Geospatial Information and Geographic Information Systems (GIS): Current Issues and Future Challenges

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Summary

Geospatial information is data referenced to a place—a set of geographic coordinates—which can often be gathered, manipulated, and displayed in real time. A Geographic Information System (GIS) is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information. In recent years consumer demand has skyrocketed for geospatial information and for tools like GIS to manipulate and display geospatial information. Global Positioning System (GPS) data and their integration with digital maps has led to the popular handheld or dashboard navigation devices used daily by millions. The federal government and policy makers increasingly use geospatial information and tools like GIS for producing floodplain maps, conducting the Census, mapping foreclosures, and responding to natural hazards such as wildfires and hurricanes. For policy makers, this type of analysis can greatly assist in clarifying complex problems that may involve local, state, and federal government, and affect businesses, residential areas, and federal installations.

Congress has recognized the challenge of coordinating and sharing geospatial data from the local, county, and state level to the national level, and vice versa. The cost of geospatial information to the federal government has also been an ongoing concern. As much as 80% to 90% of government information has a geospatial component, according to different sources. The federal government's role has changed from being a primary provider of authoritative geospatial information to coordinating and managing geospatial data and facilitating partnerships. Challenges to coordinating how geospatial data are acquired and used—collecting duplicative data sets, for example—at the local, state, and federal levels, in collaboration with the private sector, are not yet resolved.

The federal government has recognized the need to organize and coordinate the collection and management of geospatial data since at least 1990, when the Office of Management and Budget (OMB) revised Circular A-16 to establish the Federal Geographic Data Committee (FGDC) and to promote the coordinated use, sharing, and dissemination of geospatial data nationwide. OMB Circular A-16 also called for development of a national digital spatial information resource to enable the sharing and transfer of spatial data between users and producers, linked by criteria and standards. Executive Order 12906, issued in 1994, strengthened and enhanced Circular A-16, and specified that FGDC shall coordinate development of the National Spatial Data Infrastructure (NSDI).

The high-level leadership and broad membership of the FGDC—10 cabinet-level departments and 9 other federal agencies—suggest that geospatial information is a highly regarded asset of the federal government. Questions remain, however, about how effectively the FGDC is fulfilling its mission. Has this organizational structure worked? Can the federal government account for the costs of acquiring, coordinating, and managing geospatial information? How well is the federal government coordinating with the state and local entities that have an increasing stake in geospatial information? What is the role of the private sector?

State-level geospatial entities, through the National State Geographic Information Council, also embrace the need for better coordination. However, the states are sensitive to possible federal encroachment on their prerogatives to customize NSDI to meet the needs of the states.

Contents

Figures

Tables

Appendixes

Contacts

Introduction

The explosion of consumer demand for geospatial information and tools such as geographic information systems (GIS) to manipulate and graphically display such information has brought GIS into the daily lives of millions of Americans, whether they know it or not. Google Earth and handheld or dashboard navigation systems represent enormously popular examples of the wide variety of applications made possible through the availability of geospatial information.[1] The release of Google Earth in 2005 represented a paradigm shift in the way people understand geospatial information, according to some observers, because it offered multi-scale visualization of places and locations around the globe that was free and easy to use.[2]

Historically, the federal government has been a primary provider of authoritative geospatial information, but some argue that consumer demand for spatial information has triggered a major shift toward local government and commercial providers.[3] The federal government has shifted, with some important exceptions, to consuming rather than providing geospatial information from a variety of sources. As a result, the federal government's role has shifted as well toward coordinating and managing geospatial data and facilitating partnerships among the producers and consumers of geospatial information in government, the private sector, and academia. The challenges to coordinating how geospatial data are acquired and used—collecting duplicative data sets, for example—at the local, state, and federal levels, in collaboration with the private sector, are long-standing and not yet resolved.

In 2003 and 2004 the Subcommittee on Technology, Information Policy, Intergovernmental Relations, and the Census, part of the House Committee on Government Reform, held two hearings on the nation's geospatial information infrastructure. A common theme to both hearings was the challenge of coordinating and sharing geospatial data between the local, county, state, and national levels. Quantifying the cost of geospatial information to the federal government has also been an ongoing concern for Congress. At the hearing in 2003, Congressman Putnam stated:

> We need to understand what programs exist across the government, how much we're spending on those programs, where we're spending that money, how efficiently, or perhaps inefficiently, we share data across Federal agency boundaries, how we separate security-sensitive geospatial data from those open for public use, and how we efficiently, or perhaps inefficiently, coordinate with State and local governments and tribes.[4]

The explosion of geospatial data acquired at the local and state levels, for their own purposes and in conjunction with the private sector, underscores the long-recognized need for better coordination between the federal government and local and state authorities. At the same time, coordinating, managing, and facilitating the production and use of geospatial information from

[1] The development and commercial availability of Global Positioning System (GPS) data and the integration of these data with digital maps has led to the popular handheld or dashboard navigation devices used daily by millions.

[2] The National Geospatial Advisory Committee, *The Changing Geospatial Landscape*, January 2009, p. 10, http://www.fgdc.gov/ngac/NGAC%20Report%20-%20The%20Changing%20Geospatial%20Landscape.pdf. Hereafter referred to as NGAC, *The Changing Geospatial Landscape*, January 2009.

[3] NGAC, *The Changing Geospatial Landscape*, January 2009, p. 9.

[4] Prepared statement of Rep. Adam Putnam, Chair, U.S. Congress, House Committee on Government Reform, Subcommittee on Technology, Information Policy, Intergovernmental Relations and the Census, *Geospatial Information: A Progress Report on Improving our Nation's Map-related Data Infrastructure*, 108th Cong., 1st sess., June 10, 2003, H. Hrg. 108-99 (Washington: GPO, 2004).

different sources, of different quality, and which was collected with specific objectives in mind has been a challenge. The federal government has recognized this challenge since at least 1990, when the Office of Management and Budget (OMB) revised Circular A-16 to establish the Federal Geographic Data Committee (FGDC) and to promote the coordinated use, sharing, and dissemination of geospatial data nationwide.[5] Executive Order 12906, issued in 1994, strengthened and enhanced the policies in Circular A-16, and specified that the FGDC shall coordinate development of the National Spatial Data Infrastructure (NSDI). Circular A-16 was itself revised in 2002, adding the Deputy Director of Management at OMB as the vice-chair of the FGDC to serve with the Secretary of the Interior.

The high-level leadership and broad membership of the FGDC—10 cabinet-level departments and 9 other federal agencies—suggest that geospatial information is a highly regarded asset of the federal government. Questions remain, however, about how effectively the FGDC is fulfilling its mission. Has this organizational structure worked? Can the federal government account for the costs of acquiring, coordinating, and managing geospatial information? How well is the federal government coordinating with the state and local entities that have an increasing stake in geospatial information? What is the role of the private sector? Congress may wish to explore these and other questions.

This report provides a primer on geospatial data and GIS and provides several examples of their use. The report discusses issues that may be of interest to Congress: sharing, coordination, and management of geospatial information, including examples of legislation. Finally, recommendations are included from several organizations for how to improve the coordination and management of geospatial information at the federal and state levels. A discussion of classified geospatial information and national security issues is beyond the scope of this report.

GIS and Geospatial Data: A Primer

GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information—information attached to a location, such as latitude and longitude, or street location.[6] Geographically referenced information is also known as geospatial information. Types of geospatial information include features like highway intersections, office buildings, rivers, the path of a tornado, the San Andreas Fault, or congressional district boundaries. Information associated with a specific location is referred to in GIS parlance as an attribute,[7] such as the population of a congressional district, or amount of movement per year along the San Andreas Fault. Other terms common to geospatial data and GIS analysis are described in the box below.

The power of GIS is the ability to combine geospatial information in unique ways—by layers or themes—and extract something new. For instance, a GIS analysis might include the location of a highway intersection and the average number of vehicles that flow through the intersection throughout the day, and extract information useful for locating a business. GIS might include both the location of a river and the water depth along its course by season, and enable an analysis of

[5] GAO (2004), p. 11.

[6] U.S. Geological Survey, *Geographic Information Systems*, http://egsc.usgs.gov/isb/pubs/gis_poster/#what.

[7] National Research Council, *Successful Response Starts With a Map: Improving Geospatial Support for Emergency Management*, Washington, DC, 2007, p. 15.

the effects of development on runoff within the watershed. Overlaying the path of a severe thunderstorm with geospatial data on the types of structures encountered—homes, stores, schools, post offices—could inform an analysis of what types of building construction can survive high winds and hail.

Geospatial and GIS Terminology

Attribute: descriptive information about the properties of events, features, or entities associated with a location, such as the ownership of a parcel of land, or the population of a neighborhood, or the wind speed and direction over a point on the ground.

Cadastre: the map of ownership and boundaries of land parcels.

Cartography: the study and practice of making maps.

Datum: a definition of the origin, orientation, and scale of the coordinate system and its tie to Earth.

Geocoding: assignment of alphanumeric codes or coordinates to geographically referenced data. Examples include the two-letter country codes, or the coordinates of a residence computed from its address.

Geographic Information System (GIS): a digital database in which information is stored by its spatial coordinate system, which allows for data input, storage, retrieval, management, transformation, analysis, reporting, and other activities. GIS is often envisioned as a process as much as a physical entity for data.

Geospatial data: information that identifies the geographic location and characteristics of natural and constructed features and boundaries on Earth.

Global Positioning System (GPS): a navigation system supported by a constellation of satellites placed in orbit by the U.S. Department of Defense. The satellites transmit precise microwave signals that enable GPS receivers to determine their location, speed, and direction.

Hydrography: the charting and description of bodies of water.

LIDAR: acronym for Light Detection and Ranging, a remote sensing technique that uses laser pulses to determine elevation with high accuracy, usually from an aerial survey.

Map: a two-dimensional visual portrayal of geospatial data. The map is not the data itself.

Metadata: information about the quality, content, condition, and other characteristics of data.

Orthoimagery: digital or digitized aerial photographs or images in which the pixels are geometrically rectified and geographically referenced, often including details about topography and names. The rectified orthoimage is free of geometric distortions that are part of the original photograph or image.

Polygon: a feature in GIS used to represent areas (versus a point, or a line). A polygon is defined by the lines that make up its boundary, and a point inside its boundary for identification.

Sources and Types of Geospatial Data

Geospatial data may be acquired by federal, state, tribal, county, and local governments, private companies, academic institutions, and nonprofit organizations. The collection and management of geospatial data are considered by many to be the costliest components of a GIS—some experts attribute close to 80% of GIS total costs to data acquisition.[8]

[8] New York State Department of Environmental Conservation, Center for Technology in Government, *Sharing the Costs, Sharing the Benefits: the NYS GIS Cooperative Project*, Project Report 95-4, Albany, NY, 1995, p. 7, http://www.ctg.albany.edu/publications/reports/sharing_the_costs/sharing_the_costs.pdf.

It should be recognized that the amount of geospatial data is expanding rapidly, the methods for acquiring geospatial data are growing, and the ways geospatial data are being used is diversifying throughout local and state governments, as well as within the federal government. It is beyond the scope of this report to encompass the universe of geospatial data and its utility to the federal government. However, the federal government has had and continues to have a major role in the overall framework for geospatial data, including its organization, coordination, and sharing between federal agencies and with state and local entities. The organization and coordination of geospatial data are discussed further below.

Geospatial data can be acquired using a variety of technologies. Land surveyors, census takers, aerial photographers, police, and even average citizens with a GPS-enabled cell phone can collect geospatial data using GPS or street addresses that can be entered into GIS.[9] The attributes of the collected data, such as land-use information, demographics, landscape features, or crime scene observations, can be entered manually or, in the case of a land survey map, digitized from a map format to a digital format by electronic scanning. Remote sensing data from satellites is acquired digitally and communicated to central facilities for processing and analysis in GIS. Digital satellite images, for example, can be analyzed in GIS to produce maps of land cover and land use. When different types of geospatial data are combined in GIS (e.g., through combining satellite remote sensing land use information with aerial photograph data on housing development growth), the data must be transformed so they fit the same coordinates. GIS uses the processing power of a computer, together with geographic mapping techniques (cartography), to transform data from different sources onto one projection[10] and one scale so that the data can be analyzed together.

Geospatial Data from Local, State, and Federal Governments and the Private Sector

Local and state governments provide geospatial data for use in GIS for a variety of public services such as land records, property taxation, local planning, subdivision control and zoning, and others.[11] Some observers note that local governments often contract with private sector companies to acquire more recent and higher-resolution data than what is available to the federal government.[12] Whether and how the most up-to-date and detailed geospatial information is made available to users other than the local government for whom the data were acquired are long-standing issues. For example, in the immediate aftermath of a natural disaster, such as Hurricane Katrina in 2005, it may be important for the federal government to acquire the most current and detailed geospatial information about the disaster area. In many instances, however, impediments to data sharing such as lack of interoperability between systems, restrictions on use, concerns

[9] For example, thousands of amateur geospatial enthusiasts are forming mapping parties, using personal navigation devices to create their own street maps. See http://www.OpenStreetMap.org. Information derived from such groups is referred to as volunteered geographic information (VGI).

[10] A projection is a mathematical means of transferring information from the Earth's three-dimensional, curved surface onto a two-dimensional map or computer screen.

[11] U.S. General Accounting Office, *Geospatial Information: Better Coordination Needed to Identify and Reduce Duplicative Investments*, GAO-04-703, June 23, 2004, p. 13. Hereafter referred to as GAO (2004). GAO became the Government Accountability Office effective July 7, 2004.

[12] Ibid.

about data security, and a lack of knowledge about what data exist and where the data can be found could hinder a timely and effective emergency response.[13]

The federal government sometimes acquires or contracts to acquire geospatial data for federal needs, such as for updating floodplain maps from paper flood insurance rate maps to a digital format. Assessing and updating floodplain maps on a periodic basis is required by law,[14] and the Federal Emergency Management Agency (FEMA) has spent over $1.4 billion since FY2003 to convert paper flood insurance rate maps (FIRMs) to digital flood insurance rate maps (DFIRMs) and to produce a format usable in GIS.[15] Simply converting paper maps to digital formats does not necessarily improve their accuracy, which often depends on the resolution of the original data. New techniques for collecting more data, such as Light Detection and Ranging (LIDAR), will help produce more accurate floodplain maps.

Example: Using LIDAR for Floodplain Mapping

There is no single nationwide elevation dataset of sufficient resolution and accuracy to make floodplain maps that meet FEMA requirements. A fundamental requirement for accurate flood maps is accurate elevation data, which are used to draw the boundaries for the 1-in-100 chance annual flood hazard (sometimes referred to as the 100-year flood). The USGS National Elevation Dataset is a primary data source that FEMA uses to produce flood maps, but it has a level of uncertainty about 10 times larger than FEMA defines as acceptable for floodplain mapping.[16] The USGS National Elevation Dataset includes some high resolution, more accurate elevation data, but most of the USGS dataset is of poorer resolution. Alternate sources of more accurate elevation data exist, but are not available nationwide. One of these sources is provided using LIDAR,[17] which can be used to collect high resolution elevation data.[18] Because of this data gap, a National Research Council report recommends that FEMA should increase its collaboration with federal, state, and local government agencies to acquire high resolution and accurate elevation data across the nation.[19]

Geospatial data are increasingly acquired and provided by the private sector, and many companies as well as professional organizations support and promote the role of private sector data providers. One organization, the Management Association for Private Photogrammetric Surveyors (MAPPS), bills itself as the only national association exclusively composed of private geospatial firms.[20] MAPPS itself is a member of a larger coalition—the Coalition of Geospatial

[13] National Research Council, *Successful Response Starts With a Map*, 2007, p. 3.

[14] Section 575 of P.L. 103-325 requires the Director of FEMA to assess the need to revise and update all floodplain areas and flood risk zones identified.

[15] For more information on the flood map modernization initiative, see CRS Report R40073, *FEMA Funding for Flood Map Modernization*, by Wayne A. Morrissey.

[16] National Research Council, *Mapping the Zone: Improving Flood Map Accuracy*, Washington, DC, 2009, p. 38. Hereafter referred to as NRC, Mapping the Zone.

[17] See box above for definition.

[18] North Carolina instigated a state-wide LIDAR program, in part, to improve the accuracy of floodplain maps in the wake of hurricane Floyd in 1999. As a result, the state has nearly complete LIDAR coverage.

[19] NRC, *Mapping the Zone*, Recommendations.

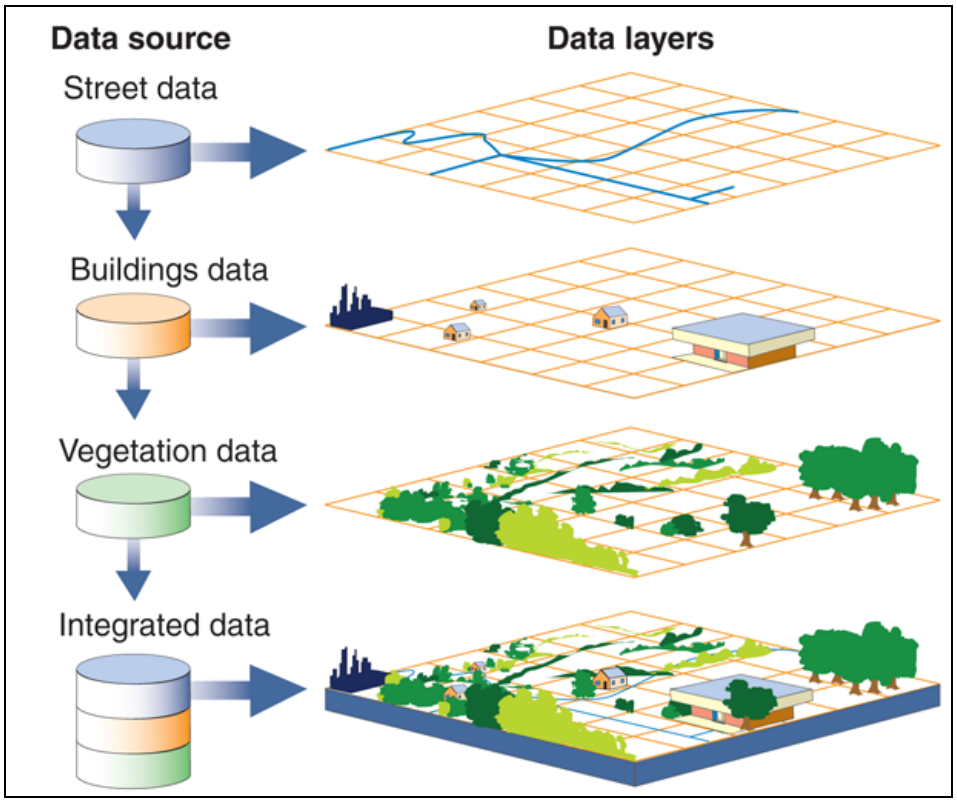
[20] See MAPPS, at http://www.mapps.org/.

Organizations (COGO). COGO is comprised of 15 geospatial-related organizations and associations.[21]

GIS Layers or Themes

The attributes of different types of geospatial data—such as land ownership, roads and bridges, buildings, lakes and rivers, counties, or congressional districts—can each constitute a layer or theme in GIS. (See **Figure 1** for a schematic representation of data layers in GIS.) GIS has the ability to link and integrate information from several different data layers or themes over the same geographic coordinates, which is very difficult to do with any other means. For example, GIS could copmbine a major road from one data layer as the boundary dividing land zoned for commercial development with the location of wetlands from another data layer. Precipitation data, from a third data layer, could be combined with a fourth data layer that shows streams and rivers. GIS could then be used to calculate where and how much runoff might flow from the commercial development into the wetlands. Thus the power of GIS analysis can be used to create a new way to interpret information that would otherwise be very difficult to visualize and analyze.

Figure 1. Example of GIS Data Layers or Themes



Source: GAO (2004), p. 5.

[21] For a list of the COGO member organizations, see http://www.urisa.org/cogo.

Examples of Why and How Geospatial Information Is Used

California Wildfires

Geospatial information is data referenced to a place—a set of geographic coordinates—which can often be gathered, manipulated, and displayed in real time. Timeliness is an important factor for some uses of geospatial information. An example is the southern California wildfires during 2008. One of the worst fires in the region, known as the Sylmar fire, sparked on the evening of November 14, 2008, and swept quickly through 11,000 acres, destroying more than 600 structures in the Sylmar section of Los Angeles before it was contained.[22] The fire forced the evacuation of thousands of residents from their homes. The speed of the fire's progress made it difficult to know where the fire was heading and to visualize escape routes. In addition, the fire jumped Interstate 210 (I-210) and Interstate 5 (I-5), two major routes of egress, on Saturday, November 15.

To assist in real-time decision making, the fire's progress was posted on the Internet in near real-time by several organizations, using reports from the ground, and the information about the fire was displayed on underlying street maps (showing where the fire crossed I-5 and I-210), terrain maps, and satellite images. (See **Figure 2**.) The Sylmar fire example underscores the informational power available when geospatial information is combined with tools for displaying the information, such as GIS and the Internet. In this instance, timeliness—the ability to post the geospatial information quickly—enhanced its value to the data users, citizens trying to avoid the path of the fire.

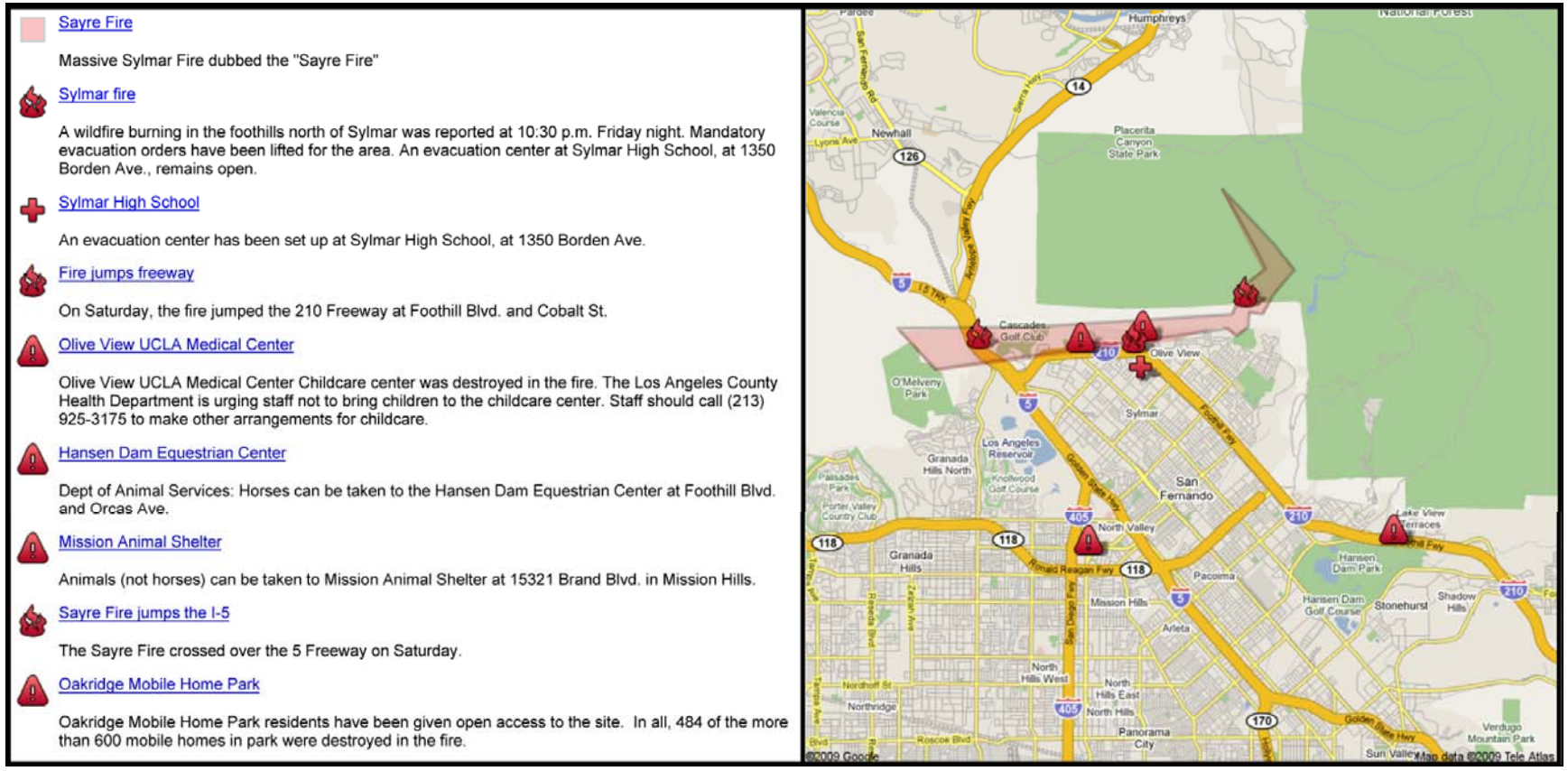
Although timeliness is often important, the analytical power resulting from combining geospatial information with GIS more typically underscores its value to policy makers at all levels. GIS often provides for unique analyses of disparate types of information—linked by their spatial coordinates—to help resolve policy questions. For policy makers, this type of analysis can greatly assist in clarifying complex problems that may involve local, state, and federal government, and may affect businesses, residential areas, and federal installations.

Base Realignment and Closure (BRAC) Program

The Base Realignment and Closure (BRAC) program is the process by which excess military facilities are identified and transferred to other federal agencies or disposed of. The City of Virginia Beach, VA, used GIS in its response to the 2005 BRAC Commission's recommendation to realign Naval Air Station Oceana, located near the population center of the city. The BRAC Commission was concerned that the city's land use was encroaching on the air station; in particular, the city was impinging on the noise zones and accident potential zone (APZ) around the air station. Because the recommended realignment of Oceana would likely cause Virginia Beach to suffer significant economic losses, the city sought to establish a baseline—using GIS—to understand the status of encroachment. In addition, the GIS analysis could inform city leaders about how to modify the municipal land use ordinance to prevent encroachment on the air station and forestall its realignment.

[22] CBS Broadcasting, Inc., "Sayre fire reaches 85 percent containment," November 19, 2008, at http://cbs2.com/local/brush.fire.Sylmar.2.865252.html.

Figure 2. Snapshot of the Path of the 2008 Sylmar Fire Near Los Angeles, CA

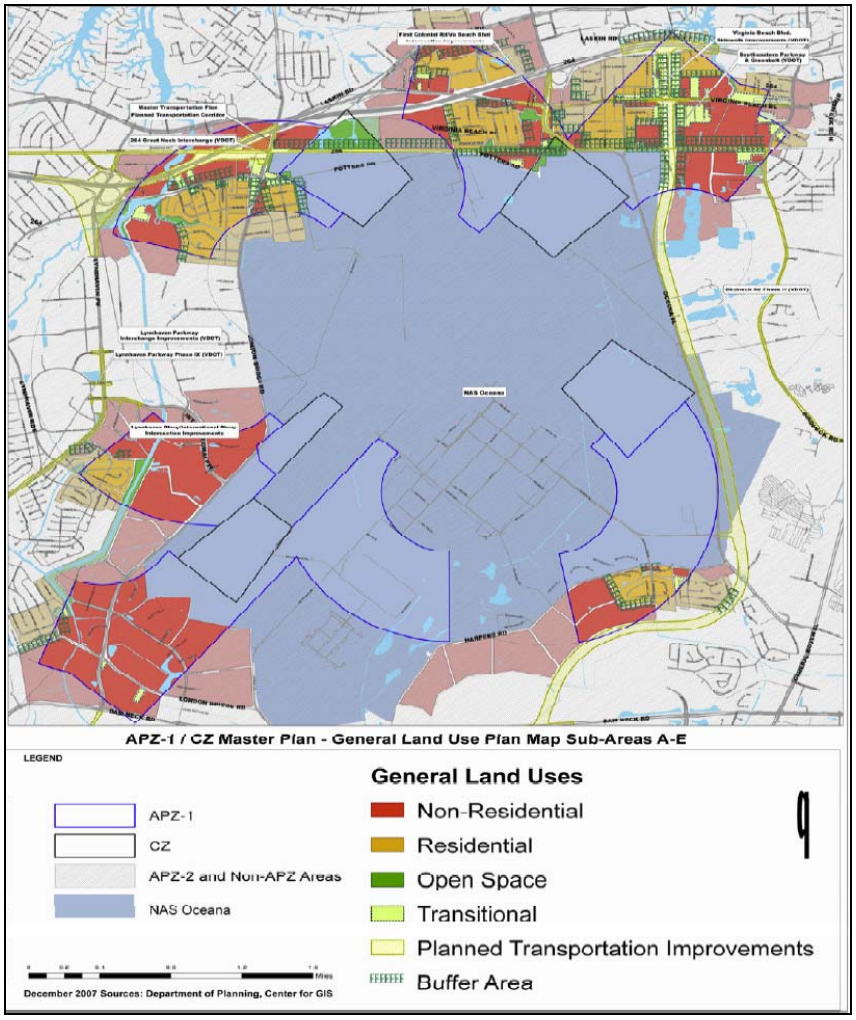


Source: ABC Eyewitness News, Sylmar Wildfire, created Nov. 15, 2008, updated Nov. 20, 2008. See http://maps.google.com/maps/ms?hl=en&ie=UTF8&msa=0&msid=100866907082629170478.00045bb5e2170708e9258&t=h&source=embed&ll=34.314638,-118.436834&spn=0.251809,0.528717&z=12. Modified by CRS.

Notes: the path of the fire with the annotation is shown with an underlying street map. The original interactive website also allows the user to choose an underlying terrain map or satellite image map.

Figure 3. GIS Analysis of Naval Air Station Oceana, Virginia Beach, VA

(example showing city land use encroachment)



Source: Figure 5, page 19, APZ-1/Clear Zones Master Plan, Second Progress Report, N.A.S. Oceana Encroachment, City of Virginia Beach.

Notes: APZ is Accident Potential Zone; CZ is Clear Zone.

To establish a baseline, city planners and GIS analysts overlaid noise zones and APZ, property, land use, zoning, and other sets of geospatial data—known as attributed boundary layers—to determine current land use and development. Within the GIS analysis, these sets of geospatial data were joined with land parcel information, and with various external databases held within the planning, real estate assessor's, and commissioner's offices. By combining geospatial data with non-spatial data, the GIS analysts helped land planners determine how the land around the air station was being used, and therefore its compatibility with the Navy's requirements. (See **Figure 3**.) The GIS analysis also enabled the city to summarize property values and acreage by its use: undeveloped, commercial, or residential.

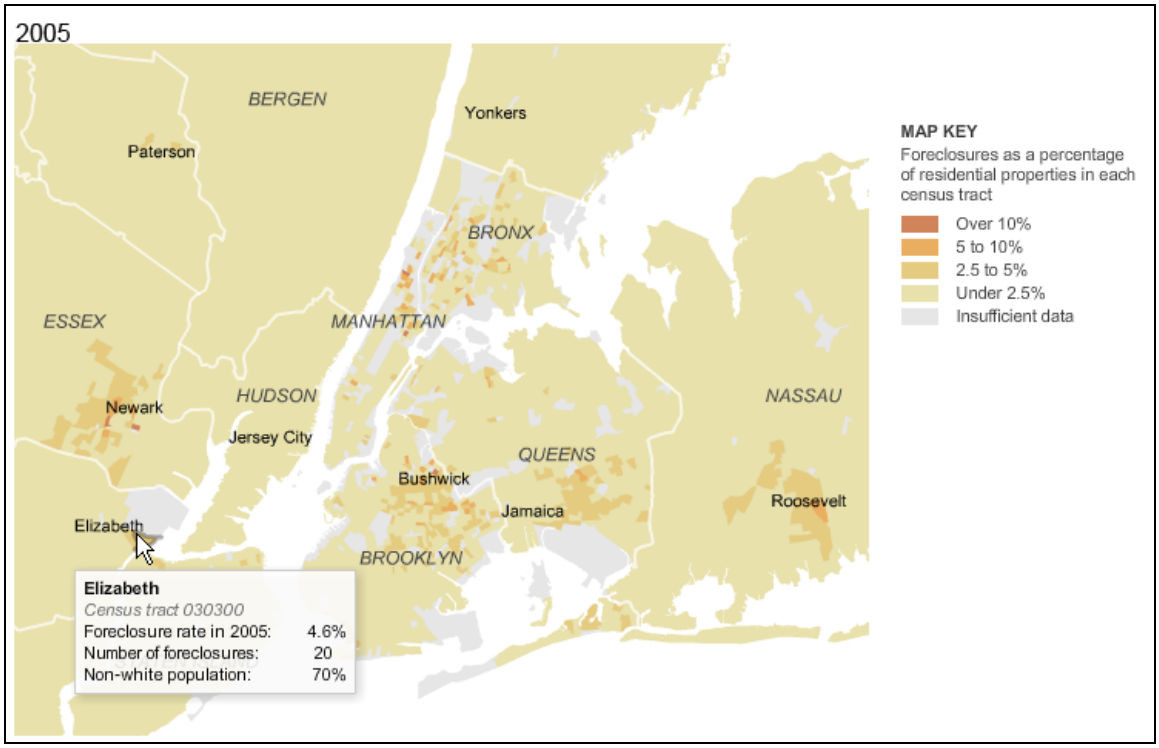
GIS helped the Virginia Beach city planners to identify on one map all of the land use around the air station (**Figure 3**). GIS analysts also provided a model of underdeveloped land—land that had additional existing by-right development capacity—but which if developed could exacerbate the

encroachment problem for the Navy. As a result of the GIS analysis, city planners recommended a change to the municipal land ordinance to prevent potential future incompatible development. Naval Air Station Oceana has not been relocated from Virginia Beach.

Mapping Foreclosures

On May 15, 2009, the *New York Times* published an online interactive map showing foreclosures as a percentage of residential properties in each Census tract in the New York City region.[23] The map shows Census tracts coded by color to represent the foreclosure rate, and as the cursor is moved over each Census tract, the map shows a pop-up window disclosing the foreclosure percentage, the number of foreclosed residences, and the percentage on the non-white population in each tract. In addition, the map allows the reader to compare foreclosure rates for each year since 2005. **Figures 4** and **5** are snapshots from the map for the years 2005 and 2008.

Figure 4. Snapshot of Interactive Map Showing Foreclosure Percentage by Census Tract in the New York City Area, 2005

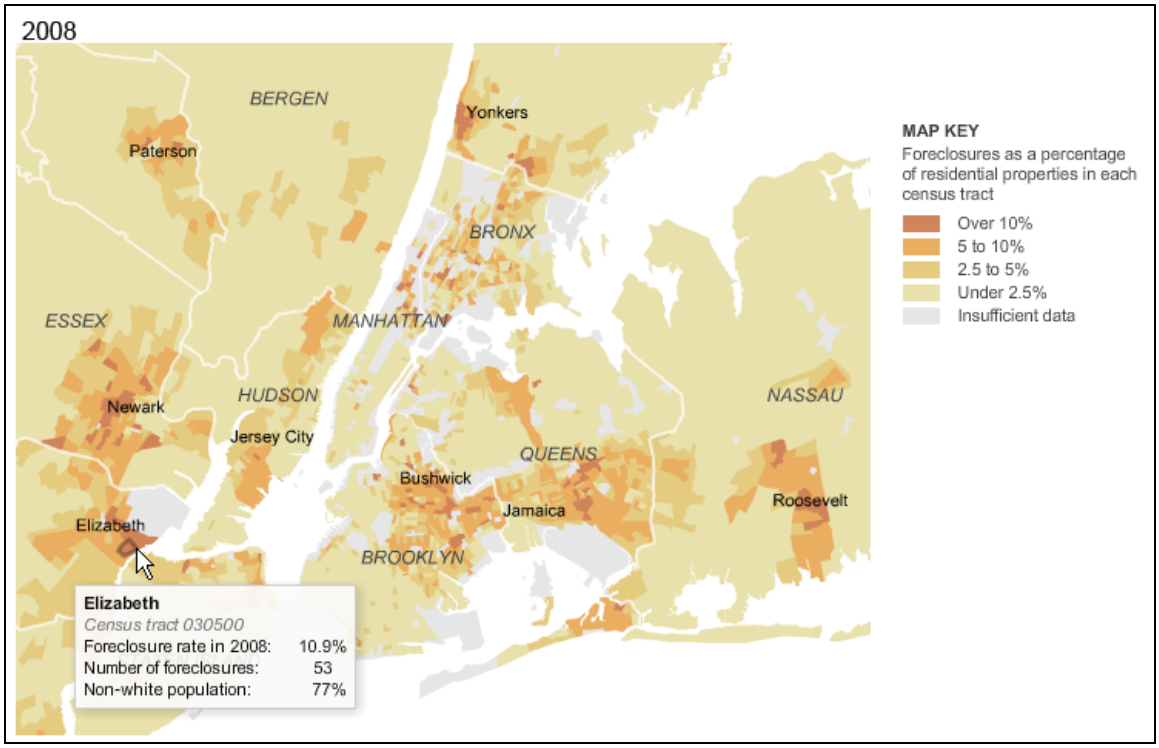


Source: New York Times, May 15, 2009, at http://www.nytimes.com/interactive/2009/05/15/nyregion/0515-foreclose.html. Modified by CRS.

Notes: The online interactive version allows the reader to point and click on any Census tract in the region. Census tract 030300 is shown here for illustration purposes.

[23] Mathew Bloch and Janet Roberts, "Mapping Foreclosures in the New York Region," *New York Times*, May 15, 2009, at http://www.nytimes.com/interactive/2009/05/15/nyregion/0515-foreclose.html.

Figure 5. Snapshot of Interactive Map Showing Foreclosure Percentage by Census Tract in the New York City Area, 2008



Source: New York Times, May 15, 2009, at http://www.nytimes.com/interactive/2009/05/15/nyregion/0515-foreclose.html. Modified by CRS.

Notes: the online interactive version allows the reader to point and click on any Census tract in the region. Census tract 030500 is shown here for illustration purposes.

By using the zoom tool provided with the map, the reader can zoom in on specific residential properties, represented by red dots, along with street names. This type of visualization, combining detailed geospatial information with demographic and financial data, lends itself to further analysis such as understanding foreclosure patterns and whether proximity to foreclosed properties has an effect on property values. Some researchers call this the "contagion effect" of foreclosed properties. One report documented how this effect discounted property values as a function of distance from foreclosed homes, and showed that the discount effect dropped off sharply with distance.[24] This type of spatial analysis of foreclosure effects, with the visualization provided by GIS maps such as the *New York Times* example, can help inform policy makers about the nature of foreclosure patterns.

[24] John P. Harding, Eric Rosenblatt, and Vincent W. Yao, "The Contagion Effect of Foreclosed Properties," *Social Science Research Network Working Paper*, July 15, 2008.

Issues with Organization and Management, Data Sharing, and Coordination

Producing floodplain maps, conducting the Census, planning ecosystem restoration, and assessing vulnerability and responding to natural hazards such as hurricanes and earthquakes are examples of how federal agencies use GIS and geospatial information to meet national needs. The amount of government information that has a geospatial component—such as address or other reference to a physical location—is as much as 80%, according to the Department of the Interior.[25] According to one report, geospatial-related industries generate at least $30 billion annually,[26] and the U.S. Bureau of Labor cites statistics that suggest the geospatial sector has been growing by about 35% per year, with the commercial side growing at 100% per year.[27]

Overarching challenges are:

- the organization and management of the vast array of geospatial information that is acquired at many levels and that has a variety of potential uses;
- data sharing, particularly among local, state, and federal stakeholders, each of whom may have a need for the same or similar data; and
- coordination among federal agencies and with other stakeholders, such as the administration and management by different agencies of all the federal lands in the United States.

Organization and Management of Geospatial Data

The need to organize and manage geospatial data between federal agencies and between the federal government, local and state authorities, the private sector, and academia is a recurring theme. It recurs, in part, because it is widely recognized that collecting data multiple times for the same purpose is wasteful and inefficient, yet it continues to occur. Alternatively, geospatial data collected to meet the requirements of, for example, a local government, could be made useful to the state or federal government if the data meet a set of basic and consistent guidelines and protocols. In fact, organizational structures exist at the federal and state levels to identify and promulgate the efficient sharing, transfer, and use of geospatial information. Ideally, these efforts would produce a national spatial data infrastructure, or NSDI. Some members of the geospatial community have indicated that the past efforts to create a national spatial data infrastructure have not met expectations, and have recently called for a new effort to build a "national GIS" or a "NSDI 2.0." (See discussion below on these proposals.) In addition to promoting the efficiency and interoperability of such a national system, some promote NSDI as "digital infrastructure" on

[25] Cited in U.S. General Accounting Office, *Geographic Information Systems: Challenges to Effective Data Sharing*, GAO-03-874T, June 10, 2003, p. 5. Hereafter referred to as GAO (2003). The *2006 Annual Report* from the Federal Geographic Data Committee claims that 80%-90% of government information has a spatial component.

[26] The National Geospatial Advisory Committee, *A National Geospatial Strategy: Recommendations for the 2008-2009 Presidential Transition Team*, at http://www.fgdc.gov/ngac/ngac-transition-recommendations-10-16-08.pdf.

[27] U.S. Department of Labor, Employment and Training Administration, at http://www.doleta.gov/brG/Indprof/geospatial_profile.cfm (viewed May 14, 2009).

par with other parts of the nation's critical infrastructure—such as roads, pipelines, telecommunications—and underscore its role in the national economy and in national security.

Background

The federal government has recognized the need to organize and coordinate the collection and management of geospatial data since at least 1990, when OMB revised Circular A-16 to establish the FGDC, and to promote the coordinated use, sharing, and dissemination of geospatial data nationwide.[28] OMB Circular A-16 also called for development of a national digital spatial information resource to enable the sharing and transfer of spatial data between users and producers, linked by criteria and standards. President Clinton issued Executive Order 12906 on April 11, 1994, to strengthen and enhance the general policies described in Circular A-16, and to specify that the FGDC shall coordinate development of the National Spatial Data Infrastructure (NSDI). OMB revised Circular A-16 most recently on August 19, 2002, to affirm the NSDI as "the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data." The revised circular incorporated Executive Order 12906, and added the Deputy Director of Management at OMB as the vice-chair of the FGDC to serve with the Secretary of the Interior.

In one sense, the FGDC exists to foster development and implementation of the NSDI. The NSDI includes the processes and relationships that facilitate data sharing across all levels of government, academia, and the private sector. Ultimately, the NSDI is intended to be the base resource and structure among geospatial data providers and users at the national, state, and local level.

The Federal Geographic Data Committee (FGDC)

Under the revised Circular A-16, 19 members comprise the FGDC (see **Table 1**). The U.S. Geological Survey, Department of the Interior, provides administrative support through the FGDC Secretariat.[29] According to Circular A-16, all federal agencies responsible for geospatial data themes are required to be members of the FGDC. Further, Circular A-16 directs the FGDC to lead and support the NSDI strategy, spatial data policy development, management, and operational decision making. As the overall coordinating entity for the NSDI, the FGDC has broad responsibilities that include all spatial data and geographic information systems activities that are financed directly or indirectly, in part or in whole, by federal funds.

Table 1. Members of the Federal Geographic Data Committee (FGDC)

Dept. of Agriculture	Environmental Protection Agency
Dept. of Commerce	Federal Emergency Management Agency
Dept. of Defense	General Services Administration
Dept. of Energy	Library of Congress
Dept. of Health and Human Services	National Aeronautics and Space Administration

[28] GAO (2004), p. 11.

[29] See the USGS National Geospatial Program, at http://www.usgs.gov/ngpo/index.html.

Dept. of Housing and Urban Development	National Archives and Records Administration
Dept. of the Interior	National Science Foundation
Dept. of Justice	Tennessee Valley Authority
Dept. of State	Office of Management and Budget
Dept. of Transportation	

The National Spatial Data Infrastructure (NSDI)

The FGDC facilitates the NSDI in cooperation with organizations from state, local, and tribal governments, the academic community, and the private sector. As specified in Circular A-16, cooperation is necessary to realize the overall vision of the NSDI, which is to assure that spatial data from multiple sources—not just federal sources—are available and easily integrated to enhance the understanding of our physical and cultural world. The five components of the NSDI are:

- *Data themes*. These are geodetic control, orthoimagery, elevation and bathymetry, transportation, hydrography, cadastre, and governmental units.
- *Metadata*. These are information about the data, its content, source, accuracy, method of collection, and other descriptions that help ensure the data are used appropriately. OMB Circular A-16 specifies that all spatial data collected or derived directly or indirectly using federal funds will have FGDC metadata.
- *National Spatial Data Clearinghouse*. The Clearinghouse is an electronic service providing access to documented spatial data and metadata from distributed data sources. The Clearinghouse is intended to provide access to NSDI for spatial data users.
- *Standards*. These are common and repeated rules, conditions, guidelines or characteristics for data, and related processes, technology, and organization. OMB Circular A-16 specifies that international standards and protocols must be used for NSDI, to broaden the global use of federal data and services. The FGDC is responsible for developing and promulgating the standards after receiving broad input from data users and providers.
- *Partnerships*. OMB Circular A-16 directs federal agencies to promote and fully utilize partnerships that promote cost-effective data collection, documentation, maintenance, distribution, and preservation strategies that leverage the federal resources. In addition to federal, state, and tribal governments, these partnerships are supposed to include private-sector geographic, statistical, demographic, and other business information providers and users.

Other Activities and Components of FGDC and NSDI

Geospatial One-Stop

According to the FGDC 2007 Annual Report,[30] the Geospatial One-Stop portal is the official means of accessing metadata resources, which are published through the National Spatial Data Clearinghouse and which are managed in NSDI. Geospatial One-Stop focuses on the discovery and access of geospatial information.[31] The Geospatial One-Stop is described as one of the three national geospatial initiatives that share the goal of building the NSDI along with NGDC itself and The National Map (described below). The FGDC focuses on policy, standards, and advocacy, and The National Map focuses on integrated, certified, base mapping content.

The National Map

According to the USGS, The National Map is envisioned as a consistent framework for geographic knowledge nationwide, and will be available as an online and interactive map service.[32] The National Map is the future product that would supplant the paper versions of topographic maps that the USGS has produced for decades. It would allow users to combine geographic information from other sources with the USGS topographic foundation data. The National Map would provide information such as high-resolution digital imagery from satellites and aerial photographs, high-resolution surface elevation data, land cover data, geographic names, and other features. Currently, The National Map is in an initial stage that can provide nationwide coverage at limited resolutions for transportation, hydrography, elevation, land cover, and cultural features. According to the USGS, The National Map will capture and integrate data in a process of continuous update, rather than by regularly scheduled cycles of review and revision. The National Map will face challenges, however, in integrating data from a variety of sources, perhaps at different scales and different resolutions, and in managing inconsistent or incomplete metadata.

USGS Geospatial Liaison Network

The National Geospatial Program (NGP) at the USGS includes the USGS Geospatial Liaison Network, which consists of USGS employees who serve as liaisons in NSDI partnership offices across the country.[33] The liaisons are intended to represent and coordinate NGP initiatives in state and local agencies, in addition to other federal agencies, in support of NSDI, The National Map, and Geospatial One-Stop. The liaisons work with statewide coordinating councils and seek partnerships with not-for-profit organizations, the private sector, universities, and consortia to support the goals of NSDI. According to the USGS, each liaison is the "local face" of the USGS NSDI and NGP.

[30] Available at http://www.fgdc.gov/library/whitepapers-reports/annual%20reports/2007/index_html.

[31] The website is called geodata.gov and is available at http://gos2.geodata.gov/wps/portal/gos.

[32] See USGS, *The National Map*, at http://nationalmap.gov/index.html.

[33] A brief description of the program, and a link to a list of the liaisons, is provided at http://www.usgs.gov/ngpo/ngp_liaisons.html.

Each state is assigned a liaison under the network, although some liaisons may cover more than one state.[34] The liaisons commonly work with the formal state GIS coordinators or councils, or with other individuals or regional groups in states where a formal GIS or geospatial coordinator or council does not exist. A large portion of the liaison's efforts is devoted to coordinating with state-level and other stakeholders on geospatial data acquisition, although some of the focus has been shifting to maintaining geospatial data as well as acquiring it.[35] In states with large federal land holdings, such as some western states, geospatial liaisons may devote relatively more time to coordinating with federal land management agencies such as the USFS, National Park Service, or BLM.[36]

Why Data Sharing Between Local, State, and National Levels Is Important

The National Research Council (NRC) has reported that the value of geospatial data is better accepted at the county level than it was in the past, especially land parcel, or cadastral, data. The benefits of sharing geospatial data so that what is produced locally can by used for national needs, however, is not as widely acknowledged.[37] In the case of land parcel data specifically, many local governments create data for their own use and do not see how a national effort would bring local benefits. The NRC notes, however, that the need for complete national land parcel data has become urgent particularly for at least one application—emergency response. During the Hurricane Katrina disaster, some critical land parcel data that was needed by emergency responders, public officials, and even insurance companies was not readily available or did not exist.[38] Further, the NRC report asserts that many of the property fraud cases associated with the hurricanes of 2005 were the direct result of poor or nonexistent geospatial data, specifically land parcel data.[39]

Example: Floodplain Mapping

In one sense, floodplain mapping represents the archetypical example of how GIS and geospatial data can be shared to fulfill national and local needs. In this case, the shared need is for accurate floodplain maps. Floodplain mapping also exemplifies the challenge to collecting and sharing geospatial data of sufficient accuracy to meet the needs of local, state, and federal data users and authorities.

In a recently released report, the NRC observed that high quality, digital mapping of floodplains using the most accurate elevation data is essential to communicate flood hazards, set flood insurance rates, and regulate development in flood-prone areas.[40] Between 2003 and 2008, the FEMA invested approximately $1 billion in the Map Modernization Program, a large-scale effort

[34] See http://www.usgs.gov/ngpo/ngp_liaisons.pdf for a list of states and their assigned liaisons.

[35] Telephone conversation with Vicki Lukas, Chief, NGP Partnerships, USGS, Reston, VA, May 21, 2009.

[36] Ibid.

[37] National Research Council, *National Land Parcel Data: A Vision for the Future*, Washington, DC, 2007, p. 2. Hereafter referred to as NRC, National Land Parcel Data.

[38] NRC, National Land Parcel Data.

[39] NRC, National Land Parcel Data, p. 7.

[40] NRC, *Mapping the Zone*, Summary.

to collect new elevation data, update existing data, and digitize older paper flood maps.[41] State governments and local partners also contributed considerable funding to the effort. The FEMA effort produced digital flood maps covering 92% of the nation's population; however, only 21% of the population has flood maps that fully meet FEMA's own data quality standards. As a result, insurance companies, lenders, realtors, and property owners who depend on the flood maps to determine flood insurance needs, plan for development, and prepare for floods still have to deal with uncertainties inherent in the less accurate flood maps.

Challenges to Coordinating

Several efforts to coordinate geospatial data among federal agencies have proven difficult to achieve. The National Map is an example of a work-in-progress attempting to integrate data from a variety of sources and produce a product that is widely available and useful to many users. In an example cited by the GAO in its 2003 testimony, the U.S. Forest Service (USFS) tried to create a national-level GIS for the forest ecosystem, but had to reconcile data from a variety of incompatible locally developed systems, which used a variety of standards for each forest and district. Most of the USFS effort went into reconciling the different data sets. Ultimately the USFS had to adopt the lowest-resolution format to maintain full coverage of all the forests, and could not use the higher-resolution local data.[42]

The National Integrated Land System (NILS) is another example of an ongoing effort to coordinate and integrate federal land data among several agencies. The Bureau of Land Management (BLM) is the designated custodian for federal land parcel information and ownership status.[43] The federal government owns approximately 650 million acres, about 29% of all land in the United States. Three federal agencies in addition to the BLM administer most federal lands: the USFS, Fish and Wildlife Service, and the National Park Service.[44] In an effort to develop a single representation of federal lands, the BLM and USFS launched a joint project called the National Integrated Land System (NILS), billed as a partnership between the federal agencies and states, counties, and private industry to provide a single solution to managing federal land parcel information in a GIS environment.[45] A limited amount of federal land data is available through NILS, which is currently in a project or prototype phase, and the project makes current information and tools available through its GeoCommunicator component.[46]

Both NILS and The National Map represent federal efforts to foster interagency sharing of data into a single product providing national coverage of federal land holdings and topography respectively. The utility of both efforts is limited by the quality, accuracy, and completeness of the underlying geospatial data. The National Map, as currently envisioned, will provide topographic information at the 1:24,000 scale, meaning that roughly one inch on the map equals 2,000 feet. That scale will likely limit The National Map's usefulness for depicting, for example, floodplain boundaries that meet the requirements for FEMA floodplain maps. Also, at some point in the

[41] For more detail on funding for the program, see CRS Report R40073, *FEMA Funding for Flood Map Modernization*, by Wayne A. Morrissey.

[42] GAO (2003), p. 6.

[43] Circular A-16, at http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html.

[44] The Department of Defense also administers a significant amount of land.

[45] See http://www.blm.gov/wo/st/en/prog/more/nils.html.

[46] See http://www.geocommunicator.gov/GeoComm/index.shtm.

future NILS presumably could provide one-stop shopping for an accurate assessment of the amount of federal land currently administered by each land management agency in the Department of the Interior and for the USFS. Currently, however, the best method for obtaining an accurate tally of federal lands is to contact each land management agency directly and request their most up-to-date data in tabular form.[47] Legislation has been introduced in Congress to address some of these challenges.

The Federal Land Asset Inventory Reform Act of 2009

On March 16, 2009, Representative Kind introduced H.R. 1520, the *Federal Land Asset Inventory Reform Act of 2009*, which would require the Secretary of the Interior to develop a multipurpose cadastre of federal "real property." The legislation defines cadastre as an inventory, and defines federal "real property" as land, buildings, crops, forests, or other resources still attached to or within the land or improvements or fixtures permanently attached to the land or structures on it. The bill requires the Secretary to coordinate with the FGDC pursuant to OMB Circular A-16, to integrate the activities under the legislation with similar cadastral activities of state and local governments, and to participate in establishing standards and protocols that are necessary to ensure interoperability of the geospatial information of the cadastre for all users. Similar legislation was introduced in the Senate and House in the 110th Congress.[48]

By developing the cadastre, the legislation is intended to improve federal land management, resource conservation, environmental protection, and the use of federal real property. As noted above, the BLM currently has responsibility for maintaining federal land parcel information and ownership status, and it is not clear if H.R. 1520 would expand the current geospatial activities at BLM, shift the custodial responsibilities to another agency, or result in a different approach or program. Some supporters of the bills introduced in the 110th Congress indicated that existing inventories of federal real property are old, outdated, and inaccurate.[49] Observers also note that the federal government lacks one central inventory that coordinates all the inventories into one usable database.[50]

The Ocean and Coastal Mapping Integration Act

The Ocean and Coastal Mapping Integration Act, introduced as S. 174 and H.R. 365 in the 111th Congress, was enacted into law as Subtitle B of Title XII of the Omnibus Public Land Management Act of 2009 (P.L. 111-11). The act establishes a federal program to develop a coordinated and comprehensive mapping plan for the coastal waters including the exclusive economic zone and continental shelf, and the Great Lakes. In establishing the program, the act addresses issues of data sharing and cost-effectiveness by fostering cooperative mapping efforts, developing appropriate data standards, and facilitating the interoperability of data systems. Further, the program established under the act would develop these standards to be consistent with the requirements of the FGDC, so that the data collected in support of mapping are useful not only to federal government, but also to coastal states and other entities. The theme of coordinating activities is underscored in several places in the act, specifically with other federal

[47] E-mail from John P. Donnelly, National Atlas of the United States, USGS, Reston, VA, February 4, 2009.

[48] H.R. 5532 and S. 3043. Neither version of the bill saw action in the 110th Congress.

[49] "Legislators return with FLAIR," *GEO World*, May 2008, p. 15.

[50] Ibid.

efforts such as the Digital Coast,[51] Geospatial One-Stop (discussed above), and the FGDC, as well as international mapping activities, coastal state activities, user groups, and nongovernmental entities.

The challenge to collect and manage the geospatial data needed to meet the requirements of the act is daunting, given the array of federal agencies, affected states, local communities, businesses, and other stakeholders who have an interest in coastal mapping. Moreover, the stakeholders require wide and disparate types of data—such as living and nonliving coastal and marine resources, coastal ecosystems, sensitive habitats, submerged cultural resources, undersea cables, aquaculture projects, offshore energy projects, and others. A coordinated effort is more likely to produce a robust coastal mapping effort called for in the act. Congress could view the development of the ocean and coastal mapping plan and its implementation as a test case: how to manage a large data collection effort—cost-effectively and cooperatively—that reaches across all levels of government and includes interest groups, businesses, NGOs, and even international partners.

Non-Federal Stakeholders

National Geospatial Advisory Committee

A National Geospatial Advisory Committee (NGAC) was formed in early 2008 to provide advice and recommendations to the FGDC on management of federal geospatial programs, development of the NSDI, and implementation of the OMB Circular A-16. The Secretary of the Interior named 28 individuals to the committee on January 28, 2008; these members represent the private sector, nonprofits, academia, and governmental agencies.[52] As part of its charter, NGAC provides a forum to convey views representative of non-federal stakeholders in the geospatial community.

In its January 2009 report, *The Changing Geospatial Landscape*, NGAC noted that as geospatial data production has shifted from the federal government to the private sector and state and local governments, new partnerships for data sharing and coordination are needed. Specifically:

> the hodgepodge of existing data sharing agreements are stifling productivity and are a serious impediment to use even in times of emergency.... When the federal government was the primary data provider, regulations required data to be placed in the public domain. This policy jump-started a new marketplace and led to the adoptions of GIS capabilities across public and commercial sectors. However, these arrangements are very different when data assets are controlled by private companies or local governments.[53]

NGAC observed further that the federal government's need for land parcel (cadastral) data, which is also emphasized by the National Research Council, is missing an arrangement for acquiring the detailed property-related data necessary to make decisions during times of emergency. The report suggests that detailed land parcel data—its use, value, and ownership—is needed by FEMA, the

[51] The Digital Coast is a NOAA-led effort envisioned as a an information delivery system for coastal data, as well as the training, tools, and examples needed to turn data into useful information. See http://www.csc.noaa.gov/digitalcoast/index.html.

[52] See NGDC website, at http://www.fgdc.gov/ngac/index_html/?searchterm=advisory%20committee. The committee is sponsored by the Department of the Interior under the Federal Advisory Committee Act.

[53] NGAC, *The Changing Geospatial Landscape*, January 2009, p. 12.

USFS, and the U.S. Department of Housing and Urban Development for emergency preparedness, response to hurricanes or wildfires, or to monitor the current foreclosure problems.[54]

NGAC Recommendations to the New Administration

In October 2008 NGAC sent recommendations to the 2008-2009 Presidential Transition Team for improving the federal role in coordinating geospatial activities, for making changes to the *U.S. Code* pertaining to non-sensitive address data, and for enhancing geospatial workforce education.[55] Most recommendations pertained to how the federal government could better coordinate geospatial partnerships with state, local, and tribal governments, the private sector, and the academic community, such as recommendations to:

- establish a geospatial leadership and coordination function immediately within the Executive Office of the President; the geospatial coordination function should be included in the reauthorization of the E-Government Act;
- require OMB and FGDC to strengthen their enforcement of OMB Circular A-16 and EO 12906;
- establish/designate Geographic Information Officers with each department or agency with responsibilities stipulated within OMB Circular A-16;
- establish and oversee an Urgent Path[56] forward for implementation of geospatial programs necessary to support current national priorities and essential government services underpinning the NSDI; and
- continue NGAC.

Access to Geospatial Information

In its recommendations, NGAC also calls for revising "restrictive statutory language as it pertains to non-sensitive address data in Title 13 U.S. Code and to 'geospatial' data in Section 1619 of the 2008 Farm Bill." In Title 13 Congress delegates responsibility for conducting the Census to the Secretary of Commerce. The law contains provisions for not disclosing or publishing private information that identifies an individual or business (Sections 9 and 214 of Title 13). The Census Bureau is forbidden to publish any private information—such as names, addresses, telephone numbers—that identifies an individual or business.[57] Interestingly, this type of geospatial information is available for some localities[58] in the United States; however, it is not provided by the Census Bureau. A proposal to amend portions of Title 13 and make geospatial data collected by the Census Bureau more accessible will likely raise issues about the privacy of personal data

[54] Ibid.

[55] See http://www.fgdc.gov/ngac/ngac-transition-recommendations-10-16-08.pdf.

[56] The NGAC recommendations further specify that an "Urgent Path" forward should include (1) Imagery for the Nation; (2) National Land Imaging Program; and (3) National Land Parcel data.

[57] 13 U.S.C. § 9 and §13. See also U.S. Census Bureau, at http://www.census.gov/privacy/data_protection/federal_law.html.

[58] For example, the website for the City of Greeley, CO, property information map, identifies names and addresses, the underlying street map and orthoimagery, together with other information such as school districts and even the nearest fire hydrant. See http://gis.greeleygov.com/origin/propinfo.html.

collected by the federal government; the value of such data for emergency management; disaster preparation; other local, regional, and national needs; and the various tradeoffs between privacy concerns and the accessibility to geospatial data.

Section 1619 of the 2008 farm bill (P.L. 110-246) prohibits disclosure of geospatial information about agricultural land or operations, when the information is provided by an agricultural producer or owner of agricultural land and maintained by the Secretary of Agriculture. Certain exceptions, contained in Section 1619 of the 2008 farm bill, apply to the prohibition. NGAC has taken the position that the statutory language could be revised to enhance the value of the geospatial data while not compromising privacy.[59]

National States Geographic Information Council (NSGIC)

At the national level, the FGDC exists to promote the coordinated development, use, sharing, and dissemination of geospatial data. At the state level, NSGIC exists to promote the coordination of statewide geospatial activities in all states, and to advocate for the states in national geospatial policy initiatives to help enable the NSDI.[60] NSGIC ties its activities to the NSDI by promoting the development of Statewide Spatial Data Infrastructures (SSDI), under a partnership called the 50-States Initiative, which ideally would lead to the creation of an SSDI for each state. In this vision, each state's SSDI would enable coordination between geospatial data producers and consumers at all levels within the state, and allow the state to share geospatial data with the national geospatial structure envisioned as the NSDI. The emphasis on organization and coordination of geospatial data and activities is seen as critical to reducing costs to states and the federal government by eliminating data redundancy—collecting the data once, using it many times—and by setting standards that allow different users to share geospatial data regardless of who collects it.

NSGIC identified 10 criteria that define a "model" state program necessary to develop effectively coordinated statewide GIS activities, and thus reduce inefficiency and waste. These include:

1. strategic and business plans;
2. a full-time, paid, GIS coordinator and staff;
3. clearly defined authority and responsibility for coordination;
4. a relationship with the state chief information officer;
5. a political or executive champion for coordinating GIS;
6. a tie to the national spatial data infrastructure and clearinghouse programs;
7. the ability to work with local governments, academia, and the private sector;
8. sustainable funding, especially for producing geospatial data;
9. the authority for the GIS coordinator to enter into contracts; and
10. the federal government working through the statewide coordinating body.

[59] Telephone conversation with Anne Miglarese, Chair, National Geospatial Advisory Committee, May 26, 2009.

[60] National States Geographic Information Council Strategic Plan 2009-2011, at http://www.nsgic.org/resources/strategicplan.pdf.

Not all states have fully embraced the need for statewide coordination of GIS activities, and states differ in their structure and organization of geospatial data among and between state, county, and local entities. For example, some states such as Arkansas share geospatial data across agencies in a very open manner; other states such as New York require more formal agreements or have restrictions to sharing data that include critical infrastructure. (Nonetheless, some level of data sharing does occur, even in the more restrictive states.[61])

Imagery for the Nation

A priority for NSGIC is a program under development, called Imagery for the Nation (IFTN), that would collect and disseminate aerial and satellite imagery in the form of digital orthoimagery. In its description of the program, NISGIC notes that digital orthoimagery is the foundation for most public and private GIS endeavors. Further, NSGIC states that as many as 1,300 different government entities across the nation are developing digital orthoimagery products, "leading to higher costs, varying quality, duplication of effort, and a patchwork of products."[62] IFTN represents an effort to establish one coherent set of geospatial data—arguably one of the most important layers in a GIS, orthoimagery—that is organized for the benefit of many stakeholders at the federal, tribal, regional, state, and local levels.

As proposed, IFTN would involve two programs: (1) the existing National Agricultural Imagery Program (NAIP) administered by the U.S. Department of Agriculture, and (2) a companion program administered by the USGS. The NAIP imagery would be enhanced to provide annually updated one-meter resolution orthoimagery over all states except Hawaii and Alaska.[63] The USGS program would also collect one-foot resolution imagery every three years for 50% of the U.S. land mass (except Alaska, which would get one-foot resolution imagery only over densely populated areas). The program would include an option for states to "buy up," or enhance, any or all of the remaining 50%. The program would also provide 50% matching funds for partnerships to acquire six-inch resolution imagery over urban areas with at least 1,000 people per square mile as identified by the U.S. Census Bureau.

NSGIC states that statewide GIS coordination councils would specify their requirements through business plans, and that all the data would remain in the public domain, which would address many of the data sharing issues discussed above. In addition, the program calls for appropriate national standards for all data, which is a goal of the FGDC, a partner to NSGIC in the development of IFTN. NSGIC estimates that the program would cost $1.38 billion during the first 10 years, and argues that this would save $120 million over the 10-year period by reducing the number of contracts, contracting for larger areas, reducing overhead, and reducing other costs associated with current efforts.[64]

[61] E-mail from Learon Dalby, NSGIC President 2008-2009, March 11, 2009.

[62] See NISGIC, Imagery for the Nation, at http://www.nsgic.org/hottopics/imageryforthenation.cfm.

[63] Imagery would be updated once every three years in Hawaii. The USGS program would produce one-meter imagery for Alaska once every five years.

[64] CRS did not review the basis for NSGIC's cost analysis, nor examine the cost benefit analysis completed for the IFTN in July 2007.

Advancing the National Spatial Data Infrastructure: The NSGIC Perspective

NSGIC considers the 50-States Initiative as one of the crucial components needed to build the NSDI and to bring consistency of geospatial information and parity to each of the states.[65] NSGIC also considers that IFTN is the first of several initiatives creating "core data layers," or baseline data programs, required to meet federal, state, and local needs.[66] NSGIC suggests that the NGAC be an interim step in the governance structure for NSDI, and indicates that the national effort to govern and coordinate the geospatial enterprise should not stifle the states from customizing aspects of the NSDI to suit their own needs:

> the federal government must not dictate the actions of state and local governments, nor should state governments dictate those of local government. However, each level of government can exert a strong influence on subordinate levels by making funding contingent on compliance with the policies and standards it establishes.[67]

NSGIC further argues that funding the resulting collaboration and compliance could be modeled on the federal highway program.[68]

A National GIS?

In early 2009, several proposals were released calling for efforts to create a national GIS,[69] or for renewed investment in the national spatial data infrastructure, or even to create a "NSDI 2.0."[70] The release of these proposals coincided with deliberation of major legislation to stimulate the U.S. economy through massive spending on the nation's infrastructure, among other things, that eventually passed as P.L. 111-5, the American Investment and Recovery Act of 2009 (ARRA). The language in the proposals attempted to make the case for considering such investments part of the national investment in critical infrastructure, both by directly supporting these national GIS and geospatial efforts, but also via secondary effects. For example, one proposal indicated that organizations rebuilding roads, bridges, and schools need updated online information networks "to rebuild in a smart, efficient, environmentally conscious and sustainable way."[71] Another proposal touted a national GIS as a tool to speed economic recovery, which should also "leave the

[65] NSGIC, Strategic Framework for the NSDI, at http://www.nsgic.org/resources/strategic_framework_NSDI_NSGIC.pdf.

[66] Ibid; for example, NSGIC suggests that Imagery for the Nation should probably be followed by Elevation for the Nation, Transportation for the Nation, Cadastral for the Nation, and so on.

[67] NSGIC, The States' Perspective on Advancing the National Spatial Data Infrastructure, October 10, 2008.

[68] NSGIC, Strategic Framework for the NSDI.

[69] These proposals are broader than what is currently envisioned as The National Map, under the USGS.

[70] See, for example, the following: *A Proposal for National Economic Recovery: An Investment in Geospatial Information Infrastructure Building a National GIS*, at http://www.gis.com/gisnation/pdfs/national_economic_recovery.pdf; *A Proposal for Reinvigorating the National Economy Through Investment in the US National Spatial Data Infrastructure*, at http://www.cast.uark.edu/nsdi/nsdiplan.pdf; and *A Concept for American Recovery and Reinvestment, NSDI 2.0: Powering our National Economy, Renewing our Infrastructure, and Protecting our Environment*, at http://www.nsdi2.net/NSDI2ProposalForAmericanRecoveryAndReinvestment_V1_4.pdf.

[71] A Concept for American Recovery and Reinvestment, NSDI 2.0: Powering our National Economy, Renewing our Infrastructure, and Protecting our Environment, p. 2.

country with a public utility, a modern geospatial information system, that itself can become a foundation for new generations of industries and technologies in the future."[72]

The timing of the these proposals and the language linking their purported benefits to national economic recovery were clearly intended to take advantage of the Obama Administration's and Congress's deliberations on economic stimulus funding. None of the proposals was included in ARRA, but their call for efforts to build a "national" GIS, or a new version of the NSDI, or for an investment in a national spatial data infrastructure, raises questions about the current efforts to build the NSDI. Efforts to construct the NSDI began in 1994 with Executive Order 12906, or even earlier when OMB revised Circular A-16 in 1990 to establish the Federal Geographic Data Committee. The more recent proposals imply that efforts which began over 15 years ago and continue today are not sufficiently national in scope, planning, coordination, sharing, or implementation, despite the existence of the FGDC, NSGIC, or other organizations such as MAPPS or COGO that are forums for organizations concerned with national geospatial issues.

The National Geospatial Advisory Committee recommended that OMB and FGDC strengthen their enforcement of Circular A-16 and Executive Order 12906; however, enforcement alone may not be sufficient to meet the current challenges of coordination and data sharing. For example, OMB Circular A-16 was last revised in April 2002, prior to the creation of the Department of Homeland Security (DHS). The current membership of FGDC does not include DHS, which itself has a significant interest in geospatial information. The example of DHS raises the broader issue of data sharing and coordination of geospatial information collected for civilian versus national security purposes in the post-September 11 era.

Congress may wish to consider how a national GIS or geospatial infrastructure would be conceived, perhaps drawing on proposals for these national efforts as described above, and how they would be similar to or differ from current efforts. Congress may also wish to examine its oversight role in the implementation of OMB Circular A-16, particularly in how federal agencies are coordinating their programs that have geospatial components. In 2004, GAO acknowledged that the federal government, through the FGDC and Geospatial One-Stop project, had taken actions to coordinate the government's geospatial investments, but that those efforts had not been fully successful in eliminating redundancies between agencies. As a result, federal agencies were acquiring and maintaining potentially duplicative data sets and systems.[73] Since then, it is not clear whether federal agencies are now successfully coordinating among themselves and measurably eliminating unnecessary duplication of effort. An additional challenge is how Congress oversees the federal geospatial enterprise when so much government information has a geospatial component, and many departments and agencies are actively involved in acquiring and using geospatial data for their own purposes.

[72] *A Proposal for National Economic Recovery: An Investment in Geospatial Information Infrastructure Building a National GIS.*

[73] GAO (2004), p. 19.

Appendix. List of Acronyms

ARRA	American Recovery and Reinvestment Act of 2009
APZ	Accident Potential Zone
BLM	Bureau of Land Management
BRAC	Base Realignment and Closure
COGO	Coalition of Geospatial Organizations
CZ	Clear Zone
DFIRMs	Digital Flood Insurance Rate Maps
FEMA	Federal Emergency Management Agency
FGDC	Federal Geographic Data Committee
FIRMs	Flood Insurance Rate Maps
GAO	Government Accountability Office
GIS	Geographic Information Systems
GPS	Global Positioning System
IFTN	Imagery for the Nation
LIDAR	Light Detection and Ranging
MAPPS	Management Association for Private Photogrammetric Surveyors
NGAC	National Geospatial Advisory Committee
NGP	National Geospatial Program
NILS	National Integrated Land System
NRC	National Research Council
NSDI	National Spatial Data Infrastructure
NSGIC	National States Geographic Information Council
OMB	Office of Management and Budget
USGS	U.S. Geological Survey

USFS	U.S. Forest Service
VGI	Volunteered Geographic Information

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