The Why, What And How of GIS Standards: Issues for Discussion and Resolution

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Abstract: *Creating standards for GIS/LIS is a long-running issue and open discussions at past conferences and meetings have helped outline broad concerns. This paper serves to focus relevant topics on the major standards issues that face state, regional and local governments in order to facilitate further dicussion. It examines why standards are needed, when they are needed and what standards are needed in GI/LI systems. Finally, comments from a standards review panel at GIS/LIS '91 in Atlanta are incorporated, organized by 10 issues identified in the first sections of this paper.*

Standards are the result "when people consciously get together to develop a method to solve a recurring problem or establish standards by plan in order to avoid the problem—creat[ing] intentional controls (standards) that require written form." (Sullivan, p.5) Standards have long been recognized as a necessary component of trade and commerce. "The earliest written standards were for weights and measures—to control dealings among individuals." (Sullivan, p.5) Over 3,000 years before Christ, the Egyptians developed a standard measurement, based on the length of the forearm of the pharaoh, which they called a cubit. The length of a cubit was "standardized" at 20.63 inches.There were standards for dividing a cubit into smaller lengths as well. The cubit was used as the basic measure for the pyramids and for Noah's ark. (Sullivan, p.5)

Sullivan asserts that the effectiveness of a standard depends on the standard having sufficient value and a sufficient number of people willing to observe it. (Sullivan, p.7) He also notes that we shouldn't expect standards to make a perfect world, since "it is not possible to either perfectly define all uses, not to foresee all contingencies." (Sullivan, p.7) Nor should we be surprized that those who promote standards sometimes have vested interests, such as gaining access to a potential market that has been previously limited due to proprietary restrictions.

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It is a given that it is not practical to create a perfect standard. There are many dynamics that affect the development, implementation and use of GIS standards. Those involved early on saw GIS standards as primarily a data file transfer exchange issue. Now, as Tosta (1992) points out, a new standard framework has emerged in addition to the data exchange: standards about metadata—"information about (the) characteristics of data is essential to intelligent use of data."

This paper documents the evolving process of discussing standards—primarily in the transfer and exchange context. In the future, metadata requirements will need to be added to URISA's standards agenda.

The issues identified by Sullivan, along with issues suggested by URISA members led to the development of this paper. The URISA Board of Directors (BoD) appointed a committee in 1989 to begin looking at the issue of GIS/LIS standards. The Association's publications began to include discussions on a fairly regular basis. Delegates from URISA participated in several conferences and meetings to collect information and help guide policy in the standards arena.

Two conferences in particular were important in developing a URISA position on GIS/LIS standards: GIS/LIS '90 in Anaheim, California, and URISA '91 in San Francisco, California. These meetings enabled URISA members to share their ideas and concerns in open-discussion forums. In addition, 12 invited speakers from a broad cross-section of the geographic and land information (GI/LI) community presented their ideas on specific aspects of GIS/LIS standards at San Francisco. Three major conclusions were drawn from these discussions:

1) Standards are an important and complicated issue.
2) Standards are needed if URISA members are to maximize the use, effectiveness and societal benefits in GI/LI systems.

3) Much work remains to be done in the area of GIS/LIS standards.

Following the San Francisco meeting, the authors prepared an earlier version of this paper to begin bringing some focus to the issues identified and to facilitate further discussion. That paper served as the background paper for a discussion held at GIS/LIS '91 in Atlanta. Because of the richness of that discussion, a summary of the panel member responses appears in this paper.

We draw heavily here on the work of several authors who have been active in URISA. We do so for several reasons, including the importance of an understanding of the needs of URISA members for GIS/LIS standards, and because of the extended time and effort many URISA members have devoted to this issue. For example, the 1991 URISA presentation by Wellar, and an earlier paper by Wellar and Parker (Wellar and Parker 1971, pp. 429-444) proved to be especially insightful. Also, the URISA paper by Croswell and Ahner (1990, pp. 88-105) provided a taxonomy of standards and GIS/LIS user needs that is particularly helpful in dealing with the question of what standards are needed.

This paper is laid out as follows: the next section considers why standards are needed; the following sections discuss the timing of standards (i.e., when standards are needed), what standards are needed in GI/LI systems, and some suggestions as to an appropriate approach for use in the development of GIS/LIS standards. Finally, we summarize the questions we asked the review panel at Atlanta to address and provide a compilation of their responses. Their comments are organized by the 10 issues identified in the prior sections. Throughout the paper, the focus is on the major standards issues that face state, regional and local governments, issues that have had relatively little discussion at a time when the number of GI/LI systems and users are both exploding.

Because of the two-year time period involved in the preparation of this paper and the subsequent discussions, there have been several relevant developments in the geographic data standard field. This includes the adoption of the Spatial Data Transfer Standard (SDTS) as FIPS (Federal Information Processing Standard) 173, development of topological-vector profile, discussion of a raster profile, and major standard efforts in a number of states including California, Florida, Texas and Wisconsin.

Finally, this article is submitted as one view of GIS/LIS standards issues as seen by a substantial portion of the URISA membership. The goal here is to organize what is known about issues that are related to GIS/LIS standards and make suggestions as to how to organize, prioritize, and carry out the work needed to resolve these issues.

Other views exist and may present equally valid viewpoints as well. However, we submit that the views presented here are worthy of attention on a priority basis, in order to insure the usefulness of the databases being constructed for the many GI/LI systems that currently exist or are being built.

Why Standards are Needed

There are several reasons for the recent increase in interest in standards for GI/LI systems. The number of GI/LI systems in place is growing rapidly. One software vendor alone has already installed over 10,000 systems. Further, the databases for these systems are being constructed at a rapid rate as well. These databases are *the* most costly portion of total costs of these GI/LI systems. Therefore, sharing of these databases, among agencies within a jurisdiction as well as among two or more jurisdictions, is one way to reduce database costs, as well as assure their long-term viability. According to Croswell and Ahner (1990), sharing of these data requires the use of a variety of standards, including:

1) hardware and physical connections
2) network communications
3) software
4) data formats
5) data presentation/user access
6) user design
7) quality factors

Therefore, standards are needed for a variety of purposes, particularly if the expectation of maximizing the effective use of GI/LI systems is to be met. Henry Tom suggests that "[e]ffective use of computer technology includes the ability to interchange computer data, software, and hardware. This ability, in large part, is dependent on standards." (Tom 1988, p. 142). Tom further suggests that the ultimate success of GIS/LIS is contingent upon integration, and that widespread integration requires long-term solutions that are "dependent upon compatibility defined by standards." (Tom 1988, p. 143)

Croswell and Ahner (1990, p. 88) identify resource sharing as the central theme that is pushing standards development: "The interest in distributed computing has demanded products which allow connection between devices, exchange of data, flexible access to software programs, and consistent procedures for user interaction." They further argue that standards are most important when hardware and software of different vendors must be linked or "where independently created databases must be exchanged."

Others may argue that reports on federal data duplication in the early 1980s, (and again recently—National Mapping Sciences Committee 1993) along with pressure from the Office of Management and Budget have had a major impact on *federal* efforts to develop transfer standards in the last 10 years. While this is undoubtedly true for transfer standards such as SDTS, efforts to *exchange*

and *share* data are much more important, at least at the state, regional and local levels. (Miller 1993)

Even when the need for standards is recognized, Wellar argues that there are enigmas that seem to delay or otherwise hinder standards implementation. (Wellar 1971, pp. 429-430) For example:

1) Standards frequently exist, but are not formally documented (i.e., *de facto* standards),
2) Standards that exist in one department are not adopted by others due to political, logical, or technical reasons,
3) Agreements in principle do not always lead to agreement on methods for achieving standards,
4) As changes occur over time, changes in standards are frequently needed, and
5) There has been an explosion in the need for a wide variety of data in a wide variety of formats, needs which have outstripped both the development of computer standards and computer standards needed to meet the requirements produced by these changes.

Twenty years after Wellar's paper, GIS/LIS standards are still needed to address these roadblocks, as well as for a variety of other reasons.

Many efforts aimed at developing standards for various aspects of GIS/LIS have been under the auspices of federal agencies or vendors in the private sector. Examples include IGES, ISIF, and DXF for data structures; DOS, UNIX, and SQL for software (including operating systems); and standard data formats such as addressing to define street name, type, and prefixes, as well as address number. The release of the draft SDTS in April of 1991 certainly broadened and heightened the discussion of standards. (U.S. Department of Interior 1991) The formal adoption of the SDTS as FIPS 173 on July 29, 1992 appears likely to further fuel these discussions.

Recognition of the need for standards to facilitate the transfer of digital data started the process—lasting nearly 10 years—that produced the SDTS. The numerous workshops and meetings involved in the production of SDTS undoubtedly have had a major impact on the digital spatial data standards in the United States, as well as other developed countries (for example, Australia has relied almost entirely on the SDTS for the development of their spatial data transfer standard). Whether the now-adopted FIPS 173 standard will meet the expectations and needs of many users, especially below the federal level, remains to be seen.

Nevertheless, the many leaders who were key players in the development of the SDTS are to be commended for their foresight and tenacity in efforts to deliver a product. Worthy of special mention in this group are the U.S. Geological Survey, Rupert Southard, and Harold Moellering from Ohio State University. The supporting documentation for the SDTS effort is especially noteworthy.

While it is too early to determine the impact that FIPS 173 will have on the GI/LI community, it appears likely that the standard itself will face several of the same problems that face all GIS/LIS efforts. The technology available to deal with GI/LI continues to evolve rapidly. Capabilities that are common in GIS software today were unknown or only dreamed of, or wished for, 10 years ago. Parallel with advances in technology have been increasing expectations of the user community. Finally, the focus has shifted from "how do we share, improve, and display map information" to a broader one of "how do we share, improve, analyze, and display information that has a spatial dimension."

Some, (including one reviewer of this paper) disagree with our assertion that SDTS was conceived and developed in a largely cartographic context. However, the attention given to map symbology and the lack of attention to significant aspects of land information that are largely the purview of state, regional and local government agencies produced a result that is less than ideal for most users at the state, regional and local levels. In spite of the adjustments made during the 10-year process of developing the SDTS, the result is a standard that has been referred to as a federal agency standard, has a cartographic emphasis, and gives attention to large data transfers as opposed to transactional, on-going data sharing among users. (By some, SDTS has also been called an "academic standard" because it attempts to address an unlimited amount of data types in contrast to the more narrow focused digital transfer standards used by the Defense Mapping Agency (DMA).

In fairness, the developers of the SDTS have never asserted that it would solve all of our spatial data handling problems. Therefore, the point of the above discussion is that while the SDTS addresses many spatial data transfer needs, particularly at the federal level, much work remains to be done to address state, regional and local needs. (This is of major importance because in the long run, local, regional and state governments collectively spend more on data development, transfer and management than federal agencies.)

Two issues that were identified in the review process of the SDTS illustrate some items that many would include in this "work to be done" category.

Issue # 1:

Is SDTS (i.e., FIPS 173) the right model for state/regional/local GI/LI Standards?

This issue is related primarily to the concerns noted above regarding the focus on federal agency needs and an emphasis on data transfers (i.e., large, one time, or at most a few times), generally in one direction, as opposed to true data sharing, involving the frequent moving of data in both directions among sharing agencies.

Issue # 2:

How are the significant transactional data requirements of state/regional/local government to be met.? (i.e., Does the adoption of FIPS 173 help in management of tax parcels, deeds, and similar land records?)

The vast majority of all land data is currently located in state, county, city and other local government offices. These data are transferred in much smaller "batches" and much more frequently than are data at the federal level. Indeed, there is a much greater tendency to exchange and share data files back and forth at the state and local levels than at the federal level. Finally, the SDTS does not include many of the components (e.g., definitions related to parcels and resource polygons), that seem to be necessary to satisfy these local and state needs.

Issue # 3:

What are the economic issues that are driving standards development?

Wellar and Parker have suggested that it is possible to ignore standards for a while, but because of the pervasive nature of standards and standardization, sooner or later the following kinds of questions are invariably raised:

- Is our definition of data element the same as theirs?
- Are the geographic boundaries being used by Department A the same as B?
- Did the timing of our survey coincide with that of the Census?
- Are the coding structures and formats of magnetic tape #AQ0711 compatible with our system?
- Are there other applications for which this expensive data set can be used?
(Wellar and Parker 1971, p. 432)

Gurda suggests that the need to economize resources is one of the two main reasons why standards are needed. The other reason is to simplify the development and operation of LIS/GIS systems. Ways Gurda identifies to simplify and economize include: exchange, coordination, collection, maintenance, application and long-term management/strategy. (Gurda 1991, p. 2)

There are a number of economic benefits that are assumed to accrue if standards are developed. Those benefits identified by Croswell include:

- Reduction in data processing costs in time, money, and effort,
- Decreases in the development and testing cycles for software,
- Facilitation of data and software interchange and conversion,
- Reduction in inconsistencies, complexities, and diversity of technical issues,
- Improved quality and management control,
- Increase in the number of product choices, and
- Generally provide a firm basis for growth and expansion.
(Croswell and Ahner 1990, pp. 143-44)

Craig *et al.* (1991) assert that "the biggest reason for sharing data is to save the cost of conversion; that is, translating the paper map into digital form." While there are significant costs to developing multi-use systems, there are major costs that must be accounted for if we do not develop such systems. Wellar, in fact, concludes that "the managerial and social costs of *not* developing comprehensive information systems will be devastating, if not fatal, to this democracy." (Wellar 1972c, p. 42) The need for standards increases as the number of tasks, functions and users for which a multipurpose LIS is used increases.

Issue # 4:

Differing objectives will produce different results in standards development.

This issue is particularly important regarding the efforts of the federal government vis-a-vis state and local government and the private sector. For example data needs of local and state government, and hence standards, are frequently driven by regulatory mandates imposed by other (usually higher) levels of government. The need for economy, efficiency, and integration also drives the need for standards. Federal data needs are more often driven by particular program responsibilities, (such as a periodic Census; delineation of wetlands or soils; or the evaluation of a particular program). However, there are increasing examples of Congress imposing mandates resulting in the need to collect and analyze information. Examples include the Swampbuster and Sodbuster provisions of the 1985 and 1990 Farm Bills, the Wetland Permitting Requirement as a result of the Clean Water Act, and floodway mapping requirements for the flood insurance program administered by the Federal Emergency Management Agency (FEMA). Again, differing specifications of data elements, items, and formats often lead to a number of specific problems as to standard setting and use. Wellar and Parker (1971, pp. 433-34) suggest the following as examples:

- Different data elements are sometimes required by different agencies to meet the requirements and mandates of programs that [have] similar subject matter.
- Producers of data such as the Bureau of the Census face a multiplicity of demands, but only selected requests can be met.
- Definitions of data elements used in programs may vary between and even within governments or agencies in the same political entity.

- User needs may vary in terms of timeliness, level of aggregation, and quality of the required data sets.

Issue # 5:

Democratization of information access is one of the primary goals of GIS/LIS development.

There is the widespread belief that LIS/GIS systems should be used to provide maximum access to the largest user base at minimum cost. However, reaching this goal is contingent on a variety of factors including privacy, liability, and relevant Freedom of Information statutes. The potential for misuse of publicly available information is great, however. Therefore, the need for consistent, well-documented information increases as ease of access increases.

Wellar has noted that data interchange is subject to the development and enforcement of restrictions that relate to confidentiality of data. He also suggests that "it may be unwise to develop the technology for interchanging data before resolving the propriety of such interchanges." He cautions that because "standardization is intended to facilitate data flows (among other things), it prompts the issue of whether or not it enhances the opportunities for abuse or misuse of confidential data." (Wellar 1972b)

Ultimately, more federal and state agencies are becoming involved with programs that have a significant impact at the local and regional level. Wellar asserts that one of the major deterrents to the effectiveness of these programs is "data problems, such as temporality, aggregation, incompatibility and confidentiality." (Wellar 1972c)

Finally, standards are needed because "no aspect of database development is independent of standards or standardization procedures. The reason for this is that unless a data element or item has a singular or unique characteristic or attribute, it will be related to some [other] element or item in some data set at some point in time. The development of a relationship may occur within or between any of the specification, acquisition, processing, dissemination, or application phases, but it will occur." (Wellar 1972a, p. 26)

Therefore, we believe there is a clear need for the development and implementation of GIS/LIS standards. As Wellar has suggested (1972c), while information systems cannot solve all of our problems, they do provide a means for bridging the gaps between urban and regional theory and applications, research and development. In the next section, we will consider appropriate timing for putting GIS/LIS standards in place.

When Do GIS/LIS Standards for State/Local Government Need to be in Place?

Issue # 6:

Is now the time to create state/local GIS/LIS standards?

The response of many to this question would be "now" or "yesterday" but there are others who would suggest caution in developing standards. For example, Michael Goodchild, director of the National Center for Geographic Information and Analysis (NCGIA), urged caution during the 1991 URISA Conference Theme Day on Standards at San Francisco. Goodchild (1991) stated that it may be too early to develop GIS/LIS standards, and that it may be more profitable to focus on the process of developing standards. Two years later, there is still merit to this idea.

The danger in not addressing GIS/LIS standards immediately is that those who are the most interested, and hopefully have the most to offer to the discussion, may be left out if involvement is delayed. That is, the development of GIS/LIS standards will proceed forthwith, regardless of whether persons with an interest in state and local GIS participate or not. Wellar (1991) cites the danger in this approach: "A few [people] may determine what many have to live with for a long period of time."

Part of the disagreement over timing appears to be due to varying views of what GIS/LIS standards are and should be and who wins or loses when across-vendor comprehensive standards are implemented. For instance, McDermott says GIS/LIS standards are not a user guide. He cites the SDTS as a good approach to standards that provides the terminology and other parts of a standard necessary for both users and producers of data. McDermott (1991, p. 10) concludes that "[t]he time for spatial data standards is here—[and a] mechanism for the exchange of spatial data such as SDTS [Spatial Data Transfer Standard] is long overdue."

Others have suggested an appropriate method for developing a GIS/LIS standards manual is to include both standards and a user guide in one manual. This latter approach, used in the Maritime Provinces of Canada, was discussed by Mary Ogilvie of the New Brunswick Geographic Information Corporation at the 1991 URISA conference. Ogilvie indicated the importance of laying out an overall strategy for standards development, getting users and other interested parties involved, and then prioritizing the work to be done. (Ogilvie 1991) New Brunswick has used this procedure and has made substantial progress since first beginning work on GIS/LIS standards in 1990. Thus far, New Brunswick has produced a standards manual that contains chapters on:

- Land policy information
- Summaries of existing provincial and federal databases
- Standards dealing with spatial referencing
- Feature and entity classification
- Real property information (New Brunswick Geographic Information Corporation, 1991, New Brunswick Land and Water Information Standards, May)

The standards manual is a loose-leaf document, with periodic updates planned after it is completed.

In 1991, Henry Tom suggested that we should develop a workable, acceptable standard that can be developed in a time frame that allows it to be useful. (Tom 1991) This suggests that we proceed as quickly as feasible, given the stated conditions, but leaves the specific timing open-ended.

The 1989 Executive Forum on Local Government GIS/Data Sharing, sponsored by URISA and NCGA (National Computer Graphics Association) concluded that "a minimum amount of data standardization is necessary to insure that various data layers can be shared, and when necessary, integrated, based on common locational references." (URISA and NCGA 1990, p. 34) The Urban GIS/Data Sharing Guidebook produced by this forum outlined four issues on which agreement is needed in order to facilitate data sharing and GIS use:

1) A standard map series providing a common locational reference with which various data layers may be built by different departments,
2) Map feature coding conventions,
3) Definition and use of data quality standards, and
4) Conventions to transfer data between different mapping software and hardware environments.

Current levels of GIS/LIS activity by state and local governments suggest there is a need for at least a "minimum standard set" sooner, rather than later. That is certainly what counties are telling the Wisconsin State Land Information Board, the body charged with policy development and administration of the Wisconsin Land Information Program. The results of the Croswell survey reported in 1990 also suggest it is time to move ahead. This conclusion is based on the fact that state and local governments can identify and rank many standards issues they currently face. (Croswell and Ahner 1990, pp. 96-99) The key seems to lie in our ability to identify major standards issues, prioritize them, and rapidly move ahead to address them.

We conclude this section on appropriate timing of GIS standards with an observation of Henry Tom, of the National Institute of Science and Technology. "Timing for GIS standards is critical. Standards appearing too early can stifle innovation, while the arrival of standards after they are most needed is too late." (Tom 1988, p. 150) We suggest that a concerted effort to develop GIS/LIS standards at the state/local levels of government is needed, and needed now.

What Standards Are Needed?

This section considers a taxonomy for computing/GIS standards, proposed by Croswell and Ahner (1990), as a basis for beginning the codification of language concerning standards for GIS/LIS.

Also borrowing from Croswell and Ahner (1990), a review of important standards issues is presented. A key issue is to determine the acceptability and relevance of both the taxonomy and type of standards needed. An executive summary of Croswell and Ahner is included in this section to set the stage for the next section—**How.** The critical question: Is the Croswell and Ahner (1990) view robust enough to use as a departure point to address the *How* and the *Who* of GIS/LIS standards? The authors of this paper and the panelists at GIS/LIS in Atlanta conclude that it is, at least until something more robust emerges.

Taxonomy of Standards

Six categories of computing standards from Croswell and Ahner (1990) illustrate the range and complexity of the overall standards issue. These are presented in Table I of "Taxonomy of Computing Standards" (Croswell and Ahner, 1990 p. 90) and described as follows:

1. Hardware and Physical Connector Standards.

These standards provide the means to connect various hardware devices. An example is the RS. 232 standard for asynchronous communications. Of immediate interest to GIS/LIS users, especially local governments, is the need for interface standards with optical, image, and document storage devices.

2. Network Communication Standards.

Communications between hardware devices involves the transfer of binary digits. Protocols which describe these "bits" must be packaged in such a way that they can transmit all the critical information. Standard protocols are emerging but data processing environments responsible for GIS/LIS implementation are dependent upon proprietary software associated with specific vendor solutions.

3. Software Standards.

Operating system standards, through the adoption of DOS for personal computers and UNIX for intelligent GIS/LIS work stations, are assisting the GIS/LIS community to implement compatible systems. Also, the inclusion of third-party relational database systems for at-

tribute data storage and management have created linkages with large existing tabular data sets.

A major remaining issue, for appliers of GIS/LIS technologies, is that the current application programming situation is dominated by proprietary solutions limiting the ability to share applications across vendor platforms.

4. Data Presentation and User Access.

Tools are needed by GIS/LIS users to extract, display, and produce geographic representations. One such display example that is supported by many software and hardware vendors is the Graphics Kernal System (GKS). Adherence to this standard ensures display flexibility and is compatible with a variety of display and output hardware. Another technique that is being implemented is graphical user interfaces (GUI) which allow the GIS/LIS user to "point and click" vs. using the more tedious and less "friendly" command language technique. The use of a standard GUI across the GIS/LIS industry would allow users to become more efficient as they interface with multiple vendors. "X" windows is such an example that may prove to be a GIS/LIS industry-wide GUI.

5. Data Structures.

Probably this is the most complex, misunderstood, and most difficult class of standards for the GIS/LIS industry and its users. For the storage, access, and manipulation of non-graphic attribute data, the relational database has proved to be quite adaptable and useful. Most GIS/LIS vendors now support links to these third-party systems. The characterization of the geographic or spatial component remains as the most perplexing and insidious restraint to the GIS/LIS user and to the exchange of graphic data.

This problem of spatial exchange is at the root of the GIS/LIS standards debate. From which data structure did the vendor emerge—raster or vector? The need to bridge the interface between these two fundamental data structures is beginning to be addressed by the GIS/LIS industry. As Croswell and Ahner (1990, p. 94) point out, two graphical exchange conventions are emerging:

- translation formats that are designed to go between vendors, such as between Intergraph and ARC/INFO, or Synercom and ARC/INFO.
- translation format from one vendor to an accepted *intermediate exchange mechanism* . Then to another vendor (e.g., the previously discussed SDTS)

At the root of this dilemma is that most of the early graphic data exchange formats were designed to handle engineering graphics and the parametrically defined items involved in engineering and architectural applications. The advent of GIS/LIS users, whose applications required the use of more complex spatial inquires such as overlay, buffering, and network analysis, required that the spatial relationships between spatial entities be maintained (i.e., spatial connectivity and adjacency relationships). These user-driven needs resulted in data structures which topologically structured these relationships. Interchange between non-topologically structured data sets is not an issue—the major standards issue is the interface between the more intelligent data structures without losing the essential spatial relationships.

6. User Design Standards.

Most of the standards associated with the issue of attribute data classification, coding rules, map accuracy, quality control, and map design have historically tended to be the responsibility of the user and the implementer. However, as users want or are required to access and use other users data, classification standards become an issue. For example, street addressing and naming conventions become fundamentally important for such applications as E911 and disaster management. A collective transportation, land use, land cover, and land use zoning classification for use at all levels of government are yet other GIS/LIS standardization examples calling for some collective effort.

7. Additional Standard Issues.

Additional GIS/LIS database issues that we can add to the list of Croswell and Ahner, are the integrity and quality of the various data elements. For example, SDTS calls for a "truth in labeling" and a "lineage report" on each data element. Does an SDTS approach fit this need for a data quality indicator? These issues also suggest the need for a "standard of documentation" for data in the system. Another issue is the transactional nature and time sensitivity of databases, such as those in local government (e.g., register of deeds documents, building permits, and emergency management functions).

Critical Standards and Implementation Issues

On the assumption that it is the users of GIS/LIS technology who should assume the responsibility for determining the overall need for standards, which standard needs immediate attention, and who shall assume responsibility, Croswell and Ahner (1990) sent a survey to 50 experienced GIS/LIS professionals. Thirty responses were received. Eleven standards issues were identified. Each issue was ranked on the basis of "how critical the issue is to the successful implementation of a GIS/LIS" and "how well the issue, pertinent to GIS/LIS, had been resolved." (Croswell and Ahner, Figure 1, p. 98) By assessing the user community, Croswell and Ahner (1990) found the most critical standards and implementation issues are:

- the translation and data exchange of graphic files (note the apparent inconsistency between need for this standard and its implementation status. Is this response from the survey in anticipation that SDTS was going to fully address this exchange standard need?)
- GIS/(LIS) database update and maintenance procedures
- hardware and software vendors development and adoption of open standards
- map accuracy guidelines and requirements

The most important standards issues in need of research by industry and professional organizations are:

- hardware and software vendor development of open standards
- third-party interfaces to geographical data analysis and data management programs
- third-party database management system interfaces

The most important standards issues receiving the least attention by the GIS/LIS industry are:

- the development of a rating system that clearly identifies the quality of the data in terms of scale, accuracy, source, and reasonable use
- in support of this quality assurance process, the associated development of procedures by which the system is updated
- to provide an index that indicates the types of geographical analyses that can be accurately performed with the data.

A variety of GIS/LIS standards issues exist. These issues vary both in complexity and the progress that has been made in addressing them. There is a need to focus user attention and resources on data issues (e.g., data structures, attribute class, quality, integrity, and lineage of data and transactiuonal updates.) Many of the "non-data" issues are best left to vendors and other speciaized groups. Data standards are the most central current need, particularly for state and local units of government that are building and maintaining GI/LI systems.

The "How" of GIS/LIS Standards

This section addresses *how* to implement GIS/LIS standards. The previous discussion has pursued what standards are; why standards are relevant; when standards are relevant; and what standards are needed. What we can conclude from this is not unusual or surprising. The need for GIS/LIS standards is not a new idea—but has now moved from adolescence to young adulthood. Because database development drives the technology and remains the most expensive part of GIS/LIS systems, it is therefore the most important component of the successful implementation of the technology. The establishment of GIS/LIS standards is fraught with all the attendant problems associated with an industrial society moving at an accelerating rate towards automated information as the medium of currency and the communication highways as discussed at the recent GeoData Policy Forum (May 1993).

We have identified a number of issues related to how GIS/LIS standards should be developed, implemented, and maintained. These issues include:

Issue #7:

Who are the appropriate players in the GIS/LIS standards game and what are their respective roles?

Issue #8:

Who is responsible for resolving GIS/LIS issues, including those raised here and those that will be identified in the future?

Issue #9:

SDTS profiles—what is the priority for their development, who should develop each one, how much time and energy is involved in creating a user profile,and how should the profile development process, in general, be approached?

Issue #10:

Communications about standards—who should communicate what to whom?

As for who should assume the responsibility, we suggest the following. Part of the GIS/LIS standards responsibility dilemma is related to two issues. GIS/LIS is a technology that cuts across a variety of existing disciplines, professions and interests. As an industry it has no obvious nor influential advocate. (See Table 3 , Summary of Major Organizations Active in Developing and Promoting Computing Standards, Croswell and Ahner, (1990) p. 101.) Second, this lack of a single advocate for state, regional and local government creates additional institutional complexity in respect to the following:

- Who determines what standards are needed?
- Who advocates for the user community for the establishment standards?
- Who should participate (e.g., North American, Australians, Europeans, etc.)?
- Who drafts the standards?
- Who tests the standards for conformance?
- Who pays for the standards development process?
- Who assumes the overall collective leadership role so that the above questions are resolved?

Because the answers to these questions are not obvious, a major concern is who should assume this impor-

tant and complex responsibility. Using the categorization provided by Croswell and Ahner (1990, pp. 101–103), some options for consideration and discussion are:

A. Professional Associations

1) **Individual Professions Solution.** Each profession assumes its own interests (e.g., ACSM on mapping standards, IAAO on cadastral and tax standards, ASPRS on raster data structures, AAG on spatial analytical protocols, AM/FM on network protocols, URISA on transactional data structures, NCGA on computer graphic protocols, etc.)
2) **Collective Professional Solution.** Professions combine their efforts through a foundation or non-profit corporation structure. One such opportunity would be to utilize the newly focused "International Geographic Information Foundation" now being established by ACSM, ASPRS, AM/FM, and URISA.
3) **Ad Hoc Professional Solution.** Reconstruct the National Committee on Digital Cartographic Data Standards (NCDCDS), which worked through the American Congress of Surveying and Mapping. Leadership and resources provided by either the Federal Geographic Data Committee (FGDC), an alliance of professions (i.e., GIS/LIS), and/or other groups (e.g., NACO, IAAO, CSG).

B. U.S. and Canadian Governmental Organizations

1) **FGDC Assume Responsibility.** Request from OMB that FGDC assume leadership responsibility for the development, testing, and implementation of all GIS/LIS standards (previously FICCDC and DCDSTF). Professional associations and industry representatives act as steering committee members and/or advisers.
2) **Use DMA Standardization Efforts.** Request from OBM and DMA that all GIS/LIS standardization efforts become part of the public domain on a non-security basis.
3) **Use NIST/FIPS Process.** Request that federal agencies (through FGDC) promulgate a coordinated set of GIS/LIS standards (i.e., Croswell and Ahner, 1990) using the NIST/FIPS process.
4) **Canadian/U.S., Australian, European Process.** Establish an international GIS/LIS commission through the auspices of the UN, World Bank, etc. to promulgate a coordinated world-wide set of GIS/LIS standards.
5) **State/Local Process.** Through some individual efforts or some combination effort of NACO, CSG, IAAO, SMACs, State Geographic Information Council and State Land Information Boards, assume the responsibility to develop the capacity to develop and implement GIS/LIS standards.

C. Industry Consortiums and Trade Associations

1) **Market Place Process.** Let industry competition determine the rate and type of standardization. Overall user demand (market place) will result in the evolution and implementation of the most important standards.
2) **Corporation for GIS/LIS Standards.** Establish a non-profit international corporation with wide participation of the overall GIS/LIS industry whose responsibility is the establishment and implementation of GIS/LIS standards. Funded by industry. Professions act as advisors.

D. University Community.

1) **Individual University Participation.** Encourage university researchers and scholars to assume responsibility for the GIS/LIS standards development process. Augment this responsibility with governmental and association resources and funds.
2) **NCGIA.** Request that NCGIA assume the responsibility for the GIS/LIS standards development process by expanding the initiatives to include GIS/LIS standards.

The selection of a single approach, or a combination of approaches, is not an easy task. Therefore, it is useful if a set of criteria can be agreed upon in the selection of an approach. We suggest the list of criteria in Table 1, that draws on earlier work of Croswell and Ahner, Tom, and Wellar (Tom 1988, pp. 147-151; Wellar 1971b, pp. 14-15; Croswell and Ahner 1990, p. 104).

The following specific action items were presented to the panel in Atlanta to obtain suggestions for modification or recommendation:

GIS/LIS sponsoring organizations assume responsibility for crafting and implementing an action plan which facilitates the development, testing , and implementation of GIS/LIS standards.

As background for this facilitation, the organization seeks funding and support for the following tasks:

TABLE 1. Criteria for the Selection of a Strategy for GIS/LIS Standards Development and Implementation

1) Will the overall user community be involved in a meaningful way?
2) Is there a procedure to develop and follow an overall strategic plan?
3) Does the strategy include both problem-solving and structural viewpoints?
4) Is the strategy built on proven, logical principles?
5) Will the strategy be equally responsive to actual situations and needs as well as to theoretical ideas?
6) Will the strategy provide an orderly and timely procedure for developing and implementing GIS/LIS standards?
7) Will the strategy be flexible enough to allow modifications over time?
8) Is the strategy feasible, in terms of cost to develop, implement, use, and maintain in a feasible time frame?

a) Creation and testing of a SDTS profile for local government GIS/LIS transactional requirements
b) Assimilation of an annotated bibliography on the need, process, and implementation of GIS/LIS standards to serve as a base line for further efforts (now underway by URISA)
c) Codify the terms, acronyms, participants, and definitions related to the promulgation of GIS/LIS standards (to some extent now included in SDTS)
d) Expand the GIS/LIS user survey (Croswell and Ahner, 1990) to cover the entire GIS/LIS industry and its user community
e) Prepare a prospectus on the state and condition of GIS/LIS standards (i. e., by assimilating the tasks above). Publish this prospectus, as a major component, in one or more of the existing professional journals).
f) Most importantly, establish and/or facilitate a process and mechanism(s) which results in the development, conformance, testing ,and implementation of GIS/LIS standards for use by the GIS/LIS user community.

Regardless of which approach or strategy is used to develop, implement, and maintain GIS/LIS standards, it will not be an easy task. Wellar summarizes the challenge as a multi-dimensional phenomenon, with the result that a change in one place causes changes in other places. "We are involved in a continuous interaction towards achieving standardization in terms of what data we specify, and how we acquire, process, disseminate, and apply the data needed to monitor, analyze, and plan the status and use of our resources." (Wellar 1972a, p. 31)

If USGS, FGDC, NCGIA, the various professional organizations, the GIS/LIS industry itself, and state and local governments and their supporting professional institutions are to have meaningful roles, they must expand their coordination and consensus building efforts both within *and beyond* the Federal establishment (e.g., see NRC 1990, p. 3).

According to Wellar (1971b) and Tom (1988), it is also important, when deciding how to address GIS/LIS standards, to keep in mind that:

1) Standardization must have a direct purpose or objective,
2) A poorly conceived standards effort can do more harm than good,
3) Good standards should not have to be enforced, since the benefits of their use are obvious
4) All levels of government have major roles to play as part of a larger system or field of endeavor if any far-reaching breakthroughs are to be made.
5) Development, approval, and use of a standard is frequently a long and arduous process.
6) A maintenance organization [is needed to] address technical issues, answer questions, and notify users of changes and updates.

Finally, because of the many problems associated with GIS/LIS standards development, the two-pronged approach suggested by Wellar and Parker seems especially appropriate. "We will have to work toward them and live without them—both." (Wellar and Parker 1971, p. 441) This is just as true today as it was 20 years ago. It is obvious that timing of standards development is critical. If we add "geographic" to Wellar's standards of information system paper of 20 years ago, our lack of progress is painfully apparent.

Challenge to the Panel

An earlier version of this paper was the subject of discussion by an industry-wide panel at GIS/LIS '91 in Atlanta. The panel was asked to concentrate on *How* standards can be implemented to meet the needs of the overall GIS/LIS enterprize, including the needs of local and state government. Their comments on three areas are particularly helpful in furthering the standards discussion:

- The assumptions and conclusions presented here
- The priorities suggested earlier
- How best to select the appropriate institutional mechanism(s) and associated criteria described above.

But especially useful were comments to help reach consensus, if possible, on:

- *What* to do,
- *Who* will do it,
- Who will *pay*,
- What to do *now* and in what *order* to do it, and
- How to initiate the long-term process suggested by Goodchild.

Summary of Panel Responses

Since there were both extensive and very thoughtful verbal and written responses to the position paper, a summary of relevant responses are presented here. They are organized by each of the ten issues presented earlier. In addition, we provide conclusions based upon the material developed in the initial position paper, verbal comments from the GIS/LIS URISA sponsored session at GIS/LIS 91, and from the written comments provided by the panelists. With this as background, we offer recommendations on how to address each conclusion and respective issue.

Summary of Issues and Comments

Issue 1: *Is SDTS the right (most appropriate) model for state and local government?*

Panel Response: SDTS is primarily a standard for federal usage. Its usefulness for state and local government depends upon how much it is used by non-federal users (Tom 1991 p.3).

SDTS provides a standard mechanism for describing and moving data between computer systems, but that process is only a small piece of the GIS/LIS business (Tosta 1991 p.2).

SDTS only facilitates moving spatial data from one agency or system to another. It standardizes description and formatting of spatial data to make data sharing more feasible: SDTS stops short of specifying what data sets are worthy of widespread transfer, and what should be the content, quality and performance standards of these data sets (Cooke 1991, p. 2).

Conclusion: SDTS is a beginning but its overall usefulness remains unclear for state, regional and local government.

Recommendation: Clarify and publicize the intended role and purpose of SDTS and related proposed profiles.

Issue 2: *How are the significant transactional data requirements of state and local government going to be met, assuming SDTS is adopted? (e.g., in particular how well does SDTS manage tax parcels, deeds, and other land records?)*

Panel Response: SDTS is not a transactional standard. The purpose of SDTS is data exchange.

SDTS has been approved as a Federal Information Processing Standard (FIPS). As a FIPS, SDTS is only mandatory for federal agencies (Tom, 1991, p.3).

Conclusion: SDTS was not designed nor intended to address transactional databases or the needs of state, regional and local government. It does not appear to address data exchange. Rather, its function is one of data transfer, presumably of most use from higher levels to lower levels of government.

Recommendation: Ask FGDC to establish a formal mechanism and process to address transactional data transfer standards.

Issue 3: *What are the economic issues that are driving standards development?*

Panel Response: Economics of standards is not really the major issue. The integrative nature of GIS/LIS applications and the potential to address complex concerns is of major consequence (Tom 1991,p. 3).

Others argue that unless standards result in cost savings to state, regional and local government, adoption and use of GIS/LIS technology will be limited (Craig *et al.* 1991, p. 21; Wellar 1972c, p. 42).

Conclusion: The economic impact of standards is unclear. Data conversion consumes the major portion of any GIS/LIS state and local project. Multi use of digital data sets is an assumed benefit. Standards are crucial to that assumption. Multi-agency participation is needed to pay for standards development.

Recommendation: Request that NCGIA or those federal agencies with economic expertise such as USDA, USDI or universities sponsor /conduct a benefit /cost analysis of the impacts of standards upon the implementation of state and local GIS/LIS system.

However the cost to develop a standard such as a user profile for local records (e.g., cadastral) are not trivial. Those who have constructed SDTS profiles suggest their creation take considerable time and expense. Knowledgeable vendors stated that to create a local cadastral records standard would require hundreds of thousands of dollars. The funds required are of a level that precludes an individual governmental entity from pursuing such a solution.

Issue 4: *Differing objectives will produce different results in standards development.*

Panel Response: Mandates at the state and local level have a major impact upon standards development.— In home-rule states like Georgia there are exceptions (Blackmon 1991, p. 1)

Differing objectives should not produce different results because standards should address common and generic needs. Differing objectives may affect the order of priorities among users—this is why the GIS/LIS community (including state and local government) needs to represent itself in the standards development process (Tom 1991, p. 3).

Nested standards may need to be developed. Standards must allow for aggregation of classes, generalization of features, and maintenance of accuracy parameters with small tolerances in geographic area, for local to global use of data. Local data nests within state data, which nests within regional, which nests within federal, which nests within global (Tosta 1991, p. 2).

In respect to performance standards it is possible to develop standards for most spatial data; it is not feasible to set one performance standard that works for all kinds of spatial data. What is a reasonable coordinate accuracy standard for a national county boundary database is inadequate for describing cadastral boundaries for tax assessment and property transfer by local government (Cooke 1991, p. 3).

The task of setting performance standards for spatial data is possible by a divide and conquer strategy—in the development of taxonomy for selected spatial data these selected sets become the definitional focus for each component of the taxonomy (Cooke 1991, p. 3).

Four fundamental data sets are proposed. These four form the basis for a National Spatial Data Infrastructure (NSDI). For more discussion of the NSDI, see *Toward a Coordinated Spatial Data Infrastructure for the Nation* (National Mapping Science Committee 1993).

1) The base topographic layer: information historically provided on 1:24,000 USGS quads. Pressing and present needs for currency and our ability to process large amounts of spatial data make digital orthophoto maps a more useful

spatial database resource than traditional cartographically derived 1: 24,000 USGS quads.

2) The cadastral layer: property boundaries, parcel identifiers, building foot prints, etc. Digital parcel maps are fundamental to a modern land record system for local government.
3) The street centerline layer: effectively a mature TIGER Census file with reliable address matching and improved street center line coordinates in GBF/DIME areas.
4) A land use / land cover layer: fundamental information regarding biodiversity, soil, vegetation, wetlands and hydrography of sufficient resolution and reliability for defining such important measures like "no net loss of wetlands" regardless of how wetlands are legally defined (Cooke 1991, p. 3).

Conclusion: Tosta suggests a nested classification; Cooke and Tom suggest a strategic approach. Differences exist but consensus seems possible. Cooke states, "there is sufficient expertise and experience in the GIS/LIS community to set quality standards and good technical practices for building the nation's spatial data infrastructure (Cooke 1991, p. 3).

Recommendation: Request that FGDC focus its initial standardization energies upon a limited set of spatial data sets. The four data sets recommended by Cooke offer a balanced and strategic benefit stream for state and local government, the private sector and federal agencies.

Issue 5: *Democratization of information access is one of the primaty goals of GIS/LIS development.*

Panel Response: Widespread access to spatial data is of federal concern. Accommodating equitable access to spatial data is a policy issue being pursued by federal agencies (Tom 1991, p. 3).

Potential misuse of information must not be discounted. Standards which address consistent and well-documented spatial data underscores the importance for standards (Blackmon 1991, p. 8).

Governments generally have the necessary institutional perspective that considers the well being of society. All levels of government including local, state, regional, federal, and even global entities need to be involved (Tosta 1991, p. 2).

Conclusion: Timely and cost effective access to information remains a tenant of institutions based upon democratic principles. Automation of spatial information requires additional societal diligence.

Recommendation: The annual professional sponsors of GIS/LIS or other consortia invite and fund a series of issues papers on access to spatial information. Invited participants should include those responsible for system implementation, representatives from the legal community and citizen groups.

Issue 6: *Is now the time to create state and local GIS/LIS standards?*

Panel Response: Now is the time (Tom 1991, p. 3).

Discussion of standards has become common place at GIS/LIS conferences, symposia and meetings. But the use of the word "standard" is loosely defined. It seems to mean something different to almost everyone. There are needs for standards in the area of data, hardware, software, networks and personnel. The overall GIS/LIS community needs to prioritize and begin work on those areas where the need for standards is critical to the successful use of GIS/LIS (Tosta 1991, p.2).

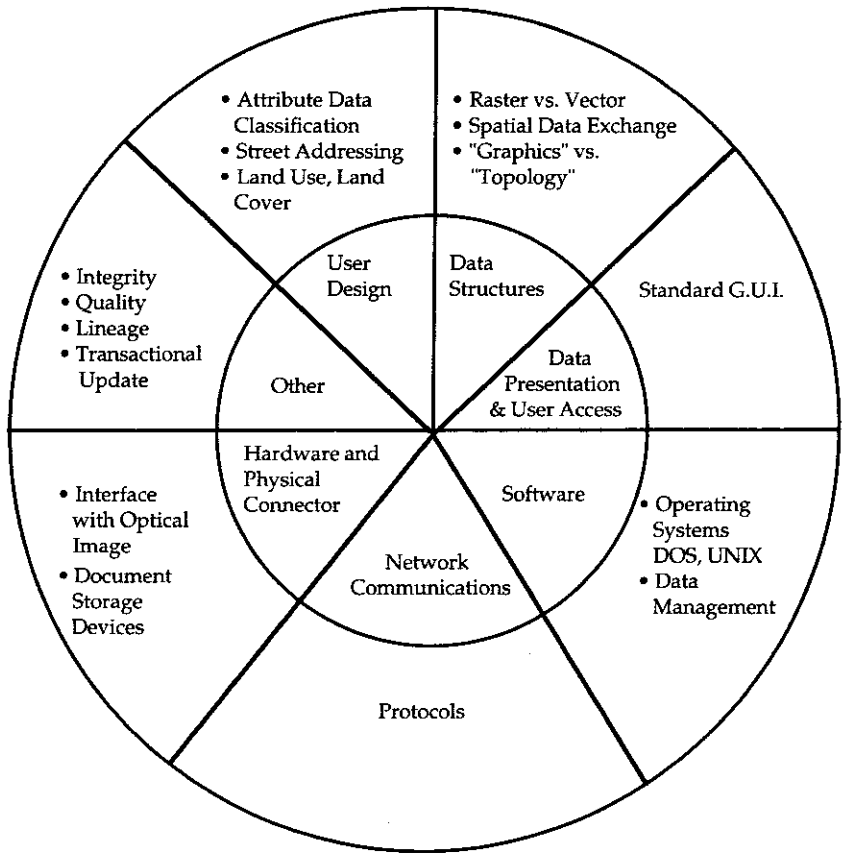
An agenda by which to prioritize standards is lacking; process models are needed because standards development is difficult and expensive (Blackmon 1991, p. 9).

GIS/LIS standards is too broad a subject to handle all at once. Technology for managing spatial information is applicable to practically all areas of human endeavor. As suggested by others a taxonomy of standards would be helpful in dividing the overall task into manageable pieces. In Figure 1, the Croswell and Ahner taxonomy is transformed into a pie-chart. (Cooke 1991) Some of the slices can be left to others. Others must be addressed by the overall GIS/LIS community. The slices best left to others are:

1) **Standards for Hardware and Physical Connection:** Today's $3000 micro has far more computing power than the 1980's $100,000 mini computer, not to mention a vastly better interactive graphics interface. Considering the robust hardware market, the GIS/LIS community shouldn't attempt to freeze any part of the hardware domain by a standards specification.
2) **Network Communications:** The much heralded LAN has arrived. Other information interests with more commercial clout and disposable expertise are championing this area of standards. The GIS/LIS community needs to focus its limited energies on areas of GIS/LIS specialization.
3) **Operating Systems:** Suddenly there has now developed an active competitive market in operating systems. Recent alliances of Apple, IBM, and Microsoft suggest a new family of operating systems is likely within two years. UNIX is maturing. The GIS/LIS community is benefiting from these efforts in both innovation and standards in operating systems.
4) **Data Presentation and User Access:** Competitive forces are moving this area of standards without direct involvement of the GIS/LIS community. The GIS/LIS community will not yet be satisfied with a single standard GUI (Graphical User Interface) due to its wide range or users with varying needs, skills, and interests.

What remains in the Croswell and Ahner taxonomy are the "data structures," "user design," and "additional slices." The common thread is these slices are data. Here is where the GIS/LIS community should focus its professional interest and responsibility. In the long view,

FIGURE 1. The Croswell and Ahner taxonomy as a Pie-Chart.



hardware and software are transient; good data are forever! (Cooke 1991, p. 2).

Conclusion: Except for Goodchild (1991, personal comment) who suggests that the process of what makes a good standard be investigated before standards are developed, the consensus position is to begin now but with a strategic focus. Using Croswell and Ahner's taxonomy Cooke suggests a plan for such a strategy (see recommendation).

Recommendation: Prepare written standards concerning performance, quality, and content for the "four broadly used spatial data sets" suggested by Cooke: base topographic layer, cadastral layer, street centerline layer, and land use /land cover layer (Cooke 1991). The preparation of these statements should be preceded by a clear written statement of goals and objectives in the form of proposal.

Issue 7: *Who are the appropriate players in the GIS/LIS standards game at the state, regional and local level, and what are their respective roles?*

Panel Response: Those that need to partake are the various professional and industry organizations such as: ASCM (American Congress of Surveying and Mapping), ASPRS (American Society of Photogrammetry and Remote Sensing), AAG (American Association of Geographers), AM/FM International, URISA (Urban and Regional Information Systems Association), and IAAO (International Association of Assessing Officers). Another state-level entity is the newly forming group, the National States Geographic Information Council initially sponsored by FGDC.

Their respective roles are to: inform, educate, and represent the specific and collective interests of the GIS/LIS community (Tom 1991, p. 3).

Conclusion: Those with an interest in standards need to step forward.

Recommendation: In 1992, we suggested that the collective professional solution was the preferred approach, led by the International Geographic Information Foundation (IGIF). The five societies (and others that may wish to participate), could provide a pool of necessary funds to support this standards preparation effort. However, given the financial and expertise requirements just to create a SDTS user profile, this may be a less viable recommendation. Also, for some of these organizations, financial issues are restricting their flexibility. The co-sponsoring of the annual GIS/LIS conference by these groups is also under review—possibly result-

ing in less interest by some to collectively participate in standards development.

Issue 8: *Who is responsible for resolving GIS/LIS issues, including those raised here and those that will be identified in the future?*

Panel Response: The resolution of standards issues needs to be through individual organization's standards committees and an industry-wide standards consortium (Tom 1991, p. 3). Expanding upon this thought (Tosta 1991, p. 2) suggests that professional organizations need to participate in standards development by providing forums for discussion and opportunities to share perspectives. Involving government players who have responsibility for the development of standards, provides exposure to GIS users, technology developers and the academic sector.

Conclusion: Essentially, the professional organizations are being requested to step forward and assume a leadership role for their members.

Recommendation: GIS/LIS conference sponsors establish an on-going annual forum and by formal invitation expand participation of other professional groups, vendors and the academic community to present, discuss, review, evaluate and introduce standards of consequence to their respective memberships and constituencies.

Issue 9: *SDTS Profiles - What is the priority for their development, who should develop each one, and how should the profile development process in general, be approached?*

Panel Response: Since the actual application of SDTS remains unclear (i.e., SDTS is not designed to address transactional structured databases) responsibility for establishing profiles remains unclear.

Conclusion: Since USGS and FGDC have fostered and promulgated SDTS, and given the expertise needed and staff resources required to write useful profiles, they are ideally positioned to help assure that state/regional/local needs are addressed.

Recommendation: Through communication with professional associations, the FGDC should keep each related professional organization informed as to the status of profile development.

FGDC should re-instate the state/regional/local group and work toward broad participation by state, local and regional participants.

Issue 10: *Communication about standards—who should communicate what to whom?*

Panel Response: Communication is critical in all aspects of standards development and use—be this for data, hardware, software or for those responsible for implementing and use of GIS. Professional organizations are the key in the communication process (Tosta 1991, p. 3).

Conclusion: Professional organizations and the FGDC need to establish formal mechanisms for communicating the status of standards.

Recommendation: FGDC should provide on a monthly or on some reccurring basis, copies for each professional association's newsletter; on an annual basis a summary of each professional meeting; and provide text for each association's journal.

Summary and Conclusions

As noted earlier in this paper, standards are produced "when people consciously get together to develop a method to solve a recurring problem or establish standards by plan in order to avoid the problem" (Sullivan 1983). This paper is the outgrowth of URISA having taken the initiative to act as a facilitator in the development of standards for GIS /LIS.

This version has benefited from ideas and suggestions from many discussants, reviewers, and colleagues. However, the authors remain responsible for any remaining errors of commission, omission, or not being able to keep up with the dynamic changes now underway technologically and politically between professional and governmental organizations regarding standards.

We look forward to a continuing dialogue on GIS/LIS standards, particularly as they relate to the increase in data sharing that must form a foundation for the long run success of GIS/LIS implementation and use. Unless we are successful in sharing the very expensive databases on which this technology depends, many system operators will find it impossible to maintain the financial and political support necessary to continue their system. And citizens who ultimately pay for these systems will see limited benefits.

To facilitate the continuation of the discussion of GIS/LIS standards, we conclude with a matrix (Table 2) summarizing the issues, conclusions and recommendations discussed in this paper. We trust that this table will foster continued discussion of GIS/LIS standards and that greater sharing of data will be the result, sooner than later.

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TABLE 2. Summary of Standards: Issues, Conclusions and Recommendations

Issue	Conclusion	Recommendation
1) Is SDTS the right model for state/regional/ local government?	It's a start, but usefulness is unclear.	Need to clarify the role and purpose of SDTS.
2) How useful will SDTS be in meeting transactional data requirements of state /local government?	SDTS is not designed to deal with transactional data.	FGDC should establish mechanisms to address transactional data transfer standard.
3) What economic issues are driving standards development?	Unclear—but cost-savings resulting from data share are potentially large.	Request NCGIA /universities/others to sponsor/ conduct benefit-cost analysis of standards impact.
4) Differing objectives will produce different results in standards development.	Several approaches are possible to develop needed standards.	Request FGDC to focus initially on a limited set of spatial data sets, but to include state/regional/ local needs.
5) Democratization is one of the primary goals of GIS/LIS	Timely and cost effective access to information is one of the basic tenants of democracy.	Associations (jointly or individually) solicit and fund a series of issue papers.
6) Is now the time to create state /local data standards?	Start now, with strategic focus, (see Cooke, 1991)	Prepare written standards concerning performance, quality, and content of four broadly used spatial data sets: base topography, cadastral, street centerline, and land use / land cover layers.
7) Who are appropriate players and what are their roles?	Professional and industry organizations need to inform, educate, and represent the collective interests.	IGIF should encourage a collective, professional approach.
8) Who is responsible for resolving current and future GIS/LIS standards issues?	Professional organizations should provide necessary leadership.	Professional associations (either collectively or individually) should sponsor on-going, annual forums.
9) What is priority order for SDTS profile development?	Developers of FGDC should facilitate the development of data profiles needed by all users, including state/regional/local governments.	FGDC should keep professional associations apprised of status of SDTS profile development.
10) Who should communicate with whom about standards?	Professional organizations need to establish formal mechanism for communicating information about standards.	FGDC should provide information to professional associations. • monthly for newsletters • annually for conferences • annually for association journals

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