The Significance of Public Safety for GIS Professional Licensing and Certification

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Abstract: *What is the relevance of public safety concerns for geographic information system (GIS) certification? How should professionals and instructors incorporate these concerns in education? The importance of public safety is developed in this article through the examination of two case studies of licensing that engage the political, philosophical, and scientific dimensions of licensing and certification. While these case studies deal with licensing, they point to a critical question for GIS certification: Is there a test that assures that GIS certification will fulfill public safety concerns? The many issues impacting public safety indicate the impossibility of a single test. GIS professional certification must reflect the broad range of public safety concerns. Despite the difficulties in establishing criteria that ensure public safety, discussions surrounding certification help articulate a core body of knowledge in GIS and GIScience, identify standards of practice, and promote research in this area. In terms of education, consideration of public safety issues should become part of curricula preparing individuals for future careers. A fundamental awareness of public safety issues can and should be appropriately anchored in GIScience education.*

Introduction

Public safety concerns connected to geographic information quality and reliability are not new (Burley 1993, Obermeyer 1993), but have recently led to an increased concern with the methods and practices of geographic information system (GIS) professionals and the credentials of those involved (Obermeyer and Onsrud 1997). Certification and licensing appear to offer a solution to these concerns, while also contributing to defining an amorphous field. This contribution includes helping resolve the difficulties that employers have in identifying suitable candidates (Huxold 2000) and supporting the professionalization of GIS (Somers 2000). In the United States, states and counties address important public safety concerns through certification of surveyors-in-training and licensing or registering of surveyors. Other countries address these issues through similar approaches. However, the breadth of GIS use takes many activities outside of this regulated area. The surveying profession in the U.S. recently has taken issue with the public safety issues inherent in untrained and unqualified people collecting original measurements used in determining the boundary or the location of fixed works (Joffe 2001). Many questions are being asked about certification proposals for GIS (Somers 2002). This article addresses the key dimension of public safety as a criteria for professional certification or licensing.

While the term "public safety" is popularly associated with public health concerns, fire, emergency medical services, and disaster planning, it is a key concern for the structures designed and built by architects and engineers that could possibly endanger members of society. For this reason, public safety is the prime reason for licensing programs that protect the public from individuals apparently claiming sufficient credentials and abilities (Allen et al. 2000).

Ostensible public safety concerns, however, may mask economic interests and attempts of an elite group to assert political control of a profession. As a result, licensing and certification can demonstrate contradictory purposes. Consider the examples of hair stylists and cooks. Hair stylists are licensed in most areas. While this activity evidences some degree of public safety concern, is this concern sufficient to require licensing? The comparatively limited public contact and corresponding low safety risk to the public clearly speak against the cost and complexity of certification or licensing, yet even poorly paid hair stylists must pay for licensing. In contrast, consider the licensing of cooks with much more public contact. Cooks are generally not licensed, although many have voluntary professional or apprenticeship certificates. However, many cases of disease spread by cooks have endangered public safety. The famous case of "Typhoid Mary" who worked as a cook at several homes and restaurants infecting hundreds of people with typhoid has become part of popular knowledge. In spite of numerous deaths, her career as a cook ended only when she was forcibly quarantined to an island in New York Harbor. The examples of licensing in the first case and the lack of licensing in the second reflect the complex interactions between public safety and professional motivations of relevant professional organizations.

Even though there are contexts in GIS with no immediate public safety implications (e.g., ecological habitat mapping), public safety has some relevance in all discussions surrounding GIS certification. Clearly, in a few areas using GIS—emergency management services, public health, fire protection, civil engineering, some engineering applications—public safety is an issue for nearly every activity (Amdahl 2001). Practitioners in these domains recognize public safety issues. Currently, they could be readily licensed, certified, bonded, and/or insured. However,

public safety concerns are much broader. A homeowner with some experience could use a GIS to determine where to put a new well. A planner could use a GIS to evaluate building conditions and code violations and call for demolition of substandard housing units. The well digging could hit an underground cable or gas line, and the destruction of affordable housing could put people on the street or in overcrowded shelters. The range of public safety issues is theoretically infinite. As a result, GIS professional certification has been proposed by some as a viable response to these concerns.

It is important to acknowledge that a number of reasons beyond public safety concerns are offered in support of GIS certification. These include the need to assist employers in assessing a job candidate's knowledge, the demand by practitioners for a way to demonstrate their hard-earned skills and knowledge, and the need to help those who wish to become GIS professionals design appropriate education and experience pathways (Huxold 2000). As well, it is useful to note that discussions about other forms of certification are current in the GIS context. In addition to the certification and licensing of individuals, software and data certification offer alternative or complementary approaches to ensuring public safety. While these are intriguing possible solutions to the issue, they involve fundamental issues outside of the scope of this discussion. This article focuses on the public safety concerns as a crucial aspect of GIS certification and points out the relevance of taking up these issues in GIScience education and research.

Certification and Licensing: Key Differences

Because the terms "certification" and "licensing" are widely used, and confused, it is important to begin by examining their respective definitions. Legal writing on the subject makes an important distinction. Certification shows that a standard or level of quality has been met. For example, the Good Housekeeping Seal of Approval is a certification that attests a product meets industry-set criteria. Certificates can be awarded by any organization or association. Certification, legally understood, is the "formal assertion in writing of some fact" (Black 1990:227). In contrast, licensing is the regulation of a profession by a government. Seen from the legal perspective, professional licensing gives "permission to do what is otherwise restricted, prohibited or illegal" (Walker 1980:769). Licensing is the government exercise of its police power, which is the constitutional law concept that empowers the government to restrict an individual's freedom to protect "public safety, health, and welfare."

The relevant difference between certification and licensing is governmental regulation and restriction of activities. Based on the legal distinction, any organization can certify people under its own authority, whereas licensing is established only through governmental legislation. Unfortunately, the terminological distinction is thoroughly muddled in practice. Certificates of licensing are awarded. The term "certified" is often mistakenly used to designate licensed persons. For example, Texas State law provides for both certified and licensed real estate appraisers. From the legal point of view, because this certification is state-controlled and legally required, a state-certified real estate appraiser actually has a form of license (Texas Appraiser Licensing and Certification Board 2001). This terminological imprecision also masks the common practices through which professional associations provide documents and criteria that legislative acts implement as licensing law and requirements. In this way, certification criteria developed by a professional group can evolve and in effect become a protectionist means to control entry to a professional field (Wilson 2001).

For this article, these distinctions are highly important. Whereas public safety concerns are always the fundamental issue in licensing, the same concerns can become highly relevant to, although not a legal foundation for, certification. Related to this, the question arises whether certification raises liability issues and implicit legal responsibilities.

Two Case Studies

Two recent controversial issues provide case studies to illustrate the thesis of this article. In the first case study, I set the stage for considering the roles of scientific, political, and philosophical issues involved in licensing and certification. This case study draws on a recent debate among members of the Association of Computing Machinery (ACM) regarding the licensing of software engineers. The second case study frames these issues in the GIS context. It provides an overview of recent activities by the National Council of Examiners for Engineering and Surveying (NCEES) to establish a new model law for the licensure of engineers and land surveyors.

The ACM Software Engineer Licensing Debate

The ACM was founded in 1947 and currently has 80,000 members. Although much larger than any GIScience or geography association, the ACM is comparably diverse with approximately 38 specialty groups; there are more than 50 specialty groups in the Association of American Geographers. Considering this breadth, the underlying scientific, political, and philosophical issues identified by the ACM hold lessons for current discussions about GIS professional certification and licensing issues for the GIScience community at large.

In May 1999, following the report of a specially commissioned panel and committee deliberations, the ACM Council concluded that "…there is no form of licensing that can be instituted today assuring the public safety" (Allen et al. 2000). As the panel stated, "the primary arguments for licensing are that it will happen with or without the involvement of the ACM and that the development of license standards will, at a minimum, strengthen software development knowledge and practice" (ACM Panel on Professional Licensing in Software Engineering 1999). Wary of implying an endorsement of existing licensing schemes, the Council decided that the ACM would withdraw from any activity that gave the appearance of condoning the licensing of software engineers. Specifically, the ACM Council adopted the panel on professional licensing in software engineering majority's recommendation that licensing "does not address the software quality problem and is premature."

The ACM Council decision to oppose software engineer licensing was based on consideration of three critical issues for GIS public safety concerns: scientific merit, political issues, and philosophical concerns. The scientific merit issue that the ACM considered revolves around this question: "Is there a test [licensing exam] that will assure the person who passes the test will be qualified to write programs that would never endanger the public? Will that person be qualified to sign off on program designs to assure they are sound, just as building designs are signed by structural architects to assure the building is sound?" (Allen et al. 2000:29). The Council and committees looking into this issue found no test to assure a software program design that would assure public safety. Further, they found that no one knows how to prepare such a test. Without building codes for programs and a vocabulary rich enough to discuss their structural integrity, the Council called for more research upon which such a test can be derived.

Political issues often remain in the background of certification and licensing discussions, masked by ostensible concerns with public safety, health, and welfare, but many times may be the underlying motivations for professional groups seeking to control a profession. The political rationale for licensing and certification is directly connected to the size and influence of disciplinary associations. For the ACM, the political issue is inseparable from economic concerns: "As traditional engineering disciplines attract fewer people than the software construction/programming disciplines attract, those groups who make their money from fees derived from licensing and accrediting engineers will look upon software engineers as a good growth area and attempt to assert their control" (Allen et al. 2000:29).

The ACM Council also discussed two philosophical concerns. The first was whether to participate in licensing activities even though the Council did not approve of licensing. Going with the majority of the panel, the Council decided that participation would be perceived as an endorsement and would "lull people into thinking we do know how to assure public safety when we don't" (Allen et al. 2000:30). The second philosophical point is the question of when to begin licensing. Some panelists hoped that beginning the licensing process would help mature the field. The Council determined that the possible harm of licensing—the consequences of using incomplete and insufficient licensing requirements—outweighs any possible good.

Although the ACM withdrew from active participation in the development of a licensing examination, it continues to work with the Institute of Electrical and Electronics Engineers (IEEE) Computer Society on definitions of an appropriate corpus of knowledge and standards for software engineering. Two task forces were formed to assess these issues and evaluate all options for ensuring public safety. Although the ACM currently opposes licensing of software engineers since no form of licensing ensures public safety, these task forces will focus on solving the software quality problem.

The scientific, political, and philosophical issues the ACM addressed are directly relevant for GIS certification and licensing discussions. The same questions that the ACM raised can be asked of GIS certification and licensing:

- Is there a test [licensing exam] that will assure the person who passes the test will be qualified to conduct GIS projects that would never endanger public safety?
- Are groups attempting to use licensing/certification as a means to generate income for their professional organizations and assert control over a burgeoning field?
- Does the participation in licensing and certification proposals indicate tacit approval of incomplete and insufficient criteria?

These questions should be discussed publicly through an open and frank discussion by the numerous groups involved in activities that GIS licensing or certification would encompass. This joint discussion may take some time. In the meantime, the public safety concerns of GIS remain. Some groups have taken on these issues directly (NCEES, see below), while others include them implicitly in their activities (American Society for Photogrammetry and Remote Sensing (ASPRS), the Urban and Regional Information Systems Association (URISA), and the University Consortium for Geographic Information Science (UCGIS)).

The NCEES Model Law

The NCEES Model Law for the Licensure of Engineers and Land Surveyors is intended to be used as "a reference work in the preparation of amendments to existing legislation or in the preparation of new proposed laws" (NCEES 2001:5). Building such a model law is tricky business. While surveyors are concerned that the wording of the model law may prohibit "them from doing the work they have historically been conducting" (Joffe 2001:35), other professionals feel threatened by the appearance of a broadening of the duties covered under legal licensure. The Model Law is important for all GIScience practitioners concerned with public safety issues.

The NCEES Model Law offers a thought-provoking example of how one professional group (surveyors) addresses public safety concerns. While much of the Model Law focuses on the constitution and maintenance of a board to organize the licensing process, it offers ample insights into the legal issues surrounding licensing and the protection of public safety. For this section, I am citing and drawing on the Model Law published in August 2001 (NCEES 2001). Discussion and working papers available at the NCEES (www.ncees.org) and the American Congress on Surveying and Mapping (ACSM) (http://www.acsm.net/nceegislis.html) provide additional insights. To improve comparability, the scientific, political, and philosophical issues framework described by the ACM Council is used here to organize an analysis of the Model Law and background documents.

Scientific Issues. The Model Law allows graduate surveyors with 4 years of combined office and field experience to be admitted to an 8-hour written examination on the principles and practice of surveying or land surveying whose contents are determined by the board. The lack of specifics for the test in terms of public

safety issues is somewhat compensated by the definition section of the Model Law. The activities identified in a non-exclusive list include the measurement of lines and angles to position fixed objects, property line and boundary work, land subdivision, locating and setting of survey monuments and reference points, and the use of GIS to perform these activities. These exemplar activities undergird some of most common surveying activities.

However, in the Model Law, the practice of surveying is not limited to the list of activities:

> The term "Practice of Surveying or Land Surveying," within the intent of this Act shall mean providing professional services such as consultation, investigation, testimony evaluation, expert technical testimony, planning, mapping, assembling, and interpreting reliable scientific measurements and information relative to the location, size, shape, or physical features of the earth, improvements on the earth, the space above the earth, or any part of the earth, and utilization and development of these facts and interpretation into an orderly survey map, plan, report, description, or project. (NCEES 2001)

Considerable concern has been raised in the GIS community at large regarding the inclusive nature of the definition that seems to include any scientifically measured representation of the earth's surface. The GIS/LIS report from October 2000 addressed this issue (GIS/LIS 2000) noting that the definition should exclude activities with low regulatory interest and activities not part of the "Practice of Surveying or Land Surveying" affecting "the health, safety or welfare of the public" (GIS/LIS 2000:3). Joffe (2001: 36) suggested that a critical distinction can be made between GIS products "intended to be used as the authoritative document for the location of parcels, fixed works, survey monuments, elevation measurements, etc." and those used for other purposes.

Recently, NCEES and the surveying community have moved toward a less inclusive definition. Suggested changes outlined in the Draft Preliminary Report of a task force of representatives from several of the professional organizations representing GIS professionals stipulate that professional surveying only include "Geographic Information System-based parcel or cadastral mapping used for authoritative boundary definition purposes wherein land title or development rights for individual parcels are, or may be, affected" (ASPRS 2002:12). Nevertheless, this controversy leaves open the debate regarding the definition of the field and thus the question of what should be tested to assure competence of licensed surveyors across the domain that they are expected to serve.

Political Issues. As it stands, the broad definition of the "Practice of Surveying or Land Surveying" suggests a political intent. By making the definition so inclusive of professional services including planning, mapping, etc., practitioners wishing to continue data collection and mapping in jurisdictions that have implemented the Model Law in this form would be required to become licensed surveyors. Analogous to attempts of related fields to colonize areas of software engineering reported by the ACM Council, this appears to be an attempt to put into place a licensing requirement that would place control of all professional GIS activities in the hands of licensed surveyors. In one of the activities listed, "planning," the U.S. planning field already has its own certification program. Generally, two reasons go against this kind of all-encompassing definition of surveying. On the one hand, this definition fails to include all related activities that affect public safety (e.g., GPS car navigation). On the other hand, the definition becomes so inclusive that the precise demarcation of surveying practice would require litigation. As it appears the suggested changes will be included in a revision of the Model Law due out in the summer of 2003 (Joffe 2002), these political issues seem to have been partially resolved.

Philosophical Issues. Since the NCEES has already promoted the Model Law and it has become the basis for the licensing of surveyors in South Carolina and other states, the philosophical issues regarding whether and when to undertake licensing in these GIS-related fields that the ACM Council identified are indeed moot.

Public Safety In GIS Certification and Licensing

Having examined some of the current discussions related to public safety and licensing in other fields, we can now turn to a consideration of how public safety issues are accounted for in current GIS certification and licensing activities. Again, it is worthwhile to consider the scientific, political, and philosophical issues. As might be expected, published documents on GIS certification contain little reference to public safety. The University Consortium for Geographic Information Science white paper titled Educational Policy and GIS: Accreditation and Certification (Obermeyer and Onsrud 1997) does not mention public safety, assuming that certificates only show a level of education or training. It even argues that UCGIS members should have little interest in certification since it would dilute the meaning of the academic degrees they award. In a later article, Obermeyer (2000) articulates the political and philosophical rationale for involving UCGIS in the certification discussion but states nothing about public safety. On the other hand, Huxold (2000) points implicitly to the importance of public safety. Taking up earlier work on certification, one of Huxold's three benefits of GIS certification is "Public benefit by the encouragement of higher levels of competency among practitioners." While public benefit is not necessarily synonymous with public safety, it does promote awareness of issues that overlap.

In discussions among surveyors, the GIS and public safety issue is foremost. Surveyors are very aware of the related scientific, political, and philosophical issues (Joffe 2001). For example, articles on certification and licensing in the Professional Surveyor deal with the control of GIS, the relationship of GIS to surveying and geomatics, and the cost of inaccurate data bases (Henstridge 1999, Schmidt 1999). In literature discussing GIS certification and licensing, the clearest articulation of the role of public safety comes from Jim Plasker, executive director of the American Society for

Photogrammetry and Remote Sensing, in a GeoSpatial Solutions article organized and edited by Rebecca Somers (2000). Discussing the NCEES contributions to revisions of the Model Law, Plasker makes clear that the reason for licensed surveyors' attention to certification and licensing is protection of the public: "Recent developments in GIS and related data acquisition technologies now make it possible for unregulated practitioners to accomplish certain surveying activities that, if not completed properly, would be detrimental to public safety or individuals' property rights" (Somers 2000:28). Corresponding to the ACM's political category, Plasker makes it clear that the surveyor's concern for public safety goes hand-in-hand with the concern that high accuracy measurements made by GIS users "will inadvertently encroach on the regulated practice of surveying" (Somers 2000:28).

All of these arguments demonstrate that it is important for GIS professionals to consider the science, politics, and philosophy of GIS certification and licensing in relationship to public safety. Without tests or standards that assure public safety, the current GIS certification and licensing discussion may be seen to be little more than an attempt to stake out professional turf. As the examples above demonstrate, licensing and certification proponents' calls for certification may reflect strong political motivations—the control of a field through certification or legislation can serve to protect the economic interests of people who define and maintain the instruments of licensing and certification.

However, a more fundamental question remains: Do certificates matter? Most people advocating certification refer to its usefulness in evaluating job candidates, in helping professionals design their own professional development activities, and in the establishment of mechanisms to assure continuing education such as those provided for their certified professionals by the American Institute of Certified Planners' or the American Institute of Architects' Continuing Education System. Depending on whether you are an employer or looking for employment, your perspectives will vary. While certificates such as the Microsoft Certified Systems Engineer certification are vendor issued and indicate the tested achievement of a skill level, point-based certification approaches such as that being promoted by URISA, which account for a lifetime of education and experience, can become so nonspecific as to be meaningless for employers looking for concrete measures of job candidates' skills and abilities. If GIS certification can be acquired through an infinite number of paths, how will it become useful for job seekers looking to distinguish their abilities? In this author's opinion, the vagueness of the current URISA certification proposal lacks specific indicators to make GIS certificates alone meaningful. [Editor's note: See the report in this issue by Huxhold and Craig for a very different perspective on the role of GIS professional certification.]

Important Questions For Education

The ACM Council's deliberations and decision should serve as a touchstone for our critical examination of what certification should accomplish in GIS. Is there a role for the consideration of public safety in the GIS certification initiatives? If so, what are the scientific, political and philosophical implications? From the philosophical perspective that the ACM raises, educators will need to ask whether GIScience is ready for certification—do we have guidelines, practices, and criteria to teach, and tests to administer that can assure public safety? If public safety is a key reason for undertaking certification of GIS professionals, it would be disingenuous to assert that it is called for when there are no grounds to assess how certification or licensing would assure public safety.

Whether or not public safety issues drive GIS certification, there is some value in GIS educators and researchers beginning to ask how they can help to develop GIS practices, tests, and criteria that assure public safety. The ACM pointed to quality as a key dimension of software engineering, and that may be an equally suitable starting point for GIS. Geographic information science can contribute to the development of quality and practice criteria to inform discussions about public safety concerns. It is important to recall that the first papers on data quality dealt with the use of GIS in public offices charged with assuring equitable policy and maintaining public safety (Chrisman 1984). Recent work on data quality presents measures of quality and means of making quality information more accessible for public decision-making (Morrison 1995, Egenhofer 1997, Widmer 1997, Goodchild 1998, Harvey 1998, Chrisman 1999;). Likewise, the division between authoritative and location-referencing GIS activities now being proposed in the NCEES Model Law revisions begins to distinguish GIS products and activities according to their importance to public safety.

Despite the difficulty of establishing certification criteria that ensure public safety, discussions surrounding certification will help to articulate a core body of knowledge in GIS and GIScience, identify standards of practice, and promote research in this area. In terms of education, consideration of public safety issues should become part of curricula preparing individuals for future careers. While we should be wary of locking in standards that may become outdated quickly, a fundamental awareness of public safety issues can and should be appropriately anchored in GIScience education.

Conclusion

The question whether GIS certification can and should, in the broadest sense, satisfy public safety concerns has yet to be directly addressed by the GIS community. Taking into account the diversity of the GIScience field, our professional activities, and social commitments, the time is simply too early for meaningful GIS licensing that assures public safety. Considering the breadth of GIS, we are not yet ready to answer the question: "What qualifications must a person possess to assure their work with GIS will never

endanger the public?" Although public safety concerns currently play a less significant role in certification than in licensing, they are still crucial for assuring the quality of GIS work and understanding the consequences of inappropriate practice. Public safety is a key issue for GIS licensing and certification and should form an important foundation in GIS education. Without appropriate consideration of public safety, we run the risk, like any profession, of damaging the public reputation of GIS.

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References

Allen, F., Hawthorn, and B. Simons, 2000, Not Now, Not Like This. Communications of the ACM, 43(2), 29-30.

Amdahl, G., 2001, Disaster Response: GIS for Public Safety (Redlands, CA: ESRI Press).

American Society for Photogrammetry and Remote Sensing, 2002, Task Force for Model Law for Surveying (Draft Preliminary Report). http://www.asprs.org/asprs/news/ncees_frame.html

Association of Computing Machinery Panel on Professional Licensing in Software Engineering, 1999, ACM Panel on Professional Licensing in Software Engineering Report to Council.

Black, H.C. (Ed.), 1990, Black's Law Dictionary (St. Paul, MN: West Publishing).

Burley, J.B., 1993, GIS Certification: Precedents and Choices. URISA Journal, 5(2), 17-19.

Chrisman, N.R., 1984, The Role of Quality Information in the Long Term Functioning of a GIS. Cartographica, 21(2), 79-87.

Chrisman, N.R., 1999, Speaking Truth to Power: An Agenda for Change. In Lowell, K. and A. Jaton (Eds.), Spatial Accuracy Assessment. Land Information Uncertainty in Natural Resources (Chelsea, MI: Ann Arbor Press), 27-31.

Connolly, J. and T. Yager, 2001, Do Certificates Matter? Infoworld, 22(January), 33-34.

Egenhofer, M., 1997, Editorial: Consistency Revisited. GeoInformatica, 1, 323-325.

GIS/LIS, 2000, GIS/LIS Addendum to the Report of the Task Force on the NCEES Model Law for Surveying, http://www.acsm.net/gislisreport.pdf

Goodchild, M.F., 1998, Uncertainty: The Achilles Heel of GIS? Geo Info Systems, 8(11), 50-52.

Harvey, F., 1998, Improving Access to Geographic Information Quality, First AGILE Meeting, Enschede, April 23-25, 1998.

Henstridge, F., 1999, GIS and the Surveyor: Who Will Control the GIS? Professional Surveyor, 19(9), http://www.profsurv.com/ps_scripts/article.idc?id=510

Huxold, W.E., 2000, GIS Certification and Accreditation: It's Time to Get Serious (Lest We All Become "Data Mappers"). http://www.ncgia.ucsb.edu/other/ucgis/certification/huxold.pdf

Joffe, B., 2001, Surveyors and GIS Professionals Reach Accord. Surveying and Land Information Systems, 61(1), 35-36.

Joffe, B., 2002, NCEES Approves Revision to Model Law for Surveyors, Directions Magazine, August 28, 2002, http://www.directionsmag.com/article.php?article_id=247

Morrison, J.L., 1995, Spatial Data Quality. In Guptill, S.S. and J.L. Morrison (Eds.), Elements of Spatial Data Quality (Oxford: Elsevier Science), 1-12.

National Council of Examiners for Engineering and Surveying, 2001, Model Law, Surveying and Land Information Systems, 61(1), 5-23, www.ncees.org

Obermeyer, N.J., 1993, Certifying GIS Professionals: Challenges and Alternatives. URISA Journal, 5, 67-76.

Obermeyer, N.J., 2000, GIS Certification and Accreditation: An Idea Whose Time Has Come, http://www.ncgia.ucsb.edu/other/ucgis/certification/obermeyer.pdf

Obermeyer, N.J., and H. Onsrud, J., 1997, Educational Policy and GIS: Accreditation and Certification, http://www.ncgia.ucsb.edu/other/ucgis/ed_priorities/aandc.html

Schmidt, W.A., 1999, Second Thoughts: Surveying and Geomatics. www.profsurv.com/ps_scripts/article.ide?id=498

Somers, R., 2000, Defining the GIS Profession and Debating Certification and Regulation. GeoSpatial Solutions, 10(May), 22-29.

Somers, R., 2002, Certification Progresses. But How Will It Help? GeoSpatial Solutions, 12(June), 38-41.

Texas Appraiser Licensing and Certification Board, 2001, Requirements for Becoming a Certified or Licensed Real Estate Appraiser or an Approved Appraiser Trainee. www.talcb.state.tx.us/pdf/forms/requirements.pdf

Walker, D.M., 1980, The Oxford Companion to Law (Oxford: Clarendon Press).

Widmer, F., 1997, Qualität in der amtlichen Vermessung. Vermessung, Photogrammetrie, Kulturtechnik, 95(4), 172-176.

Wilson, L., 2001, Certification vs. Licensing. www.anma.com/licvscert.htm