GIS CONCEPTS, IMPLEMENTATION, ORGANIZATION AND MANAGEMENT: THE EXPERIENCE OF SAN DIEGO, CALIFORNIA

Presented at the United Nations Seminar on GIS, City Sustainability, and Environment
Cairo, Egypt
10-14 December, 1995
by
William J. Bamberger
Manager, GIS Services
San Diego Data Processing Corporation
San Diego, California, U.S.A.

INTRODUCTION

San Diego, California is a metropolitan area in the southwest corner of the United States. With a population of 2.7 million, San Diego County is surrounded by the Pacific Ocean on the west, Mexico to the south, the Imperial Valley desert to the east and urban Orange County to the north. The City of San Diego, the sixth largest city in the U.S. with a population of 1.2 million, is the urban center of the San Diego metropolitan area. There are seventeen smaller cities in San Diego county.

This paper describes the development of San Diego's geographic information system (GIS). San Diego was one of the first places in the U.S. which organized a multi-participant project to develop a GIS. The GIS is now fully operational, with new applications being developed each year. The paper describes the goals and objectives for the system, the chronology of development, how the GIS project is organized, how the system is used, and the resources required to develop and operate the system. Also included are recommendations, based on San Diego's experience, for other metropolitan areas to proceed with development of their geographic information systems.

GIS GOALS AND OBJECTIVES

GIS in San Diego, California, U.S.A. has been implemented through the Regional Urban Information System (RUIS), a multi-participant project organized by the City of San Diego and County of San Diego. Officials of these two local governments conceived of RUIS in 1984 when both agencies saw the potential in the newly-emerging GIS technology. Although growth management, planning and environmental preservation were considered to be the key political issues that GIS could address, government officials saw the potential for GIS in many other areas of City and County management. City and County officials were willing to invest in GIS technology because they felt that GIS would:

- reduce or eliminate redundant activities;
- provide a way to integrate and share government information among departments and agencies;

- provide better tools for managing government facilities and operations;
- provide better information for decision making;
- improve the public's access to government information.

The high cost of implementing a GIS was the motivation to develop a single system to meet the needs of both the City and County governments. Although the two agencies had never worked together to develop a computer system prior to RUIS, City and County officials realized that by sharing costs of system development and operating overhead, GIS technology could be affordable to both agencies.

The general functions included in San Diego's GIS are:

- base map maintenance
- land planning, regulation and permitting
- facility management and planning
- environmental planning and analysis
- public safety and law enforcement
- transportation and vehicle routing.

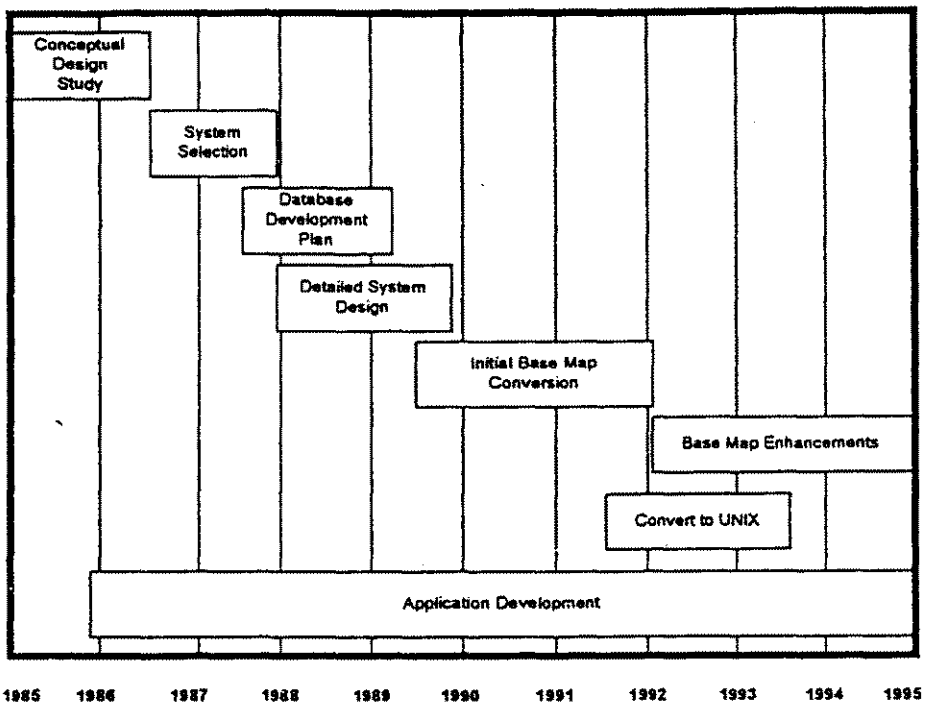
The Conceptual Design Study, completed in 1986, validated the concept of a highly integrated system using a common database. It also recommended the sequence for system and application development and proposed a plan for system implementation.

GIS IMPLEMENTATION

The development chronology in Figure 1 shows the steps and time frames for system implementation.

Conceptual Design. The conceptual design phase began in early 1985 and lasted eighteen months. The conceptual design was based on interviews with 238 staff representatives from 36 different departments. The result was a seven-volume report containing the conceptual data model, proposed applications, hardware/software concept, the implementation plan and schedule, and a cost estimate. This phase was completed with the assistance of the RUIS Task Force, consisting of management-level staff from the 28 City and County departments that use maps and/or geographic information.

Figure 1
Development Chronology



System Selection. The system selection process began with a request for proposals (RFP) for GIS software and hardware. The RFP was developed by a multi-department team (the System Evaluation Committee) and was based on the conceptual design study. Each potential vendor was required to prepare a "structured demonstration" designed to show how well their system met the requirements identified in the conceptual design study. Following the demonstrations, the RUIS Administrator and Project Manager visited organizations using each vendor's products. San Diego Data Processing Corporation, the not-for-profit corporation responsible for developing and operating the system, established a Technical Review Committee to assess the system architecture of the candidate products. Because none of the vendors could meet all of the requirements, the selection process lasted eighteen months while negotiations for enhancements to the systems were conducted with each vendor.

Database Development Plan. The next phase--the database development plan--began while the system selection process was underway. The database development plan evaluated alternative methods and data sources to build the GIS database. Three approaches were evaluated: (1) digitizing or scanning existing maps, (2) developing a new base map from aerial photographs, or (3) acquiring a digital base map that was being developed by the local utility company, San Diego Gas and Electric Company (SDG&E). The Data Conversion Evaluation Committee, consisting of staff from the departments that were to be the primary users of the base map, determined that the third option--acquiring the digital base map from SDG&E--was the best alternative, *if* the map could be obtained at a low cost.

Negotiations between RUIS and SDG&E concluded with a signed agreement in March 1990. According to the agreement, RUIS licensed the digital base map from SDG&E at no cost, but agreed to return to SDG&E all base map updates and enhancements made during the next ten years. RUIS is allowed to sublicense the data to other organizations, paying a royalty fee to SDG&E. After ten years, RUIS and SDG&E each own the base map without restriction.

Base Map Conversion. The initial base map conversion phase began in the fall of 1989, six months before the SDG&E base map was acquired. Anticipating acquisition of the SDG&E data, the initial effort was to prepare tabular road and parcel attributes. The tabular attributes were then attached to the SDG&E base map. An eight-person quality control staff was assembled to check and correct the map and attribute data. The quality control effort was completed in late 1991, and the base map maintenance process began.

Base map enhancements have continued to be made to the RUIS base map since the initial conversion was completed. The enhancements include on-going quality control and linking the base map to property characteristic and ownership data.

Convert to UNIX Client Server. About the time the initial base map conversion was completed, a group of GIS users and data processing professionals was assembled to reassess the GIS platform. This group concluded that the GIS should be converted from a mainframe environment to a UNIX client-server environment. A plan was developed to accomplish the migration over a 24 month period. The plan was completed on schedule in mid-1993.

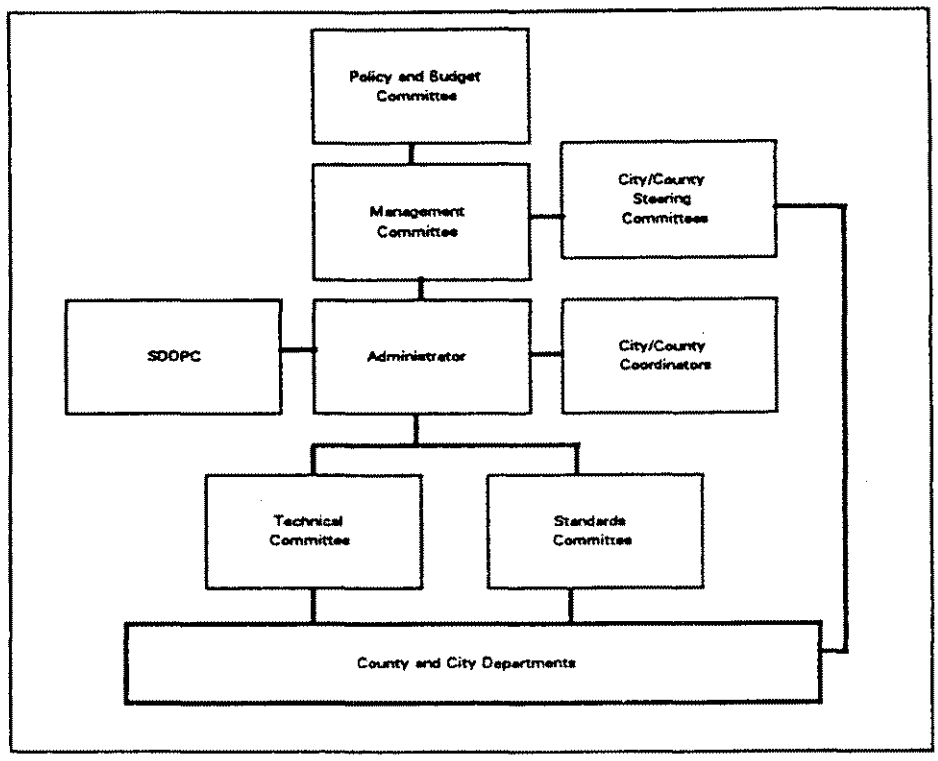
Application Development. The application development phase began very early in RUIS's history. RUIS managers recognized that the GIS would take many years to develop and that interim "successes" were needed to maintain the support of City and County management and elected officials. The first application developed by RUIS was the Building Permit and Inspection System (BPIS), the first computer system ever to be implemented jointly by the City and County of San Diego. BPIS, implemented in 1987, is a tabular mainframe system that issues permits, tracks building plans and schedules building inspections. BPIS was followed by the Road Information Module (RIM) a tabular road and address system.

GIS ORGANIZATION

Organization Structure

An important consideration with a multi-departmental/multi-jurisdictional system is how it is organized and managed. Traditional government organizational structures are hierarchical and do not provide for cross-department management. RUIS has created an organizational structure, illustrated in Figure 2, which cuts across jurisdictional and department lines.

Figure 2
RUIS Organizational Structure



At the top of the RUIS organization is the three-member **Policy and Budget Committee**, consisting of the San Diego City Manager, the County Chief Administrative Officer and the Executive Vice President of San Diego Data Processing Corporation. This committee sets the budget and the general policies under which RUIS operates.

The **Management Committee** serves under the Policy and Budget Committee and is responsible for establishing an annual work program and determining operating policies. The Management Committee consists of the Assistant City Manager, a Deputy County Administrator and the Executive Vice President of SDDPC.

The **RUIS Administrator** works under the direction of the Management Committee and is responsible for the day-to-day administration of the program. The Administrator's duties include developing the annual work plan and budget, managing the contract with SDDPC, disseminating GIS technology to City and County departments, serving as chair-person of the Technical Committee, establishing strategic relationships with other organizations, and marketing RUIS data.

The **City and County Coordinators** are responsible for coordinating the RUIS activities within their jurisdictions.

San Diego Data Processing Corporation (SDDPC), a not-for-profit corporation owned by the City of San Diego, provides the technical staff, hardware, software and telecommunications networks required by RUIS. SDDPC employs a staff of twenty-five GIS analysts and nineteen data conversion technicians.

The Technical Committee consists of professional-level staff from the City and County departments that are the primary GIS users. This advisory group meets bi-weekly to discuss work plans, application development projects, and a variety of technical issues. The RUIS Administrator is the chair of the Technical Committee.

At its monthly meetings the **Standards Committee** sets the standards that are used throughout the RUIS community. The standards, documented in a Standards Manual, include data models, hardware, software, networks, map products, and base map maintenance. The Standards Committee also publishes a Metadata Catalogue which documents all of the GIS data available in RUIS.

Strategic Alliances

The success of RUIS can be attributed in part to the strategic alliances that have been established to share information and capabilities. The more important strategic alliances are:

San Diego Gas and Electric Company (SDG&E). In March of 1990 RUIS signed an agreement with SDG&E to acquire a digital base map which SDG&E had created for their facility management system. The SDG&E base map provided RUIS with county-wide road and parcel data, to a spatial accuracy of +/-10 feet. By licensing this database at no cost, RUIS saved millions of dollars. County utility customers also benefit from the alliance because RUIS provides base map updates and enhancements to SDG&E.

San Diego Association of Governments (SANDAG). SANDAG, a regional planning agency, has been using GIS technology since the early 1970's. SANDAG has extensive GIS data layers which are used for regional planning. The agreement between RUIS and SANDAG provides for a free information exchange between the two organizations. SANDAG is connected to the RUIS network, enabling seamless access to each organization's data. Because the RUIS base map is more accurate than that previously used by SANDAG, SANDAG is realigning its GIS data to the RUIS base map.

Automated Regional Justice Information System (ARJIS). ARJIS is a county-wide crime reporting system. RUIS provides maps and a geographic base file to ARJIS. The geographic base file, based on the RUIS road network, enables ARJIS to geocode crime incidents to police beats and to assign geographic coordinates to each crime incident. With the data provided by RUIS, the ARJIS users are able to perform a variety of geographic queries. In return, ARJIS funds a portion of RUIS's data maintenance and central file server costs.

U.S. Geological Survey (U.S.G.S.). RUIS has joined forces with several other organizations to develop digital contour data for San Diego. U.S.G.S. is providing the source maps, San Diego State University is providing the technical resources, and five local organizations are providing funding. The resulting public domain data will be distributed by U.S.G.S.

Federal Emergency Management Agency (FEMA). RUIS has entered into an agreement with FEMA to provide base map data for FEMA's Flood Insurance Rate Maps. The printed maps distributed by FEMA use RUIS base map data. In return FEMA provided to RUIS a digital flood plain layer that aligns with the RUIS base map.

U.S. Bureau of the Census. RUIS, in conjunction with SANDAG, has begun a pilot project to determine whether the Census Bureau can use the RUIS base map to create the TIGER file for San Diego. If the pilot study is successful, RUIS will provide road and geographic boundary data to the Census Bureau, reducing the Census Bureau's effort to build the San Diego TIGER file. The RUIS participants will benefit because the census geography (census tracts and blocks) for the 2000 census will be aligned to the RUIS base map.

San Diego State University (SDSU). SDSU's Department of Geography has a nationally-recognized GIS program. SDSU provides GIS training for RUIS, conducting two week-long workshops per year. SDSU graduate students also serve as interns for RUIS.

The System's Users

The **City and County Departments** are the users of the RUIS system. This group is rapidly growing, but currently includes the following:

City of San Diego	County of San Diego
Planning Department	Department of Planning and Land Use
Engineering Services	Public Works
Police Department	Sheriff
Fire Department	Department of Social Services
Development Services	Assessor
Communications and Electrical	Registrar of Voters
Transportation Planning	Animal Control
Environmental Services	Environmental Health
Water Utilities	
Metropolitan Wastewater	
Real Estate Assets	
Housing Commission	
Southeast Economic Development Corp.	
Economic Development Services	

San Diego Data Processing Corporation

San Diego Data Processing Corporation (SDDPC) is responsible for developing and operating San Diego's GIS. SDDPC provides the staff, computers, software and telecommunications networks. SDDPC also provides GIS consulting services and training.

GIS APPLICATIONS

Many GIS applications are in operation in the City and County of San Diego. Most maps in the City and County have been converted to GIS maps, all derived from the central RUIS base map. This has eliminated many redundant mapping efforts. RUIS has also replaced many manual operations with automated systems, and has streamlined systems by adding a spatial dimension. Applications currently in operation or under development are listed below.

Base Map Maintenance. The first GIS application implemented by RUIS, Base Map Maintenance is used to update the RUIS base map when new subdivisions, parcel maps and records of survey are recorded. The base map maintenance application is used by the departments that are responsible for maintaining the base map. The process includes the City of San Diego Engineering Services Department, the County Department of Public Works, the County Department of Planning and Land Use, the County Assessor's Office and the San Diego Association of Governments.

Emergency Response Management. The Emergency Response Management System (ERMS) is a GIS application that assists the San Diego Fire Department in planning responses to fire emergencies. ERMS determines the quickest routes and passes this information to the Computer Aided Dispatch System. ERMS also helps to identify areas that are not well served by existing fire stations and facilitates identifying the best location for new fire stations.

Crime Mapping and Reporting. CRIME--the Crime Reporting and Incident Mapping Environment--is a GIS application developed for the San Diego Police Department and the County Sheriff. Crime analysts use CRIME to map and spatially analyze crime patterns. CRIME also produces maps for beat patrols, neighborhood watch and elected officials.

Computer Aided Dispatch (CAD). RUIS has implemented a linkage between the GIS database and the San Diego Computer Aided Dispatch system. This linkage enables road information maintained in the GIS to update the CAD geofile (the file used to determine the geographic location of crime incidents or fire and medical emergencies). This transactional update process is a creative solution to eliminate redundant maintenance of road information in the CAD system.

Building Permits and Inspection. RUIS developed a tabular system to issue building permits, track the checking of building plans, and schedule building inspections. The building permit database has been linked to the GIS to produce maps of building activity.

Land Planning and Regulation. City and County Planning Departments use GIS for a number of applications. Planners use GIS to evaluate specific plans for large scale projects to determine their environmental impacts. They also use GIS for viewshed and noise analysis. In addition, planners use GIS to determine whether endangered species will be affected by development. The endangered species analysis uses a GIS layer of vegetation that was developed through a cooperative effort involving many agencies in San Diego County. The City of San Diego is currently pilot testing the development of a zoning application as part of their "Process 2000" program, which will completely revamp the land development review and permit process.

Codes Enforcement. The County Department of Planning and Land Use is converting codes enforcement data from a card index tracking system to a GIS-based system linked to the RUIS base map. The new system will reduce staff time by consolidating multiple complaint investigations and allowing complaints to be cross-referenced to other databases. It also provides maps for analysis of code violation patterns and communicates enforcement problems to County management and elected officials.

Water and Sewer Facility Management. One of the largest users of GIS in San Diego is the City's Water Utilities Department, which is responsible for providing water and sewer services to 250,000 customers in the City of San Diego. The Water Utilities Department has converted all water and sewer facility data to computerized GIS layers and have developed a facility management and mapping system called SPLASH--System for Planning, Locating and Analyzing Sewer and Hydrology.

Water Meter Route Management. The City's Water Utilities Department has implemented a GIS-based water meter route management system. The system is used to redraw meter routes to make them more efficient. The improved routes have resulted in a substantial savings in the department's operation costs.

Street Light Maintenance. The City's Communications and Electrical Division uses GIS to manage street light maintenance. A street light layer and a GIS "front end" application was developed which links a pre-existing tabular database (residing on a mainframe) to the GIS. The system improves the service request process by providing better tracking of problem lights and enhancing the re-lamping scheduling process.

Pavement Management. The City Streets Division is developing a GIS-based pavement management system that will improve maintenance scheduling. From their desktop personal computers, city staff will be able to track road maintenance, estimate maintenance costs, identify maintenance requirements and plan future work. Street segment identification codes from a tabular system have been matched to the RUIS road network to preserve the city's investment in road information.

Storm Drain Management. Storm drain maps have been converted to digital form as part of the City of San Diego's Capital Improvement Program. A new GIS application will enable engineers

to simulate the flow through the drainage system and help identify the source of pollutants that enter it.

Refuse Collection. The City's Refuse Collection Division is using GIS to reduce vehicle maintenance and labor costs The refuse collection application links the Refuse Division's address file to the RUIS base map enabling the division's planners to create maps of collection areas, collection routes and landfills. The maps are used to evaluate, redraw, and optimize collection areas and routes. The division also saves costs by using the GIS to prepare "house counts," in a matter of minutes compared to days before the GIS application. They also use the GIS to prepare mailing lists for customer notifications. The Refuse Collection Division recently received a Technology Achievement Award from Public Technology Inc. for their GIS applications.

Census Mapping. RUIS has redrawn 1990 census geography to align with the parcel-based RUIS base map. This enables city and county demographers, planners and economists to use census demographics in conjunction with other data in the RUIS database. The RUIS census geography is also used to build administrative areas--e.g. police beats--that are based on aggregations of census tracts or blocks.

Geologic Hazards. The City of San Diego Development Services Department uses GIS to identify geologic hazards as part of their development review and permit process. GIS layers of earthquake faults, unstable soils, areas subject to liquefaction, and other hazard categories have been developed and are used in conjunction with the RUIS base map. In addition to expediting work within the Development Services Department, the geologic hazards application provides quicker response to individual citizens who have questions about the geologic stability of a particular property.

Digital Orthophotography. In 1992 the City of San Diego began a project to develop a digital orthophotograph database for the entire City of San Diego. Covering nearly 400 square miles at a resolution of 1 pixel equals 1/2 foot, this was one of the largest digital orthophotograph projects undertaken up to that time. The resulting orthophotos are stored on an optical disk jukebox which is accessible to both GIS and Computer Aided Design and Drafting workstations throughout the City. With a spatial resolution of +/- 1.5 feet, the orthophotos have been used to assess the spatial accuracy of the RUIS road and parcel layers.

Digital Terrain Modelling. In conjunction with the digital orthophoto project digital terrain models (DTMs) for the City of San Diego were developed. The DTM data were designed to support 2 foot contour intervals for use in preliminary engineering studies. The DTM data are available on-line to City RUIS and CADD users.

Social Services. The County Department of Social Services uses GIS to make important logistical decisions, such as locating social service offices. The county-wide social service case load file has been geocoded and is available on-line in conjunction with other data in the RUIS database.

Property Management. The City's Real Estate Assets Department uses a desktop GIS application to manage the city's property. The RUIS parcel data has been linked to the tabular property file to provide mapping and spatial analysis tools.

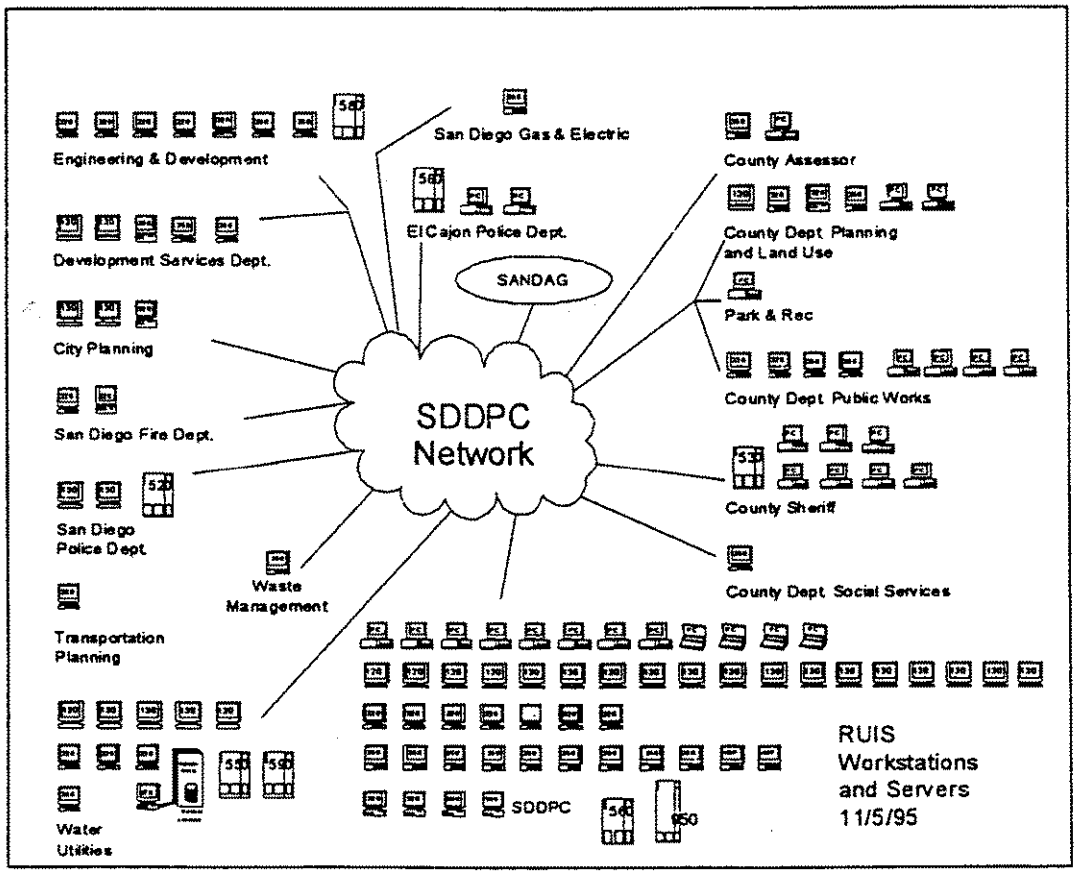
Address Matching and Validation. RUIS provides a mainframe address matching/validation system to verify and geocode customer addresses. The "ADMATCH" system is used by many non-GIS applications such as the Water Customer Information System, the Business Tax System and the Building Permit and Inspection System.

SYSTEM RESOURCES

Hardware Components

RUIS is a client-server GIS, using UNIX workstations and personal computers. Figure 3, below, illustrates the hardware configuration. The central file server, located at the SDDPC offices, is an

Figure 3
RUIS Hardware Configuration



IBM RS/6000 Model 950 with 30 gigabytes of memory. The RUIS base map and other common GIS databases are stored on the central file server. There is also a "development environment"

used by the application development staff which is located at SDDPC. The development environment consists of an RS/6000 Model 560 server and 36 workstations. Figure 3 also shows the hardware that is located at user sites. There are a total of 57 workstations at 16 different locations. The GIS users are on a high speed wide area network, consisting of T1 and T3 lines, using intelligent hub and router technology. The wide area network supports both token ring and ethernet local area networks at user sites.

Software Components

RUIS uses the suite of GIS software products from Environmental Systems Research Institute (ESRI), including Arc/Info® and ArcView®. Arc/Info components include ArcStorm®, GRID®, COGO®, ArcScan®, TIN® and ArcTools®. RUIS also uses the Ingres® relational database management system from Computer Associates. Cartographic information is managed by Arc/Info; attribute data is managed by Ingres.

Data Components

RUIS currently contains over 70 GIS data layers. The most important are listed in the table, below. RUIS has prepared a complete Metadata Catalogue that documents all data layers.

RUIS Data Layers

Data Layer	Size (in megabytes)
Roads	320
Parcels	1,110
Legal lots	1,467
Survey monumentation	4
Hydrology	2
Municipal boundaries	2
Census tracts	2
Census blocks	92
ZIP Codes	2
Political districts	3
Fire demand zones	10
Ownership areas	1
Public Land Survey	1
Water Facilities	2,750

Data Layer	Size (in megabytes)
Sewer Facilities	2,000
Vegetation	40
Orthophotos	60,000
Digital Terrain data	2,000
Geologic hazards	15

Personnel and Training

The technical staff to develop and operate the GIS is provided by San Diego Data Processing Corporation. The numbers and types of staff are shown in the table, below. Except for the data conversion staff, all GIS personnel have college degrees in computer science, geography or a related field. SDDPC built the GIS staff from a combination of existing staff (mostly "traditional" data processing professionals) and newly-hired GIS professionals. The data processing professionals had to be re-trained in many new skills, including GIS, relational databases and client-server. Much of this training was purchased from the software and hardware vendors. The newly-hired GIS professionals had very good GIS skills, but limited knowledge of data processing principles and practices. They underwent training in application development and project management techniques.

SDDPC Staffing

Position	Number
GIS Applications Manager	1
GIS Analysts (Application Developers)	20
System Administration	5
Database Administration	1
Data Conversion	22
Clerical/Financial	4

The base map data is maintained by staff in several City and County departments. The base map maintenance staff includes the following:

Base Map Maintenance Staff

Department	Number
City of San Diego Engineering Services	6
County of San Diego Public Works	5
County of San Diego Planning and Land Use	1
SANDAG	1

In addition, there are many City and County staff who use the GIS on a regular basis. These include land use planners, civil engineers, drafters, land surveyors, crime analysts, police officers, emergency vehicle dispatchers, property managers, building officials, administrative analysts, economists, demographers, utility planners, clerks and managers.

Costs

From its inception RUIS has maintained detailed records of the costs of system development. Through July of 1995 RUIS development has totaled $10.7 million. The components of the costs are shown in the table below. The actual costs compare favorably to the costs projected in 1986 as part of the conceptual design study. At that time the GIS was projected to cost between $10.1 and $16.4 million. The costs to develop the base map--about $2.5 million or $3.00 per parcel are low compared to most GIS projects. This low cost is attributed to RUIS's acquisition of the base SDG&E digital map, discussed earlier in this paper.

Operation and maintenance costs are approximately $3.0 million per year.

System Development Costs

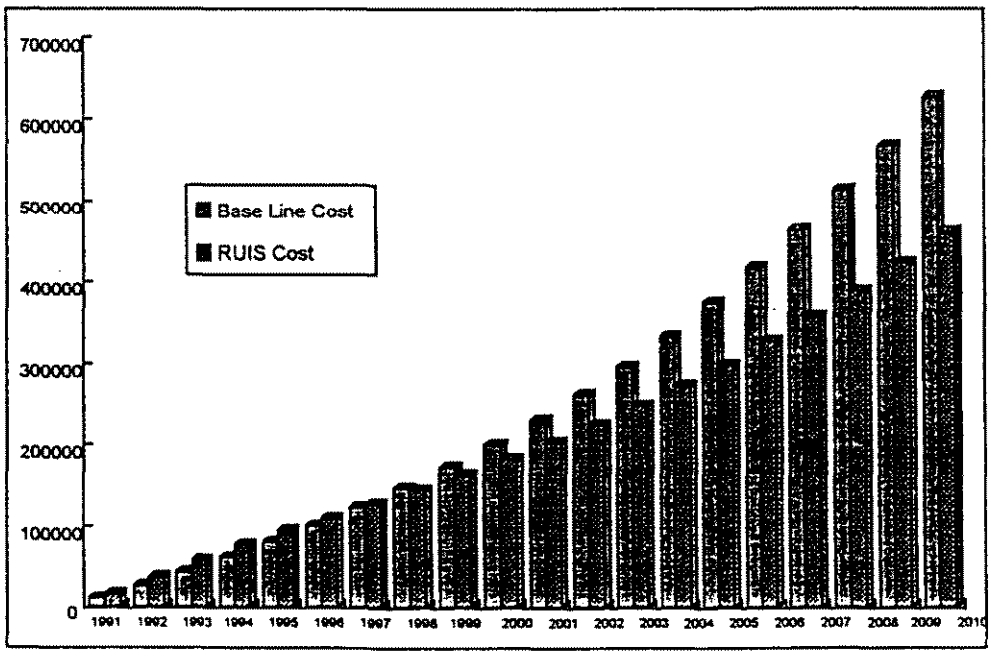
Cost Category	Costs
Conceptual Design Study	$97,000
Database Development Plan	$309,000
System Evaluation and Selection	$290,000
Application Development	$2,800,000
Computer and Support	$3,577,000
Base Map Conversion	$2,489,000
Administration	$1,116,000
TOTAL	$10,678,000

QUANTITATIVE AND QUALITATIVE IMPACT OF THE SYSTEM

RUIS has demonstrated that an enterprise approach to GIS can significantly benefit the way local governments conduct business. RUIS has eliminated many expensive manual map drafting processes, and replaced them with a single automated base map. RUIS also contributes to the day-to-day operations within the City and County. As part of the RUIS system design effort, RUIS contracted with a consultant to prepare a cost-benefit study. That study estimated that the GIS would save the City and County substantial costs, after an initial 5 to 7 year investment period. Over a 20-year period, the total savings to the City and County were estimated to be $165 million, or an average annual savings of $8.25 million. Figure 4, below, shows a comparison of the projected costs with and without the GIS through the year 2010.

Another way to judge the benefits of the GIS to City and County departments is to assess how willing the departments are to pay for the technology. Although the base map was funded centrally, City and County departments are required to justify and pay for their specific GIS applications. This ensures that each new application is considered to be a good investment by the departments that use the applications. The departments must budget for the applications and justify the cost of application development and data conversion. In this era of very limited resources, this requires the departments to cut other budget items to pay for their GIS applications. The rapid development of new GIS applications is evidence that the City and County departments place a high value on RUIS technology.

Figure 4
RUIS Cost-Benefit Analysis
Cumulative Costs - Baseline vs. RUIS



CONCLUSIONS

San Diego's experience demonstrates that GIS technology produces significant benefits for local governments. GIS has improved services to citizens, increased the efficiency of city and county staff, and enhanced decision-making. However, implementing an enterprise GIS involves many organizational and management challenges, most importantly a commitment and an organizational structure to encourage cooperation among the participants. To implement its GIS San Diego had to bring in technical experts to assist with training, system design, and system implementation. It also had to develop a staff skilled in new technologies, including GIS, relational databases, client-server, and local area networks. Finally, the implementation of the GIS in San Diego required the patience of city and county management and elected officials, who had to wait for several years before the benefits became evident.

RECOMMENDATIONS

The following recommendations are based on San Diego's experience in implementing its GIS:

- **Multi-participant Approach:** Agencies covering a common geographic area should work together to develop a single GIS. This saves money and provides all agencies with more information.

- **System Planning:** Thoroughly evaluate the requirements for the GIS and develop a conceptual design and implementation plan before acquiring hardware, software or data.

- **Organization:** Develop an organization structure that encourages cooperation and data sharing. This structure should enable participation from all levels within the organization.

- **Funding:** Prepare accurate cost estimates and identify funding sources before beginning GIS implementation.

- **Short Term Results:** Implement the GIS so that interim products are available in the short term, recognizing that the ultimate system will take many years to develop.

- **Technical Experts:** GIS technology requires special expertise. Use consultants to assist and train your staff during the initial phases of the GIS project.

- **Data Maintenance:** Develop processes and organizational commitments to maintain all data in the GIS.