Geospatial Technology Competency Model

September 1, 2014

Employment and Training Administration
United States Department of Labor
www.doleta.gov

Table of Contents

About the Model 3
Tier 1 – Personal Effectiveness Competencies 7
1. Interpersonal Skills 7
2. Integrity 7
3. Professionalism 7
4. Initiative 7
5. Dependability and Reliability 8
6. Lifelong Learning 8
Tier 2 – Academic Competencies 9
1. Reading 9
2. Writing 9
3. Mathematics 9
4. Geography 10
5. Science and Engineering 10
6. Communication—Listening and Speaking 11
7. Critical and Analytical Thinking 11
8. Basic Computer Skills 12
Tier 3 – Workplace Competencies 14
1. Teamwork 14
2. Creative Thinking 14
3. Planning and Organizing 14
4. Problem Solving and Decision Making 15
5. Working with Tools and Technology 15
6. Checking, Examining, and Recording 16
7. Business Fundamentals 16
Tier 4 – Industry-Wide Technical Competencies 18
1. Core Geospatial Abilities and Knowledge 18
Tier 5 – Industry-Sector Technical Competencies 22
1. Positioning and Data Acquisition 22
2. Analysis and Modeling 23
3. Software and Application Development 25
Resources Reviewed 27

About the Model

The Geospatial Technology Competency Model (GTCM) is depicted as a pyramid with nine tiers. This depiction illustrates how occupational and industry competencies build on a foundation of personal effectiveness, academic, and workplace competencies. Each tier consists of one or more blocks representing the skills, knowledge, and abilities essential for successful performance in the industry or occupation represented by the model. At the base of the model, competencies apply to a large number of occupations and industries. As a user moves up the model, the competencies become industry- and occupation-specific. This document specifies competencies required for worker success in the geospatial industry, from the most general "Personal Effectiveness Competencies" (Tier 1) to the sector-specific competencies presented in Tier 5. Additional occupation-specific competencies and requirements (Tiers 6-8), as well as management competencies (Tier 9) are beyond the scope of this document.

Although the pyramid graphic implies a third dimension, the GTCM presented in this document is a two-dimensional model. A true three-dimensional GTCM would include consideration of the domain-specific competencies required for success in each of the many allied fields that rely on geospatial technologies and employ geospatial professionals. A list of such allied fields is presented among the Technical Content Areas associated with the Analysis and Modeling sector of Tier 5, the industry sector in which many geospatial technology end-users work. (A three-dimensional "market forecast framework" is suggested in Mondello, Hepner and Williamson, 2004.)

Expected uses of the GTCM include career guidance, curriculum development and assessment, recruitment and hiring, continuing professional development, criteria for voluntary certification, and outreach efforts intended to communicate characteristics of the geospatial field to the public. GTCM users should bear in mind that the pyramid framework is not intended to suggest a sequence of competency attainment or that certain competencies are of greater value or higher skill than others. The body of the GTCM is a table that contains definitions and associated key behaviors for each competency block depicted in the pyramid.

Foundational Competencies

Tiers 1 through 3 represent the "soft-skills" and work readiness skills that most employers demand. Each tier covers a different group of competencies:

Tier 1 – Personal Effectiveness Competencies are personal attributes essential for all life roles. Often referred to as "soft skills," personal effectiveness competencies are generally learned in the home or community and honed at school and in the workplace.

Tier 2 – Academic Competencies are primarily learned in a school setting. They include cognitive functions and thinking styles. Academic competencies are likely to apply to all industries and occupations.

Tier 3 – Workplace Competencies represent motives and traits, as well as interpersonal and self-management styles. They are generally applicable to a large number of occupations and industries.

Industry-specific Competencies

Tier 4 – Industry-Wide Technical Competencies cover the knowledge, skills, and abilities from which workers across the industry can benefit, regardless of the sector in which they operate. These competencies are considered cross-cutting, as they allow a worker to move easily across industry sub-sectors. Because of this, many of the critical work functions on this tier deal with awareness or understanding, rather than performing specific job tasks.

Listed in this tier are 43 examples of "Critical Work Functions" that many geospatial professionals will be expected to perform during their careers. Following the Work Functions are "Technical Content Areas" – the background knowledge upon which skills and abilities are based. These lists are exemplary, not exhaustive; geospatial professionals are called upon to demonstrate other abilities and knowledge depending on their particular roles and positions. Furthermore, few if any workers are responsible for every Critical Work Function in any one job. Thus, the examples cited represent both the core competencies of the geospatial field and the diversity of professional practice within it.

Tier 5 – Industry-Sector Technical Competencies represent a sub-set of industry technical competencies that are specific to an industry sector.

This tier identifies Critical Work Functions and Technical Content Areas required for worker success in each of three industry sectors: (1) Positioning and Geospatial Data Acquisition; (2) Analysis and Modeling; and (3) Software and Application Development. The sectors represent clusters of worker competencies associated with three major categories of geospatial industry products and services. The Critical Work Functions listed for each sector are exemplary rather than exhaustive, representing the diversity of professional practice in the geospatial field. The responsibilities of many individual geospatial professionals span two or even three sectors. However, few if any workers are responsible for every Work Function listed in a given sector. A few Critical Work Functions are restricted in some circumstances by U.S. State law to professionals who are licensed to perform such tasks.

Positioning and Data Acquisition: Sales of geospatial data account for over one-third of total geospatial industry revenues. In the U.S., Federal, state, and local government agencies are major consumers, but utilities, telecommunications firms, and other geographically-extensive organizations also rely on up-to-date geospatial data for their business operations. Workers in this sector are expert in the unique geometric and thematic properties of geospatial data, and are especially knowledgeable about the factors that affect data quality. They know how various data production technologies work—including the Global Navigation Satellite System (GNSS—and its component technologies such as GPS), airborne and satellite-based sensors, photogrammetric

instruments, surveying instruments, real time GPS/GIS mapping systems, and other field data collection devices—and know how to deploy them to meet project requirements. Others are expert in field data collection, qualitative survey methods, administrative records and databases, and other data capture methods and technologies used to collect georeferenced observations and measurements. In addition to traditional modes of capturing data through remote sensing, surveying, and other field-based methods, this sector includes newer modes that incorporate the positioning capabilities of mobile phones and in-car navigation systems, as well as volunteered geospatial data gathered from social media and Internet technologies. Despite many laypersons' assumption that the world has already been mapped, the efforts of a large portion of the geospatial workforce continue to be devoted to the production of georeferenced data.

Analysis and Modeling: This sector encompasses the professional end-users of geospatial data and software, many of whom are employed in geospatial occupations within allied industries (such as those identified in the Technical Content Areas section below, under Organizational and Institutional Aspects). Successful practitioners in this sector know when and how to employ analytical functions of geospatial software tools to render valid and reliable information from geospatial data. Many are fluent with both data-driven "exploratory" analyses as well as model-driven analyses for hypothesis testing and prediction. Some analysts specialize in designing and implementing geospatial databases that enable efficient analyses. Others specialize in processing remotely-sensed image data. Still others are licensed by state governments to perform legal analyses of land records.

Software and Application Development: This sector accounts for the largest share of sales revenue earned in the geospatial industry. Geospatial software products vary from full-featured GIS software products, to specialized applications targeted to the needs of particular user communities, to component toolkits used by developers to create specialized end-user applications. Software products also include applications for processing, analysis, or adding value to remotely sensed data. In addition to workers employed by commercial software development firms, many geospatial professionals in diverse settings create specialized software applications to automate routine tasks and to customize end-user interfaces. Increasingly common is non-professional development of customized map "mashups" based on online mapping systems that expose Application Programming Interfaces. However, the Work Functions outlined below apply specifically to geospatial professionals whose primary work roles include software and application development.

Upper Tiers

Tiers 6 through 8 represent the specialization that occurs within specific occupations within an industry. Information on occupational competencies is available through O*NET OnLine (http://online.onetcenter.org/) and in an ongoing series of DACUM occupational analyses performed by the National Geospatial Technology Center (http://www.geotechcenter.org). Requirements for licensure and certification of Professional Surveyors, Professional Photogrammetrists, and GIS Professionals, are published by the National Council of Examiners for Engineering and Surveying (http://www.ncees.org/), the American Society for Photogrammetry and Remote Sensing (http://www.asprs.org), and the GIS Certification Institute

(http://www.gisci.org). The Geospatial Management Competency Model (GMCM) specifies 74 essential competencies and 18 competency areas that characterize the work of most successful managers in the geospatial industry. The GMCM (http://www.urisa.org/resources/geospatial-management-competency-model/) is an element of the U.S. Department of Labor Employment and Training Administration's (DOLETA's) Competency Modeling Initiative and corresponds to Tier 9 of the GTCM.

Tier 1 – Personal Effectiveness Competencies

1. Interpersonal Skills: Demonstrating the ability to work effectively with others.
Respecting diversity ▪ Interact appropriately and respectfully with supervisors and coworkers ▪ Work effectively with people who have diverse personalities and backgrounds ▪ Respect the opinions, perspectives, customs, and individual differences of others ▪ Be flexible and open-minded when dealing with a wide range of people ▪ Use appropriate strategies and solutions for dealing with conflicts and differences to maintain a smooth workflow ▪ Listen to and consider others' viewpoints
2. Integrity: Displaying accepted social and work behaviors.
Behaving ethically ▪ Treat others with honesty, fairness, and respect ▪ Respect the morals and beliefs of society **Taking responsibility** ▪ Take responsibility for accomplishing work goals within accepted timeframes ▪ Accept responsibility for one's decisions and actions
3. Professionalism: Demonstrating commitment to the values, standards of conduct, and well-being of one's profession.
Demonstrating self-control ▪ Stay calm, think clearly, and act decisively in stressful situations ▪ Accept criticism and attempt to learn from mistakes **Maintaining a positive attitude** ▪ Demonstrate a positive attitude towards work ▪ Strengthen your profession by mentoring junior colleagues and championing continuing professional development **Professional appearance** ▪ Follow rules and standards of dress and personal hygiene **Social responsibility** ▪ Refrain from substance abuse
4. Initiative: Demonstrating gumption at work.
Taking initiative ▪ Take initiative in seeking out new responsibilities and work challenges

Persisting
- Pursue work with energy, drive, and effort to accomplish tasks
- Persist at a task despite interruptions, obstacles, or setbacks

Setting challenging goals
- Establish and maintain personally challenging but realistic work goals

Achievement motivation
- Strive to exceed standards and expectations

5. Dependability and Reliability: Displaying responsible behaviors at work.

Fulfilling obligations
- Behave consistently, predictably, and reliably
- Fulfill obligations, complete assignments, and meet deadlines

Following directions
- Follow written and verbal directions
- Comply with organizational rules, policies, and procedures

6. Lifelong Learning: Displaying a willingness to learn and apply new knowledge and skills.

Demonstrating an interest in learning
- Demonstrate an interest in personal and professional lifelong learning and development
- Seek feedback, and modify behavior for improvement

Using change as a learning opportunity
- Treat unexpected circumstances as opportunities to learn and adopt new techniques

Participating in learning activities
- Broaden knowledge and skills through job shadowing and continuing education
- Seek and maintain membership in professional associations
- Read technical publications to stay abreast of new developments in the industry
- Maintain certifications and continuing education credits

Integrating and applying learning
- Use newly learned knowledge and skills to complete specific tasks

Identifying career interests
- Take charge of personal career development by identifying personal interests and career pathways

Tier 2 – Academic Competencies

1. Reading: Understanding written sentences and paragraphs in work-related documents.

Comprehension

- Locate, understand, and interpret written technical and non-technical information in documents such as charts, graphs, manuals, maps, memos, records, reports, schedules, surveys, tables, and titles
- Infer or locate meaning of unknown or technical vocabulary
- Understand the essential message and purpose of written materials

Information analysis

- Evaluate and analyze written materials critically, synthesizing information from multiple sources
- Discriminate reliable from unreliable sources

Attention to detail

- Identify relevant details, facts, and main ideas

2. Writing: Using standard English to create work-related documents.

Organization and Development

- Create documents such as case studies, charts, contracts, designs, diagrams, directions, graphs, legal descriptions, letters, manuals, maps, plans, records, reports, and surveys
- Communicate thoughts, ideas, information, messages, and other written information, which may contain technical material, in a logical, organized, coherent, and persuasive manner
- Develop ideas with supporting information and examples

Mechanics

- Use standard syntax and sentence structure
- Use correct spelling, punctuation, and capitalization; use appropriate grammar (e.g., correct tense, subject-verb agreement, no missing words)
- Write in a manner appropriate for business; use language appropriate for the target audience; avoid unnecessary jargon; use appropriate tone and word choice (e.g., writing is professional & courteous)
- Avoid plagiarism by paraphrasing, citing, and referencing sources properly

3. Mathematics: Using the principles of mathematics to solve problems.

Know and apply mathematical principles:

- Number Systems and Relationships – whole numbers, decimals, fractions, and percentages
- Number Operations and Computation – addition, subtraction, multiplication, and division
- Measurement and Estimation – measurement of time, temperature, distances, length, width, height, perimeter, area, volume, weight, velocity, and speed; unit conversion; numerical analysis to obtain approximate solutions when necessary
- Mathematical Notation – the language of mathematics to express mathematical ideas
- Mathematical Reasoning and Problem Solving – inductive and deductive reasoning, conjectures, arguments, strategies, and interpretation of results
- Statistics and Probability – standard deviation, variance, tests of significance, sampling, probability,

and confidence intervals

- Algebra – equations, patterns, functions, 3D vectors, and matrices
- Geometry – size, shape, and position of figures; using geometric principles to solve problems
- Trigonometry – relationships among the sides and angles of triangles on planes and spheres

4. Geography: Understanding the science of place and space. Knowing how to ask and discover where things are located on the surface of the earth, why they are located where they are, how places differ from one another, and how people interact with the environment.

Know and apply geographic skills, including:

Subject-specific Geographic Knowledge

- Human–Environment Interaction: Know and apply geographic information about relationships between nature and society (e.g., pollution from industrial development, economic effects of drought)
- Regional Geography: Know and apply knowledge of the physical and human geography of a specific country or world region
- Physical Geography: Know and apply geographic information about the processes that shape physical landscapes; weather, climate and atmospheric processes; ecosystems and ecological processes; and natural hazards
- Cultural Geography: Know and apply geographic information about culture and cultural processes, including religion, language, ethnicity, diffusion, meaning of landscapes, cultural significance of place

Geographic Skills

- Geographic Information Systems (GIS): Use GIS to acquire, manage, display, and analyze spatial data in digital form
- Cartography: Producing, creating, and designing paper or digital maps
- Field Methods: Use interviews, questionnaires, observations, photography, maps, GPS, GIS, and other techniques to measure geographic information in the field
- Spatial Statistics: Use quantitative methods to process spatial data for the purpose of making calculations, models, and inferences about space, spatial patterns, and spatial relationships

Geographic Perspectives

- Spatial Thinking: Identify, explain, and find meaning in spatial patterns and relationships, such as site conditions, how places are similar and different, the influence of a land feature on its neighbors, the nature of transitions between places, how places are linked at local, regional, and/or global scales
- Global Perspective: Possess and apply knowledge of how people, places, and regions are linked by global networks and processes (e.g., globalization, international trade, immigration, Internet technology, global climate system)
- Interdisciplinary Perspective: Draw on and synthesize the information, concepts, and methods of the natural and social sciences for geographic research and applications

5. Science and Engineering: Knowing and applying the principles, rules, and methods of science and engineering to solve problems.

Scientific knowledge and methods:

Scientific Method – the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of a

hypothesis

Subject-specific Scientific Knowledge

- Physical Sciences, including Agricultural Science – production of goods through the growing of plants, animals, and other life forms; Biology – the phenomena of life and living organisms; Environmental Science/Ecology – the relationships between organisms and their environments; Forestry – the cultivation, maintenance, and management of forests; Geology – the origin, history, and structure of the earth; Hydrology – properties, distribution, and effects of water on the Earth's surface; Meteorology and Climatology – phenomena of the atmosphere, especially weather and weather conditions; Oceanography – scientific study of oceans, the life that inhabits them, and their physical characteristics; Physics – matter and energy and their interactions
- Social sciences, including Anthropology – the origins and social relationships of human beings; Demography – the characteristics of human populations; Economics – the production, distribution and consumption of goods and services and their management; History – the interpretation of past events involving human beings; Political Science – the government of states and other political units; and Sociology – the study and classification of human societies

Engineering knowledge and methods:

Engineering Methods

- Design – design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models
- Engineering technologies, including computer-aided engineering and drafting, site surveying, leveling, and ground-based laser scanning

Subject-specific Engineering Knowledge

- Familiarity with applications of science and engineering principles

6. Communication—Listening and Speaking: Giving full attention to what others are saying and speaking in English well enough to be understood by others.

Listening

- Receive, interpret, understand, and respond to verbal messages and other cues
- Give full attention to what other people are saying, take time to understand the points being made, ask questions as appropriate, and refrain from interrupting at inappropriate times
- Pick out important information in verbal messages

Speaking and Presenting

- Speak clearly and confidently using common English conventions including proper grammar, tone, and pace
- Express information to individuals or groups taking into account the audience and the nature of the information (e.g., explain technical concepts to non-technical audiences)
- Influence others; present thoughts and ideas persuasively; gain commitment and ensure support for proposed ideas

7. Critical and Analytical Thinking: Using logic, reasoning, and analysis to address problems.

Reasoning

- Use logic and reasoning to identify strengths and weaknesses of alternative solutions, conclusions, or approaches to problems
- Use inductive and deductive reasoning to analyze, synthesize, compare, and interpret information

- Draw conclusions from relevant or missing information
- Understand the underlying relationship among facts and connections between issues
- Organize problems into manageable parts

8. Basic Computer Skills: Using a computer and related applications to input and retrieve information.

Navigation and File Management

- Use scroll bars, a mouse, and dialog boxes to work within the computer's operating system
- Access and switch between applications and files of interest

Internet and E-mail

- Navigate the Internet to find information
- Open and configure standard browsers
- Use searches, hypertext references, and transfer protocols
- Send and retrieve electronic mail (e-mail)
- Write e-mail with an appropriate tone
- Manage personal schedule and contact information
- Navigate the Internet to find and attend online training, web conferences, webinars, self-paced training, and other applicable interactive sites
- Employ collaborative/groupware applications to facilitate group work

Writing and Publishing Applications

- Use a computer application to compose text and insert graphics
- Format, edit, and print text
- Save and retrieve word processing documents

Spreadsheets

- Use a computer application to enter, manipulate, and format text and numerical data
- Insert, delete, and manipulate cells, rows, and columns
- Create and save worksheets, charts, and graphs

Presentations

- Use a computer application to create, manipulate, edit, and present digital representations of information to an audience

Databases

- Use a computer application to manage large amounts of information
- Create and edit simple databases
- Input data
- Retrieve detailed records using a query language
- Create reports to communicate the information

Graphics

- Work with pictures in graphics programs or other applications
- Choose and create graphs, diagrams, and other information graphics that most effectively and

appropriate represent particular data sets

- Insert graphics into other files/programs

Tier 3 – Workplace Competencies

1. Teamwork: Working cooperatively with others to complete projects.

Identifying team membership and role

- Accept membership in the team and identify with its goals
- Determine when to be a leader and when to be a follower depending on what is needed to achieve team's goals and objectives
- Identify roles of team members and effectively communicate with all members of the team

Establishing productive relationships

- Collaborate with others to formulate team objectives and develop consensus for best outcome
- Give and receive feedback constructively
- Be open to considering new ways of doing things and the merits of new approaches to work

Meeting team objectives

- Use teamwork skills to achieve goals, solve problems, and manage conflict

2. Creative Thinking: Recognizing, exploring, and using a broad range of ideas and practices.

Employing unique analyses

- Employ unique analyses and generate original, innovative ideas and solutions in complex areas
- Develop innovative methods of obtaining or using resources when insufficient resources are available

Generating innovative solutions

- See the possibilities of "what can be" and inspire a shared sense of purpose within the organization
- Entertain wide-ranging possibilities to develop unique approaches and useful solutions
- Integrate seemingly unrelated information to develop creative solutions

Seeing the big picture

- Understand the pieces of a system as a whole and possess a big picture view of the situation

3. Planning and Organizing: Planning and prioritizing work to manage time effectively and accomplish assigned tasks.

Planning and Organizing

- Approach work in a methodical manner
- Apply effective organizational skills
- Break down large problems into more manageable component tasks
- Develop and implement a plan for a project
- Keep track of details to ensure work is performed accurately and completely
- Find new ways of organizing or planning work to accomplish tasks more efficiently

Adaptability and Flexibility

- Change gears in response to unpredictable or unexpected events, pressures, situations, and job

demands
- Effectively change plans, goals, actions, or priorities to deal with changing situations
- Compare actual and ideal performance in order to identify performance gaps or opportunities

Time Management
- Develop a timeline for sequencing the activities of a project
- Establish specific goals to accomplish work in a timely manner
- Prioritize various competing tasks and perform them efficiently according to their urgency
- Ensure that others receive needed materials in time
- Stay on schedule
- Keep all parties informed of progress and all relevant changes to project timelines

4. Problem Solving and Decision Making: Applying critical-thinking skills to solve problems by generating, evaluating, and implementing solutions.

Identify the Problem
- Anticipate or recognize the existence of a problem
- Identify the nature of the problem by analyzing its component parts and defining critical issues
- Locate, obtain, and review information relevant to the problem

Generate Alternatives
- Generate a variety of approaches to the problem
- Think creatively to develop new ideas for and answers to work related problems
- Use logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems
- Build models to conceptualize and develop theoretical and practical frameworks

Choose and Implement a Solution
- Decisively choose the best solution after contemplating available approaches to the problem
- Commit to a solution in a timely manner
- Use strategies, tools, resources, and equipment to implement the solution
- Observe and evaluate the outcomes of implementing the solution to assess the need for alternative approaches and to identify lessons learned

5. Working with Tools and Technology: Selecting, using, and maintaining tools and technology to facilitate work activity.

Selecting tools
- Identify, select, and apply tools or technological solutions appropriate to the task at hand

Using tools
- Operate tools and equipment in accordance with established operating procedures and safety standards
- Use information technology and computer applications as it supports the gathering, storage, manipulation, and transfer of data and information

Keeping current on tools and technology

- Demonstrate an interest in learning about new and emerging tools and technologies
- Identify sources of information concerning state-of-the-art tools, equipment, materials, technologies, and methodologies
- Seek out opportunities to improve knowledge of tools and technologies that may assist in streamlining work and improving productivity

Troubleshooting and maintenance

- Help people adapt to the changes brought on by new technologies and helping them to see the value and benefits of new technology
- Troubleshoot and maintain tools and technologies

6. Checking, Examining, and Recording: Entering, transcribing, recording, storing, or maintaining information in written or electronic/magnetic format.

Obtaining information

- Compile, code, categorize, calculate, tabulate, audit, or verify information or data
- Perform with rigorous exactness and a high degree of accuracy
- Apply techniques for observing and gathering data

Maintaining logs, records, and files

- Implement quality assurance and quality control procedures
- Organize records and files to maintain data

Detecting errors

- Detect and correct errors or inconsistencies, even under time pressure

7. Business Fundamentals: Knowledge of basic business principles, trends, and economics.

Economic/Business/Financial Principles

- Basic understanding of markets, economic terminology, and business principles

Economic System as a Framework for Decision-making

- Quantify the costs and benefits of an information technology solution for a given organization
- Assess patterns of technologies by examining their effects on parts of an organization, as well as the effects on the organization's interactions with customers, suppliers, distributors, and workers
- Explain the relationship between individual performance and the success of the organization

Business Ethics – Act in the best interests of the company, your co-workers, your community, other stakeholders, and the environment

- Legal/Financial
  - Comply with the letter and spirit of applicable laws
  - Use company property legitimately, minimizing loss and waste; report loss, waste, or theft of company property to appropriate personnel
  - Maintain privacy and confidentiality of company information, as well as that of customers and co-workers

    - Comply with intellectual property laws
    - Protect trade secrets
- Environmental/Health/Safety
    - Hold paramount the safety, health, and welfare of the public
    - Maintain a healthful and safe environment and report any violations/discrepancies
    - Ensure equipment and systems are designed to be environmentally friendly and strive to continually minimize the resulting carbon footprint
- Social
    - Emphasize quality, customer satisfaction, and fair pricing
    - Deal with customers in good faith; no bribes, kickbacks, or excessive hospitality
    - Recognize and resist temptations to compete unfairly

Marketing

- Demonstrate an understanding of market trends, company's position in the market place, and defined market segments
- Understand position of product/service in relation to market demand
- Uphold the company and product brand through building and maintaining customer relations
- Integrate internal and external customer demands and needs into the product

Entrepreneurship

- Demonstrate skills in leadership and team building, including enlisting others to work toward a shared vision
- Discuss strategies for managing growth, including using replicable processes to create enterprises that are sustainable

Geospatial Business Fundamentals

- Demonstrate awareness of the various professions, agencies and firms that comprise the geospatial technology industry
- Understand the respective roles of the private sector, universities, non-profit organizations, and government agencies in the geospatial market
- Make a business case for a given organization's investment in geospatial technology, including value added and risks minimized
- Recognize ethical implications of bidding and other business practices in geospatial business contexts and make reasoned decisions about appropriate actions

Tier 4 – Industry-Wide Technical Competencies

1. Core Geospatial Abilities and Knowledge
Critical Work Functions: **Earth Geometry and Geodesy** ▪ Discuss the roles of several geometric approximations of the earth's shape, such as geoids, ellipsoids, and spheres ▪ Describe characteristics and appropriate uses of common geospatial coordinate systems, such as geographic (latitude and longitude), UTM and State Plane Coordinates ▪ Explain the relationship of horizontal datums, such as North America Datum of 1983 (NAD 83) or the World Geodetic System of 1984 (WGS 84), to coordinate system grids and geometric approximations of the earth's shape ▪ Describe characteristics and appropriate uses of common map projections, such as Transverse Mercator, Lambert Conformal Conic, Albers Conic Equal Area, Azimuthal Equidistant, and Polar Stereographic **Data Quality** ▪ Discuss the elements of geospatial data quality, including geometric accuracy, thematic accuracy, resolution, precision, and fitness for use ▪ In the context of a given geospatial project, explain the difference between quality control and quality assurance ▪ Identify data quality and integration problems likely to be associated with geospatial and attribute data acquired with legacy systems and processes ▪ Calculate and interpret statistical measures of the accuracy of a digital data set, such as Root Mean Square Error (RMSE) **Positioning Systems** ▪ Describe the basic components and operations of the Global Navigation Satellite System (GNSS), including the Global Positioning System and similar systems ▪ Explain the role of GNSS in location-based services ▪ Collect and integrate GNSS/GPS positions and associated attribute data with other geospatial data sets ▪ Describe characteristics and appropriate uses of inertial measurement systems **Remote Sensing and Photogrammetry** ▪ Use the concept of the electromagnetic spectrum to explain the difference between sensors (e.g. optical, microwave, multispectral, hyperspectral, etc.) ▪ Differentiate the several types of resolution that characterize remotely-sensed imagery, including spatial, spectral, radiometric, temporal, and extent ▪ Describe characteristics and appropriate uses of active and passive sensors ▪ Compare the capabilities and limitations of various sensor types in the context of project requirements ▪ Explain the use of sampling ground truth data for quality assurance in remote sensing ▪ Define "orthoimagery" in terms of terrain correction and georeferencing

Cartography

- Employ cartographic design principles to create and edit visual representations of geospatial data, including maps, graphs, and diagrams
- Demonstrate how the selection of data classification and/or symbolization techniques affects the message of the thematic map
- Critique the design of a given map in light of its intended audience and purpose

Geographic Information Systems

- Demonstrate understanding of the conceptual foundations on which geographic information systems (GIS) are based, including the problem of representing change over time and the imprecision and uncertainty that characterizes all geographic information
- Use geospatial hardware and software tools to digitize and georeference a paper map or plat
- Acquire and integrate a variety of field data, image data, vector data, and attribute data to create, update, and maintain GIS databases
- Specify uses of standard non-spatial data models, specifically the relational data model and its extensions
- Compare advantages and disadvantages of standard spatial data models, including the nature of vector, raster, and object-oriented models, in the context of spatial data used in the workplace
- Describe examples of geospatial data analysis in which spatial relationships such as distance, direction, and topologic relationships (e.g. adjacency, connectivity, and overlap) are particularly relevant
- Use geospatial software tools to perform basic GIS analysis functions, including spatial measurement, data query and retrieval, vector overlay, and raster map algebra
- Demonstrate a working knowledge of GIS hardware and software capabilities, including real time GPS/GIS mapping systems

Programming, application development, and geospatial information technology

- Demonstrate understanding of common geospatial algorithms, such as geocoding or drive time analysis, by writing or interpreting pseudo code
- Recognize GIS tasks that are amenable to automation, such as route generation, incident response, and land use change analysis
- Identify alternatives for customization and automation, such as APIs, SDKs, scripting languages
- Identify the information technology components of a GIS, such as databases, software programs, application servers, data servers, SAN Devices, workstations, switches, routers, and firewalls
- Compare benefits and shortcomings of desktop, server, enterprise, and hosted (cloud) software applications
- Discuss trends in geospatial technology and applications
- Compare the capabilities and limitations of different types of geospatial software, such as CAD, GIS, image processing
- Recognize opportunities to leverage positioning technology to create mobile end-user applications

Professionalism

- Identify allied fields that rely on geospatial technology and that employ geospatial professionals
- Participate in scientific and professional organizations and coordinating organizations
- Demonstrate familiarity with codes of professional ethics and rules of conduct for geospatial

professionals
- Identify legal, ethical, and business considerations that affect an organization's decision to share geospatial data
- Be familiar with the historical origins of geospatial technology

Technical Content Areas: Headings correspond to select knowledge areas identified in the first edition of the GIS&T Body of Knowledge (UCGIS 2006).

Conceptual Foundations
- Spatial and topological relationships

Geospatial Data
- Earth geometry and its approximations, including geoids, ellipsoids, and spheres
- Georeferencing systems, including coordinate systems and land partitioning systems
- Datums, horizontal and vertical
- Map projections
- Data quality, including geometric accuracy, thematic accuracy, resolution and precision
- Surveying, including numerical methods such as coordinate geometry, least-squares adjustment, and network adjustments
- Global Navigation Satellite System, including GPS, GLONASS, Galileo, Beidou (a.k.a. Compass), QZSS, and navigation applications
- Data input, including field data collection, digitizing, scanning, and data conversion
- Terrain modeling and representation
- Photogrammetry
- Remote Sensing, including aerial imaging, image interpretation, image processing, multispectral and hyperspectral remote sensing, and full-motion video
- Metadata, standards and infrastructure
- Alternative positioning technologies, such as wifi, TV, cell, and RFID.

Data Modeling
- Database Management Systems, including relational, object-oriented, and extensions of the relational model
- Data Models, including grid, raster, TIN, hierarchical, topological, vector, network, and object-oriented
- Geospatial data compression methods
- Data archiving and retrieval

Design Aspects
- Conceptual Models

Analytical Methods
- Geometric Measures
- Overlay Analysis
- Viewshed Analysis

- Network Analysis

Cartography and Visualization

- Principles of Map Design, including symbolization, color use, and typography
- Graphic Representation Techniques, including thematic mapping, multivariate displays, and web mapping
- Data Considerations for Mapping, including source materials, data abstraction (classification, selection and generalization), and map projections
- Map Production

GIS&T and Society

- Legal issues, including property rights, liability, and public access to geospatial information.
- Ethical issues, including privacy, geographic profiling, and inequities due to the "digital divide"
- Codes of ethics for geospatial professionals

Organizational and Institutional Aspects

- Professional, scientific and trade organizations, such as AAG, ACSM, ASPRS, GITA, MAPPS, NSGIC, and URISA
- Professional certification and licensing bodies, including GISCI, ASPRS and NCEES
- Federal agencies, such as U.S. Geological Survey, U.S. Census Bureau, National Geospatial-Intelligence Agency
- International organizations, such as GSDI, ISPRS, and ICA
- Publications, including scholarly journals, trade magazines, and blogs
- State and regional coordinating bodies, such as NSGIC and state Geographic Information Offices
- Standards organizations, such as FGDC and OGC

Tier 5 – Industry-Sector Technical Competencies

1. Positioning and Data Acquisition: Knowledge of the unique geometric and thematic properties of geospatial data, the factors that affect data quality, and data production technologies. Includes data collection, data capture methods and technologies used to collect georeferenced observations and measurements.
Critical Work Functions: ▪ Use specialized geospatial software to transform ellipsoid, datum, and/or map projection to georegister one set of geospatial data to another ▪ Geocode a list of address-referenced locations to map data encoded with geographic coordinates and attributed with address ranges ▪ Discuss examples of systematic and unsystematic land partitioning systems in the U.S. and their implications for land records ▪ Recognize that land records are administered differently around the world ▪ Explain the distinction between a property boundary and its representations, such as deed lines, lines on imagery, boundary depictions in cadastral (land records) databases ▪ Plot a legal boundary description from a deed or plat ▪ Design an integrated measurement system solution for acquiring and processing geospatial data ▪ Identify sampling strategies for field data collection, including systematic, random, and stratified random sampling, and describe circumstances favorable to each ▪ Explain how spatial autocorrelation influences sampling strategies and statistics ▪ Perform requirements analysis for remotely sensed data acquisition using resolution concepts ▪ Explain the concept of "bit depth" and its implications for remotely-sensed image data ▪ Plan a remotely sensed data acquisition mission, including specifying an appropriate sensor and platform combination suited for particular project requirements ▪ Illustrate the differences between ellipsoidal (or geodetic) heights, geoidal heights, and orthometric elevation in relation to GNSS ▪ Differentiate between Real time Precise Positioning Service (PPS) and Real time Standard Positioning Service (SPS) ▪ Perform GNSS data post-processing (such as National Geodetic Survey's Online Positioning Service) and real time (such as Real Time Kinematic) ▪ Collect and integrate carrier phase (survey grade) GNSS positions and associated attribute data with other geospatial data sets. ▪ Explain GNSS data quality issues, such as multipath, PDOP, and signal-to-noise ratio ▪ Explain major GNSS error sources, such as ionospheric delay, clock error, ephemerides, and satellite health ▪ Produce an orthoimage data product with geometric accuracy suitable for project requirements ▪ Explain aerotriangulation ▪ Produce a metadata document that conforms to a geospatial metadata standard ▪ Understand how to conduct primary research and implications of data privacy and confidentiality ▪ Describe how textual information can be harvested and geocoded from social media sites ▪ Explain the process of acquiring and integrating large and heterogeneous datasets (spatial or nonspatial) ▪ Explain how a mobile device calculates location coordinates (e.g., GNSS, triangulation, trilateration,

etc.)
- Compare differential GNSS and autonomous GNSS

Technical Content Areas: Headings correspond to select knowledge areas identified in the first edition of the GIS&T Body of Knowledge (UCGIS 2006).

Geospatial Data
- Earth Geometry
- Land Partitioning Systems, including metes and bounds, USPLS, and long lots
- Georeferencing Systems, including coordinate systems
- Datums
- Map Projections
- Data Quality
- Land Surveying
- Global Navigation Satellite System
- Field Data Collection
- Photogrammetry
- Remote Sensing
- Metadata

2. Analysis and Modeling: Knowledge and application of the analytical functions ("exploratory" analyses as well as model-driven analyses) of geospatial software tools.

Critical Work Functions:
- Describe an example of a useful application of a buffer operation in GIS software
- Perform a site suitability analysis using intersection and overlay functions of GIS software
- Use GIS software to identify an optimal route that accounts for visibility, slope, and specified land uses
- Perform dynamic segmentation on transportation network data encoded in a linear reference system
- Explain how leading online routing systems work, and account for common geocoding errors
- Use location-allocation software functions to locate service facilities that satisfy given constraints
- Develop conceptual, logical, and physical models of a geospatial database designed in response to user requirements
- Explain the Modifiable Areal Unit Problem (e.g. ecological fallacy, choropleth mapping, etc.) with relation to data aggregation
- Explain characteristics and appropriate uses of geospatial modeling techniques (e.g. neural networks, cellular automata, heuristics, agent-based models, and simulation models)
- Demonstrate familiarity with the existence of predictive models and their applications
- Employ cartographic techniques to represent different kinds of uncertainty, including uncertain boundary locations, transitional boundaries, and ambiguity of attributes
- Establish, re-establish and/or monument property boundaries; represent such boundaries in plats, records, and descriptions, all under personal and professional liability as stipulated in legal statute and precedent
- Determine appropriate image data and image analysis techniques needed to fulfill project requirements
- Outline workflows that identify sequence of procedures involved in geometric correction, radiometric

correction, and mosaicking of remotely sensed data

- Explain how to quantify the thematic accuracy of a land use/land cover map derived from remotely-sensed imagery
- Evaluate the thematic accuracy of a data product derived from aerial image interpretation, such as a soils map, using ground verification methods
- Explain the difference between pixel-based and object-based image classification
- Perform object-oriented image classification using specialized software tools

---

Technical Content Areas: Headings correspond to select knowledge areas identified in the first edition of the GIS&T Body of Knowledge (UCGIS 2006).

Analytical Methods

- Basic Analytical Operations, such as buffers, overlay, neighborhoods, and map algebra
- Basic Analytical Methods, such as point pattern analysis, spatial cluster analysis, multi-criteria evaluation, and spatial process models
- Analysis of Surfaces, including interpolation of surfaces, surface features, and viewshed analysis
- Geostatistics, including spatial sampling, semi-variogram modeling, and kriging
- Data Mining, including pattern recognition
- Network Analysis, including least-cost paths, flow modeling, and accessibility modeling

Design Aspects

- Analysis Design

Data Modeling

- Database Design

Geocomputation

- Neurocomputing
- Cellular Automata Models
- Heuristics
- Genetic algorithms
- Agent-based Models
- Simulation Models
- Uncertainty

Geospatial Data

- Land Surveying
- Field Data Collection
- Remote Sensing, including algorithms and processing

Cartography and Visualization

- Graphic Representation Techniques, including dynamic and interactive displays, Web mapping and visualizations, and visualization of uncertainty

GIS&T and Society

- Ethical Aspects, including obligations to individuals, to employers and clients, to colleagues and the profession, and to society
- Legal Aspects, including liability

Organizational and Institutional Aspects

- Allied industries in which professionals need to understand geographic principles, such as Agribusiness; Economic Development; Military/Intelligence; Homeland Security; Emergency Management & E911; Environmental and Natural Resources; Forestry; Coastal and Marine Resources Management; Real Estate and Land Management; Telecommunications; Energy, Exploration and Mining; Utilities (Public and Private) and Power Generation; City, State, County, Provincial and other Local Government; Transportation and Logistics (Fleet Management, Mobile Resource Management, Road and Highway Planning and Maintenance); Urban and Regional Planning; Mobile Location-Based Services and Communication (Navigation, Location-based alerts, Location-based gaming, Location-based search); Telematics
- Allied industries in which geographic information is a crucial part of many job functions, including Advertising, Marketing and Market Research; Architecture, Engineering and Construction; Banking and Finance; Insurance; Cultural Resource Management; Health Care; Education; Journalism and Publishing; Law Enforcement; Manufacturing; Politics and Elections; Public Safety and Health; Restaurants and Food Service; Entertainment; Retail; Tourism

3. Software and Application Development: Design and development of geospatial software and applications, including GIS software products, applications for processing, analysis, or adding value to remotely sensed data, and applications to automate routine tasks and to customize end-user interfaces.

Critical Work Functions:

- Develop use cases for user-centered requirements analyses
- Perform a feasibility study and cost/benefit analysis
- Design a geospatial system architecture that responds to user needs, including desktop, server, and mobile applications
- Communicate effectively with end-users to ensure that software applications meet user needs
- Optimize geospatial system performance
- Identify appropriate software development tools for particular end uses
- Create geospatial software programs using programming languages such as C, C++, and Java
- Ensure that software code complies with industry standards, such as those promulgated by the Open Geospatial Consortium (OGC)
- Identify the factors that affect the interoperability of geospatial software applications
- Automate geospatial analysis methods such as transformations, raster analysis, and geometric operations
- Use scripting languages such as Python and others to automate repetitive tasks in desktop geospatial software
- Customize geospatial software using proprietary and open source software components, such as ESRI's ArcObjects, Intergraph's GeoMedia software suite, and the GeoTools open source project
- Use scripting languages such as JavaScript, PHP, and KML to create web mapping applications
- Employ query languages such as SQL to interrogate spatial databases
- Work effectively in teams to plan and coordinate software and application development

- Stay informed about trends and best practices in information technology and software engineering, such as unit testing, version control, and continuous integration
- Evaluate open source software components for re-use and potential return contributions
- Realize opportunities to leverage positioning technology to create mobile end-user applications
- Explain how geospatial software in large enterprises fits into SOA (Service Oriented Architectures) and SaaS (Software as a Service)
- Be able to leverage new architectural opportunities such as cloud computing

---

Technical Content Areas: Headings below correspond to select knowledge areas identified in the First Edition of the GIS&T Body of Knowledge (UCGIS 2006). Professionals who work in this sector are also responsible for knowledge areas defined in bodies of knowledge of the Computer Science, Software Engineering, and Information Technology fields.

Analytical Methods

- Structured Query Language
- Spatial Queries

Design Aspects

- System Design
- Project Definition
- Resource Planning
- Database Design
- Analysis Design
- Application Design
- System Implementation

Resources Reviewed

Developer	Resource	Link
American Congress on Surveying and Mapping	ACSM Career Center	http://www.acsm.net/index.cfm?fuseaction=page.viewpage&pageid=724
American Society for Photogrammetry and Remote Sensing	ASPRS Certification Program	http://www.asprs.org/membership/certification/index.html
American Society for Photogrammetry and Remote Sensing	Professional Aspects of Photogrammetry	http://www.asprs.org/membership/certification/appendix_b.html
American Society for Photogrammetry and Remote Sensing	Certification Examination Matrices	http://www.asprs.org/membership/certification/certification_examination_matrix.html
American Society for Photogrammetry and Remote Sensing	Career Brochure	http://www.asprs.org/career/
Association of American Geographers	AAG Career Guide	https://communicate.aag.org/eseries/scriptcontent/custom/giwis/cguide/
Association of American Geographers	Careers in Geography	https://communicate.aag.org/eseries/scriptcontent/custom/giwis/cguide/opportunity/cguide_field.cfm
Bureau of Labor Statistics	Surveyors, Cartographers, Photogrammetrists, and Surveying and Mapping Technicians	http://www.bls.gov/oco/ocos040.htm
Career OneStop	Occupation Profile: Cartographers and Photogrammetrists	http://www.careerinfonet.org/occ_rep.asp?next=occ_rep&Level=&optstatus=111111111&jobfam=17&id=1&nodeid=2&soccode=171021&stfips=01&x=68&y=17
Daratech, Inc.	GIS Markets & Opportunities	http://www.daratech.com/research/gis/
Department of Geography, University of Colorado	Aerial Photography and Remote Sensing	http://www.colorado.edu/geography/gcraft/notes/remote/remote_f.html
Department of Geography, University of Colorado	GPS Overview	http://www.colorado.edu/geography/gcraft/notes/gps/gps_ftoc.html
Digital Quest Inc.	Digital Quest curricula – STARS, SPACE, AGIS	http://www.digitalquest.com/products.php#stars
Employment and Training Administration	High Growth Industry Profile	http://www.doleta.gov/BRG/Indprof/geospatial_profile.cfm
Employment and Training Administration	High Growth Job Training Initiative Investment Center	http://www.doleta.gov/Brg/JobTrainInitiative/
Employment and Training Administration	Identifying and Addressing Workforce Challenges in America's Geospatial Technology Sector	http://www.doleta.gov/BRG/pdf/Geospatial%20Final%20Report_08212007.pdf
ESRI	Geospatial Learning Pathways	http://training.esri.com/gateway/index.cfm?fa=pubPaths.paths
ESRI	Defining the Components of the Geospatial Workforce—Who Are We?	http://www.esri.com/news/arcnews/winter0506articles/defining1of2.html
ETA /Association of American Geographers	Defining and Communicating Geospatial Industry Workforce Demand	
GeoCommunity	What Skills Does A GIS Analyst Require?	http://careers.geocomm.com/resources/gisanlystskills.html

Geospatial Workforce Development Center, University of Southern Mississippi	Workforce Development Models for Geospatial Technology	
Geospatial Industry Workforce Information System (GIWIS)	Geospatial Competency Model	
Gaudet, C. H., H.M. Annulis, and J.C. Carr (2003)	Building the Geospatial Workforce. *URISA Journal* 15:1, 21-30.	www.urisa.org/files/Gaudetvol15no1.pdf
GIS Certification Institute	Core Competency-based Certification Program Model	http://www.gisci.org/Competency_Based/core_competency_model.aspx
GIS Certification Institute	Core Competency Checklist	http://www.gisci.org/Competency_Based/CC-1_form.pdf
GIS Certification Institute	GISP Survey Reveals Support for Certification Exam	http://www.gisci.org/PDFs/GISCI_Report_GIS_%20Survey_Results.pdf
GIS Development: The Geospatial Resource Portal	GIS Tutorials	http://www.gisdevelopment.net/tutorials/
Institute for Advanced Education in Geospatial Sciences	IAEGS Curriculum	http://geoworkforce.olemiss.edu/courses.php
Institution of Civil Engineering Surveyors	Photogrammetry and Remote Sensing	http://www.ices.org.uk/pdf/GE%20Photogrammetry%20&%20Remote%20Sensing.pdf
Kansas State Board of Technical Professions	Land Surveying Curriculum	http://www.kansas.gov/ksbtp/LS%20Curriculum%20Approved%20Dec%208%202006.pdf
Mohave Country, Arizona	Geographical Information System (GIS) Technician job description	http://legacy.co.mohave.az.us/depts/hr/job_desc/GIS%20Technician.pdf
Mondello, C., G.F. Hepner, and R.A. Williamson (2004)	10-Year Industry Forecast prepared for American Society for Photogrammetry and Remote Sensing	http://www.asprs.org/news/forecast/
National Academy of Sciences, National Research Council	National Science Education Standards	http://www.nap.edu/readingroom/books/nses/
National Association of State Directors of Career Technical Education	Career Cluster Resources for Science, Technology, Engineering, and Math	http://careerclusters.org/resources/ClusterDocuments/stemdocuments/STEMFinal.pdf
National Association of State Directors of Career Technical Education (NASDCTE)	Science, Technology, Engineering, and Math Career Lattice	http://careerclusters.org/resources/ClusterDocuments/stemdocuments/1STEMModel.pdf
National Center for Geographic Information & Analysis	NCGIA Core Curricula	http://www.ncgia.ucsb.edu/pubs/core.html
National Center for Geographic Information and Analysis	Core Curriculum in GIS Science	http://www.ncgia.ucsb.edu/giscc/
National Center for Geographic Information and Analysis	GIS Core Curriculum for Technical Programs	http://www.ncgia.ucsb.edu/cctp/
National Council for Geographic Education	The Eighteen National Geography Standards	http://www.ncge.org/i4a/pages/index.cfm?pageid=3314
National Council of Examiners for Engineering	Model Law	http://www.ncees.org/About_NCEES/Publications/Publications/Model_Law.php

and Surveying		
National Council of Examiners for Engineering and Surveying	Model Rules	http://www.ncees.org/About_NCEES/Publications/Publications/Model_Rules.php
National Geodetic Survey	OPUS	http://www.ngs.noaa.gov/OPUS/
National Geospatial Technology Center	Meta-DACUM Job/Occupation Analysis for GIS & Remote Sensing	http://www.geotechcenter.org/uploads/2/4/8/8/24886299/metadacum_gis_rs_june_2014.pdf
National Park Service	Job Titles for Information Management	http://home.nps.gov/applications/hafe/training/careers2.cfm?Career_code=inf
National Science Foundation	Integrating GIS and Remote Sensing for Technical Workforce Training at Two-Year Colleges - Geospatial Education Workshop	http://esdepo.gsfc.nasa.gov/docs/files/2005_Geospatial_Education_Workshop.pdf
National Society of Professional Surveyors	Certified Survey Technician	http://www.nspsmo.org/index.cfm?fuseaction=Page.viewPage&pageId=527
New Hampshire Space Grant Consortium	Careers in Geospatial Technology	http://www.geospatialcareers.net/
Occupational Outlook Quarterly	Geography Jobs	http://www.bls.gov/opub/ooq/2005/spring/art01.pdf
Office of Apprenticeship, U.S. Department of Labor	Geospatial Specialist	http://www.doleta.gov/OA/bul05/Bulletin%202005-08%20Occ%20(lms)-Occ-Geospatial%20Specialist.pdf
Office of Apprenticeship, U.S. Department of Labor	Still Photographic Specialist	http://www.careeronestop.org/competencymodel//modelFiles/Still%20Photographic%20Specialist.pdf
O*NET OnLine	Summary Report: Cartographers and Photogrammetrists	http://online.onetcenter.org/link/summary/17-1021.00
O*NET OnLine	Summary Report: Geodetic Surveyors	http://online.onetcenter.org/link/summary/17-1022.01
O*NET OnLine	Summary Report: Geographers	http://online.onetcenter.org/link/summary/19-3092.00
O*NET OnLine	Summary Report: Geospatial Information Scientists and Technologists	http://online.onetcenter.org/link/summary/15-1099.06
O*NET OnLine	Summary Report: Geographic Information Systems Technicians	http://online.onetcenter.org/link/summary/15-1099.07
O*NET OnLine	Summary Report: Mapping Technicians	http://online.onetcenter.org/link/summary/17-3031.02
O*NET OnLine	Summary Report: Precision Agriculture Technicians	http://online.onetcenter.org/link/summary/19-4099.02
O*NET OnLine	Summary Report: Remote Sensing Scientists and Technologists	http://online.onetcenter.org/link/summary/19-2099.01
O*NET OnLine	Summary Report: Remote Sensing Technicians	http://online.onetcenter.org/link/summary/19-4099.03
O*NET OnLine	Summary Report: Surveyors	http://online.onetcenter.org/link/summary/17-1022.00
O*NET OnLine	Summary Report: Surveying Technicians	http://online.onetcenter.org/link/summary/17-3031.01
Oregon Department of Forestry	GIS Skill Development: Strategies to develop competencies	http://www.odf.state.or.us/gis/arc/tasks/6/20070504_GIS_skill_development_Final.doc
Pennsylvania State University	Fundamentals in Land Surveying Exam	http://surveying.wb.psu.edu/psu-surv/LSIT.htm

Solem, M., I. Cheung, and M.B. Schlemper (2008)	Skills in Professional Geography: An Assessment of Workforce Needs and Expectations.	*The Professional Geographer* 60:3, pp. 356-373.
Southwest Missouri State University	Internet Mapping Curriculum to Produce Educated and Skilled Internet Cartographers	http://lazarus.elte.hu/cet/madrid-2005/cammack.pdf
State of Montana	Cartographer Role	http://mt.gov/REVENUE/abouttheagency/Roles/PAD/Cartographer_Role.pdf
State of Oregon	Cartographer 3 Job Description	http://egov.oregon.gov/DAS/HR/class/ccrt/spec/3118.pdf
Sullivan, D., T. Brase and A.B. Johnson (Eds)	A Plan for the National Coordination of Geospatial Technology Education from a Community College Perspective	National Science Foundation, 25-30.
Texas Skill Standards Board	GIS Technician Skill Standards	http://www.tssb.org/wwwpages/repos/rationale/gis.htm
Town of Jupiter, Florida	GIS Manager Job Classification	http://www.jupiter.fl.us/HumanResources/upload/GIS%20Manager.pdf
Town of Jupiter, Florida	GIS Technician Job Classification	http://www.jupiter.fl.us/HumanResources/upload/GIS%20Tech.pdf
U.S. Geological Survey	Geographic Information Systems	http://erg.usgs.gov/isb/pubs/gis_poster/#what
United States Geospatial Intelligence Foundation	Geospatial Intelligence Certificate Program Accreditation	http://usgif.org/education/accreditation
University Consortium for Geographic Information Science	Geographic Information Science and Technology (GIS&T) Body of Knowledge	
University of Colorado	Notes and Study Materials for GIS and the Geographer's Craft	http://www.colorado.edu/geography/gcraft/notes/notes.html
Virginia Jobs	Career Guide for Photogrammetrist	http://jobs.state.va.us/careerguides/Photogrammetrist.htm
Virginia Jobs	Career Guide for Cartographer and Photogrammetrist	http://jobs.state.va.us/careerguides/Cartographer.htm
Virginia's CTE Resource Center	Competency List for Geospatial Technology I	http://www.cteresource.org/verso2/framework/tasklist/technology_education/geospatial_technology_i/2009/8423
Virginia's CTE Resource Center	Competency List for Geospatial Technology II	http://www.cteresource.org/verso2/framework/tasklist/technology_education/geospatial_technology_ii/2009/8424
Workplace Learning and Performance Institute - University of Southern Mississippi	Geospatial Technology Apprenticeship Program	http://www.usm.edu/wlpi/research/gtap.html