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GEOGRAPHIC INFORMATION SYSTEMS

Status at Selected Agencies

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Information Management and
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The Honorable Sidney R. Yates
Chairman, Subcommittee on
Interior and Related Agencies
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

As agreed with your office in February 1990, we are providing summaries of geographic information system (GIS)[1] activities at the Departments of Interior, Agriculture, Commerce, and Energy, as well as at the Army Corps of Engineers, the Federal Highway Administration, the Environmental Protection Agency, and the Federal Emergency Management Administration. Appendixes I through IV describe the agency mission, GIS applications, estimated GIS budget, computer hardware and software used for GIS, and planned GIS procurements, where applicable, for each organization.

Results in Brief

The information in the appendixes led to several observations. First, the federal government's dollar investment in GIS technology is significant. The Office of Management and Budget reported in October 1988 that at least $165 million would be needed each year to fund electronic mapping efforts, which largely include GIS. Also, some agencywide computer systems containing GIS cost hundreds of millions or even billions of dollars to implement and operate.

Second, federal government GIS applications support diverse missions. These applications currently include analyzing the impact of earthquakes, assessing insect infestations in spruce forests, developing farm conservation plans, managing land and water resources, assisting with the decennial census, producing nautical charts and maps, identifying populations at risk from radon exposure, preparing response plans to natural or manmade disasters, and identifying construction sites for engineering projects.

[1] A geographic information system consists of computer hardware and software capable of manipulating, analyzing, and presenting spatially-referenced information. This is information associated with a specific place on the earth, such as the geographic location and the characteristics of a lake, road, or stand of trees.

Abbreviations

ALMRS	Automated Land and Mineral Records System
DIS	Distributed Information System
GAO	General Accounting Office
GIS	Geographic Information System
IEMIS	Integrated Emergency Management Information System
IMTEC	Information Management and Technology Division

of aquifer characteristics and water-use patterns, and preparation of maps for publication.

Estimated GIS Budget

According to the Interior Digital Cartography Coordinating Committee fiscal year 1988 annual report,
Cost estimates for the National Geologic Mapping Program are

- $800,000 for fiscal year 1990,
- $500,000 for fiscal year 1991, and
- $500,000 for fiscal year 1992.

Estimates for the Digital Cartographic Data Bases are

- $47.3 million for fiscal year 1990,
- $57.8 million for fiscal year 1991, and
- $75.4 million for fiscal year 1992.

Estimates for the Geographic Names Information System are $550,000 per year for fiscal years 1990, 1991, and 1992.

According to exhibit 43B submitted with the fiscal year 1991 budget request, the Water Resources Division will obligate $5 million each year for fiscal years 1990 and 1991, and $4 million for fiscal year 1992, for the purchase of additional memory and other system enhancements for the Distributed Information System.

Computer Hardware and Software Used for GIS

Hardware includes 88 minicomputers and 5 workstations. Software includes the public domain Geographic Resources Analysis Support System; a variety of commercial GIS software, such as ARC/INFO and SPANS; and software developed by Geological Survey personnel.

Planned GIS Procurements

The National Mapping Division will procure off-the-shelf GIS hardware and software in the MARK II modernization program to further automate the production of the Division's map products. In addition, the Division will upgrade the GIS systems for its GIS laboratories and will acquire high performance work stations for its global change program. Some of these systems may be acquired through the Geological Survey's Distributed Information System (DIS) II procurement.

use information to support the public and 220 Bureau offices nationwide.

Estimated GIS Budget

According to the fiscal year 1991 exhibit 43B, the Bureau of Land Management will obligate $3.4 million for fiscal year 1990 and $3.1 million for fiscal year 1991 for GIS minicomputers. It also plans to obligate for GIS graphics peripheral equipment, $2.0, $2.4, and $3.5 million, respectively, for fiscal years 1990 through 1992. For ALMRS, it intends to obligate $28.8, $26.0, and $22.0 million, respectively, for fiscal years 1990 through 1992.[1]

Bureau officials also estimated that $1 million per fiscal year would be expended for maintenance and enhancement of the existing GIS.

Computer Hardware and Software Used for GIS

Hardware consists of 70 minicomputers. Software includes the public domain Map Overlay and Statistical System, the Cartographic Output System, and the Automated Digitizing System.

Planned GIS Procurements

The Bureau of Land Management originally planned to issue a request for proposals for ALMRS in December 1989, with contract award scheduled for January 1991. After reviewing the Bureau's budget requests, the Office of Management and Budget halted the procurement in November 1989 because of concerns about increasing cost estimates. Issuance of the request for proposals now depends on negotiations between the Bureau and the Office of Management and Budget.

Bureau of Indian Affairs

The Bureau of Indian Affairs works with Indian and Alaska natives, government agencies, and other interested groups in the development and implementation of a wide variety of services and activities, including programs to fully utilize the natural resources of Indian lands consistent with resource conservation. The Bureau also acts as trustee for Indian lands and monies held in trust by the United States, and assists in realizing maximum benefits from such resources.

[1]Another $60 million was spent for ALMRS prior to fiscal year 1990, and $80.9 million in estimated obligations is planned for fiscal years 1993 through 1995. Total funds, spent and projected, may increase to $211 million

land-use restraints on the availability of federal and state lands for mineral exploration and development. The Bureau's Minerals Availability System contains an extensive data base of nearly 200,000 minerals locations that can be provided to GIS workstations.

Estimated GIS Budget

Bureau of Mines officials estimated that about $240,000 per fiscal year is spent on personnel salaries for GIS work.

Computer Hardware and Software Used for GIS

Hardware consists of seven microcomputers, software includes commercial PC-ARC/INFO.

Planned GIS Procurements

The Bureau of Mines requested $750,000 in fiscal year 1991 for GIS activities. The greatest portion of these funds will be used to further GIS applications in the various mineral land and resources program areas. A smaller portion of these funds will be used to purchase larger capacity workstations. Some microcomputers currently used by the Bureau do not have the capacity to permit working with mineral resource data for entire states.

Bureau of Reclamation

The Bureau of Reclamation is responsible for providing water and hydroelectric power, river regulation and flood control, outdoor recreation opportunities, and protection of fish and wildlife habitats for areas and industries under its jurisdiction. The Bureau's functions include:

- planning, design and construction, operation and maintenance, and repair and rehabilitation of projects that conserve and effectively utilize national water resources;
- salinity control, groundwater and hazardous waste management, water quality and environmental enhancement, and dam safety evaluation; and
- administration of loans to state and local governments for construction and rehabilitation of water supply systems.

Applications to Support Mission

The Bureau of Reclamation has implemented an integrated GIS and remote sensing program for the inventory, analysis, and management of natural resources. In particular, the Bureau is using GIS to classify land

environmental assessments such as the impact of dredging on ecosystems, and to develop master plans and comprehensive conservation plans in order to manage the 460 refuges in the National Wildlife Refuge System.

Estimated GIS Budget

The Fish and Wildlife Service estimates that $500,000 was spent to develop the current GIS, and that $5 million per fiscal year supports GIS work (including data collection and digitizing).

Computer Hardware and Software Used for GIS

Hardware consists of six minicomputers. Software includes commercial ARC/INFO, and the Map Overlay and Statistical System, developed by Fish and Wildlife Service personnel.

National Park Service

The National Park Service's objectives are to assist state and local governments and citizen groups to develop park areas, administer more than 350 properties under its jurisdiction for citizen enjoyment and education, protect the natural environment of these areas, and preserve historic properties.

Applications to Support Mission

The National Park Service provides GIS technology to Park Service managers for resource management at individual national parks, wildlife inventory and habitat analysis, determinations of resources at risk from fires or gypsy moths, environmental assessments of roads or oil/gas wells, determinations of visual impact of buildings on national parks, and development of educational aids for visitors.

Estimated GIS Budget

National Park Service officials estimate that $560,000 (supplemented by project funds) financed the development of 50 data bases for individual national parks. The Service plans to allocate $1.5 million in fiscal year 1991 to add data to existing data bases and to create data bases for parks not currently possessing them.

Computer Hardware and Software Used for GIS

Hardware consists of 33 workstations. Software is the public domain Geographical Resources Analysis Support System.

GIS Activities at the Department of Agriculture

Within the Department of Agriculture, GIS is used by the Forest Service, the Soil Conservation Service, the Agricultural Research Service, and the National Agricultural Statistics Service. The following paragraphs describe GIS activities in these agencies.

Forest Service

The mission of the Department of Agriculture's Forest Service is to provide a sustained flow of resources such as outdoor recreation, forage, wood, water, wilderness, wildlife, and fish in a combination that best meets both current and future needs. The agency also administers the energy and mineral resources of the national forest system, and conducts and disseminates research products that advance resource management, use, and protection.

Applications to Support Mission

The Forest Service uses GIS at 138 out of its 880 offices located nationwide. GIS is used to support forest management projects and explore other applications related to the agency's mission. The Forest Service is planning to acquire a new nationwide system that will integrate GIS, administrative, scientific, technical, and telecommunications applications. GIS uses include project planning and research.

For example, forest management planning may involve decisions about land uses, such as harvesting trees in a manner that preserves scenic and recreational amenities, promotes soil conservation, and protects water quality. GIS applications support the visual and analytical combination of data on resources, timber characteristics, soils, and water needed to prepare, evaluate, and modify plans quickly and relatively easily. Similarly, wildlife biologists may use GIS in research to study the interactions between wildlife populations and their environment by mapping and analyzing factors such as the relationships between population ranges and density, vegetative cover, exposure, food sources, and human activities.

Estimated GIS Budget

The Forest Service's estimated fiscal year 1990 cost for GIS is $15.3 million. This figure includes hardware and software acquisition, contract services for digitizing and training, personnel costs, travel, and other overhead costs. These expenditures for GIS will enable the Service to deal with current high priority resource issues such as the impact of wild fires on national forests and the impact of logging on spotted owl habitat.

ranch conservation planning. In particular, the Service has developed three soil survey geographic data bases:

- the Soil Survey Geographic Data Base, used for county, township, and watershed resource planning and management, and for farm and ranch conservation planning;
- the State Soil Geographic Data Base, used for river basin, multistate, state, and multicounty resource planning, management, and monitoring; and
- the National Soil Geographic Data Base, used for national, regional, and state resource appraisal, planning, and monitoring.

Estimated GIS Budget

Soil Conservation Service officials estimate that $5.9 million for fiscal year 1990 and $6.4 million for fiscal year 1991 will be spent for GIS.

Computer Hardware and Software Used for GIS

Soil Conservation Service officials estimate that 5 percent of the hardware inventory consists of minicomputers and 95 percent consisted of microcomputers. Software consists of 5 percent commercial ARC/INFO and 95 percent public domain Geographical Resources Analysis Support System.

Planned GIS Procurements

According to the fiscal year 1991 exhibit 43B, the Soil Conservation Service plans to install the Geographical Resources Analysis Support System software on the Field Office Communication and Automation System hardware, and integrate it with the Computer Assisted Management and Planning System in the Service's field offices. Total cost to implement the Field Office Communication and Automation System is estimated to be $85 million.

Agricultural Research Service

The Agricultural Research Service administers basic and applied research in animal and plant protection and production; in conservation and improvement of soil, water, and air; in processing, storage, and distribution of farm products; and in human nutrition. This research is conducted in cooperation with federal and state agencies, universities, and private organizations.

Estimated GIS Budget

No funds have been allocated for GIS work in fiscal year 1990. However, National Agricultural Statistics Service officials have proposed spending about $700,000 for GIS work for fiscal year 1991.

Computer Hardware and Software Used for GIS

No hardware has specifically been designated GIS.

National Oceanic and Atmospheric Administration

The mission of the National Oceanic and Atmospheric Administration is to explore, map, and chart the global ocean and its living resources and to manage and conserve those resources; to describe, monitor, and predict conditions in the ocean, atmosphere, sun, and space environment; to issue warnings against impending destructive natural events; to assess the consequences of inadvertent environmental modification; and to manage and disseminate environmental information. The Administration's products include meteorological forecasts, nautical and aeronautical charts, geodetic surveys, and environmental data from satellites.

Applications to Support Mission

The National Oceanic and Atmospheric Administration uses GIS technology for oceanographic and meteorologic analysis, to automate the production of nautical and aeronautical charts, and to monitor coastal pollution and impact on fisheries habitat. In particular, the Administration uses GIS to model oil and chemical spills on coastal waters and conduct arctic ice analysis, and has developed a digital National Coastal Wetland Data Base for GIS based on the wetland maps for the National Wetlands Inventory of the U.S. Fish and Wildlife Service.

In addition, the Administration's Nautical Charting Division is developing a geographically referenced Navigation Information Data Base and a nautical-chart digital graphics data base for GIS, and is planning to incorporate expert systems and the Integrated Digital Photogrammetric Facility into the development of the Automated Nautical Charting System II to automate the production of nautical maps.

Estimated GIS Budget

According to agency officials, the National Oceanic and Atmospheric Administration's National Ocean Service spent:

- $200,000 for hardware acquisition,
- $250,000 for system development over three years, and
- $175,000 per year for staff salaries for GIS application work;

and its National Environmental Satellite, Data and Information Service spent $250,000 for acquisition of hardware and GIS software for workstations and microcomputers.

Computer Hardware and Software Used for GIS

The National Ocean Service hardware includes six microcomputers connected on a local area network for oceanographic and meteorological analysis.

GIS Activities at Other Selected Federal Agencies

The GIS activities of the Department of Energy, the Federal Highway Administration, the Army Corps of Engineers, the Federal Emergency Management Agency, and the Environmental Protection Agency are discussed in this appendix

Department of Energy

The Department of Energy is responsible for long-term, high-risk research and development of energy technology, energy conservation, marketing of federal power, the nuclear weapons program, the energy regulation program, and a central energy data collection and analysis program. In particular, the Department:

- conducts programs to increase the production and utilization of renewable energy (solar, wind, geothermal, alcohol fuels) and improve the energy efficiency of transportation, buildings, and industries;
- collects, processes, and publishes data on energy resource reserves, energy production, demand, consumption, distribution, and technology; and
- performs analyses to determine the microeconomic and macroeconomic impacts of energy trends on regional and industrial sectors.

Under the Department's auspices, the Bonneville Power Administration:

- markets electric power and energy from federal hydroelectric projects in the Pacific Northwest;
- constructs, operates, and maintains transmission systems that integrate federal power projects, and interconnects with nonfederal utility systems; and
- is responsible for energy conservation, renewable resource development, and fish and wildlife enhancement in the Pacific Northwest.

Applications to Support Mission

The Department of Energy is using GIS technology in several parts of the agency. For example, Energy's Office of Conservation and Renewable Energy uses GIS technology to design solar power systems for specific locations. In addition, the Bonneville Power Administration uses GIS technology to conduct environmental impact analyses in order to plan electrical transmission system sites that minimize impact on national forest and wilderness areas.

Since 1981, Energy's Pacific Northwest Laboratory has been developing a GIS-based Integrated Emergency Management Information System (IEMIS) for the Federal Emergency Management Agency. The Laboratory

funding technology transfer centers, demonstrations, and microcomputer software development, user manuals, and guidelines.

Applications to Support Mission

The Federal Highway Administration has integrated several data bases into the National Highway Network data base which will form the basis of the National Integrated Transportation Data Base, and has used GIS to conduct national and regional analyses in support of upcoming Federal highway legislation. To promote the use of GIS, the Administration will hold classes and demonstrations of GIS developed by Iowa, Maryland, and Wisconsin transportation authorities for other state and local governments. In addition, the Administration is starting a research project to incorporate GIS into "intelligent vehicles" to provide drivers with real-time information on road conditions and alternate routes.

Estimated GIS Budget

According to Federal Highway Administration officials:

- $325,000 for GIS hardware and software acquisition and development of the National Highway Network data base was funded by the Military Traffic Management Command;
- $225,000 is planned to be obligated for fiscal year 1992 for design and evaluation of the National Highway Network;
- $100,000 this fiscal year will be spent to provide demonstrations of transportation planning GIS for state and local governments;
- $150,000 this fiscal year will be spent to develop GIS training classes to be held in fiscal year 1991;
- $500,000 is planned to be obligated for fiscal year 1992 to develop national digital transportation data standards and the National Integrated Transportation Data Base; and
- $100 million per year starting in fiscal year 1992 is proposed for the research project to develop "intelligent vehicles" to provide drivers real-time information on road conditions and alternate routes.

Computer Hardware and Software Used for GIS

Hardware includes one microcomputer for developing and using the National Highway Network Data Base (the Federal Highway Administration plans to acquire a second microcomputer) and two microcomputers and a workstation for the GIS demonstrations. Software includes commercial ARC/INFO, SPANS, and TRANSCAD.

hazard mitigation, preparedness planning, relief operations, and recovery assistance.

On the national level, the Federal Emergency Management Agency develops and coordinates procedures to ensure effective operation of the federal government during national security emergencies and to assure availability of required resources for defense and civilian needs. It manages the 24-hour center for collection and dissemination of emergency information, and is responsible for the design, development, operation, and maintenance of facilities and resources for routine and emergency telecommunications, information processing, and warning systems requirements.

Applications to Support Mission

The Federal Emergency Management Agency is using GIS technology in several parts of the agency. For example, the State and Local Programs and Support Directorate uses GIS to geographically display threat and state and local emergency management capability information, and to administer the Fire Suppression Assistance Program.

The Agency's National Preparedness Directorate has developed several GIS to assist in national emergency management planning:

- the Emergency Resource Management System in conjunction with the Transattack Resource Data base is used for analyzing the effects of nuclear attack;
- the PC Risk Estimation system is a field office version of the Emergency Resource Management System for regional planning for natural or man-made disasters; and
- the Integrated Emergency Management Information System was developed to increase the Agency's ability to review analytical options in planning emergency measures; evaluate preparedness resources commitments and improve preparedness exercises by simulation of complex interactive events; allow study of post-event recovery options in order to optimize use of resources; and encourage the maximum access to the Integrated Emergency Management Information System from other federal agencies and state and local governments through networked computers.

Estimated GIS Budget

The State and Local Program and Support Directorate has spent $920 for commercial GIS software and $15,000 for METAFIRE software for the Fire Suppression Assistance Program.

- identifying and characterizing the nature and extent of problems and monitoring remedial actions at Superfund sites; and
- implementing a Results/Risk Analysis and Management System to target regulatory activities based on environmental risks and to determine if Agency programs are having an impact on environmental quality.

Estimated GIS Budget

Environmental Protection Agency officials estimate that $700,000 this fiscal year covers funding for GIS hardware and software purchases, GIS activities at the Agency's GIS Centers of Excellence and regional offices, and purchases of data from other government agencies.

Computer Hardware and Software Used for GIS

Hardware includes three mainframes, seven minicomputers, four workstations, and nine microcomputers. Software includes commercial ARC/INFO at all sites and the public domain Geographical Resources Analysis Support System and Map Overlay and Statistical System at one site each.

Planned GIS Procurements

The first week in April 1990, the Environmental Protection Agency released a request for proposals to procure GIS workstations. These workstations will be linked by communication networks to support 600 users at Agency program offices and laboratories and state government offices. According to the request for proposal, the equipment must execute ARC/INFO software. The Agency anticipates awarding a contract by the end of 1990. Each program office will fund GIS workstation purchases from the contract out of individual project funds.

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The National Preparedness Directorate has spent $250,000 over 4 years for the development of the Emergency Resource Management System and the PC Risk Estimation system. In addition, the Directorate has spent $5.5 million over 10 years for the development of the Integrated Emergency Management Information System, and has allocated $1 million this fiscal year for software improvements and the development of a microcomputer version of this system.

Computer Hardware and Software Used for GIS

Hardware includes 1 minicomputer, 12 workstations, and 6 microcomputers. Software includes commercial ATLAS GRAPHICS, PC GLOBE, PC USA, MAPMASTER; METAFIRE from the Department of Agriculture Forest Service for the Fire Suppression Assistance Program; the Emergency Resource Management System and the PC Risk Estimation system which are developed and maintained by Agency personnel; and the Integrated Emergency Management Information System which is developed and maintained by the Department of Energy Pacific Northwest Laboratory for the Federal Emergency Management Agency.

Environmental Protection Agency

The Environmental Protection Agency endeavors to abate and systematically control national air, radiation, and water pollution, hazardous waste, pesticides, and toxic substances. The activities of the Agency include the development of national programs, regulations, surveillance and inspection programs, and standards for pollution control; development of emergency preparedness guidelines; coordination of research for pollution control; and technical direction, training, and evaluation of regional pollution control activities.

Applications to Support Mission

The Environmental Protection Agency uses GIS technology to identify and assess regional environmental problems and trends. Examples of the Agency's GIS activities include:

- assessing risks to ground water from contaminants (such as underground storage tank leaks or road salt drainage) in order to develop well-head protection plans;
- developing emergency response management plans for hazardous spills;
- identifying pollution sources and populations at risk from radon or air pollution exposure (by mapping areas exceeding standards);
- studying long term impacts on surface water of acid rain for the Direct/Delayed Response Project, and characterizing the chemical status of lakes and streams for the National Lakes and Streams Survey;

Army Corps of Engineers

In the Civil Works Programs, the Army Corps of Engineers researches, develops, manages, and executes engineering, construction and real estate programs related to rivers, harbors, and waterways; administers laws for protection and preservation of navigable waters and related resources such as wetlands; and assists in the recovery from natural disasters.

Applications to Support Mission

The Army Corps of Engineers is applying GIS technology to project siting, infrastructure and resource inventory and management, simulation of alternative plans, general master planning, installation management, natural resource data base development, and special research topics. In particular, the Corps' Construction Engineering Research Laboratory developed the Geographic Resources Analysis Support System to provide management tools for Army environmental planners and land managers.

The Corps' Waterways Experimentation Station is using a GIS based system to process aircraft and satellite data for wildlife habitat identification and mapping. Similarly, the Corps' Cold Region Research and Engineering Laboratory is employing GIS to provide field offices with a tool for water resource management planning and to link satellite data of rainfall, snow cover, and soil moisture to hydrologic models.

Estimated GIS Budget

The Army Corps of Engineers has spent approximately $5.6 million through fiscal year 1988 for the acquisition of GIS hardware and software. However, not all this hardware is dedicated solely to GIS work.

Computer Hardware and Software Used for GIS

A 1988 Army Corps of Engineers survey indicated that the Corps' GIS hardware included 18 microcomputers, 25 mid-range computers, 3 large computers, and 2 computers which are also used for Computer Aided Design and Drafting. At that time, software included the public domain Geographic Resources Analysis Support System and Map Overlay and Statistical System, and commercial ARC/INFO, ERDAS, and EPPL.

Federal Emergency Management Agency

The Federal Emergency Management Agency is chartered to (1) coordinate the emergency preparedness and response resources at all government levels to prepare for and respond to all natural, technological, and attack-related emergencies; and (2) integrate activities concerned with

also has initiated projects to assess radiation fallout and hazardous waste risk at the Hanford nuclear processing facility, to conduct global climate studies, and to determine the best sites for wind turbine facilities.

Energy's Oak Ridge National Laboratory has been developing and using GIS since 1969 for national energy strategies, environmental impact assessments and monitoring (such as strip mining damage), air and ground pollution analysis (including acid rain, radiation fallout, hazardous waste), global climate and coastline flooding studies, military strategic planning and facility management, and emergency management.

Estimated GIS Budget

Office of Conservation and Renewable Energy officials estimate spending $1 million per year for developing an automated geographical data base of national solar radiation and other renewable resources.

Bonneville Power Administration officials estimate spending $60,000 for fiscal year 1990 for equipment, $50,000 per fiscal year for acquiring data and conducting analyses, and $200,000 to $250,000 per fiscal year for staff salaries.

Pacific Northwest Laboratory staff spent $8 million on wind power GIS development but presently have no funding for updating the data base, and estimate spending an average $1 million per year on other GIS work. Oak Ridge National Laboratory staff estimate spending an average $2.5 million per year on GIS work.

Computer Hardware and Software Used for GIS

Hardware includes 2 mainframe computers, 3 minicomputers, 12 microcomputers, and 32 workstations (3 of which are connected to a minicomputer). Software includes commercial ARC/INFO, the public domain Geographical Resources Analysis Support System, and IEMIS and other GIS software developed by agency personnel.

Federal Highway Administration

The Federal Highway Administration coordinates the use of highways with other modes of transportation to achieve the most effective balance of transportation systems. In addition, the Administration provides technical assistance to promote the use and adoption of innovative highway engineering practices by state and local governments, through

The National Environmental Satellite, Data and Information Service hardware includes a mainframe computer, three minicomputers, and a microcomputer plus five workstations and two microcomputers connected to the main National Oceanic and Atmospheric Administration weather system computer for a joint project with the University of Miami.

The Nautical Charting Division hardware includes a minicomputer for developing a prototype GIS that would allow field offices to better manage their data acquisition (prototype may be installed at 50 sites), and a mainframe computer, two stereoplotters, and five microcomputers for the Integrated Digital Photogrammetric Facility. The Nautical Charting Division is procuring 40 workstations as part of the Automated Nautical Charting System II project.

Software has been developed by National Oceanic and Atmospheric Administration personnel or by contractors as part of system procurements.

Planned GIS Procurements

The Nautical Charting Division awarded a contract in September 1988 for procurement of 40 workstations and development of GIS software for the Automated Nautical Charting System II project. Current estimated contract cost is $8 million, but it may increase to $14 million if requirements change. The Nautical Charting Division will conduct functional and performance tests later this year and plans 6 months of operational tests in 1991 and final acceptance tests in spring 1992.

GIS Activities at the Department of Commerce

Within the Department of Commerce, GIS is used by the Bureau of the Census and the National Oceanic and Atmospheric Administration as discussed in the following paragraphs.

Bureau of the Census

The Census Bureau collects, tabulates, and publishes statistical data about the nation's population and economy for the development and evaluation of economic and social programs. The principal functions of the Bureau include the decennial censuses and current reports on population and housing; the quinquennial censuses and current reports on agriculture, state and local governments, manufacturers, mineral industries, distributive trades, construction industries, and transportation; and statistics on foreign trade including data on imports, exports, and shipping. Bureau products include printed reports, computer tapes, special tabulations, and statistical directories that are useful in locating information on specific subjects.

Applications to Support Mission

To support the 1990 census, the Census Bureau developed the Topologically Integrated Geographic Encoding and Referencing system which will combine maps, addresses, and other census geographical information into one automated data base. The Bureau started disseminating the census data files to government agencies and private industry in 1989. However, delays in the development of the Topologically Integrated Geographic Encoding and Referencing system will result in the census data files not being updated with the map changes identified during pre-census activities until after the 1990 census data are tabulated.

Estimated GIS Budget

According to the fiscal year 1989 exhibit 43B, the Census Bureau will obligate for the Geographic Support System $2.4 million per year for fiscal years 1990 through 1992.[1]

Computer Hardware and Software Used for GIS

Software for the Topologically Integrated Geographic Encoding and Referencing system was developed by Census Bureau personnel. The census data files were developed through leased time on mainframes.

[1]Total funds for the Topologically Integrated Geographic Encoding and Referencing system through fiscal year 1993 are estimated to be $330 million.

Applications to Support Mission

The Agricultural Research Service uses GIS technology in studies pertaining to planning and managing land and water resources, rangeland productivity, landscape ecology, mapping of soils, vegetation, and animal geography. One major use is investigating the hydrologic characteristics of watersheds to determine the spatial variability of surface and groundwater resources, and to study the transport of pesticides and other chemicals into the groundwater system. Other small scale studies include mapping bee and other insect movements and spread in particular regions, and mapping vegetation using satellite data to characterize crop productivity and consumptive water use.

Estimated GIS Budget

Agricultural Research Service officials estimate that the GIS hardware and software budget ranges from $5000 to $40,000. In addition, an estimated annual budget of $300,000 is needed to set up and maintain GIS at various Service facilities. These figures do not include funds for data acquisition, which could constitute a major part of the Service budget.

Computer Hardware and Software Used for GIS

Hardware consists mostly of microcomputers, but one application used a minicomputer. Software includes public domain Geographical Resources Analysis Support System, Map Overlay and Statistical System, and Map Analysis Program; and commercial ARC/INFO, ERDAS, EPPL, ELAS, SPANS, SURFER, and TAP.

National Agricultural Statistics Service

The National Agricultural Statistics Service prepares estimates and statistical reports on production, supply, and prices for crops, cattle, hogs, sheep, poultry, and related processed products. The Service prepares these estimates by canvassing producers, processors, and buyers associated with agriculture, and issues reports on a weekly, monthly, and annual basis.

Applications to Support Mission

The National Agricultural Statistics Service has no strictly GIS projects ongoing, but it does have a research project on digital cartography called Computer Assisted Stratification and Sampling to computerize a manual process of land use delineation and measurement. The Service's GIS activities are not much beyond educational at this point.

The Forest Service plans to acquire a nationwide GIS as part of a national Integrated Information Management Program. The estimated cost of the GIS component of the national program is $1.2 billion over the expected 12-year life of the system. This figure contains $237 million for direct capital investment in hardware and software, plus $92 million in direct support costs for contracting and installation of the hardware and software. The remaining $906 million represents the management and overhead costs above the direct supervision of the acquisition.

Computer Hardware and Software Used for GIS

Current hardware includes 94 minicomputers, 29 microcomputers, 11 workstations, and 4 systems external to the Forest Service at other agencies and universities. Both public domain and commercial software packages are used for GIS. The public domain software includes the Map Overlay and Statistical System, the Geographical Resources Analysis Support System, and the Data General version of the Forest Service's Wildland Resource Information System. Commercial software includes ARC/INFO, SPANS, ERDAS, and GEO.

Planned GIS Procurements

The Forest Service has examined alternatives for placing GIS capabilities in all of its 880 field offices. The Service received a Delegation of Procurement Authority from the General Services Administration, and had planned to issue a request for proposals by the end of March 1990. However, issuance of that request has been postponed pending final external review and authorization to proceed.

Soil Conservation Service

The Soil Conservation Service is responsible for developing a national soil and water conservation program by providing technical assistance to private land users. The Service's activities include conducting soil surveys to determine soil use potentials (for crops or wetlands) and conservation treatment needs, conducting river basin and flood plain surveys and developing water resource and flood prevention programs, providing soil maps, resource data, and practical suggestions for treating and using land, and developing implementation plans for installing land treatment measures.

Applications to Support Mission

The Soil Conservation Service uses GIS technology in the development of soil survey geographic data bases and maps for natural resource management, for river basin and watershed planning, and for farm and

Office of Surface Mining Reclamation and Enforcement

The primary responsibilities of the Office of Surface Mining Reclamation and Enforcement are to assist state governments in regulating surface coal mining and reclamation activities, and to perform mine plan and permit application reviews on federal lands.

Applications to Support Mission

The Office utilizes GIS technology as part of its Technical Information Processing System, to assist federal and state regulatory agencies in conducting environmental evaluations in order to determine the suitability of land for mining and reclamation, in conducting inventories of mine permits and abandoned mines, and in determining the volume of coal deposits and impact of mine fires.

Estimated GIS Budget

According to the fiscal year 1991 exhibit 43B, the Office of Surface Mining Reclamation and Enforcement will obligate $1.4 million per year for fiscal years 1990 through 1992 for its Technical Information Processing System.[5]

Agency officials estimate that $200,000 was spent to install the current geographic information system. In addition, $40,000 per fiscal year is spent on personnel training and installing new versions of software.

Computer Hardware and Software Used for GIS

Hardware includes 1 minicomputer with geologic surface modeling software, linked to 27 microcomputers (located in field offices). Software includes commercial ARC/INFO.

[5]$4.2 million in estimated obligations is planned for fiscal years 1993 through 1995

in terms of its suitability for irrigation, to develop wetland and irrigated-land maps, to assess environmental impact for water management studies, and to study the change in wildlife habitat over time.

Estimated GIS Budget

According to the Interior Digital Cartography Coordinating Committee fiscal year 1988 annual report, the Bureau of Reclamation estimates that $1.2 million for fiscal year 1990, $1.4 million for fiscal year 1991, and $1.5 million for fiscal year 1992 will be spent on GIS programs and remote sensing programs. For the Bureau's Earth Science Division, officials estimate that GIS work is currently about 11 percent of total project funds, but that this will probably double to about 22 percent in the next 5 years.

Computer Hardware and Software Used for GIS

Hardware includes several minicomputers and 12 workstations. Software includes public domain Map Overlay and Statistical System and commercial ARC/INFO.

Fish and Wildlife Service

The mission of the Fish and Wildlife Service is to conserve and protect fish and wildlife and their habitats. In the area of habitat preservation, the Service's activities include

- biological monitoring and studies of ecology and wildlife populations;
- surveillance of pesticides, heavy metals, and thermal pollution; and
- environmental impact assessments for hydroelectric dams, nuclear power sites, stream channelization, and dredge-and-fill permits.

Applications to Support Mission

In its National Wetlands Inventory project, the Fish and Wildlife Service has applied GIS technology to construct the Wetlands Analytical Mapping System (for digitizing, editing, and storing wetland data from aerial photographs into a digital data base), the Map Overlay and Statistical System (for geographically analyzing the digital wetlands data base), and the Cartographic Output System (for producing color maps, diagrams, and graphs).

The Service uses these systems to track wildlife migration patterns and the rate of loss of national wetlands, to study the wildlife suitability of wetlands for natural resource planning and management, to conduct

Applications to Support Mission

Through its Indian Integrated Resource Information Program, the Bureau of Indian Affairs utilizes GIS technology to assist its field offices in a wide range of natural resource management activities concerning forest, range, agriculture, wildlife, and water resources.

For example, the Phoenix, Arizona, field office for the Fort Apache Reservation uses GIS to plan, track, and quantify timber harvesting, reforestation, thinning, prescribed burning, and wildlife habitat conflicts. The Billings, Montana, field office for the Fort Belknap Reservation uses GIS to support water-rights litigation by developing maps showing potentially irrigable areas, currently irrigated areas, and historically irrigated areas. In addition, the Portland, Oregon, field office for the Yakima Reservation uses GIS to assess areas at risk to spruce budworm infestations.

Estimated GIS Budget

Bureau of Indian Affairs officials estimated that $2.9 million per fiscal year is planned for the Indian Integrated Resource Information Program for fiscal years 1990 through 1992.

Computer Hardware and Software Used for GIS

Hardware includes two minicomputers and five microcomputers (located at field offices). Software includes commercial ARC/INFO.

Bureau of Mines

The Bureau of Mines is responsible for ensuring adequate supplies of nonfuel minerals for national security and other needs. The Bureau collects, analyzes, and publishes statistical and economic information on all phases of national nonfuel mineral resource development, including exploration, resource availability, production, shipments, demand, prices, imports, and exports. Research is conducted by the Bureau to provide the technology for extracting, processing, using, and recycling these resources at reasonable costs and without harm to the environment and to the workers involved.

Applications to Support Mission

In its Mineral Land Assessment Program, the Bureau of Mines uses GIS technology to facilitate evaluation of mining districts and identification of areas that are favorable for mineral deposits.

In its Inventory of Land Use Restraints Program, the Bureau uses GIS technology to evaluate and display the impact of formal and informal

According to the fiscal year 1991 exhibit 43B, the Geological Survey will obligate $14 million for fiscal year 1990 for MARK II and $20 million each for fiscal years 1991 and 1992.[1] For DIS II, it will obligate $11.3, $13.6, and $12.9 million, respectively, for fiscal years 1990 through 1992.[2]

Bureau of Land Management

The Bureau of Land Management is responsible for the total management of 270 million acres of public lands and for the mineral resource management of an additional 300 million acres, where mineral rights are owned by the federal government. Bureau programs provide for

- the protection, development, and use of public lands and resources;
- the development of energy and mineral leases that ensure compliance with applicable regulations governing the extraction of these resources; and
- the surveying of federal lands and the establishment and maintenance of public land and mining claim records.

Applications to Support Mission

Through its Land Information System, the Bureau of Land Management utilizes GIS technology to develop resource management plans for public lands under its jurisdiction. The Land Information System links resource information from national land and mineral records and from the national Public Land Survey System.[3]

For example, the Bureau has used GIS to study the impact of cattle grazing on range land erosion and the coastal erosion on fishery productivity, to develop environmental impact statements concerning disposal sites for spent oil-shale pilings, to conduct inventories of mineral and coal resources, and to assist in granting mine permits.

The Bureau plans to incorporate GIS into its Automated Land and Mineral Records System (ALMRS). The mission of ALMRS is to develop and implement an efficient automated system for recording, maintaining, retrieving, and graphically displaying land description, ownership, and

[1] $43 million in estimated obligations is planned for fiscal years 1993 through 1995. Total spent and projected is $118 million, which includes $21 million spent prior to fiscal year 1990.

[2] $47.3 million is planned for fiscal years 1993 and 1994

[3] The Public Land Survey System is a rectangular survey system consisting of 1-mile square sections, which is used to track public land ownership, use, and mineral rights

GIS Activities at the Department of the Interior

Within the Department of the Interior, GIS is used by the United States Geological Survey, the Bureau of Land Management, the Bureau of Indian Affairs, the Bureau of Mines, the Bureau of Reclamation, the Fish and Wildlife Service, the National Park Service, and the Office of Surface Mining Reclamation and Enforcement. The following paragraphs discuss GIS activities in these agencies.

United States Geological Survey

The United States Geological Survey's primary responsibilities are to identify national land, water, energy, and mineral resources; classify federally owned lands for mineral and energy resources and water power potential; investigate natural hazards, such as earthquakes, volcanoes, and landslides; and conduct the National Mapping Program. Products of the Geological Survey include maps, digital and cartographic data, and reports on its energy, mineral, and water resource investigations.

Applications to Support Mission

The Geological Survey is using GIS technology in several parts of the agency. For example, the Geologic Division uses GIS to assess mineral and energy resources, and to study the impact of natural hazards such as earthquakes and coastal erosion.

The National Mapping Division operates three cooperative and interdisciplinary GIS research laboratories for improving the use and application of the Geological Survey's GeoData (cartographic, hydrologic, and geologic data) to solve earth science, land use, and resource management problems. The technology is demonstrated and transferred both within the Geological Survey and to other government agencies. Applications are diverse and have included geologic and watershed modeling, earthquake hazards reduction, environmental assessment, hazardous waste, urban planning, public health, forest and wildlife management, mineral resource development, and others. GIS technology will be applied in the MARK II modernization program to automate the preparation of the Division's map products. GIS will also be used to characterize land for modeling global change.

The Water Resources Division has installed GIS at 40 offices located nationwide and linked them together with the earth science Distributed Information System. GIS applications include boundary mapping for irrigation water rights, support of groundwater modeling studies, analysis of the relationship between land use and groundwater quality, analysis

Contents

Third, the hardware and software used in the GIS application varies within and across agencies. Specifically, hardware includes minicomputers, microcomputers, workstations, and mainframes. Software types include commercial software such as ARC/INFO, which is a trademark of the Environmental Systems Research Institute, public domain software such as the Geographic Resources Analysis Support System, which was developed by the Army Corps of Engineers, and software developed by agency or contractor personnel. Telecommunications can be an important part of GIS; however, we did not specifically address telecommunications as part of the survey.

Scope and Methodology

Our work, conducted during February and March 1990 in the Washington D.C. area, is based primarily on interviews with program and contract officials. In addition, we obtained and reviewed summary reports issued by the Federal Interagency Coordinating Committee on Digital Cartography, the Interior Digital Cartography Coordinating Committee, the Army Corps of Engineers, and the Environmental Protection Agency. We also reviewed agency budget exhibits submitted with the fiscal year 1991 budget request that displayed information technology obligations by fiscal year.

We will be sending copies of this report to the Chairman, House Committee on Appropriations, and other interested members of Congress; the agencies surveyed; the Director, Office of Management and Budget; and others upon request.

This information was compiled under the direction of JayEtta Z. Hecker, Director, Resources, Community, and Economic Development Information Systems, who can be contacted at (202) 275-9675 should you require additional information. Other major contributors are listed in appendix V.

Sincerely yours,

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Assistant Comptroller General