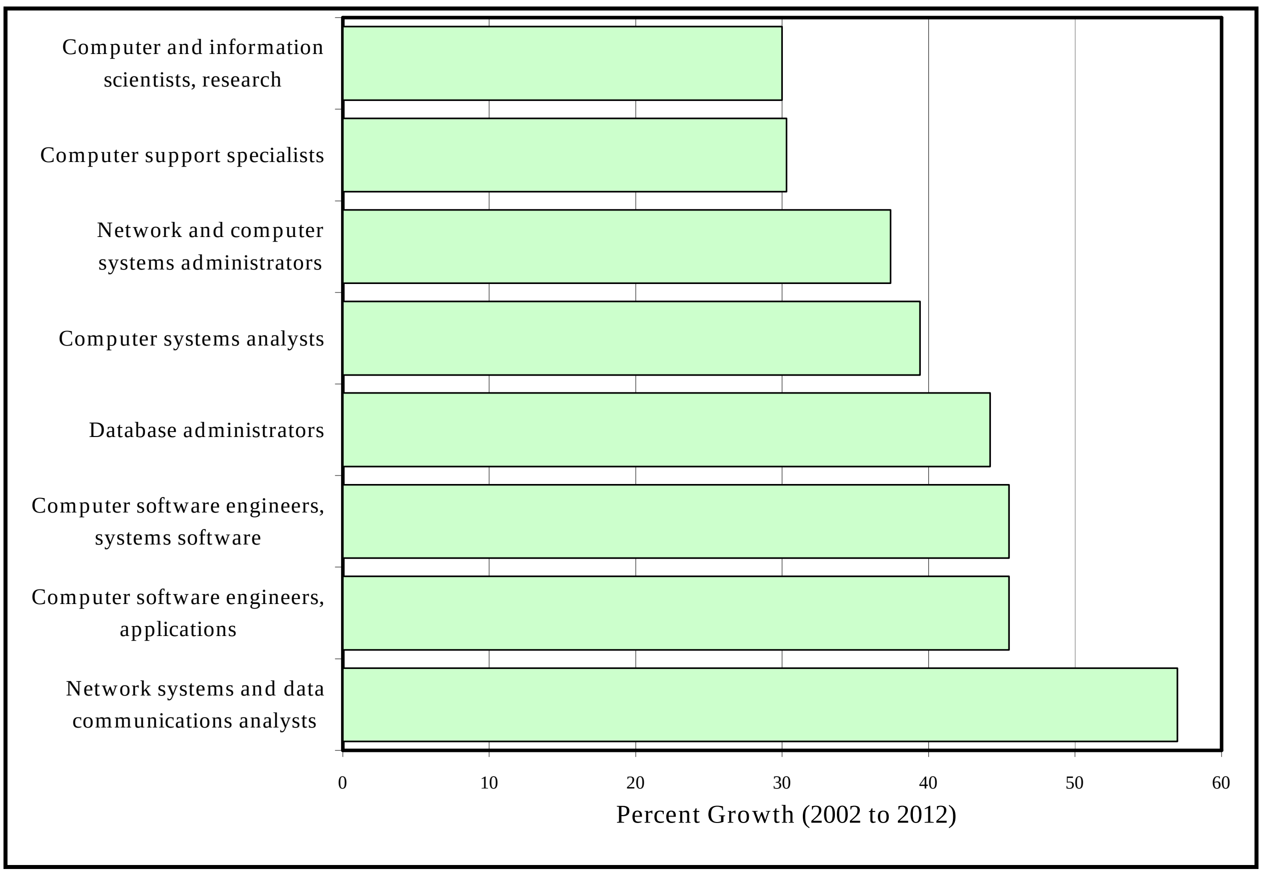
From the 146 occupations listed in Appendix C, we single out the following occupations that are considered “high job growth” (with at least 15% growth expected from 2002 to 2012) and “high wage” (with median salary of at least 28,000 dollars). These occupations are listed in Table 2. DOL BLS also provides projection of job growth by occupations from 2002 to 2012. The following analysis is based upon this projection. The latest projections (2004 to 2014) are expected to be released by BLS in the Spring of 2006.

Table 2: Occupations Identified as High Job Growth and High Wage (2002-20012)

OCCUPATIONAL TITLES	2000 SOC	PERCENT CHANGE 2002-2012	PRECENT CANGE RANK	2002 SALARY	MEDIAN SALARY RANK
11 MANAGEMENT					
Computer and information systems managers	11-3021	36.1	VH	85240	VH
Sales managers	11-2022	30.5	VH	75040	VH
Medical and health services managers	11-9111	29.3	VH	61370	VH
Social and community service managers	11-9151	27.7	VH	43080	VH
Education administrators, postsecondary	11-9033	25.9	VH	64640	VH
Marketing managers	11-2021	21.4	H	78250	VH
Education administrators, elementary and secondary school	11-9032	20.7	H	71490	VH
Transportation, storage, and distribution managers	11-3071	19.7	H	59660	VH
General and operations managers	11-1021	18.4	H	68210	VH
Chief executives	11-1011	16.8	H	126260	VH
13 BUSINESS & FINANCIAL OPERATIONS					
Emergency management specialists	13-1061	28.2	VH	43560	VH
Meeting and convention planners	13-1121	21.3	H	37420	H
Appraisers and assessors of real estate	13-2021	17.6	H	41760	H
15 COMPUTER & MATHEMATICAL OCCUPATIONS					
Network systems and data communications analysts	15-1081	57.0	VH	58420	VH
Computer software engineers, applications	15-1031	45.5	VH	70900	VH
Computer software engineers, systems software	15-1032	45.5	VH	74040	VH
Database administrators	15-1061	44.2	VH	55480	VH
Computer systems analysts	15-1051	39.4	VH	62890	VH
Network and computer systems administrators	15-1071	37.4	VH	54810	VH
Computer support specialists	15-1041	30.3	VH	39100	H
Computer and information scientists, research	15-1011	30.0	VH	77760	VH
17 ARCHITECTURE & ENGINEERING OCCUPATIONS					
Environmental engineers	17-2081	38.2	VH	61410	VH
Environmental engineering technicians	17-3025	28.4	VH	36850	H
Surveying and mapping technicians	17-3031	23.2	VH	29230	H
Landscape architects	17-1012	22.2	VH	47400	VH
Architects, except landscape and naval	17-1011	17.2	H	56620	VH
Cartographers and photogrammetrists	17-1021	15.1	H	42870	VH
19 LIFE, PHYSICAL, & SOCIAL SCIENCE OCCUPATIONS					
Environmental science and protection technicians, including health	19-4091	36.8	VH	35320	H
Epidemiologists	19-1041	32.5	VH	53840	VH
Environmental scientists and specialists, including health	19-2041	23.7	VH	47600	VH
Market research analysts	19-3021	23.4	VH	53810	VH
Hydrologists	19-2043	21.0	H	56530	VH
Geographers	19-3092	19.5	H	53420	VH
Atmospheric and space scientists	19-2021	16.2	H	60200	VH
21 COMMUNITY & SOCIAL SERVICES OCCUPATIONS					
Medical and public health social workers	21-1022	28.6	VH	37380	H
Educational, vocational, and school counselors	21-1012	15.0	H	44100	VH
25 EDUCATION, TRAINING, AND LIBRARY OCCUPATIONS					
Self-enrichment education teachers	25-3021	40.1	VH	29320	H
Instructional coordinators	25-9031	25.4	VH	47350	VH
Secondary school teachers, except special and vocational education	25-2031	18.2	H	43950	VH
Archivists, curators, and museum technicians	25-4010	17.0	H	35270	H
Elementary school teachers, except special education	25-2021	15.2	H	41780	VH
27 ARTS, DESIGN, ENTERTAINMENT, SPORTS, AND MEDIA OCCUPATIONS					
Public relations specialists	27-3031	32.9	VH	41710	H
Technical writers	27-3042	27.1	VH	50580	VH
Writers and authors	27-3043	16.1	H	42790	VH
33 PROTECTIVE SERVICE OCCUPATIONS					
Detectives and criminal investigators	33-3021	22.4	VH	51410	VH
First-line supervisors/managers of fire fighting and prevention worker	33-1021	18.7	H	55450	VH
First-line supervisors/managers of police and detectives	33-1012	15.2	H	61010	VH
39 PERSONAL CARE & SERVICE OCCUPATIONS					
Flight attendants	39-6031	16.0	H	43140	VH
43 OFFICE & ADMINISTRATIVE SUPPORT OCCUPATIONS					
Cargo and freight agents	43-5011	15.5	H	31410	H
53 TRANSPORTATION & MATERIAL MOVING OCCUPATIONS					
Airline pilots, copilots, and flight engineers	53-2011	18.5	H	109580	VH
Airfield operations specialists	53-2022	17.2	H	36010	H
Aircraft cargo handling supervisors	53-1011	15.6	H	37220	H
Commercial pilots	53-2012	14.9	H	47970	VH

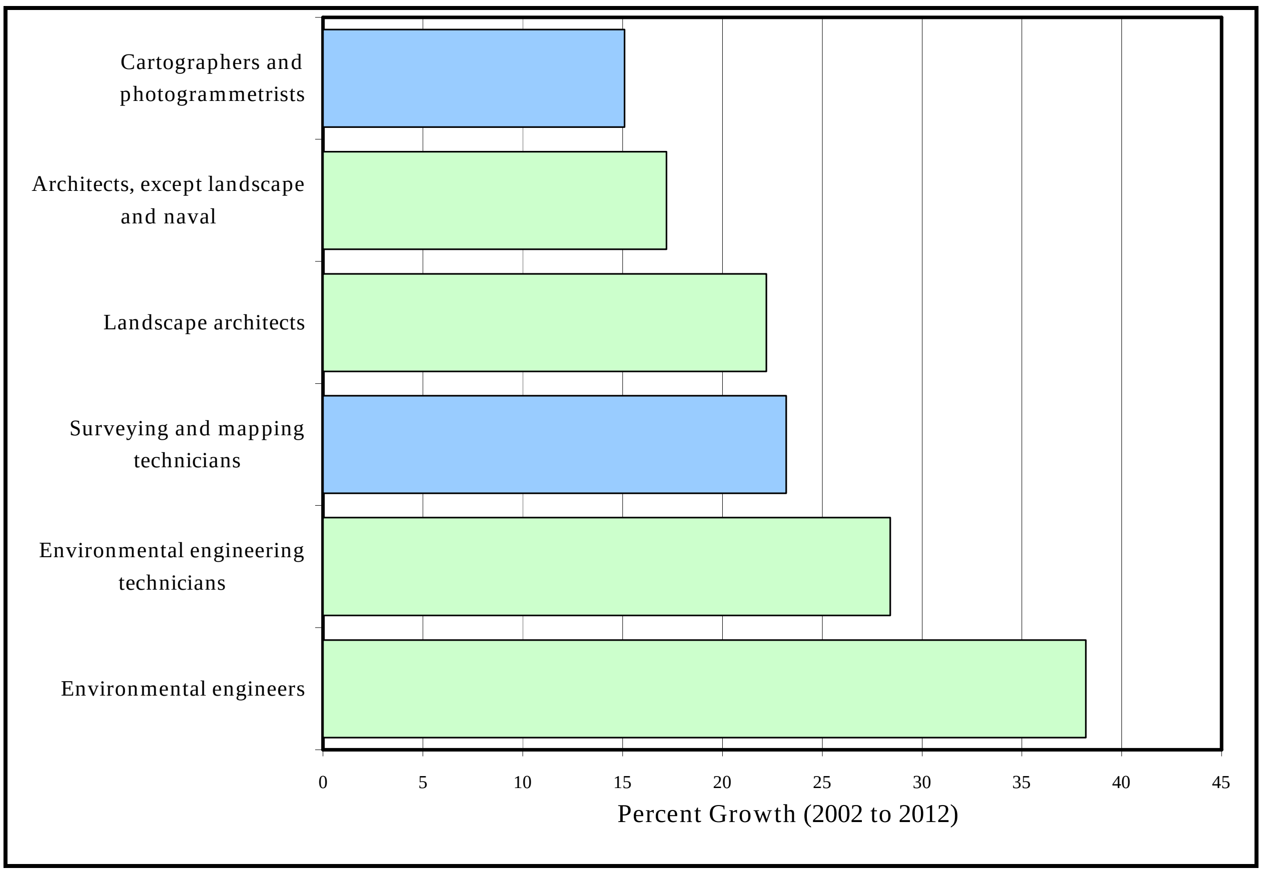
The following analyses highlight projections (2002 to 2012) in three general occupational groups: Computer and Mathematical Occupations; Architecture and Engineering Occupations; and Physical, Life, and Social Science Occupations. Many geospatial industry workers are computer scientists and information technology (IT) professionals. URISA Model Job Descriptions for GIS Professionals (2000) and the NSGIC report (2005) demonstrate that the majority of geospatial workers are working in the IT division within their organizations. The growth of these eight computer and mathematical occupations should serve as a good indicator of the growth of geospatial workforce needs. The number of jobs in these eight occupations will grow from about 2.2 million in 2002 to 3.1 million in 2012, with an estimated growth of 900,000 jobs (Figure 3).

Figure 3: Select High Job Growth/High Wage Computer & Mathematical Occupations (SOC 15:XXXX) related to Geospatial and Geographic Technology Fields.



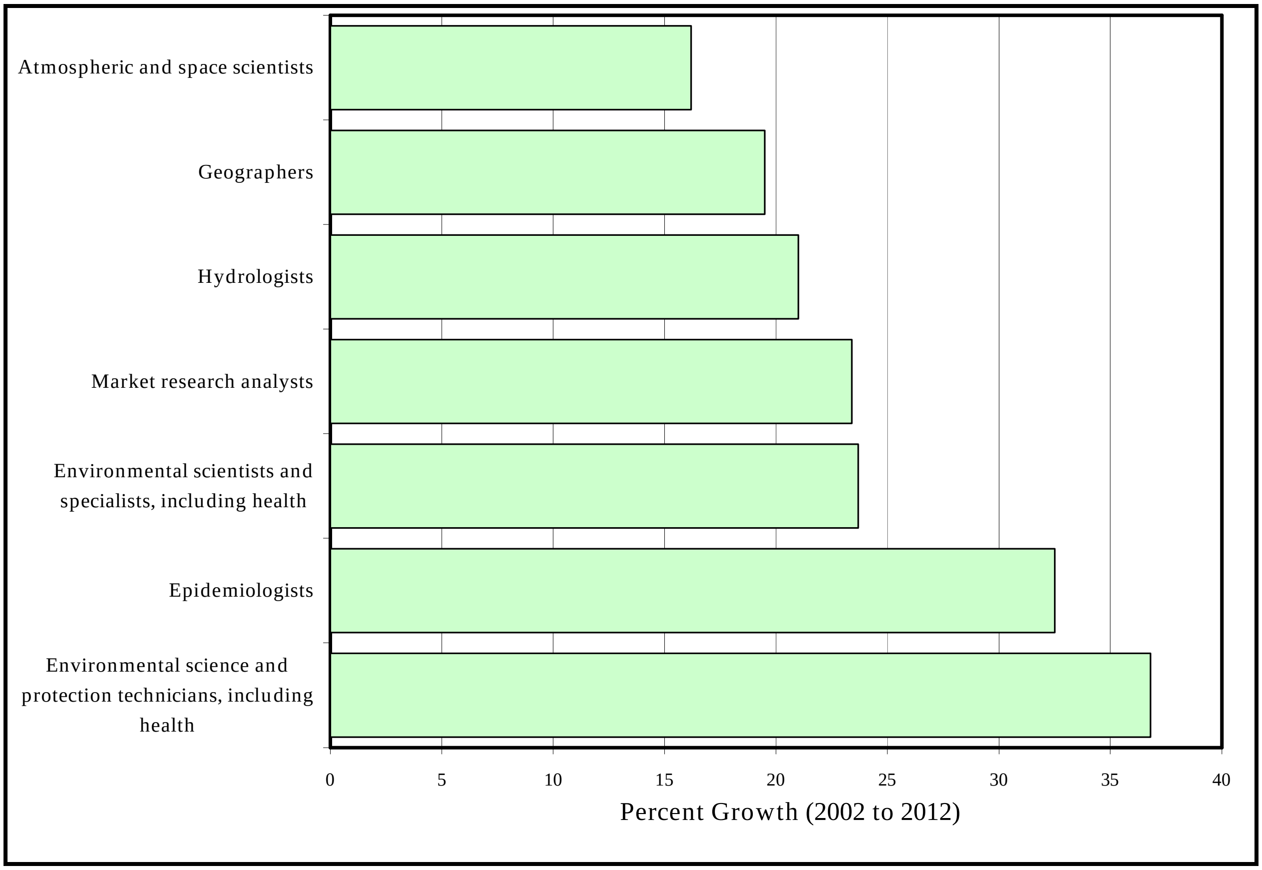
In the Architecture & Engineering Occupations, six high wage occupations are expected to grow by at least 15% between 2002 and 2012 (Figure 4). Of these occupations, two are directly related to the geospatial workforce. They are Cartographers/Photogrammetrists and Surveying/Mapping Technicians (highlighted in blue). These two occupations can be characterized as 100% geospatial. The other occupations may require a substantial degree of geospatial expertise and knowledge in order to perform the job functions and roles within the organizations. These six occupations are expected to grow from 271,000 jobs in 2002 to 334,000 jobs in 2012. An estimated 63,000 new jobs are expected by 2012.

Figure 4: Select High Job Growth/High Wage Architecture & Engineering Occupations (SOC 17:XXXX) related to Geospatial and Geographic Technology Fields.



There are many occupations within the Life, Physical, and Social Science Occupations Group that require geospatial expertise, experience, and knowledge. Figure 5 shows high wage occupations with an expected job growth of at least 15% between 2002 and 2012. Clearly, a large number of geographers have a geospatial background and are performing geospatial tasks on a day-to-day basis. Other occupations, such as market research analysts and epidemiologists, are increasingly requiring geospatial skills and competencies. These select seven occupations will grow by about 60,000 jobs (248,000 in 2002 to 309,000 in 2012).

Figure 5: Select High Job Growth/High Wage Life, Physical, and Social Science Occupations (SOC 19:XXXX) related to Geospatial and Geographic Technology Fields.



Recommendations For Estimating Geospatial Workforce Demand

At the minimum, we need to assess the geographic variation of geospatial workforce demands at the state-by-state basis. There are a few potential approaches:

- *Survey individual industry representatives in distinct metropolitan areas;*
- *Coordinate with professional associations to distribute surveys;*
- *Collaborate with associations such as NSGIC and NACo to gather workforce demand information from state and local governments.*

Given the difficulty of estimating geospatial workforce demand without adequate measuring tools (appropriate SOC codes for the wide range of geospatial activities), we recommend a combination of top-down and bottom-up quantification methods. Bottom-up methodology would involve intensive surveying of industry in a metro area, such as the Denver pilot area, to determine current and projected geospatial workforce demand. Top-down methodology could possibly be developed to determine the quantity of geospatial demand within the broad occupational categories described above. Once determining the degree to which geospatial skills are used in the Hydrology profession, for example, it could be determined that a linear relationship would exist between growth in the overall profession and growth in the geospatial portion of that profession. Assessing geospatial demand within the professions could be accomplished by rigorous surveying of representative industry components for each profession.

V. GEOSPATIAL SKILLS & COMPETENCIES

The University of Southern Mississippi's Geospatial Workforce Competency Model

To date, the most comprehensive work related to geospatial workforce competencies has been conducted by the University of Southern Mississippi. Gaudet et al. (2003) identified 12 roles (see Table 1) and 39 competencies within the geospatial workforce. Competency is defined as the knowledge, skills, and abilities an individual needs to do their job. Role is not a job description, rather it is a grouping of competencies targeted to meet specific expectations of a job or function. These roles appear to cross the technological components of the geospatial technology industry. For example, training as a role can take place in an organization specializing in GIS, as well as in remote sensing.

Using the online feedback mechanism, we asked participants and stakeholders to identify the roles for which there are or will be a shortage of skilled workers in the next 10 years. The last column in Table 3 expresses the responses in percentage of all respondents. Forty-three percent of all respondents believe that there is and will be a shortage of skilled workers in the role of application development in their organizations now and during the next 10 years. One-third of respondents project that six of twelve roles are experiencing or will experience labor shortage in the next ten years.

Respondents entered 23 additional roles (See table 4 below). Some of these roles can be interpreted as subsets of roles listed in Table 1. For example, "application development" in Table 1 may include "geo software engineering" and "spatial programming". On the other hand, "photogrammetry" and "technical writing" are characterized as technical competencies, not roles in the Geospatial Workforce Competency Model, as presented by Gaudet et al (2003). There are several roles identified by our respondents that may represent emerging geospatial roles or corresponding competency needs to be identified. These include: data conversion, portal, interoperability, and standards.

A disproportionately higher percentage of the above "other" roles were submitted from respondents working in non-profit organizations. Eight of the 23 roles (35%) were submitted by NPOs, whereas only about six percent of all respondents come from NPOs. Private and public company respondents clearly identified "application development" as the role with the largest labor shortage. This is different from the educators, who identified "visualization" as the role with the largest shortage. Our analyses show that perceived current and future shortages of skilled labors in geospatial roles differs from one sector to the next.

Table 3: Geospatial roles where shortages are expected in the next 10 years

ROLE	**DEFINITION**	**% OF RESPONDENTS EXPECTING SHORTAGES**
Application Development	Identify and develop tools and instruments to satisfy customer needs	43
Data Analysis	Process data and extract information to create products, drive conclusions, and inform decision making reports	36
Data Management	Catalog, archive, retrieve, and distribute geospatial data	36
Project Management	Effectively oversee activity requirements to produce the desired outcomes on time and within budget	35
Systems Analysis	Assess requirements for system capacities including inputs, outputs, processes, timing, and performance, as well as recommend necessary additions or adaptations	33
Visualization	Render data and information into visual geospatial representation	33
Systems Management	Integrate resources and develop additional resources to support spatial and temporal user requirements	28
Other	*Note: respondents wrote in 23 additional roles*	23
Coordination	Collect geospatial and related data	22
Training	Analyze, design, and develop instructional and non-instructional interventions to provide transfer of knowledge and evaluation for performance improvement	22
Management	Efficiently and effectively apply the company's mission using financial, technical, and intellectual skills and resources to optimize the end products	17
Data Acquisition	Inter-organizational facilitation and communication	13
Marketing	Identify customer requirements and needs, and effectively communicate those needs and requirements to the organization, as well as promote geospatial solutions	10

Table 4: Additional Geospatial Roles Identified

Architecture	Photogrammetry
Common standards & Interoperability	Portal
Cross-discipline Specialists	Rights Management
Data Conversion	Security
Database Administration	Software architecture & development
Geo software engineering	Spatial programming
Geographic Information Specialist (broader than data analysis)	Systems integration
GIS Education	Technical writing
GIS related software engineering and systems integration	Training in each field not just generic training
GIScientists	use of Standards
Leadership	Using GIS technologies to solve problems in other fields translating real world problems
Mathematics (Statistics) and technical writing	

Current and future skilled labor shortage in geospatial roles

Gaudet et al (2003) also established a set of 39 geospatial technology competencies (see Gaudet et al. 2003, table 3). They are divided into four groups:

- Technical Competencies
- Business Competencies
- Analytical Competencies
- Interpersonal Competencies

Twelve competencies are identified as "core competencies", shown in bold in Table 5. In our two round table events, we focused upon the thirteen technical competencies, the definitions of which are provided in Table 6.

Table 5: Geospatial Technology Core Competencies in University of Southern Mississippi's Geospatial Workforce Competency Model (Source: Guadet et al 2003, Table 3, page 28).

TABLE 3
Geospatial Technology Core Competencies
(Note: Core competencies are shown in bold)

Technical Competencies	Business Competencies
Ability to Assess Relationships Among Geospatial Technologies	**Ability to See the "Big Picture"**
Cartography	Business Understanding
Computer Programming Skills	Buy-in/Advocacy
Environmental Applications	**Change Management**
GIS Theory and Applications	**Cost Benefit Analysis/ROI**
Geology Applications	Ethics Modeling
Geospatial Data Processing Tools	Industry Understanding
Photogrammetry	Legal Understanding
Remote Sensing Theory and Applications	Organization Understanding
Spatial Information Processing	Performance Analysis and Evaluation
Technical Writing	**Visioning**
Technological Literacy	
Topology	

Analytical Competencies	Interpersonal Competencies
Creative Thinking	Coaching
Knowledge Management:	**Communication**
Model Building Skills	Conflict Management:
Problem-Solving Skills	**Feedback Skills**
Research Skill	Group Process Understanding
Systems Thinking	**Leadership Skills**
	Questioning
	Relationship Building Skills
	Self-Knowledge/Self-Management

Table 6: Geospatial Technology Workforce Technical Competency Definitions
(Source: Gaudet et al 2003, Table 3, pages 26-27)

Geospatial Technology Competency Definitions	Core
Ability to Assess Relationships Among Geospatial Technologies – examining the effects of geospatial technologies on parts of an organization, as well as the effects on the organization's interactions with customers, suppliers, distributors, and workers	YES
Cartography – organizing and communicating geographically related information in either graphic or digital form	
Computer Programming Skills – being able to understand and use a set vocabulary and grammatical rules for instructing a computer to perform a specific task; knowledge of high-level languages; ability to create or revise a program	
Environmental Applications – applying GIS technologies for environmental assessment or management purposes	
Geology Applications – applying GIS technologies for geological purposes	
Geospatial Data Processing Tools – knowing and being able to apply the skills needed to operate currently used geospatial data processing tools	
GIS Theory and Applications – understanding the theory behind GIS and being able to identify and implement modern day applications for it	YES
Photogrammetry – recording, measuring, and plotting electromagnetic radiation data from aerial photographs and remote sensing systems against land features identified in ground control surveys, generally in order to produce planimetric, topographic, and contour maps	
Remote Sensing Theory and Applications – understanding the underlying theories related to acquiring an object without contacting it physically such as aerial photography, radar, and satellite imaging	
Spatial Information Processing – the process of modeling, examining, and interpreting model results necessary for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding	
Technical Writing – the ability to "translate" technical information to nonspecialists	YES
Technological Literacy – understanding and appropriately applying existing, new, or emerging technologies	YES
Topology – understanding how map features represented by points, lines, and areas are related, with specific emphasis on the issues of connectivity and adjacency of features	

During the first roundtable event, only the technical competencies were distributed to the industry leaders and the responses were wide-ranging. In general, three main questions emerged during the discussion. First, do the four core technical competencies cover all the integral attributes of a successful geospatial professional? Second, why is there no discussion of the level of competency? Third, why are geological and environmental applications isolated as technological competencies? What about meteorological and hydrological?

The online feedback mechanism asked if the 13 Gaudet technical competencies adequately describe the range of technical competencies in respondents' organizations. Sixty-two percent answered "No". Additional technical competency recommendations included the following: geodetic science, surveying, cartography, computation geometry, artificial intelligence, diverse software engineering skills, data acquisition, visualization and conversion, mathematical and quantitative skills, statistical analysis, data fusion and mining, GPS, linear networks, integration and interface of domain knowledge with the technology.

Recommendations

- There is a clear need to refine and update the University of Southern Mississippi's Geospatial Workforce Competency Model. We should continue to work with Gaudet et al. to refine the model as it is the nature of an emerging industry to require timely updates.
- There is a sense of confusion between the terms "roles", "competencies", "occupations", and "job titles". During the round table events, there was much discussion about the unclear distinction between these four terms.
- There seems to be a strong consensus to add a fifth group of competencies. This group is best titled as "application competencies" and it should include fields such as Environmental Applications, Geological Applications, Natural Resource Management, and Demographic and Social Applications.
- There was a clear emergence of need for technical competencies in areas such as standards and interoperability.
- It is also necessary to determine the level of competency in addition to the type of competency.

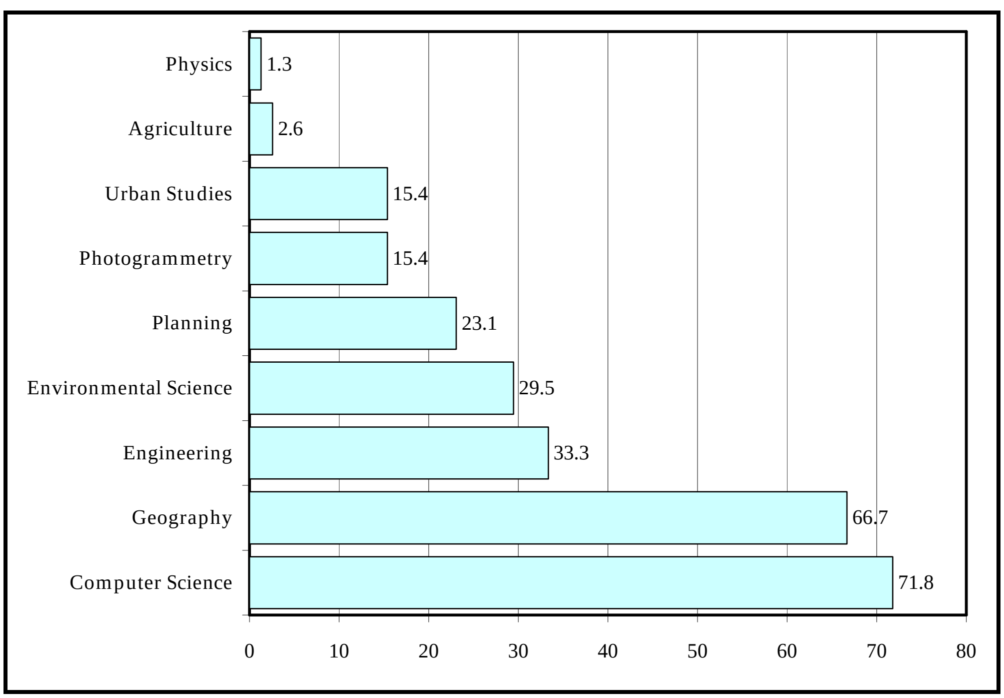
VI. MEETING GEOSPATIAL WORKFORCE NEEDS

Critical Academic Disciplines in Educating and Training Geospatial Workforce

The Urban and Regional Information Systems Association's (URISA) *Salary Survey 2003 for IT/GIS Professionals* provides perspective on the composition of the academic home of educational programs relevant to the GIS workforce. The top six disciplines (with at least 10% of respondents) for educational degrees for the IT/GIS professionals surveyed were: Geography (41.5%), GIS (23.7%), Other (17.6%), Planning (11.8%), Engineering (10.8%), and Computer Science (10.2%).

In our online feedback mechanism, we asked respondents to identify the academic disciplines that are critical in providing training and education for the future of the geospatial workforce. Figure 6 shows that the two most often identified disciplines were computer science (71.8%) and geography (66.7%). The other important disciplines in descending order with at least one-fifth of the respondents identifying them are engineering (33.3%), environmental science (29.5%) and planning (23.1%). There is slight difference when comparing responses obtained from respondents of different organizations. Geography is identified most frequently by respondents from the educational, governmental, and non-profit sectors. Response from private and public companies indicates that computer science plays the more critical role.

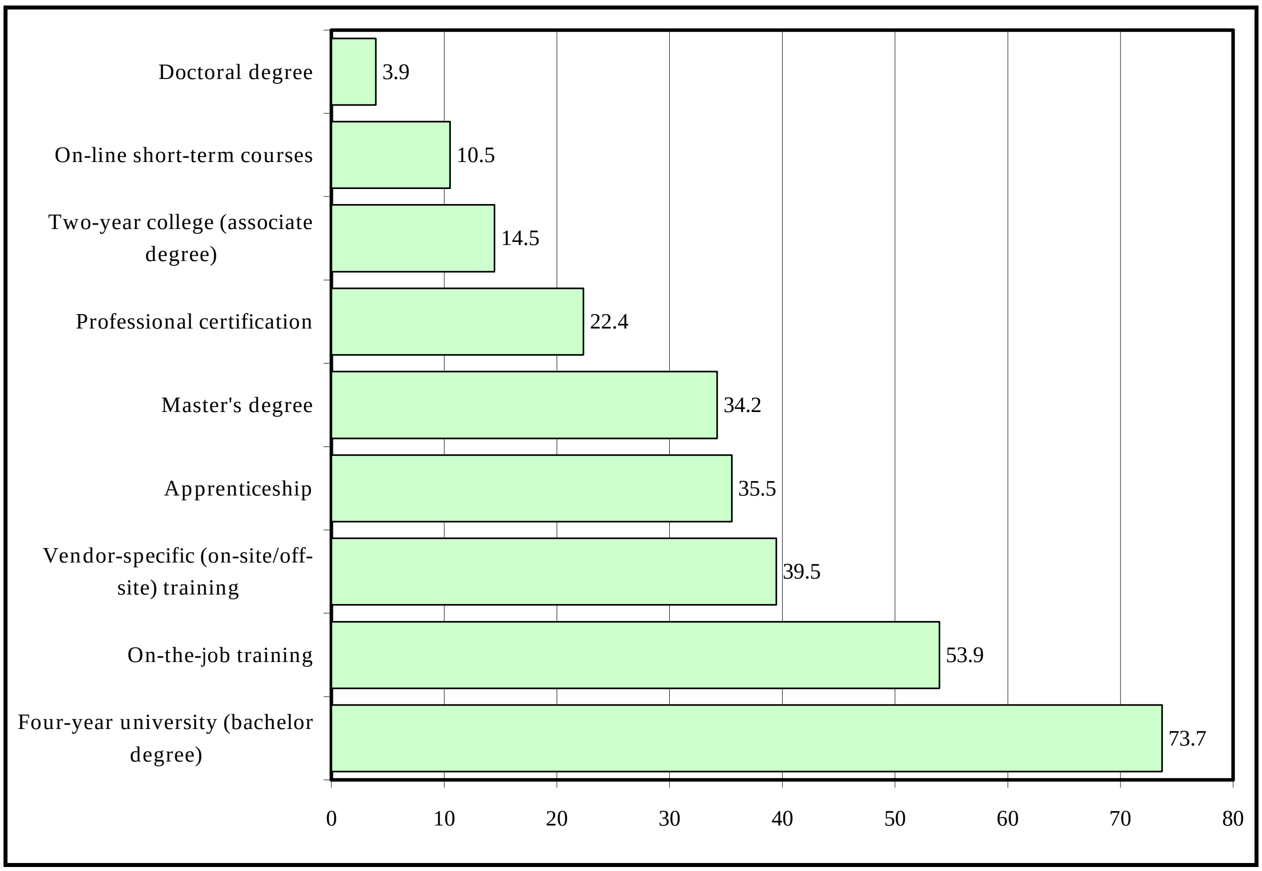
Figure 6: Critical Academic Disciplines for the Future of the Geospatial Workforce



Crucial Mechanisms in Delivering Geospatial Workforce Training and Education

The online feedback mechanism identified educational/training mechanisms as successful strategies for long-term sustainability of the geospatial technology workforce. Figure 7 shows that 73.7% of all respondents identified the four-year university (bachelor's degree) as an important training and educational mechanism. This is followed by on-the-job training (53.9%), vendor-specific (on-site/offsite) training (39.5%), apprenticeship (35.5%) and master's degree (34.2%).

Figure 7: Important Training and Educational Mechanisms for Sustainable Workforce



There is also clear difference in emphasis based upon the types of respondents' organizations. Across all four sectors, the four-year university degree is the most cited important educational mechanism. However, strong emphasis is placed on on-the-job training and vendor-specific (on-site/offsite) training by the private and public companies, as well as governmental organizations. Educators place considerable emphasis on Master's degree and professional certification.

Additional comments to the feedback mechanism stressed the following important areas of education: continuing education in emerging technology fields; coop and internship programs; hands-on training in the chosen work field; bringing educational efforts to the primary schools; practical applications; training professionals in the scientific method and problem solving.

BLS provides projections of employment in 2012 by SOC titles (see Appendix C) as well as general training and educational requirements. Table 7 summarizes projected 2012 employment of all 124 occupations listed in Appendix A. These 124 occupations were identified as occupations that may benefit from geographic and geographic technology trainings. As shown in Table 7, the majority of the projected jobs require some form of post-secondary education (ranging from associate to doctoral degree). In the occupations identified, just over 25% require on-the-job training (ranging from short, moderate, to long-term). The projected figures point to the continuing importance of the four-year university, life-long continuing education, and on-the-job training, as well as the emergence of two-year community colleges.

Table 7: Projected Employment (2012) by Primary Type of Training and Educational Attainment Level

Type of Training/Education Level	**Total 2012 (1000)**	**%**
Postsecondary vocational award	739	2.95
Associate degree	1133	4.52
Bachelor's degree	9636	38.40
Bachelor's plus experience	5600	22.32
Master's degree	849	3.38
Doctoral degree	30	0.12
Short-term on-the-job	4078	16.25
Moderate-term on-the-job	721	2.87
Long-term on-the-job	486	1.94
Work experience in a related occupation	1821	7.26
Total	25093	100.00

The January roundtable identified a number of additional educational mechanisms. They include:

- online education
- library science as an educational training mechanism
- K-12 education specific to geography
- informal education for kids through games such as geocaching
- incorporation of geography into business classes for business informatics
- embedding geospatial capabilities into fundamental courses such as business, development, or database management
- incorporate No Child Left Behind or STEM program values and engage the Department of Education as well as DOL
- do not overlook the value of educational organizations such as GITA, AAG, and URISA in professional development activities

To develop a long-term strategy to narrow the gap between geospatial workforce demand and supply, we must start by understanding the obstacles. During the October 6th roundtable, many issues were raised and discussed.

- Although it is the most comprehensive geospatial workforce model to date, the Gaudet et al (2003) competency model was developed at a time when there was no way to get a list of the knowledge, skills and abilities (KSA) for the industry. The intent of the model was to create a way to articulate KSAs and get definitions for the cross-cutting fields in which the geospatial workers are actively engaged.

- The trend to offshoring geospatial work is having a strong effect on our industry and how we define the demand for US workforce skills. Historically the US has been labor short but this is not the case in countries doing the offshored work. There is a competitive battle going on, a struggle. It is harder to offshore health services, contrasted to technical services which are much more mobile.

- Proper and easily understood job titles and descriptions are critical in building training strategy and curriculum development that aim at building a sustainable pipeline of geospatial workforce. Despite some efforts by URISA in developing a model GIS description, industry-wise commonly acceptable job and occupational titles and their descriptions are still lacking.

- There has been a shift in the industry from lots of digitizing and data entry in the early stages, to current interest in automated data collection. Thus there has been a change in the nature of jobs. Integrative trends will transform the industry over next 10 to 20 years, resulting in a shift from GIS as a cartographic tool into core industries for decision making, management, and planning. Employment will move out of the basement and into the boardroom. There will also be a trend to omniscient field-based systems.

- The geospatial industry doesn't have a process to strategically align with enterprise architecture. A talented GIS technician frequently has never been challenged in terms of presenting management information to the CIO.

- GIS people are becoming more management oriented but we need to teach management to be more spatially literate.

- Where is IT in the geospatial industry? These groups need to be more integrated. Those championing GIS have to speak the language of the source of funding they need to secure.

- From a state and local government perspective, people are there and qualified, but there is rigidity in the classification system. It may be necessary to fall back to retrain people in geospatial technology and adjust pay scales.

- There are issues with aging labor force, resulting in a need for life long learning to be coupled with short term needs.

- Some of the geospatial issues are common to disruptive technologies. Current educational processes don't have the speed or budget to go into leading edge technology.

The concluding session of the January roundtable provided a group discussion of gaps between future competency needs and current training and education. Our participants provided many insightful comments and suggestions as to how the educators and the industry (both government organizations and private companies) should work together to narrow the wide gap between workforce needs and supply.

Recommendations to Close the Gap Between Geospatial Workforce Demand and Supply

- Currently we have geography being taught much more than GIS. Further, there are lots of CAD design classes but few are connecting this to geospatial applications. Only a small percentage of our students are involved in either of these programs. Geospatial must be embedded in core curriculum of K-12 and K-16.
- The National Resource Council report "Learning to Think Spatially" is now available online. It addresses the need to integrate geospatial thinking into existing courses, as there is no chance of adding geospatial courses to tightly controlled curriculums. This approach would help to increase standards to include geospatial. (Read online at http://www.nap.edu/catalog/11019.html)
- Within social, behavioral and economic sciences, there is not enough emphasis on use of geospatial methods and techniques. There will be a need for emphasis on spatial analysis within the domains of statistics and quantitative analysis.
- GIS has recently gone off the desktop and into the enterprise. There is a greater demand for enterprise operations managers. When there is innovation, it is possible to quickly fill positions at the entry and managerial level, but there are gaps at the middle.
- In August of 2005, a Geospatial Education Workshop titled "Integrating Geographic Information Systems and Remote Sensing for Technical Workforce Training at Two-Year Colleges" was held at the National Science Foundation. The workshop was a collaboration between National Council for Geographic Education, NSF-Advanced Technology Education Program, ESRI, USGS-Land Remote Sensing Program, and NASA-Landsat Program and Earth Observing System Office. Two-year colleges were urged to assume strong roles in training new geospatial technologists and meeting on-the-job training needs of local professionals.
- The UCGIS Body of Knowledge is a tremendous resource for developing long-term comprehensive curriculum for the geospatial workforce. (See website at http://www.ucgis.org/priorities/education/modelcurriculaproject.asp) There is considerable parallel between the BOK and Gaudet et al (2003) Geospatial Workforce Competency Model.

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