The National Center of Excellence for Geospatial Technology (GeoTech Center) is a National Science Foundation funded project to support geospatial education at USA Community Colleges. One of the objectives and motto of GeoTech is to empower community colleges to expand the geospatial workforce. To meet this objective, GeoTech developed a process to identify the skills and competencies industry needs students to possess for entry level geospatial occupations and create curriculum guidelines based on those competencies.

This document gives an overview of the history of developing geospatial industry aligned competencies. It provides the methodology created to identify and use the industry defined competencies to build a model course and certificate. It also includes where to find the Tools and Models, how they have been used to create curriculum and lists some planned future work by the GeoTech Center.
In the last few decades geospatial technology has evolved from focused projects carried out on mainframe computers using command line to Cloud computing bringing visualizations and analysis of various topics through a web browser to cell phones, tablets and Desktop. All of these do have something in common – a database that allows users to analyze and visualize data geospatially. Creating that database and defining the methods and process to carry out a valid analysis requires specific skills and competencies. Different professions utilizing geospatial technology or individuals becoming specialists in that field need to have specific knowledge in order to carry out and produce valid outcomes and visualizations.
GeoTech needed to identify what skills and competencies are needed by the geospatial industry. What method could be used to effectively determine industry needs? Once the needs were defined, how could a curriculum be designed to meet those needs within the structure of a community college?

Our first task in this process was to review what had been done related to industry needs and find any resources that existed to help us reach our objectives.
There has been a long history of efforts to define the competencies needed by professionals in the geospatial field and even to question if there was a **geospatial industry or profession**. A detailed discussion is beyond the scope of the presentation, but can be found in *Geographic Information Science & Technology Body of Knowledge* (DiBiase, D., DeMers, M, Johnson, A., Kemp, K., Luck, Ann, Plewe, B and Wentz, L., 2006). Many other academic, industry and professional organizations including GISCI, URISA and ASPRS have also contributed to the effort.

One effort was funded by the USA Dept. of Labor (DOL) to GITA, AAG and Wharton Business School focused on defining the industry and its workforce skills and competency needs. The DOL posted a draft Geospatial Technology Competency Model (GTCM) in its Competency Clearinghouse, but reaching a consensus and finalizing the GTCM was not easy. Part of the difficulty came from the fact that many **different application areas** use geospatial technology and each of the application areas are aligned with different professional organizations – each of which have different viewpoints as to what competencies should be included in a GTCM.
Early work by the University of Southern Mississippi as part of its Workforce Development grant supported by funding from NASA laid the groundwork to define roles and duties for the geospatial workforce. It defined four Skill Areas that not only included the technical geospatial competencies, but stressed that the workforce was seeking people who could also think critically, problem solve, communicate effectively, work in teams and understand basic business competencies and also had “domain” competencies for different applications of GIS&T.
The GIS&T Body of Knowledge (BoK) was a big step forward and was meant to represent the Domain of Geographic Information Science and Technology and not define what anyone should know about GIS&T. Created by the University Consortium for Geographic Information Science (UCGIS) and published in 2006, it is very academic in focus with over 1,660 educational objectives in 10 Knowledge Areas. It was focused on GIScience and intentionally did not include topics on remote sensing, GPS/GNSS or computer science. It is still a very useful document and can now be downloaded from the Association of American Geographers at http://www.aag.org/galleries/publications-files/GIST_Body_of_Knowledge.pdf. UCGIS is currently working on a version 2.0 for the BoK and is seeking input from all interested stakeholders. The current work is under the direction of John Wilson from the University of Southern California.
The GeoTech Center Team and its National Advisory Committee (NAC) included several individuals that had been active in many of the organizations to help define the profession, the industry and the Body of Knowledge associated with Geospatial Science and Technology. The Chair of the NAC, Deidre Sullivan, recommended in 2009 that the GeoTech Center contact the Dept. of Labor and volunteer to help finalize the GTCM. This offer was accepted.

The U.S. Department of Labor Employment and Training Initiative was looking at ways to support important workforce domains in high impact occupations. It created a “structure” to help define the skills and competencies needed by the workforce. This interactive pyramid of Building Blocks includes those foundational and interpersonal skills in tiers that become more occupation specific as you go from the bottom to the top of the pyramid. The GTCM was in Draft form when the GeoTech Center was initially funded.

GeoTech, under the direction of David DiBiase, convened a panel of industry experts that proposed a revised GTCM. The revised GTCM was published and the public was encouraged to make comments and recommendations. The public input (including industry and academic experts) was incorporated into the GTCM and submitted to the DOL. The final version of the GTCM was approved by the DOL in July 2010. A more detailed discussion of the process is included in the Journal of the Urban and Regional Information Systems Association (URISA) Special GIS Education Issue in an article entitled *The New Geospatial Technology Competency Model: Bringing Workforce Needs into Focus* (DiBiase, D., Corbin, T., Fox, T., Francica, J., Green, K., Jackson, J., Jeffress, G., Jones, B., Mennis, J., Schuckman, K., Smith, C. and Van Sickle, J., Vol. 22, No. 2, 2010).

Starting at the bottom of the pyramid are foundational skills common to many industries. As you rise in the pyramid, the next Tiers focus on Academic and Workplace Competencies and finally the yellow Tiers are Geospatial Industry-Wide or Sector Competencies. The upper block of Tiers are “Occupationally” specific and were intentionally not completed by the panel. These upper occupation-specific Tiers are important for defining what would be in a curriculum designed to prepare students to work in specific workforce domains.

The GeoTech Center is funded by the NSF Advanced Technology Education Directorate (ATE). ATE grants must focus on preparing Technicians or those skills and competencies needed by entry level workers.
Here is the information about one “Block” on the Geospatial Technology competency Model. You can also go to this site and download a document that includes all of the links and more details about the competencies.
The DOL also created new Occupational Codes related to geospatial technology. The O’Net Online site (http://www.onetonline.org/) lists the new Occupational Codes and provides links to each occupation. Listed here are several “entry” level occupations – GIS Technician, GIS Technologist and Remote Sensing Technician. By clicking on the Occupation title, you can get more information related to that occupation including some skills and competencies.
This is the linking page for GIS Technicians. It is useful, but not very detailed or specific. It is not sufficient to define what should be included in a Geospatial Technology Certificate program to prepare students to enter that occupation.
The GeoTech Center found that the very general competencies from the Occupational Codes were not sufficiently defined to create a curriculum. The five lowest Tiers of the GTCM did not differentiate between those competencies needed for a specific Occupation. To remedy this, the GeoTech Center undertook additional work to determine just what the industry wanted an entry level geospatial worker to be able to do.
As part of this additional work, the GeoTech Center used a process called DACUM which stands for “Developing a Curriculum”. A DACUM is a facilitated activity where “expert workers” from that occupation are brought together for two intense days and guided by a facilitator to define what they do as part of their occupation. They also suggest knowledge areas, and other related needs to carry out the specific job classification tasks and duties. John Johnson, GeoTech’s DACUM Facilitator carried out several DACUMs for GIS Technician or Technologist and remote sensing level occupations across the USA. The outcome from a DACUM event is a two sided graphic listing the Tasks and Duties as well as the knowledge and abilities need for that occupation.
This is an example of a DACUM outcome from an event held at Gainesville State College. Many industries and educational institutions use this process to help build training and education programs. One weakness of a DACUM is that it may represent only the “local or regional” workforce at one point in time.
In order to overcome some of that limitation, John Johnson developed a meta-analysis process to incorporate outcomes from Multiple DACUMs held around the USA at different times. He then clustered 476 job tasks into 55 task categories. These tasks were then generalized under eight duty categories. The DACUMs also included knowledge, skills and behavior classes.
The results were then vetted with more than 475 industry experts in order to define those most common or important for entry level geospatial occupations. Details of this process are outlined by John Johnson in an article in the Special Education Issue of the Journal of the Urban and Regional Information Systems Association (URISA), entitled *What GIS Technicians do: A Synthesis of DACUM Job Analysis*. Vol. 22, No. 2, 2010.
The 475 competencies were grouped by Johnson under eight duty categories. Each competency includes a Verb and noun(s). Such as: Evaluate data sources. Since the expert workers described their tasks, some competencies were very similar with minor variations in language to describe them. Also new remote sensing DACUMs were done that added to the number of competencies. The redundant competencies were eliminated leaving approximately 320 competencies needed by entry level geospatial occupations.
### Methodology – How to Go From Lists to Curriculum?

- **Start with GTCM structure:**
  - 5 Tiers compiled by experts from Industry, vetted by workforce across nation and approved by Dept of Labor

- **Compile a MetaDACUM:**
  - Long lists of skills & competencies from “expert workers”

- **Compile Model Course Outlines:**
  - Expert Geospatial Educator Panels:
    - Take long “lists” of competencies and determined courses, descriptions and Student Learning Outcomes
    - Parse list of competencies by depth into model courses
    - Choose the courses that should be included in a Model Certificate program

Even with the GTCM, Occupational Codes and MetaDACUM, we were left with long lists of skills and competencies that are not easy to use to define what should be included in a particular course or how those courses could be combined to create a program that provided students with courses covering the needed competencies.

A process was then needed to parse those competencies into a logical set of courses that could constitute a Model Geospatial Certificate. Tools were also required to help track and review what competencies should be included in specific courses or to assess a current curriculum against the industry defined needs.
This is the Prototype Version 0.2 of the GTCM Worksheet initially developed by David DiBiase and refined by Chris Semerjian at Gainesville State College. This is an Excel Workbook with four worksheet tabs (Overview, Program Bio, Definitions, Assessment Worksheet) for institutions to use to assess how well their geospatial program aligns to workforce needs.
This early version of the Assessment Worksheet tab was used to review the Gainesville College geospatial program. It includes only the GTCM Tiers and competencies. The course numbers are on the right in this example and the graphic circles represent the depth of inclusion of each competency for that course at Gainesville based on a scale of 0 to 4 – with zero meaning that it was not included in the course.
Panels including approximately 15 educators were brought together in webinars to learn about the process and receive guidance in using the new Course Content tools. They each filled out the new Excel Worksheet Course Content Tool included an Assessment spreadsheet tab for a specific course. This tab listed the 320 plus competencies refined from the competencies in the MetaDACUM. Educators were asked to give each competency a value based on a scale of 0 to 4.
This is the scale and examples using Blooms key words and representative activities that was used to rank each competency using a ranking scale of 0 to 4 with 0 meaning it should not be included in the course, 1 at an awareness level and included only as a small part of a lecture or demo to a value of 4 where the student should have been exposed to the competency as a major topic that provides them with enough time to acquire the competency and use it independently.

<table>
<thead>
<tr>
<th>Value</th>
<th>Level of inclusion in course</th>
<th>Bloom’s Key Word Examples from 6 Levels*</th>
<th>Representative type of Presentation and/or Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>do not include</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Awareness</td>
<td>recognize, communicate</td>
<td>included as part of a lecture or demo</td>
</tr>
<tr>
<td>2</td>
<td>Comprehension</td>
<td>grasp meaning, interprets, comprehends</td>
<td>included as part of a lecture and as part of an activity</td>
</tr>
<tr>
<td>3</td>
<td>Application /Analysis</td>
<td>apply, calculate, demonstrate, employ, illustrate, interpret, relate, use</td>
<td>included as part of a major topic of a Module and applied in an activity</td>
</tr>
<tr>
<td>4</td>
<td>Synthesis Mastery</td>
<td>Compare, construct, contrast, design, develop, ...</td>
<td>included in depth as major topic of a Module with a significant activity to apply the skill or competency independently</td>
</tr>
</tbody>
</table>
Educators where also asked to provide titles of courses that might be included in a Model Geospatial Certificate. The GeoTech Center Team then wrote draft descriptions and Student learning outcomes for each of the proposed courses. These were the 10 initial courses identified by the expert geospatial educator panels.

The Geo 100 course was defined as a “stand alone” course that may or may not be included for credit in a Model Geospatial Certificate Program.

It should be stressed that this is a “model” and that course titles are suggestions only and other optional titles covering the same material should be localized to meet the needs of the program. Educators wishing to use the model should consult with their local geospatial user community to adapted the model to meet the needs of their community.

We started the process with two courses: the stand alone Awareness course and the first course in a Model Certificate, Introduction to Geospatial Technology.
Approximately 15 faculty were asked to fill in the depth value for each competency. This is an example of the rankings made by one of the educator panels for one of the courses.

The depth values from all the panel members were then added together and divided by the number of panel members. This provided an average score. The Variance (how similar or dissimilar the scores were) was calculated to aid in determining whether a competencies should be “In” or “Out” of a course. A face-to-face workshop of the panel was then held where they hotly debated the title of the course, the model course description, Student Learning Outcomes and the depth values for each skill and competencies. The outcome of this debate for the course and competency values were published after the event for public comment. The GeoTech partners used the outcomes and public comments to create a Draft Model Course Outline and Model Certificate based on a consensus reached by the educators.
The Draft Model Course Outlines were then reviewed at a workshop in May in Atlanta prior to the Spatial Plexus conference by approximately 30 faculty. Faculty reviewed each Draft Model and debated the Model Courses in the Certificate. The recommendations were reviewed and have been finalized by the GeoTech partners.

It should be noted that these Model Course Outlines and Model Geospatial Technology Certificate are still being updated as more than 200 educators have downloaded the documents and continue to make recommendations as they are used by educators from community colleges and universities. Updated Model Courses have been published on the Moodle Server of the GeoTech Center (http://moodle.delmar.edu).

The models have been used as the basis for creation of eLearning courses under development by the National Information Security & Geospatial Technology Consortium, a DOL funded project.

They have also been used to define a California Community College Model Course and Geospatial Certificate program which is explained in detail at the end of this presentation.
This is an Excel document containing all the values for the seven Model Courses – the program itself includes 8 courses – with the 8th course being an Internship course where students use their acquired skills in a workplace experience. It is available from the Moodle Server and the GeoTech Center website.

It should be noted that after the first two courses were reviewed, the Excel spreadsheet was updated with additional competencies identified by John Johnson for entry level remote sensing educators. The educators were then asked to rereview the first two courses to see if there were any changes needed.

In addition, the original eight categories were then regrouped under twelve Competency Clusters.
The original eight Duty Categories did not seem to help define the category for all of the skills and competencies. This led to the development of 12 Competency Clusters which may prove to be more useful in organizing competencies and creating curriculum.
A Knowledge Map was created to show the connections between different competency clusters. This is a draft concept and needs to be refined, but it is based on the concepts behind the Mathematics Knowledge Map at the Khan Academy (http://khanacademy.com/). This may help students see how concepts are related and enable educators to create resources to focus on specific competency clusters.
If you could then zoom in on a cluster such as Cross-Cutting, you could see how the competencies aligned with this cluster.
Zooming in more, you can see how Topology could be further broken down and if this was truly interactive, you could see a mini-lecture on each of the topics with additional resources available. While this is a concept, it would be useful for students and faculty in a flipped classroom format where students would learn about the competency via the resources connected to the competency and faculty could provide hands on use and discussion related to the topic.
Model Course Outline and Pack Contents

- **Example syllabus**
  - Description & Student Learning Outcomes
  - Course Learning Units & other resources
- **Course outline**
  - Aligned with course syllabus teaching units/SLOs
  - Resource List
- **Evaluation Rubrics**
- **Model Course Spreadsheet**
- **Curriculum for some courses**

Each of the model courses include a complete Example Syllabus with the basic topics usually required in college syllabi. It also includes a more detailed course outline with suggested units/modules in order of presentation for a course. Also included is an Evaluation Rubric tied to the Student Learning Outcomes. We plan to include teaching resources linked to the competencies they cover. Some of the Model course outlines include detailed resources for teaching the course – the Cartographic Design & Visualization includes detailed lecture notes. We hope to build more resources for teaching the courses in the next year and if refunded, to also investigate best practices for teaching geospatial technology. All of these resources are freely available to educators and linked from the GeoTech website. You can view these resources or download the Model Course Packs as word or PDF documents after logging in to the site.
http://geotechcenter.org

The is the GeoTech Center Web site – notice there is a link to the GTCM and other resources, but click on the Tab that says GTCM and choose Model Courses.
You can then click on Moodle Server or even easier just go to http://moodle.delmar.edu and request an account to download the Models and all documents. Once you request a login, you should receive access information in two business days.
### Potential Benefits of National Guidelines - Models

- **Alignment** of local curriculum with nationally recognized standard
- **Foster articulation** between education silos
- **Pre-, Post- or Self-test** for students, industry
- **Help identify** gaps or weaknesses or strength of a geospatial program
- **Be the basis for future certification efforts**, such as the GISP or “Badges” = Micro-Credentials

The Model Courses and Certificate, while useful for assessing or developing curriculum, it can have other benefits including alignment of local curriculum to a nationally recognized standard. This may help students that take courses at more than one institution receive credit for all the courses they take.

It may help with articulation of courses between institutions in that each course can be compared using the Assessment Tools.

It can provide the basis of testing for students or for industry when hiring new employees or providing a way for employees to advance.

It can help educators assess their program to identify gaps in their program or promote their program based on unique offerings.

It might be the basis for creating “certifications” or for creating Badges or Micro-credentials. Badges are discussed in more detail in the final report of the California Community College report.
This is the outcome from a study based on the GeoTech Center Model Courses and Certificate that was completed by the California Community College Geospatial Information Support Network (C3GIS.net) project funded by the California Community College Chancellor’s office. This project included 30 expert geospatial educators and industry users that met via webinars and a face-to-face meeting between June and December 2012.

Both the educator and industry panels felt that an Internship was an essential core course. Industry also felt that Cartography and Topology were very important. Most also felt that advanced courses should include more analysis and Programming skills.

During the process, educators discussed the format of the courses and teaching methods. Most of the faculty thought that a 3 unit format was the most appropriate format, but stressed that they did not follow a strict lecture/lab format. Lectures were brief and integrated into the class time rather than in a long block disconnected to hands on activities. This is much more in line with the flipped classroom and active learning.

A full copy of the report and recommendations is available from c3gis.net or from Ann Johnson at ann@c3gis.net or Chris Lewis at chris@c3gis.net.
The C3GIS.net project also identified additional courses that could be made optional electives for a Model Geospatial Certificate. It was highly recommended that the Geospatial Awareness course be included as an elective so that students do not loose credits. The Awareness course is an excellent feeder course for programs as it has qualified as a General Education Course and transfers between some two year and 4 year programs.

In order have these additional electives, it was also felt that collaboration between colleges should increase with a better system for students and faculty to find and take courses to meet their career objectives.
With refunding by NSF in 2013 (pending at this time) the next steps would be to create full curriculum and resources to teach these courses. This would include defining best practices in teaching the competencies. If refunded, GeoTech Center plans to set up a mentoring process to help colleges assess or develop geospatial curriculum to meet workforce current and future needs. This will include updating the GTCM with the DOL and updating the Model Courses and Certificate with input from industry.
Thank You!

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