GIS Development Process: A Framework for Considering the Initiation, Acquisition, and Incorporation of GIS Technology

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Abstract: *This paper proposes a framework for considering a broad array of critical issues associated with GIS technology-transfer that have typically been treated in isolation. The framework relates the process of GIS implementation (and organizational-content issues that affect that process) to three GIS technology-transfer stages and establishes equal status for technical and non-technical barriers to GIS implementation. The suggested* GIS Development Process *is iterative and non-linear. It is composed of five "issues-of-interest" or phases (participation, context evaluation, vision creation, change, and technical implementation) and moves through three "points-in-time" or stages (initiation, acquisition, and incorporation). The tasks proposed in each phase can be repeated as often as necessary during each stage to ensure achievement of established goals, and may be addressed concurrently or in any appropriate order. The process presents a* **facilitative** *rather than a directive approach, and carries the technology transfer effort beyond establishing an automated system to supporting its* **acceptance and use** *by people outside the original implementation team.*

Many commonly accepted GIS technology-transfer strategies acknowledge the importance of not only hardware, software, data and procedures, but also the significant role played by people. When GIS technology was originally introduced, mastery of the technical components was an understandable preoccupation (hardware, software, standards, data, etc.). As hardware and software became more accessible and sophisticated, GIS advocates began understanding the complexity of automating geographic information systems, realizing that success was not necessarily guaranteed by a perfect, technical tool. This awareness stimulated the shift from an overwhelmingly technical preoccupation to a more balanced approach which incorporates non-technical or "people" issues as well. These non-technical issues have been labeled: organizational and human dimensions, institutional barriers, political climate, interpersonal dynamics, corporate culture, human factors, and resistance to change (Kanter 1983; Somers 1989; Anderson 1991; Campbell 1992; and Medyckyj-Scott and Hearnshaw 1993). The problem addressed by this paper is the absence of a comprehensive methodology or framework for addressing both the technical and "non-technical" issues affecting GIS implementation.

This author presents a framework structured to accommodate and relate the many sound implementation strategies (technical and organizational) offered to date, and to incorporate the issues (system acceptance and use) facing the implementors of a new GIS. Traditionally, implementation strategies have, as Webster's dictionary defines the verb, "[provided] the means for the carrying out of [plans]." The practice of "putting **plans** into action" characterizes the approach taken under traditional implementation strategies. Pushing the "conceptual envelope" of this accepted term (implementation) too far, may result in obscuring its original meaning and failing to clearly convey new ideas.

In order to expand the existing implementation framework to a point where it can encompass a more inclusive array of issues than have been addressed by traditional strategies, the terms **develop** and **process** are combined to name the new model, a GIS Development Process. The term, develop, is used to convey the idea of "causing to unfold or evolve gradually" and, process, to suggest a "continuing development involving many changes." The framework establishes equal status for

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technical and non-technical barriers to GIS implementation, suggests a facilitative rather than a directive approach, and carries the effort beyond acquiring the technology to supporting its acceptance and use by people outside the original implementation team.

Models Provide a Foundation for the GIS Development Process

Avoidance of the "organizational and human dimensions" (Campbell 1994) of technology transfer and innovation/adoption creates critical barriers to successful GIS implementation. The inclusion of non-technical issues shifts the focus from GIS technology transfer and computer-system installation *projects* to a *process* involving people doing their work. The core institutional issues defining this process (people, organizations, goals, change and technology) are identified and treated by authors reviewed in this article with varying degrees of frequency and effectiveness in the technology-transfer methods discussed below.

Some of the variance among the implementation methods can be attributed to the approach used. Describing an investigative approach employed to study GIS adoption success, Onsrud and Pinto (1991) identified two models: a content model and a process model. The *content model*, defined in terms of organizational or institutional factors that constrain or facilitate GIS implementation, addresses the non-technical issues of communication channels, information sharing, corporate culture, etc. The *process model*, in turn, lists key steps in the implementation process and focuses on the technical and managerial tasks of identifying user needs, preparing a formal proposal, conducting a pilot project, and purchasing the system. Some of the technology-transfer methods discussed below identify critical success factors (content), while others list steps in the geographic information/automation project or define a "pathway" (process) for introducing GIS. The goal of the two models—successful GIS implementation—is the same, but the route taken differs, resulting in an emphasis on different core issues.

Another explanation for such disparate treatment of core institutional issues is suggested by Obermeyer and Pinto (1994), who describe two discrete stages in the implementation process. They identify *initiation* (concept introduction) and *acquisition* (design and geographic information/automation) as distinct stages. The objectives of the two stages are different, thus creating a unique focus for each effort, and consequently emphasizing a different set of issues.

A third stage is identified by Campbell (1992), *incorporation*, suggesting yet another objective (acceptance and use of the technology) for GIS implementation. As a goal, acceptance and use of GIS technology moves the ultimate vision for GIS implementation in local government beyond automating geographic information systems to a future state: using GIS technology for the daily tasks and decision-making required by governing mandates (Jaffray 1993, Mead and Johnson 1994, Ventura 1994). All operational GIS installations must move into this third stage if the promises of GIS technology are to be realized. The transition from acquisition to incorporation is proving to be an unexpectedly challenging process for local governments.

The models discussed above address many "pieces" of valuable information about GIS implementation. One constraint to using this information is the absence of a framework within which to relate the content and process models to each other or to the three distinct stages of GIS implementation. Experienced GIS implementors recognize and use the information offered by these authors, but new enthusiasts may overlook valuable strategies when technology-transfer guidelines are incomplete or not clearly delineated. This paper incorporates the content- and process-model themes identified by Onsrud and Pinto (1991), and the stages described by Campbell (1992) and Obermeyer and Pinto (1994), into a new framework for guiding GIS implementation: a *GIS Development Process*. This process is intended to provide a framework for considering a broad array of critical issues that have typically been treated in isolation.

The paper opens with a discussion of GIS literature which has presented information about non-technical issues affecting GIS-implementation efforts. The next section surveys GIS technology-transfer methods offered in the literature and evaluates their treatment of GIS-implementation stages (initiation, acquisition, and incorporation) and associated core issues (people, organizations, goals, change, and technology). Finally, the author proposes a method for GIS technology transfer. The tasks defined by the GIS Development Process can be repeated as often as necessary to ensure successful achievement of established goals, and may be addressed concurrently or in any appropriate order.

A Balanced View of GIS Implementation

GIS literature increasingly acknowledges the complexity of GIS implementation efforts in terms of critical organizational issues that influence successful incorporation.

> *It appears likely that for many organizations successful GIS implementation may well be extremely difficult unless far greater consideration is given to the organizational and human dimensions of implementation.*
>
> (Campbell 1994, p. 322)

Individuals involved in early efforts to introduce GIS technology to their organizations were concerned pri-

marily with the technical dimensions of hardware and software, as well as data collection, accuracy and management (Burrough 1989, Star and Estes 1990, Antenucci *et al.* 1991). This technical 'starting line' influenced individuals who refined the technology. The focus of their work, and therefore the terminology used to discuss it, adopted a technical bias; most notably the process of introducing automated systems. The work associated with the transfer of GIS skills and automating geographically referenced information systems was labeled *implementation*. This term and the associated concepts continue to influence discussion today.

As the technology became more sophisticated, expectations for its success increased. When these expectations were not realized, GIS advocates began to search for non-technical barriers to GIS implementation (Saarinen 1987; Brown and Friedley 1988; Foley 1988; Brussaard 1989; Peitz, Cihon, Nyerges 1989; Somers 1989; and Campbell 1992).

GIS Advocates Address Technology Implementation Concerns

Following the purchase of GIS software and the acquisition or automation of databases, many organizations seemed less than satisfied with the results (Croswell 1989). The feasibility studies and user-needs analyses indicated a great deal of interest and potential for the use of automated geographic data, but the resulting system implementation was often less successful than anticipated. Financial support from participating departments was difficult to obtain, or in some cases withdrawn from the project. Consensus on a standard software package was difficult to reach (Canavan 1993).

Numerous authors have identified institutional or organizational issues as critical dimensions of the GIS technology-transfer effort (Anderson and Preecs 1989; Levinsohn 1989; Campbell 1994; Parr 1994; and Pinto and Azad 1994). GIS literature reviewed below suggests five issues critical to the effort: people, organizations, goals, change, and technology (Table 1).

People

Intuitively, we recognize that people are the basic elements of organizations. Whenever observations are made about an organization, they reflect the behavior and values of the people who form it. This can be seen in the guidelines skillfully drawn by Brown and Friedley (1988) to assess "organizational preparedness" for GIS implementation. They carefully and honestly portray the critical importance of organizational structure, rules and history. Once again the influence of organizational issues comes through as Campbell (1994) and Ventura (1994) review GIS technology adoption and use. Campbell identifies critical areas for concern as: people, the organization, and its ability to change. She also places strong emphasis on extensive involvement by many levels of participants in several aspects of the implementation process. Ventura more specifically targets institutional and organizational factors which influence possibilities for successful GIS technology-transfer and its truly "beneficial use."

TABLE 1. Issues Affecting GIS Implementation. (Surveyed authors' emphasis on core issues which present barriers to GIS implementation.)

Authors	People	Organization	Goals	Change	Technology
Evans (1987)	X	X			
Brown and Friedley (1988)	X	X		I	I
Foley(1988)	X	I		X	I
Croswell (1989)	X	X	I	I	
Somers (1989)	I	I		X	
Star and Estes (1990)				I	X
Huxhold (1991)	I	I	I	I	X
Marx and Newman (1991)	X	I	I	I	I
Korte (1992)	X	X	X		I
Onsrud and Pinto (1993)	X	X			
Queen and Blinn (1993)	I	I		I	X
Campbell (1994)	X	X		X	
Ventura (1994)	I	X		I	

X Issue thoroughly addressed I Issue identified

Organizations

During an investigation of GIS adoption success, Onsrud and Pinto (1993) examine the interpersonal and institutional variables which affect GIS acquisition decisions. Their research explores the relationships among the organizational or "content" factors affecting GIS implementation success and the steps of technology acquisition or the "process" itself. Korte (1992) similarly acknowledges the importance of people and the institutional structure when he recognizes ". . . management, operational, and organizational problems . . . must be solved *before* the GIS can reach its full potential" (p. 98). Finally, Evans (1987) offers specific guidelines for system analysis and design, addressing the organizational placement of data processing and user involvement.

Goals

Korte (1992) also relates the failure to define goals (direction and purpose for the GIS project) directly to success or failure of the technology-transfer effort. Applications were offered as a focus for GIS projects by Huxhold (1991), and again by Marx and Newman (1991), without the specific definition of project goals. Few authors acknowledge the importance of facilitating the creation of goals as benchmarks and guidelines for GIS implementation.

Change

The necessity for change is addressed by Somers (1989) when she states ". . . [an] underlying concept [for successful GIS implementation] is that planned organizational change must be incorporated into the GIS development process" (p. 50). Similarly, Foley (1988) identifies "failure to anticipate work pattern changes" and the absence of organizational flexibility as sources of GIS automation problems. Technology transfer unavoidably stimulates change in the way tasks are performed. As GIS implementation experiences are examined, the impact of changes caused by technology-transfer activities is more frequently recognized and addressed.

Technology

Queen and Blinn (1993) offer a brief introduction to GIS, presenting both the components and functions of the technology, and suggesting a planning model for GIS implementation. While their focus is primarily technical, the authors suggest an expanded role for users, identifying a few of the "adjustments" an organization must make to support GIS technology transfer. The introduction to GIS offered by Star and Estes (1990) also reflects a predominantly technical approach. The technical focus is illustrated by a description of five essential GIS elements, beginning with data acquisition and ending with product generation. No people or institutional issues are mentioned. Huxhold (1991) provides a comprehensive, technical foundation for introducing GIS to local government. Practical examples support the technical concepts, while at the same time identifying the importance of people and the organizational setting to GIS implementation success.

The critical importance of non-technical issues is a persistent theme in the work reviewed above. Surveyed authors have identified one or more of the core issues related to GIS implementation and offered suggestions for managing the influence of these issues. Table 1 reveals that the surveyed works have emphasized the influence of people and organizational issues on the technology-transfer effort to a greater degree than either change issues or the technology itself. Only Korte (1992) has specifically addressed the core issue of establishing a GIS vision (goals for the new system) for guiding the transfer effort. While the above noted authors have identified and proposed solutions to *specific* non-technical barriers (core issues) to GIS implementation (see Table 1), the authors reviewed below propose implementation *strategies* which address the same core issues (see Table 2).

The following section presents GIS implementation strategies identifying both the core issues emphasized and the stage (Initiation, Acquisition, and Incorporation) addressed, in order to illustrate the breadth of issues which define the GIS technology-transfer effort. Authors who have suggested technology-transfer methods (Table 2) also acknowledge the complexity associated with non-technical dimensions of GIS implementation and continue to discuss the 'core' issues identified by authors reviewed earlier (Table 1). The emphasis placed on specific issues by the author(s) of each implementation method is reflected in Table 2, and varies depending upon the stage (Initiation, Acquisition, Incorporation) addressed by the method offered. As Table 2 shows, most of the authors who propose implementation methods identify all five core issues as relevant to the effort, and give increased attention to the core issues of goals and change.

GIS Implementation Methods Reviewed

GIS advocates are elucidating the complexity of GIS implementation in terms of the core issues identified above and offering methods to address them. The implementation methods reviewed below could be presented in several ways. One classification method would categorize them as content or process approaches to GIS technology transfer. Second, they could be categorized by their treatment of core implementation issues: people, organizations, goals, change, technology. A third classi-

TABLE 2. Issues Addressed by GIS Implementation Methods.

Authors	People	Organization	Goals	Change	Technology
Ezigbalike *et al.* (1988)	I	X	X	X	
Aronoff (1989)	I	I	I	I	X
Levinsohn (1989)	X	X	I	X	
Antennuci *et al.* (1991)		I	I	X	X
Gilman and Keenan (eds) (1991)	X	X	X	X	X
Marble and Wilcox (1991)	X	I	X	I	X
Peuquet and Bacastow (1991)	X	I	I	X	X
Ventura (1991)	X	X	X	X	X
Crane *et al.* (1992)	I	I	I	I	X
Brown and Moyer (eds) (1994)	X	X	I	X	X
Mead and Johnston (1994)	X	I		X	
Obermeyer and Pinto (1994)	X	X	I	X	I
Pinto and Azad (1994)	X	X		X	I
Huxhold and Levinsohn (1995)	X	X	X	X	X

X Issue thoroughly addressed I Issue identified

fication might identify the stage (Initiation, Acquisition, or Incorporation) emphasized by the author(s) which reflects the objective of their efforts.

It seems most useful in this paper to discuss the GIS implementation methods in terms of the stage or stages that appear to be of primary concern to the author(s) based upon stated or implied goals (Table 3). For example, if the method's immediate objective is to introduce GIS concepts to members of the organization and acquire funding (initiation), then technology and potential users are emphasized. If project funding has been approved, the primary goals become analysis, design, and installation of the technology (acquisition). Under this focus the organization's mission, existing functions or structure, and the technology itself are primary concerns. When implementation of the technology is underway, attention shifts from operating the system to gaining acceptance by users outside the core implementation group and ensuring continued support for the system (incorporation). Once again, people and

TABLE 3. Stages Addressed by GIS Implementation Methods Reviewed.

Authors	I Initiation	II Acquisition	III Incorporation
Ezigbalike *et al.* (1988)		X	
Aronoff (1989)	I	X	I
Levinsohn (1989)		X	
Antennuci *et al.* (1991)		X	I
Gilman and Keenan (eds) (1991)		X	
Marble and Wilcox (1991)		X	
Peuquet and Bacastow (1991)		I	X
Ventura (1991)	X	X	I
Crane *et al.* (1992)	X	X	
Brown and Moyer (eds) (1994)	X	X	I
Mead and Johnston (1994)			X
Obermeyer and Pinto (1994)			X
Pinto and Azad (1994)	I	I	
Huxhold and Levinsohn (1995)		X	I

X Stage thoroughly addressed I Stage identified

their attitudes are of primary importance. Although successful GIS technology transfer necessitates attention to all three stages, Table 3 shows that, with few exceptions, the primary focus of the methods reviewed is the Acquisition stage.

Stage I: Initiation—GIS Concept Introduction and Funding Commitment

When individuals in an organization learn about GIS technology, a series of events can be anticipated. The people involved begin to read material about GIS, to attend workshops, visit organizations where GIS has been implemented, and to discuss the possibility of applying the technology to their work. The Initiation stage has begun. The objectives of this first stage of GIS implementation are to learn about the technology, explore the appropriateness of GIS for their organization, and to gain official sanction for the next stage: Acquisition. The core issues emphasized during the Initiation stage are people, the organization, and the technology. Under specific consideration during the preliminary exploration will be the possibility of financial and management support. GIS advocates will distribute information about the technology and "test the water" for interest and resource commitment.

Three methods addressing initiation

- *The Multipurpose Land Information* (MPLIS) *Guidebook* (Brown and Moyer (eds.) 1994 and Ventura 1991) contribute to the creation of solid foundations for the Initiation stage. The Guidebook provides all the information and references needed to support both the successful initiation and acquisition of GIS technology. Unfortunately, the breadth and depth of information contained in this work can overwhelm readers, obscuring any basic method that might be employed to guide GIS implementation.
- Ventura (1991) provides both conceptual information about the technology and techniques to "sell the GIS vision," offering a comprehensive approach to land information system (LIS) initiation in local government. He also identifies organizational barriers and offers a detailed, technical "pathway" for LIS acquisition. Ventura additionally addresses the crucial nature of user participation and institutional influences on the implementation effort, providing a solid foundation for successful incorporation. Both content- and process-model approaches are used to convey the complexity of GIS technology transfer. The absence of a conceptual structure clearly conveying the iterative nature of the implementation process is the only weakness attributable to the LIS implementation guide.
- The influence of interpersonal and institutional variables on GIS implementation is confronted by Pinto and Azad (1994) as they address the political aspects of the Initiation and Acquisition stages. The authors identify political aspects of implementation as organizational political behavior (OPB) and offer suggestions for proactive management strategies. Pinto and Azad use case studies to illustrate the influence of OPB in two situations. A "multi-track cognitive-device" for the classification of case-study implementation events is proposed suggesting the occurrence of events both as sequential steps and concurrent or parallel activities. The principle focus of the paper reveals the central role of political behavior in successful GIS implementation. The paper also suggests a flexible implementation method based on activity tracks and decision points. Even though goals for the GIS technology-transfer effort are not specifically identified as a major decision point, the track implementation method offers categories or tracks that facilitate inclusion of other non-technical issues in the implementation effort.

The Initiation stage emphasizes technology, people, and the organization. Consideration of potential changes to the organization, and a preliminary exploration of goals for the use of GIS in the organization, represent additional dimensions of this stage. Not only the objectives (technology investigation and project funding) change during the next stage (Acquisition), but the people involved may change as well. Many of the first GIS advocates will fade from view when the skills required become more technical and enthusiasts are assigned to new projects, or when they experience frustration and burnout. While the three methods presented above have been chosen to illustrate this stage, most authors treat initiation in tandem with the second stage, Acquisition.

Stage II: Acquisition—GIS Needs Analysis, Design, and Implementation

The Acquisition stage begins when GIS advocates have confidence that financial and political support exist to establish a budget. A feasibility study or, more frequently, a user-needs analysis, generally performed by a consultant is the first funded activity. The objectives of the Acquisition stage of GIS implementation are to expand awareness of the benefits of GIS technology, increase support for the effort, acquire hardware and software, implement, and finally operate the system. Under consideration during the needs analysis and design steps of the Acquisition stage will be the possible base or location for the system, and establishment of formal funding mechanisms.

At this point in the technology-transfer process, the core issues emphasized are the organization, the technology, and future users. A more specific study of the organization's functions and goals, potential for change, and ability to support innovation must be also undertaken. The group of GIS enthusiasts will grow as new

applications and information about the technology spread through the organization. People will begin to comprehend and resist or thoughtfully consider the individual and organizational changes required to accommodate the new technology. The organization's ability to accommodate change plays an important role in determining the success of any innovation, including GIS technology (Somers 1989).

Seven methods targeting acquisition processes

- A framework for the technology-transfer process is offered by Aronoff (1989). Implementation is presented as a six-phase process:

  1. Creating awareness of GIS possibilities
  2. Developing system requirements
  3. Evaluating alternative systems
  4. Justifying and developing a technology-transfer plan
  5. Acquiring hardware and software
  6. Operating the system and maintaining political support

  Although the range of issues that Aronoff addresses is comprehensive, the information he provides in the areas of user participation and incorporation (acceptance and daily use) is limited.

- While the *GIS Guidelines for Assessors* (Crane *et al.* 1992) target a tax assessment subject area, and provide a comprehensible introduction to basic GIS concepts, the primary objectives are system planning and implementation. Crane *et al.* (1992) present a thorough introduction to GIS concepts and design, creating a solid foundation for the Initiation stage of GIS implementation, as well as addressing the purchase of GIS technology. The guidelines identify people as one important component of a GIS, and provide a defining set of principles that successful GIS projects have in common. The GIS guidelines identify all the core issues noted above; however, the authors emphasize technical concepts and system design (acquisition).

- A structured approach to GIS design is offered by Marble and Wilcox (1991) who draw heavily upon design techniques developed by software engineers. This design approach recognizes the influences of institutional constraints and the complex environments into which this new technology is being introduced. The authors target the importance of staff participation, defining requisite organizational changes, the methods used to introduce the technology, and acceptance of the solution from both a technical and social perspective. Unfortunately, the level of detail is much greater for the technical-process (acquisition) than the institutional-content section (initiation and incorporation) of this design method.

- An LIS implementation methodology is proposed by Ezigbalike *et al.* (1988) which begins with an analysis of the institutional environment and a review of organizational objectives to establish guidelines for the LIS project. The authors demonstrate a prototype to future users for review and input during the technology-transfer effort in order to maintain their interest in the project. This LIS implementation method follows the 'step' pattern of a process model, and identifies people and organizational issues, but focuses primarily on system design and modeling (acquisition).

- The design of LIS is given a strategic planning approach by Levinsohn (1989). People, the organization, and change provide the focus for his technology acquisition and design method. The critical importance of organizational flexibility is also identified by this well-developed approach when the author states ". . . some level of change to the information handling routines is necessary to bring about cost-effective implementation of LIS" (p. 37). The main elements of Levinsohn's approach to LIS acquisition are: situation assessment, identification of key players and issues, commitment to the process by all players, identification of alternatives, and consensus on action. The intent of this method (LIS design) limits consideration of issues to those within the Acquisition stage.

- Gilman and Keenan (eds.) (1991) offer a guide to GIS planning and implementation for local government which treats institutional and "people" issues thoroughly. The guide identifies three issue categories (policy, management, and technological) and lists critical success factors. Planning and system implementation are well delineated by the steps offered for "GIS planning and procurement." However, the authors underestimate the significance and complexity of the identified core issues and implementation activities. While the guide incorporates all significant core issues, the method described for GIS implementation is less than complete because little attention is paid the Initiation stage, and even less to the Incorporation stage.

- As suggested by the subtitle, *A Guide to the Technology*, Antenucci *et al.* (1991) offer a predominantly technical model for GIS implementation composed of five stages (Concept, Design, Development, Operation and Audit). The five stages are partitioned into 17 steps that subdivide the implementation process into logically related areas focusing primarily on technical concerns. The well-illustrated guide to GIS reflects the expertise of its authors and expands the technical discussion by presenting an application-focused design philosophy, acknowledging the need to anticipate and plan for change, and addressing the importance of gaining and maintaining project support. These issues are, however, generally discussed outside the framework of the implementation stages and steps.

The emphasis of the Acquisition stage, as discussed above, has traditionally been on GIS technology and the organization's existing structure and activities. System design, purchase, and operation have been the objectives of this stage. However, in order to support successful GIS incorporation, a thorough exploration of long- and short-term goals for the technology, and potential changes to the organization should be undertaken. Both the objectives and participants may change during the final stage, Incorporation. New GIS advocates are needed when knowledge about the agency and its operations are critical to acceptance and daily use of the technology.

Stage III: Incorporation— GIS Acceptance and Use

During the Incorporation stage, attention is refocused upon: potential users, functions and goals of the organization, and changes in work patterns and information flow required to facilitate acceptance and use of the new technology. Recognition of the importance of GIS acceptance and its integration into daily activities usually occurs when the technology is in place, the database is under development, and people are expected to begin using it. Perhaps the Initiation stage is a more appropriate time to begin creating a foundation for acceptance and use of the technology. If the GIS is implemented in isolation, or with limited participation, many potential users will have difficulty understanding how it can be used to support their work. Facilitating acceptance and creating patterns of reliance on GIS, thereby gaining continued support, will be much more effective if a foundation is begun early in the implementation process.

Four works emphasizing acceptance and use

- The diffusion method presented by Mead and Johnston (1994) effectively addresses the democratization of GIS technology for the U.S. Forest Service, and provides valuable suggestions for supporting the incorporation process following technology acquisition. Since this method addresses field-level diffusion of the technology (incorporation), the focus is on people and the information stored in the computer, with little attention on organizational issues.
- The incorporation of GIS technology is a major focus in the review of organizational and managerial aspects of implementing a GIS offered by Obermeyer and Pinto (1994). They acknowledge the difficulty associated with gaining acceptance and use of these systems in the following terms: "A necessary part of the evolution of ever more complex information systems has been the introduction of these new systems into organizations to aid in their day-to-day operations" (p. 13). The authors focus on managerial roadblocks to the successful application of GIS technology and thoroughly present information critical for informed responses to the identified roadblocks. While Obermeyer and Pinto do not offer a complete GIS implementation methodology, due to the emphasis placed on incorporation, they do address several important topics "... identifying crucial social factors and processes in the adoption, implementation, and utilization of [GIS] technology" (p. 14).
- Peuquet and Bacastow (1991) emphasize 'prototyping' as a method for system design, when they address organizational issues and GIS incorporation for the U.S. Army. The strategy they propose "... allows the organization and the people in it to adapt and evolve in parallel with the other components [system design and implementation]" (p. 315). Using iterative prototyping the process begins with feasibility evaluation and identification of goals and objectives. In this situation, the Initiation stage had occurred and formal GIS acquisition was being addressed through normal channels by a "... series of formalized [linear] and discrete steps ... intended to produce an effective product at a reasonable price" (p. 309). This method also identifies critical "content" issues (the organization and its goals) while offering a "process" for GIS design and use. Critical information about organizational climate, however, is given only as background information.
- Finally, Huxhold and Levinsohn (1995) suggest successful incorporation begins with a strong strategic planning model as the foundation. Although the authors specifically target the Acquisition stage (system planning, design, implementation, and operation), assuming the reader's commitment to such a step, the foundation provided by their GIS paradigm also creates a high degree of certainty for GIS acceptance and use (incorporation). As a guide for the technology-transfer process Huxhold and Levinsohn offer a GIS implementation framework with four elements:

  1. GIS paradigm
  2. GIS data-management
  3. GIS technology
  4. Organizational structure

  First, the GIS paradigm element recognizes that decisions about any element affect the other elements, and acknowledges the iterative process of system design and implementation. Second, the GIS data-management element describes geographic data collection, representation, and management. Third, the GIS technology element guides technological decisions required to handle data for selected business functions. Finally, the organizational structure element identifies institutional actions required to achieve successful system implementation. By addressing the important role and powerful impact of people, their goals for GIS, and potential changes within the organization, they have in fact encompassed key incorporation concerns in their GIS paradigm. Although the primary objective of this method is GIS acquisition, the authors treat all the core issues so comprehensively they lay the groundwork for successful incorporation.

The authors discussed in this section have contributed many 'pieces' of valuable information about GIS implementation. A major barrier to using the information offered is the absence of a complete picture or framework within which to relate the concepts or pieces of information one to another or to the three distinct stages of GIS implementation. Veterans of GIS implementation actions recognize and employ individual pieces of the GIS puzzle offered by these authors, but new participants can miss the big picture when pieces are missing or not clearly identified. The GIS development method proposed below includes all the identified pieces and offers a framework for their consideration.

GIS Development Process

Introducing . . . GIS [tools] into an established organization is a process, which necessarily includes evaluating and probably changing some organizational work patterns and attitudes. Any restructuring [of these patterns and attitudes] must be a clearly identified part of the GIS development process.

(Anderson and Preecs 1989, p. 396)

The final section of this paper offers a framework, the GIS development process, within which to organize the many 'puzzle' pieces offered to date about GIS technology-transfer activities. Five core issues (people, organizations, goals, change, technology) and three implementation stages (Initiation, Acquisition, and Incorporation) critical to the development process were identified above. The proposed framework incorporates the three implementation stages and represents the five core issues as phases: participation, context evaluation, vision creation, change, and technology implementation (Table 4).

Content-model issues (people, the organization, goals, resistance and adaptation to change) are addressed in the participation, context evaluation, vision creation and change phases. *Process-model* activities (user-needs assessment, RFP preparation, technology installation, pilot projects, etc.) are undertaken during context evaluation and technology implementation phases. During the technology implementation phase, formal agreements and budgets are drafted, software is installed, the landbase is developed, applications are created, and the technology is accepted and used for daily tasks. As Figure 1 suggests, the first four phases of the process affect each other, while all four phases influence technical implementation.

This development process is iterative and non-linear. The phases of the process are repeated as often as necessary in each stage to ensure successful achievement of established goals and may be addressed concurrently or in any appropriate order. For example, as GIS enthusi-

FIGURE 1. Phases of the GIS Development Process and how they interrelate.

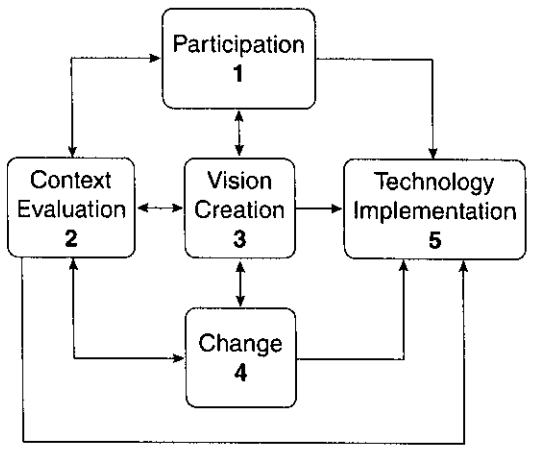


TABLE 4 GIS Development-Process Matrix.

	Stage		
Phase	**I Initiation**	**II Acquisition**	**III Incorporation**
1 Participation (People)	Educate champions Form Ad Hoc discussion groups	Involve managers and users Formalize committees	Identify future users Create informal user groups and Ad Hoc task forces
2 Context Evaluation (Organization)	Informal Apply Evolution Matrix	Formal Circulate Surveys Begin GIS Analysis	Informal Continuous
3 Vision Creation (Goals)	Informal Educational	Formal Workshops Publish GIS vision, GIS Design	Informal/Formal Focus Groups
4 Change (Change)	Informal Facilitate new partnerships and new ideas	Formal Redefine roles and work flow Evaluate change feasibility Evaluate the GIS vision	Formal/Informal Continuous
5 Technology Implementation (Technology)	Formal Agreements Budgets	Formal Proposals Pilot Projects System purchase and installation Data conversion	Continuous GIS used daily

asts learn more about the technology and observe the reactions of co-workers and managers, the goals for GIS technology (vision) may change, triggering another iteration of the development phases to assess the new context and refine the GIS vision.

As the development-process phases move through the Initiation, Acquisition, and Incorporation stages, each of the five phases (participation, context evaluation, vision creation, change, technology implementation) are addressed in each of the three stages (Table 4). The emphasis placed on each development phase (issue-of-interest) changes appropriately as the process moves through each stage (point-in-time). Samples of players, products, and phase activities for each stage are suggested by Table 4. This iterative development-process can be thought of as the phases of the moon moving through the seasonal stages of the year. The first development-process phase iterations address the Initiation stage, emphasizing education of the participants and the procurement of financial and political support. The next iterations address the Acquisition stage and emphasize the technology while GIS advocates work with future users and evaluate the context in which they work. Subsequent phase iterations address the Incorporation stage, once again emphasizing system users and their adjustment to the new technology. Although each stage has a unique emphasis, they all require consideration of the range of issues represented by the five phases.

Participation

As the first phase, participation is delineated by the author to be both a separate phase of the development process and a critical element of each of the subsequent phases (Anderson 1991). In the treatment of this phase, reference will be made to the necessary components for successful participation: leadership, education, and communication. User participation as employed here refers to the initial step of bringing GIS into any organization, and as a key element in all subsequent phases of the development process: context evaluation, vision creation, change, and technology implementation.

Context Evaluation

This phase of GIS development consists of an assessment of organizational preparedness (Brown and Friedley 1988). This phase examines the existing level of automation and potential organizational flexibility with regard to the introduction of change. It also examines the degree of work group autonomy and the ability to work laterally within the bureaucratic structure.

Vision Creation

The context evaluation phase is followed by the consensual creation of a plan or vision for the agency GIS (Levinsohn 1989). During the vision creation phase, GIS advocates facilitate the development of a vision which can be supported by participating individuals and agencies. Finally, the group should develop a set of "success factors" (benchmarks) to be used as guidelines for the process, measures for determining project progress, and goals for the evaluation of GIS development success.

Change

The change phase addresses both the agency's vision of GIS and the context of the proposed system. This phase must *realistically* assess any organizational changes required for successful development of the proposed vision (Somers 1989). If the GIS vision requires more organizational change than the advocates are willing to promote, the vision should be adjusted accordingly.

Technology Implementation

The final phase, technology implementation, is the action or *tactical* phase, while the first four are primarily planning activities or *strategy* phases (Obermeyer and Pinto 1994). The information gathered and strategy established in the first four phases influence the tactics of the technology implementation phase.

Phase 1—Participation: Getting People More Than Involved

> *Participants in a strategic design process must be consulted at all stages of activity from defining the process, to resolving institutional issues and designing system applications. Effective participation requires a structured process and that all participants understand and commit to the process. Participation builds commitment. Commitment is required to facilitate change. And some level of change to the information handling routines is necessary to bring about cost-effective implementation of LIS.*
>
> (Levinsohn 1989, p. 37)

People are a very important part of any organization. Therefore, anything that affects them can have a profound effect on the activities of the organization. The mixed reactions people have to automating the work around them will affect their attitude toward the development of a GIS. In addition, the dynamic, complex nature of GIS will require an alternative to the limited user-involvement (user-needs analyses) of traditional information-system analysis and design.

User participation, as discussed here, involves the active exchange of ideas among several layers of users (elected officials, managers, technicians, clerks) and other affected groups (the public and utilities) in a variety of ways and in many situations (training, interviews, brainstorming workshops, newsletter publication, GIS demonstrations). While such extensive participation is a component of all phases of the GIS Development

Process treated in this paper, it is introduced here as Phase One. This phase consists of an identification of numerous participants who will play a variety of roles in the process and a discussion of three other fundamental components of successful participation: leadership, education, and communication. Without appropriate leadership, which recognizes the importance of the user input, an environment will not be created to encourage user involvement. If the group has disparate levels of knowledge about GIS concepts and technology, many will be reluctant to contribute (Wingrove 1989). And if the group lacks the appropriate skills (listening *and* speaking) little effective communication will occur.

The changing work force also affects the way we act in the workplace. We can no longer assume that project participants will be a homogeneous group of people who will automatically do what they are told. People are expecting an increasingly participatory role in the workplace and in the definition and design of their work (Spencer 1989). Involving people in decision-making that affects their work is becoming recognized as a highly motivational activity. People involved with GIS development recognize the changing roles to be played by managers and technical users (Anderson and Preecs 1989; Marble and Wilcox 1991; Peuquet and Bacastow 1991).

Few manual GIS activities have been documented with the formal rules which govern activities such as accounting or payroll. Under these circumstances, system implementation becomes an extraordinarily creative process calling upon the imagination and energy of potential users to visualize new ways of doing their work. This creative aspect of GIS implementation makes it imperative that many people become involved in the development of applications and the introduction of new routines in their workplace. These potential users will need to learn about GIS concepts in order to creatively assist system designers with the application of GIS technology to their work.

This level of participation, beginning in the Initiation stage and continuing through Acquisition, will provide a strong foundation for system acceptance and use, the objective of the final stage, Incorporation. Participation is the cornerstone of this development process. The activities discussed above, leadership, education, and communication do not occur in a vacuum. They are, in fact, very much influenced by the environment in which they occur. The context evaluation phase considers some of the aspects of the environment into which the GIS will be introduced.

Phase 2—Context Evaluation: What are the Rules and Norms of the Workplace?

> *One of the most significant findings of the research [about GIS effectiveness in Great Britain] concerns the impact of the inherent characteristics of organizational cultures on the ability of the environments studied to sustain the development of innovations such as GIS.*
>
> (Campbell 1994, p. 321)

The GIS Development Process is iterative and non-linear, with the development phases influencing each other. The process could as easily begin with the formulation of a vision for GIS as with participation or the definition of organizational context. Indeed, vision creation begins during the initial exploration of GIS technology and associated evaluation of its probable acceptance in a specific context (Initiation). People begin to imagine different applications for the new technology. However, since we all know something about the place we work, it seems logical to continue the development process by describing the work environment or potential context into which GIS will be introduced.

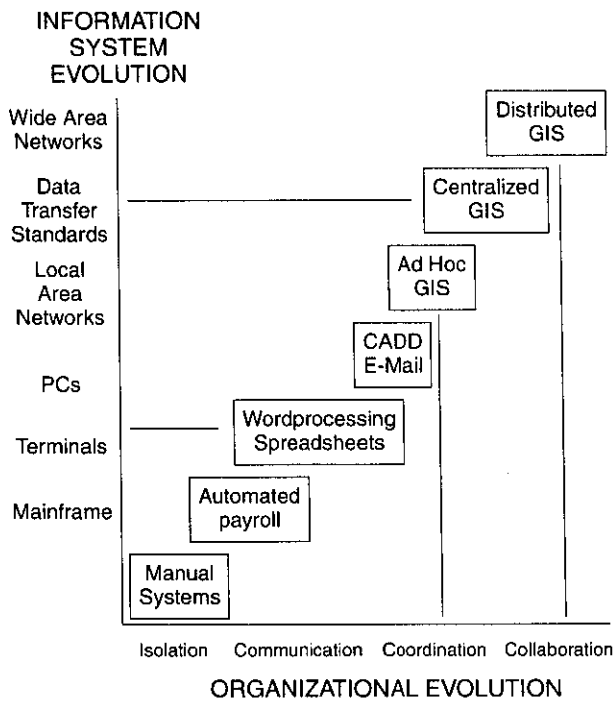
The context evaluation phase, calls attention to the critical nature of communication patterns and personal relationships in the work place. The context sets the tone for all activity in the workplace and must be understood in order to successfully introduce new activities or concepts (GIS). Some of the problems associated with GIS development are the product of segmented organizational structures (Kanter 1983) which restrict communication between users in various departments. For example, independent units of government, each guided by a specific mandate (planning, taxation, engineering, public safety, etc.), have developed in relative isolation due to budget, legal, and leadership factors.

The acceptable level of participation, in the context of concern, will control the GIS vision creation activity. The acceptable level of participation is one of the potential subjects for the change phase of the development process. Also, the technology-implementation activity is surrounded by the context and totally dependent upon it for all necessary resources. The context of any activity has an impact on the outcome.

In order to develop plans for the introduction of GIS technology into an organization, it is wise to understand the organizational context which will affect the new system and into which the system will be placed. During the course of informal interactions the first step of context evaluation, attitude assessment, has begun (Brown and Friedley 1988). As the education and exploration activities move along, and some level of support for incorporating GIS technology into the organization begins to appear, discussions about the future occur and additional information on attitudes begins to surface (Initiation stage).

The cultural audit, another context evaluation tool (Sankar 1988), is critical for success of the Acquisition and Incorporation stages. This audit can reveal the level of support and opposition to the initial vision of GIS for the organization, and reveal many potential barriers to

FIGURE 2. **A GIS Evolution Matrix suggests levels of information system expertise and organizational sophistication required for successful GIS Development.**



acceptance and use of the technology (incorporation). The attitude assessment evaluates instances of behavior by individuals, while the cultural audit explains some of the behavior. The cultural audit attempts to identify organizational policy that defines the level of cooperation which occurs both within a department, and between one department and others. The audit also seeks out any policies (management's attitude) which may control the level of automation in the department. These "attitudes" heavily influence the fate of the GIS development effort.

The GIS evolution matrix (adapted from Saarinen 1987) allows a preliminary appraisal of GIS development potential by drawing attention to the level of information system expertise and organizational sophistication needed for successful GIS development (Figure 2). The matrix illustrates a range of information system expertise from main frame to networked systems. It also indicates a continuum of organizational development from isolated (segmented and independent) to collaborative. For example, the matrix suggests that if coordinated ventures are evident in an organization, *ad hoc* GIS success would be likely when data sharing is made possible by "sneaker net" or a local area network (LAN).

During the Acquisition stage, a formal mechanism for gathering additional information may be employed. Sieber (1991) suggests the circulation of a survey to all informed decision-makers and participating managers to gauge levels of GIS-technology awareness and development-process understanding. This survey can address feelings about automation and cooperation, as well as identify other potential obstacles to the development process.

Context evaluation is an on-going process. Organizations implementing GIS will repeat it through several iterations of the phases in all three development-process stages. The evaluation will also help identify the sometimes elusive levels of commitment to GIS technology and the changeability of the organization. Dreams for new GIS applications may also surface as people learn more about GIS. These dreams become the starting point for formal, GIS vision creation. Questions about possible applications should be recorded and brought forth in phase 3, vision creation.

Phase 3—Vision Creation: Formulating Images of the Future GIS.

> *A strategic vision defines the general direction and ambitions for GIS development. The vision should be defined in terms that are meaningful to the organization, using what was determined during the situational analysis as the basis for the vision statement. There are two reasons for developing a strategic vision for the GIS implementation: (1) to build commitment for the GIS and (2) to align the direction of GIS implementation with other aspects of the organization.*
>
> (Huxhold and Levinsohn 1995, p. 65)

Action often begins with the image or vision of a desired state, usually different than the current condition. During the Initiation stage, the GIS vision (held by early GIS-technology investigators) is commonly a "wish-book" of vague ideas stimulating conversation and investigation. The GIS vision-creation process expands general awareness and refines the GIS advocates' dreams. During the Acquisition stage the vision should be formalized and incorporated into a strategic plan. The vision then becomes a distillation of the strategic plan for GIS in the organization, a mission statement. It is the starting point for the GIS Development Process and then becomes a goal for the process.

If more than one individual is to be involved in any activity, the desired state must be described to the uninitiated. As many GIS enthusiasts have found, this can be a challenging task. Whenever an activity (GIS development) is so complex that the efforts and special skills of more than one person are involved, the activities become segmented and it is easy to lose sight of the purpose for the effort. This effect is exacerbated when a

group of people from different professions (e.g., planners, engineers and assessors) share these tasks.

This problem is further complicated by the legal mandates guiding local government departments in which these professionals work. The consensual creation of a GIS vision statement can mitigate some of the negative affects of this division of labor (segregation of professional disciplines, inadequate patterns of communication, etc.). The various work groups will have helped create the GIS vision statement and this vision will become a reminder of the consensual process and the desired goal. The process not only establishes a pattern to guide system implementation, but can create a bond of common understanding among the disparate participants (Senge 1991).

The vision creation phase begins during the Initiation stage with conceptual GIS education and uses a workshop method to facilitate and formalize the vision creation process during the Acquisition stage. Given the dynamic nature of the development process the vision will undoubtedly change again during the Incorporation stage when even more participants and their applications become involved with the effort.

Vision creation is *not* a peripheral undertaking; it is central to the GIS Development Process. The critical nature of a vision, and the process which leads to its refinement, cannot be overstated. The GIS Development Process is a journey *requiring* a destination (the vision) and an itinerary (the strategic plan). Vision creation has been called the first step of the strategic plan (Curtice 1989) and is used in the development process to guide automated information-system implementation. The success of the Incorporation stage is largely dependent on the acceptance of a vision for GIS. The cooperation of all affected parties is required for successful GIS development (Dueker 1987). The participants must be informed and willingly accept new ideas and the consequent changes. This acceptance can be facilitated by the consensual creation of a GIS vision.

Vision creation is one product of participation in a specific context and is potentially affected by change in the context. The Vision creation phase of the development process begins with a *definition* of the GIS vision, and will result in a list of fundamental vision elements. Some of these elements are:

- the reason the effort is necessary,
- a list of participants,
- a timeline,
- a generalized definition of the GIS functions that the participating organizations will implement, and
- a statement about system architecture (technology), administration, and implementation.

The GIS vision may contain any other items that a specific organization finds significant.

Pieces of the vision can be found in most documents written by an agency about their GIS activities. Each organization will have a different vision of GIS based upon their activities and responsibilities. A GIS vision can be as basic as automated mapping, and perhaps include permit tracking, or as complex as a regional consortium of utilities and several levels of government. The complexity of the vision will be determined by organizational structure and culture as well as the organization's level of automation sophistication (see Figure 2). The wide range of potential GIS functions and configurations available, as well as the participants' particular culture, combine to create a unique vision for each organization.

The GIS vision, like the organization, is not static. As the players learn more about the technology and begin to understand how this new tool can be applied in their daily work, the original vision for GIS technology in their agency will change. The next phase, change, addresses this and other change-related issues (work patterns, departmental relations, communication channels, and new organizational structures).

Phase 4—Change: A GIS Development Process Involves Change

> *The GIS must fit the organization, but the organization must also make some adaptations in order to make effective use of the GIS.*
>
> (Somers 1989, p. 39)

GIS advocates hold a vision for their organization. They work within the larger context of the organization, and have an understanding of the rules and norms which define appropriate behavior and successful projects in both their departments and the agency or company as a whole. Throughout the evolution of the GIS vision, and activities surrounding efforts to move the development process forward, organizational constraints will be identified by GIS advocates, future users, and system developers. If GIS in local government is to be a cooperative project shared by independent departments (cost and complexity make this an appropriate approach) the interaction of many people in these departments will have to change (Cleveland 1985). This becomes a decision point for the group. The feasibility of the project must be determined. Obermeyer and Pinto (1994) contend "[t]he concept of implementation in the context of organizations may be viewed as a change phenomenon or a process for creating organizational change" (p. 14). Can the organization be modified enough to accommodate the vision or must the GIS vision be redefined to better fit the current climate (context) of the organization? Will both the vision and the organizational structure be flexible enough to accommodate the demands placed upon them by system-implementation activities?

The GIS Development Process identifies some of the organizational constraints placed upon the introduction of GIS technology in the context evaluation phase. The *incorporation* of IS technology by an organization is a process that continuously evolves, affecting many areas of the organization; it is not a project which has a predetermined conclusion (Kraemer *et al.* 1989). The development process moves on, in the change phase, to call for open acknowledgment of the relevant issues, identification of alternatives using group communication techniques (Spencer 1989), and commitment by the group to plan for organizational change and vision modification (Senge 1991). Among other issues to be incorporated in the evaluation, planning, and implementation of any change is the fact that organizations are not static—personnel change, laws change, funding is gained and lost.

Planning for and thinking about GIS must be long range (Huxhold and Levinsohn 1995), especially if the organization is moving from manual systems and segmented structures to automated systems and integrated structures. Information-technology adjustments also create a changing technical environment for data-processing or information-service departments. These factors create a dynamic environment (moving target) for the introduction of GIS technology. The author does not suggest that massive structural change nor radical change of the vision will be required in every organization in order to introduce GIS technology. However, GIS advocates must acknowledge contextual constraints, estimate the probability of modifying them, and reassess the GIS vision accordingly.

In summary, as much as we may want to believe it, nothing is static, the environment, personal relationships, workplace rules and space all change. Acknowledging this dynamic state of affairs and consciously guiding it is a challenge delivered to GIS advocates and other change agents (Kanter 1983). No one wants change thrust upon them without the opportunity to "see it coming" and perhaps influence some of the consequences. The participatory nature of the GIS Development Process recognizes these dynamics and enables people to influence many of the decisions which will eventually affect their work (Marx and Newman 1991). The incorporation of GIS by an organization demands a number of changes. Some of the changes required will be addressed in the next phase of the development process, technology implementation.

Phase 5—Technology Implementation: Applying Strategies and Taking Action

> *Implementing large Spatial Information Systems (SIS) [includes] very important problems like figuring out what users really want, adapting the technology to the organizational needs, and implementing new operational [and] administrative procedures.*
>
> (Bedard 1989, p. 43)

The introduction of information technology to any organization is a risky venture. The potential benefit of any computer system is tempered by the character (culture) of the organization itself, and the attitudes of the participants as discussed in the context evaluation and participation phases of this GIS Development Process. As Bedard (1989) suggests, the users must be consulted during the analysis and design activities, and new procedures must be developed to support both new information and new tasks. The finished product or information system will be patterned after the goals and dreams of the system designers' vision, modified by the ability of the organization to adapt to the new technology, and be limited by the availability of technical expertise to modify the technology appropriately for the organization. Budget constraints will obviously affect each of these considerations. Phases 1 through 4 of this GIS Development Process have identified several non-technical, system-implementation constraints and offered solutions to issues only superficially addressed by traditional GIS implementation strategies.

The technology implementation phase of this GIS Development Process draws heavily upon the first four phases to support the introduction of GIS technology with user participation, vision creation, and preparation for probable changes to the organization. The process also identifies some of the institutional nuances (context) surrounding system implementation that significantly affect its use and attempts to address them.

In particular, the process recognizes the comprehensive nature of injecting a complex information system into an established organization. Therefore, the management information systems (MIS) concept of structured system development (Curtice 1987) is offered as a core. This concept presents a technique for organizing the complex implementation activities associated with automating information systems and associated tasks. System analysis and design begin during the Acquisition stage using structured system-development methodologies. During this stage, strong emphasis is placed on technology and involving the people affected by the proposed GIS, as well as incorporating requisite organizational changes.

Several authors have presented thorough methodologies for the technical aspects of GIS implementation (Marble and Wilcox 1991; Ventura 1991; Brown and Moyer (eds.) 1994; Huxhold and Levinsohn 1995). The reader is referred to these comprehensive works for more specific information.

Conclusions

We must remember that first and foremost, an organization is a collection of people. The level of cooperation and participation by those people (users) will determine the level of GIS development success. The central theme of this GIS development method is a proactive approach to involving people (elected officials, managers, users, GIS technicians) affected by the process. The Development Process offered here relies on participants to address many institutional problems as they facilitate the incorporation of GIS technology by their organization.

Traditionally, GIS implementation activities have addressed system analysis and design; the purchase, installation, and operation of hardware and software; and database creation for a GIS project. The GIS Development Process proposed here encompasses the technical, system-implementation activities of the Acquisition stage noted above; the formalization of project partnerships during the Initiation stage; and the facilitation of GIS acceptance and use during the Incorporation stage. The GIS Development Process provides a comprehensive framework for considering technical, organizational, and human dimensions that determine success in a GIS development effort. Unless GIS advocates acknowledge and address these dimensions, by using a structure for associating the numerous implementation-methods offered, fulfillment of the technology's promise will, in all likelihood, continue to be extremely difficult. The development process presented here offers such a structure, and requires GIS advocates to acknowledge the iterative, cyclical nature of a development effort based on the assumption that all five phases (participation, context evaluation, vision creation, change, and technology implementation) must be addressed in each of the three stages (Initiation, Acquisition, and Incorporation).

The Development Process phases are based upon technical and organizational dimensions associated with any GIS development effort and represent the "core issues" identified by many other authors. The suggested process offers an organic approach for considering these issues in the context of the three stages (Initiation, Acquisition, and Incorporation) characteristic of any GIS development effort.

The proposed GIS Development Process is based upon an awareness of certain observable realities (Anderson 1991). First, the development process is built upon the fact that *geographic information systems currently exist* in manual and automated states. This manual system is composed of a variety of activities (tax parceling, right-of-way drafting, preliminary design, and land-use coding, etc.) performed by public and private sector employees (assessors, planners, and engineers) who gather and use geographically related information to perform their assigned and mandated responsibilities. This premise defines the context into which the technology will be introduced.

Second, the transfer of GIS technology into its new context is both a *process* and a *project*. It is not a finite activity. A GIS will continuously evolve. The incorporation and institutionalization of GIS technology by an organization requires the positive participation of a critical mass of individuals in a *development process*. The steps of this process (leading to acceptance and use of any new system) must address a myriad of constraints to the adoption of an automated information system.

Third, the GIS Development Process proposed here recognizes among those constraints the uninitiated users' view of the potentially invasive nature of GIS technology. A technology which promotes a *vision* of organization-wide and inter-departmental integration of information resources can seem threatening and produce reactions of fear, resistance, vindictive compliance, and sabotage.

Additionally, the GIS Development Process recognizes that GIS is fundamentally collaborative, requires a wide array of participants, and generates new organizational structures and procedures. The *changes* caused by these new structures will be felt throughout the organization.

Finally, the process suggests the people who work daily with manual geographically-based information are experts about the information to be automated and must be part of the development process. The process requires the active *participation* of all players affected by the ripples of change which will inevitably flow from the implementation of an automated GIS.

These realities by their very nature add enormous complexity to any GIS development effort; to ignore them will obscure the barriers constraining development success. The iterative nature of the proposed GIS Development Process addresses these complex realities on a cyclical basis. This GIS Development Process offers an alternative to conventional solutions by addressing core issues repeatedly as the process moves through each development stage. To continue applying traditional, linear solutions to a multi-faceted problem is to court disaster. In the best case, the new system may be used as a centralized automated-mapping tool. The worst-case scenario reveals the equipment in a corner, collecting dust. The proposed Development Process, in contrast, holds out the prospect of realizing the true potential of this maturing technology.

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