

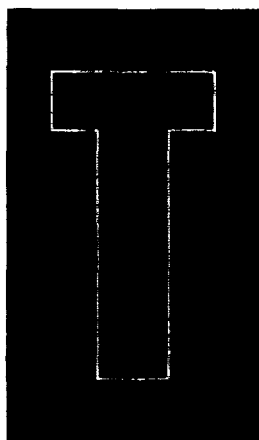


# Standards to Support the National Spatial Data Infrastructure

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■ This article provides an overview of the National Spatial Data Infrastructure (NSDI), the Federal Geographic Data Committee (FGDC), and the roles, responsibilities, and activities related to standards within the NSDI and the FGDC. Federal agencies have been assigned responsibility to develop standards to further the development of the NSDI. Identifying needed standards and the best approaches to developing them and promoting their use are areas of significant debate. The FGDC has established several subcommittees and working groups to facilitate these activities, but questions about who provides resources, who actually develops and implements standards, what standards are critical, how to develop the most useful standards, and how to encourage the use of standards are unresolved.



The recent rapid spread and growing sophistication of technologies, such as geographic information systems (GIS) for managing and using geographic information, have led to dramatic increases in the demand for digital geospatial data. Geospatial data can be defined as any information referenced to the Earth that describes the location (e.g., coordinates) or characteristics of that location. The spread of GIS technologies has been especially noticeable within government agencies. The distribution of GIS tools has also fostered an environment where digital geospatial data can be created by almost anyone, rather than being within the purview of a few centralized government agencies. This situation is resulting in a multitude of data sets, many of which are difficult to locate, and which, when found, may not be usable because of unknown or unacceptable quality.

The concept of a National Spatial Data Infrastructure (NSDI) has gained favor recently as a vision that could bring some much needed organization to the current geospatial data morass. The NSDI is conceived as an umbrella of technologies, policies, standards, individuals, and organizations that contribute to the collection, management, distribution, and use of geospatial data [Federal Geographic Data Committee 1994]. Current activities within the NSDI include development of a geospatial data clearinghouse to facilitate finding and gaining access to data; numerous partnership activities to coordinate production, management, and use of geospatial data among all levels of government and the private sector; development of a plan for building a digital geospatial framework data set as a foundation for additional collection and analysis of geospatial data; and a variety of standards efforts to facilitate the collection, transfer, and use of geospatial data. The feasibility of developing the NSDI has increased steadily over the last several years as geospatial data computing and telecommunications networks have become more pervasive.



Following is a description of the Federal Geographic Data Committee (FGDC), which is leading the NSDI efforts, and a discussion of the need for and role of standards in developing and maintaining the NSDI. This article is not intended to be a comprehensive or scholarly review of standards and GIS literature, but to provide a personal perspective on the NSDI, on the activities of the FGDC, on the need for standards in the NSDI, and on the challenges of meeting those needs.

## Background

It is difficult to pinpoint the origins of discussions about the NSDI in the United States, but the most likely source is the Mapping Science Committee (MSC) of the National Research Council within the National Academy of Sciences (NAS). This committee produced a report in 1990 about future mapping activities, which several times referred to a "national geographic data infrastructure," an "information infrastructure" and a "national spatially referenced digital data infrastructure" [MSC 1990]. Specific definitions were not offered, other than the statement that the "infrastructure will include not only myriad data sets. . . but also complex systems for coordinating, storing, processing, managing and distributing them [data sets]" [MSC 1990].

More recently, the NAS/MSC released a study titled "Toward a Coordinated Spatial Data Infrastructure for the Nation," acknowledging that new approaches to geospatial data collection and management must be developed if geographic technology use is to be widespread [MSC 1993]. This report defines the NSDI as the "total ensemble of geographic information at our disposal that describes the arrangement and attributes of features and phenomena on the Earth, as well as the materials, technology, and people necessary to acquire, process, store, and distribute such information to meet a wide variety of needs. In its broadest sense, the infrastructure also includes the cultural, environmental, economic, political, legal, and educational values and institutions that support, facilitate, and shape its character, including the forms in which spatial data are represented and utilized throughout society" [MSC 1993].

Concurrent with the NAS/MSC efforts, during the late 1980's the Office of Management and Budget (OMB) within the Executive Office of the President began to examine the activities of federal agencies related to collecting and using geospatial data. In October 1990, the OMB issued a revised Circular A-16, entitled "Coordination of Surveying, Mapping, and Related Spatial Data Activities," which identified the need for "eventual development of a national digital spatial information resource, with the involvement of Federal, State, and local governments, and the private sector" [OMB 1990]. The circular establishes the FGDC and assigns specific responsibilities for coordinating geospatial data themes to different federal departments, acknowledging, as noted

above, that nonfederal entities are to be involved as well. The specific coordination responsibilities assigned to federal agencies are as follows: "the facilitation of exchange of information and transfer of data; the establishment and implementation of standards for quality, content, and transferability; and the coordination of the collection of spatial data to minimize duplication of effort where practicable and economical" [OMB 1990]. Circular A-16 establishes the authority and responsibility for various federal agencies to coordinate the development and implementation of standards for quality, content, and transfer related to their primary data themes. The focus of these activities is on the data, not on the technologies for processing the data.

During the last four years, the FGDC has initiated several activities to make the NSDI operational and to assist federal departments in carrying out the responsibilities assigned in Circular A-16. Additionally, Vice President Gore identified the NSDI as one of the key initiatives to "reinventing government" in his National Performance Review Report in September 1993 [Gore 1993]. In April 1994, President Clinton signed Executive Order (EO) #12906: "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure." This EO designates the FGDC as the lead entity in developing the NSDI and provides a level of credibility and accountability for the NSDI that did not previously exist. The EO also specifies goals and dates for the various NSDI activities initiated by the FGDC. The EO reinforces the need for federal agencies to carry out their assigned responsibilities in developing standards and stipulates that federal agencies will not expend funds, either directly or indirectly, for geospatial data collection unless FGDC standards are met [Clinton 1994].

## FGDC Structure

The FGDC is made up of a collection of committees, working groups, and subcommittees. At the highest level is a steering committee, chaired by the Secretary of the Interior, Bruce Babbitt, and consisting of policy level representatives of thirteen other federal agencies with interests or activities related to geospatial data. The steering committee addresses issues of concern across agencies at a political or policy level and provides general oversight and endorsement of other FGDC activities.

Thematic subcommittees of agency representatives were formed by the federal departments with assigned responsibilities for coordinating geospatial data themes, including development of standards. A dozen subcommittees are addressing themes such as cadastral data, geologic mapping, surface transportation, cultural and demographic resources and vegetation. Additionally, a series of working groups are considering cross-cutting activities such as standards, clearinghouse (data access), and data archiving. The activities of the working groups are relevant to all of the thematic subcommittees. For example, the



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Standards Working Group provides general guidance on developing standards to all of the subcommittees and works on generic standards (e.g., metadata) that are not unique to any one theme of data. The chairs of the subcommittees and working groups (as well as any agency that does not have responsibility for chairing a subcommittee or group) make up the Coordination Group. The Coordination Group is charged with ensuring that all of these activities proceed in an integrated fashion.

For the most part, representatives in all of the groups of the FGDC are federal employees. However, a concerted effort is underway to involve representatives of nonfederal sectors through a series of open meetings and workshops, particularly when the discussions are related to standards. Some of the subcommittees have contracted with outside consultants to assist in developing standards. Others have opened their membership to include nonfederal representatives.

### **Standards Process**

The FGDC recognizes that standards dictated from the top down, with little involvement from the likely users of those standards, have little chance of acceptance. Thus, the FGDC has adopted a process for developing standards that depends on direct involvement of the user community. A subcommittee or other entity involved in geospatial data standards can submit a draft standard to the FGDC Coordination Group for review. The Coordination Group expects that the process of developing this draft included extensive discussions with potential users and implementers of the standard. The FGDC acknowledges that various standards authorities are already in existence, although none of these deals specifically with standards for geospatial data collection or representation. The submitting body is expected to identify what the ultimate authorities for adoption of the standard are likely to be. This means, for example, that the standard may be adopted by the FGDC, and may also be submitted to the National Institute of Standards and Technology (NIST) to become a Federal Information Processing Standard (FIPS), or submitted to the American National Standards Institute. The nature of the standard, its intended use and user base, and the goals of the submitting body are likely to determine the final authorities for the standard. The submitting body is also expected to recommend the long-term maintenance authority for the standard.

Submitting the draft standard to the Coordination Group sets in motion a series of activities that include announcement of the standard in the Federal Register, notice of the standard in a variety of GIS publications, discussion of the standard at national, regional, and local user group meetings, and solicitation of comments from the broad community of users. The submitting body is expected to review the comments received, react, adopt appropriate changes, and, if the standard is significantly changed, repeat the process. If the standard is complex or difficult to understand, the submitting body is expected to conduct pilot studies or other demonstrations to show the usability and applicability of the standard.

After these activities are completed and a final, fully reviewed standard has been submitted, the Coordination Group officially votes on whether to adopt the standard. If accepted, the standard is then forwarded to the Steering Committee of the FGDC for formal adoption. Throughout this process, federal representatives are expected to keep their agencies informed. The final vote within the FGDC signifies federal agency endorsement of the standard.

This process was recently followed in the adoption of the metadata standard. This standard was established to catalog geospatial data for the clearinghouse and to understand data quality. The entire process, from an initial workshop on the need for a standard, through broad-based testing and review of the standard, to official adoption of the standard by the FGDC on June 8, 1994, took approximately two years.

### **NSDI Standards Issues**

As more organizations use GIS technologies for managing and analyzing information, the need to share data increases. This is partly a function of the tremendous costs associated with producing geospatial data bases and partly the GIS's ability to integrate numerous forms of geospatial information. The NSDI is built on the premise that geospatial data collection has become a much more distributed activity. Granted, the need for another's data is not universal. Some organizations with limited applications or significant resources will develop and maintain all of the geospatial data that they require themselves. However, even in these situations, many offices within a single agency may find the need to share data across traditional organizational boundaries.

A GIS provides the means to integrate and examine data that are linked by being representations or



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measurements of some aspect of the same space. The increasing complexity of environmental and resource problems and the availability of this powerful information-handling capability are causing many users to demand more knowledge about geography than they traditionally were able or willing to handle. Although GIS tools provide capability, geospatial data often limit what can be done with the tools. Data sharing has become prevalent not simply because of a desire to share, but because of real requirements to know more about the environment and places on the earth and because of the costs of geospatial data. All agencies have limited resources for data collection and maintenance. Interdependencies develop in building and sharing geospatial data bases as agencies attempt to minimize investments and maximize returns. These interdependencies are one force driving the need for consistency and standards in digital geospatial data.

Although the need for standards may be obvious, the standards themselves are not. Agencies have traditionally collected data for single, specific purposes. Agencies (and individuals) view the world differently, solve different problems, and have different requirements for data. There are unlikely to be any "universal" data sets, although the FGDC is exploring a concept of "framework" data sets that might meet most users' needs in any given geographic area. The following questions have arisen in every one of the FGDC subcommittees: what geographic knowledge about the resource (or theme) is of interest, how is the resource spatially represented, how is information collected about the resource to spatially and adequately represent it, and what standards will promote sharing, but not be so onerous as to be ignored or impossible to implement? Different answers to these questions are provided by every subcommittee and often within subcommittees. Weiss [1993] points out that committees (in general) only achieve consensus when everyone is equally unhappy (the "Principle of Equal Pain"). Consensus related to data may be more difficult to achieve than consensus related to other activities, since many people either have traditional ways of looking at the world (and building their data bases about it) or have unique ways of "sensing" and gathering information.

Nonetheless, several standards are under development within the FGDC subcommittees, including, for example, consistent classifications for depicting wetlands and vegetation, standards for map symbology and color coding for geologic maps, a consistent linear referencing system for transportation and hydrologic networks, a common definition of "shoreline,"

standard content and transfer formats for cadastral data, and standards for cartographic representations of base maps. All of these are in the draft development stage, or are out for public review.

To an outside observer, the progress to date by the FGDC on standards related to the NSDI would very likely appear slow. Two standards, one started long before the current structure of the FGDC was established, have been formally endorsed by the FGDC. The Spatial Data Transfer Standard (SDTS) was nearly a decade in development, did not go through the FGDC standards process, although it was built on a similar process, and was adopted by NIST as a FIPS in 1992 and endorsed by the FGDC also in 1992. Additionally, the metadata standard was adopted as noted above. Both of these standards are critically important for data sharing activities and have contributed to the evolution of the Geospatial Data Clearinghouse within the NSDI.

The NSDI concept of a clearinghouse envisions distributed data producers advertising the availability of data through standardized descriptions of their data sets (metadata). Users are able to find, sort through, select, and download the data sets of most use and interest. This model envisions, and current standards support, electronic transfer of entire data files. Future developments in software, data models, and standards will probably lead to interoperability and data sharing at more detailed levels than simply that of entire data files (e.g., objects or features). The efforts of the Open GIS Consortium (OGC) on these interoperability standards are discussed elsewhere in this issue.

The two standards already endorsed by the FGDC are critical steps along the path to the NSDI. The steps include (1) the ability to find geospatial data sets of interest and to identify appropriate uses of those data sets (metadata); (2) the ability to transfer or move data without loss of content or structure (SDTS); and (3) the ability to collect data to support multiple-purpose rather than single-purpose uses. The last step is enormous and represents the current work of most of the FGDC subcommittees.

### **Conclusions**

Developing standards is a difficult and thankless task. Kleinrock [1992] neatly sums up the reality of standards in his observation that "[standards] efforts are almost always slow, laborious, political, petty, boring, ponderous, thankless, and of the utmost criticality." The activities under the NSDI are about forging new relationships and partnerships to develop, maintain, and use digital geospatial data sets, and about mak-



ing higher quality data more accessible to all users. But it is new ground, with new technologies, new ways of communicating, new skills to learn, and new ideas about who is in charge and who owns what. The challenges are real, but so are the rewards. **SV**

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