Developing GIS Management Strategies for an Organization

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Abstract

An organization's strategies for managing Geographic Information Systems (GIS) play a crucial role in the success of the technology within the organization. As with any technological innovation, the key factor in GIS success is how it is applied to solve the organization's business problems. Corporatewide strategies to introduce, implement, and operate the GIS determine how well it serves business needs.

This article addresses management and organizational issues associated with GIS technology adoption in complex organizations. I discuss issues related to managing the introduction and use of GIS and alternative strategies for integrating GIS into business operations. The article draws on a variety of experiences to highlight key organizational factors that must be considered when developing a GIS strategy.

Keywords: Geographic Information Systems; Management; Technology applications

Introduction

The management issues related to introducing and implementing technology in an organization are often more crucial to success than the technological issues. This is the case for many technologies, and it is particularly relevant for Geographic Information Systems (GIS).

Several GIS characteristics differentiate it from other technologies and necessitate specialized organizational and management approaches. These issues include the characteristics of geographic data and their role in the organization's business operations, the current state of GIS technology and its future directions, the relationship of GIS technology with other technologies in the organization, and the multiuse nature of GIS data. When GIS is introduced into an organization, the organizational impacts and implications must be addressed as carefully as the technological ones.

GIS is a broad term used to refer to many different types of technologies and organizational implementations. In fact, the GIS in one organization could be very different from that in another. For some organizations, such as local governments, GIS may represent a data and operational framework that affects and ties together most activities of the organization. In other organizations, GIS may consist only of a simple tool used to complete a single task. The types of GIS implementations vary widely, involving different levels of technology, numbers of users, and impacts on operational tasks and organizations themselves.

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The key factor in developing management strategies for the introduction, implementation, integration, and operation of GIS in any organization is to determine the appropriate role of GIS in the organization and to understand the implications of that role. An organization's particular GIS management approach consists of an appropriate combination of a GIS organizational model and specific GIS management strategies.

GIS Organizational Models

The starting point in devising a GIS management strategy for an organization is the development of an appropriate organizational model, which establishes the basic character of GIS operations. The appropriate GIS organizational model for any organization is based on its intended role.

Role of GIS in the Organization

GIS plays many different roles in organizations. To some, it is an integrating technology that provides a new perspective and basis for operations and involves major organizational impacts. Although most GIS management advice assumes this perspective, other classes of GIS use are growing faster than this traditional model. Particularly in the applications classed as business GIS, GIS may have a more limited function, and therefore other principles apply and different models are relevant. The role GIS plays in an organization affects the business operating environment. GIS could play a prominent role that draws attention to GIS, or it could play a more subtle role.

Determination of the role and scope of GIS in the organization leads to the appropriate model for implementation and management. Although GIS can play a wide variety of roles in organizations, few characteristic GIS implementation types exist. Each situation has different impacts and implications.

Alternative Models

Alternative GIS organizational models are based on differing arrangements concerning the scope of GIS, the degree of integration of GIS into business operations, the degree of centralization of GIS operation and use, and the degree of centralization of management control. Although many variations can arise from different combinations of these factors, GIS organizational models can generally be classified into three types: (1) enterprise GIS, (2) GIS data and service resource, and (3) GIS as a business tool.

Enterprise GIS. In this environment, GIS provides an information and operations framework for a major portion of the activities and applications within the organization. The GIS database and software are designed to be used by myriad applications. Benefits result from the reduction of duplicated effort and the widespread availability of resources in many operational areas. The integrated information and operation provided by GIS also serve corporate decision making and operations. This level of integration is typical of many local government and utility applications. Likewise, in many businesses the same GIS data and functionality are integral to many operations.

In this type of organization, GIS is used by many departments and individuals, but coordination and control are centralized. Most users have direct GIS access through their own systems and run their own applications. Some software and data may be local, and depending on the users' capabilities and the overall system management, users may be responsible for some development. GIS design, implementation, expansion, and standards are centrally managed, as are the operations of the core system software and databases. Wherever GIS management is placed in the organization, it manages the environment and coordinates the users.

An enterprise GIS generally follows a comprehensive GIS design and implementation process and can take several years and several million dollars to complete. The GIS database and software are designed to meet all users' requirements, although compromises are sometimes required. Nevertheless, the value of the entire system outweighs even the benefits to individual users. Widespread business process engineering and organizational change may necessarily accompany GIS implementation. Although some organizations, particularly public sector ones, resist significant organizational changes, such adjustments are necessary to realize ultimately the full benefits of GIS technology.

Data and Service Resource. In an environment where GIS is used as a data and service resource, many groups within the organization may be involved in their own GIS activities, but they may occasionally need outside assistance. GIS is not integral to their operations and does not tie them together but rather supplements their designated functions. For example, a group may need to produce maps from time to time, but map production is not a regular part of its operations. In such situations, users are served by an organizational unit that provides GIS-related data and services when needed. The GIS service group may run a GIS site, build and provide access to databases, provide operational and applications services (do jobs), and offer guidance on standards. Users generally have not integrated GIS into their basic operations, although each user may have some of his or her own GIS tools and data. This occasional need for GIS resources may be found in some companies and large public sector organizations.

The characteristics of the service group are determined by the organization's GIS-related operations. Engineering, environmental, and professional services companies, for example, often set up GIS units to provide mapping and analysis capabilities to their traditional business centers. Other companies, such as systems integrators, establish GIS centers to provide a business focus for selling GIS-related services to clients. In the government sector, a state GIS center may provide GIS assistance to a number of agencies and build databases that are used by various groups.

Service-center GIS follow the traditional GIS development process to some extent—usually within the limits of the known, funded applications at the time they are initiated. Immediate users usually drive development, while GIS management is usually outside the line departments. Further system development occurs when new needs arise, although coordinated efforts are performed only to the extent that funding is available. Benefits are often realized by centralizing some GIS resources—map and geographic information can be collected once, maintained in one place, and made available to all users; equipment and software need not be duplicated; and persons with GIS skills can assist those outside their immediate departments. Most of these benefits result from reducing GIS-related costs by sharing resources rather than requiring users to develop their own. Because there is little formalized control,

duplication of effort among user groups continues to occur, but users believe that the benefits they receive from autonomy in development outweigh possible corporate losses. Time will tell how successful this approach proves. For this model to be viable, the benefits offered by use of the organization's GIS service center must far outweigh those that each business unit would have by acting on its own, whether developing all of its own GIS support or contracting out for some of it. In some cases, the incentives to maintain autonomy have eroded the GIS service center.

Business Tool. A business unit needing limited GIS capability to support its operations may follow a business tool model of GIS. For example, a company's marketing group may need map and demographic information and a means of displaying and analyzing data. Each business unit requiring GIS capabilities pursues its own interests or perhaps takes the initiative to work with other business units but without centralized control. Desktop and other limited GIS software and hardware systems and commercially available data may be purchased. Each business unit's GIS expenditures and required skill levels are relatively small, and there are significant benefits to being able to proceed autonomously.

This type of GIS operation is typical of the recent growth area of business GIS. A wide range of companies producing products and services use GIS in relatively isolated operations for many applications ranging from market analysis to facility siting to customer service. The typical profile of an organization that uses GIS in the decentralized business-tool mode is as follows:

1. GIS applications deal with data on a relatively small scale over a wide area (city- or county-size region to the whole United States or world).

2. Large-scale applications (at the parcel boundary or block level) are performed for only small areas (several blocks to a portion of a city) at a time, if at all.

3. Emphasis is on demographic and economic data rather than detailed land characteristics (except for limited areas, as discussed earlier).

4. GIS functions performed by applications are generally statistical analysis and map display; geocoding is also an important function.

5. Widespread use of large-scale continuous base maps is not generally needed.

Another GIS use that differs greatly in application type but raises similar organizational issues is that of an embedded GIS "engine" or database handler in a scientific or business operation. The operation of this GIS has nothing to do with other operations in the organization—all that may be relevant to others are the input and output of the application. The GIS is designed to improve the application itself, and the end user need not be aware of any GIS-specific processing, let alone interface. This type of GIS operation is seen, for example, in computer-aided dispatch and other routing applications run by government and businesses.

Recent technological developments are creating a third area of GIS business tool use, which is somewhat a combination of the two discussed here. GIS and mapping tools are being made available to traditional business and other applications, which makes these applications GIS enabled. For example, a mapping function may be made available as a function of a

spreadsheet. Users have the GIS tools available within their applications and think of themselves as application rather than GIS users.

GIS could fulfill a business-tool, single-purpose role at any level of the organization—as a specific operational tool or as a management-level tool relating to a decision support system. In any event, GIS is secondary to the application itself and stands alone, under the control of the business unit only. The business-tool model begins and grows according to specific business needs. It is fostered by an operating environment in which profit centers are business units, projects, or contracts, and there are no mechanisms or incentives for profit center managers to expend their own resources to benefit other units or the corporate bottom line.

When decentralized and isolated GIS operations are extensive within an organization, it often appears that centralized control or at least coordination would save money by reducing duplicated efforts. This supposition can be evaluated only within the context of the particular organization's needs and operations. It is likely, however, that some coordination—at least for further GIS developments—could reduce cost if similar hardware, software, and data were used by the different business units.

Establishing a GIS Model for an Organization

As mentioned earlier, the guiding factor in determining the appropriate model for GIS operations in any organization is the role GIS will play in the organization. Other factors include:

1. The scope and extent of GIS operations, including the number of users, applications, and GIS databases and their distribution throughout the organization

2. The degree to which GIS is integrated into applications. GIS functionality may be tightly integrated into operations or serve as an add-on. (In the latter case, it may only be an optional part of an application.)

3. The frequency of GIS use, which is a combination of scope and integration

4. Complexity of GIS tools, which determines the size of the GIS resources related to each business unit and the organization as a whole and also affects the sophistication of the operation and the skills and time needed to run GIS

5. The operational structure of the organization: the operating, reporting, and responsibility structures and procedures that prevail also apply to GIS; the operation and autonomy of business units and profit centers is a major determinant of the cost of coordination

An organization may employ different GIS operational models at different times. Different models may be most suitable at different stages of the GIS life cycle. Although one model may facilitate GIS development and use at one stage, the ultimate model chosen may be different. In addition, sometimes changing circumstances indicate that a different model should be adopted (Somers 1996b). The role GIS plays in the organization and the resultant GIS organizational model must then be matched with appropriate GIS management strategies.

GIS Management Issues and Strategies

GIS management is a broad area, but several key principles form common ingredients to successful GIS implementation. GIS management approaches share many characteristics with other technologies and management issues and also have some unique aspects. Many of the basic principles of GIS management are derived from project management, information systems development and management, organizational design and development, business process reengineering, technology implementation, and business management. The special characteristics of GIS and its relationship to the organization require attention to specific aspects of management and the development of some specialized strategies. There are several key elements to successful GIS management strategies.

At this time, there are no critical, rigorous, or research-based studies that evaluate GIS management approaches, but hundreds of organizations' experiences have indicated certain strategies that work in specific situations. Many individuals share these experiences and lessons in various forums in the GIS industry. (Predictably, however, information is not shared as freely in the business sector as in the public sector. Written information regarding business use of GIS is often limited to selected applications and does not address business strategies for managing and using GIS.) Other authors have discussed the state of research, or rather lack thereof, regarding GIS management approaches. Wellar (1988, 1989) observes that most of the management requirements in this field are based on an experience of one, and Craig (1991) comments on the absence of any true research-based guidance. Croswell (1991) analyzed several published papers regarding GIS and information systems (IS) implementation and derived some "maxims of success." His conclusions coincide with many of the management strategies discussed here. Obermeyer and Pinto (1994) have addressed the need for more rigorous GIS management guidance and have examined relevant management literature that may serve as a basis for the development of specific GIS management approaches. Thrall (1995) has proposed five stages of GIS reasoning and noted the current absence of adequate information in the last stage, GIS implementation and management. Other authors have evaluated GIS implementation within specific sectors—notably, Campbell and Masser's (1995) studies of GIS implementation in British local government.

While we await a more rigorous approach to the study of GIS management practice, the accumulated weight of many organizations' experiences provides much valuable information and guidance. This article identifies strategies based on this accumulated experience, drawn from GIS, IS, and management literature; personal discussions with hundreds of GIS implementers and users; and direct personal experience with dozens of GIS projects. In spite of the limited study of GIS management, some significant principles have emerged from its practice. The GIS management strategies discussed in this article represent the approaches that emerge repeatedly and significantly as successful practice in GIS implementation. GIS management strategies must be evaluated with regard to the specific situation and adapted as appropriate. The following discussion outlines some of the more prevalent strategies, or "best practices," in GIS management.

The GIS Implementation Process

GIS implementation involves designing, acquiring, installing, and operationalizing the necessary components—including data, software, hardware, and people—to fulfill an organi-

zation's GIS needs. Although the characteristics of the final GIS implementation for each organization differ, some basic principles apply to most situations. The management challenge is to understand GIS, the principles of GIS implementation, the alternatives, the organization's needs, and how to put these components together.

The traditional GIS implementation process consists of a series of steps or activities. The first step, project planning, involves establishing the scope of the GIS, identifying the development team, acquiring the required background information, and developing a preliminary implementation plan. The next step, requirements analysis, involves determining the functional and data requirements for the GIS applications and users and assessing resources, opportunities, and constraints in the organizational and institutional environment. The design step entails developing a conceptual design for the system, database, applications, and organizational components and confirming the design with respect to the requirements analysis results. The system acquisition and development phase involves developing software, hardware, and data specifications for system selection and acquisition and data acquisition or conversion. Implementation involves installing software, hardware, and databases; developing applications; and performing the organizational development required to support and use the GIS. Finally, the operations and maintenance phase consists of integrating GIS into the organization's operating environment, supporting users, and managing the ongoing process of data and system maintenance. This basic process is applicable to GIS of all sizes and applications, although the time and effort required for the steps may vary greatly (Somers 1995b).

The GIS development steps are generally performed in sequence, although many activities can be performed concurrently. In fact, most traditional writings on GIS development advocate sequential system development and stress the importance of completing all aspects of one step before moving on to the next. Relatively recently, however, many organizations are finding great advantages to using variations on the traditional development methodology. Several developments in the technology, markets, and practice of GIS are driving these alternative development approaches. These developments include commercially available geographic data and thematic data, software packages designed for specific applications, and general economic and business conditions that demand quick results.

Many alternative GIS implementation approaches are driven by cost-benefit issues—particularly by the desire to reduce immediate costs. Cost reduction and cost-benefit rationale are, after all, what usually drive GIS in the first place. Benefits are realized from two basic features of GIS: the technology can greatly reduce the time and costs involved in certain operations, and data costs can be lowered through reduction in duplication of data (particularly map) collection, maintenance, and output. The ability to share costs of database development and system implementation among multiple users is behind the multipurpose GIS design and implementation methodology. Although most GIS cost-benefit analyses prove a good case for proceeding with GIS, the amount of the initial expenditures and the distance of the payback point can present problems. An organization must consider the cost-benefit time frame, not just net cost-benefit or payback point. These considerations may lead to some alternative development plans.

Alternative approaches that accelerate the GIS implementation process have many benefits, such as providing immediate products and applications to meet users' current needs, spread-

ing out the expenditure schedule, tying specific expenditures directly to specific benefits, maximizing system utility, and maintaining user and management support. Many potential pitfalls are also involved in straying from the standard development process. The challenge for any organization implementing GIS is to know which shortcuts can be taken—what data can be bought rather than collected or converted, which applications can be bought rather than developed, which types of requirements analyses and designs have been done enough that the results are known, and which product and service providers are qualified. If an organization has a good handle on the long-term scope, design, and organizational integration of its GIS, many short-term steps can be implemented. Low-initial-cost alternatives are eroding some of the rationale and discipline behind the multipurpose GIS implementation methodology. Success with alternative GIS development approaches is based on solid planning, analyses, and design. The implementation approach must then be carefully planned, so that initial, opportunistic steps contribute to the final design (Somers 1988–96).

A primary factor in managing GIS implementation is developing an appropriate process based on the various alternatives. Many organizations have failed in their implementation efforts because they blindly followed a process or advice that was used in another organization's situation but was not as well suited to theirs. Analysis and planning are critical activities that must be carefully completed before beginning GIS implementation. Everyone seems to agree that this is so, but a surprisingly large number of organizations simply adopt a prescribed methodology and set themselves directly on that path without preliminary planning and analysis of their situation.

Another key factor in GIS implementation management success is flexibility, which must be built into the process, maintained, and exercised as needed. Because the GIS implementation process can take a long time, particularly with respect to technology and environmental changes, flexibility is crucial to success. The GIS implementation manager must be able to adjust to arising constraints and problems and take advantage of new opportunities.

Finally, a critical, yet often overlooked, factor in GIS implementation is the handling of the transitions between the phases of the development process, which can be more difficult and more critical to success than the steps of implementation themselves (Somers 1995b). This is particularly true with regard to organizational issues. Although many GIS project managers capably plan the technical tasks and transitions, the organizational aspects are often disregarded—largely because they are not well understood or are underestimated. Delivering a technical tool to a person or organization that has not been properly prepared can cause a technically sound GIS to fail.

The GIS implementation process described here is adapted from information system development methodologies and takes a basically linear approach. This type of process is discussed often in the literature. It can be seen from all of the additional management considerations, however, that this process is more complex than it appears on the surface. Recently, in recognition of the crucial role that organizational issues play in GIS development, alternative perspectives and approaches have been suggested that incorporate organizational aspects directly into the GIS development process. Saarinen (1987) discusses GIS development with respect to information systems and organizational evolution. Ventura (1989) proposes criteria and methods for evaluating the implementation process. Cullis (1994) discusses the need to "unlock the social gate" to integrate GIS into the organization, referring to Mayo's (1985) model for technology adoption. Anderson (1992) discusses reactive versus

proactive approaches to GIS development.

Obermeyer and Pinto (1994) distinguish between the process model and the content model components of the GIS implementation process. Carrying this concept further, Anderson proposes a nonlinear model for GIS development that incorporates organizational aspects. Campbell (1994) focuses on the incorporation of GIS into the organization as a separate issue from simple implementation. Campbell and Masser (1995) also stress this perspective in their study of GIS in practice. They find that GIS implementation in organizations—British local governments in particular—has fallen short of expectations, and they suggest different perspectives on the GIS implementation process as potential means of understanding some of the problems. They subscribe to a "social interactionist" perspective on GIS implementation that focuses on the social and institutional context into which GIS is being introduced. These new perspectives on the GIS implementation process have been instigated by observations that organizations appear to have significant problems with the application of the prescribed implementation process within complex organizational environments. In the future, these research efforts may yield some new GIS development and implementation insights and models.

Strategic Vision, Scope, and Business Impacts of GIS

To provide direction for the GIS and for all implementation and operations activities, it is necessary to establish a vision that defines the role GIS plays in the organization, its scope, and its relationship to business operations. Establishing a strategic vision and goals for GIS is critical to its success, whatever the scope of the implementation. In a large, multiparticipant GIS effort, all participants must fully understand and share that vision, since they will be responsible for making it a reality. Many GIS problems and failures can be traced to a single source—conflicting ideas concerning what the GIS should be (Somers 1988–96; 1996a).

The bottom line in devising a GIS strategy must be responsiveness to business needs. Although the development of strategic vision and role definition is commonly thought of as a top-down process, that is only part of the task. The purpose and role of the GIS must also be defined from the perspective of the business process it will serve. Particularly in a competitive environment, every aspect of GIS implementation and use must be evaluated with respect to business needs. This need for a customized fit is another reason why following the example of a different organization or a prescribed generalized approach rarely works as effectively as developing a system designed specifically for a particular organization (Somers 1988–96).

Assessment of Organizational Risk

Assessing organizational risk at the outset of a GIS project can increase the chances for success. Croswell (1991) comes to this conclusion because of his observation that organizational culture, lack of understanding of GIS, and unpreparedness are often cited as obstacles to GIS implementation. Many GIS implementers are frustrated by what they see as inex-

plicable or illogical resistance to GIS. They make various assumptions about the source of the problems and the possible solutions. An organizational risk assessment provides a structured and analytical framework for examining the organizational components that hinder GIS implementation. Gibson et al. (1984) discuss formal procedures for evaluating risk and suggest that project implementation strategy be based on the results of the risk assessment.

Coordinating GIS Participants and Users

One of the basic principles of GIS is shared data and system facilities. Sharing GIS resources among many users is one of the major benefits of GIS. It provides the opportunity to reduce duplicated efforts related to data, software, and hardware; this savings is often the basis of the cost-benefit analysis for GIS. Sharing GIS facilities among many users, however, can create a complex environment, and the management of such an environment can be challenging.

Committee and team approaches, which are useful for coordinating participants and guiding project development, are frequently employed for multiparticipant GIS projects. Coordinating multiple GIS users within an organization involves two perspectives: addressing the varied interests of the participants and establishing lateral management in a vertically structured organization. Participants bring many different interests, application needs, data needs, priorities, organizational issues, and political interests to a common project—the GIS. Strategies are needed to address these varied interests and to develop the necessary compromises. Lateral communication and coordination within a hierarchical bureaucracy is not a new issue and is not unique to GIS. Many organizations have addressed this problem while working on projects involving more than one department. GIS can complicate the issue, however, because its data and processes can have impacts throughout the organization.

Common models for coordinating participants, employed by most organizations operating extensive multipurpose GIS, recognize that participants have three levels of interest in the GIS: policy, technical development, and usage. An executive committee, which typically consists of the heads of the major departments involved in the effort, provides policy guidance and support to the GIS. A technical committee provides the driving force for the design and development of the GIS; members of this committee are mid-management to senior technical level representatives from the major departments or user types involved in the project. The technical committee—a workgroup that facilitates the development of the GIS, particularly the requirements analysis and functional design—discusses details, reaches compromises, and refers its recommendations to the executive committee for approval and funding. A users' group represents a third level of participation. It is most relevant once the GIS is operational, when it provides an open forum for users. During the development phase, particularly for a large GIS effort, identification of the user group facilitates outreach to the future user community regarding system requirements analysis and GIS communication. A GIS manager and support staff coordinate these groups of users and manage the system's implementation and operational efforts.

This basic committee structure has become fairly universal for multiparticipant projects in which GIS plays an integral role in the organization's operations. Most local and state gov-

ernments and utilities use this basic model, which is a good indication that the basic model works well for such organizations. Benefits of this model include establishment of the necessary lateral communication channels and management lines across a hierarchical organization, formation of team-based workgroups, focus on the GIS project, and identification of a leader for the GIS project. The phenomena that provide these benefits, however, also introduce some problems, including "matrix-management" problems, delays involved in working with teams, group dynamics and conflicts that develop in a team situation, valuing visibility over progress, and a project manager's agenda with the project priorities (Somers 1994).

Any organization implementing a multiparticipant GIS must understand and analyze the benefits and inherent problems of committee and team environments in the context of that organization. Some organizations have concluded that in spite of the multiuse goals of their GIS, they would have been better off implementing it without imposing the committee environment. For other organizations and GIS applications, the multipurpose function of the GIS is not sufficient to warrant a committee setup.

Managing the GIS Committee and Team Environment

In a committee environment, each committee must first have a clear charter regarding the types of issues it will address, and then it must remain focused on these issues. A clear plan should specify the matters to be addressed by each committee—as well as by the GIS manager—and how information, recommendations, approvals, and directives should flow among the committees and staff. The appropriate committee composition follows the GIS project definition. Organizational and professional interests should be appropriately represented according to the role of GIS in the organization.

A committee's operating procedures, which also must be clearly defined, must address how often a committee meets, how and when special meetings can be called, how the meetings will be run, and how meetings will be documented. Issues related to the decision-making process are particularly important and may be adapted from general management techniques, such as the Delphi method for GIS criteria suggested by Thrall and McCartney (1991).

Committees that represent all participants can become very large; complete representation may be achieved at the expense of progress. In particular, the technical committee is supposed to deal with the myriad issues related to system design, implementation, and operation. Decision making and progress may be hard to achieve—at least in the required time frames—if this group consists of more than eight people. It is often useful to break a large committee into smaller workgroups—each with a mandate to research, analyze, and present recommendations on specific issues.

Finally, committee members, particularly those on the technical committee, must make adequate time commitments. GIS-related activities could consume 25 to 100 percent of team members' time for significant periods. GIS projects are delayed when committee production, reviews, and approvals fall behind schedule because members could not contribute enough time to the project. Committee members' resource commitments must often go far beyond simply attending meetings (Somers 1995a).

Communication and Providing Information

Communication is crucial to the success of the multiparticipant GIS environment. It can be time-consuming: communication requirements grow in relation to the number of participants and differences in applications, professional backgrounds, priorities, organizational interests, and personal agendas. All involved parties—future users as well as committee members—must be kept in the communication network from the time they are first contacted through the entire project life cycle. Users and committee members must be informed of project developments and receive GIS education and updates regularly. Project management must also remain open to users' concerns and additional requests. As a GIS project progresses, users typically develop new requirements that must be analyzed, even if their implementation is postponed. Adequate project staff resources must be available to provide the communications required to support the GIS committees and users.

To participate usefully in the GIS effort, participants need adequate information regarding GIS and the project goals. They must receive the right kind and amount of education and information at the right times. Participants from different application areas and levels of the organization have varied interests, backgrounds, and needs related to understanding GIS. The type of information required by the CEO differs greatly from that required by a service representative, and the service representative's needs differ from those of the marketing analyst. GIS education and orientation must be tailored to the specific audience, which often requires conducting several events for different groups from various applications areas, professional backgrounds, and levels in the organization. Furthermore, education is an ongoing need throughout the GIS project. In addition to the supplemental education necessitated by the introduction of new users, applications, data, and technologies, education needs grow along with the project. As the participants become more knowledgeable about GIS, their need for additional information grows (Somers 1995a).

Leadership and Support

In a large, multiparticipant GIS project, two types of leadership are crucial to success: someone to manage the GIS implementation and operation and someone to provide support and influence at the policy level.

A large GIS effort must have a focal point, a manager who coordinates the network of committees and participants. Among the many technical and managerial qualifications a GIS manager must possess, he or she must be able to manage this complex environment, work with diverse individuals and groups, manage teams, educate, motivate, and lead. All are critical to the success of the GIS.

A second kind of leadership critical to the success of an extensive GIS effort is a project champion who provides executive-level support and influence. The need for such leadership is cited repeatedly when discussing successful GIS projects, but many projects still lack this key ingredient. The project manager can function in a dual role as an effective project champion only if he or she is high enough in the organization. The project champion's support and efforts ensure continued political and financial support in the face of pressures that otherwise would erode the project's resources and delay its implementation (Somers 1995a).

Management and Control of GIS

Basically, control and management of GIS may be centralized or decentralized. In an enterprise or information-framework GIS, an organizational unit may be established to manage the GIS environment and run the core system, whereas usage is decentralized. In an environment in which GIS is used occasionally by various users, it may be set up as a separate service with a designated group that manages the GIS and also controls users' applications services. In an environment in which GIS is used as a business tool, management and control may be decentralized to the user business units.

In an extensive GIS environment involving committees, a GIS staff, and many different users, special concerns regarding GIS control and management arise. Whatever the committee or team setup, the organizational location of the GIS manager is considered the location of the GIS itself. In any organization, there are implications involved in the location of the GIS. Its location can be an important factor determining the success of the GIS, or at least the ease with which success can be achieved. There are three basic areas in which the GIS management could be placed—in a line organization, in a support area, or at the executive level. Each of these locations has advantages and disadvantages.

Location in a line organization places GIS management within an operating unit such as planning, marketing, or customer service. The advantages of this placement include the direct connection of GIS to an operational need and budget. If the GIS is to serve users in other departments, however, such a location can be a disadvantage in terms of coordination difficulties, lack of inherent authority, lack of visibility, and possibly a weak budget position.

Location in a support unit includes departments such as information systems, technology support, or management services. Advantages of such placement include the institutionalization of GIS within an existing support environment, a professional and objective image for the GIS and its personnel, and separation of the GIS budget and operations from those of the line departments. Disadvantages involve the perception that the GIS staff is removed from operational needs, a potentially weak budget position, and difficulties in integrating GIS into the operational units of the organization.

Location at the executive level means that the GIS manager reports to one of the top decision makers in the organization, such as the CEO. Advantages include high visibility, inherent authority, top executive support, and a strong budget position; disadvantages may include too much visibility in a highly political atmosphere and a perception on the users' part that the GIS management is too far removed from operational concerns. Difficulties in integrating GIS into operations may arise when GIS management is located at the executive level. Another problem with GIS placement at the executive level is that the GIS may evolve into a separate department, leading to major problems if such a structure was not the intended organizational configuration.

Experiences of many organizations have demonstrated these advantages and disadvantages. In the past, many GIS projects were initiated in line departments because of the inherent advantages of being tied directly to an operational need and a budget line item, as well as the direct support and control of a manager who saw the need for GIS. As such projects expanded to serve other departments, coordination difficulties arose. More recently, in recognition of the multiparticipant nature of GIS and the need for better coordination and

funding mechanisms, many GIS projects are started at the support or executive level. These projects, in turn, have suffered from the disadvantages at these locations. GIS projects and programs often tend to move within the organization or evolve over time. The most common move is from line levels to support or executive levels. In the development of multiparticipant projects, the tendency is to initiate them at higher levels in the organization. GIS management may also move when the project passes from the developmental to the operational stage (Somers 1990, 1994).

Some organizations create a special GIS unit for the development phase of the system. The concept of fostering the development of a technological innovation, such as GIS, in a nonline area of an organization has a foundation in organizational management literature (Galbraith 1982). The benefits of this arrangement are that the innovation is separated and protected from the demands and scrutiny of day-to-day operations during its critical development phase. Once development is finished, however, the technology must be integrated into the regular organization where it will be used in operations. For organizations attempting to implement this model for GIS, the greatest challenge has proved to be in integrating GIS into the organization after the initial development and implementation (Somers 1988–96).

The appropriate configuration and placement of GIS management and control within an organization depends on the role and scope of the GIS, the organization model used, and the specific operational aspects of the organization. In any situation, however, the challenge in developing strategies for GIS management is to provide system and user support without unnecessary obstacles. The ultimate goal of the GIS is to improve the users' environments. GIS management must support business processes rather than build a GIS empire.

Personnel Issues

Personnel issues are heavily discussed in the GIS field. Much is made of the importance of staffing—perhaps too much. Most of this discussion pertains specifically to the traditional large, multipurpose GIS in a public sector setting, where personnel issues are more important than in organizations in which the GIS has a more limited organizational impact.

Personnel issues must be addressed with the proper focus on the role of GIS in the organization. For some organizations, personnel matters are not a large issue—particularly for those using GIS as a limited business tool. Regardless of the extent and impact of GIS within an organization, however, at least the basic personnel issues—staff responsibilities, staff configuration, position requirements, position descriptions and pay scales, job classes and career paths, staffing, and training—must be addressed. Most of these factors are the same for GIS as for any professional or operational area. Factors that make the GIS personnel issues unique relate largely to the relative newness of the technology within the organization and in general. Again, GIS shares this phenomenon with many technologies.

GIS personnel planning for any organization relates directly to the role of the GIS and its design and operational characteristics, which drive the staff needs, position descriptions and qualifications, staffing process, and training needs (Somers 1994). For an extensive GIS implementation, personnel issues may be significant. The organization may need to establish a new class of GIS-related positions to support the system, particularly in its operational

phase. In an organization in which GIS is used as a limited business tool in only one area, the only personnel issue may be providing the appropriate training for the individual who will be using the GIS.

Data Access

One of the most important challenges for the future is managing the GIS data access environment. Data sharing has always been a major reason for GIS development, and it is gaining importance every day. More organizations and individuals are realizing the benefits of having access to others' data, and such benefits are driving many activities and debates. The access issues relate to organizations sharing data, individuals and organizations seeking one-way access to data, access to public data, business opportunities involving access to data, privacy, ownership, strategic and business advantages and losses, and restrictions to access, among others. Financial issues relative to data access include cost sharing, fair charges for access and services, profit, and ownership. Many of these issues are interrelated, complicating debates in this area.

Fees and rights to access aside, the major issues involved in the data access environment relate to technical standards of data access and sharing. GIS metadata (information about the data relating to source, quality, limitations, and other aspects), data standards, data transfer procedures, and system interoperability will be key factors in the GIS environment of the future. Progress continues on resolving the technical issues related to data access, but the major obstacles are institutional and managerial, including policies for data access, data-sharing arrangements and agreements, pricing, rights and responsibilities, restrictions on access and use, maintaining privacy and security, and control of the data-sharing environment. Issues related to GIS data access are being examined, notably by Onsrud and Rushton (1995), but have not yet been resolved. The current absence of guidelines and operational evaluations in the data access area of the GIS field presents a challenge for those trying to establish data access policies and procedures for their own organizations.

Timing

Successful timing in GIS is largely an art. When developing implementation schedules, certain technical and organizational dependencies are inherent. Technically, certain components must be completed before a dependent component can be developed. Organizationally, components must be prepared before technical changes can take place. The timing of many technical and organizational aspects must be coordinated.

Beyond the obvious scheduling dependencies, however, successful progress, adoption, and use of GIS is the result of strategic timing that takes into account a variety of factors. For example, strategic timing of GIS project initiation can ultimately determine whether the project is ever implemented. A related issue is project formalization. Many GIS efforts have developed successfully by starting quietly, without formalization of activities or funding, and then the project is formalized and funding obtained once there are demonstrable results (Somers 1995a).

Related to this issue is the timing of committee formalization. Unwieldy committees and large numbers of project participants often cause project delays. In some cases, it may be

better to start small, with only one user or application, and involve others once momentum has been established. Likewise, the timing for moving from isolated GIS applications to a coordinated operation must be carefully considered. Other issues of timing include the rate of development and expansion and when to publicize GIS. In a business environment, GIS timing must take into consideration not only cost-benefit and internal operational issues but competitive ones as well.

Integrating GIS into an Organization's Operations

Successful adoption and integration of GIS into an organization's operations depends on all of the previously discussed issues, each of which must be considered by itself and in combination with the others. Organizational and management issues must be addressed in concert with technical considerations. While the technical tasks involved in system design and implementation are occurring, the organizational issues that facilitate the design and affect the implementation and adoption of the GIS must also be addressed. The key to success is coordinating all of the goals, activities, and impacts.

The primary factor in integrating GIS into an organization is understanding GIS's role in the organization. The scope, purpose, and vision for GIS in the future of the organization will drive the development of organizational plans. The impact of GIS on work processes and business operations can be profound. The use of GIS could change all work processes and reconfigure the operational environment of the organization, or it could simply be added to selected operations, or the extent of its impact could be anywhere in between.

Many other important issues affect the integration of GIS into an organization's operation, including strategic planning, educating users, training, involving users in system planning and design, transitions, organizational changes, personnel and career issues, GIS support services, the organizational environment, and the GIS development process.

Strategic Planning. The first step in the GIS development process—strategic planning—is crucial to the last step—GIS adoption. Many problems encountered during the development process can be traced back to miscalculations or omissions in the planning process (Somers 1988–96). Strategic planning for GIS is discussed extensively in the literature, most recently by Huxhold and Levinsohn (1995).

Educating Users. Everyone involved in GIS development must receive the appropriate information and education in the right format at the right time. To provide input to the GIS design, to accept it when it is delivered, and to use it properly, people need to understand what GIS is, how it operates, and how it will affect their jobs (Somers 1988–96).

Training. Education and training are different functions, and different users need different combinations of both. Timing, focus, and context are important elements in training. Training must be carefully scheduled to coincide with operational use. Users should be trained far enough in advance of the date on which GIS is to be implemented in their area to meet operational expectations and ensure that GIS data does not become outdated from lack of maintenance. If users are trained too far in advance of GIS implementation, however, their skills will fade before they have a chance to use them. An important phase of training is the time during which the users are learning how to use their new skills within the operational

environment. If users feel uncomfortable with training or with use of the GIS, it will not be easily adopted. A good training plan facilitates GIS implementation (Cullis 1995; Somers 1994).

Involving Users in the Planning and Design of the System. The future users of the system must participate in the planning and design phase if they are to accept fully the delivered system. Users' input and participation during analysis and implementation provide the information necessary to design the GIS capabilities that will meet their needs. Establishing a cooperative relationship so that users feel ownership of the system is also important. Concepts related to the user-centered design of information systems, such as those discussed by Eason (1988), are very relevant to GIS. Open consensus during the requirements study phase is an important ingredient to the successful adoption of GIS (Cullis 1995). The challenge in this area is to include enough user participation to ensure valid design and user acceptance while ensuring that the progress of system implementation is not impeded.

Transitions in Operations. The manner in which GIS is phased in affects its success. The transition to the use of GIS must often be planned so that it does not disrupt operations. Accurate timing can be particularly difficult if GIS implementation entails extensive business process redesign and organizational changes.

Organizational Changes. Successful GIS implementation and adoption usually require some degree of organizational change, which can be very difficult to effect because organizations are naturally resistant to it. This resistance has many sources, including bureaucratic operating procedures, personal resistance, and habit. The design of the target organizational configuration and operation is derived from the GIS design. Making the changes to implement the new organization can be complicated, however. Multiple transitions may be needed to achieve the desired state. Preparing individuals, establishing evaluation and reward systems that reinforce the changes, and many other considerations must be addressed by research and literature in organizational design and development (Somers 1989). These concerns are related to those discussed extensively in the organizational change literature, particularly that related to technology adoption and current interests such as reengineering businesses (Hammer and Champy 1993).

Personnel and Career Issues. Users must see the benefits of GIS from a personal perspective, not just from organizational or business views. Personal acceptance and support of GIS can be a crucial factor in the success of its adoption (Somers 1988–96). Cullis (1995) also discusses the importance of the users' perspective in successful adoption of GIS.

GIS Support Services. A major factor in user acceptance is the technical support environment. If GIS is well supported, the system and database run smoothly, the environment is user-friendly, and response is timely, then it will gain favor with the users. The GIS must make the users' lives better, not worse (Somers 1988–96).

The Organizational Environment. When implementing a comprehensive or large GIS effort, it is important that the environment of the organization be prepared in many respects. Brown and Friedley (1988) identify four critical areas of the organizational environment: (1) the level of information systems distribution in the organization, (2) the maturity of the organization and its information systems, (3) the GIS implementation roles, and (4) the participants' attitudes toward GIS and each other.

The GIS Development Process. Design and management of an appropriate GIS development process is crucial to ultimate integration of the GIS into the organization. The development process must incorporate the organizational aspects of GIS initiation, development, and operationalization (Anderson 1996; Somers 1988–96). Successfully handling all the components of the GIS development process requires skill and knowledge, including the ability to recognize early the skills and expertise required and the level present in the organization, as well as how much outside assistance must be obtained. In addition to GIS education and training, the use of a consultant to help with the GIS development and adoption process can be beneficial. Resources invested in expertise can save many times their value by helping the organization avoid bad decisions and investments.

Organizational issues are as important as technical ones, and the organizational design and implementation plan and process deserve as much attention as the technical design and process. The two plans should begin at the same time and proceed together. Most organizations concentrate on the technical plans and ignore the organizational issues until it is too late (Somers 1988–96).

Developing an Effective GIS Implementation and Management Strategy

Each organization's GIS management strategy is unique—or should be, in order to be successful. Because organizations have unique environments, characteristics, goals, GIS requirements and goals, and operations, they must develop their own GIS management strategies by drawing from the common GIS methodologies management components and fitting them to their own situations.

The first step in developing an effective GIS management strategy for an organization is to establish the strategic vision for GIS in the organization and define its role and scope. The result provides fairly clear guidance regarding the implementation approach and management strategies that will be most appropriate and effective and indicates the types of organizational issues that will be important. Although establishing a vision for GIS may be an obvious first step, a significant number of organizations either omit this step or perform it only superficially, often for similar reasons. Many organizations do not realize the importance of this step, consider it wasted time when they could be taking action, or do not know how to perform it effectively. Experience has shown, however, that time involved in specifying the role and scope of GIS in the organization is well spent and reduces problems, delays, and failures later in the implementation process.

Because GIS implementation and management must be goal driven in terms of the final operating environment desired, the goals should be very specific in operational terms. For example, a goal to "have the street network and demographic database and display software operational by December 1996" seems specific, but it is not descriptive enough to provide managerial and organizational guidance. A goal that describes which business units will be using the application, how their business processes will work with GIS incorporated, and how their results will be affected provides more information regarding managerial and organizational implications. These implications may include business process redesign, organizational changes, changes in management reporting and decision making, changes in employee evaluation and rewards standards, and many other related issues.

The second step in developing an effective GIS management strategy involves evaluating alternative approaches with respect to the specific role of GIS in the organization. The alternative organizational models presented earlier are generalized but provide for very different directions and implications in GIS implementation, operation, and management. They involve different levels of integration and therefore different levels and types of organizational impacts. They also set organizations on very different paths for future development and use of GIS. Once a basic approach is chosen, however, guidance becomes more specific.

Specific organizational and management strategies are derived from the GIS design and from the operational model that fits the role of GIS for the organization. The management plan should address the degree of centralized management of the GIS, placement of GIS management and support, involvement of users in GIS planning and implementation, coordination of users, organizational changes, preparation of users, personnel issues, transitions to GIS operations, integration into business operations, user support, data access, and integration of technology changes.

Several factors affect the development of an organizational model and appropriate management strategies, some of which include potential benefits of shared geographic data among a number of business operations, specific operational needs of business operations, cost-benefit trade-offs related to implementation alternatives, varied impacts on current business operations, and related organizational impacts. Particularly relevant issues include the following:

1. The organization's vision, goals, and strategic plan

2. The vision, goals, and role for GIS within the organization

3. The degree to which GIS data ("base data" and applications data) are to be shared among applications and users

4. The degree of autonomy of business units

5. The presence and use of related technologies and data, including desktop mapping, imaging, global positioning satellite technology, demographic and firmagraphic data and processing software, and data analysis software

6. The potential for business process reengineering and organizational change

7. Strategic and operational time frames for implementing GIS

8. Financial issues, including requirements for cost-benefit justification and return as well as levels and schedules of funding availability

These and other factors determine the direction and detail of GIS planning, and the GIS plan provides the information for the development of an organizational plan and management strategies.

Conclusion

There is still little research-based guidance on GIS management issues. Available books are limited to specific issues, such as an examination of traditional management theory relevant to GIS, discussion of the GIS planning process in generalized government settings, data sharing issues, and studies of GIS implementation in regional and local government settings. The most useful GIS management guidance today is still conveyed by those operating in the field. It is left to the reader or listener, however, to synthesize, relate, and apply available GIS management information to his or her organization. The primary principle in analyzing and using this available advice is organization context—the environment in which an organization's experiences occurred and the environment in which another organization is planning to use GIS.

The best approach to the development of GIS management strategies for an organization is to follow a top-down development approach, guided by three main factors:

1. The role and scope of GIS in the organization

2. The GIS organizational model that suits the role—enterprise, data and service, or business tool—and appreciation of the implications involved in the particular model

3. Information on specific managerial issues from the GIS field, evaluated in the context of the organization's goals, plans, and situation; basic strategies include the following:

    a. Developing an appropriate GIS implementation process

    b. Establishing the strategic vision and role of GIS

    c. Performing an organizational risk assessment

    d. Coordinating participants

    e. Effectively managing the GIS committee and team environment

    f. Providing appropriate communication and information

    g. Ensuring necessary leadership and champion-level support

    h. Developing an effective model and procedure for management and control of the GIS

    i. Establishing appropriate personnel policies

    j. Managing the data access environment

    k. Strategic timing

    l. Effective methods for integrating GIS into the organization's operations

Developed on these basic principles, each organization's GIS approach will be unique. There is no single key to the successful incorporation of GIS. Many factors come into play and must all be accounted for. Although no single factor can ensure GIS success, the absence of any one could cause failure. All management and integration aspects must be overseen simultaneously, and the GIS management strategy for each organization must take into account its own unique combination of these factors.

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