# Building the Geospatial Workforce

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***Abstract:*** *In response to an increase in the number of skilled workers needed to sustain the geospatial workplace, the Geospatial Workforce Development Center developed the Geospatial Technology Competency Model that identifies the roles, competencies, and outputs for the geospatial technology industry. A rigorous research methodology was utilized to develop a competency model that integrates the technical, business, analytical, and interpersonal skills required for the geospatial marketplace. Organizations can use the Geospatial Technology Competency Model to describe the kinds of workers needed in the geospatial information technology industry, improve employee recruitment and selection, manage the performance of existing employees, and design geospatial information technology training and education programs.*

## Introduction

The worldwide market for geospatial technologies has enormous market potential. Currently estimated at $5 billion, the market is projected to have annual revenues of $30 billion by 2005 (remote sensing market: $20 billion; geographic information services market: $10 billion). In the mapping market alone, worldwide annual revenues for satellite and aerial data products are estimated to increase from $2.2 to $4.2 billion over the next 5 years. High-resolution satellite imagery product revenues are estimated to increase from $1.4 to $3.8 billion in the same period. In the United States, remote sensing industry annual revenues are projected to increase steadily from the 1992 benchmark of $0.75 billion to $4 billion by 2005 (National Aeronautics and Space Administration (NASA) 2001).

As an emerging growth industry, there is a serious shortfall of professionals and trained specialists who can utilize geospatial technologies in their jobs. The growth of this market demands support of the education, training, and development of geospatial professionals and specialists. A strategy is required to meet the challenge of providing a well-trained workforce while at the same time perpetuating an expanding market of persons trained, familiar, and ready to apply geospatial technologies when solving workplace and societal challenges.

The Office of Education and the Earth Science Applications Directorate (formerly the Commercial Remote Sensing Program) at the NASA John C. Stennis Space Center implemented the National Workforce Development Education and Training Initiative (NWDETI) in an effort to develop a well-trained geospatial workforce. The Geospatial Workforce Development Center (GeoWDC) at The University of Southern Mississippi is part of this initiative. NWDETI is a customer-focused effort to meet workforce demands for the emerging multi-billion dollar geospatial industry and to help the U.S. maintain its global leadership in geospatial technologies.

## The Geospatial Workforce

With increased market potential comes an increased need for a systematic approach to developing a workforce to support industry growth. The workforce planning process must be a customer-driven process that determines workforce needs and provides the foundation for appropriate training and education opportunities.

Concurrent with the growth and development of the geospatial industry is an increased research interest in geospatial workforce training and development. For example, the Urban and Regional Information Systems Association (URISA) has led an effort to create and implement geographic information system (GIS) certification with the goal of establishing workplace standards for the GIS industry (http://www.urisa.org). Other organizations such as the Association for Geographic Information (http://www.agi.org) have been actively involved in conducting job and task analyses to create a set of skill profiles for GIS positions in the U.S. and the United Kingdom. The University Consortium of Geographic Information Science (http://www.ucgis.org) has focused efforts on the academic preparation of GIS professionals by developing a model curriculum. Current activities related to professional certification in GIS are documented and available at http://institute.redlands.edu/users/kemp/certification/. The American Society for Photogrammetry and Remote Sensing (http://www.asprs.org) has also been involved with developing a remote sensing core curriculum.

Efforts to understand the geospatial industry needs and academic preparation requirements have not gone without some debate. Certification, accreditation, and licensure – each with a different purpose and focus – have struggled for definition within the geospatial profession (Huxhold 1991, Goodchild and Kemp 1992, Obermeyer 1993). In fact, the categorization of GIS as a profession with standards is part of the debate. Academic programs supporting GIS education, according to Wikle (1999), vary in the structure, duration, sponsorship, and intended student population.

Given the lack of agreement on GIS as a profession, the most appropriate academic program to prepare those who would work in this "profession," and the absence of recognized standards or industry certification, it is no surprise that organizations equipped with increased geospatial technology capabilities for decision support are questioning the kind of people to hire. The scope of this study is to better understand the work being done by geospatial technology professionals and the work roles they perform in their organizations.

While the authors acknowledge and understand the continuing challenges related to the development of educational responses to these issues of debate, the purpose of this research is to focus on the work needs as they exist in the geospatial industry and how a market-driven approach can better assist in the workforce planning process. One such process is the use of a competency model because it provides a more comprehensive and flexible approach to identify those workforce competencies required by the geospatial profession.

## Competency Models

The roots of competency models date back more than 20 years, and represent a process that was popularized by the late psychologist, David McClelland. According to Briscoe and Hall (1999), the major approaches to developing a competency framework are accomplished using a research-based, strategy-based, or a values-based approach. The recent resurgence in applying competency models helps organizations and whole industries focus on what is needed to succeed in today's workplace.

Perhaps part of the renewed interest in competency models is the shift in workforce development from a focus on workplace activity to workplace results. Organizations need a framework for workforce development to help them achieve the results needed for success. Creating a workforce development plan requires an analysis of the work that is required. With the changing nature of jobs and work, the concept of a "job" is becoming obsolete. In many high-technology industries, cross-functional project teams are common and employees shift from project to project throughout the year. Even the job of managers changes in such situations, for they must serve their project teams as facilitators, gatherers of resources, and removers of roadblocks (Mathis and Jackson 2000). What has become apparent, given the cross-functional nature of work and the speed with which technology changes work tasks and responsibilities, is a more flexible technique for approaching workforce development. Traditional job and task analyses are not flexible and often become obsolete by the time they are complete.

Today's fast-changing workplace requires that the basis for recruiting, selecting, and compensating individuals is their competence and skills, rather than a job title. The best approach to develop a workforce is to focus less on specific tasks and duties and more on identifying work-related competencies. Competencies can be described as "behaviors that distinguish effective performers from ineffective ones" (Dalton 1997:48), can include motives, beliefs, and values (Mirabile 1997), and are generally representative of the tasks and activities used to accomplish a specific job (McLagan 1996). Groups of competencies typically include knowledge, skills, abilities, or characteristics associated with high performance on the job. Knowledge is the understanding needed for a particular subject or process, while the skills would include both the technical and nontechnical requirements to accomplish a task. Abilities are those appropriate on-the-job behaviors needed to bring both knowledge and skills to bear (LeBleu and Sobkowiak 1995).

When competencies are identified, they should be organized and presented in a meaningful way for use by employees, hiring organizations, and curricula developers. The resulting framework of competencies is a competency model. The term "competency model" refers to the knowledge, skills, and abilities identified for successful performance for a particular organization or industry. Pat McLagan defines competency model as "a decision tool that describes the key capabilities for performing a specific job (1980: 23)."

A competency model is a set of success factors, often called competencies, that include the key behaviors required for excellent performance in a particular role. Excellent performers on-the-job demonstrate these behaviors much more consistently than average or poor performers. These characteristics include key behaviors that drive excellent performance. These characteristics are generally presented with a definition and key behavioral indicators. (Sanchez 2000:510)

"The construction of a competency model calls for the correct identification of the critical competencies required for effective performance (Ingalls 1979:32)." In order to achieve "correct identification," the designer of the model must conduct extensive research into the company or industry concerned with workforce development. Role experts—individuals who function in specific areas of expertise in their job—must be interviewed. A common mistake during the design process is that management, without input from role experts—makes decisions about the skills necessary to perform a certain job. "Building a so-called competency model based solely on the beliefs and opinions of a group of people, albeit powerful people, makes it a useless exercise (Dalton 1997:48)." The "useless exercise" yields an "ideal"—and often impractical—model rather than a model displaying the expected outcomes. Role experts provide input so that the expected model lends itself to flexibility. The model looks to the future rather than just the present, and the model is not specific to the job. Because of the focus on competencies instead of job titles or job descriptions, the model can grow and develop with the changing needs of the organization or industry.

## Competency Model Benefits

Competency modeling is an attempt to describe work and jobs in a broader, more comprehensive way (Zemke and Zemke 2000). Competency-based performance models yield a common language across positions within an industry. It is the best approach when creating a performance management system, and it enables workforce development professionals to identify core capabilities required of any employee in any position across an entire organization or industry (Gilley and Maycunich 2000). Robinson and Robinson (1996) encourage the use of a performance model when describing "should" performance for a specific position or job cluster.

In addition to performance management benefits, results from competency models can be easily translated into training curricula. While training programs based on work-oriented task analysis can become dated as work undergoes dynamic change, training programs based on competency assessment are more flexible and perhaps have more durability (Bohlander et al. 2001).

The Geospatial Technology Competency Model (GTCM) developed at The University of Southern Mississippi most importantly provides a way to articulate the kinds of workers needed in the industry. The GTCM provides a research-based set of competencies for hiring organizations to use to improve employee recruitment and selection and to create competency-based performance management systems to help professionally develop existing employees in the industry. Finally, the GTCM offers a research framework for training providers and academic institutions to use for creating the most effective and efficient training and education opportunities.

## Research Methodology

The methodology for the study was conducted in several major research phases designed to systematically analyze and validate geospatial technology workforce requirements.

### Phase One

The first phase was to review current literature and identify existing skills and standards for related roles, competencies, and outputs for the geospatial industry. This phase is consistent with Lucia and Lepsinger (1999), wherein researchers seek to build on and validate existing competencies. Additionally, this phase sought to identify existing geospatial stakeholder organizations in order to create a task force of geospatial technology experts. Through an iterative process, this task force provided input and feedback for a preliminary list of geospatial competencies derived from an extensive literature review.

### Phase Two

Subsequent to the creation of a preliminary list of competencies, the second phase of the research methodology was initiated, consistent with McLagan and Suhadolnik (1989) methodology to involve industry stakeholders. For Phase Two, individuals were identified to participate in focus group sessions designed to bring together active participants in the geospatial industry from public and private organizations both large and small, trade and professional associations, and educational institutions. Collectively, focus group participants represented more than two hundred years of geospatial technology expertise and experience brought to the table for each focus group session. These diverse stakeholders were charged with defining and reaching consensus for a baseline definition of the geospatial industry and determining present and future workforce needs for the industry. In addition, focus group participants were asked to identify geospatial work roles and to review international geospatial workforce standards. For a detailed listing of all focus group participants, see the Workforce Development Models for Geospatial Technology report, accessible on the GeoWDC Web site http://www.geowdc.usm.edu.

### Phase Three

A first draft of the GTCM was the result of the third phase of the research methodology. For this phase, focus group participants who are considered industry stakeholders utilized a group decision support system made available by the NASA John C. Stennis Space Center. The focus group activities centered on (a) validating the roles and role definitions created in the second phase, (b) identifying the products and services provided by geospatial technology professionals and the quality requirements associated with each, (c) identifying ethical challenges and future forces for the geospatial technology workforce, and (d) defining the required workplace competencies for each work role.

In order for the GTCM to have meaning and relevance for those who will ultimately use the model, industry stakeholders were involved from the beginning to help guide competency model development. The early participation gave members of the geospatial community the opportunity to review the scope of the study, revise role definitions and outputs, and revise preliminary competency menus. This effort helped structure activities for focus group participants who were considered industry stakeholders. Representatives from the following organizations participated in focus group sessions for this study:

- American Society for Photogrammetry and Remote Sensing
- Environmental Protection Agency
- Environmental Systems Research Institute
- Federal Emergency and Management Agency
- Geospatial Information Technologies Association
- Global Initiatives, Inc.
- Louisiana Department of Environmental Quality
- Mississippi State University
- National State Geographic Information Council
- Pennsylvania Department of Military and Veterans Affairs
- Spatial Technologies Industry Association
- University Consortium for Geographic Information Science
- Urban and Regional Information Systems Association
- U.S. Department of Interior, United States Geological Survey (USGS), Earth Resources Observation Systems (EROS) Data Center
- U.S. Department of Labor
- U.S. Naval Oceanographic Office

Focus group data were analyzed and interpreted, resulting in the preliminary draft of the competency model. Additionally, Phase Three provided a quantified matrix of the work roles, role definitions, outputs for each role, quality requirements for each output, ethical challenges for each role, and future forces for the geospatial industry.

### Phase Four

Using the matrix developed above, Phase Four research activities included the development of survey questionnaires for each role and validation of the preliminary competency model by exemplars or top performers for each role. According to McLagan (1997), the use of role experts is a generally accepted way to have job experts pool their experience and expertise to define work and competencies. Phase Four allowed role experts the opportunity to validate the geospatial roles, competencies, outputs, and quality requirements defined by industry stakeholders in previous focus group sessions.

Since the deliverables (outputs) for each role are unique, separate questionnaires were required for each of the 12 geospatial technology work roles. Face-to-face interviews were conducted with role experts, or exemplars, currently working in the geospatial industry. Employees from more than 28 companies in 15 major cities across the U.S. participated as role experts. Of the 119 role experts interviewed, 67 (56%) were from the private sector and 46 (39%) represented public organizations. In addition, the researchers sought to balance Fortune 500 with small business organizations, and to include role experts working with a variety of end-user applications.

It should be noted that the research methodology did not use a random sample of geospatial technology professionals. Instead, competency modeling methodology requires a purposeful sample of qualified respondents who meet exemplar criteria. Furthermore, to ensure the integrity of the role expert data collection process, face-to-face questionnaire administration was used instead of traditional survey data collection techniques (i.e., mail, online, or phone interviews).

When presented with the preliminary list of competencies, 119 role experts in Phase Four were asked to identify the level of importance and the level of expertise for each competency required in their work role. The following scale was used to rank the importance of competencies:

0 – insignificant
1 – minimal importance
2 – moderate importance
3 – somewhat important
4 – very important
5 – critical

In addition, role experts were presented with checklists to validate the outputs and quality requirements that best demonstrate excellent performance for the role in which they had been identified as an exemplar. McLagan and Suhadolnik (1989) criteria were used to interpret the data for the final competency model. Data analysis required that at least 75% of the role experts for an individual role agree that the quality requirements were appropriate for a specific output. Data collected from these face-to-face role expert interviews were tabulated and analyzed using SPSS to create the final model.

## Results

### Industry Definition

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.

Consensus was reached among focus group participants for the following industry definition:

> Geospatial technology 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.

### Geospatial Roles and Role Definitions

The heart and soul of the Geospatial Technology Competency Model are the roles, competencies, and outputs for geospatial work. "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. An "output" is a product or service that an employee or group of employees delivers to customers, clients, colleagues, or coworkers.

As shown below in Table 1, 12 distinct work roles were identified by focus groups for the geospatial technology industry.

### Outputs (Deliverables) and Quality Requirements

In addition to the 12 geospatial technology roles defined by focus group members, 138 key products or services (outputs) were identified that are a result of performing the day-to-day activities in a particular role. Also generated was a list of quality requirements necessary to produce an excellent product or service. In other words, how will one recognize that a deliverable (output) is excellent? Role experts validated outputs and quality requirements during face-to-face interviews.

An example of an output identified in the role of "Data Acquisition" is metadata. The quality requirements for metadata identified by focus groups and validated by role experts are that metadata: ensures correct attribution, is created in a format that is compliant with company/customer policy, is comprehensive, is accurate, is in a correct/consistent format, and is compliant with

| TABLE 1<br>Geospatial Technology Role Definitions | |
|---|---|
| Applications Development | Identify and develop tools and instruments to satisfy customer needs |
| Data Acquisition | Collect geospatial and related data |
| Coordination | Interorganizational facilitation and communication |
| Data Analysis and Interpretation | Process data and extract information to create products, drive conclusions, and inform decision-making reports |
| Data Management | Catalog, archive, retrieve, and distribute geospatial data |
| Management | Efficiently and effectively apply the company's mission using financial, technical, and intellectual skills and resources to optimize the end products |
| Marketing | Identify customer requirements and needs, and effectively communicate those needs and requirements to the organization, as well as promote geospatial solutions |
| Project Management | Effectively oversee activity requirements to produce the desired outcomes on time and within budget |
| Systems Analysis | Assess requirements for system capacities including inputs, outputs, processes, timing, and performance, as well as recommend necessary additions or adaptations |
| Systems Management | Integrate resources and develop additional resources to support spatial and temporal user requirements |
| Training | Analyze, design, and develop instructional and non-instructional interventions to provide transfer of knowledge and evaluation for performance improvement |
| Visualization | Render data and information into visual geospatial representations |

standards. For a listing of all outputs and quality requirements by role, see the Role Profiles section of the Workforce Development Models for Geospatial Technology accessible on the GeoWDC Web site http://www.geowdc.usm.edu.

## Competencies

Data analysis and interpretation yielded 39 geospatial technology competencies as depicted in Table 2 below. These competencies are the key areas of knowledge and skill that enable individuals to perform geospatial technology work or to produce the outputs or key deliverables for their jobs.

For a competency to be defined as important for a specific role, a mean rating of at least 3.5 on the importance scale or a 4.0 mean rating by at least 50% of the role experts responding for a single role was required. When interpreting responses from all role experts combined, 15 competencies yielded a mean rating of at least 3.5 on the importance scale. These 15 core competencies determined to be critical for the overall geospatial technology industry are shown in Table 3 in bold print.

Geospatial technology competencies were organized into four categories: technical, business, analytical, and interpersonal (Table 3). For geospatial technology professionals to be successful in today's marketplace, it is critical to understand that the knowledge, skills, and abilities required for their jobs include a blend of technical, business, analytical, and interpersonal competencies. Not surprisingly, geospatial technology professionals do not operate in a technical vacuum. They are required to demonstrate competencies in all four categories depending upon the roles they occupy. This blend of technical and non-technical workforce requirements is not unique to this industry, but this blend is too often overlooked during the workforce planning process.

The final table shown (Table 4) is the Geospatial Technology Competency Model that identifies competencies in four categories required for the 12 geospatial technology roles. This matrix is a big picture view of the knowledge, skills, and abilities needed in the geospatial marketplace. For a breakdown of the competencies by role, including the level of expertise required for each competency by role, visit the profiles section of the previously cited report accessible at http://www.geowdc.usm.edu.

## Conclusion

This article describes the methodologically rigorous approach used to develop the Geospatial Technology Competency Model. The Competency Model approach provided the best framework for defining the workforce requirements for the geospatial marketplace. However, no study is without limitations. First, the authors recognize that industries are not static, and this is particularly true

| TABLE 2<br>GEOSPATIAL TECHNOLOGY COMPETENCY DEFINITIONS |
|---|
| **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 |
| **Ability to See the "Big Picture"** – identifying trends and patterns that are outside a normal paradigm of the organization sources |
| **Business Understanding** – demonstrating awareness of the inner workings of business functions and how business decisions affect financial or non-financial work results |
| **Buy-in/Advocacy** – building ownership or support for change among affected individuals, groups, and other stakeholders |
| **Cartography** – organizing and communicating geographically related information in either graphic or digital form |
| **Change Management** – helping people adapt to the changes brought on by new technologies and helping them to see the value and benefits of new technologies |
| **Coaching** – helping individuals recognize and understand personal needs, values, problems, alternatives, and goals |
| **Communication** – applying effective verbal, nonverbal, and written communication methods to achieve desired results |
| **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 |
| **Conflict Management** – helping people work together to resolve disputes through constructive processes and techniques |
| **Cost Benefit Analysis/Return on Investment (ROI)** – understanding the relative costs of each geospatial technology, or combination of geospatial technologies and assuring that the organization is receiving a good value for the dollars spent on these technologies |
| **Creative Thinking** – recognizing, exploring, and using a broad range of ideas and practices; thinking logically and creatively without undue influence from personal biases |
| **Environmental Applications** – applying GIS technologies for environmental assessment or management purposes |
| **Ethics Modeling** – modeling exemplary ethical behavior and understanding the implications of this responsibility. |
| **Feedback Skills** – communicating information, opinions, observations, and conclusions so that they are understood and can be acted upon |
| **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 |
| **Group Process Understanding** – understanding how groups function; influencing people so that group, work, and individual needs are addressed |
| **Industry Understanding** – demonstrating awareness of the vision, strategy, goals, and culture of the geospatial technology industry |

*Table 2 continued*

| |
|---|
| **Knowledge Management** – the efforts to systematically find, organize, and make available a company's intellectual capital and to foster a culture of continuous learning and knowledge sharing so that organizational activities build on existing knowledge |
| **Leadership Skills** – influencing process of leaders and followers to achieve organizational objectives through change |
| **Legal Understanding** – ability to understand legal issues affecting the application of geospatial information technology |
| **Model Building Skills** – conceptualizing and developing theoretical and practical frameworks that describe complex ideas in understandable, usable ways |
| **Organization Understanding** – seeing organizations as dynamic, political, economic, and social systems that have multiple goals; using this larger perspective as a framework for understanding and influencing events and change that can impact implementation and support of geospatial technologies |
| **Performance Analysis and Evaluation** – the process of comparing actual and ideal performance in order to identify performance gaps or opportunities |
| **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 |
| **Problem-Solving Skills** – the ability to consider alternative courses of action and select and implement appropriate solutions |
| **Questioning** – gathering information from stimulating insight in individuals and groups through use of interview, questionnaires, and other probing methods |
| **Relationship Building Skills** – establishing relationships and networks across a broad range of people and groups |
| **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 |
| **Research Skill** – selecting, developing, and using methodologies such as statistical and data collection techniques for formal inquiry |
| **Self-Knowledge / Self-Management** – knowing one's personal values, needs, interests, style, and competencies and being able to manage their effects on others |
| **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 |
| **Systems Thinking** – identifying inputs, throughputs, and outputs of a subsystem, system, or suprasystem and apply that information to improve the application of geospatial technologies; realizing the implications of geospatial technology or many parts of an organization, process, or individual; taking steps to address the impact of applying these technologies |
| **Technical Writing** – the ability to "translate" technical information to nonspecialists |
| **Technological Literacy** – understanding and appropriately applying existing, new, or emerging technologies |
| **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 |
| **Visioning** – seeing the possibilities of "what can be" and inspiring a shared sense of purpose within the organization |

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

| | |
|---|---|
| <u>**Technical Competencies**</u><br>**Ability to Assess Relationships Among Geospatial Technologies**<br>Cartography<br>Computer Programming Skills<br>Environmental Applications<br>**GIS Theory and Applications**<br>Geology Applications<br>Geospatial Data Processing Tools<br>Photogrammetry<br>Remote Sensing Theory and Applications<br>Spatial Information Processing<br>**Technical Writing**<br>**Technological Literacy**<br>Topology | <u>**Business Competencies**</u><br>**Ability to See the "Big Picture"**<br>Business Understanding<br>Buy-in/Advocacy<br>**Change Management**<br>**Cost Benefit Analysis/ROI**<br>Ethics Modeling<br>Industry Understanding<br>Legal Understanding<br>Organization Understanding<br>Performance Analysis and Evaluation<br>**Visioning** |
| <u>**Analytical Competencies**</u><br>**Creative Thinking**<br>Knowledge Management:<br>Model Building Skills<br>**Problem-Solving Skills**<br>Research Skill<br>Systems Thinking | <u>**Interpersonal Competencies**</u><br>Coaching<br>**Communication**<br>Conflict Management:<br>**Feedback Skills**<br>Group Process Understanding<br>**Leadership Skills**<br>Questioning<br>**Relationship Building Skills**<br>**Self-Knowledge/Self-Management** |

for the geospatial industry. The competency model provides a baseline from which to build as the industry continues to evolve. One criticism of competency assessments is how accurate and comprehensive they are no matter how carefully developed. Inevitably, there were intangible and unmeasured components of every role required that were not captured. Those familiar only with traditional job and task analyses and unfamiliar with using competency-based performance approaches will more than likely misunderstand the intent and purpose of the Competency Model if time and effort is not made to understand workforce planning processes. Finally, the breadth and depth of end-user applications for geospatial technologies continues to expand. While the researchers developed an intentional focus on a limited number of end-user applications–albeit the most widely used applications at the time–there are now 12 defined federal applications for geospatial technologies (http://esnetwork.org) that would provide a more comprehensive framework for study.

The participation from industry, governmental, and educational community representatives was key to this research initiative. These partnerships are consistent with NASA's commitment to create a customer/industry driven model and to utilize existing resources to create systemic change in the way students and the incumbent workforce are trained and retrained.

Current efforts are underway to make an online tool available as a self-assessment to determine an individual's key role of interest or practice for the geospatial industry. The results of the assessment will provide a framework for an individual's career development. An additional use of the tool is to help human resource managers find and retain geospatial professionals. The GTCM online assessment tool will be available at http://geowdc.info. Researchers are also developing partnerships with other federal agencies to integrate the GTCM with the existing workforce development infrastructure. The value of the Geospatial Technology Competency Model will ultimately be measured by its implementation as a tool for performance management, employee recruitment and selection, career development, and as a curriculum framework for training and education.

**Table 4**
**Geospatial Technology Competency Model©**

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

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