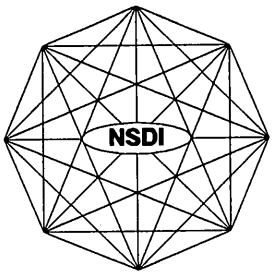

National Spatial Data Infrastructure

Development of a National Digital Geospatial Data Framework

Federal Geographic Data Committee

April 1995

Federal Geographic Data Committee
Department of Agriculture • Department of Commerce • Department of Defense • Department of Energy
Department of Housing and Urban Development • Department of the Interior • Department of State
Department of Transportation • Environmental Protection Agency
Federal Emergency Management Agency • Library of Congress
National Aeronautics and Space Administration • National Archives and Records Administration
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Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

For more information about the committee, or to be added to the committee's newsletter mailing list, please contact:

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Preface

This proposal of a data framework to organize and enhance the activities of the geospatial data community to meet needs for basic themes of data was developed in response to a request in Executive Order 12906, *Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure* (U.S. Executive Office of the President, 1994). The request stated:

> in consultation with State, local, and tribal governments and within 9 months of the date of this order, the FGDC shall submit a plan and schedule to OMB [U.S. Office of Management and Budget] for completing the initial implementation of a national digital geospatial data framework ("framework") by January 2000 and for establishing a process of ongoing data maintenance. The framework shall include geospatial data that are significant, in the determination of the FGDC, to a broad variety of users within any geographic area or nationwide. At a minimum, the plan shall address how the initial transportation, hydrology, and boundary elements of the framework might be completed by January 1998 in order to support the decennial census of 2000.

The proposal was developed by representatives of local, regional, State, and Federal agencies under the auspices of the Federal Geographic Data Committee (FGDC). The individuals are listed in the appendix of this report. This Framework Working Group identified the purpose and goals for the framework; identified incentives for participation; defined the information content; developed preliminary technical, operational, and business contexts; specified the institutional roles needed; and developed a strategy for a phased implementation of the framework.

Members of the working group presented the concepts of the framework for discussion at several national and regional public meetings. The draft of the report also was provided for public, written review. These discussions and reviews were the source of many improvements to the report.

The FGDC approved the report for submission to the Office of Management and Budget on March 31, 1995.

The FGDC would like to thank the working group members for their diligent efforts in developing the concept of the framework, and the many members of the public who provided their thoughts and insights at public meetings and during the written review.

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Executive Summary

While applications of digital geospatial data vary greatly, users have a recurring need for a few common themes of data. Because of a lack of investment, coordination, and common approaches, these needs are not being met. As a result, important information is not available for many areas, and multiple organizations support duplicate data for other areas. A means to maintain and manage the common information being collected by the public and private sector does not exist. This results in increased costs and reduced efficiency for individual organizations, as well as for the Nation.

The concept of a framework to organize and enhance the activities of the geospatial data community to meet these needs is proposed. The framework would provide a base on which to collect, register, or integrate information accurately. To be successful, the framework data must be dependable and trustworthy, be created from the "best" data available, and be easy to access and use. Demands placed on data contributors must be minimized.

Both data contributors and users will enjoy benefits from the framework. These benefits include reduced expenditures for data, increased ease of obtaining and using data collected by others, accelerated development of mission-critical applications, increased number of customers for data products linked to the framework, and improved recognition of programs.

The information content for the framework will include the data themes of geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadastre. The features encoded will include a minimum set of information needed to classify, name, and uniquely identify a feature.

The framework has technical, operational, and business contexts. The technical context considers the needs to provide data at different resolutions and time periods, to ease the burden of using the framework, and to maintain the integrity of data contributed to the framework. The following technical aspects are proposed for the framework: a feature-based data model; permanent, unique feature identification codes; reference to existing horizontal and vertical geodetic datums; methods to integrate data for geographic areas that are adjacent or overlap; and the provision of metadata. The proposed operational context requires the ability to process changes to framework data using transactions, access past versions of framework data, and locate framework data using the National Geospatial Data Clearinghouse. Several of the proposed techniques in the technical and operational contexts are not well understood, and may be demanding to implement. To make certain that framework data are used widely, a business context is advocated that minimizes financial, organizational, and technical barriers to accessing and using the framework.

Innovative institutional arrangements are needed to ensure a robust and well-maintained framework. Ideally, the framework data for a geographic area will be developed, maintained, and integrated by organizations that produce and use data for that area. In addition, there is a need to guarantee that the geographically-based units of framework data can be integrated to support applications for different or larger geographic areas. To accommodate these sometimes conflicting needs, six institutional roles for the framework are proposed:

- policy establishment — to provide overall guidance for the framework.
- theme expertise — to guide the development of the framework to meet new trends and needs in the user community.
- framework management — to provide continuing, operational support for the framework.

- area integration — to incorporate contributions of data into the framework for a geographic area.
- data production — to generate data used to build and maintain the framework.
- data distribution — to provide framework data to users.

These roles could be filled by many organizations from the geospatial data community.

The proposed framework sets ambitious goals for the development of creative institutional arrangements and technical capabilities needed for the full implementation of the framework. A phased implementation strategy is proposed to allow these to be developed, tested, implemented, and improved. The first phase, named "Version 0," makes use of existing capabilities such as the National Geospatial Data Clearinghouse and the FGDC metadata standard to identify data and data producers that may be able to contribute to the framework. "Version 0" activities represent a continuing effort to identify potential contributions to the framework. "Version 1," to be conducted from 1995 to 1998, calls for the establishment of initial institutional arrangements, development of basic specifications and procedures, pilot projects to test these arrangements and specifications, a "Framework '98" project to focus on the needs of the decennial census of 2000 for some themes of data, and investigation of advanced capabilities required to implement the full suite of framework capabilities. "Version 2," to be phased in starting in 1998, envisions the continued evolution of institutional arrangements, expansion of framework operations to include data collection and maintenance, and implementation of advanced capabilities developed in Version 1.

Where Are We? The Current Situation and Its Consequences

The use of digital geospatial data[1] and geographic information systems continues to expand in the public and private sectors. While the needed geospatial data can vary greatly in geographic area, purpose, and content, these needs almost always include a few, basic themes of data. These data — geographic features such as roads, railroads, streams, lakes, governmental units, and cadastre, as well as geodetic control, digital orthorectified imagery, and elevation data — may orient a user and link the results of an application to the landscape; may provide the geospatial foundation on which an organization may perform analyses; or may provide a base on which an organization can accurately register and compile attribute information or other themes of data.

The need for these themes of data is widespread among all sectors of the economy and in many disciplines. The draft results of a recent study of geospatial data users nationwide reports that transportation, hydrography, boundary, elevation, and cadastral data are required by a majority of users (Frank and others, 1994)[2]. The National Academy of Sciences recommended that "geodetic control, orthorectified imagery, and terrain (elevation) data be considered the critical foundation of the national spatial data infrastructure", and recognized the importance and widespread usefulness of transportation, boundary, hydrographic, and cadastral data, as well as natural resource data, to the geospatial data community (Mapping Science Committee, 1995). A survey of the geospatial data community conducted by the U.S. Geological Survey also reported the importance of these themes of data to users (U.S. Geological Survey, 1994).

Under the National Spatial Data Infrastructure (NSDI)[3], efforts are proceeding to link data producers and users to help meet needs for these and other data. The National Geospatial Data Clearinghouse[4], a distributed, electronically connected network of geospatial data producers, managers, and users, is being developed to allow users to determine what geospatial data exist, find the data they need, evaluate the usefulness of the data for their applications, and obtain or order the data as economically

[1] Geospatial data are "information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies." (U.S. Executive Office of the President, 1994)

[2] The nationwide study surveyed the needs of users from 30 varied disciplines, including biology, forestry, and wildlife; utility operations, communication, and transportation; emergency services; architecture, construction, engineering, and surveying; urban and regional planning; and banking, finance, insurance, and real estate.

[3] The National Spatial Data Infrastructure (NSDI) "means the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data." (U.S. Executive Office of the President, 1994).

[4] The National Geospatial Data Clearinghouse is comprised of many distributed, electronically linked, stores of information about geospatial data. To participate, data producers describe available data in an electronic form and provide these descriptions (or "metadata") to communication networks, such as the Internet. In addition to these metadata, data producers also may provide access to the geospatial data. Using the Internet, data users can search the descriptions provided by producers to locate data that are suitable for their applications.

as possible (Federal Geographic Data Committee, 1994a). A standard[5] has been developed for metadata, or "data about data" that describes the content, quality, condition, and other characteristics of data, with which data producers can describe their data (Federal Geographic Data Committee, 1994b). The Spatial Data Transfer Standard (SDTS) (U.S. Department of Commerce, 1992) was developed to help reduce technical barriers to data sharing. Efforts such as these are encouraging communication and data sharing within the geospatial data community, and are an important starting point for reducing duplication of effort and improving the efficiency and effectiveness of collecting and managing geospatial data.

Building on these and other activities, a more intensive effort is needed within the NSDI to meet the large and growing need for the development and maintenance of the framework geospatial data that are a starting point for most applications. Insufficient investment of resources, lack of innovative institutional arrangements, and lack of consistent technical approaches have limited the Nation's ability to organize resources to develop and maintain these important data. The relative importance of these factors varies geographically and by theme. Consequences include:

- In many parts of the country, there are no data, or the data are incomplete and not maintained. Investment is needed to collect and maintain even a basic level of framework data.

- In other parts of the country, high resolution data that could contribute to a framework are being collected[6] but are not generally usable for the following reasons:

  — a lack of arrangements by which these data routinely can be located and made available to others.

  — a lack of institutions to coordinate data collection and maintenance; accept, certify, and incorporate data contributions; and receive and act on reports of errors.

  — a lack of means or interest to disseminate data routinely to organizations not participating in a project.

  — a lack of standards that would simplify the integration of data across local boundaries or for a large area.

[5] The "Content Standards for Digital Geospatial Metadata," developed by the Federal Geographic Data Committee, specify the information content of metadata for a set of digital geospatial data. The purpose of the standard is to provide a common set of terminology and definitions for documentation related to these metadata. The standard specifies information that helps prospective users to determine what data exist, the fitness of these data for their applications, and the conditions for accessing these data. Metadata also aid the transfer of data to other users' systems.

[6] The working group discussed the subjects of the amount of data suitable for the framework that is being collected by the public sector, the geographic areas for which data are available, and the plans to maintain these data. Much of the information about the state and status of data that may be useful to the framework is anecdotal, and the working group agreed that better information is needed. The FGDC plans to work with other organizations to better determine what current efforts might contribute to the framework.

- a lack of standards and techniques that enable data to be integrated into other organizations' data holdings without endangering their existing investments in spatial and attribute data.

- a lack of a certification process for data, which hinders data sharing efforts, especially in cases where a number of organizations are involved.

- a lack of plans, or knowledge of plans, to maintain data.

- Many organizations are collecting data, but relatively few routinely maintain these data. In the long term, the issue of duplicate data maintenance efforts could be by far the largest cost issue.

The lack of a structured approach to meeting data needs causes difficulties in the geospatial community. An organization may collect (and then try to maintain) data — often a time consuming and expensive task that is outside the primary business of the enterprise, and that may duplicate the work of other organizations. An organization may try to obtain the data from other organizations — a time consuming task of locating sources of data, negotiating different arrangements and licenses for data, integrating a multitude of data collected to different standards and specifications, and making arrangements to receive updates. Lack of reliable data may cause organizations that collect data to locate and register observations inaccurately, and lose the ability to analyze data properly or integrate data from others.

In aggregate, the consequences to the Nation are the loss of benefits from existing investments in geospatial data, and the loss of potential benefits of new or expanded applications of data. The lack of a structured approach reinforces duplicate data collection and maintenance activities, hinders data exchange, and lessens the value of existing and new investments in data to the community. These result in diminished ability to build partnerships within the public sector and between the public and private sectors. They also slow the use of geospatial data in the Nation's commerce and attendant benefits of economic efficiency. The framework would provide a focus to marshall resources from different sectors to meet the wide need for this basic information.

Purpose and Goals

The framework is a basic, consistent set of digital geospatial data and supporting services that will:

- provide a geospatial foundation to which an organization can add detail and attach attribute information.

- provide a base on which an organization can accurately register and compile other themes of data, such as soils, vegetation, or geology.

- orient and link the results of an application to the landscape.

The framework will help data producers locate their information in its correct position and provide a means of integrating this information with other geospatial data.

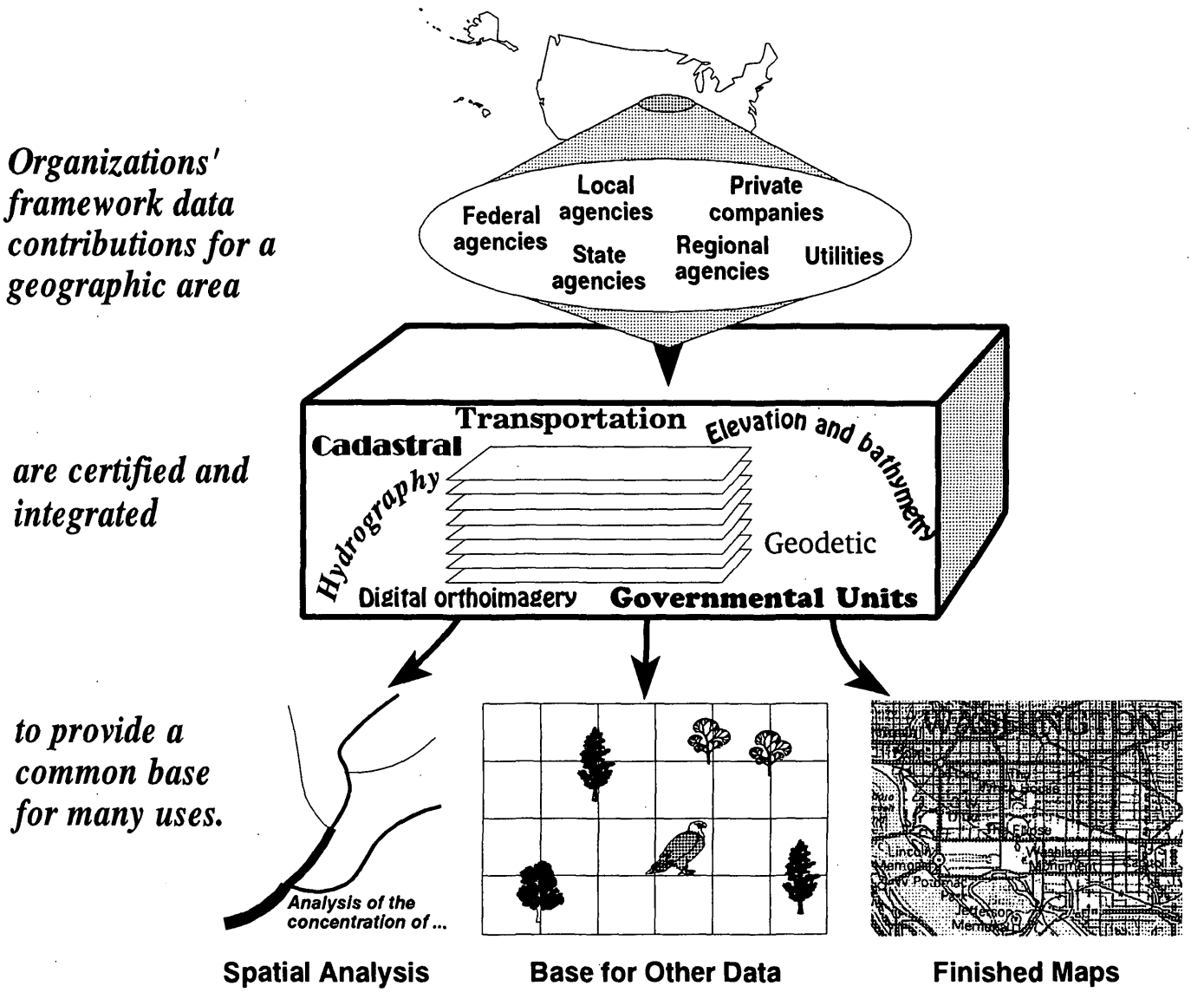

Figure 1. Framework data would provide a geospatial foundation for many activities.

The design of the framework must consider the needs of the geospatial data community: Federal, State, regional, local, and tribal governments; the private sector; non-governmental organizations; academia; and others.

The framework should be widely used and widely useful. Inherent in this goal are the following:

- The framework will be "data you can trust." Framework data will be certified as complying with standards for specific characteristics.[7]

[7] The existence of the framework will not preclude the development and use of other data in the NSDI. The National Geospatial Data Clearinghouse allows data producers to describe whatever holdings they wish to offer to the community, and to report the characteristics of these data.

- Framework data will be a robust set of information:

  — The framework should contain the "best" data[8] available. It should incorporate the high resolution data collected by the geospatial data community.

  — The framework also should include consistently generalized, lower resolution data needed for regional or national studies. To be "certified" as framework data, these data will be produced from higher-resolution framework data. Links or references among different representations of features should exist.

- Framework data will represent real world features and positions (not cartographic symbols and offsets).

- Users must be able to integrate framework data (and updates to these data) into their applications and still preserve an existing investment in attribute and other information.

- The framework should be a reliable and dependable supplier of data. The technical demands for using the data should be minimal and stable.

- Access to the framework should be available at the least possible cost. The goal is to provide data at no more than the cost of dissemination. There will be no restrictions on the use of data obtained from the framework. Value-added products generated from framework data will be encouraged.

- The framework should be implemented quickly and evolve with users' changing needs and capabilities.

The approach to building the framework should encourage many organizations to contribute to its construction and maintenance. Inherent in this goal are the following:

- The framework should place minimal additional technical and other demands on contributors. The means of contributing data should be stable. The framework should be able to incorporate data from many sources.

- The framework should evolve with contributors' changing requirements and capabilities.

- The framework should accommodate the contributions of a large number of geographically-distributed organizations, and be sensitive to the different missions, goals, resources, and schedules of these organizations.

- The framework should facilitate contributors' plans to provide value-added information and services for their data.

The framework will be operated and maintained by participants who agree to provide digital geospatial data that meet various content, quality, policy, and procedural criteria.

[8] The idea of "best" data, however, is a complicated one. Different applications require, or at least tolerate, different mixes of qualities normally associated with the idea of "best" data: currentness, positional and attribute accuracy, consistency, and completeness.

Why Participate? Benefits from the Framework

Building and maintaining the framework data must involve a wide variety of organizations in the geospatial data community in an ongoing, cooperative effort. Contributors and users will benefit from the increased availability and dependable supply of basic data.

With the increasing need to incorporate a growing number of themes of data, few organizations can afford to create all data they need. Contributing data to the framework may require a little more effort than an organization would expend for its immediate needs, but the organization recoups this investment when it uses data from the framework, or thematic and attribute data registered or linked to the framework, that are provided by others.

The framework will help an organization:

- reduce expenditures for data collection and integration by spreading the costs for data development across many agencies and programs. This approach will help local agencies develop partnerships with other levels of government to share the cost of developing data that are useful to national and regional, as well as local projects.

- obtain useful and usable data for areas surrounding its jurisdictional (and data base) boundaries. Often organizations find that understanding problems and developing solutions require knowledge of areas outside of their boundaries. For example, urban environmental problems often need to be considered in the context of watersheds or air basins. The framework will provide data for these outside areas that can be used with the data held by the organization.

- focus on its primary business ("back to basics"). As an organization sees that reliable, basic data are or will be available, it can focus efforts on the organization's mission and needs rather than continually developing basic data. This argument becomes more relevant as one considers the effort required to maintain geospatial data.

- benefit more quickly and easily from data collected by others. Other organizations will use framework data as a base on which to register other themes of data, or attach attribute information. Organizations whose data form the framework will find it easier to incorporate and take advantage of these other data. For example, local agencies providing framework data will benefit by having their data used in Federal programs such as the census. Use of these locally-produced data by the Census Bureau would help local agencies reduce the costly effort of integrating the census results into their data bases.

- simplify and speed the development of applications needed for such activities as emergency response, natural resource management, and economic development as errors and uncertainty are reduced. Expert staff personnel could concentrate on enhancing applications instead of supporting the basic geospatial data. Users will spend less time struggling with inadequate information, and in correcting or updating basic information.

- benefit from standardized data. "Permanent" feature identification codes and standard feature categories will mean software, as well as the information it manipulates, can be reused much more broadly and easily. Standardized information also will improve the quality and reduce the cost of systems development, training, and data maintenance.

- gain access to guidelines and tools for developing data, creating metadata, participating in the National Geospatial Data Clearinghouse, and other activities that will be useful for local activities.

- gain customers for other data products and services. The framework is designed to be a basic geospatial reference set to which other information can be linked. Participants that also provide spatially-referenced attribute data that can be linked to the framework can increase their customer base.

- work with other organizations to provide consolidated direction to software vendors on needed improvements, such as automated tools for metadata development and data generalization.

- gain recognition of programs. Being recognized as a contributor to the framework effort will give participants higher visibility and credibility in the competition for scarce funding or for market share, and offers a public relations bonus for good citizenship.

In addition, the framework offers benefits to the entire community. Through improved utility of geospatial data, the framework will make organizations' efforts more broadly useful beyond any one community or set of customers.

Proposed Framework Characteristics

The proposed characteristics of the framework are described by Information Content (the data in the framework), Technical Context (issues related to the organization of the data), Operational Context (issues related to processing services for the data), and Business Context (principles to encourage the use of the framework).

Information Content

The information content of the framework will include geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral data.[9]

Geodetic Control

Geodetic control provides the means for determining locations of features referenced to common, nationally-used horizontal and vertical coordinate systems. It is the essential ingredient in developing a common coordinate reference for all other geographic features. Control stations are monumented

[9] In the public review and other discussions, additional themes were nominated for inclusion in the framework. Examples include census geography (such as census tracts, block groups, blocks), land cover, land use, soils, wetlands, utilities (such as communications, energy, and water), and ZIP codes. Persons providing these recommendations noted that these themes also are important to many applications, and suggested that the themes included in the framework signalled a bias against some applications.

The framework is to provide a means to attach attribute information, to provide a base on which other data (such as census geography, land cover, land use, soils, utilities, wetlands, and ZIP codes) can be compiled, and to provide a means of linking the results of an application to the landscape. This definition was used to select the themes for the framework. The exclusion of themes from the framework is not intended to denigrate other themes or to deny the frequency with which they are used. The framework is required to provide the base on which to compile these themes.

points (or in some cases active Global Positioning System control stations) whose horizontal or vertical location is used as a basis for obtaining locations of other points. The framework will include geodetic control stations; and the name, feature identification code[10], latitude and longitude (with accuracy code), orthometric height (with accuracy code), and ellipsoid height (with accuracy code) for each station.

Digital Orthoimagery

An orthoimage is a georeferenced image prepared from a perspective photograph or other remotely-sensed data in which displacements of images due to sensor orientation and terrain relief have been removed. Orthoimages have the same metric properties as a map and a uniform scale. Digital orthoimages are composed of an array of georeferenced pixels, or picture elements, that encode ground reflectance as a discrete digital value. Many geographic features, including those that are part of the framework, can be interpreted and compiled from an orthoimage. Orthoimages also can serve as a backdrop and link the results of an application to the landscape.

The framework may include imagery that varies in resolution from sub-meter to tens of meters. Accurately positioned, high-resolution data (one meter or smaller pixels) are thought to be the most useful to support the compilation of framework features, especially those that support local data needs. In some areas lower resolution imagery may be sufficient to support framework needs.

Elevation Data

Elevation refers to a spatially referenced vertical position above or below a datum surface. The framework includes elevations of land surfaces and the depths below water surfaces (bathymetry).

For land surfaces, an elevation matrix, or a regularly spaced grid of locations with elevation values, will comprise the framework. Elevation values will be collected at post spacings of not greater than 2 arc-seconds. In areas of low relief, a spacing of 1/2 arc-second or finer is desired.

For depths, the framework will consist of soundings and a gridded bottom model. Depth of water is determined relative to a specific vertical reference surface, usually derived from tidal observations. In the future this vertical reference may be based on a global model of the geoid or the ellipsoid, which is the reference for expressing Global Positioning System height measurements.

Transportation

The framework transportation data includes the centerlines of roads, trails, railroads, and waterways; airports; ports; and two types of supporting structures: bridges and tunnels. Roads will have the attributes of feature identification code (using linear referencing system(s) where available), functional class, name (including route numbers), and street addresses[11]. Trails will have the attributes of feature identification code (using linear referencing system(s) where available), name, and type. Railroads will have the attributes of feature identification code (using linear referencing system(s) where available) and type. Waterways will have the attributes of feature identification code (using linear referencing system(s) where available) and name. Airports and ports will have the attributes of

[10] Feature identification codes are explained in the "Technical Context" section.

[11] Street addresses will be encoded as a range of addresses between road intersections.

feature identification code and name. Bridges and tunnels will have the attributes of feature identification code and name.

Hydrography

The framework hydrography data will be based on the approach being developed for the U.S. Environmental Protection Agency's Reach File Version 3.0 (RF3)[12]. A reach defines a surface-water feature that may or may not be connected to other surface-water features. Reaches that are connected to one another hydrologically form a skeletal structure representing the branching patterns of surface-water drainage systems. Connectivity and direction of flow are desired, but are not required, for the framework.[13]

The feature identification code for each reach will be the Reach Code. The design of this code allows reaches to be subdivided in a way that links the parts to the original reach. In addition to the code, the reach will have the attributes of name, reach type (identifying the geographic features, such as stream/river, lake/pond, wash, or shoreline represented by the reach), and spatial representation (identifying the spatial elements used to delineate the reach, such as single line, open water area, open water shoreline, transport path, junction, or "super node").

A shoreline is the intersection of the water's surface with land, and is usually referenced to some analytically determined stage of the tide or water level (as in lakes and rivers). Multiple shorelines are included in the framework due to the wide variety of uses and the complex nonlinear relationships between various shorelines. Attributes will include shoreline type (or tidal reference).

Governmental Units

The geographic features for governmental units included in the framework are Nation, States and statistically equivalent areas (of which there were 57 in 1990), counties and statistically equivalent areas (3,248 in 1990), incorporated places and consolidated cities (19,371 in 1990), functioning and legal minor civil divisions (in 28 states and the District of Columbia) (17,021 in 1990), Federal- or State-recognized American Indian Reservations and Trustlands (362 in 1990), and Alaska Native Regional Corporations (12 in 1990). Each will have the attribute of name and the applicable Federal Information Processing Standard (FIPS) code. In addition, the boundaries of the features will include information about other features (such as roads, railroads, or streams) with which the boundaries are associated, and the description of the association (such as coincidence, offset, or corridor).

Cadastral

Two aspects of cadastral information are included in the framework: cadastral reference systems (such as the Public Land Survey System (PLSS) and similar systems for areas not covered by the PLSS (for example, the Connecticut Western Reserve in the State of Ohio)) and large, publicly-

[12] Note that the approach being developed to encode the Reach File is endorsed; the Reach File itself is not endorsed as being the hydrography component of the framework (although it will contribute to the development of the framework in many areas).

[13] Several reviewers urged that direction of flow and connectivity be required for the framework. Many data producers (such as local governments) that collect the "best" data that is sought for the framework do not collect this information routinely. The decision to list this information as desired (but not required) was made to include and encourage data from these important producers.

administered parcels[14] (such as military reservations, national forests, and state parks). Features include the survey corner, survey boundary, and parcel. Each instance will have the attribute of name or other common identifier, and information on quality. It is desirable that each instance have a feature identification code. Cadastral reference system information for the Public Land Survey System will be provided to the section level or equivalent.

Technical Context

Evaluation of the goals resulted in a multi-resolution, feature-based framework design. This approach incorporated the following decisions:

- To meet the different needs of users, the framework will support geospatial data at varying resolutions[15]. Multiple resolutions of data (for example, data at different levels of generalization and having nominal positional accuracies of 50, 10, and 1 meter) may exist at any given location. Where suitable higher resolution data exist, the lower resolution data will be generalized from the higher resolution data.[16] The data will be generalized according to a set of predefined rules for each theme. Alternate rule sets may be needed for a broad range of generalization.

- To allow maintenance of users' existing investments, to minimize the effort required to integrate data from the framework, and to link representations at different resolutions, a consistent method of identifying units of framework data is needed.

To provide for these capabilities, the framework will provide a multifaceted model of geographic reality. The approach will employ the concept of a 'feature', which is a description of geographic phenomenon (for example, a road) at or near the Earth's surface. Each occurrence of a phenomena (e.g. a road) is assigned a unique, "permanent" feature identification code. A feature will be linked to spatial objects (such as points, chains, and polygons) to identify the location of the feature; different sets of spatial objects will exist for different resolutions.

The feature identification code provides users a "key" through which they can associate framework data to their attribute data, serves as a tracking mechanism for performing transactional updates, and

[14] Several reviewers noted the vital role that parcels play in the Nation, and urged that all parcels be included in the framework. There is no doubt that parcels are an important component of the NSDI, and the framework as proposed will provide the means to link parcels to other themes of framework data. The question is should all parcels be included in the framework? Concerns about the large number of parcels, the frequency and rapidity with which they can change, and the inherent local responsibility for parcels (and their potential role to support financially other local geospatial data activities) led to the conclusion that they should be excluded from the proposed framework. Pilot studies will be used to evaluate the decision.

[15] For readers who are more comfortable thinking in terms of the cartographic concept of scale, the "smallest scale" data in the framework would be equivalent to data found on 1:100,000-scale maps. No limit on the "largest scale" data in the framework is set. Any limit likely will be based on the efficiency with which very large scale data can be integrated into the framework.

[16] Decisions to store lower resolution data sets for later use, or to regenerate them "on demand," will be based on the state of technical means to generalize data and business issues such as costs and legal requirements.

provides a link among representations of a feature at different resolutions and across different areal extents. Once assigned, the "permanent" code should change only when necessary.

When a feature is captured, it may be further described by a set of attributes and relationships. Attributes define the feature's characteristics; examples include name and function. Relationships may be defined to express interactions that occur between features, such as flow in a river system or connectivity in a transportation network.

Use of a common means of referencing coordinate positions on the Earth is essential to allow contributions to the framework to be joined and integrated. In addition, to be used as the locational framework for other thematic data, the coordinate system used for framework data must be well established, clearly specified, and consistent with national and world use. Horizontal coordinate information for framework data would be referenced to the North American Datum of 1983. The use of longitude and latitude coordinates is encouraged for the framework.[17] Vertical coordinate information would be referenced to the North American Vertical Datum of 1988 for elevations and appropriate tidal datums for depths.

Framework data will be encoded using vector or raster spatial data models as appropriate to theme and feature content. Raster data models will be used for elevation and image data; vector data models for transportation, hydrography, governmental units, and cadastral data. Vector-based spatial objects will conform to topological rules[18].

The framework will retain past versions of data so that information is available for historical or process studies. Access to past versions is required to support historical thematic data that are registered to the framework, and time-based studies essential in many applications. A "movie" roll-forward/roll-back capability often is sought in base geographic data for research and policy studies.

As a general principle, the positions of contributed data will not be modified. For example, if a road crosses the boundary of two (otherwise equivalent) contributions, the positions of the road at the common edge will not be geometrically joined (that is, there may be gaps, overlaps, or intersections with spurs at the edges of adjoining contributions). The disjoint lines that represent the location of the road will be associated through a common feature, resulting in "logical seamlessness." The decision to allow this result is based on the assumption that organizations that integrate data would not have information better than those that contributed the data, and so there is little basis for "repairing" the data. Of course, data producers will be encouraged to work with those in adjoining jurisdictions to align their data and remove these ambiguities.

Lower resolution data generalized from these data will be "geometrically seamless" (joined) if the alignment ambiguities present in higher resolution data sets can be resolved within the error tolerances of the lower resolution data sets.

[17] Longitude and latitude coordinates offer a seamless coordinate system for most of the United States and can be readily converted to map projection and grid (for example, Universal Transverse Mercator and State Plane Coordinate System) coordinate systems.

[18] Examples of these rules can be found in section 3.4.3 of Part 1 of the Spatial Data Transfer Standard (U.S. Department of Commerce, 1992).

As a goal, framework data sets should be integrated across themes. In the near term, this goal will be difficult to achieve for places where data are collected at different resolutions and by different data producers.

Metadata detailing the characteristics and quality of the framework data must be provided. Quality information includes positional and attribute accuracy, completeness, logical consistency, and lineage.

Operational Context

The framework should provide the following operational characteristics:

- the framework must support transactional updating so that producers only provide change files and users only need to process changes. This approach reduces the impacts of change on existing investments.

- access to an official version of framework data (current and past versions) by information networks and digital media must be ensured.

- users should be able to find framework data through the National Geospatial Data Clearinghouse.

In addition, the contributions will cover a minimum areal extent that is economical to process. There is some minimal areal extent for which the resources required to manage the data holding will exceed the value of the data contributed. This extent will vary by theme and other factors.

Important companions to framework data are Global Positioning System (GPS) technologies and related services provided by GPS base stations and differential GPS techniques that are tied to the national coordinate reference systems. These technologies can significantly lower the costs of acquiring accurately-positioned data. They also provide a means for users to locate themselves in reference to framework data during field operations.

To exploit the capabilities of the GPS, the following items are needed: (1) a network of a few, very accurately positioned and easily accessed monumented points, (2) a set of continuously operating reference stations, (3) a high resolution geoid (needed to relate heights determined by conventional surveying to those determined by GPS techniques), and (4) precise post-fit GPS satellite orbits.

The Federal Government has proposed enhancing the National Spatial Reference System (NSRS) to provide this capability. Included in the upgraded NSRS will be 25 to 50 continuously operating reference stations at the most accurately determined geodetic control stations in the Federal Base Network. Observables from GPS satellites will be recorded and made available through electronic networks. Differential GPS base stations operated by the public and private sectors can be positioned relative to the reference stations and provide information that are tied to a single, consistent, and very accurate coordinate reference system.

Business Context

A goal of the framework is that it be widely used and useful. To attain this goal, the framework will:

- avoid restrictive practices that would inhibit use of the framework. The principles[19] provided in U.S. Office of Management and Budget Circular A-130, "Management of Federal Information Resources" (U.S. Office of Management and Budget, 1993), should guide the framework.

- provide information about limitations of data, including suggested or optimal uses of data, disclaimers, and liability clauses.

- be available in public, non-proprietary format(s).

- conform to approved standards. This allows users to know the characteristics of the data. At a minimum, conformance to relevant FGDC standards should be required and subject to verification.

- contain data that are certified to ensure that they meet the minimal standard for all framework criteria. A certification process is essential; an independent assessment is needed to establish and maintain trust.

Institutional Roles

The strategy for identifying the institutional roles balances different aspects of the framework. The framework must take advantage of geospatial data that are being created locally and regionally by many organizations in the geospatial data community. Many of these data are created for an area in response to an issue or need of local importance. Creating, maintaining, and distributing framework data will involve many organizations. To encourage local ownership of the framework, and the responsiveness of the framework to local needs, framework operations, especially those of "area integration," must be located (both geographically and operationally) close to local data producers and users.

[19] Principles from the U.S. Office of Management and Budget Circular A-130 (U.S. Office of Management and Budget, 1993):

> "(7) Avoiding Improperly Restrictive Practices. Agencies shall:
>
> (a) Avoid establishing, or permitting others to establish on their behalf, exclusive, restricted, or other distribution arrangements that interfere with the availability of information dissemination products on a timely and equitable basis;
>
> (b) Avoid establishing restrictions or regulations, including the charging of fees or royalties, on the reuse, resale, or redissemination of Federal information dissemination products by the public; and,
>
> (c) Set user charges for information dissemination products at a level sufficient to recover the cost of dissemination but no higher. They shall exclude from calculation of the charges costs associated with original collection and processing of the information."

Not all issues that the framework addresses are local. Applications serving regional and national markets for the private sector, ecosystem studies, regional and multi-State concerns, and many Federal activities require data that are consistent for large geographic areas. In addition, consistency among a large base of users provides economies of scale and other incentives that encourage private investment in computer software and services required for the framework. Work will be needed to gather, integrate, and certify the locally-produced data to meet the goal of nationally consistent, integrated framework data.

Six institutional responsibilities have been identified to attain this goal: policy establishment, theme expertise, framework management, area integration, data production, and data distribution. These roles may be carried out by many different organizations. Organizations that have policies, missions, and mandates needed to undertake these roles will be the most successful participants in the framework.

Policy Establishment

The role of establishing policy provides overall guidance for the development and operation of the framework. Policies are of key importance because of the distributed nature of the responsibilities for the framework, and the requirement that framework data support applications of varying natures and geographic areas. These responsibilities include approving standards; identifying resources needed for the framework; designating and working with framework managers and others to obtain funding; initiating pilot studies, concepts, and implementation strategies; encouraging partnerships; resolving issues caused by different views among the themes; and coordinating and resolving competing ideas about the operation and advancement of the framework. The FGDC will facilitate the development of partnerships within the geospatial data community to fill this role.

Theme Expertise

The changing needs of the public and private sectors must be considered if the framework is to be a robust and viable effort. These needs include accommodating new standards and techniques. Many of these requirements will be developed within the organizations and disciplines that generate or use the bulk of themes of framework data, and contribution of this thematic expertise to identify needs and trends is required. The FGDC will facilitate the development of partnerships within the geospatial data community to fill this role.

Framework Management

Beyond the role of determining needs and trends is that of providing nationwide continuing, operational support to the framework. The responsibilities include:

- managing the production of a theme of data (or "theme management") that meets the user requirements by:
    - creating and maintaining framework data for those areas not covered by certified data producers.

- certifying and coordinating the activities of the area integrators and serving as an area integrator on a national basis.

- generating and maintaining lower resolution data, including positional adjustments based on higher-resolution data.

- determining the needs for maintenance within themes.

- managing the integration of the themes of data (or "integration management") to ensure that a "whole" framework can be assembled from its thematic parts. The scope of duties is similar to those listed above for "theme management."

- recommending and developing (in cooperation with groups providing theme expertise and others) technical standards that describe the essential characteristics of the theme data and the rules and processes for data generalization (e.g. simplification, selection, aggregation, and dimensionality parameters), and maintaining these standards.

- developing certification policies and procedures to ensure conformance to framework standards.

- ensuring the maintenance of a record of the official data's location, and a safe archive.

Because of the size of the task and the variations among the themes of data, a consortium of organizations knowledgeable about the themes and having national responsibilities is needed. This role could be filled by Federal agencies that have been assigned to lead efforts for data by Office of Management and Budget Circular A-16, "Coordination of Surveying, Mapping, and Related Spatial Data Activities" (U.S. Office of Management and Budget, 1990)[20].

[20] The Federal agencies assigned by Circular A-16 to coordinate themes of data are as follows:

Theme	Federal Agency
Geodetic control	Department of Commerce
Elevation	
onshore (part of 'base cartography')	Department of the Interior
offshore	Department of Commerce
Digital orthoimagery (part of 'base cartography')	Department of the Interior
Transportation	Department of Transportation
Hydrography	Department of the Interior (FGDC responsibility shared with the Interagency Advisory Committee on Water Data)
shoreline (part of 'bathymetry')	Department of Commerce
Governmental units (part of 'cultural and demographic')	Department of Commerce
Cadastral	Department of the Interior

Area Integration

A certified area integrator incorporates the contributions of data producers into the framework. An integrator:

- implements the technical standards that describe the essential characteristics of the theme data.
- implements certification policies and procedures to ensure a particular data set conforms to the framework standards. This activity could include both guidance documents and verification software. Certification authority could be delegated to data producers.
- coordinates data creation and maintenance activities for an area. The integrator is the focal point for users to report problems with data or to request enhancements or modifications.
- updates the framework from contributions.
- provides guidance to ensure that data producers integrate their data among themes and geographic areas.

Two aspects of integration are needed for a robust framework: integration within a theme (providing coverage for an area by knitting together contributions that cover smaller areas), and integration among themes (bringing different themes for the same area into accord). An organization may not be willing or able to provide both services for a geographic area.

Areas of responsibility could cover different units of geography (for example, a State, a group of states, or part of a State). The units of geography may vary regionally (for example, in some parts of the country, integration might be done on the basis of political units such as counties or states, but in other parts by ecosystems). In addition, the units of geography may vary by theme within a region (for example, cadastral data might be done on the basis of political units, and hydrography on the basis of watersheds). The framework managers will be the default integrators for those areas not having an integrator.

Data Production

This function would involve producing or maintaining framework data to standards. Some producers may provide framework data under contract. Others may propose including their existing data as part of the framework.

The data producers must:

- provide data and updates to data using the framework standards. This activity includes:
  - encoding required metadata.
  - performing and reporting the results of required data quality tests.
  - encoding data, including feature identification codes, to framework standards.
- provide the data and metadata without restriction to the area integrators.

Data Distribution

The data distributor is the primary source of framework data for users. The distributor may not be the same agency that produces or integrates the data. There may be many data distributors, but only one will be responsible for holding the official distribution copy.

Framework Implementation

The framework will take a number of years to be realized. Near term requirements, such as those stated in Executive Order 12906, make it apparent that a phased implementation is needed. This approach requires that ongoing nationwide activities be effectively combined with those at the State, regional, and local levels.

The developmental aspects of some concepts in the framework, and the recognition of the variability among institutional arrangements and technical abilities in the geospatial data community have led to a phased implementation strategy. This strategy allows progress to be made in developing the framework while design and testing of more advanced capabilities are conducted, and options for institutional arrangements are explored. This approach also allows for changes in directions of the framework in response to new technologies and needs. Activities for the different phases will occur concurrently.

The phases are called "versions" of the framework. The characteristics of the first two versions, labelled Version 0 and Version 1, and the actions required to implement them are described below. Activities for Version 2 also are outlined.

Version 0: Identify Existing Data

Version 0 identifies data that exist or are in work that may contribute to the framework, and makes this information available to the community. Activities will require data producers to document their data using the FGDC metadata standard, and to provide these metadata to the community through the National Geospatial Data Clearinghouse.

The accomplishments of this activity include:

- identify data that may contribute to later versions of the framework.
- identify producers of data for an area. This identification may lead to local discussions of how data can be produced with less duplication.
- require data producers to document their data in a consistent way, which will be an essential activity in all versions of the framework.

Actions and Time Frame

The actions needed and activities that are underway include:

- implement and register sites (called "nodes") that participate in the clearinghouse network. The FGDC's NSDI Competitive Cooperative Agreement Program provides seed funding for

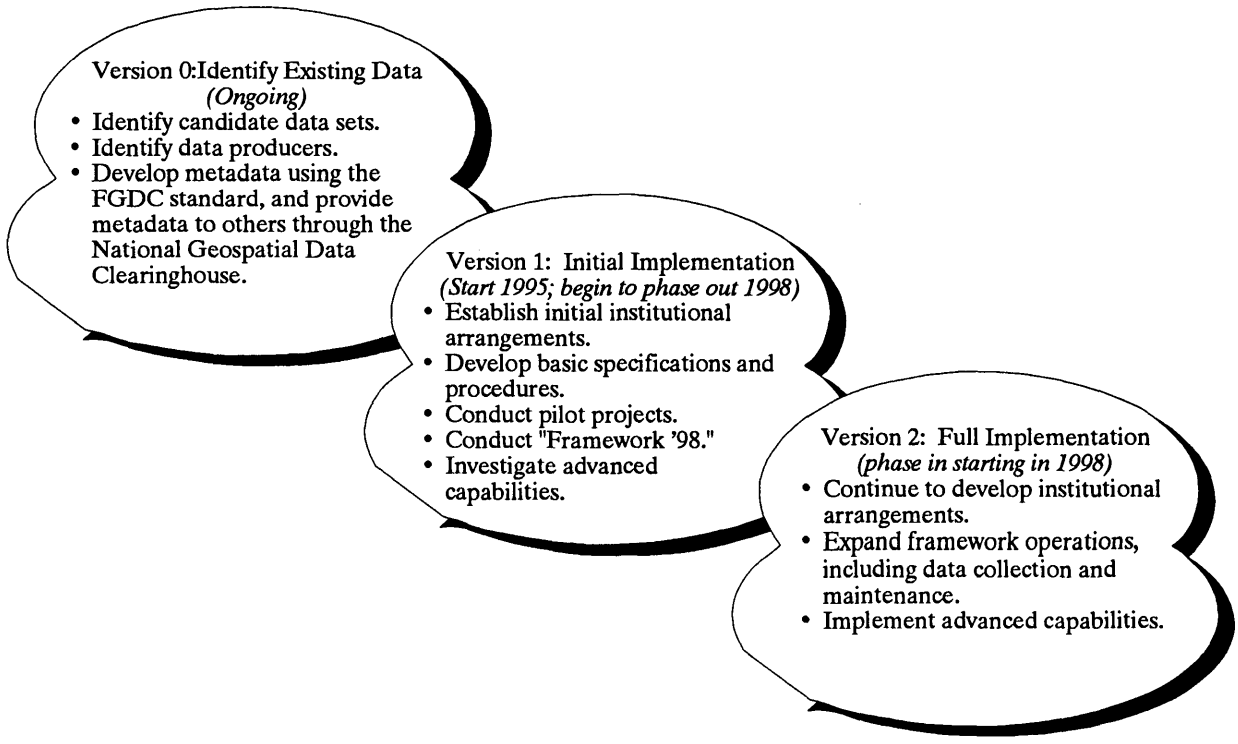

Figure 2. Steps to developing the framework.

nodes. The program funded 9 nodes in 1994; funding for another 20 nodes is anticipated in 1995.

- adapt and implement advances in providing information using the Internet and related software tools. This activity is ongoing and takes advantage of improvements that often are developed outside of the geospatial data community.

- train data producers to use the FGDC metadata standard. The FGDC offers training classes on the standard; Federal and State agencies also are beginning to offer training. Written training materials are being prepared.

- develop tools to collect metadata. Some Federal agencies and private developers are investigating or developing software and other aids for recording metadata. The FGDC is working with the geographic information system (GIS) software vendor community to support the standard in their products; support for these efforts have been provided by the geospatial data community.

Beyond this initial activity, the clearinghouse will continue to identify potential data contributions, and provide framework data to users.

Version 1: Initial Implementation

Version 1 develops and implements the technical capabilities and institutional arrangements for a basic set of framework capabilities, and conducts investigations of the more advanced characteristics proposed for the framework.

The planned accomplishments of this activity include:

- investigate and begin to implement the institutional arrangements required for the framework.
- investigate and develop the initial specifications for information content and procedures for data certification and intra-theme ("horizontal") integration.
- conduct prototype and pilot projects to test the proposed institutional and technical plans, with specific attention to meeting the deadlines outlined in Executive Order 12906.
- support investigations of the more advanced technical aspects of the proposed framework characteristics, such as inter-theme ("vertical") integration, data update strategies, and data generalization.

Actions and Time Frame

From 1995 to 1998, the actions begin to establish institutional arrangements, conduct "proof of concept" projects, encourage the data collection activities in support of the framework, and organize a basic level of operational activities.[21] Institutional and operational activities are described separately.

Institutional

Begin to establish the necessary organizational relationships and agreements for framework operations (with attention to the requirements of the 1998 deadline); prototype arrangements needed for framework operations, especially those of area integrators; and raise the awareness of the framework by organizations whose participation is needed:

- begin to identify the long term organizational structures, arrangements, and partnerships needed within the geospatial data community to sustain the framework, and explore the alternatives.
- States should identify and empower organizations for framework activities that can (1) participate in theme expert groups, (2) initiate partnerships to build the framework, and (3) serve functional roles as area integrators. Such organizations should include the interests and capabilities of county, regional, and local jurisdictions, and the private sector. The National States Geographic Information Council will recommend a process to determine the most suitable organization(s) in each State.
- clarify and synchronize the authorities and responsibilities of Federal agencies for the framework.
- incorporate State, regional, local, and tribal governments, the private, academic, and non-profit sectors, and others in FGDC subcommittee and working group activities.

[21] The framework is a different way of doing business for all the parties concerned. During this time, organizations must continue to support their existing operations to meet their mandates and missions. Because of this need, resources must be available during the transition period to both maintain existing operations and participate in the framework. In the short term, additional resources will be needed. Once operational, the framework should result in net savings over the aggregate costs of existing operations and more than recover the additional initial expenditures needed for its establishment.

- the Federal Government will commit to the use of framework data to build and maintain its national data bases as the framework matures.

- conduct surveys and use other means to identify potential data contributors and area integrators. Surveys of State, regional, and local government activities have been recommended, and some work has been done. The FGDC is working with the U.S. Office of Management and Budget to survey Federal agencies for potential contributions to the framework.

- to support the executive order's deadlines to support the decennial census of 2000, establish a "Framework '98" project staffed by key Federal agencies and persons from State and local government agencies.

- establish a means of continuing communication and information exchange among framework participants.

- begin to implement the long term organizational structures, arrangements, and partnerships needed to sustain the framework.

Operational — conduct studies and technical prototypes to remove technical impediments for the initial implementation of framework data, especially those needed to meet the 1998 deadline; raise the technical expertise of the community so that a larger number of organizations can participate; develop recommendations of framework standards; and encourage the production of framework data that do not require further prototyping or technological development.

- working with the geospatial data community through pilot projects and other means, theme management agencies begin to develop certification policies and data archive procedures.

- conduct framework "proof of concept" projects. The projects would evaluate, exchange, integrate, and update data sets from all parts of the geospatial data community, investigate cross-theme integration, and test framework management, theme expertise, and area integrator responsibilities. Projects being considered include:

  - investigate the integration of Topologically Integrated Geographic Encoding and Referencing (TIGER), digital line graph (DLG), and local data sets in a major metropolitan area.

  - investigate the integration of State-produced, high resolution hydrography data, digital orthoimage data, and Reach File codes for the certification and maintenance of multiple resolution hydrography data.

  - investigate the use of survey or parcel level information as a framework component, and the use of cadastral data as the basis for building partnerships. Identify roles, assess organizations' capabilities, investigate the ability to integrate cadastral with other themes of data, and evaluate the applicability of the FGDC's developing cadastral data standards.

  - investigate the integration of digital orthoimage data of different resolutions, and test the ability to generalize high resolution image data.

- investigate the integration of elevation, bathymetry, and coastal shoreline information.
- investigate the integration of high-resolution elevation data to support flood plain management.
- investigate the integration of themes of data to support ecosystem studies.
- investigate the development of educational curricula that focus on geospatial data collection to construct framework data sets at the high school level using GIS and telecommunications technologies.

- using partnerships to leverage resources, expedite the collection of geodetic control, elevation, and digital orthoimage data as quickly as resources allow.
- build public outreach, education, and technology transfer programs (activities may include workshops for partners and manuals of instruction).
- develop "proof of concept" framework data sets for evaluation by the user community.
- to support the executive order's deadlines to support the decennial census of 2000:
  - through the "Framework '98" project, collect and update transportation, boundary, and hydrography data.
  - target the production of digital orthoimage data to support the geographic areas addressed by the "Framework '98" project.
- through the use of pilot and other projects, continue the cooperative production, enhancement, and update of other themes of framework data.

Version 2: Full Implementation

Starting in 1998, implement the advanced concepts into framework operations, continue the maintenance and update of framework data, and evolve routine operations for the framework.

- build on the results of pilot studies and the "Framework '98" project to extend the responsibilities for framework operations, especially the roles of area integrator, data producer, and data distributor.
- seek additional contributors for framework data to increase coverage, currentness, and responsiveness.
- implement, evaluate, and improve the long term arrangements needed to sustain the framework.
- collect and maintain framework data.

The actions and time frames for version 2 will be based on the experience gained and progress made while implementing version 1.

For More Information

To obtain additional details about the framework please contact the FGDC Secretariat by mail at the U.S. Geological Survey, 590 National Center, Reston, Virginia 22092; by telephone at (703) 648-5514; by facsimile at (703) 648-5755; or by Internet at gdc@usgs.gov. Additional information about the framework also will be available by anonymous FTP from ftp://fgdc.er.usgs.gov/pub/, or through the World Wide Web at http://fgdc.er.usgs.gov/fgdc.html.

References

Federal Geographic Data Committee, 1994a, National Geospatial Data Clearinghouse (factsheet): Washington, Federal Geographic Data Committee (also available from ftp://fgdc.er.usgs.gov/pub/).

Federal Geographic Data Committee, 1994b, Content standards for digital geospatial metadata (June 8): Washington, Federal Geographic Data Committee (also available from ftp://fgdc.er.usgs.gov/pub/).

Frank, S. J., Goodchild, M. F., Onsrud, H. J., and Pinto, J. M., 1994, Framework data sets for the NSDI (December 2 draft).

Mapping Science Committee, 1995, A data foundation for the national spatial data infrastructure: Washington, National Academy Press, 45 p.

U.S. Department of Commerce, 1992, Spatial Data Transfer Standard (SDTS) (Federal Information Processing Standard 173): Washington, National Technical Information Service (also available from ftp://sdts.er.usgs.gov/pub/sdts/).

U.S. Executive Office of the President, 1994, Coordinating geographic data acquisition and access: the National Spatial Data Infrastructure (Executive Order 12906): Washington, Executive Office of the President (also available from ftp://fgdc.er.usgs.gov/pub/).

U.S. Geological Survey, 1994, User evaluation of selected current products (internal report).

U.S. Office of Management and Budget, 1990, Coordination of surveying, mapping, and related spatial data activities (Circular A-16): Washington, U.S. Office of Management and Budget (also available from ftp://fgdc.er.usgs.gov/pub/).

U.S. Office of Management and Budget, 1993, Management of Federal information resources (Circular A-130): Washington, U.S. Office of Management and Budget.

Membership of the Framework Working Group

Name	Affiliation	Nominated by
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Penny Capps	U.S. Army Corps of Engineers	U.S. Army Corps of Engineers
Charles Dingman	Bureau of the Census	FGDC* Cultural and Demographic Subcommittee
Michael Domaratz	FGDC Secretariat	FGDC Secretariat
Christopher Friel	Florida Marine Research Institute	Coastal States Organization
Dennis Goreham	Utah Automated Geographic Reference Center	National States Geographic Information Council
CAPT Melvyn Grunthal	National Oceanic and Atmospheric Administration	FGDC Federal Geodetic Control Subcommittee
Steve Guptill	U.S. Geological Survey	FGDC Standards Working Group
Susan Carson Lambert	U.S. Geological Survey	FGDC/IACWD** Water Subcommittee
Kenneth Lanfear	U.S. Geological Survey	FGDC/IACWD Water Subcommittee
Jerry Mills	National Oceanic and Atmospheric Administration	FGDC Bathymetric Subcommittee
John Moeller	Bureau of Land Management	FGDC Cadastral Subcommittee
Sheryl Oliver	Illinois Department of Energy and Natural Resources	National States Geographic Information Council
Bob Parrott	San Diego Association of Governments	National Association of Regional Councils
Roger Petzold	Federal Highway Administration	FGDC Ground Transportation Subcommittee
James Plasker	U.S. Geological Survey	FGDC Base Cartographic Subcommittee
Charles Roswell	Defense Mapping Agency	Defense Mapping Agency
Cyril Smith	Kansas GIS Policy Board	Urban and Regional Information Systems Association
Todd Smith	Minnesota Department of Transportation	American Association of State Highway and Transportation Officials
Gary Speight	Bureau of Land Management	FGDC Cadastral Subcommittee
Gary William Thompson	North Carolina Geodetic Survey	American Congress on Surveying and Mapping
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Nancy Tosta	FGDC Secretariat	FGDC Secretariat

* FGDC — Federal Geographic Data Committee

** IACWD — Interagency Advisory Committee on Water Data