Who Are We? – Defining the Components of the Geospatial Workforce

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Currently we are in the midst of a geospatial labor market shortage that shows every sign of growing more acute in the years to come. The explosive growth in the utilization of geospatial tools and data in nearly every sector of the global economy has been driven by dramatic increases in the capabilities of our tools and in the increased availability of better spatial data. This growth has created a substantial demand for additional, highly qualified personnel in all areas of the geospatial industry.

We are in a poor position to satisfy this demand for additional geospatial personnel since we have only a very vague notion of who we are and what – in the aggregate – we are currently doing, let alone what is going to be required in the years to come. This fuzzy situation is reflected in the disarray currently seen in the geospatial activities of the higher education system, both at the community college and the university level. Unlike manufacturing industries where apprentice training is a significant source of workers, higher education has been and still is the primary source of new geospatial workers. Presently far too many academic programs concentrate upon imparting only basic skills in the manipulation of existing GIS software to the near exclusion of problem identification and solving, mastery of analytic geospatial tools and critical topics in the fields of computer science, mathematics and statistics, and information technology.

This state of supply side disarray is not surprising given that existing academic geospatial programs have been established with little or no feedback from the geospatial industry to assist them in identifying the specific knowledge and skill sets that are required to support particular geospatial activities. The diverse levels of knowledge and skills present in the existing geospatial workforce, coupled with the prospect of a strongly increasing demand for even more knowledgeable and skilled workers, has led to the development of strong concerns in both the geospatial industry and academia about sustaining and improving the quantity and quality of existing and future workforce components. To alleviate these concerns steps must be taken in the very near future to establish a reliable stream of new entries to the geospatial workforce who are, in general,

better qualified than in the past and whose numbers are more in line with developing estimates of the future demand for specific types of geospatial workers.

What are the perceived problems with the geospatial workforce?

The initial problem is that the concept of a "Geospatial Industry," centered upon a newly identified and rapidly growing and highly technical sector of the economy, has only recently emerged. Something beyond just a "GIS plus" concept, this sector encompasses a broad variety of activities focused upon the acquisition, management, manipulation, analysis, and visualization of spatial and spatial–temporal data. Its recent recognition is based, in large part, upon the rapid growth in geospatial applications that has occurred over the last fifteen years in response to substantial developments in the critical primary spatial data acquisition area (GPS, remote sensing, surveying, etc.), geographic information systems (GIS), and in the development of specialized geospatial analytic and visualization tools. These developments have been closely interwoven with contemporaneous advances in computer science and information technology

At present the geospatial industry, because of its relative newness, lacks a comprehensive, global view of itself, its activities and the workforce that supports these activities. Instead we have a number of overlapping and often myopic views that reflect the views of individual organizations (both public and private) as well as, on the academic side, the traditional approaches of various disciplines. The effective integration of these varying, and only too frequently overlapping, views of what we do and how we go about doing it must represent a high priority. Without such a global view in hand the difficulty of solving our second major problem, that of identifying specific geospatial workforce components and defining the types and levels of knowledge, skills and experience each component requires, is substantially increased.

The existing geospatial workforce comes from a wide variety of backgrounds. Its heterogeneous character makes it extremely difficult for us to categorize specific components of the workforce in terms of either required or desirable knowledge, skill and experience levels. Many of the tasks that are undertaken by geospatial workers cut across traditional disciplinary boundaries and require the integration of a number of knowledge and skill components. The geospatial analyst must, for example, be able to understand the manner in which the approach that was adopted to acquire the spatial data being used will impact the analytic results he or she is obtaining "downstream" and, similarly, the individual who is engaged in primary spatial data acquisition activities must be knowledgeable about, and sensitive to, the requirements of the analytical users of the resultant spatial data.

The growing importance of geospatial–based activities recently led the U. S. Department of Labor to identify the geospatial industry, together with 13 other sectors as the focus of its High Growth Job Training Initiative. The 14 sectors were selected based upon the following criteria:

(1) They are projected to add substantial numbers of new jobs to the economy or affect the growth of other industries; or
(2) They are existing or emerging businesses being transformed by technology and innovation requiring new skills sets for workers.

In addition to the geospatial industry, only biotechnology and nanotechnology were identified as being among the most important of these emerging and evolving fields. (Gewin, 2004) This represents an additional strong mandate to address these major geospatial workforce problems in a comprehensive fashion.

Why do we need to know more about the existing geospatial workforce?

Identification and categorization of existing geospatial workforce components will make it possible for us to generalize about such things as, for example, the relative demand for a particular type of worker vs the demand for the same type of worker in another part of the geospatial industry. We also would be able to make specific statements about, say, how the necessary entry level knowledge, skills and experience differ between different types of geospatial worker (this type of information is, of course, critical to any effective restructuring of academic geospatial curricula). It also would permit more ready evaluation of the prior background and work experience of individuals who are seeking to change positions within the industry. Without an operational, structural model of both the geospatial industry and its workforce we find ourselves in a weak position from which to address either the geospatial industry's future development or its related future workforce needs.

Questions of how the existing geospatial workforce is structured aside, we possess very little information on critical demographic and other attributes of the workforce. These include such things as age, gender and other differences within the geospatial workforce, the relative importance of foreign workers, etc. Also, since we have a strong interest in things of a spatial nature, the spatial distribution of industry components, geospatial workers and even users is of considerable interest.

What are the perceived problems with the existing geospatial workforce?

There is a solution to both our quality and quantity problems, but any such program must be rooted in vitalizing and restructuring the relevant instructional programs in our

system of higher education, including not only the colleges and universities but also our community colleges. Because of the high level of technology encountered in the sector, and the continuing rapid changes that are expected to occur in this technology, any such activity must also explicitly address the availability of continuing, in–service professional and technical education for the existing members of the geospatial workforce. Such educational programs will require the coordinated efforts of academia, industry and government, applied over a significant period of time, to attain the needed results.

But what do we mean when we identify a need for "better qualified" persons in the geospatial workforce? Questions that have been repeatedly raised in this context have focused upon two broad concerns. The first of these is a declining depth of both conceptual knowledge and practical skills in the area of computer science/information technology among those individuals currently entering the geospatial workforce. For example, the potential utility of the modern GIS extends far beyond what is provided by the icons available on the default screen display. But this potential is likely to remain unrealized if the individual user of geospatial technology has only a minimal conceptual and operational knowledge of such things as databases, system design approaches, the role of the operating system, or is unable to respond to the notion of reconfiguring the available object modules with a bit of programming. While there is perhaps, in theory, a role for a limited number of "crank turners" in the geospatial industry it would seem to be one area where the demand is very limited.

The second major concern is one of breadth rather than depth and arises out of the broad scope of geospatial activities and their generally high level of interdependence. As pointed out in an earlier example, the geospatial analyst and the collector of geospatial data cannot effectively operate in ignorance of what each other is attempting to accomplish and what limitations restrict their respective activities. In much the same way, those whose primary concern lies in the use of geospatial data and tools in problem solving must have an operational understanding of what can and what cannot be accomplished within the context of current geospatial capabilities.

Certainly no one individual can become a specialist in all of the many technical areas that contribute to the geospatial industry, but there is a significant need for a broader basic understanding of these among all workers in the geospatial industry. While difficult to accomplish, given existing educational approaches, the development of a "basic core" of common knowledge that is shared among all members of the geospatial workforce is a highly desirable goal.

Given the substantial gap that exists between what we are currently capable of doing in the geospatial realm and what we anticipate that we will need to do in the near future, it is certain that the substantial pace of scientific and technical development within

the geospatial industry will not only continue but will most likely accelerate substantially in the years to come. Those individuals who makeup the geospatial workforce must be capable of dealing with a continuing pattern of rapid change as well as with the substantial challenge of adapting existing knowledge and tools to uses in a variety of new, complex situations. Thus, flexibility, spatial problem identification and solving capabilities, an above average knowledge of computer and information science, as well as the ability to spend their career in a near continuous learning mode become critical characteristics at nearly all levels of the future geospatial workforce.

Addressing our geospatial workforce problem

Identifying that significant problems exist with respect to the geospatial workforce and establishing general goals for their resolution are certainly necessary steps, but before moving on to define potential, operational solutions we must have a clear notion of where it is we are going. Our present situation is made more complex since nearly all of what we currently know about the geospatial industry and its workforce components is basically anecdotal in nature. This brings to mind the classic tale of the blind men and the elephant and raises, in turn, the difficult question of how are we to determine the path or paths that will take us to our desired destination if we are not sure of where we are starting from?

In attempting to approach any operational solution it is apparent that a major difficulty arises from our lack of a well defined notion of the overall scope of the geospatial industry and its associated workforce. As an initial step, we need to agree upon a detailed geospatial industry domain description that is accepted by a majority of the interested parties. Lacking this common global definition it becomes difficult to identify, let alone focus effectively upon, specific components of the geospatial workforce.

Such a detailed domain definition permits us when dealing with a specific organization (private or public) to be able to classify that organization as being, in terms of its activities, either fully or partially involved with the geospatial industry. And, of course, we must be able to make similar decisions with respect to the components of that organization's workforce. Is ESRI part of the geospatial industry? Is Jack Dangermond part of the geospatial workforce? What about the people working in the ESRI shipping department? And what about all those who make up the ever growing geospatial user community? Examining a large organization that has several thousand employees we might identify, say, a GIS department of 25 persons who are serving an internal user community of perhaps 400 persons. Do we include the GIS staff and exclude the 400 direct users? Include the 400 users and exclude the thousands of other employees? Without clear definitions we are free to do almost anything that we want but then no two assessments will ever agree and our knowledge of the geospatial industry will be as cloudy as ever.

In developing working definitions of the scope of both the geospatial industry and its workforce I would suggest that we recognize at the start the need to distinguish between (a) workers whose primary concern lies in the area of relevant *knowledge generation and integration* activities, (b) workers whose primary concern is with problems of *tool development and testing*, and (c) workers whose concern is primarily focused upon the *practical utilization of knowledge and tools*. The latter area could, if desired, be easily subdivided into activities associated with the primary acquisition, storage and management of spatial data on the one hand, and those that are focused upon problem identification and resolution on the other. These three (or four if you choose) general areas not only generate specialized demands for workers with particular sets of skills and experience levels, but during periods of rapid technological change workers in the three (or four) areas need to be closely linked to each other by strong communication channels supporting technical interaction. Figure 1 illustrates this suggested structural view.

In addition to the three (or four) general areas identified above, there is a frequently overlooked, but very critical supply side component that must also be addressed when defining the scope of the geospatial workforce. That is, the relevant *educators and trainers* whose combined efforts result in the creation of new entries into the geospatial workforce and in the continuing technical education and training of existing geospatial workers. Failure to explicitly consider the factors influencing the quantity and quality of these particular workers ("training the trainers," etc.) can easily result in a significant, negative impact upon any geospatial workforce quality and quantity goals that may be established.

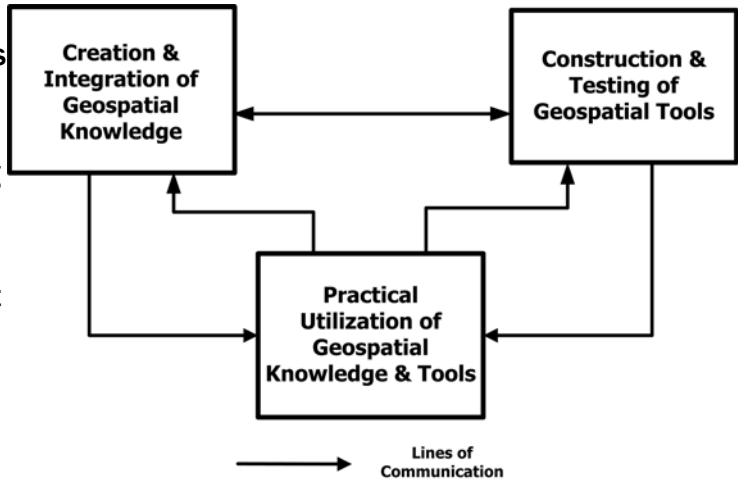

Figure 1
Structural Elements of the Geospatial Workforce

A previous definition of the geospatial industry

Several years ago it was suggested that the geospatial industry be defined as:

... 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 as well as development and

life–cycle management of information technology tools to support the above.[1]

This older and rather awkward definition is more than a bit misleading since the geospatial industry, while a heavy user of information technology, is certainly not derived from that field and cannot realistically be considered to be a subdivision of information technology (IT) anymore than can, say, the modern banking industry. Referring to it as a "field of practice" produces a focus only upon the "utilization" aspect of the industry and extending the definition to include the limited development of IT tools admits only a portion of the "tool construction and testing" aspect of our broader interests (e.g., it excludes, for example, the development of new remote sensing and surveying instruments). While the domain of discourse must be carefully defined, any working definition that we do adopt certainly needs to be far more representative of where we come from and what we do.

Toward working definitions of the geospatial industry and its workforce

To hopefully initiate further discussion on the topic, let me suggest the following strawman definition of the geospatial industry. This draft definition needs to be discussed at some length, and modified as necessary, by those involved in or having a major concern with the geospatial industry.

The geospatial industry engages, at a variety of spatial scales, in the acquisition, integration, analysis, visualization, management and distribution of data having an explicit spatial and temporal context. A critical component of the industry involves the design, construction and testing of both hardware and software tools to support these activities. Because of the highly technical nature of the industry it is also essential to include in and definition those organizations and individuals in the higher education community who are engaged in relevant instructional activities.

The notion of relevant scales is not commonly encountered in industry definitions but its insertion here reflects the comment some years ago by Dr. Michael Dacey, a geographer, that a primary difference between the disciplines of physics, geography and astronomy was a matter of their respective focus upon different segments of the scale continuum. We have no problem with geospatial investigations of various planetary objects but we do not do astronomy. On the other end of the scale continuum we increasingly work at

[1] Geospatial Workforce Development Center, University of Southern Mississippi as quoted in a recent U.S. Department of Labor brochure.

sub–meter levels and some of our analytic tools (map projections, spatial statistics, etc) are even being applied at the molecular level.

Omitted from my strawman definition of the geospatial industry is any explicit mention of the "use" of the products that are created. My rationale here follows the general notion of excluding from, say, a definition of the banking industry, the users of checking accounts as opposed to workers providing these accounts. However, in a geospatial context, the situation is far more complex. Within what we might identify as a "class" of geospatial users who focus upon activities such as analysis, visualization, interpretation and management with a primary focus upon problem resolution we find a substantial degree of technical differentiation ranging from, say, the operation of a high–end integrated GPS/GIS dispatching system on the one hand to an individual looking for the location of a local business. In my own opinion, the first is clearly "in" and the other clearly "out." However it is questions such as these that need to be discussed at some length by all of those concerned.

Within the context I have suggested for the geospatial industry I would suggest that the definition of the geospatial workforce be limited to those individuals who are employed within the industry, or who act as contractors to the industry, on either a full time or part time basis and whose position involves the need for some specified level of technical knowledge. What level? Again, a topic to be debated. The upper end of the skill spectrum does not really need to be carefully defined but the lower end must be examined with some care. The difference between, say, a general secretary and a legal secretary in terms of specialized skills is generally accepted. Are similar distinctions present in the geospatial workforce? If so, we need to identify them.

Is anything currently being done with respect to these concerns?

There have been several mentions of the need for give-and-take focused upon the development of working definitions of the scope of the geospatial industry and its workforce. Are such discussions going to take place? I am pleased to note that they are already beginning. The Employment and Training Administration of the U.S. Department of Labor has recently made a substantial award to the Geospatial Information & Technology Association (GITA – www.gita.org) and the Association of American Geographers (AAG – www.aag.org) to begin discussions on these definitional topics with a large group of organizations and individuals. In addition, the two organizations will develop a pilot Web-accessible server of geospatial industry, job, and educational information called GIWIS.

When we finally have workable definitions that effectively define the bounds of the geospatial industry and its workforce components we will be in a much stronger position to

forecast future demands for specific workforce categories and to identify the specialized knowledge, skills and experience that are needed by workers in each of these groups. This information will also prove valuable in more clearly focusing the ongoing attempt by the University Consortium for Geographic Information Science (UCGIS – www.ucgis.org) to identify viable modern undergraduate curricula in the area of Geographic Information Science & Technology (GI S&T). We will also be able to develop certificate and in–service training programs that will provide more effective in–service knowledge and skill updates to members of the existing geospatial workforce.

With the required structural elements in hand, we will be in a position to begin building a much more substantial and accurate picture of the geospatial industry and its future growth and workforce requirements. But what data are currently available to support such an effort?

What do we currently know about who is involved in the geospatial industry?

In terms of either organizations or people, regretfully, a great deal less than we really need to know at this point. From an organizational standpoint, the term "geospatial" or almost anything resembling it fails to appear in either the 2002 version of the North American Industry Classification System (NAICS) or in the revisions that have been adopted for the 2007 version. The only specific codes that appear at all relevant are 54136 *Geophysical Surveying and Mapping* and 54137 *Surveying and Mapping (other than geophysical)*. This means that there is relatively little in the way of current industry statistics that can be extracted from existing government tabulations. We are not even in a position to select a limited number of NAICS codes and attempt to call the result "geospatial" since our activities touch upon so many different NAICS codes.

The question of "membership" in the geospatial industry is further complicated by the fact that many of the creators and users of geospatial technology and data are governmental and non–governmental organizations (NGOs) and that within these, as well as within most private sector companies, only a portion of the organization normally deals directly with geospatial technology and its products. Currently, we are unable to identify the extent of the involvement of any specific organization without utilizing our yet to be determined domain definition and then engaging in the primary acquisition of the necessary organizational data.

Given the difficulties encountered in establishing membership criteria and then the need to make an "in or out" decision with respect to individual organizations and their components, it is not surprising that we currently have only minimal knowledge of the existing geospatial workforce. We are unable to speak in any definitive way even to questions of simple demographics such as the composition of the geospatial workforce by

age, gender, race, citizenship, duties that they perform, or the locations where they work and reside. And, as well, we know little on an industry–wide basis about current job descriptions, educational backgrounds, what knowledge and skills needed and desired for each position, etc.

An interesting example of some of the kind of things that we should know on an industry–wide basis may be found in a presentation given by Clint Brown, ESRI's Director of Software Products, in San Diego in August of 2005. ESRI software Products works closely with ESRI Software Development and currently employs just over 200 workers. One major component of ESRI's participation in the geospatial industry lies in the tool constructing and testing category identified earlier. Such activities clearly require an advanced level of education and training as contrasted, for example, with organizations whose primary concern is with more routine application of existing geospatial tools.

Two illuminating slides from this presentation are shown here as Figures 2 and 3. Figure 2 provides a brief profile of the employees in ESRI Software Products; of special note are the number of individuals holding advanced degrees (80%), the high proportion of foreign nationals (50%) and significant number of women (33%). Also of importance is the very heterogeneous disciplinary background of the employees including many who hold dual degrees. In Figure 3 we see a list of some of the general skills that are considered

Figure 2

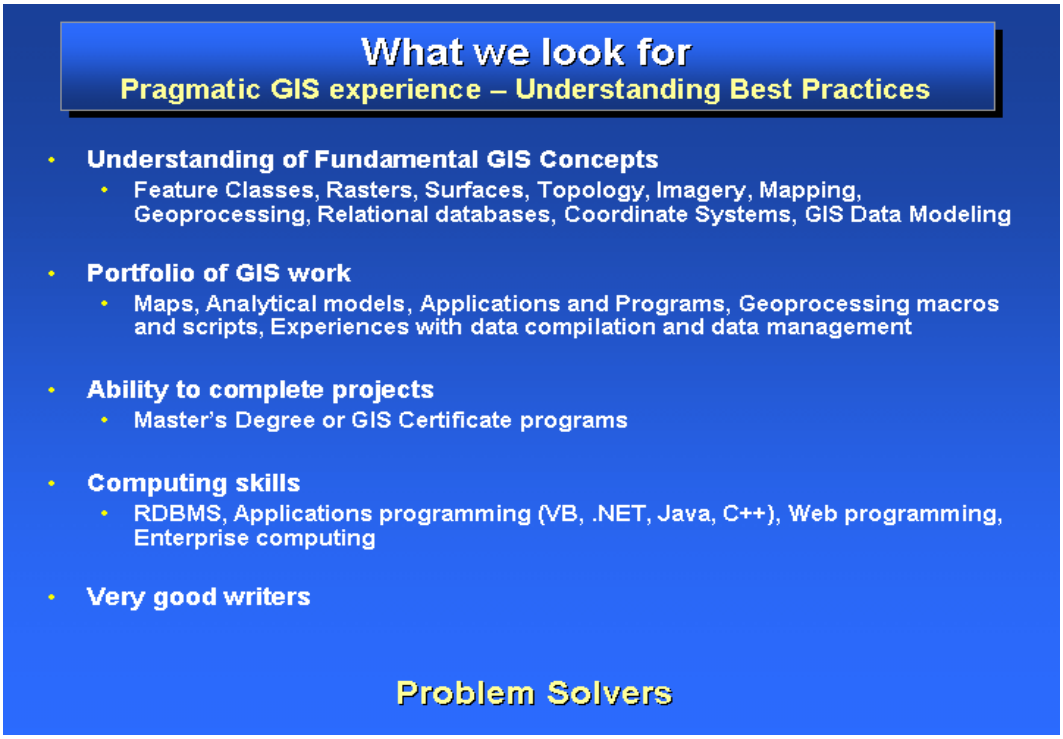

Figure 3

desirable for work in this area. Prominent here are advanced knowledge and experience in both GIS concepts and in computer and information technology.

In light of the item mentioned at the bottom of Figure 3 ("Problem Solvers") it is interesting that in informal discussions I have had with a large number of users and developers of geospatial technology they stress the extreme importance of their workers ability to:

- Identify the spatial components of a problem,
- Define one or more geospatial products that will significantly contribute to the solution of the problem,
- Identify the combinations of existing geospatial tools and data that are necessary to create each product, and
- To learn from experience gained in solving geospatial problems and to apply what has been learned to the next problem.

Often, these skills appear to be valued far higher than the individual's manipulative skills with existing geospatial software. In my estimation, this reflects both the complexity of many geospatial problems as well as the continuing rapid development and increasing sophistication of the tools that are being applied to the solution of these problems.
What do we need to do?

As perhaps part of, or hopefully following closely upon, the GITA/AAG study a number of things need to be done as rapidly as possible if we are to effectively deal with the workforce problems generated by a rapidly expanding geospatial industry. The sequence in which the following activities are approached is also important since they are dependent upon each other.

1) We need to develop and adopt a generally accepted definition of the scope of the geospatial industry. This definition should exist at both a general level as well as at a detailed level that permits the operational assignment of membership to the defined set. Hopefully the current GITA/AAG operations will place us within striking distance of doing this.

2) Working within the context of the more detailed operational definition of the geospatial industry, we need to begin activities that will lead to the specific identification of all of those organizations falling within our definition. For each organization that is so identified, we need to obtain certain basic information about the nature and extent of their involvement in geospatial activities. In the present context, this implies the need for fairly detailed workforce information as well. This is not going to be an easy task.

3) Based upon the information obtained, we need to develop a composite picture of the geospatial workforce as it currently exists. This composite view must also be broken down into clearly defined, relatively homogeneous components that are identified on the basis of a combination of the geospatial activities undertaken and the knowledge, skills and experience required to carry out these activities. Again, it is hoped that the joint GITA/AAG study will make a major contribution here.

4) Based upon this information, together with the stated expectations of the individual organizations and combined with general economic and demographic forecasts, we should develop statements of future geospatial workforce needs at as detailed a level as possible.

5) Based upon items (3) and (4) above, we should carefully define the desired characteristics of each component of the stream of new employees expected from the higher education system and suggest what specific changes in current curricula, staffing, infrastructure, etc., will be needed to make this occur. The UCGIS Model Curricula project should be able to contribute to this goal. Special attention must also be given, in the educational context, to the enhanced delivery of adequate in–service education and training to current and future members of the geospatial workforce.

6) It is likely that significant changes will be required in the present higher education activities in order to achieve the desired quantity and quality goals for the future geospatial workforce. These changes will progress only in a slow and erratic fashion without concerted and continuing support from both the geospatial industry and government. We need to identify the most effective ways to initiate these changes and work together to provide this support.

In conclusion

We have reached the point where we are clearly being hampered by the lack of a firm notion of just what makes up the geospatial industry and exactly what will define our future technical workforce requirements. It is my firm belief that failure to address these concerns in the very immediate future will lead to long run difficulties of considerable magnitude. With respect to the geospatial workforce, failure to begin making preparations now for our future needs is highly likely to not only impede the continuing growth of the geospatial industry but also to have serious impacts upon society as a whole.

What can you or your organization do? Certainly you should participate as fully as possible in the ongoing GITA/AAG study mentioned here. Do you have existing workforce information (such as that seen in Figures 2 & 3)? If so, share it (on a confidential basis if necessary) with the ongoing GITA/AAG study since it appears that we will have to build our initial view of the workforce from such bits and pieces. Check with your local institutions of higher education. What are they doing in the area of geospatial education? Is it relevant from your point of view? Encourage and become involved with their geospatial programs and encourage them to address the questions of breadth and depth raised here.

References

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