United States General Accounting Office

GAO

Fact Sheet for the Chairman,
Committee on Government Operations,
House of Representatives

September 1991

GEOGRAPHIC INFORMATION SYSTEMS

Information on Federal Use and Coordination

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GAO

United States
General Accounting Office
Washington, D.C. 20548

Information Management and
Technology Division

B-245438

September 27, 1991

The Honorable John Conyers, Jr.
Chairman, Committee on
Government Operations
House of Representatives

Dear Mr. Chairman:

This report responds to your March 1991 request on the use and acquisition of federal geographic information systems (GIS), which are digital computer systems designed to capture, store, display, analyze, and model data referenced to locations on the earth's surface. As agreed with your office, we are providing information on the use of GIS by federal agencies and on the scope of coordination.

Much of the information contained in this report is based on our analysis of data gathered through a recent governmentwide survey of the GIS activities of 110 federal agencies. This survey was conducted by the Federal Interagency Coordinating Committee on Digital Cartography, which is now the Federal Geographic Data Committee (FGDC). The FGDC is responsible for promoting the coordinated development, use, sharing, and dissemination of GIS data governmentwide. We also interviewed officials and analyzed documents from agencies using GIS. A detailed explanation of our objectives, scope, and methodology is contained in appendix I.

Results in Brief

The use of GIS by federal agencies is growing. The number of agencies reporting widespread use of GIS is expected to more than double from 18 agencies in fiscal year 1990 to 44 in fiscal year 1992. Although the Office of Management and Budget cannot identify total federal GIS expenditures, individual agencies reported modest GIS expenditures in fiscal year 1990. However, by fiscal year 1992, planned expenditures are expected to increase by approximately 60 percent. The two largest uses for GIS governmentwide are the management of natural resources and environmental assessment and monitoring. In addition, several agencies use multiple GIS applications such as emergency planning and response, hazardous and toxic waste tracking, and tactical and strategic defense analyses.

Many agencies have neither official mechanisms or programs in place to coordinate their GIS projects or cooperate with other federal, state, or

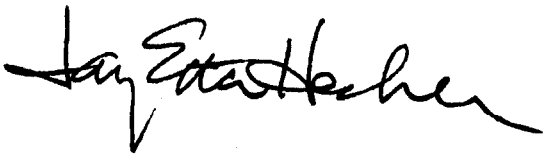
local agencies. In addition, most agencies have not developed written policies regarding GIS or instructions for disposing of spatial data. Nonetheless, many federal agencies obtain GIS data from other federal, state, and local agencies.

Appendix II provides additional information on GIS use and coordination in a question and answer format. The first five questions address federal GIS use, and the remaining seven questions address federal GIS coordination. Appendix III provides a list of the 82 agencies, of the 110 surveyed, who are planning to use GIS in some way in fiscal years 1990, 1991, or 1992, according to the recent governmentwide survey.

Although we did not obtain written agency comments on a draft of this report, we discussed the results of our work with FGDC officials and have incorporated their comments where appropriate. As arranged with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days after the date of this letter. We will then send copies to interested congressional committees; the Director, Office of Management and Budget; and other interested parties.

Should you have any questions about this report or require additional information, please contact me at (202) 275-9675. Major contributors to this report are listed in appendix IV.

Sincerely yours,



JayEtta Z. Hecker
Director, Resources, Community,
and Economic Development
Information Systems

Contents

Abbreviations

ADP	automated data processing
DLG	digital line graph
FGDC	Federal Geographic Data Committee
GAO	General Accounting Office
GIS	geographic information system
IMTEC	Information Management and Technology Division
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
R&D	research and development
SDTS	Spatial Data Transfer Standard
T&E	test and evaluation
TIGER	Topologically Integrated Geographic Encoding and Referencing

Objectives, Scope, and Methodology

Our objectives were to obtain information on (1) the use of GIS by federal agencies and (2) the scope of federal GIS coordination. To accomplish our first objective, we analyzed data contained in a recent GIS survey of 110 federal agencies.[1] After converting the survey's data into a computer file, we used mainframe-based statistical software to select, analyze, and chart selected responses. Of the 110 agencies surveyed, we selected and analyzed responses from the 82 who planned to use GIS in fiscal years 1990, 1991, or 1992. The figures presented in appendix II were developed based on our analysis. We did not verify the accuracy of responses with officials from individual agencies.

To accomplish our second objective, we interviewed officials responsible for federal GIS oversight, standards setting, and coordination in several key agencies and organizations, including the Office of Management and Budget, the U.S. Geological Survey, and the FGDC, which is responsible for GIS coordination among federal agencies. We also obtained and analyzed selected GIS documents from other federal agencies.

Our work was performed in accordance with generally accepted government auditing standards, between June and August 1991 at various locations, including:

- Office of Management and Budget in Washington, D.C.;
- U.S. Geological Survey headquarters in Reston, Virginia;
- Soil Conservation Service headquarters in Washington, D.C.;
- Environmental Protection Agency headquarters in Washington, D.C.;
- Defense Mapping Agency headquarters in Washington, D.C.;
- National Institute of Standards and Technology (NIST) headquarters in Gaithersburg, Maryland;
- U.S. Postal Service headquarters in Washington, D.C.; and
- U.S. Bureau of the Census' Geographic Division in Suitland, Maryland.

Although we did not obtain written agency comments on a draft of this report, we discussed the results of our work with FGDC officials and have incorporated their comments where appropriate.

[1] A Summary of GIS Use In The Federal Government, Federal Interagency Coordinating Committee on Digital Cartography, Reports Working Group, U.S. Geological Survey, Fall 1990.

Questions and Answers About Federal GIS Activities

What Are Geographic Information Systems?

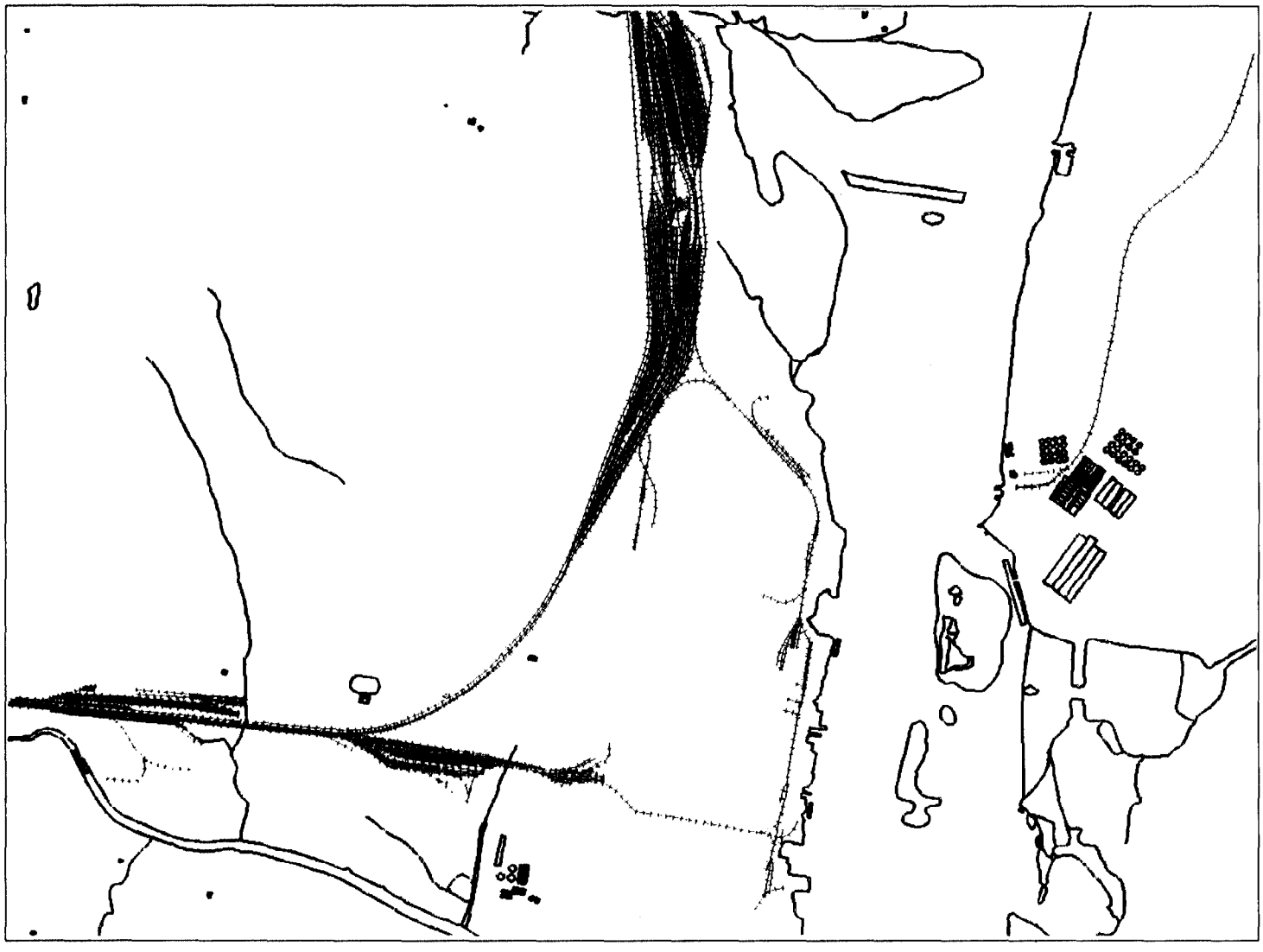
A GIS is a digital computer system that captures, stores, displays, analyzes, and models natural and artificial environments using data referenced to locations on the earth's surface. GIS or spatial data are usually described by a geographic position and attributes in a computer-readable form. For example, spatial data representing a building would identify the building; the geographic position, such as its longitude-latitude coordinates; and attributes, such as its name and use.

The use of GIS has grown dramatically in the 1980s in the government, as well as in the research and private sectors. The explosive growth in GIS was stimulated by many factors, including advances in computer graphics and data base management technology, the increased sophistication of GIS applications, the increased accuracy of spatial data achieved through the use of the Department of Defense's Navstar Global Positioning System,[1] the ability to incorporate satellite images, and the advent of inexpensive, microcomputer-based GIS applications. More importantly, complex environmental concerns, growing regulatory pressures, the need to better manage scarce resources, and more public participation in environmental decisions are leading policymakers to use GIS as a tool for modeling policy scenarios and understanding complex geographic problems.

Similarly, the private sector may also derive significant benefits from the advances in GIS and from the development of national-level spatial data bases. For example, two of the major spatial data sources—the U.S. Geological Survey's Digital Line Graph (DLG) and the Bureau of the Census' Topologically Integrated Geographic Encoding and Referencing (TIGER) data bases provide the base data layer for many GIS applications, including applications in commercial logistical operations such as dispatching, parcel and mail delivery, and emergency vehicle routing. Figures II.1a, II.1b, and II.1c provide examples of DLG and TIGER maps representing an area in Alexandria, Virginia, near the Potomac River.

[1]The Global Positioning System is a space-based radio navigation system designed to provide precise, continuous, all-weather global positioning and navigation data. The system's receivers use the time difference between signals from different satellites to establish the latitude-longitude coordinates of the system's location.

Figure II.1a: Example of Selected DLG Map Features Showing Bodies of Water and Railroads in Alexandria, Virginia[a]



Source: U.S. Geological Survey, National Mapping Division, GIS Research Laboratory
[a]DLG maps also show other features such as roads and boundaries.

Figure II.1b: Example of TIGER Map Showing Streets in Alexandria, Virginia

Source: U.S. Geological Survey, National Mapping Division, GIS Research Laboratory

Figure II.1c: Example of Combined DLG and TIGER Maps Showing an Area in Alexandria, Virginia

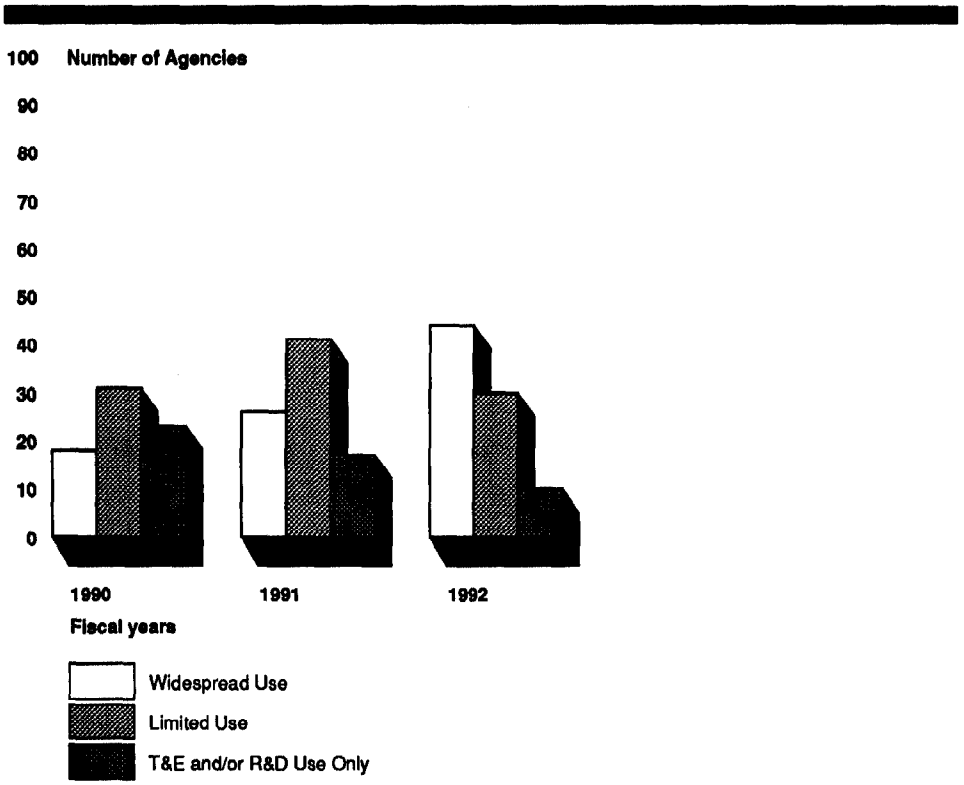
Source: U.S. Geological Survey, National Mapping Division, GIS Research Laboratory

What Are the Levels of the Current and Planned Use of GIS by Agencies?

Figure II.2 shows that the use of GIS among federal agencies is rapidly increasing. In fiscal year 1990, 18 agencies reported widespread use of GIS, while in fiscal year 1991, 26 agencies projected widespread use. Fiscal year 1992 projections showed that 44 agencies are planning to use GIS on a broad scope. Thirty-one agencies reported limited use in fiscal year 1990, 41 agencies projected limited use in fiscal year 1991, and 30 projected limited use in fiscal year 1992. Test and evaluation and/or

research and development is falling, from 23 agencies in fiscal 1990 to 10 in fiscal year 1992.

Figure II.2: Agencies' Levels of GIS Activity in Fiscal Years 1990, 1991, and 1992



Number of agencies whose GIS use is widespread may include other levels of use.

Number of agencies whose GIS use is limited may include other levels of use.

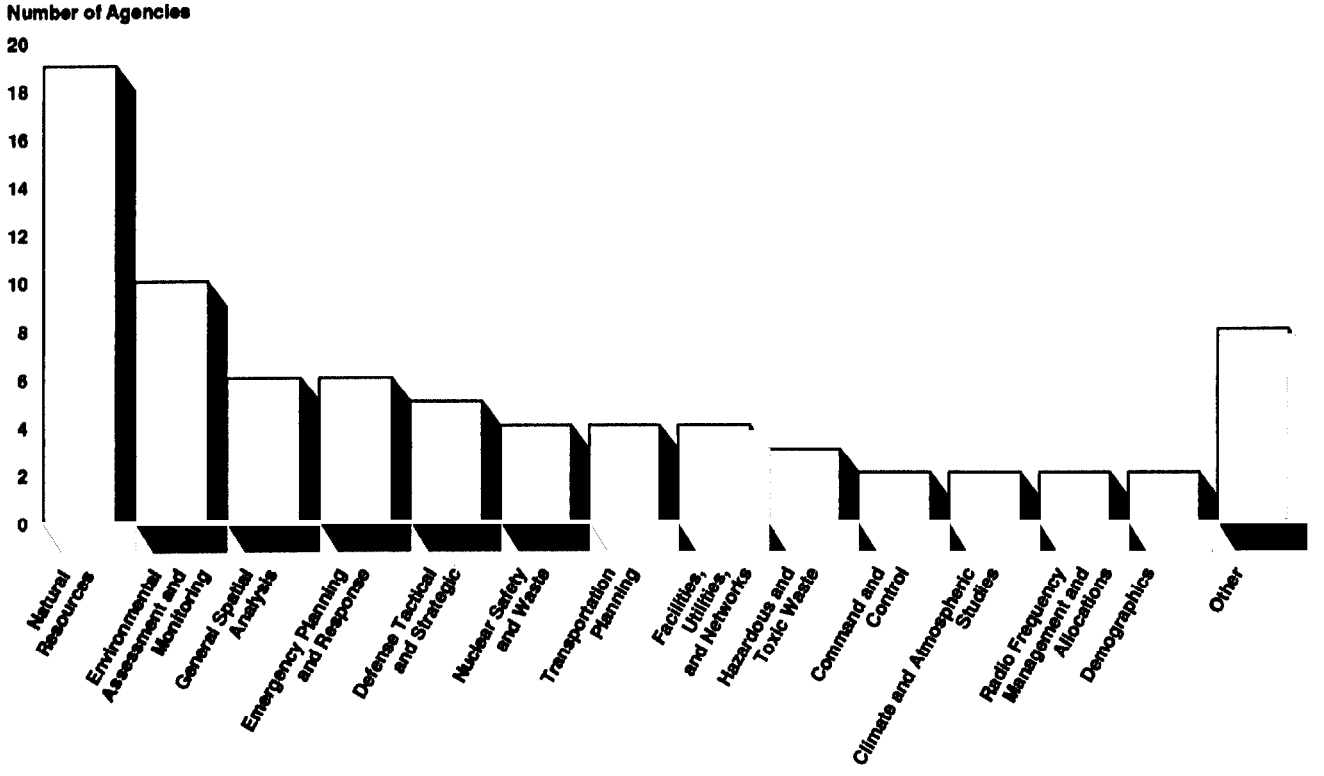
Number of agencies performing test & evaluation and/or research & development does not include widespread or limited use.

For What Purpose Are Agencies Using Their GIS?

Agencies reported using GIS for many different purposes (see fig. II.3). For example, the Oak Ridge National Laboratory's Environmental Sciences Division uses its GIS to perform landscape pattern analyses, regional assessments for acid rain, hazardous waste management, watershed research, and global climate change research. Managing natural resources is the most frequently cited GIS use by federal agencies; the second largest use is environmental assessment and monitoring.

Other areas of GIS use include tracking hazardous and toxic waste; analyzing tactical and strategic defense data; and assessing nuclear safety, health care, and narcotics.

Figure II.3: Categories of GIS Use



What Were FY 1990 GIS Expenditures, and What Portion of These Expenditures Was Allocated for Operational GIS Use?

The reported GIS expenditures were generally modest with 54 agencies reporting expenditures of up to $1 million. Sixteen agencies spent between $1 million and $5 million, while only four agencies spent over $5 million on their GIS systems (see fig. II.4).

As illustrated in figure II.5, 29 agencies reported that over 75 percent of these GIS expenditures were for operational use. Eight agencies spent between 50 and 75 percent of their GIS budget on operational use. Seventeen agencies reported that less than half of their GIS expenditures were

for operational use, while 19 reported no expenditures for operational use.

Figure II.4: Number of Agencies Whose GIS Expenditures Are Within the Designated Funding Level Ranges in Fiscal Year 1990

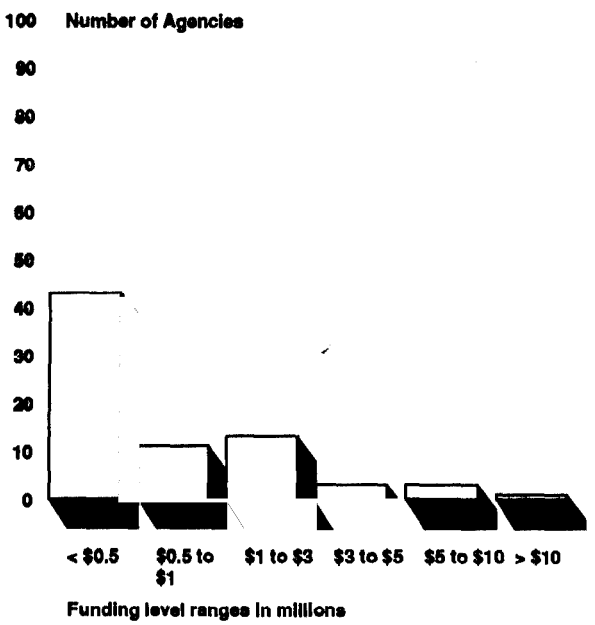
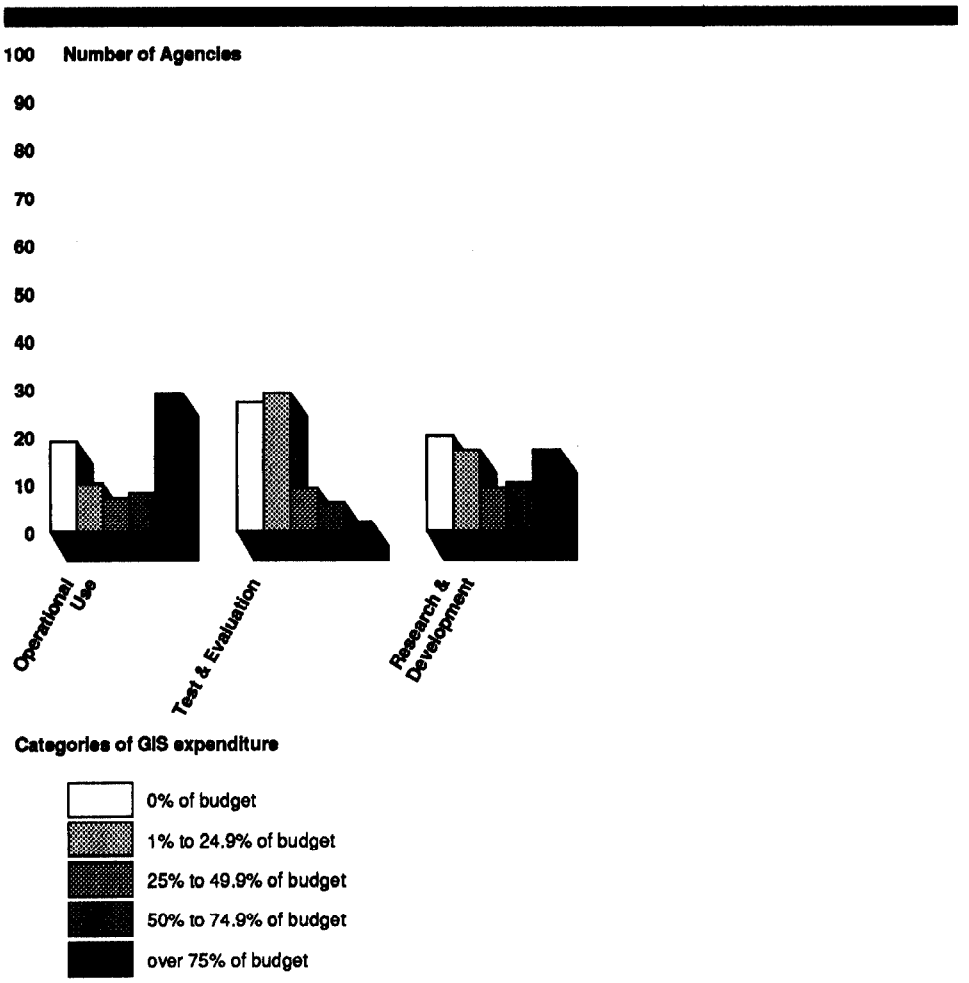


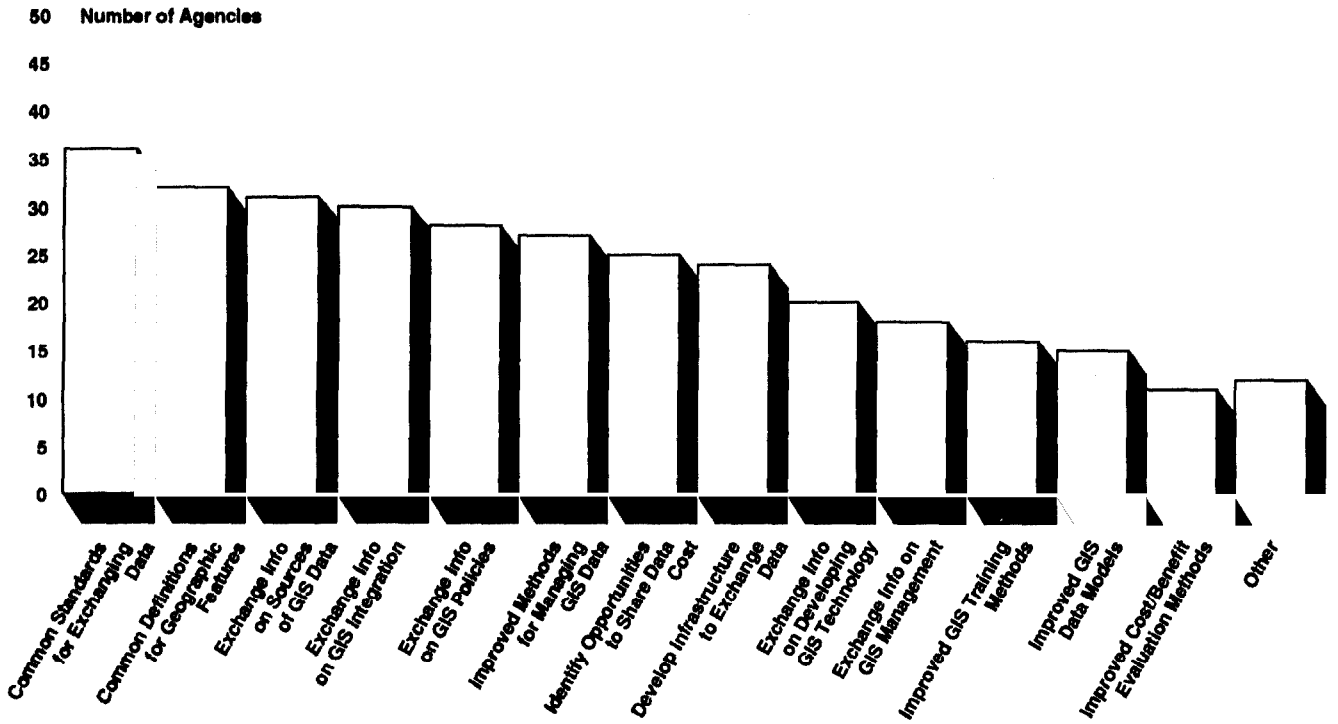
Figure II.5: Number of Agencies Spending Within Dollar Ranges According to Category of GIS Expenditure in Fiscal Year 1990



What Efforts or Activities Were Perceived by Agencies Using GIS to Be Most Useful in the Development of Their GIS?

Agencies polled found common standards for exchanging data to be the most useful activity in developing GIS. Other activities or efforts thought to be most useful included creating common definitions for geographic features and exchanging information on sources of spatial data, GIS integration, and GIS policies. Figure II.6 lists the activities agencies found most useful in developing their GIS.

Figure II.6: Activities/Efforts Found Most Useful by Agencies for Developing GIS



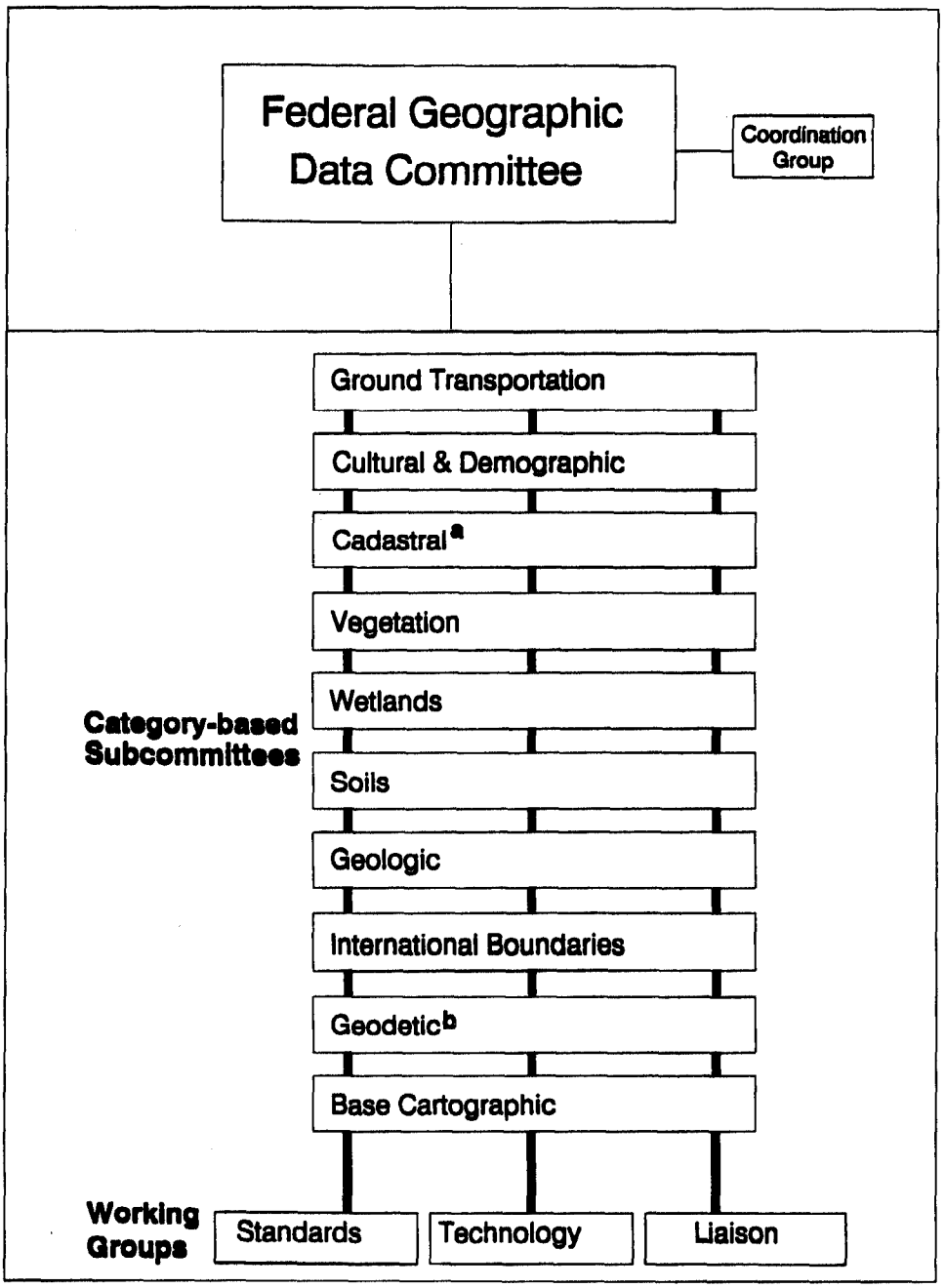
How Are Federal GIS Activities Coordinated?

In October 1990, the Office of Management and Budget issued revised Circular A-16, titled Coordination of Surveying, Mapping, and Related Spatial Data Activities. The revised circular established the FGDC, which replaced the Federal Interagency Coordinating Committee on Digital Cartography. The FGDC was created to promote the coordinated development, use, sharing, and dissemination of surveying, mapping, and other spatial data.

The FGDC's responsibilities include (1) promoting the development, maintenance, and management of the National Geographic Data System, a group of distributed data base systems that are national in scope for surveying, mapping, and related spatial data; (2) encouraging the development and implementation of standards; (3) promoting technology development, transfer, and exchange; and (4) publishing technical and management articles and reports, including biannual federal GIS surveys. FGDC is also responsible for strengthening coordination between federal agencies, state and local governments, academia, and the private sector.

The U.S. Geological Survey is the lead agency for the FGDC and heads a steering committee that oversees the FGDC's subcommittees and working groups. Figure II.7 illustrates the organization of the FGDC. The ten subcommittees coordinate activities related to each spatial data category, while the three working groups deal with issues common to all spatial data categories and promote consistency among subcommittees. As further categories of spatial data are identified, the committee plans to form additional subcommittees.

Figure II.7: FGDC Structure



[a]Cadastral data show the boundaries and subdivisions of public lands and private estates for the purpose of describing and recording ownership.

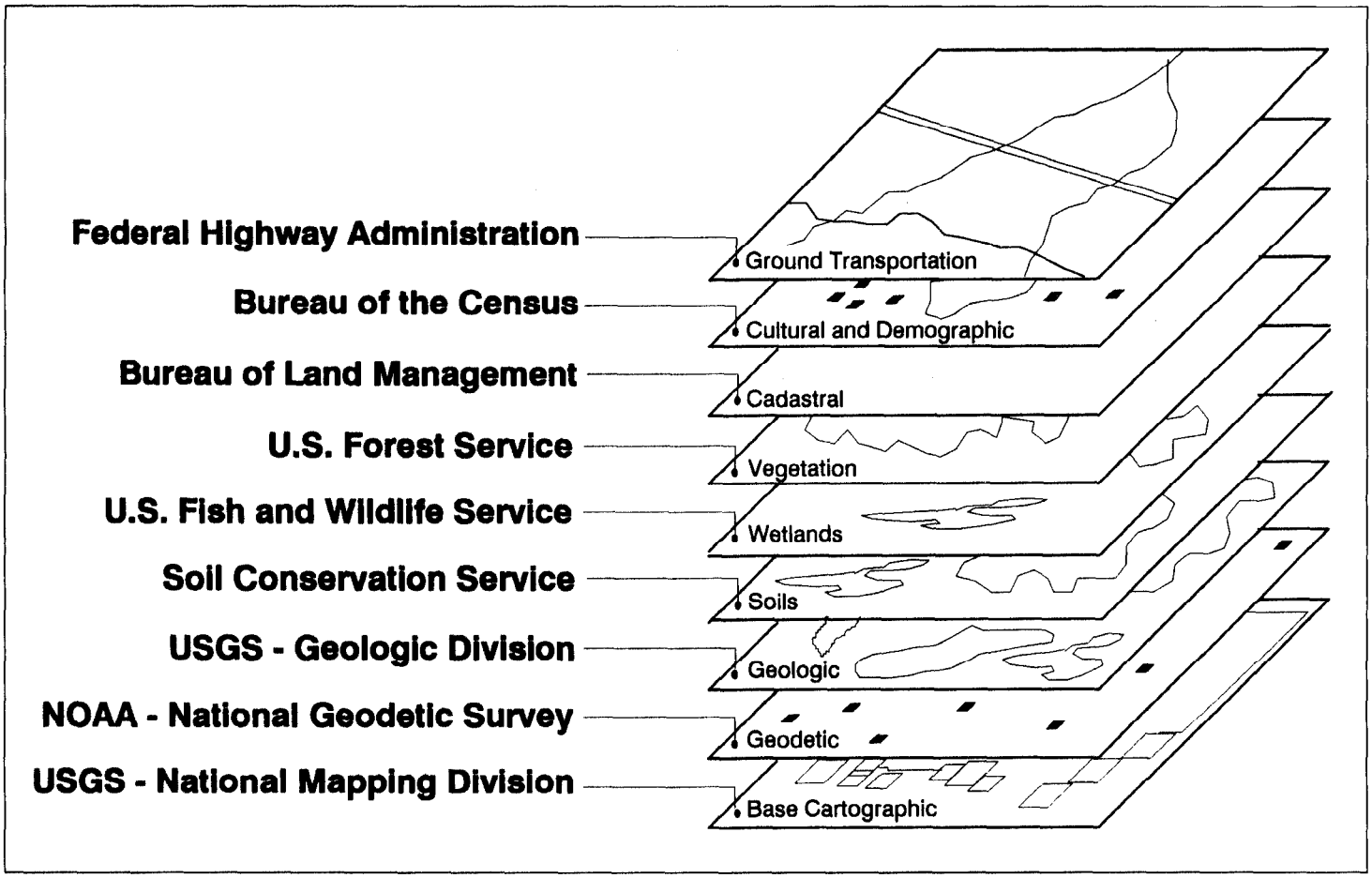
[b]Geodetic data describe the size and shape of the earth and the position and elevation of points on the earth's surface.

What Agencies Are Responsible for the Development and Maintenance of Key Layers of Spatial Data?

Circular A-16 assigned the responsibility to lead the coordination of selected categories of national spatial data to the Departments of Agriculture, Commerce, Interior, State, and Transportation, with FGDC assuming overall responsibility for coordination. Each of these departments then delegated responsibility to appropriate component agencies. Figure II.8 depicts these agencies and their responsibilities for specific categories of spatial data.

The agencies' coordination responsibilities include facilitating the exchange of information and the transfer of data; establishing and implementing standards of quality, content, and transfer capability; and coordinating the collection of spatial data to minimize duplication of effort. As new layers of spatial data are identified, other agencies will be assigned responsibility for coordinating these data.

Figure II.8: Agencies Responsible for Coordinating Major National Spatial Data Layers



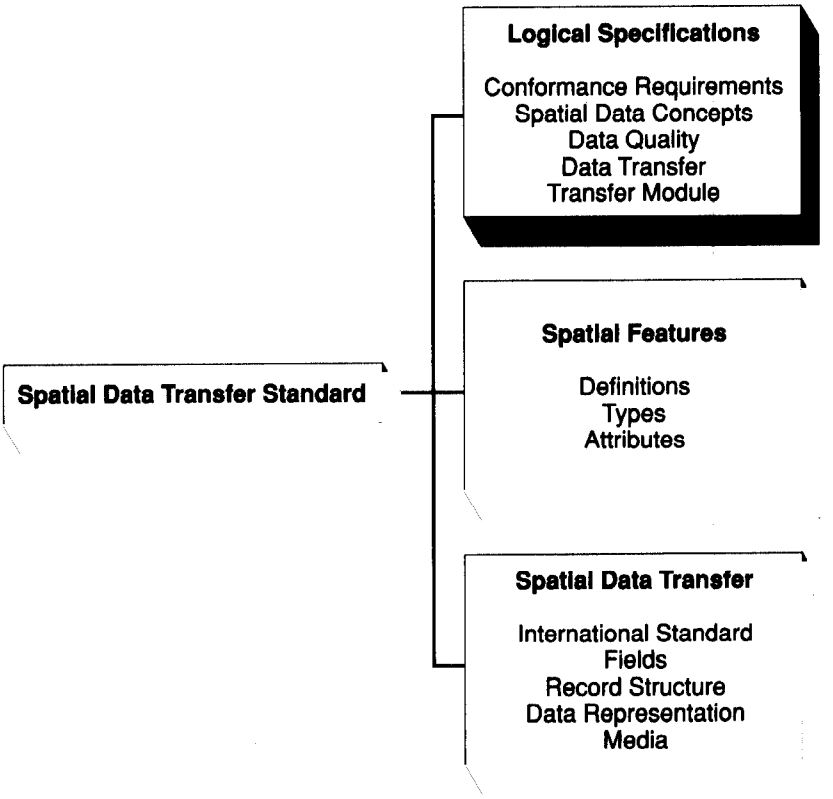
What Are the Federal GIS Standards?

NIST plans to issue a national standard later this year for the exchange and transfer of spatial data between dissimilar geographic information systems. This standard, known as the Spatial Data Transfer Standard (SDTS), is being developed under the leadership of the U.S. Geological Survey's National Mapping Division and with the cooperation of FGDC, NIST, the academic community, government, and private industry.

According to the manager of NIST's GIS Standards Laboratory, the goals of SDTS are to ensure (1) that no data are lost during data transfer, (2) that accuracy of data and their relationships are preserved, and (3) that the integrity of transferred files is maintained. The SDTS will consist of three parts, as illustrated in figure II.9. Part 1 will describe conformance

requirements, provide a conceptual model of spatial data, define fundamental cartographic objects and terms, establish requirements for data transfers, and discuss specifications for transfer modules. Part 2 will focus on spatial features and describe cartographic attributes and definitions. Finally, Part 3 will contain information on the use of existing international standards to implement SDTS.

Figure II.9: The Proposed Spatial Data Transfer Standard

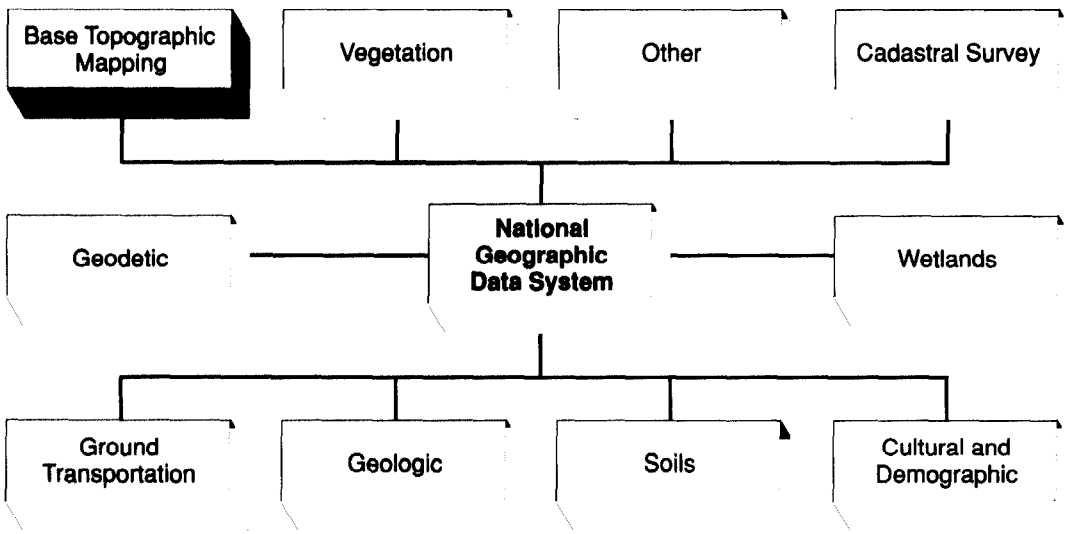


What Is the Proposed National Geographic Data System?

FGDC is developing the concept of a national system of independently held and maintained federal spatial data bases. This system, known as the National Geographic Data System, will include selected spatial data bases developed and used by federal agencies. Figure II.10 shows examples of spatial data bases. To be included in this system, spatial data bases will need to adhere to SDTS and be fully supported by the sponsoring federal agency.

In exploring means of setting up the system, FGDC is reviewing systems and approaches adopted by other agencies that identify widely distributed data bases. One such system, the National Aeronautics and Space Administration (NASA) Master Directory,[2] provides directories to help users find data of interest, contains summaries about the data sets, and is linked to other agency systems. It also provides points of contact for additional information about the listed data sets. The directory software is government-owned and was provided by NASA to other federal agencies.

Figure II.10: The Proposed National Geographic Data System



[2]The NASA Master Directory, located at the Goddard Space Flight Center, was selected to serve as the Global Change Master Directory for describing the global change data holdings of all federal agencies.

How Many Agencies Have a Mechanism for Coordinating With Other GIS Users or an Official GIS Program to Cooperate With Other Agencies?

Few agencies reported having mechanisms to coordinate the development of spatial data with GIS users who use the same categories of spatial data in other federal, state, or local government agencies (see fig. II.11). Fifty-one of the 82 agencies had no mechanism for coordination with other agencies, but 31 agencies coordinated with other federal agencies, and some of those 31 also coordinated with state or local agencies.

As shown in figure II.12, most of the agencies surveyed had no official GIS programs to cooperate with federal, state, or local government agencies. Additionally, most agencies had no cooperative GIS projects with other agencies. Twenty-seven agencies had official programs to cooperate with other federal agencies, including some state and local agencies.

Figure II.11: Agencies With Mechanisms for Coordinating With GIS Users in Other Federal, State, or Local Government Agencies

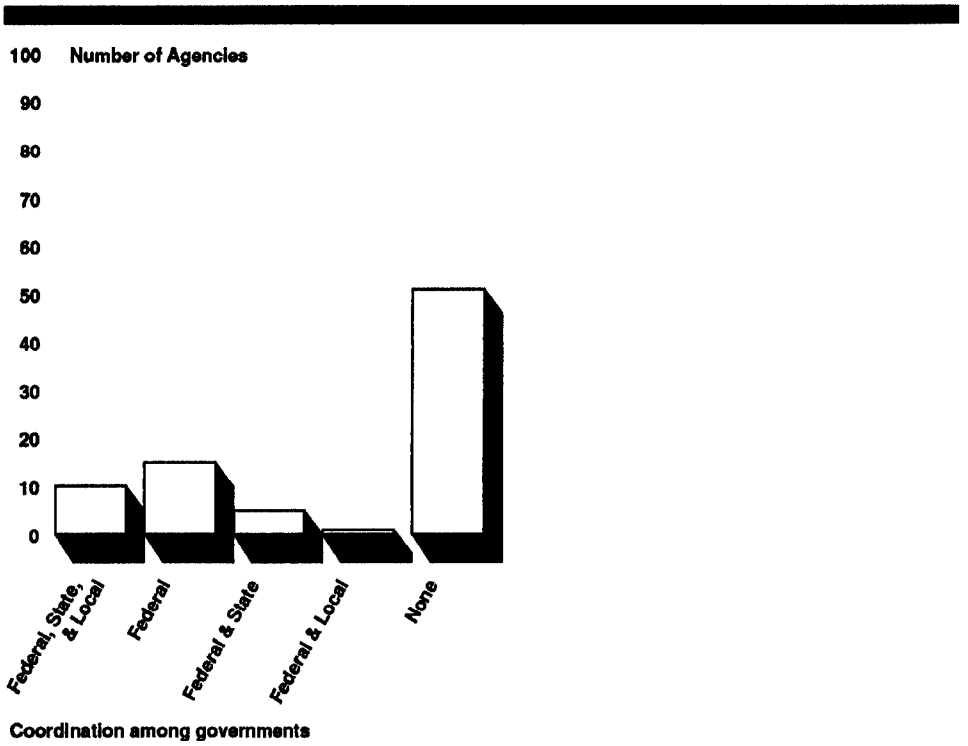
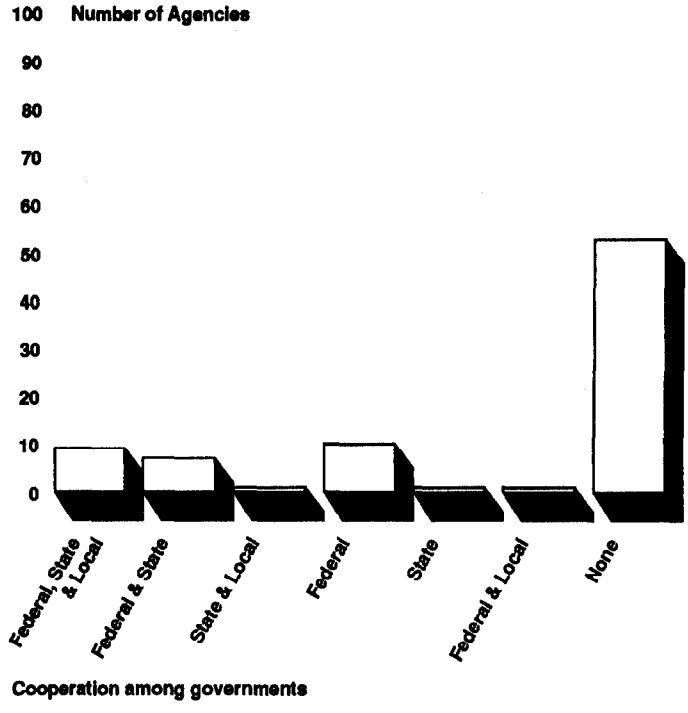


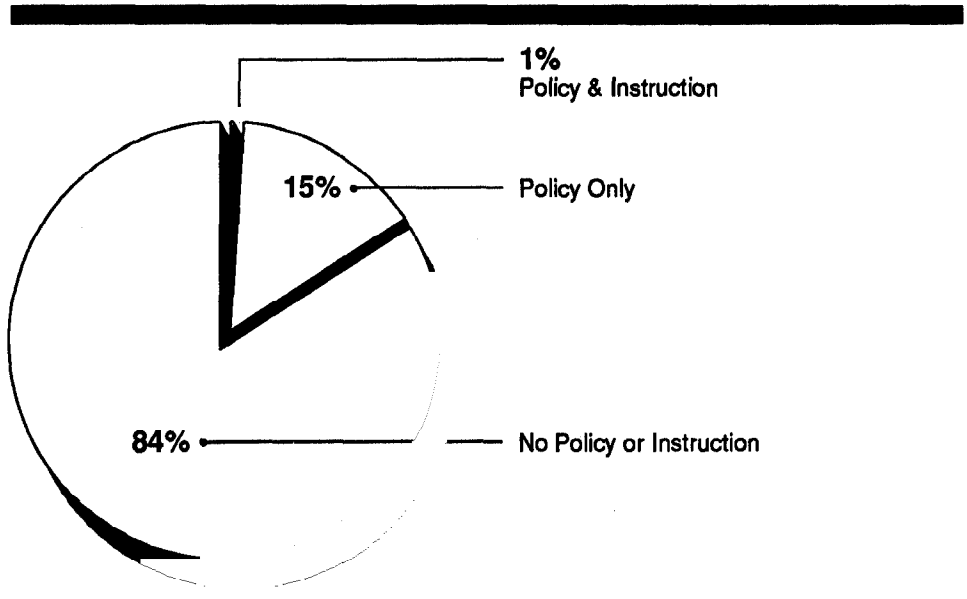
Figure II.12: Agencies With Official GIS Programs to Cooperate With Other Federal, State, or Local Government Agencies



How Many Agencies Have Adopted GIS Policies or Standards?

Figure II.13 shows that 84 percent of the 82 agencies using GIS did not have any (1) written policies regarding GIS or (2) instructions for disposing of spatial data that are no longer needed. Fifteen percent of the agencies had written GIS policies, but no instructions were in place. Only one agency (approximately 1 percent of all agencies surveyed) had both written policies and instructions in place.

Figure II.13: Percent of Agencies With Written Policies Regarding GIS and Instructions for Disposing of Data That Are No Longer Needed



How Many Agencies Use Spatial Data Created by Other Agencies and Provide Their Data to Others?

Of the agencies who reported using major data sets other than those generated internally, 63 obtained major data sets from other federal agencies, 20 from state or local agencies, 27 from private companies, and 9 from foreign agencies (see fig. II.14).

Figure II.15 shows that 35 agencies did not create new data sets or disseminate data used in or produced by their GIS applications. However, 27 agencies created and disseminated data sets to others. Ten agencies created new data sets but did not disseminate them, while ten other agencies disseminated data used in their GIS applications.

Figure II.14: Number of Agencies Using Major Data Sets From Other Sources

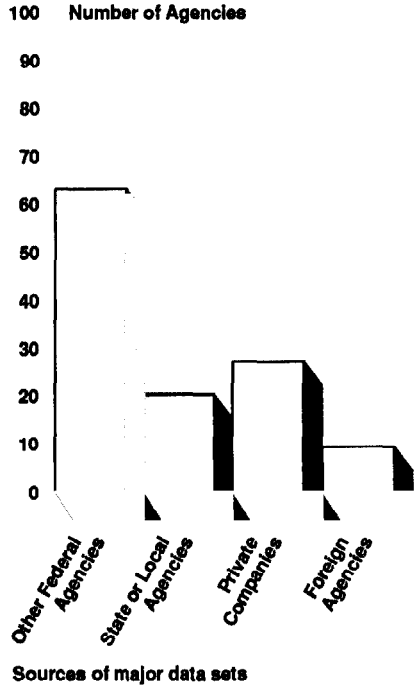
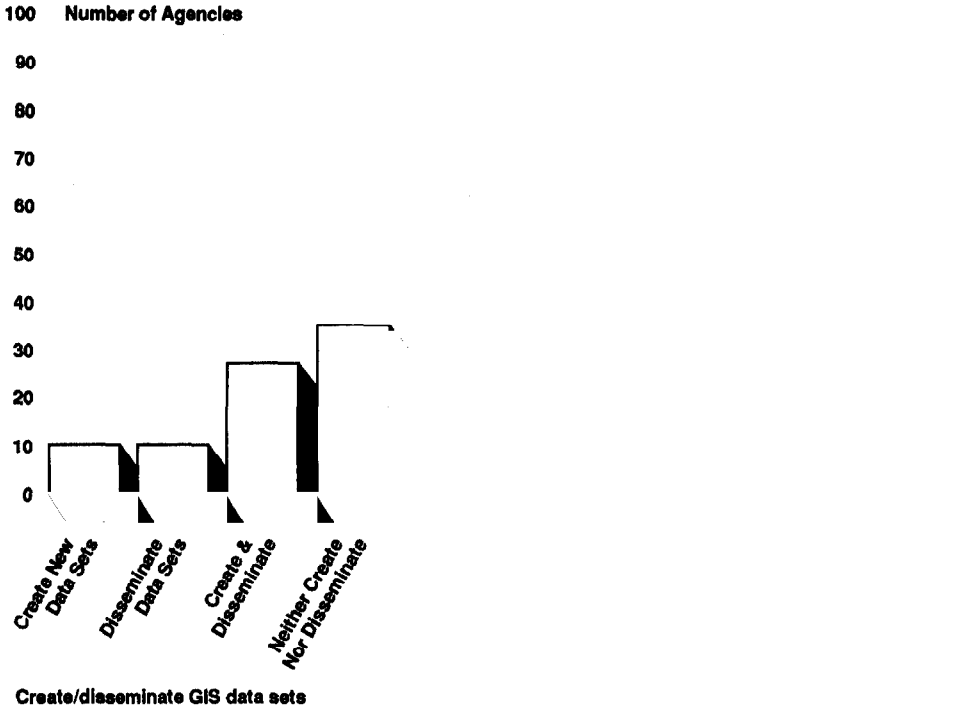


Figure II.15: Agencies Who Create New Data Sets And/Or Disseminate Data Used in or Produced by Their GIS Applications



Federal Agencies Planning to Use GIS

Of the 110 agencies surveyed by the Federal Interagency Coordinating Committee on Digital Cartography, the 82 listed below reported some form of GIS use in fiscal years 1990, 1991, or 1992. GIS use includes widespread (broad) use, limited use, use for research and development (R&D), or use for test and evaluation (T&E).

	Levels of GIS Use for Fiscal Years		
	Actual	Projected	
Department or Agency	**1990**	**1991**	**1992**
Department of Agriculture			
Soil Conservation Service	Broad	Broad	Broad
Agricultural Research Service	Limited	Limited	Limited
Forest Service	Limited	Limited	Broad
Animal and Plant Health Inspection Service	T&E	Limited	Broad
National Agricultural Statistics Service	None	R&D/T&E	R&D/T&E
Department of Commerce			
National Geophysical Data Center	Broad	Broad	Broad
National Ocean Service	Limited	Broad	Broad
National Climatic Data Center	Limited	Limited	Broad
Bureau of the Census	Limited	Limited	Limited
National Marine Fisheries Service	Limited	Limited	Limited
National Institute of Standards and Technology	R&D/T&E	R&D/T&E	R&D/T&E
Department of Defense			
Army Corps of Engineers/ Engineer Topographic Laboratories	Broad	Broad	Broad
Naval Oceanographic and Atmospheric Research Laboratory	Broad	Broad	Broad
Defense Mapping Agency	Limited	Broad	Broad
Army Corps of Engineers	Limited	Broad	Broad

(continued)

Department or Agency	Levels of GIS Use for Fiscal Years		
	Actual	Projected	
	1990	1991	1992
Department of Energy			
Bonneville Power Administration	Broad	Broad	Broad
Oak Ridge National Laboratory	Broad	Broad	Broad
Oak Ridge National Laboratory/ Environmental Sciences Division	Broad	Broad	Broad
Idaho Operations/Idaho National Engineering Laboratory	Limited	Broad	Broad
Nevada Operations/SAIC, Incorporated	Limited	Broad	Broad
Nevada Operations/EG&G	Limited	Broad	Broad
Savannah River Laboratory/ESS	Limited	Limited	Broad
Oak Ridge Operations/ TRANSCOM Project	Limited	Limited	Broad
San Francisco Operations/ Lawrence Livermore National Laboratory	Limited	Limited	Broad
Environmental Measurements Laboratory	Limited	Limited	Unknown
Morgantown Energy Technology Center	Limited	Limited	Limited
Pittsburgh Energy Technology Center	Limited	Limited	Limited
Nevada Operations/ Reynolds Electrical and Engineering Company, Incorporated	T&E	Limited	Broad
Nevada Operations/ Headquarters	None	Limited	Broad
Nevada Operations/Holmes and Narver, Incorporated	T&E	Limited	Broad
Richland Operations/ Westinghouse Hanford	R&D	Limited	Broad
Naval Petroleum Reserves/ California	T&E	Limited	Limited
Nevada Operations/Fenix and Scisson of Nevada	None	Limited	Limited
Savannah River Forest Station	T&E	Limited	Limited
Savannah River Laboratory/ ETG	R&D/T&E	Limited	Broad
Savannah River Site/ ESH&QA	R&D	Limited	Limited
Southwestern Power Administration	None	Limited	Limited
Savannah River Site/ Facilities and Services	None	R&D/T&E	Limited
Nevada Operations/ National Oceanic and Atmospheric Administration/ National Weather Service	None	R&D	Limited
Nevada Operations/Desert Research Institute	None	R&D/T&E	R&D
Chicago Operations/Solar Energy Research Institute	R&D	R&D	R&D
Oak Ridge National Laboratory/Energy Division	R&D	R&D	R&D
Savannah River Ecology Laboratory	R&D	R&D	R&D
Department of Health and Human Services			
Centers for Disease Control/National Center for Health Statistics	Limited	Broad	Broad
Office of Human Development Services	None	R&D	T&E

(continued)

Department or Agency	Levels of GIS Use for Fiscal Years		
	Actual	Projected	
	1990	1991	1992
Department of the Interior			
Bureau of Indian Affairs	Broad	Broad	Broad
Bureau of Land Management	Broad	Broad	Broad
Geological Survey/Water Resources Division	Broad	Broad	Broad
National Park Service	Broad	Broad	Broad
Office of Surface Mining, Reclamation, and Enforcement	Broad	Broad	Unknown
Bureau of Reclamation	Broad	Broad	Broad
Fish and Wildlife Service	Broad	Broad	Broad
Geological Survey/ Geologic Division	Limited	Broad	Broad
Bureau of Mines	Limited	Limited	Broad
Geological Survey/ National Mapping Division	Limited	Limited	Broad
Department of Justice			
Drug Enforcement Administration	Limited	Limited	Broad
Environment and Natural Resources Division	Limited	Limited	Limited
Civil Rights Division	Unknown	Limited	Limited
Immigration and Naturalization Service	T&E	Limited	Limited
Federal Bureau of Investigation	R&D/T&E	R&D/T&E	R&D/T&E
Department of Labor			
Bureau of Labor Statistics	Limited	Limited	Limited
Department of State			
Department of State	None	T&E	Limited
Department of Transportation			
Transportation Systems Center	Limited	Limited	Broad
Coast Guard	Limited	Limited	Limited
Federal Aviation Administration/National Flight Data Center	Limited	Limited	Limited
Federal Highway Administration	Limited	Limited	Limited
Federal Railroad Administration	T&E	Limited	Broad
National Highway Traffic Safety Administration	R&D	T&E	Limited
St. Lawrence Seaway Development Corporation	T&E	T&E	Limited
Urban Mass Transportation Administration/ Office of Planning	None	R&D/T&E	Unknown

(continued)

Department or Agency	Levels of GIS Use for Fiscal Years		
	Actual	Projected	
	1990	1991	1992
Department of the Treasury			
Internal Revenue Service	Limited	Limited	Limited
Customs Service	R&D	R&D	R&D
Independent Agencies			
Agency for International Development	Broad	Broad	Broad
Environmental Protection Agency	Broad	Broad	Broad
Federal Communications Commission	Broad	Broad	Broad
Tennessee Valley Authority	Broad	Broad	Broad
Central Intelligence Agency	Limited	Limited	Broad
Federal Emergency Management Agency	R&D/T&E	R&D/T&E	Limited
National Archives and Records Administration	R&D	R&D/T&E	Limited
National Capital Planning Commission	R&D/T&E	Limited	Broad
Nuclear Regulatory Commission	R&D/T&E	Limited	Limited
Postal Service	T&E	Limited	Broad

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