GIS PROJECT PLANNING AND IMPLEMENTATION

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Summary

Geographic information systems (GISs) have gained widespread attention and use in recent years. The technology can provide many benefits to the organizations, groups, and individuals who use it. However, the effectiveness of the technology depends on how it is implemented.

Most successful GISs are implemented according to a structured process that assures that the end product will meet the users' needs. It is a standard IT implementation process, adapted to the special characteristics and challenges of GISs, comprising five basic phases: planning, requirements analysis, design, acquisition and development, and operation and maintenance. The process defines, refines, and implements the GIS components incrementally, building upon the results of each phase.

The resultant GIS can take one of myriad forms, depending on the nature of the organization and the GIS project, and the organization's goals and needs. Different types of organizations have different approaches to GIS implementation, ranging from the large, complex, highly coordinated enterprise-wide efforts of many local

governments to the small, independent GIS implementations found in some areas of companies. Individuals and groups also implement a wide variety of GISs.

Other major factors that affect GIS implementation include various implementation drivers, cost effectiveness, and data and system availability and characteristics. Trends for the future include much more widespread use of geospatial data and technology, coupled with the integration of GIS and mainstream technologies.

1. Introduction

GIS technology and systems have increased dramatically in popularity, use, and interest over the past decade. Today, organizations and groups of all types, as well as individuals, use GISs for a wide variety of spatial data activities. A GIS is a powerful tool for creating, managing, analyzing, and using geospatial data. As such, it can provide users with many benefits: improving operations, saving money and time, and facilitating decision making. GISs can also enable data analysis and manipulation that were previously impossible.

However, while GISs can be very useful to organizations and individuals, their effectiveness and success depends upon how well they are planned, implemented, managed, and used. This article discusses GIS planning and implementation methods, results, and issues. It also addresses the evolution of GIS implementation and the trends affecting its future direction.

2. GIS Planning and Implementation Process

Although GISs can differ greatly, most effective systems are planned and implemented following a structured process that ensures that the GIS ultimately meets the users' and the organization's needs.

The GIS planning and implementation process comprises five basic phases:

1. Planning: defining the scope of the GIS and developing a general plan;
2. Requirements analysis: determining users' specific requirements.
3. Design: integrating all requirements and developing data and system specifications;
4. Acquisition and development: acquiring system components and putting them together to create a unique system; and
5. Operations and maintenance: putting the system into operation and maintaining the data and the system.

The process is illustrated in Figure 1. Each component of the GIS is further defined and developed in each successive step. In addition, the process includes feedback loops from each step indicating that information obtained or developed in one step may require backtracking to a previous step to re-examine assumptions or requirements. For example, while performing the cost–benefit analysis in step three it may become apparent that users need to scale back their expectations (step two) or that an larger budget must be established (step one).

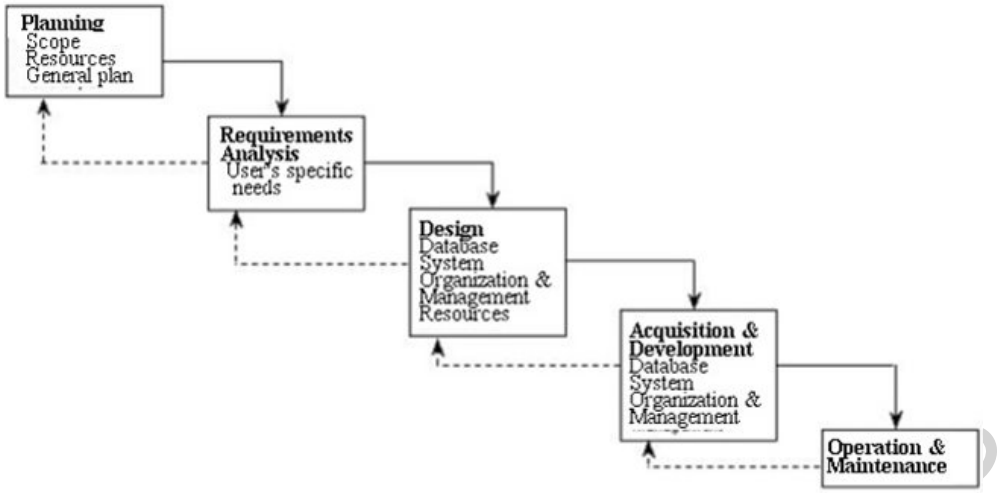

Figure 1. The GIS implementation process

2.1. Planning

Planning is an important step for any type of GIS. It provides a firm foundation for GIS implementation and operation, and helps avoid costly mistakes. Planning establishes the direction for the GIS. The major aspects that are addressed during the planning phase include:

- *Scope.* The basic nature of the GIS and its role in the organization are defined. This includes recognition of the GIS as a one-time project or ongoing program (discussed in Section 3.1), the types of applications and users that will be included, how much (if any) integration with other systems and databases will be required, and how the GIS will affect the way the organization does business. The scope, nature, and role of the GIS indicate directions for further planning and implementation activities.
- *Participants.* The scope of the GIS determines who should be involved in its design and implementation. Participants may include users and stakeholders, management and policy makers, the task team that will plan and implement the GIS, and a designated project manager. Also, to ensure that the identified participants can participate effectively in the subsequent implementation steps, adequate GIS background and education is provided, based on individuals' needs.
- *Resources.* Although detailed analysis has not yet been done at this step, the scope of the GIS provides an indicator of the amount and type of resources required. Resources include money, time (in terms of a schedule), labor force, and skill sets. In addition, the scope of the GIS indicates the general types of benefits that can be expected, so it is possible to do a general comparison of benefits to costs. Estimates made at this early stage in GIS planning are necessarily very rough estimates, but help establish basic planning resources and goals.

- *Approach.* Finally, a general plan is developed at this point. Again, the scope of the GIS is the major determinant. It indicates the type of planning and implementation approach that is required. For a small or simple GIS project, the decisions may be obvious and easily made. For larger and/or more complex GISs, more complex planning methods are needed. For example, a simple, single-purpose GIS project that will map resource sites may necessitate only a simple implementation process that is carried out by the end-user. The data and system needs may be straightforward. A multipurpose, enterprise-wide GIS program for a local government, on the other hand, would require a complex planning and implementation process that would aid decision making, and choices from among myriad options. It would also require the involvement of many participants, and often outside assistance.

GISs that are large, complex, multipurpose, and/or multiparticipant require more extensive planning. In addition to each of the elements mentioned above being more complicated, more sophisticated planning techniques are required. Strategic planning approaches are often used for these types of GIS in order to examine effectively broad, diverse goals and viewpoints, establish understanding and agreement, and ensure that the GIS fits the organization's overall goals.

2.2. Requirements Analysis

The requirements analysis provides the detailed information necessary for GIS implementation. In this task the future uses of the GIS and the current geospatial data-handling situation are examined in analytical detail. Each work process is examined in terms of its purpose or goal, the process steps, the inputs and outputs, the data involved, and the functions performed.

As part of this task, the current geospatial data handling environment and resources are addressed. This includes analysis of the current forms and sources of geospatial data: maps, files, systems, and other sources. The IT environment of the organization, if applicable, is also addressed in terms of how the GIS would fit in.

The requirements analysis results in a clear, documented specification of users' detailed GIS needs as well as the organizational support factors. The working products produced include:

- A description and/or diagram of each future GIS work process; including specific data needs and functionality requirements.
- The expected benefits to be derived from each GIS application.
- Any constraints, opportunities, or problems associated with individual work processes.

For a simple GIS project, this analysis may involve only one or two applications. For a large GIS, this process may involve examining dozens of work processes to be performed by hundreds of users (see also *GIS and Society)*.

2.3. Design

GIS design is the culmination of the requirements analysis, and often included as the last part of that step. It involves putting all of the requirements together, and designing the GIS components that will support all the users' needs. This task is preparatory to obtaining GIS software and data.

In the design task, the key components of the GIS are specified, including:

- *Database.* Data are the most important component of a GIS. Case studies and industry experience indicate that organizations spend the largest portion (as much as 80 percent) of their GIS budgets on data. Database design includes identifying all the data that must be in the GIS, the characteristics of those data, and how they are to be structured and organized in order to meet the users' and the organization's needs. Data modeling is an important component of database design (see also *Conceptual Modeling of Geographic Applications).*
- *System.* The system components include GIS-specific software and applications, as well as database support, hardware, supporting systems software, and systems integration. Small GIS projects may require only a self-contained system, using simple geospatial databases and software. Larger, multipurpose GISs usually involve complex database systems, a suite of GIS software products, specially developed applications, and systems integration. Furthermore, organizations developing multi-participant GISs usually attempt to minimize the number of different GIS software packages that they use in order to minimize redundancy and simplify support. Increasingly, web access to GIS data and applications is becoming an important component of GIS programs.
- *Organization and management.* In addition to the technical database and system components, the GIS design also specifies the management components that will support them. Management aspects include organizational components such as GIS support staff, the GIS labor force for tasks such as data creation, and training. Important management components include data management, system management, and project management for GIS implementation.
- *Resources.* The resources involved in the GIS, as designed, are also detailed at this point. This includes a detailed cost/benefit analysis based on the detailed GIS design, budget, and funding sources, and implementation plans for resource utilization and system implementation.

Again, for a simple GIS, the design task may be straightforward. For a large, multipurpose GIS, on the other hand, the design task can be very complex and technically demanding.

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Biographical Sketch

Rebecca Somers, President of Somers-St. Claire, is a consultant specializing in GIS implementation and management. She has more than 20 years' experience helping government agencies, companies, and non-profit organizations develop GIS projects, programs, publications, and instructional resources. She has published dozens of articles on GIS planning, development, and management. She is also a prominent GIS workshop instructor, writes the MGIS Management Strategies column for *Geospatial Solutions*, and is writing a book on GIS implementation and management to be published by John Wiley & Sons in 2003. Her education includes a M.A. from the State University of New York at Buffalo, specializing in

GIS; a B.A. in Geography from the State University of New York at Buffalo; and post-graduate studies in business management and information technology management at the University of Virginia, the University of Nebraska at Omaha, and the University of Calgary.