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Understanding Guidance on GIS Implementation: A Comprehensive Literature Review

by

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Abstract

This technical report reviews the literature that provides guidance on GIS implementation. It defines *Guiding Literature* and five *Classes* of publications included therein. It reviews a representative number of publications of each *Class* and organizes the proposals by subject. In addition, it analyses the *Guiding Literature* in terms of issues addressed, theoretical consistency, and theoretical diversity. The contributions of this report are two fold. First, it documents a comprehensive review of the literature on GIS implementation. It can be used as an easy-reference to the Guiding Literature as well as to proposals on one specific subject. The second basic contribution of this report is concerned not with the adequacy of the theories themselves but with their organization for practical use. The results suggest that the current theories need to be organized in a single, comprehensive guide.

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Part I: Definition of Goals and Scope

1- Introduction

This report is part of a research project that will result in a comprehensive guide to GIS implementation. The most basic step toward the development of such a guide is understanding and documenting the current ideas on the subject. This is a first concern of the report. A second concern is to verify whether or not those ideas are organized in a convenient guide for the practitioner. It is not a goal of this report to contradict any idea or to propose new ones. Instead, the focus is actually on organizing the current ideas in an objective and understandable package. In other words, this report addresses the following questions: What does the literature say about GIS implementation? Are the proposals compatible among themselves or are they contradictory? What are the alternative approaches? Are the ideas organized in a comprehensive guide for practitioners?

The publications on GIS implementation are very heterogeneous regarding how the proposals are presented. For example, some proposals are presented as "steps to GIS implementation" while other are presented as lists of "success factors". How can we compare ideas from a list of success factors with step-by-step directions? It is difficult to compare the whole list of success factors with step-by-step directions as a whole, but it is easier to compare what both publications say about one specific issue such as pilot projects. Thus, in order to ease the comparison of ideas, we have defined a set of specific issues on GIS implementation and organized the proposals according to each subject.

This report is organized in four parts. In Part I (Section I and Section 2) we present the goals and scope of the report. Section 2 presents a framework for organization and comparison of theories concerning GIS implementation. This framework defines the criteria for literature selection, the classes of literature fulfilling such criteria (or Classes of Guiding Literature), and the specific issues on GIS implementation. Part II overviews a representative sample of the Guiding Literature. Section 3 presents some general features and Sections 4 to 8 describe and analyze separately each class of Guiding Literature. Part III comprises the overall analysis and comparisons. Section 9 presents a summary of the proposals on each issue defined in the framework, and Section 10 analyzes the coverage of each class of proposals (which issues are addressed). Section 11 and 12 verify respectively the theoretical consistency and diversity of the proposals. In Part IV we present our conclusions and the bibliographic references.

2- Framework for Classification and Comparison

In this Section we define the term "Guiding Literature" for GIS implementation, and five "Classes" of Guiding Literature. We also define a set of specific issues on GIS implementation.

2.1- Defining *Guiding Literature*

One can identify findings concerning GIS implementation in most parts of the GIS literature, or even in the literature from other fields. For example, one can identify findings about GIS implementation in implementation histories. However, the main objective of these *implementation histories* is not guiding GIS implementation but, instead, reporting about the

implementation in one specific organization: Describing its applications, the major problems, the solutions adopted, the next steps, etc.

We defined as *Guiding Literature* that literature whose main purpose is to provide guidance for the process of GIS implementation. We defined three specific characteristics of (or criteria for) the *Guiding Literature*:

- Literature specific to GIS field;

- Literature whose explicit purpose is to give directions for GIS implementation;

- Literature whose directions refer to the implementation process as a whole and not only to part of the process.

Due to the first criterion we exclude, for example, all the literature on implementation of information systems in a general sense because this literature is not specific to GIS. The second criterion excludes, for example, the *implementation histories* (such as [BARLAZ90, DOUGLAS91, EDMONDSON91, HOBBS94, JONES93, JUHL94, MORRISON93, SCIULL191, SUSSMAN93]) because they do not have *'providing guidance'* as a main, explicit purpose. Finally, the third criterion excludes the literature limited to address one specific issue of GIS implementation because the main purpose in this case is not to guide the implementation process as a whole, but only part of the process. Examples of this kind of literature are:

- Cost-benefit evaluation [ROURK93a, ROURK93b, EPSTEIN91, ALSTON92, GILLESPIE94, DICKINSON88, JACKSON94, POE92, ROGERS93, CALKINS91, WILCOX90, SMITH92];

- User needs assessment [WIGGINS91];

- Data modeling [EGENHOFER92], [HAZELTON92];

- Data acquisition, data conversion [NOONAN92], [BACHMANN921, [SOMERS92], [CANNISTRA94], [PATTERSON941, [MONTGOMERY93];

- Data sharing [SCHALL94], [JONES921, [PASCARELLA94], JONSRUD95].

The literature excluded by the selection criteria is valuable for understanding GIS implementation. However, for the goals of this paper, it has secondary importance in relation to the literature which fulfills all three criteria because this last literature is primarily intended to guide implementation of GIS as a whole, while the former is not.

2.2- Classes of Guiding Literature

We identified five basic classes of literature fulfilling the selection criteria, or *Classes of Guiding Literature*:

- **Implementation Methodologies**. The Implementation Methodologies are the proposals intended to teach someone how to implement GIS, through step-by-step directions. They usually address primarily the implementation of the (geographic) information system

itself, looking like an adaptation of a methodology for information systems design. The steps are usually phases of the information system design process (such as user needs analysis, database modeling, etc.). The discussions about topics not directly related with information system design (such as GIS staffing and system management) are inserted in this main discussion (system design);

- **Implementation Strategies** . The Implementation Strategies are similar to the Implementation Methodologies but they address GIS implementation in a more generic way. They usually propose general and broad stages or phases to GIS implementation. Some of these stages can look like the steps from the Implementation Methodologies, but their focus is not on guiding the design of the information system itself. Instead, they focus on the strategic planing of the implementation process, on proposing the implementation pace and scope, on how to prioritize applications, on how to manage user resistance and unwillingness of managers, etc.;

- **Success Factors & Dependencies**. This class incorporates the literature that proposes lists of key determinants of implementation success. These key determinants of success can be generic strategies/activities that must be adopted /carried out (such as getting top management support, involving users in design, etc.) or conditions that ease or hinder the implementation (such as resistance to change, lack of data or personal skills, etc.);

- **Research Findings**. The Research Findings class includes the literature that presents results of research projects on GIS implementation. The papers usually involve theoretical discussions, description of some sort of field surveys and/or case-studies, and, finally, the statement of research conclusions (or findings). Some of these findings assume a format very similar to that one typical of the Success Factors & Dependencies class;

- **Implementation Guides**. Implementation Guides are the books whose primary goal (of the whole book) is to guide GIS implementation. Some of their directions are presented through a combination of presentation formats adopted by other classes (such as *step-by-step directions* and *list of success factors*).

2.3- Specific Issues on GIS Implementation

Through a thorough reading of the Guiding Literature, we constructed a list of the primary specific issues on GIS implementation discussed in the literature. We grouped the issues under four broad themes, as shown in the rows of Table 2.1. The first group of issues, Overall Strategy, refers to the strategic planing of the implementation process. The issues of this group are: The role of strategic planning and organizational risk evaluation; and the recommended implementation pace and scope (departmental or organization-wide system, full & fast or gradual implementation, etc.). The Information System Design group comprises the issues directly related to the technical design of the information system. We selected the issues: Implementation plan; GIS design model (design activities, and their sequence); The role & position of pilot project; and Detailed design techniques (techniques of data modeling, cost-benefit analysis, etc.). The issues of the Project Enabling Strategies group refer to the management of difficulties for project enablement: How to get and sustain top level support; How to manage organizational conflicts and user resistance; Funding strategies (cost sharing and cost allocation); Communication channels and project marketing; and Training strategy and roles. Project &

System Management group includes issues related to the management of the implementation process and start up of management routines for the operational system. The issues selected for this group are: System location & coordination bodies (project/system management under control of planning department, under direct control of top-level managers, board of representatives, etc.); GIS staffing (required positions) and the role of consultants & contractors; Project control (schedule, budget, etc.); and Management of risks and of the information system function & strategy (strategic evaluation of the project results in comparison with the initial strategic planning and risk assessment).

We will use a Table similar to Table 2.1 for showing the coverage of the methods set forth by each of the primary references we cover in this report. The last three columns indicate how the issues are addressed. The column "Mention" indicates that the publication mentions the importance of considering that specific issue during GIS implementation but does not present any proposal concerning how or when to do that. For example, we would indicate "mention" if a publication states that it is very important to get top level support but does not suggest how to get such a support. One example of a "Generic Proposal" is getting top-management support through education of leaders (without further details). One example of a "Detailed Proposal" would be the discussions of an alternative strategy for GIS implementation as a mechanism to get top-level support (how to obtain short-term results, low initial investments, how to prioritize applications in order to ease obtaining top-level support, etc.).

	Mention the Importance	Generic Proposals	Detailed Proposals or Insights
Overall Strategy			
role of strategic planning or risk evaluation			
implementation pace and scope			
Information System Design			
implementation plan			
GIS design model			
role & position of pilot project			
detailed design techniques			
Project Enabling Strategies			
top-level persuasion / support			
organizational conflicts / user resistance			
funding strategies			
communication channels / project marketing			
training strategy and role			
Project & System Management			
system location / coordination bodies			
GIS staffing, consultant & contractors			
project control			
management of risks, IS function & strategy			

Table 2.1- Issues on GIS Implementation

Part II: Description of Proposals and Intra-Classes Comparison

3- Overview and General Features

Table 3.1 presents an overview of the publications included in each Class, as well as some general features - application domain, prevailing position of the authors, and nature of the main publication. Sections 4 to 8 summarize these and some other publications. In order to simplify the text, these sections contain some words or even phrases from the original papers (sometimes without quotation marks).

Main Reference	Application Domain	Author's Position	Publication's Nature
Implementation Strategies			
Somers 94	no domain but example (municipal)	consultant	conference paper
Peuquet 91	U.S. Army	university/Army	journal paper
Ferrari 94	local governments	university	conference paper
Hedges 94	AM/FM	consultant	conference paper
Anderson 92	municipal	university	conference paper
Implementation Methodologies			
Antenucci 91	-	consultant	book chapter
Love 91	-	consultant	conference paper
Clarke 91	-	?	book chapter
Vastag 94	local government	consultant/ university	journal paper
Ventura 91	county agencies	university	booklet
Success Factors & Dependencies			
Croswell 91	-	consultant	journal paper
Ventura 92	local government	mix	compendium chapter
Engelken 94	AM/FM	consultant	conference paper
Koller 92	other (Survey of Israel)	other	conference paper
Research Findings			
Campbell & Masser	local governments	university	journal & conference papers, book chapters
Onsrud & Pinto	local governments	university	journal paper, book chapter
Budic	local governments	university	journal paper
Pinto & Azad	no domain but example (transportation dept.)	university/ consultant	journal paper
Azad & Wiggins	local & regional governments	university/ consultant	conference paper
Implementation Guides			
PTI & ICMA	local government	user associations	book
Huxhold & Levinsohn	-	university/ consultant	book
Korte	-	consultant	book

Table 3.1- General Features of the Guiding Literature

The column "Application Domain" shows what proposals are aimed at one specific application domain (such as local governments or AM/FM) and what proposals are not. The phrase "no domain but examples" is used when one proposal does not define a domain, but present examples within one single domain. Most of the proposals refer to a specific domain, somehow. Even in the proposals which do not define one specific domain, there are elements representative of certain domains (for example, Request for Proposals/Bids - typical of public

organizations). The *Implementation Strategies*, the *Success Factors & Dependencies*, and the *Research Findings* have prevailingly addressed one specific domain. The *Implementation Guides* and the *Implementation Methodologies* present the opposite (not so strong) bias.

4- Implementation Strategies

4.1- The Dual-Track Implementation of Somers

Somers proposes a dual-track development strategy [SOMERS94]. After a preliminary requirement analysis and core design, by the first track one implements immediate applications and data (short-term track) while by the other track one continues the detailed analysis and design. The short-term results are obtained by:

- **Sacrificing detail and accuracy**. Somers does not question the benefits of a detailed base map, but argues that the development of such a detailed data base takes a great deal of time and money, and in the meantime the system is not very useful. According to Somers, low accuracy data (10-201 can support around 80-90% of initial applications of a local government setting, while increasing the positional accuracy from 10-20' to 5' could involve over a ten-fold cost increase;

- **Independent Applications.** Somers argues that while it is usually clear that great savings will accrue from the reduced redundancy and resource sharing of a multi-purpose, multi-user GIS, developing such a large and complex system takes a great deal of time and resources, and nobody has any use of the GIS until the whole system is in operation.

The proposals of Somers suggest that both sacrificed goals, high accuracy and a multi-purpose, multi-user system, can be achieved through a long-term track in parallel to a short-term track with immediate results.

According to Somers, dual-track development can possibly result in temporary mixed accuracy of data and mixed degrees of development, increasing the complexity of the development process and of the data base management. To solve these problems Somers proposes increasing project management time and establishing a conceptual (core) design defining how independent applications will fit together in the long-term.

The proposals of Somers address difficulties regarding enabling GIS projects due to their long-term results. Somers says that "*Organizations today focus on the short-term - whether that is good or bad, GIS developers must respond to this environment. Great GIS plans mean nothing to many organizations if there is nothing to show for them today*" [SOMERS94]. According to Somers, dual-track development, with short-term results, can ease the star-up of the GIS and its continuation. In addition, Somers presents the following justifications to the proposed approach:

- The *Traditional* approach to development of GIS is rigid and therefore inadequate when critical elements are changed, such as funding, staff time, or application priorities;

- The proposed alternative approach is iterative, and provides the learning achieved through prototyping;

- It may be the case that some departments are ahead of the corporate staff in recognizing the need of GIS;

- New opportunities arose in the market: Acquiring commercial, public, or third-party data as well as simplified and application-specific software.

4.2- Iterative Prototyping of Peuquet & Bacastow

Peuquet and Bacastow presented a case study of GIS development in the US. Army [PEUQUET91] and pointed out the following findings:

- The classical project life-cycle does not work well when the project involves the initial introduction of a given technology within any organization (because functional and organizational requirements can not be defined in advance of using the technology);

- There must be an organizational recognition of the need for, and a strong commitment to, significant changes in the organizational structure. The determination of this structure and how the GIS is to function within the organization must be included as an integral part of the development process;

- The involvement of the entire organization is essential for a successful first development effort. Based on these findings the authors proposed iterative prototyping with a gestalt view as an overall implementation strategy. After defining a preliminary set of requirements, a working model is developed and implemented, provoking experimental organizational changes. Both the functional and the organizational requirements are derived and tested through iterations including organizational changes (in incremental steps). The basic heuristic is empirical experimentation, as opposed to pre-specification. The authors also mention the need for a carefully balanced development team, and a figure (who they name "system mentor") providing guidance and neutral "company" view to ensure that the objectives of the development are not exclusively driven by technology or by particular interests. According to the authors, the advantages of using such an iterative approach are:

- Lower level of risk (comparing to the *traditional* approach), since ideas are tested incrementally;

- Greater responsiveness to change, since the agreement to use and evaluate such a gestalt prototype constitutes an implied contract for change (including managers and users);

- Gradually familiarizing the user with the technology from a realistic and contextual point of view;

- Refining requirements;

- Project flexibility.

4.3- CDS/LG-GIS, of Ferrari and Garcia

Ferrari and Garcia pointed out the difficulties for implementation of GIS in Brazilian local governments (difficulties for the persuasion of managers, difficulties in sustaining the project due to long-term results and changes in elected officials, etc.) and proposed an implementation strategy for that environment [FERRARI94].

The proposed strategy comprises three general phases. The main goal of the first phase, *Persuasion* is to convince top level managers to try the technology. In *Persuasion* phase a GIS project should be inserted in a *Sectorial Evolution Proposal* - SEP. The SEPs should address problems which are exerting high political or economical impact on one particular organization. Each SEP involves the identification of a problem, of a solution, of supporting needs (such as information needs), and of alternative solutions (one of them including GIS). The SEPs can also include a pilot-project to ensure technical viability, and to establish a concrete link between the SEP and the GIS. Since in this phase there is not funding commitment to GIS, the development of a pilot project can be supported by other organizations interested in future technical or commercial relationships, or must be restricted to the department's financial autonomy.

The main goals of the second phase, *Familiarization*, are: Familiarizing users with GIS and new work methods; Getting commitment from users and top managers; And diffusing such conditions throughout the organization(s). The proposed approach is the incremental diffusion of small and independent applications throughout the departments or organizations composing the municipal administration. Like in the *Persuasion* phase, the applications should be inserted in SEPs, but no longer under a pilot project status. The SEPs and involved applications should be effectively implemented, provoking changes in the operational routines.

The *Globalization* phase consists of an inter-departmental or inter-organizational effort for the planning of a integrated system to be implemented within a medium to long-term horizon. The idea of several independent applications should now be replaced by the view of an integrated system sharing data, data acquisition and maintenance processes, and support activities. Like in the other phases, the GIS applications are designed to support plans for organizational evolution.

The authors argue that their proposal address, first, the production of a "*good quality GIS*" by fulfilling real information needs (supporting problem resolution or organizational evolution). This can be achieved by inserting GIS projects in "*Evolution Plans*". A second goal is to enable the project. They argue that it is easier to obtain and to show benefits from SEPs than from a GIS project itself, easing the persuasion of managers. The authors also argue that the two first phases are a preparation of the organization(s) to take part in a (bigger, more complex, long-term, and expensive) multi-participant project, familiarizing the users and increasing the commitment throughout the organization(s).

4.4- The Hedges' Incremental Implementation & Re-Engineering

Hedges proposes an overall implementation strategy for the utilities environment [HEDGES94]. Hedges criticizes other approaches historically adopted. According to Hedges, the *initial departmental projects* have shown a limited impact and a tendency to mechanize existing processes while the *early enterprise-wide* AM/FM projects have shown enterprise-wide impact but long development cycles. Hedges also consider inadequate either process re-engineering

prior to AM/FM development (long-term approach, when possible) or AM/FM implementation prior to process re-engineering (because it can automate data no longer required).

The proposed approach is incremental implementation of AM/FM as a mechanism to supprt process re-engineering. The author argues that the long implementation cycles of traditional AM/FM projects have become unacceptable for many utility executives, and that an incremental implementation approach tend to justify continued internal funding and support. Such an incremental approach can also signal about the "workability" of the overall technology, and allow the project team to mature and become independent of continued third-party assistance. The proposed features for the basic applications are: Small, inexpensive, fast, easy development, visible results, and leveraged (built as much as possible upon the preceding modules). The proposed system architecture comprehends a corporate database, distributed computing (client-server), open system architecture (*interoperability*), and AM/FM/GIS as a core (enterprise-wide) systems technology.

According to Hedges, the steps to develop a successful implementation plan for the incremental AM/FM implementation & re-engineering are:

- Business area analysis to identify and prioritize the business processes to be re-engineered and/or automated;

- Initial high-level assessment of AM/FM technology and geographic database requirements;

- Assessment of potential data sources and conversion requirements (data source matrix);

- Anticipating, at a high level, the benefits that will be achieved through each one of the processes to be re-engineered;

- Developing an implementation plan. Each implementation module should be small, fast, visible, etc.;

- Developing a detailed cost/benefit analysis, and detailed implementation plan for each implementation module;

- Managing the implementation of each module minimizing "scope creep" (additions should be implemented in future modules).

4.5- The Proactive Approach of Anderson

Anderson proposed a "*proactive approach for the introduction of GIS technology*" [ANDERSON92]. Anderson argues that in the traditional GIS technology transfer process, user participation is restricted to interviews in the needs assessment phase. User resistance is a reaction (Anderson name "*reactive*" such a traditional approach). In the proposed "proactive" approach, Anderson advocates extensive user participation (affected people) not only in needs assessment, but in all phases of GIS technology transfer.

Anderson addresses GIS implementation through five non linear phases "*occurring concurrently and occasionally repeated within a subsequent phase*": (1) Participation (GIS

education and communication); (2) Context Evaluation (by an "*open court*"); (3) Vision Creation ("*created consensually*', instead of by a "*small group of GIS advocates*"); (4) Change (to assess "*openly and realistically*" any organizational changes required for the implementation of the proposed vision); And (5) Implementation (formal analysis and design using a structured system-development methodology).

4.6- Other Implementation Strategies

Born and Jansen-Dittmer [BORN93] propose that the responsibility for GIS implementation and definition of its goals should he on top management. The goals "*should be an improvement of the strategic position of the organization*" (pg. 157), and (should be) "*defined in the field of market goals*"(pg. 163). They believe that, following this strategy, "*the consequent goal orientation can be ensured and the effect on the organization culture can be controlled*" (pg. 164).

Roe [ROE91] proposes "an organizational approach to implement GIS", arguing that the focus of system implementation should not be to automate but, instead, to improve management practice. According to the author, this correct focus can be achieved through socio-technical system design (referring the approach proposed by Eason [EASON89]). Roe agrees with Chrisman [CHRISMAN87] when suggests that one goal of GIS implementation and use should be to demonstrate that people are treated more equitably.

The model proposed by MacNeill and Allan [MACNEILL94] is based on an adaptation process applied to an initial system. The model associates prototyping, user needs assessment, and eventual creation of new applications with new data availability. Each cycle is a response to the availability of new data.

Kevany and Barrowman [KEVANY90] argued that a low cost GIS configuration can satisfy most or all requirements of some organizations, and it can provide an interim solution for larger organizations. In addition, they suggest that a low-cost configuration can ease initial justification and the procurement procedures, and can be used as a training tool.

4.7- Coverage Analysis and Content Comparison

Table 4.1 summarizes the coverage of the Implementation Strategies. The letters printed into the table's cells identify the proposals through their author's initials. The letter "A" identifies [ANDERSON92], "F'-[FERRAR194], "H" - [HEDGES94], "P" - [PEUQUET91], and "S" identifies [SOMERS94].

4.7.1- Strategic Planning and Risk Evaluation

Hedges proposes, as a first step in a GIS implementation project, a business area analysis for identifying and prioritizing the business processes to be re-engineered and/or automated. For the definition of the initial applications, Ferrari and Garcia recommend elaborating *Sectorial Evolution Proposals* addressing areas of high economical or political impact. Somers included strategic planning in the proposed strategy but without further explanations about its role. Somers also mentioned the importance of performing an environmental risk evaluation before defining an implementation strategy. A similar reference was made by Ferrari and Garcia.

4.7.2- Implementation Pace and Scope

We identified three main proposals regarding implementation pace. Peuquet and Bacastow proposed iterative prototyping with a gestalt view for the initial introduction of GIS technology, arguing that the approach is adequate to derive technical and organizational requirements, that it presents lower risk than traditional approaches, and that it produces gradual commitment among users and managers. Ferrari and Garcia proposed a three-stage approach: small, independent applications in the two initial phases of implementation, and a global, (multi) organization-wide planning and implementation. They argue that the two first phases ("*Persuasion*" and "*Familiarization*") are a preparation of the organization to take part in a bigger multi-participant project (in the third phase, "*Globalization*"). Somers proposed dual-track implementation. After a preliminary requirements analysis and core design, one short-term track based on independent, small, low accuracy applications, and a long-term track pursuing a multi-purpose, highly accurate GIS. The goal of the short-term track is to ease getting and maintaining top-management support. Both Ferrari & Garcia and Somers propose small and independent applications in the short-term, and a (multi) organization-wide system in the long-term The actually intended scope is the (multi) organization-wide one. The short-term scope is only an enabling strategy. No other proposal argued the contrary.

	mention the importance	generic proposals	detailed proposals or insights
Overall Strategy			
strategic planning/ risk evaluation		H, F, S	
implementation pace and scope		H	F, P, S
Information System Design			
implementation plan			
GIS design model			
role & position of pilot project			
detailed design techniques			
Project Enabling Strategies			
top-level persuasion/ support			H, F, S
organizational conflicts/ user resistance			A, P
funding strategies			
communication channels/ project marketing			
training strategy and role		S	F
Project & System Management			
system location/ coordination bodies			
GIS staffing, consultant & contractors			
project control			
management of risks, IS function & strategy			

Table 4.1- Coverage of the Implementation Strategies

In addition to those three main proposals, Hedges advocated incremental implementation combined with process re-engineering for utility companies, and Kevany & Barrowman suggested low-cost configurations as an interim solution for counties. Both proposals agree with the prevailing idea of short-term results and low initial investments in order to ease top-management persuasion. "*Incremental*" implementation was also advocated in [AL-ANKARY91, FOX91, YEH91].

4.7.3- Enabling Issues

The main concern of the Implementation Strategies included in this section are enabling issues. The proposals of Somers, Ferrari & Garcia, Hedges, and Kevany & Barrowman focus on obtaining top-management support. To ease getting such a support, they proposed short-term results, low-initial investment, and defining goals on the business field. Anderson's and Peuquet & Bacastow's proposals focus on user resistance and organizational conflicts. They propose intensive user participation in design and decisions. Anderson proposes a "*Proactive*" approach in which the GIS vision is created "*consensually*". Peuquet & Bacastow propose iterative prototyping with gradual introduction of changes.

4.7.4- Training Strategy and Role

Training was addressed also as an enabling concern. Ferrari & Garcia proposed one phase, named *Familiarization*, whose main goal is to familiarize users with GIS and with new work methods. *Familiarization* is achieved through use of small and independent applications. They argue that the *Persuasion* and *Familiarization* phases are necessary to prepare the organization to take part in larger projects. Somers and Kevany & Barrowman cited training as an additional benefit of the strategy they propose. Kevany & Barrowman argued that an *intermediate low cost configuration* can be used as a training tool. Somers argued that the dual-track approach provides the learning achieved through prototyping.

5- Implementation Methodologies

5.1- The Methodology of Antenucci and Others

One of the chapters of the book of Antenucci, Brown, Croswell, Kevany and Archer [ANTENUCCI91] presents a methodology for GIS implementation. The methodology comprehends five stages and seventeen steps, presented bellow. Figure 5.1 presents the temporal view of the five stages.

> Stage 1: Concept. The Concept Stage is composed by user requirements analysis and feasibility evaluation (Steps One and Two).
>
> > Step 1: Requirement Analysis. The objective of Step One is to assess requirements for the GIS based on user-supplied information. Requirement analysis involves identifying the organizations and groups that may benefit from the GIS and dividing them into functional areas and levels of significance. Individual representatives with knowledge of the organization should participate in the analysis. It may be necessary to provide a basic training to the participants through workshops, conference attendance, or other techniques. The analysis should be conducted by a combination of internal staff and outside consultants;

Step 2: Feasibility Evaluation. The feasibility evaluation is based on a cost-benefit analysis. The authors recommend to include in such analysis a period of seven to ten years, and the participation of a consulting expert ;

Stage 2: Design. If the result of the feasibility study is a decision to proceed the GIS implementation, the project enters the Design Stage. Design Stage comprehends the implementation plan (Step 3), and System & Database design (Steps 4 and 5).

Step 3: Implementation Plan. The implementation plan defines and controls all subsequent steps in the process. It should identify and describe individual tasks, assign responsibilities and resources for each task, indicate relationships among tasks, define products and milestones, and establish a schedule. A computer-based project management program may be used to update the plan and to monitor and report on its status;

Step 4: System Design produces specifications to guide software acquisition;

Step 5: Data Base Design develops specifications to create and maintain the database, and to guide the acquisition of database services;

Stage 3: Development. In the development stage, an organization acquires GIS software, hardware, and data conversion services, and develops procedures to operate the system. These activities can occur in parallel.

Step 6: System Acquisition. Request for proposals, evaluation, and system acquisition;

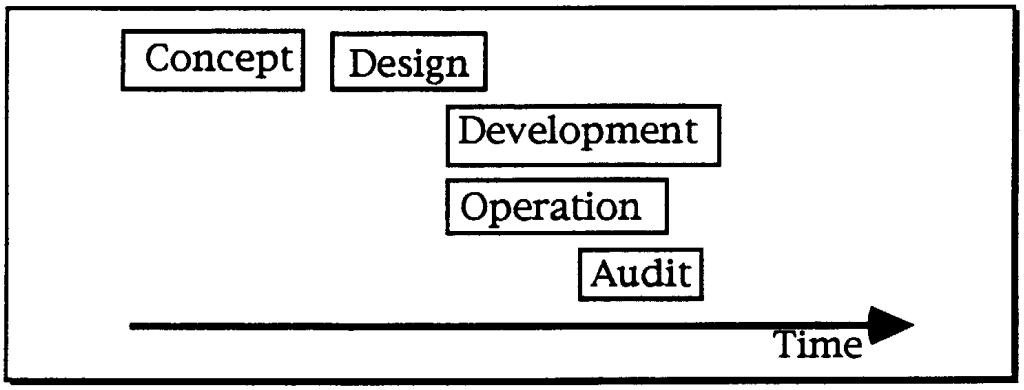

Figure 5.1: Five Stages of Antenucci and Others (adapted from [ANTENUCCI91])

Step 7: Data Base Acquisition. Same as Step 6;

Step 8: Organization, Staffing and Training. According to the authors, the most appropriate approach to GIS organization varies from project to project. For multi-participant projects, the organizational structure may be centralized, with one body providing GIS services to the participants, or it may be distributed, with each participant operating independently of the others (in this case, standards for sharing data and resources should be established). Overall management of multi-

participant projects may be assigned to a single organization or to a policy board of representatives from the participating organizations. Within one single organization, the GIS responsibility may be assigned to an existing unit, a new GIS unit can be created and placed in an existing department, or an independent GIS department may be created. Whether shared or operated by a single organization, a project manager responsible for all aspects of implementation is necessary. Regarding staffing, the authors suggest specific functions such as implementation project manager, system manager, data base administrator, system analysts, programmers, and operators. Regarding training, the authors propose different types of training. The GIS manager and key support staff should receive the most intense training, representatives from user organizations should be trained on system use and operation, and managers throughout the organization should receive training on GIS applications and opportunities. The training may be provided by the software vendor or by other organizations. The authors also suggest to encourage attendance to GIS workshops, conferences and other events.

Step 9: Operating Procedure Preparation. Before installation and operation of the system, the organization should design the operating procedures to be embedded in the organization's routines. These procedures govern all aspects of system's operation and management such as back-up of data base and software, management of maintenance contracts, support for system users, and authorization for application development and installation;

Step 10: Site Preparation. Selection of optimal locations, installation of adequate power supply, air-conditioned, etc.;

Stage 4: Operation. Operation Stage comprehends the following five interdependent steps: System installation, pilot project, data conversion, application development, and conversion to automated operations (Steps 11 to 15).

Step 11: System Installation. This step includes system delivery and installation, and the acceptance tests;

Step 12: Pilot Project. The authors mention that *one of the major purposes* of the pilot project is to anticipate technical problems. They also suggest other possible objectives such as to verify procedures for database development, to verify the estimates of costs and benefits, and to provide hands-on training for staff. They propose developing the pilot for a small geographic area which is representative of typical or critical conditions. They also argue that, since the pilot *frequently takes place* before the in-house staff has obtained adequate experience, a consultant may conduct some aspects of the pilot;

Step 13: Data Conversion comprehends data base loading with quality-control. Only a portion of the data base may be initially converted. The remainder of the data is loaded in phases as it becomes available from compilation and digitizing activities;

Step 14: Applications Development. The authors suggest that sophisticated application programs should be acquired from the GIS vendor, from third-party firms, or from other organizations which use the same software;

Step 15: Conversion to Automated Operations, possibly in phases over an extended period of time;

Stage 5: Audit.

Step 16: System Review. The authors propose periodic reviews (or audits) to keep the project on track (or to bring it back). A review should be similar to the procedures used to develop the initial plans for system implementation. The audit culminates with a revised statement of goals, policies, procedures, and actions to be taken within specific time frames and budgets;

Step 17: System Expansion is a special case of audit intended to support system expansion.

The authors suggested that organizational support can be built and maintained through a favorable cost-benefit analysis, through top-down political influence, or through education.

5.2- The GIS SDLC of Love

Love presented a GIS SDLC (System Development Life Cycle) [LOVE91] which embraces technical methodologies from sources in both MIS and GIS fields. Love considers the SDLC an "*humanistic approach*" (pg. 483) aimed at to ensure that customer and contractor understand and share the same view about all aspects of the GIS project under development. The general goal is to deliver, within the defined budget and deadlines, a system which actually satisfies user requirements. The proposed methodology consists of 8 stages:

Stage 1: Implementation Plan. According to Love, the implementation plan is a detailed expansion of the SDLC describing each step in the process from the issuing of the job brief to the final evaluation;

Stage 2: Familiarization. The main goal of this stage is to familiarize the designer (contractor) with the organization and its people. Familiarization stage is a period of intense interaction between contractor and user: Workshops, informal interviews with management and users, etc.;

Stage 3: Pilot Study. Stages 3,4,5, and 6 compose system definition. The pilot study comprehends a working model of a GIS over a limited geographic area. Its goal is to improve communication between contractor and users;

Stage 4: Requirements Formulation and Analysis. Love proposes to define user requirements through questionnaires and workshop sessions with all users involved. The questionnaires ask the users the objectives, functions and processes of organization's departments, problems and possible solutions, data deficiencies, their individual expectations of a GIS, their "wish list", etc. The workshops give users an exposure to the pilot system. Love says that the workshops are designed to "*stimulate the imagination of*

the users and to set the context for the questionnaires" (pg. 480). This Stage also involves the compilation of a Resource Inventory including hardware and software available for the project, data, and user attitudes (positive/negative);

Stage 5: System Specification and Design Document. This document details alternative solutions for achieving the requirements, and becomes the Implementation Report which is submitted to management for approval;

Stage 6: Database Schema Design;

Stage 7. Program Design and Development. Love proposes adopting an interative prototype approach with a series of check points for evaluation and feedback from users;

Stage 8: Operational System Installation. According to Love, as a result of the iterative prototype approach system installation is a relatively short process.

5.3- The GIS Acquisition Model of Clarke

Clarke proposed a general model for GIS acquisition comprising four stages and fourteen steps [CLARKE91].

Stage 1: Analysis of Requirements. According to Clarke, this first stage is an iterative process for identifying and refining user requirements.

Step 1: Definition of Objectives. In this step one should define the scope and objectives of GIS acquisition and obtain support from management and users. The objectives should be stated from management's perspective, they should focus on results, and should be measurable. Users must understand that the project will result in benefits for them;

Step 2: User Requirement Analysis. Through interviews, documentation reviews, and workshops, one should identify the required information products and related information;

Step 3: Preliminary Design includes preliminary functional and database specifications and a market survey of potential system suppliers;

Step 4: Cost-Benefit Analysis. The costs, benefits, changes in roles and procedures, and risks of failure should be measured against the alternative of continuing with the current data, processes, and information products. The cost-benefit analysis may indicate whether the project should proceed, should be postponed, or whether the objectives, requirements, and design must be improved. Three categories of GIS benefits may be defined: efficiency (time and cost savings through faster data processing or reduction of duplicated effort), effectiveness (improvements in the decision-making process caused by more timely or new information), and intangible (improved public image, improved cooperation through data sharing, increased staff professionalism and morale, etc.);

Step 5: Pilot Study. The primary objective of pilot study is to test the preliminary GIS design before finalizing the system specifications and committing major resources. Secondary objectives are to develop the understanding on and confidence in GIS. The pilot should include a representative data set (for example, all kinds of data but only for a small geographic area). The hardware and software for the pilot may be leased, and should not imply in commitment to future purchase,

Stage 2: Specification of Requirements. In this second stage user requirements are developed into a specification and request for proposals document,

Step 6: Final Design includes finalizing the functional and database specifications, performance specifications, and constraints.

Step 7: Request for Proposals combining the specification with the contractual requirements of the agency,

Stage 3: Evaluation of alternatives. This third stage comprises three successive evaluations (steps 8 to 10);

Step 8: "Shortlisting". The proposals which failure to meet mandatory requirements, or with too generic responses, should be eliminated. The remaining proposals should be evaluated through a scoring system based on the fulfillment or not of system requirements.

Step 9: Benchmark Testing for refining the preliminary scores. Clarke recommends to apply the benchmark tests to a maximum of five systems, selected through the preliminary evaluation (shortlist);

Step 10: Cost-Effectiveness Evaluation. The ratios of scored benefits versus costs (of a normalized hardware configuration) should be determined. The costs should include the operating costs for a nominal system life (at least five years) to ensure that the original cost-benefit analysis remains valid.

Stage 4: Implementation of the System;

Step 11: Implementation Plan. The implementation plan involves defining priorities, defining and scheduling tasks, and developing a resource budget and management plan. Clarke suggests to prioritize products with positive results early in the implementation;

Step 12: Contract;

Step 13: Acceptance Testing, including tests of functionality, performance and reliability (availability and recovery);

Step 14: Implementation. Implementation step comprehends training users and support staff, performing initial data capture and product development, and introducing performance monitoring as a system management task.

5.4- The General Implementation Guide of Vastag and Others

Vastag, Thum, and Niemann proposed a *general guide* for LIS/GIS implementation which, according to the authors, should be adapted to the unique circumstances of each local government [VASTAG94]. The proposed guide involves the following stages:

- Awareness should be generated by a person who is willing to champion LIS/GIS (the "White Knight"). The authors understand that such a "White Knight" should ensure that the use of LIS/GIS is prudent and ethical. They include as examples of possible benefits of GIS/LIS better public access to information and more citizen involvement in the land planning and development process;

- Feasibility stage includes organizational needs assessment, organizational requirement analysis, and feasibility determination. The organizational needs assessment will help determine the overall scope of the system in terms of people, institutions, and applications. The organizational requirements analysis sorts out which individuals are interested in employing LIS/GIS, and what expertise they have;

- Conceptual Design stage comprises user needs assessment, user requirement analysis, application & database conceptualization, and system development plan. User needs assessment differs from the organizational needs assessment because it is a detailed assessment designed to gather specific information for producing technical specifications. In user needs assessment one should gather information about data, procedures, and products. The information can be obtained through mandate/statute reviews, construction of data-flow diagrams, questionnaires and interviews. Requirement analysis determines the hardware, software, communications, personnel and training requirements. In application & database conceptualization, one must identify priority applications and the data needed to support them. The system development plan defines the procedures and timelines for completing implementation;

- Development stage comprehends initial technology acquisition & installation, application prototype/database physical design/quality assurance, pilot project (application & database development and evaluation), and system operation plan. The pilot project is used to evaluate the database and applications. System operation plan lays out the tasks necessary for full implementation. According to the authors, at this point, the team should address the issue of interagency data integration; and

- Operation stage consists of application development and implementation/database development (full scale data conversion), application & database maintenance, and system audit/evaluation. The authors understand that the team must evaluate the system periodically to ensure that it is progressing in the right direction.

The authors also propose that LIS/GIS must, by its very nature, be an integrated program from top to bottom, from one organization to another.

5.5- The Steps Toward Land Record Modernization of Ventura

Ventura suggests that an automated land information system (LIS) is a necessary component of an overall land records modernization plan [VENTURA91] (see also [VENTURA93] and [VONDEROHE91]). One assumption of the proposal of Ventura is that the envisioned system is a multipurpose LIS. The author argues that: "*Although it may require more effort to start a system that meets the needs of many groups, long run benefits are more likely to result, and the benefits are likely to be larger*" (pg. 2). Another assumption is that the agencies will be starting implementation with relatively little automated geographic data. Ventura proposed six steps toward land record modernization, described bellow.

Step 1: Technology Introduction

The purpose of this first step is to introduce an organization to the new concepts and methods, and to introduce potential users to the implementation process. The author presents five kinds of activities involved in this first step: (1) Identifying the people who will have the lead responsibility for system implementation; (2) Educating the leaders in all aspects of GIS implementation; (3) Convincing decision-makers that changes are needed; (4) Conducting a preliminary census of spatial data users (it can be used to select initial project participants, and to identify basic data resources and custodians); and (5) Introducing potential users to the technology. Ventura suggests to include initially those departments which record or produce basic spatial data, or which are large-volume users. Other users can be included when the system is *technically mature*. Ventura also suggest that in situations where there is little experience with LIS., it may be appropriate to start small, with only a few participants. The author understands that education is a valuable tool for overcoming some of the fear of change, and that the best arguments for persuasion of management or elected officials are those based in costs and benefits. Educational activities may include site visits, workshops, short courses, and technical readings.

Step 2: User Needs Assessment

Ventura presents two purposes for user needs assessment: (1) To help understand current land information systems, and (2) to provide detailed information for components and applications of the new automated system. The author proposed a Conceptual Assessment of the system, or the assessment of its overall scope in terms of people, institutions and applications. The major elements to be identified are: the goals of the system (whether primarily a land records system or whether a planning system or other), the bounds of the project (who is included, geographic extent, layers included), general time lines and development stages (priorities for application development), connections of the LIS with other information systems or databases, and the responsibilities of each participant. Ventura suggested to discuss these ideas with a small group first (possibly the LIS steering committee). The Detailed Assessment starts after agreement on the general goals and scope of the LIS is reached. This detailed information should be gathered from potential users through questionnaires, interviews, mandate reviews, and data flow diagrams. Information about data (data sources, flows, transactions, updates, and data models), processes (mandates, procedures, applications, and analysis), and products (information products, advantages of LIS) should be gathered.

Step 3: System Requirement Analysis

According to the author, in this step one should determine the appropriate software and hardware based on the results of needs assessment. Ventura presented five major elements of system requirement analysis:

- Determining software functionality, by ranking priorities in application development as what is *essential*, what is *desirable*, and what would be *nice to have*,

- Determining hardware requirements in terms of type of operating system, speed/ memory of CPU, size of hard disk, compatibility with computing environment, and network / distributed processing capabilities;

- Defining the degree of system customization, required data accuracy, approach for partitioning space (layers, raster or vector), etc.;

- Plans for the transition to automated operations such as staff responsibilities and database maintenance procedures; and

- Request for proposals.

Steps 4, 5 and 6

The author presents only an overview of the last three steps:

- (4) System Design defining application modules, database models, specification of hardware & software, and administrative framework;

- (5) Implementation plan including definition of tasks, responsibilities, needed resources (funds, data, staff), and timelines; and

- (6) Pilot projects providing experience on a small scale before full commitment to new methods.

5.6- Other Implementation Methodologies

Kevany presented an *Automation Roadmap for startup of an MPLIS* (Multi Purpose LIS) *automation project* [KEVANY93]. The Roadmap of Kevany comprises twelve basic task areas: Requirement analysis, conceptual design and feasibility study, strategic & implementation plan, organization & staff training, system design, database design, system acquisition, system installation, database development (including data loading), application programs & operating procedures development, pilot project, and automated operations & maintenance. The basic content of Kevany's proposal is equivalent to another proposal of Kevany & others [ANTENUCCI91], described in section 5.1 of this report. Joffe [JOFFE90] presented an outline of GIS development consisting of five stages: Strategic planning, system specification, database construction, system implementation, and ongoing operations. De Man [De Man90] argued that to ensure coherence in the various decisions and choices concerning GIS planning and design one should develop a strategic information plan at the "object system" level. De Man's approach to GIS planning and design involves identifying the "Relevant Decision Areas" and determining

which decisions must be taken now and which ones may be left open to permit more confident choices in the future. Teixeira & others [TEIXEIRA93] propose three phases to GIS implementation: Preliminary design, design and implementation, and normal operation. Aronoff [ARONOFF89] presented a *framework for implementation* covering the entire *technology transfer process*, from awareness to adoption (incorporation in day-to-day activities). The proposed framework consists of six phases: Awareness and sale of ideas, developing system requirements, evaluation of alternative systems, system justification and development of an implementation plan, system acquisition and start-up, and the operational system. Dias [DIAS93] proposed four steps for GIS implementation: User requirement analysis, cost-benefit analysis, implementation plan, and tasks specification.

5.7- Coverage Analysis and Content Comparison

Table 5.1 presents the coverage of the Implementation Methodologies. The letters printed into the table's cells identify the proposals through their author's initials. The letter "A" identifies [ANTENUCCI91], "C" identifies [CLARKE91], "L" - [LOVE91], "Va" - [VASTAG94], and "V" - [VENTURA91]. The Implementation Methodologies addressed prevailingly the Information System Design group. Most of the proposals were included in the discussion about GIS design model.

5.7.1- GIS Design Model

Table 5.2 presents a summary of the proposed GIS design models. The vertical dimension represents time or sequence of events. For example, in the first column (Antenucci & others), *feasibility*/C-B (feasibility or cost-benefit analysis) is placed bellow of *needs analysis*. This means that *feasibility* should be performed after *needs analysis*. We changed some original words of the models to ease comparisons.

As shown in Table 5.2, the relative position of some tasks differs from one model to another. We discuss some of these differences bellow.

Position of User Needs in relation to the definition of project scope and goals.

Ventura, Vastag & others, and Clarke place the definition of goals and scope before (a comprehensive) user needs assessment. In this case the role of user needs assessment would be to gather detailed information for system design and specification. Love, and Antenucci & others propose no mechanism for definition of goals and scope before needs assessment. In this last case the role of needs assessment includes the definition of goals and scope (such a definition would be -based on the results of needs assessment).

Position of Feasibility or Cost-Benefit Analysis.

For all the models feasibility analysis is a basis for project approval and commitment of funds. The difference lies on how many tasks are performed before feasibility analysis and before project approval. Antenucci & others and Clarke place feasibility analysis after user needs assessment while Vastag & others place it before. Note that the tasks performed before project approval must be funded or enabled some other way (because the "approval" of funds/ resources comes after that).

Position of Pilot Project.

All the models include a pilot project but they do not agree about its relative position. Love places the pilot before (and during) user needs assessment. In the proposal of Clarke, the pilot is positioned after a preliminary design and before system specification. Vastag & others, Ventura, and Antenucci & others place the pilot after system design. If the pilot is placed after the design, its main role will be to test such a design. By the other hand, if the pilot is placed before (or during) needs assessment and system conception, it can be used as a mechanism of communication between users and developer, helping the assessment of user needs and system definition.

Position of Implementation Plan.

Love recommended to place the implementation plan as the first implementation activity. Antenucci & others and Vastag & others place it after user needs assessment and feasibility analysis, and before detailed design. Clarke and Ventura position the implementation plan after system conception and design. The most immediate consequence of the position of the implementation plan is how many activities it will help coordinate: All the activities, including user needs assessment and design, or only the effective implementation (acceptance test, data base loading, etc.).

	mention the importance	generic proposals	detailed proposals or insights
Overall Strategy			
strategic planning/ risk evaluation			
implementation pace and scope		V, Va	
Information System Design			
implementation plan		V	A,L,C,Va
GIS design model		V	A,L,C,Va
role & position of pilot project		A,V	L,C,Va
detailed design techniques			V[1]
Project Enabling Strategies			
top-level persuasion/ support	C	A,V	
organizational conflicts/ user resistance		V	
funding strategies			
communication channels/ project marketing		Va	
training strategy and role		A,C,V	
Project & System Management			
system location/ coordination bodies			A
GIS staffing, consultant & contractors		L	A
project control		A	
management of risks, IS function & strategy		A,Va	

Table 5.1- Coverage of Implementation Methodologies

1. User needs analysis

Training, Education, and Awareness Generation.

Vastag & others proposed *awareness generation* (through GIS championing) as a first stage. Ventura included *education of leaders* in the beginning of the implementation process as well. In both cases the main goal is to obtain support for the project. Antenucci & others and Clarke included training as an activity of the implementation process, but not in its beginning. In this last case, the training program addressed system operation and use.

5.7.2- Implementation Pace and Scope

Ventura and Vastag & others suggest that the envisioned scope of LIS/GIS implementation should be an integrated, multipurpose system. In situations where there are little experience about LIS, Ventura suggests to "start small" and that the departments which record or produce basic spatial data, or which are large-volume users, should be addressed first.

Antenucci & others[2]	Clarke	Love	Vastag & others	Ventura
-user needs -feasibility/C-B -implemtt. plan -system & DB design **bellow, in parallel** -system & DB acquisition -organization, staffing & training -design of new procedures - installation -pilot -DB conversion -full developmt. -transition -system review	-scope & goals definition -user needs -preliminary design -feasibility/C-B -pilot -specification -RFP & system selection -review of feasibility/C-B -implemtt. plan -contract, acceptance test -training, DB loading, & start to monitor performance	-implemtt. plan -familiarization user-contractor -pilot -user needs -specification -DB design -full developmt. -installation	-awareness generation -organizational needs & overall scope definition -feasibility/C-B -user needs -conceptual DB/ system design & specification -implemtt. plan -acquisition & installation -detailed design -pilot & design evaluation -operation plan -full develop. & DB conversion -system review (or evaluation)	-preliminary census of data users -education of leaders/ introducing users to LIS -initial definition of goals & scope, timelines, develop. stages, and responsibilities -user needs -specification -transition plan -RFP -system design -implemtt. plan -pilot

Table 5.2- Simplified System Design Models

6- Success Factors & Dependencies

6.1- The Dependencies and Success Factors of Croswell

Croswell reviewed GIS implementation histories and other information system literature and synthesized the obstacles for GIS implementation reported therein [CROSWELL91]. Croswell pointed out major groups of obstacles:

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2. According to Figure 5.2, all the activities included in the stages Development, Operation and Audit can occur in parallel, as well as part of the Design stage. In this Table, this means that all tasks bellow "system & DB design" can occur in parallel. We will consider such a parallelism in our analysis, when pertinent. In the other proposals, we represent parallelism between two tasks by joining them in a single task (for example as in "Pilot" & "Design Evaluation", in the Vastag & other's model).

- Planning/ Management Support (lack of, or inadequate implementation plan, lack of understanding or commitment by management, and inadequate high-level support or mandate);

- Organizational Coordination of Conflicts (inadequate coordination or communication among participants, internal power struggles, and conflicts with main data processing organization);

- Training/Understanding of Technology (insensitivity to cultural/cognitive issues, poor system documentation, lack of trained staff or recruitment problems, and lack of understanding of the technology); and

- Data and Software Standards / Data Integration (data integration or inconsistency problems, no accepted standards for procedures or data).

Based on this study Croswell presented the following guidelines to "*increase the opportunities for success*" in GIS implementation:

- Perform an Initial Evaluation of Organizational Risk - An evaluation of the readiness of the organization to accept and effectively use the technology. The project implementation pace should be based on the results of the risk assessment. If the managers or users are not ready to accept the GIS, additional education may be necessary before proceeding;

- Get Commitment from Management. According to Croswell, the real benefits of GIS technology lie on the organization-wide integration, and this integration requires support from management;

- Assign a GIS Manager Early in the Project;

- Adopt a Structured Approach for System Development. Croswell suggests to consider the use of a prototype project to test the database design and GIS applications;

- Involve Users in Design to provide accuracy in requirements assessment and to encourage a cooperative spirit,

- Formulate a Goal-Oriented Plan and Schedule. The implementation plan should describe implementation steps, milestones, the responsibilities of those involved (staff, managers, outside contractors), staff time requirements, etc.;

- Develop a Project Organization that Encourages Cooperation and Consensus. Croswell suggests two main coordination bodies, the Policy body and the technical body. The former, consisting of top-level management and senior managers from the major departments involved in the project, is responsible for decisions on major issues and *development milestones of the project.* This group should resolve problems of interdepartmental coordination. Croswell also suggests that management can encourage communication and coordination between multiple departments by dispel fears associated with new technology (loss of job, prestige, or authority) and by defining organizational-

wide goals and benefits. The *technical body* comprises mid-level managers and technical staff. It is responsible for the detailed issues of system planning and implementation;

- Allocate Sufficient Staff Time;

- Keep Users, Managers, and Constituents Informed through periodic presentations by the GIS manager and newsletters even after the system is operational; and

- Provide Education and Training at All Implementation Stages. Before selection of GIS hardware and software, educational activities may involve seminars on GIS concepts, presentations by vendors, and attendance at conferences. After hardware and software selection, specific training to different users and a continuing education in-house program to new users should be provided.

6.2- The Dependencies of Ventura, Huxhold, Brown and Moyer

Ventura and others presented the barriers from the traditional organizational structure to implementation of MPLIS (multi-purpose land information systems) [VENTURA92]. They argue that "Recognizing these barriers should be helpful in developing a program to move from current manual or semi-automated procedures to an MPLIS, and managing it in such a way as to ensure its long-term success" (pg. 4). Those barriers are:

- *Departmentalization* (the organization-wide goals become secondary);

- *Inter-professional Barriers*. According to the authors, the diversity of professions, background, and knowledge results in different values and expectations and makes communication more difficult;

- *Resistance to change*. Individuals may view changes as threatening their jobs, as difficult, unnecessary, or as a mistake (personal inertia). Resistance to change may also occur when there is substantial investment in existing procedures or when there is "something to hide" - like poorly managed or incomplete data (organizational inertia); and

- Lack of access to (new) skills necessary for the design and management of the MPLIS. The authors also propose the following "*organizational keys in moving toward an MPLIS* ":

- Getting top level *management support* before, or at least early in, the development process. The authors argue, however, that the lack of such support is not a fatal flaw, and that through cooperative agreements it is possible to get the necessary funds (see also the topic "*cost sharing*", bellow).

- *Committees to support* MPLIS development (steering committee, or policy body, and technical committee);

- *Cost sharing* among the participants, as "An alternative to acquiring the up-front budgetary support necessary for an MPLIS.." (pg. 10);

- *System location*. The authors proposed two approaches: (1) Creating a whole new organization, or (2) dividing the responsibility between the data processing department (hardware and software) and each other functional unit (maintaining the records for that particular file);

- *Economic factors*. It is recommended to define the costs and benefits of the MPLIS and to document the costs of the current manual system in order to build the necessary management support;

- *Technical factors* (the form and quality of existing records, and the suitability of existing hardware and software for new or expanded applications);

- *Personal factors* (level of education, exposure to and experience with computing and LIS, personal motivation);

- *Personnel factors* (the need to train or hire the competent staff necessary, and the need to keep the staff, once it is in place). The authors suggest to develop a personnel plan defining the positions required to develop and operate an MPLIS, and an ongoing training program to keep staff up-to-date. They suggest some specific MPLIS personnel functions: MPLIS manager, MPLJS (or GIS) analyst, MPLIS system administrator, MPLIS data base administrator, MPLIS programmer, MPLIS processor (or a "super user"), MPLIS Digitizer, and other possible functions (cartographers, draftsmen, and photogrammetrists).

6.3- The Success Factors of Engelken

Engelken presented three critical elements for the success of AM/FM projects [ENGELKEN94]:

- *The right person at the helm of the project*. Engelken argues that the project manager must have high level of both *intellectual energy* (intellectual capacity to understand and solve complex issues) and *personal energy* (capacity to establish and maintain personal relationships at all levels within the organization). According to the author, communication can make the difference between a project being a technical success or being recognized as a business success;

- *The right environment in the company for foster success*. Engelken argues that projects can fail if they are out of phase with the readiness of the organization to embrace it, and proposes two ways for assessing and cultivating the right environment- (1) Through education of users and executives, and (2) by conducting an initial feasibility study comprising a business case for the project on the basis of both economic and strategic criteria and a measure of the receptiveness for the project among executives and users. The author also argues that the project must provide regular usable deliverables to maintain continued support; and

- A *good plan* identifying all necessary steps to achieve clearly defined goals within realistic time frames and resources.

Engelken also proposes practical project *management tips* to increase the chances of success:

- Use a computerized project scheduling tool;

- Be sensitive to project risks and develop contingency and risk mitigation plans as these risks begin to materialize, and

- Provide for both project 'contingency' and project 'discovery' budgets within the project plan.

6.4- The Success Factors of Koller

Koller [KOLLER93] analyzed the factors that limit the introduction of innovations in large western organizations and proposed a set of success factors to overcome these impediments in similarly conservative environments:

- Obtaining top management support;

- Providing appropriate training to management and professional workers;

- Associating monetary and other incentives (for the workers) to productivity gains based on the new technology;

- Delaying criticism until the original idea has at least been developed into a clearer concept;

- Modifying the organizational climate to allow mistakes and to encourage the taking of calculated risks;

- Allocating special management time and effort to start-up projects;

- Opening informal lines of communication between departments that are participating in the innovation; and

- Patience.

Koller also presented a case study of successful GIS introduction (Survey of Israel), and attributed the implementation success to a people-oriented philosophy, saying: "*..much managerial effort was spent on interdepartmental persuasion, interpersonal communication, incentives to the individuals involved, political infighting, training, appropriate changes to the physical (and psychosocial) environment, and marketing the project to outside bodies*" (pg. 78).

6.5- Other Success Factors

DiSera [DiSERA93] pointed out the main obstacles for the introduction of an organization-wide AM/FM system in a large public utility.:

- *Different priorities between departments*;

- *Management commitment*. DiSera argues that many upper level managers do not understand the technology, its potential for decision support, and the need for an organization-wide implementation strategy;

- *Territorialism* (power struggles regarding information property and control, fears about budget cuts or loss of power, etc.);

- *Political constraints*. DiSera mentions that AM/FM projects need the support from elected officials, who tend to think in terms of short-term results (within one electoral term). Their short-term thinking makes difficult a long-term funding commitment, and creates an ongoing threat of discontinuity in development; and

- Funding strategy (difficulties to achieve agreement about cost distribution among departments or about cost recovery involving service rate increases).

DiSera argues that by acknowledging and addressing those obstacles the utility company will help ensure organizational acceptance and support (ultimately resulting in a successful implementation and long-term viability).

Antenucci, Brown, Croswell, Kevany and Archer [ANTENUCC191] (pg. 235) presented the elements of success in GIS implementation: Rigorous planning, focused requirements;, realistic appraisal of effort, dedicated and motivated staff, adequate finance plan, thoughtful time, and balanced expectations. Ferrari and Garcia [FERRARI94] (pg. 34) pointed out characteristics of the environment which hinder GIS implementation: Difficulties to convince managers due to (only) long-term benefits, inconsistent data, difficulties for coordinating multi-departmental needs, non-familiarized users, lack of planning practice and governmental stimulus to planning, and resistance to change. Hawkes [HAWKES92] presented factors for success in a multi-user, multi-vendor GIS project: Strong executive commitment and solid budgetary commitment, strong project management, common goals and focus, high-quality data, and easy of access and updating. The proposals of Korte [KORTE92] and PTI & ICMA [PT191] include Success Factors & Dependencies too, but they are described in Section 8.

6.6- Coverage Analysis and Content Comparison

Table 6.1 presents the coverage of the *Success Factors and Dependencies*. The letters printed into the table's cells identify the proposals through their author's initials. The letter "C" identifies [CROSWELL91], "E" identifies [ENGELKEN94], "K" - [KOLLER93], and N" identifies [VENTURA92]. A prevailing feature of the *Success Factors & Dependencies* is that the proposals are generic. They do not focus on any specific group. The only issue which received more than one specific proposal is System Location/ Coordination Bodies.

6.6.1- Strategical Planning and Risk Evaluation

Croswell and Engelken propose to assess the organization's readiness to embrace GIS. Engelken also proposes a business case based in economic and strategic criteria.

6.6.2- Implementation Pace and Scope

Croswell argues that the real benefits of GIS lie on organization-wide integration. Korte suggests the same idea. Elgenken suggests that the project should provide regular deliverables to maintain continued support. Croswell understands that the definition of the implementation pace should be based on a organizational risk evaluation.

6.6-3- Implementation Plan

Engelken understands that the implementation plan should be sensitive to project risks, and should involve contingency plans and risk mitigation plans as these risks begin to materialize. Elgenken also recommends to provide budgets for project contingency and discovery, and to use a computerized project scheduling tool. Koller suggests to allocate special management time to start-up projects. Croswell described the general goals of a implementation plan: Sequence of events, schedule, responsibilities, etc.

6.6.4- Top Level Persuasion/ Support

Ventura & others indicated *getting top level support early* as a key factor to implementation success. To get top-level support, they propose to evaluate the costs and benefits of the multi-participant LIS and the costs of the current manual system. The authors argue, however, that the lack of top level support is not a "*fatal flaw*", and that through cooperative agreements it is possible to get the necessary funds.

6.6-5- Organizational Conflicts/ User Resistance

Koller proposes to provide monetary and other incentives (for the workers) due to productivity gains based on the new technology. Croswell proposes user involvement and organizational-wide goals and benefits. In addition, Croswell suggests that a *policy body* should be responsible for solving problems of departmental coordination.

6.6.6- Funding Strategies

Ventura & others suggested cost sharing as a strategy for project funding.

6.6.7- Communication Channels/ Project Marketing

Croswell proposes to keep users, managers, and constituents informed through periodic presentations by the GIS manager and newsletters even after the system is operational. According to Engelken, communication can make a difference between a project being a technical success and being a business success. Engelken suggests that the project manager should establish and maintain personal relationships at all levels of the organization.

6.6.8- Training Strategy and Role

Croswell proposes to provide education and training during all implementation stages. Before software selection, educational activities may include seminars, presentations, and attendance at conferences. After system selection, specific training and an in-house program to train new users should be provided.

	mention the importance	generic proposals	detailed proposals or insights
Overall Strategy			
strategic planning/ risk evaluation		C, E	
implementation pace and scope		C, E	
Information System Design			
implementation plan		C, E, K	
GIS design model			
role & position of pilot project			
detailed design techniques			
Project Enabling Strategies			
top-level persuasion/ support	C, K	V	
organizational conflicts/ user resistance		C, K	
funding strategies		V	
communication channels/ project marketing	K	C, E	
training strategy and role	E, K	C	
Project & System Management			
system location/ coordination bodies			C, V
GIS staffing, consultant & contractors		V	
project control			
management of risks, IS function & strategy			

Table 6.1- Coverage of the Success Factors & Dependencies

6.6.9- System Location/ Coordination Bodies

Croswell proposed two main coordination bodies: (1) The policy body, formed by top-level managers and senior managers from major departments involved, and (2) the technical body, comprising mid-level managers and technical staff. The policy body is responsible for the major decisions and for coordination of conflicts while the technical body should deal with detailed issues of planning and implementation. Croswell also suggest to *assign a GIS manager early in the project*. Ventura & others propose a similar project organization: Steering committee (or policy body), and technical committee. They also proposed two approaches for system location: (1) Creating a whole new organization, or (2) dividing the responsibility between the data processing department (hardware and software) and each other functional unit.

6.6.10- GIS Staffing, Consultant & Contractors

Ventura & others suggested personnel functions such as MPLIS (Multi-purpose Land Information System) manager, MPLIS analyst, MPLIS system administrator, MPLIS database administrator, MPLIS programmer, and MPLIS digitizer.

7- Research Findings

7.1- The Findings of Campbell and Masser

Campbell and Masser performed a series of studies related to GIS adoption. They conducted two surveys (1991 and 1993) in all the 514 British local government authorities, addressing both GIS users and non-users [CAMPBELL92b, MASSER94b, MASSER93]. They also conducted 12 case studies in British local governments [CAMPBELL94], interviews with system designers and users in Massachusetts and Vermont [CAMPBELL92a], and other analysis [CAMPBELL93, CAMPBELL91]. We report bellow some of the findings from these studies.

Overview of GIS Adoption

Table 7.1 shows the evolution of GIS adoption in British local governments between 1991 and 1993.

Spatial, Demographic and Political Influences on GIS Adoption

Masser presents a statistical analysis about the influences of population size, rate of growth, and agency location (north or south of Great Britain) on GIS adoption in British local governments [MASSER93]. The author concludes that, statistically, population size is the most important predictor of GIS adoption, that the effect of the agency's location (North or South) is not so important, and that the rate of growth (increasing or decreasing) and the political party influence is minimal.

Perceived Benefits, and Nature of Use

The authors analyzed the perceived benefits from GIS introduction of GIS. In the Survey of 1991, 60% of the respondents as the most important ones "improved information processing facilities" (such as data integration and better access to information). A further 31% stressed better quality in decisions (at the operational level - 38%, managerial level - 28.8%, and strategical level - 25%), and only around 6% linked the main benefits to savings. Based on the majority of respondents who perceived "a greater range of tools with which to display and analyze information" rather than more fundamental administrative advances, Campbell suggest s that GIS had exerted a limited impact on those organizations [CAMPBELL93]. The findings of the twelve case studies confirm a limited impact, even after a minimum of two years of experience [CAMPBELL94]. Campbell reports that only three of the case studies had reached the stage where at least one application was being employed by end users. A further seven were either still developing the system or had achieved an operational application but it was not being used. Two remaining case studies had abandoned the development. Most of the applications being developed aimed to assist operational activities. The key application area for most authorities were automated mapping facilities.

	1991	1993
Already have GIS facilities	16.5%	29.0%
Plans to acquire GIS within one year	8.6%	9.7%
Considering the acquisition	44.2%	27.0%
No plans to introduce GIS	30.7%	34.2%

Table 7.1: GIS Adoption in British Local Governments (adapted from [MASSER94b])

Campbell reports similar findings from the interviews performed in Massachusetts and Vermont [CAMPBELL92a]. Campbell mentions that a number of agencies with technically operational systems felt frustrated by the limited use of these facilities by professional staff and decision-makers. The main concerns at that time were ownership and control of information, and how to ensure that this information will be utilized within the policy-making process. According to Campbell, a number of individuals suggested that a more effective GIS utilization would have been assisted by addressing such matters at the project start-up rather then part way ahead.

Corporate Versus Departmental Approach

Campbell and Masser reported that there is a 50:50 split between a more corporate and departmental approaches in British local governments [MASSER94a]. Regarding the influence of the adopted approach on the perceived benefits of the GIS, Campbell mention that "Mere appears to be little support for the suggestion that strategic and efficiency type benefits are associated with corporate systems" [CAMPBELL93].

Campbell points out the main advantages and disadvantages of the corporate and departmental approaches to GIS implementation Table 7.2 resents some of the suggested advantages and disadvantages.

	Corporate	Departmental
Advantages	-increased efficiency due to reduced duplication leading to time, staff and cost savings.	-independence, control over priorities and access; -clear lines of responsibility.
Disadvantages	-variations in department's priorities, awareness, and skills between departments; -inter-departmental disagreements about standards, leadership, etc.	-departmental isolation, absences of authority-wide benefits, lack of system and data compatibility, lack of support in terms of finance, technical specialists, and training.

Table 7.2: Advantages and Disadvantages of Corporate and Departmental Approaches (adapted from [CAMPBELL93]).

Typology of GIS Implementation

Based in the broad trends revealed by the survey findings, Campbell identified a three-fold typology of system implementation [CAMPBELL93]:

- Classically corporate. This implementation style occurs when a large number of departments (possibly the whole authority) participate in the project, and when the lead is taken by the computer services or planning department. This approach has been adopted by 15% of the surveyed organizations;

- Theoretically pragmatically corporate. This style is characterized by the involvement of only three or four departments with the lead taken by the computing or technical service type department (in certain cases involving joint responsibility for the project). This approach can arise from a pragmatic decision amongst departments to pool resources, or from attempts to a coordinated and wide-ranging implementation which have fallen short of this goal. This approach was found in around 35% of the surveyed systems;

- Fiercely independent. This approach occurs when the introduction is conducted by a single department. The department is likely to be involved with technical services, to have considerable experience on information handling, and to have in-house technical expertise. This approach was adopted by around 50% of the surveyed systems.

According to the identified trends, in all the three approaches the GIS is not expected to provide, primarily, improvements in efficiency or in the quality of decisions. It is likely to enhance the information processing facilities, instead.

Four Success Factors

Campbell proposes four factors which enhance the chances of achieving successful implementation [CAMPBELL94]:

- Simple applications producing information which is fundamental to the work of potential users;

- An awareness of the limitations of the organization in terms of the range of available resources;

- User-directed implementation; and

- A large measure of stability with respect to the general organizational context and personnel, or an ability to cope with change.

7.2- The Survey of Onsrud and Pinto

Onsrud and Pinto performed a large-scale survey in local government organizations that had acquired GIS technologies [ONSRUD93a, PINT093]. They asked the respondents to indicate:

- The relative importance of some selected factors to the successful adoption of GIS in their organizations;

- The sequence of steps taken to GIS acquisition;

- Their perceptions about the usefulness and value of GIS to their organizations; and

- General features of the respondents and of their organizations.

The survey obtained a response rate of 50 percent (256 responses). The sections bellow show the results of statistical analysis performed on the survey's responses, and the authors' conclusions.

The Factors Predictive of Success

The research defined eleven groups of factors (independent variables) possibly predictive of success in GIS adoption (dependent variable). The authors employed three measures of success: "Perceived Value", "System Use", and a combination of both. For the measure "system use", the independent variables which were found statistically significant are "Utility" and "History of Past Failures" ("Utility" refers to the advantages of the new system over current processes, adequate data accuracy, consistency with organizational goals, easy of generating results, and to the ability to expand the types of uses in the future). In other words, the system is perceived as useful when members of the organization perceive the advantage of the new system over the old methods, when those members have had experience with past computer systems failures, and so on. By another viewpoint, the system is most likely to be used when such conditions are present. For the measure "Perceived Value", the significant groups of factors are "Utility", "Ease of Use" (availability of existing data, ease of data transfer, availability of skilled people, GIS compatibility with existing computer systems), "History of Past Failures", and "Proximity to Other Users". These results mean that the GIS is most likely to be (perceived as) valuable to the organization when it is easy to assimilate and use, when the users perceive its advantages over old methods, and so on. For the "aggregate measure of success", defined by a combination of both variables "System Use" and "Perceived Value", the factors significant factors are "Utility", "Ease of Use", "History of Past Failures", and "Cost". The factor "Cost" (cost of hardware and software, data entry, cost of retraining staff, and easy of pilot study) is relevant in a negative sense. Cost is regarded as an unimportant factor by those more successful adopters, and as important by those less successful. The authors suggest that the lack of pressing concerns about costs is a significant predictor of the perceived success. The authors highlight that "Utility" and "History of Past Failures" are significant in all the three measures.

The Steps to GIS Acquisition

The questionnaires suggested possible steps to GIS acquisition. The respondents were asked to rank order these steps to most accurately represent the progression of events in their organizations. The results of this analysis include the percentage of respondents indicating that one specific step was undertaken, and the prevailing order in which those steps were executed:

- (1) Seek and acquire a GIS consultant (undertaken by 55% of the respondents);
- (2) Prepare informal proposal for GIS introduction (78%);
- (3) Identify GIS user needs (93%);
- (4) Seek staff support for GIS (87%);
- (5) Match GIS to tasks and problems (85%);
- (6) Identify GIS location within organization (83%);
- (7) Prepare formal proposal for GIS introduction (76%);
- (8) Undertake request for proposal - RFP (80%);
- (9) Conduct a pilot project (76%);

- (10) Enter a contract for purchase (96%);
- (11) Acquire GIS technology (100%).

According to the authors, the steps 4, 5, and 6 were always grouped strongly together, suggesting that these steps typically occur simultaneously with each other (or that their order is inconsequential). They also suggest that those more successful in their ultimate use tend to progress the acquisition through overlapping steps.

The authors performed the same statistical analysis using different subgroups of respondents (more/less successful). but they have not found significant differences on the sequence of steps. Other results are presented in [PRJT093]. A background discussion on their research is presented in [ONSRUD91, ONSRUD92].

7.3- The Survey and Case Studies of Budic

Budic conducted four case-studies and a survey (99 respondents) in local government agencies of the United States [BUDIC93a]. The goal of the research was to identify the factors affecting success in GIS adoption. "Adoption" was measured in terms of organizational adoption (utilization of the technology for performing organizational tasks) and individual adoption (level, type and intensity of utilization of the technology by staff members, for organizational purposes).

The possible factors influencing adoption success were organized in personal factors, GIS management activities, organizational environment, and organizational internal context. The research results show that the significant factors are:

- Personal factors: Perceived relative advantage from GIS technology, Compatibility with previous computer experience; Exposure to GIS technology, Communication behavior (networking); and Attitude toward work-related change,

- GIS Management: Provision of incentives for prospective users; GIS training; Securing financial resources; Initiation of tandem structure (manager-technician team); Commitment;

- Organizational Environment: Political support; Governmental mandates; Provision of external funding; Size of the jurisdiction; Variability of the jurisdiction (rate of growth);

- Organizational Internal Context: Organizational conflict, Organizational change/ stability; Motivation for incorporation of GIS technology; Resources (financial, human, technological). Based on these results, Budic proposes *directions for designing policies for the successful diffusion of GIS technology*. According to Budic, the prime element of such a policy would be to seek political support for GIS during its initiation. Other fundamental element would be the choice of the implementation strategy. Budic identifies three GIS implementation approaches: (1) Planned (comprehensive approach; (2) Incremental approach; and (3) Experimental approach. Budic suggests that the Planned approach is the most likely to lead to successful implementation of GIS (its full incorporation into organizational functions). The main difference between the Budic's Planned approach and the other two lies on the amount of management action. The Planned approach involves extensive GIS management activities intended to foster d individual and organizational adoption. Budic understands that GIS management may

influence individual employees and eliminate effects of negative attitudes. For example, Budic suggests that providing incentives to individual employees who are using GIS may change their perception of personal benefits from the project. Budic concludes that GIS management can speed up the diffusion of GIS technology by reducing anxiety and fear of GIS due to complexity, facilitating contacts between GIS users and non-users, increasing the exposure to the technology, building confidence in working with computers, showing GIS-related (organizational and personal) benefits, providing conditions for gradual change, and facilitating the acquisition of GIS-knowledge. Other results are presented in [BUDIC93b, BUDIC94].

7.4- The Proposals of Pinto and Azad

Pinto and Azad studied the influence of organizational politics in GIS implementation success [PINT094]. They presented a bibliographic review on organizational political behavior (OPB) and proposed a framework defining the ways politics can help or hinder GIS implementation. The authors proposed two managerial principles to promote success in GIS implementations:

- (Principle 1) Learn and cultivate "positive" OPB. The authors define three possible political attitudes: The “naive" or apolitical attitude (willingness to ignore organizational politics); The "shark" attitude (express purpose of using politics and aggressive manipulation to "reach the top"); And "political sensibility". They understand that both the "naive" and the "shark" attitudes are inadequate, and suggest a "politically sensible" attitude. By such an attitude, one regards OPB as necessary to advance the department's goals, and uses negotiation and bargaining, networking, expanding connections, and one uses the system to give and receive favors,

- (Principle 2) Understand, accept, and practice "WIIFM". "WIIFM" is an acronym which means "What's In It For Me?". The authors mention that there are situations in which managers feel frustrated when fail to convince other departments and individuals to support GIS implementation. They suggest that other departments are not likely to offer their help and support unless they perceive that it is in their interests to do so. They argue that simply assuming that these departments understand the value of GIS is simplistic and usually wrong.

The authors presented two case studies to illustrate the proposed principles. They suggest that the major opportunities for "positive" use of organizational politics occur when the organization faces controversial decisions such as decisions about the organizational location of GIS unit, the scale of the base map, priorities for application development, software and hardware platform, and job re-classifications.

7.5- The Survey of Azad and Wiggins

Azad and Wiggins surveyed work-units of 14 local and regional government organizations. The study involved 12 to 18 persons in each organization, in a total of 150 persons [AZAD93a]. Based on the results of this survey, the authors proposed the properties of successful implementation processes. "Success" was evaluated in terms of user satisfaction, perceived usefulness, and ease of use. The authors grouped the *strongest predictors* of success in three categories:

- Flexible plans. The authors observed that precise plans were typically rigid and centralized, allowing little opportunity for technology adaptation, task reinvention, experimentation, or even mid course correction.

They also observed that in the most successful cities, planning efforts gave balanced attention to social and technical components;

- Organizational actions. Organizational actions include the use of champions, user involvement in all decisions, providing users with high-quality and long-term learning support, and top management support;

- Commitment to change or the group's attitude toward change (positive or negative). The authors suggest that resistance to change is observed more often in organizations than in its employees. For example, they mention that organizations are reluctant to invest in training their employees, and seldom acknowledge changes in employee skills, tasks, or performance with changes in job titles or in their salaries.

The Taxonomy of GIS Outcomes of Azad, and Other Survey Results

In another study [AZAD93b] Azad proposes a taxonomy to assess and measure success in GIS implementation. Success is measured in terms of the quality of the GIS, the quality of geographic information, and in terms of the influence the GIS has on individuals and organizations - use, user satisfaction, individual effectiveness, and organizational effectiveness. Wiggins reports other survey results in [WIGGINS93].

7.6- Other Research Findings

Obermeyer and Pinto's book [OBERMEYER94] presents a literature review and background discussions on topics such as the definition of implementation success, critical factors for system implementation, overview of the role of management in an organization, the basic elements of a MIS (management information system), the relationship between geographic information and MIS, principles of map representation, economic justification for GIS, and geographic information sharing. Eason [EASON93a, EASON93b] suggested that a major obstacle to the diffusion of advanced information systems, and GIS, is the lack of effective means of gaining organizational and user acceptance. As an answer, Eason proposed an alternative model for system design which, different from the "technocentric" design methods, is user-centered. The basic strategy of Eason's model is to serve both organizational and human objectives. Other examples of Research Findings are [CULLIS94], [BACON91], and the papers of [MASSER93b].

7.7- Coverage Analysis and Content Comparison

Table 7.3 presents the coverage of the Research Findings. The letters printed into the table's cells identify the proposals through their author's initials. The letter "A" identifies Azad and Wiggins, the letter "B" identifies Budic, "C" identifies Campbell and Masser, "Or"- Onsrud and Pinto, and "P" identifies Pinto and Azad. As shown in Table 7.3, the Research Findings are characterized by a low coverage. Most part of the proposals were classified as "generic

proposals". The unique issue addressed by more than one proposal is "Organizational Conflicts/ User Resistance".

7.7.1- Implementation Pace and Scope

Campbell states that "there appears to be little support for the suggestion that strategic and efficiency type benefits are associated with corporate systems".

7.7.2- Implementation Plan

Based on their findings, Azad and Wiggins suggested "flexible plans" allowing task reinvention, experimentation, or even mid course correction.

7.7-3- GIS Design Model

Onsrud and Pinto point out a sequence of steps to GIS acquisition: Seek and acquire a GIS consultant, prepare informal proposal for GIS introduction, identify GIS user needs, seek staff support for GIS, match GIS to tasks and problems, identify GIS location within organization, prepare formal proposal for GIS introduction, undertake request for proposal - RFP, conduct a pilot project, enter a contract for purchase, and acquire GIS technology.

7.7.4- Organizational Conflicts and User Resistance

Budic understands that GIS management may influence individual employees and eliminate negative attitudes. For example, Budic suggest that providing incentives to individual employees who are using GIS may change their perception of personal benefits from the project. Pinto and Azad suggest two principles: (1) Learn and cultivate "positive" OPB (using negotiation, bargaining, networking, expanding connections, and using the system to give and receive favors); and (2) Understand, accept, and practice “WIIFM" (What's In It For Me?"). They suggest that no department is likely to support GIS unless they perceive that it is in their interests to do so.

7.7-5- System Location/Coordination Bodies

Campbell identified three approaches to system location:

- Classically corporate (centered lead, including all the departments);

- Theoretically/ pragmatically corporate (involving only three or four departments with the lead taken by the computing or by a technical service type department); and

- Fiercely independent.

7.8.6- GIS Staffing, Consultant & Contractors

Onsrud and Pinto suggest to hire a consultant as a first step to GIS acquisition.

	mention the importance	generic proposals	detailed proposals or insights
Overall Strategy			
strategic planning/ risk evaluation			
implementation pace and scope		C	
Information System Design			
implementation plan		A	
GIS design model		O	
role & position of pilot project	O		
detailed design techniques			
Project Enabling Strategies			
top-level persuasion/ support	A, B		
organizational conflicts/ user resistance	A	B, P	
funding strategies			
communication channels/ project marketing	A		
training strategy and role	A, B		
Project & System Management			
system location/coordination bodies	O		C
GIS staffing, consultant & contractors		O	
project control			
management of risks, IS function & strategy			

Table 7.3: Coverage of the Research Findings

8- Implementation Guides

8.1- The Management Framework of Huxhold and Levinsohn

Huxhold and Levinsohn's book focus on management of GIS projects [HUXHOLD95]. In the first two chapters the authors set the theme, scope and conceptual foundations of their proposals. A major element is a management framework: "*There is a need for a guiding philosophy supported by policy and management guidelines, and an organizational structure to implement and monitor the policy and guidelines - a management framework*" [HUXHOLD95], pg. 31. The Third Chapter presents strategic planning as the project foundation. In Chapter Four the authors overview implementation planning. Chapter Five presents a system design methodology (techniques for needs analysis and system & database definition). The authors present their ideas about implementation management (staff and training needs, acquisition of external services) in Chapter Six. In Chapter Seven they present their proposals regarding system management (organizational placement, managing personnel, annual plan and budget).

8.1.1- Strategic Planning

According to the authors, strategic planning should encompass:

a)Development of a *situational analysis* The intent of the situational analysis is to preview how the people and the organization as a whole will respond to planning,

suggested change, and to the introduction of new technology. One should identify the organization's purpose, how does it operate, its culture and management style, the driving forces for GIS, the staff experience and the organizational *constraints* (resources, policy), and risks

b)Establishment of a *strategic vision* of the GIS use in the organization, defining the general direction and ambitions concerning GIS development. The authors mention two reasons for developing a strategic vision statement: (1) To build commitment for the GIS and (2) to align the direction of GIS implementation with other aspects of the organization. To arrive at a strategical vision they suggest to involve senior management and users, to appoint a task force, to summarize the key issues and beliefs of the organization, and to use workshops to reach consensus;

c) *Feasibility*. The authors suggest the definition of a planning horizon (they suggest three years) and assessment of:

- *Financial feasibility* (whether the anticipated costs are compatible with the returns and with the amount the organization is able or willing to spend;

- *Technical feasibility* (whether the required technology is available, practical, and usable by the intended staff with reasonable amounts of training); and

- *Institutional feasibility*. Through discussion with senior managers, to determine their willingness to commit to long-term projects. If they are not willing, "*several smaller projects should be more appropriate*" (pg. 72). The authors suggest that *"Institutional feasibility, more than technical and financial feasibility, is tightly bound with the scope of the project*" (pg. 72-73);

d) Definition of a *strategic approach* and project scope; and

e) Preparation of a *strategic plan* document, which should be reviewed periodically for realignment.

Strategic Planning for Multiparticipant Projects

The authors understand that the structure and characteristics of multiparticipant projects will vary according to each project. The participants may share a combination of data, technology, and development effort or costs. They propose to define such institutional arrangements right after situational analysis.

8.1.2- Implementation Planning

According to the authors, the purpose of implementation planning is to translate the strategies defined in strategic planning stage into a series of specific project tasks, to arrange these tasks into a logical sequence, to schedule time and resources, and to define the means to manage all the implementation process - a management framework.

The authors understand that implementation planning should proceed in parallel to the implementation activities themselves. "*As work proceeds, more detail becomes known,*

permitting more detailed planning" (pg. 91). As a general rule, the authors suggest a detailed planning for the next 3 months. They present the general stages of the implementation process and their connections with the management framework (for details, see Figure 4.1 of the Huxhold and Levinsohn's book, at page 90):

- Based on the strategic planning, project initiation and start-up plan;

- User needs analysis;

- General design and specifications;

- Applications planning and selection (and definition of the implementation management framework);

- Detailed design, specifications, and implementation of each application;

- Operation & maintenance, and annual operating plan (and definition of the operating management framework). The authors presented an outline for the implementation plan

a) Introduction;

b) Background. Review of the strategic vision and other relevant background information;

c) Scope and Objectives of Project (restatement, as a reminder);

d) Conceptual Overview. The business functions that will be supported (and how), the data that will be converted, the units that will be affected, and the overall sequence of development - who will be affected first (and why);

e) The Management Framework. The participants, their roles and responsibilities, the committee and work group structure, their members and authority;

f) Task descriptions (major steps);

g) Schedule;

h) Budget. Present the current, committed, and planned budgets for the project;

i) Administration. Description of how the project will be administrated: Management authority, administration of funds, personnel management, contracting practices and restrictions, standards/architecture, and other administrative policies, restrictions, or special dispensations.

The authors also suggest to include frequent review points, to make no individual task longer than 5 days, to ensure that there is a person responsible for each task, and to use a pilot project to deal with uncertainty. As an example of management framework, the authors suggest the following elements:

- Management authority (steering committee), composed of policy makers and department heads of sponsoring agencies, which is responsible for policy decisions, approval of plans, resource allocation and conflict resolution;

- Liaison committee, composed of management representatives from interested (but not sponsoring) agencies, which is responsible for project monitoring/ communication;

- User working group, composed of line managers and professionals from sponsoring agencies, which is responsible for facilitating needs analysis and design studies, and for reviewing project plans and specifications;

- Design and implementation group, composed of project manager, and of internal or contracted analysts and programmers; and

- Project management team, composed of project manager, project leader(s) and end-user appointments, which is responsible for project plans and deliverables, and for coordination of GIS implementation.

8.1.3- System Design Methodology

The authors propose a *functional approach* to system design, comprising the following elements:

- Documentation of the current *physical model* of the organization. All the organizational units should be identified as well as their functions which require maps or other geographic information;

- Development of the *current logical model* of the system, allowing top management to review the efficiency of current system and to identify possible changes;

- Defining the *new logical model* of the system;

- Definition of *data requirements*.: (1) An *inventory of geographic information* needs (a description of each required maps or drawings); (2) A *map inventory* (characterization of all maps and drawings currently used by potential users); and (3) An *information needs matrix*. defining the importance of each component of the map inventory (one dimension of the matrix) for each one of the functions surveyed (the second dimension). This matrix can be helpful for setting priorities regarding applications, and for determining the contents of a shared database;

-*Definition of requirements for applications* (inputs and outputs of each function);

- Prioritizing applications; and

- Defining *hardware and software requirements*.

8.1.4- Implementation Management

The authors suggest the staff positions and differentiated training program presented in Table 8.1. They also present a table of products and services which, depending on the type of organization, *may be/will almost certainly be* externally acquired. For example, they suggest that *municipal organizations* will "*almost certainly* " acquire external consultancy on information technology, *GIS hardware*, GIS software and related technologies, and *document imaging.*

Staff Position	Training Focus	Training Time
senior management	benefits and implications of GIS	beginning of GIS planning
business unit managers	familiarization, resources allocation	during all the process
non-technical end-users	familiarization, GIS use	beginning of GIS planning
operations staff	GIS operation	prior to needs analysis
systems staff	GIS design techniques, software customization	prior to needs analysis & design, prior to installation and testing
project team	GIS concepts, GIS management	prior to project start

Table 8.1- Staff Positions & Differentiated Training Program of Huxhold and Levinsohn

Huxhold and Levinsohn outline the steps of a procurement process: Gathering information about products and services, elaborating functional specifications and request for proposals, evaluation of proposals, benchmark test, selection and negotiation, and follow-up (notification of unsuccessful respondents and debriefing). They also suggest:

- The possibility of including pilot projects;

- The importance of project reporting activities, demonstrations, and presentations;

- Alternative ways to manage the transition to an operational system: The directive change (imposed by commands and edits), and the participative change (acceptance and commitment before change).

8.1.5- Managing the System

The authors point out four required activities for the management of an operational GIS:

- Determining the most effective organizational placement for the GIS. The authors propose three alternatives: (1) The GIS under control of an operating unit of the organization, (2) the GIS under control of an administrative or other enterprise-wide organizational unit, and (3) the GIS under direct control of the top elected official;

- Retaining and managing qualified staff by providing clearly defined job descriptions and career progression opportunities, by allowing autonomy over user relations and task completion, by involving staff with challenging technologies; and by acknowledging staff of their role in the overall mission of the unit and of the organization as a whole;

- Preparing an annual budget distributing the costs across all users according to their request for GIS services and their utilization of the system. The authors propose two general methods: (1) The allocated method, which establishes funds directly in user

department budgets, and (2) the centralized method, which establishes funds in a separate budget account for the entire organization; and

- Using a project management system that can identify, describe, and report about all work of the GIS unit. All the activities should be defined as projects - either direct projects (new applications, requested changes, installation of software or equipment, etc.), or indirect projects (routine problem resolution, administration or support activities such as back-ups, preventive maintenance, etc.). All the work requests and other planned projects should be organized in a annual work plan. The annual work plan should be a basis for fund and project approval, definition of priorities, staff allocation, etc. It can be also used to monitoring the status of each project, staff performance, etc.

8.2- The Manager's Guide to GIS, of Korte

The book of Korte is intended to be a "*non-technical manager's guide to evaluating the need for and implementing a geographic information system*" [KORTE92]. The book is divided in two parts. The first part defines a GIS, presents a typical local government GIS, and reviews four leading GIS software products (Chapters One to Four). The second part, which contains directions for selecting and implementing a GIS, is described bellow.

8.2.1- The Seventeen Steps for Selecting and Installing a GIS

The seventeen steps of Korte are divided into three phases: Planning, Analysis, and Implementation.

Phase One: Planning

Step 1: Develop a Project Plan. The plan may be simply these seventeen steps, but it should also assign responsibilities, define a schedule and a budget;

Step 2: Obtain Study Approval (the approval is only for the plan, and not for all the process);

Step 3: Educate Managers from the departments which might eventually use the system. It is suggested a half-day technology seminar consisting of an overview of GIS technology, applications, costs, benefits, and pitfalls. Alternative techniques are to bring a system in for demonstration, or to arrange for the managers to attend a GIS conference;

Step 4: Review Existing Operations and Needs. The operations of all potential GIS users should be examined. The process should include a review of the mission and organization of each department, of how it collects, uses, analyzes, and distributes geographic data, and of the needs and problems it has when using this data;

Phase two: Analysis

Step 5: Analysis and Recommendations. The collected data is analyzed to determine whether the GIS is feasible or not. The report should describe potential GIS uses, the GIS database, sources of data, required software functions, and needs regarding new staff

positions and training. It should also include a cost-benefit analysis and a detailed plan with schedule and budget;

Step 6: Obtain Pilot Project Approval

Step 7: Prepare Functional Specifications and Standards. The results of the previous analysis are reformatted for presentation to vendors;

Step 8: Solicit Vendors - Request for Bid (RFB) and Request for Proposals (RFP);

Step 9: Evaluate Bids and Proposals. Select Vendors;

Phase Three: Implementation

Step 10: Detailed Database Design. Once hardware and software is selected, it is possible to refine the schematic database design into a detailed design for that specific system;

Step 11: Conduct a Pilot Project. The key goals of the pilot are to test the detailed database design and the cost estimates for data conversion. Management can, then, make a final decision about proceeding with, delay, or cancel the GIS project before major expenditures are made,

Step 12: Refine the Detailed Database Design

Step 13: Database Conversion

Step 14: Procure GIS Hardware and Software. If the database conversion is done in-house, the users should be trained and at least part of the system must be purchased and installed before this work can begin;

Step 15: Train Users. The training must be completed in time for users to take over database maintenance;

Step 16: Test and Correct the Data;

Step 17: Maintain the Data. The entire maintenance process should be planned in advance. This requires two supporting efforts: Ongoing training for new users, and user support for operating problems and software customization;

8.2.2- The Pitfalls and the Keys to Successful Implementation

In Chapter Eighth Korte discusses the Keys to Successful Implementation, and in the subsequent chapter the author presents The Piqalls of a GIS. The Korte's keys to successful implementation are:

- *Management support*. Obtaining full top management support (and not a partial approval), even if this implies in a delay before starting the project;

- *Data conversion*. The largest portion of the cost of a GIS program is data conversion. Therefore, it is important to carefully consider which information is really necessary;

- *Database maintenance*. The GIS implementation plan should ensure that all the resources needed to take over database maintenance are available in advance of database delivery;

- *Training* (initial training following system installation and a program to train new users;

- *User support and software customization*. A GIS package will not provide optimal use of the technology unless it is customized for particular user's needs;

- *Database cost sharing* between institutions interested in data for the same geographic area.

The common pitfalls of a GIS are:

- *Failure to consider risks; Failure to done goals.* Without clearly defined goals there are no measures for success;

- *Overstating benefits;*

- *Experimental projects*. When an organization interested in GIS decides to give it a try, the GIS receives too-little funds, support, and priority to have a real chance of success. The organization may eventually become convinced that the technology does work, but it must still start from scratch to develop plans for a truly effective GIS program;

- *No longterm planning*. Once defined the goals, plans covering the sequence of events, schedule, and assignment of responsibilities should be defined. The plans should be tailored for the eventual implementation of a fully integrated GIS;

- *Lack of management support*; Lack of user training; Lack of user support;

- *Lack of user involvement*. Without user involvement the project loses the background from their experience, and a sense of indifference or hostility toward the new system is created;

- *Systems that cannot be expanded or modified*;

- *Budget overrun* (or budget underestimation);

-*Failure to report results* to top management, regardless of whether those results are good or bad.

8.2-3- Others Chapters of Part H

In Chapter Six Korte highlights the importance of a planning process as a first implementation step. Korte presents the ways an implementation plan may help ensure success. It may sort out implementation issues and guide the implementation, set goals and a measure for

success. According to Korte, some typical components of a GIS plan are: Introduction and background, existing operations, current limitations and needs, general GIS requirements, conceptual database design, implementation phases and schedule, and expected costs and benefits.

Chapter Ten advocates the use of a consultant in the strategic decisions made during the planning process, and lists the typical objectives of consultants' services: Review and document the current procedures for handling land records, document the problems, limitations, data, processing requirements, and potential applications, develop the GIS conceptual design, implementation plan, cost estimates, and specifications. Chapter Seven addresses GIS software selection. Chapter Eleven describes basic staff positions or functions: GIS manager, GIS database manager, cartographer, system manager, and programmer. In Chapter Twelve Korte presents the types of costs (hardware and software, database creation, and maintenance), the "s of savings a GIS can provide (more cost-effective decisions, improvements in productivity, and cost avoidance), and a sample calculation for determining the hourly cost of GIS operation. Chapter Thirteen presents the factors to be considered when defining base map accuracy, and Chapter Fourteen brings suggestions to overcome common problems in getting data from CAD systems into a GIS. Chapter Fifteen presents a case study of GIS implementation.

8.3- The Guide to GIS Planning and Implementation of P11 & ICMA

Public Technology inc. (PTI) and International City Management Association (ICMA) published a local government guide for GIS planning and implementation [PTI91] . We will reference these institutions as the "authors" of the Guide.

8.3.1- Introduction and Summary of Critical Success Factors

The first Chapter defines GIS, proposes its objectives, suggests possible data and applications, and presents examples of estimates of GIS costs and potential benefits. Then a summary of critical success factors for GIS implementation is presented. The success factors are divided in three categories: Policy, management, and technology:

(Policy)

- One should verify whether or not the "GIS solution" fits the jurisdiction's long-term goals and overall information master plan. Although GIS can be an extremely important part of government planning and problem solving, it is not the total solution;

- Obtaining the understanding and support of top management to conduct an accurate GIS needs assessment is a crucial first step. If a decision is made to implement GIS, the continued involvement of a top-level champion for the entire project is critical to success;

- A GIS usually requires partnerships for sharing data, development and equipment costs. Potential partners are adjacent cities and counties, utilities, and other regional authorities;

- A GIS is a long-term venture that requires a long-term resource commitment. Responsibility for the GIS should be centralized (one unit within the jurisdiction should be charged with overall responsibility). The designated GIS organization should have a dearly defined service orientation toward user departments;

- Local governments should examine revenue opportunities in sales of products to other departments and to external groups including the private sector, other governments, school boards, and utilities. Without some mechanism to price the information, the city departments may not be efficient in the use of this resource. The local government should conduct a brief market assessment of the potential demand for outputs from the GIS;

(Management)

- A GIS is a multi-departmental management tool that can integrate departmental decision making. Despite of its cross-departmental nature and capabilities, it is important to keep expectations and time lines realistic, with a phased startup that all departments agree on, and with visible 'early' results;

- Do not hesitate to use experts during some phases of implementation. Depending on the in-house expertise and system requirements, consulting may be desirable for management of multi-department or multi-agency GIS, cartographic and related data conversion, bid evaluation and negotiations, feasibility study, hardware & software installation and database design, application development, and marketing of GIS products and services;

- Use team-building and inter-group activities to create an environment of confidence, commitment, and participation;

- Follow an implementation plan. Breaking the tasks down into identifiable and manageable steps helps to keep the GIS teams on track. Each phase results in a product or report, a tangible goal for the teams to work toward, as well as a tool for management in gauging progress;

- Make sure the priority applications drive the choice of a GIS;

- Chose the first applications strategically. Select that ones with high potential of success and visibility. Identify a champion who can "spread the word". The authors quote and highlight the words of Habern W. Freeman, from Harford County, Maryland: "My approach to acquisition of GIS/LIS is political, but above all practical. To sell GIS to elected officials, council members, or commissioners, you must first show an immediate product, such as a land-use map with zoning, sewers, roads, etc. It's almost certain that if you first try to convince elected officials to spend millions of dollars to collect information in order to have a product in five years, you will be doomed to failure";

- Maintain a clear distinction between the data conversion process and applications development;

- Use membership in organizations and associations to build local capacity;

(Technology)

- When choosing GIS vendors for hardware and software, take into account vendor reliability, system flexibility, and existing hardware and databases.

8.3.2- Policy Issues and Implications

Chapter Two suggests policies to drive GIS implementation.

Guidelines for Planning Teams

The guide recommends that policy makers should direct the GIS needs assessment team to answer questions such as:

- What problems does a GIS solve? Does a GIS improve services to residents and the business community? How can we quantify this improvement?

- How important are cost savings resulting from a GIS, and how are the savings calculated?

- How soon will GIS products be available? What is the timetable?

- How do we prepare our organization to assimilate a GIS? How will we manage risk?

- What are the advantages and tradeoffs of working jointly with partners to share costs?

- Can we sell access to our GIS?

Scope, Ownership, and GIS Configuration The authors present some possible GIS configurations:

- Single department GIS;

- Shared GIS dominated by single department;

- Multidepartmental GIS, typically managed by a separate office or by the information services department. According to the authors, multidepartmental GIS, though desirable, may not work in the local context due to lack of departmental cooperation. In this last case, another alternative is to use small-scale packages;

- Multiagency GIS, where costs and responsibilities are shared among more than one local government unit, or between a number of governmental or non-governmental partners.

Suggestions Regarding Public Access

Regarding electronic access to GIS products and services, the authors suggest:

- Find out the state regulations about revenues from local government databases;

- Know the market; and

- Consult with the city or county attorney on privacy, security, and responsibility over inaccuracies.

Funding Sources

The authors also present examples of funding strategies adopted by several local governments.

8.3.3- The Steps to GIS, and Other Management Issues in Its Planning and Implementation

Chapter Three presents the following steps to GIS planning and procurement:

- Step 1: Obtaining Top Management Support

- Step 2: Establishing the GIS project Team. Two teams are suggested, the policy team and the implementation or technical team. The policy team, which includes top managers, should make the final decisions on goals and resource allocation, and provide general guidance to the technical team. A project leader or coordinator should be assigned. The technical team should include professionals from all the involved departments. It is also suggested to use a consultant to complement in-house available skills;

- Step 3: Needs Assessment. The Guide presents two components of needs assessment: An inventory of current information resources and an exploration on their gaps. Through interviews, questionnaires, and document review, all potential resources should be inventoried (that includes automated resources, manual processes and files, and personnel). The authors advocate a very thorough analysis of needs. They state that "It is often not readily apparent which processes can benefit from GIS technology, so it is always better not to exclude any information during the inventory of resources" (pg. 46). They also suggest that the most valuable outcome of a very thorough needs analysis is the gradual evolution of an organization-wide perspective by the team members;

- Step 4: Preparing a Preliminary Implementation Plan. This step should translate the results of needs analysis into project design and functional requirements. The implementation plan should meet the long-term strategic objectives, and the short-term delivery of applications within clear budget limits. The plan should define specific stages, applications, equipment, personnel, timetables, and cost estimates. Key elements to be identified are major GIS applications, functions, priorities, the early applications, any known limitations (such as existing systems), cartographic data maintenance needs, links or enhancements to existing automated systems, project benefits, costs and risks, and project time frames and milestones. The expected total duration of the project, the approximate total annual costs, and the project management structure may also be recommended. The preliminary implementation plan should then be presented to the policy team;

- Step 5: Beginning the GIS Procurement Process. The policy team reviews the preliminary recommendations, and agree to fund the project. The implementation plan may be refined to reflect or emphasize the management priorities;

- Step 6: Appointing a Selection Committee. The selection committee may have representatives from the policy and technical teams, line departments, and information services department;

- Step 7: Requesting Proposals

- Step 8: Evaluating and selecting Vendors. Such an evaluation proceeds with the disqualification of all bids that do not meet the mandatory criteria, in-depth review of the finalists, benchmark testing, and selection of the first-choice vendor for negotiations;

- Step 9: Negotiating and Awarding a Contract. The first-choice vendor should be notified that if the negotiations fail, the selection committee reserves the right to discontinue the negotiations and begin to negotiate with the second finalist. The objectives of negotiation can include a reduction of item pricing, hardware or software loans, trial periods or evaluation period discounts, additional no-charge installation assistance, consulting, training, or other advantages. The client must share with the prospective GIS supplier all the perceived risks and costs that are unacceptable. The vendor is then asked to minimize or share such risks

Installation (installation activities are not presented as steps)

Installation includes prototype project, cartographic data conversion, database design and (high-priority) applications development, full-scale implementation (priority should be given to core applications such as map maintenance), establishing processes and responsibilities for system support, documentation, and training.

8.3.4- Technological Issues and Future Trends

The last two chapters of PTI & ICMA's Guide present technical definitions (GIS/LIS, AM/FM systems, CADD systems), a review of GIS technology (software, platforms, functions and capabilities, network, database issues), and future trends.

8.4- Other Implementation Guides

The Federal Geodetic Control Committee (FGCQ published a *guidebook intended primarily for the people who must evaluate, plan and implement land information systems at the local level* [BROWN89-94]. As the chapters of such a guidebook have been written by different authors and in different times, we choose analyzing each chapter separately. Other related literature is [FORREST90].

8.5- Coverage Analysis and Content Comparison

Table 8.2 presents the coverage of the Implementation Guides. The letters printed into the table's cells identify the proposals through their author's initials. The letter "H" identifies [HUXHOLD95], "K" identifies [KORTE92], and "I"', identifies [PT191]. The Implementation Guides addressed prevailingly two groups of issues: Information System Design and Project & System Management. Other issues with a reasonable coverage are Implementation Pace and Scope and Funding Strategies. The issue Training Strategy and Role received only generic proposals.

8.5.1- Strategic Planning

Huxhold and Levinsohn's proposal about strategic planning comprises situational analysis, establishment of a strategic vision, assessment of financial feasibility, technical feasibility and institutional feasibility (willingness of managers to commit to long-term projects);, definition of strategic approach and project scope, and preparation of a strategic plan document which should be reviewed periodically.

8.5.2- Pace and Scope

Huxhold and Levinsohn propose that the definition of the scope of the project should be based on the institutional feasibility assessment (part of the strategic planning process). If senior managers are not willing to commit to long-term projects, the authors understand that several smaller projects should be more appropriate. PTI and ICMA consider a multidepartmental, organization-wide approach desirable, but they suggest small-scale packages as an alternative for those cases where there is lack of departmental cooperation and agreement. They also suggest short-term delivery of applications (with "visible" early results). Korte suggests long-term planning for a fully integrated GIS.

8.5.3- System Design Model

Table 8.3 presents a summary of the proposed GIS design models. We identified two main innovative features in these models (see also discussion in Section 5.7):

- Huxhold and Levinsohn placed *Strategic Planning* as a foundation of the implementation process (this is not emphasized in any other model);

- The model of Korte includes three opportunities for project approval. The first opportunity is a *Study Approval.* After user needs analysis and general system conception, Korte suggest an approval for development of the pilot project, and after the development of the pilot there is a final decision to proceed, delay, or cancel the project before full data conversion.

	mention the importance	generic proposals	detailed proposals or insights
Overall Strategy			
strategic planning/ risk evaluation			H
implementation pace and scope		H, K	P
Information System Design			
implementation plan		P	H, K
GIS design model		H	K, P
role & position of pilot project		H, P	K
detailed design techniques			H, K, P
Project Enabling Strategies			
top-level persuasion/ support	K		
organizational conflicts/ user resistance	K		
funding strategies		K, P	H
communication channels/ project marketing	H, K, P		
training strategy and role		H, K, P	
Project & System Management			
system location/ coordination bodies			H, P
GIS staffing, consultant & contractors			H, K, P
project control	P		H
management of risks, IS function & strategy	H		

Table 8.2- Coverage of the Implementation Guides

8.5.4- Implementation Plan

The PTI and ICMA's proposal place the implementation plan after needs analysis. Korte proposes a project plan as a first step of implementation and a detailed implementation plan after needs analysis and system conception. Huxhold and Levinsohn understand that the implementation plan should proceed in parallel with the implementation activities. They suggest a start-up plan after strategic planning and, as a general rule, a detailed plan for the next three months.

8.5.5- Pilot

Huxhold and Levinsohn suggest to include a pilot project in the implementation process to build understanding, reduce uncertainty and risks, and to determine the impact on operations and procedures. They do not suggest a specific position for the pilot within the GIS design model. Korte and PTI & ICMA place the pilot after detailed design and before full data conversion. Korte suggests that the key goals of the pilot are to test the detailed database design and the cost estimates for data conversion.

8.5.6- Detailed Design Techniques

Huxhold and Levinsohn's Guide contains a detailed description of techniques for the needs analysis, application design, definition of priorities, and shared database design. Korte describes techniques to assess implementation costs and the cost of hourly operation. PIT and ICMA detail techniques to elaborate Request for Proposals (RFPs).

8.5.7- Funding Strategies

Huxhold and Levinsohn propose to distribute costs across all users according to their request for GIS services and their utilization of the system. The authors propose two budgetting methods: (1) The allocated method, which establishes funds directly in user department budgets, and (2) the centralized method, which establishes funds in a separate budget account for the entire organization. Korte and the PTI & ICMA's Guide suggest cost sharing between institutions interested in data covering the same geographic area. PTI and ICMA also suggest to examine revenue opportunities in sales of products.

Huxhold & Levinsohn	Korte	PTI & ICMA
-strategic planning (situational analysis, GIS vision, feasibility, strategic approach & scope definition) -start-up plan -user needs assessment -general design & specification -application planning & selection -detailed design and implementation of applications -operation & maintenance	-project plan -study approval -education of managers -user needs assessment -analysis & recommendations (general conception, implementation plan, feasibility) -obtain pilot approval -specifications, RFP & vendor selection -detailed DB design -pilot project (& final decision to proceed) -data conversion, system acquisition, training users -test & maintain DB	-obtain top level support -define project team -user needs assessment -preliminary implementation plan (applications, priorities, timelines, cost/benefit) -submit to approval -procurement process (RFP, selection and contracting) -installation (pilot ,data conversion, high priority applications development, full scale implementation, training)

Table 8.3- Simplified GIS Design Models of the Implementation Guides

8.5.8- Training strategy and role

Huxhold and Levinsohn presented a sample of GIS education & training program (see Table 8.1 in Section 8.1.0 Korte's and the PTI & ICMA's proposals include a training program after system installation, suggesting an orientation toward system operation. In addition, Korte mentions the importance of an ongoing program to train new users, and PTI and ICMA suggest membership in users' associations.

8.5.9- System Location & Coordination Bodies

Huxhold and Levinsohn propose three alternatives for system coordination: (1) The GIS under control of an operating unit of the organization; (2) The GIS under control of an administrative or other enterprise-wide organizational unit; and (3) GIS under direct control of the top elected official. PTI and ICMA's Guide presents similar configurations: Single department GIS, shared GIS donated by single department, multidepartmental GIS managed by a separate office or by the information services department, and multiagency GIS where the responsibilities are shared among the partners.

Regarding project coordination, the PIT & ICMA's Guide suggests a policy team (top managers, responsible for main decisions), a technical team, and a project leader. Huxhold and Levinsohn present an example of management framework composed by steering committee (policy makers/department heads of sponsoring agencies, responsible for major decisions), liaison committee (management representatives from interested, non-sponsoring agencies), user working group (line managers and professionals of sponsoring agencies, responsible for facilitating needs analysis and design studies), and project management team (project manager, leaders, and user appointments, responsible for coordination of GIS implementation).

8.5.10- GIS Staffing, Consultant & Contractors

PTI and ICMA recommend that, depending on the in-house expertise and system requirements, consulting may be desirable for management of multi-department or multi-agency GIS, cartographic and related data conversion, bid evaluation and negotiations, feasibility study, hardware & software installation and database design, application development, and marketing of GIS products and services. Huxhold and Levinsohn presented a table of products and services which, depending on the type of organization, *may be/will almost certainly be* externally acquired. For example, they suggest that *municipal organizations* will "*almost certainly* " acquire external consultancy on information technology, *GIS hardware*, GIS software and related technologies, and *document imaging*. Korte advocates the use of a consultant in the strategic decisions made during the planning process, and lists the typical objectives of consultants' services: Review and document the current procedures for handling land records, document the problems, limitations, data, processing requirements, and potential applications, develop the GIS conceptual design, implementation plan, cost estimates, and specifications. Korte also describes basic staff positions or functions: GIS manager, GIS database manager, cartographer, system manager, and programmer.

8.5.11- Project Control

Huxhold and Levinsohn propose to include periodic reviews in the implementation plan, to use a project management system, to define all activities as specific projects, and, when the system is operational, to prepare an annual budget and working plan to monitor the evolution of each specific project.

Part III: Overall Analysis and Comparison

9- Overview of the Proposals on Each Group of Issues

In this section we will present an overview of the proposals on each group of issues of our framework. We will present the prevailing idea regarding each subject, or the main alternatives, without any reference to their authors. More detailed explanations on each issue are exposed in sections 4 to 8.

9.1- The Issues of the Information System Design Group

Information System Design group was addressed primarily by the proposals classified as Implementation Methodologies and Implementation Guides. The focus of this group is on the issue GIS Design Model. Most of the proposals on the other issues were included in this main discussion.

9.1.1- The Alternative Models for System Design

Table 9.1 shows two basic models of GIS implementation. A key feature which differentiates these two approaches is the role and position of user needs assessment. In the first model there is a preliminary definition of goals and scope, and user needs assessment is used only to collect information to support the detailed design and specification. A variation of this approach would be to define the project scope based on a situational and feasibility analysis, before user needs assessment. In the second model no previous definition of goals and project scope exists. In this last case, in addition to support detailed design, a comprehensive user needs assessment is used to help "discover" the best goals and scope for the project.

In addition, we identified the following alternative proposals concerning the position of feasibility/cost-benefit analysis/project approval:

- Feasibility analysis as one of the first task of implementation (before user needs assessment), and possibly based on a situational analysis;

- After needs analysis (in this case, there should be another way to fund/enable the assessment of user needs); and

- More than one single opportunity for project approval: Study approval (before user needs analysis), approval for development of pilot project (after user needs analysis), and final decision (after the pilot project).

9.1.2- Implementation Plan

We identified different alternatives regarding the position of the implementation plan in the design methodology. The implementation plan was positioned:

- As a first phase of the implementation process;

- After user needs analysis, and before system design;

- After user needs analysis and system design;

- As a general project plan and first step of implementation, complemented by a detailed implementation plan after user needs analysis and system conception;

- As a flexible plan, developed in parallel with the implementation activities themselves (detailed plans for the next three months of project). The most immediate consequence of the different approaches concerning the position of the implementation plan refers to the activities it will help coordinate - the implementation plan may comprehend all the activities (including user needs assessment and design), or only the effective implementation (database loading, acceptance test, user training). Sections 4 to 8 present several other generic proposals about the implementation plan such as: providing budgets for project "contingency" and "discovery".

9.1.3- Pilot Project

Although there are several generic proposals about pilot project, we identified only two basic alternatives concerning its role and position:

- Before system design, to help defining system requirements; and

- After system and database design, to test the design and cost estimations. Other proposed roles for the pilot are: Building understanding and training, determining the impact on operations and procedures, etc.

9.1.4- Detailed Design Techniques

Some of the proposals that addressed the group System Design Model included detailed design techniques for user needs analysis (and, possibly, design of applications and shared database); estimation of implementation costs and cost of GIS hourly operation; and elaboration of request for proposals (RFPs).

9.2- The Issues of the Overall Strategy Group

This group was addressed primarily by the Implementation Strategies class. The main concerns or motivations for most of the proposals are enabling issues - discussed in Section 9.3.

9.2.1- The Role of Strategic Planing

We identified the following alternative focus in the proposals addressing strategic planning:

- Focus on business area analysis to identify and prioritize the business processes to be re-engineered or automated, or to identify the areas of high political or economical impact to be addressed first; and

- Focus on situational analysis, organizational risk evaluation, assessment of the readiness of the organization to embrace the GIS project, assessment of the willingness of

managers to commit to long-term projects, etc. Most of the proposals suggest strategic planning/risk evaluation as a first step of the implementation process. A variation of this approach proposes, in addition to an initial effort, further developments in parallel to the implementation activities and periodic reviews.

	First Model	Second Model
System Design Model	-preliminary definition of goals and scope; -user needs assessment within the previously selected scope; -global system design and specification; -effective implementation, possibly phased	-comprehensive user needs assessment; -global system conception & design; -effective implementation, possibly phased
Role of User Needs Assessment	-support to detailed design	-definition of system goals & scope; -support to detailed design
Source of Goals & Scope	-defined by managers or steering committee	-discovered through user needs assessment
Scope	-integrated, multi-participant project in the long-term; -limited scope, at first	-integrated, multi-participant project
Pace	-global conception within the previously defined scope; -possibly phased effective implementation	-global conception; -possibly phased effective implementation

Table 9.1: Two Alternative GIS Design Models

9.2.2- Implementation Pace and Scope

The prevailing proposal concerning the envisioned project scope is an organization-wide, multipurpose (possibly multi-agency) system. Although we did not find any explicit proposal against this general idea, we have found two variations:

- Small or independent applications in the short-term (and organization-wide scope in the long term);

- Organization-wide scope desirable, but small scale systems suggested as an alternative for situations where there is lack of departmental cooperation or agreement.

Figure 9.1 illustrates the four main alternative approaches to implementation pace that we identified in the surveyed literature. The three last approaches have a common feature: They do not agree with the "traditional" approach in which an user needs assessment and full system design are performed before obtaining the first practical results. They propose some instance of short-term results before (multi-phase), in parallel to (multi-track), or in substitution to (iterative prototyping) the detailed analysis and design of a multipurpose GIS. Most of the generic proposals concerning implementation pace corroborate the strategy of short-term results. Their major concern usually is obtaining and sustaining top level support.

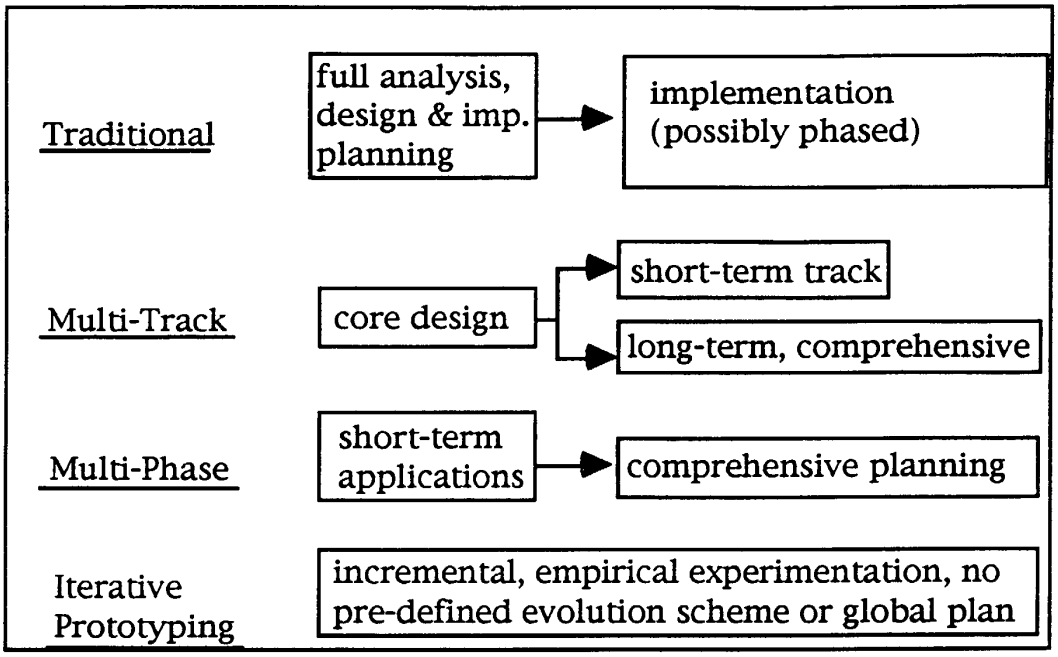

Figure 9.1- Alternative Implementation Paces

Note that the "traditional" approach can include "incremental implementation". Incremental implementation in this case refers to a phased development of application programs, database loading and transition to new operations, according to the priorities defined in an implementation plan. The key feature differentiating the "traditional" approach from the other is not the "implementation itself', but the global system conception before any short-term result.

9.3- The Issues of the Project Enabling Strategies Group

The most detailed proposals on enabling issues come from the Implementation Strategies class (specially on the issues obtaining top level support, decreasing user resistance, and familiarizing users).

9.3.1- Proposals About Top-Level Persuasion/Support

We identified three basic approaches for gaining and sustaining top-management support:

- Through a favorable cost-benefit analysis,

- Through education of leaders/awareness generation in the beginning of the implementation process; and

- Through an overall implementation strategy that eases the persuasion of top-level managers (short-term results, low initial investments, etc. See more details about these strategies in Section 9.2 and in Section 4).

9.3.2- Proposals on Organizational Conflicts and User Resistance

We found three similar approaches concerning user resistance (major concern) and organizational conflicts. We will present below some specific terms of each approach, and their main alternative focus:

- Interative prototyping, gradual/experimental system conception and introduction of changes;

- "Proactive" approach (instead of "Reactive"), emphasizing extensive user participation in design and decisions (decisions are taken "consensually" or by an "open court");

- User-centered design, emphasizing the creation of a socio-technical system to serve organizational and human objectives and evolutionary growth. Another proposal concerning user resistance is eliminating negative personal attitudes through management activities such as providing incentives to individual employees who are using GIS technology. The proposals whose main focus is on organizational conflicts are:

- Defining organization-wide goals and benefits; and

- Using "positive" organizational political behavior (OPB): negotiation, bargaining, networking, expanding connections, using the system to give and receive favors, etc.

9.3-3- Funding Strategies

The proposed funding strategies are:

- Cost sharing among different organizations interested in data about the same geographic area;

- Revenue opportunities in sales of GIS products;

- Distributing costs across all users according to their request for GIS services, through one of these two methods: (1) Allocated method - establishes funds directly in the user department; and (2) Centralized method -establishes funds in a separate budget account for the entire organization.

9.3-4- Communication Channels/Project Marketing

The proposals concerning communication channels/project marketing are very generic. They usually mention the importance of communication channels (such as reporting processes, presentations, informal lines of communication, etc.) for project success.

9.3.5- Training Strategy and Role

We identified the following approaches for training/education programs:

- Education of leaders/awareness generation in the beginning of the implementation process. The main objective in this case is obtaining support;

- Training after system design and implementation. In this case the training is directed to system operation and use;

- Phase of familiarization based on small and independent applications. The major concern in this approach is familiarizing the users with GIS and enabling them to participate in bigger organization-wide projects;

- Ongoing training program to train new users;

- Complementary educational activities: Membership in user associations, attendance at workshops, etc.;

- Different training programs for different classes of users. For example, different approaches for Senior Managers (training on benefits and implications of GIS - start of GIS planning), Project Team (training on GIS concepts and GIS management - prior to project start), Operations Staff (GIS operation - prior to needs analysis), System Staff (GIS design techniques and software customization - prior to installation and testing); Non-Technical End Users (familiarization/GIS use - during GIS planning); and Business Unit Managers (Familiarization/Resource allocation - during the entire process).

9.4- The Issues of the Project & System Management Group

Most parts of the specific proposals in this group address the issue System Location/Coordination Bodies. The other issues were usually addressed with very generic proposals.

9.4.1- Project Coordination Bodies

We found similar proposals about project coordination structures. They propose two main bodies:

- A technical body or project team, composed by GIS staff and mid-level managers, responsible for performing the detailed planning and implementation activities; and

- A policy body or steering committee, composed by top-level managers and representatives of the (main) departments involved, responsible for the main decision and for coordination of conflicts.

Another structure proposed was the Liaison Committee, composed of managers/representatives from non-sponsoring agencies, responsible for facilitating needs analysis and design studies. In addition, several proposals highlighted the importance of assigning a GIS project manager early in the implementation process.

9.41- System Location

We identified several alternatives for system location. The most basic choice is whether the system will be either a single-departmental system, independent systems, or either a multi-

participant or shared system. Figure 9.2 presents the main alternative locations for multi-participant GIS.

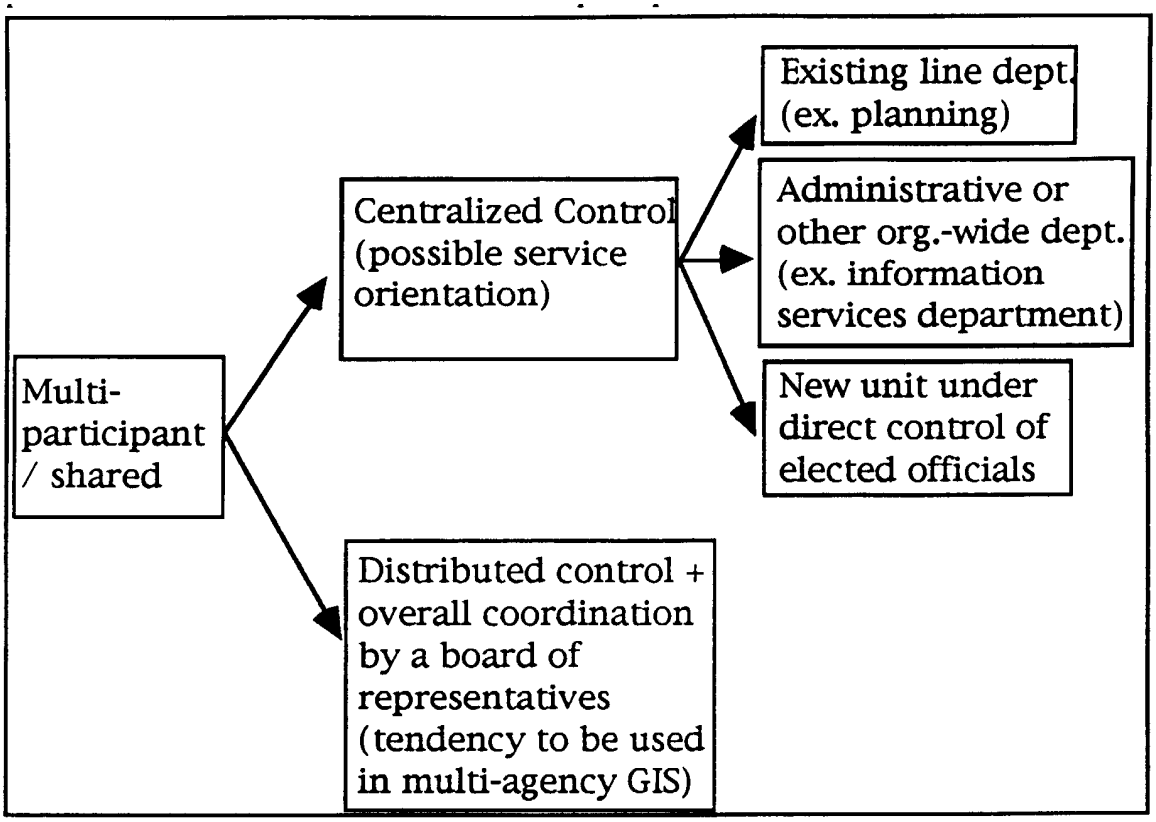

Figure 9.2: System Location Alternatives for Multi-Participant GIS

An additional alternative for system location is dividing the responsibility between the department of information services (hardware and software) and all other department involved. Another proposal classified the systems which involve all the departments as "classically corporate", and the systems which involve only three or four departments as "theoretically/pragmatically corporate".

9.4.3- GIS Staffing and the Role of Consultants & Contractors

The use of consultants and contractors was proposed as dependent on the in-house expertise, and on the intended domain (utilities, local government, etc.). For example, one proposal states that for municipal applications the need of consultancy on information technologies, GIS hardware, GIS (software and related technologies), and document imaging is "almost certain". Another proposal advocates using a consultant during the planning process in activities such as reviewing current procedures, documenting problems and limitations, documenting data processing requirements and application, developing a GIS conceptual design, implementation plan, cost estimates, and specification for purchasing. Using contractors in activities such as system management, data conversion, application development, and in marketing of GIS products was also suggested. The functions/positions proposed for GIS staffing are GIS manager/implementation project manager, system administrator, database administrator, GIS analyst, programmer, digitizer, cartographer, and operator.

9.4.4- Project Control and Management of System Function, Goals and Strategy

Very few proposals have addressed these issues. It was proposed that project control be based on check-points defined in the implementation plan, and the possible use of a project management tool for monitoring and reporting about the project. Regarding management of risks, system function and implementation strategy, we found only generic proposals including stages such as "audit" or "review" after most part of implementation activities, or proposals suggesting periodic reviews of the strategic planing document during the implementation process.

10- Coverage Analysis

The theme *GIS Implementation* is very broad - it can involve the choice of GIS software, data acquisition, strategic partnerships, project management, etc. It is not surprising that some papers of the *Guiding Literature* address or emphasize different issues that others. Table 10.1 summarizes the coverage of the *Classes of Guiding Literature*. We selected a set of publications of each class and verified what issues these publications address (and how specific are the proposals). The letters printed into the table's cells identify the publications through their authors' initials. The lowest row works as a legend for the upper cells. For example, the first three columns of Table 10.1 refer to the publications representing the *Implementation Strategies* class. In these columns the letter "A" identifies [ANDERSON92], the letter "F" identifies [FERRAR194], "H" identifies [HEDGES94], and so on. In the next three columns (*Implementation Methodologies*), the letter "A" identifies [ANTENUCC191], "C" identifies [CLARKE91], "L" identifies [LOVE91], and so on.

As Table 10.1 shows, the *Implementation Strategies* address basically two groups of issues: Overall Strategy and Project Enabling Strategies. The enabling issues are presented as the main motivation for the proposed alternative strategies for GIS implementation. For example, all the *Implementation Strategies* propose some sort of short-term results as a mechanism to ease obtaining top-level support.

The *Implementation Methodologies* address primarily the issues on the Information System Design group. They also address most part of the issues from the other groups, but only with generic proposals. Their main focus is on the GIS design model (the sequence of activities, or steps) and all the suggestions on other issues are included in this main discussion. The *Implementation Guides* present a two fold focus. They focus on the Information System Design Group, like the *Implementation Methodologies*, but they also present a strong coverage of the issues of the Project & System Management group. The other issues received prevailingly generic proposals.

The *Success Factors & Dependencies* do not focus in any specific group of issues. Instead, their generic proposals are distributed over all the four groups. The *Research Findings* have a similar coverage. They usually present theoretical considerations and research results as a strong foundation of their proposals, and in this sense they differ from the *Success Factors & Dependencies*. But the conclusions of the *Research Findings*, where they present most part of their practical proposals, are as generic as the Success Factors & Dependencies, and part of them have the same style. For example, some research results define "variables predictive of successful outcomes" [AZAD93a], "factors affecting GIS adoption" [BUDIC93a], or "factors

that are critical for successful system adoption after acquisition" [ONSRUD93]. The meaning of these three descriptions of results is very similar to success factors".

All the issues of Table 10.1 were addressed. Most part of them were addressed with a reasonable amount of detailed proposals. Only the issues "Communication Channels/Project Marketing" and "Management of) Risks, GIS Function and Implementation Strategy" have not received any detailed proposal. The issue "Project Control" received a very low coverage as well.

Table 10.2 summarizes the coverage of the *Classes of Guiding Literature*. One *Class* has a "FOCUS" associated to one specific group of issues when this group is addressed with "detailed proposals" by most part of the literature included in that *Class*. The symbol "some" indicates that such a group received secondary consideration (prevailingly through "generic proposals" or "mention"). The symbol "-" means that the group of issues is not addressed at all by the corresponding *Class*. Table 10.2 shows that no single publication, or even no single class, presented a "FOCUS" in all the four groups of issues. Even the *Implementation Guides* are not fully -comprehensive in this sense. However, all the four groups received at least one "FOCUS". This means that there are well developed theories (several "detailed proposals") on all the four groups of issues but these theories are not organized in a single package. In order to have access to well developed theories on all the four groups of issues, one has to gather information from several sources, and from more than one *Class of Guiding Literature* (does this constitute a problem?).

	Implementation Strategies			Implementation Methodologies			Success Factors & Dependencies			Research Findings			Implementation Guides		
	mention	generic proposal	detailed proposal or insight	mention	generic proposal	detailed proposal or insight	mention	generic proposal	detailed proposal or insight	mention	generic proposal	detailed proposal or insight	mention	generic proposal	detailed proposal or insight
Overall Strategy															
strategic planning/ risk evaluation		H,F,S						C,E							H
implementation pace and scope		H	F,P,S		V,Va			C,E			C			H,K,P	
Information System Design															
implementation plan					V	A,C,L,Va		C,E,K			A			P	H,K
GIS design model					V	A,C,L,Va					O			H	K,P
role & position of pilot project					A,V	L,C,Va				O				H,P	K
detailed design techniques						V									H,K,P
Project Enabling Strategies															
top-level persuasion/ support			H,F,S	C	A,V		C,K	V		A,B			K		
organizatnl. conflicts/ user resistance			A,P		V			C,K		A	B,P		K		
funding strategies								V						K,P	H
communic. channels/ project marketing					Va		K	C,E		A			H,K,P		
training strategy and role		S	F		A,C,Va		E,K	C		A,B				H,K,P	
Project & System Management															
system location/ coordination bodies						A			C,V	O		C			H,P
GIS staffing, consultant & contractors					L	A		V			O				H,K,P
project control					A								P		H
mangmt. of risks, IS function & strategy					A,Va								H		

	A - [ANDERSON92] F - [FERRARI94] H - [HEDGES94] P - [PEUQUET91] S - [SOMERS94]	A - [ANTENUCCI91] C - [CLARKE91] L - [LOVE91] V - [VENTURA91] Va - [VASTAG94]	C - [CROSWELL91] E - [ENGELKEN94] K - [KOLLER93] V - [VENTURA92]	A - Azad & Wiggins B - Budic C - Campbell & Masser O - Onsrud & Pinto P - Pinto & Azad	H - [HUXHOLD95] K - [KORTE92] P - [PTI91]

Table 10.1- Coverage of the Classes of Guiding Literature

	Overall Strategy	Information System Design	Enabling Issues	Project & GIS Management
Impl. Strategies	FOCUS	-	FOCUS	-
Impl. Methodologies	some	FOCUS	some	some
Impl. Guides	some	FOCUS	some	FOCUS
Research Findings	some	some	some	some
Success Factors	some	some	some	some

Table 10.2: Summary of the Coverage of All Classes

11- Theoretical Consistency

The Overall Strategy and the Project Enabling Strategies groups received a “FOCUS" from the class Implementation Strategies (Table 10.2). The other two groups of issues received a “FOCUS" from the Implementation Methodologies and Implementation Guides. We verified if the proposals on the *Overall Strategy* and *Enabling Issues* groups are compatible with the proposals on the two other groups. We have not found a clear relationship between the proposals on these two former groups with the proposals on the group *Project & System Management*. But we have found a relationship between the *Overall Strategy* group and the *Information System Design* group.

One key issue on the *Overall Strategy* group is the proposed implementation pace. All the *Implementation Strategies* propose some form of short-term results in order to ease getting and sustaining top-level support, decreasing user resistance, or familiarizing users. Instead of a comprehensive, organization-wide user needs assessment and system design, the *Implementation Strategies* propose to start with small and independent applications (before a comprehensive planning process); Or to perform only a core design followed by a dual-track implementation process (one track with short-term results and the other one comprehensive, long-term focused); Or to implement GIS through iterative cycles of development, use, improvement of user skills and system capabilities. The key, common point is the absence of a single design process comprising all the final, envisioned scope (usually an organization-wide system) before obtaining the first practical results.

The overall strategy and implementation pace have a straight relationship with the issue "GIS design model", from the *Information System Design* group. We found two basic models of GIS design. A feature which differentiate these two basic approaches is the role and position attributed to user needs assessment. In one model there is a preliminary definition of goals and scope, and the main utility of user needs assessment is to collect information for the detailed design and specification. In the other model there is not a definition of goals and scope before user needs assessment. In this case, a comprehensive user needs assessment is used to help defining the most adequate goals and scope for the project. Despite this basic difference, both models have a common feature: Both involve a comprehensive process of system design before the implementation itself and, therefore, before obtaining the first practical results. Figure 11.1 illustrates these two models of GIS design ("a" and "b") and a generalization ("c"). Note that the implementation itself can be phased. The key common feature is the full GIS design comprising all the envisioned scope, and before obtaining the first practical results. Surprisingly, this key common feature of the two basic models of GIS design is precisely the opposite approach to that one consensually advocated by the *Implementation Strategies* (absence of a design process comprising all the intended scope before the first practical results).

Although the GIS design models present this "global design" bias, one can not say that their authors actually advocate a global design before some short-term results. In fact some of the proposals which focus on "GIS design model" addressed the issue "implementation pace" with "generic proposals" (see Table 10.1 and 10.2) and recommended, for certain cases, short-term results or small projects. So, it is possible that these publications treat -implementation pace" and "GIS design model" as separate issues and while they teach "GIS design model" they do not intend to address strategic issues like implementation pace. A problem still remains: One needs to learn about GIS design model, one needs to learn about the strategic issues (like implementation pace), and the theories addressing both subjects must be compatible. However, according to the analysis above, they are not.

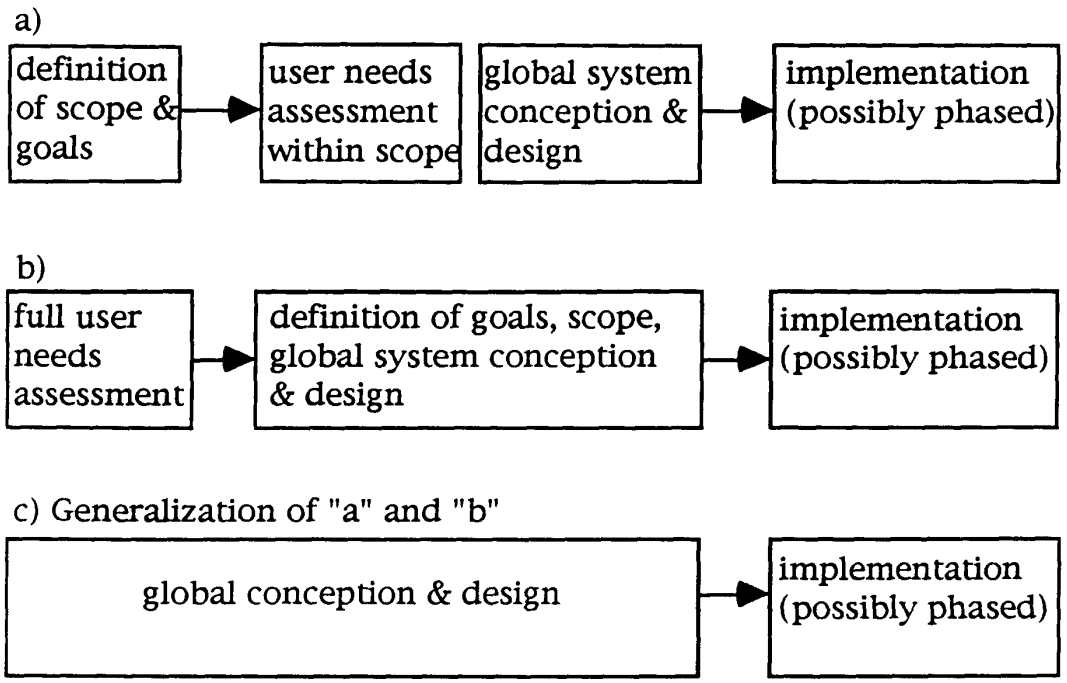

Figure 11.1: Two Basic Models of GIS Design (a & b) and Their Generalization (c)

12- Theoretical Diversity

The coverage analysis has shown that most issues are addressed by more than one publication and, in some instances, by more than one kind of publication. Having several proposals on one single issue does not necessarily mean that there are different theories in that issue because all the proposals can be consensual.

We studied the *Guiding Literature* to determine its *Theoretical Diversity*: If the different proposals on one single issue are *consensual, complementary,* or *alternative* (mutually exclusive). Table 12.1 shows which one of these qualifiers best characterize the set of proposals on each issue. The attribute *inconclusive* means that the proposals on that issue are not clearly characterized by any of the former qualifiers. For example, the issue "communication channels/ project marketing" is *inconclusive* because it received no "detailed proposals" (see Table 10.1). Some issues are characterized by a combination of qualifiers. The combination "*qualifier a* AND *qualifier b* means that part of the proposals are best described by "*a*" while other part is best described by "*b*". For example, the issue "implementation pace and scope" is *consensual* in the sense that all the proposals involve some sort of short term results. But the proposals disagree

about how to achieve such results and, therefore, they are also *alternative*. The combination "*a* OR *b*" means that one can understand that set of proposals as being either "*a*" or "*b*".

According to Table 12.1, the proposals on most part of the "conclusive" issues are either *complementary* or *alternative* (or a combination of both). If the *alternative* approaches come from different publications, one needs to consult these various publications to be able to choose the most adequate approach for one's needs. The same applies for someone interested in having access to *complementary* theories.

Overall Strategy	
strategic planning/ risk evaluation	(can be either) complementary OR alternative
implementation pace and scope	(part) consensual AND (part) alternative
Information System Design	
implementation plan	alternative
GIS design model	alternative
role & position of pilot project	complementary OR alternative
detailed design techniques	inconclusive
Project Enabling Strategies	
top-level persuasion/ support	complementary OR alternative
organizational conflicts/ user resistance	inconclusive
funding strategies	complementary
communication channels/ project marketing	inconclusive
training strategy and role	complementary OR alternative
Project & System Management	
system location/ coordination bodies	consensual OR complementary
GIS staffing, consultant & contractors	inconclusive
project control	inconclusive
management of risks, IS function & strategy	inconclusive

Table 12.1- Theoretical Diversity of the Guiding Literature

Part IV: Conclusions and Bibliographic References

13- Conclusions

In this report we have presented a comprehensive review of the literature intended to provide guidance on GIS implementation. We have defined the term *Guiding Literature*, five basic *Classes* of publications, and a set of specific issues. We have reviewed a representative number of publications from each *Class*, organizing their proposals by subject. We have also analyzed the coverage, theoretical consistency, and the theoretical diversity of the *Guiding literature*. The results of our analysis have shown that there are well developed theories but that these theories are not organized in a single publication or even in a single *Class* of publications. Some issues are conveniently addressed by one *Class* while other issues are adequately addressed only by another *Class*. The analysis has also shown that theories from different sources, addressing different issues, are sometimes inconsistent among themselves. We found alternative approaches concerning several issues. In most part of them, each publication advocates its own approach without presenting other alternatives.

We understand that this report presents two basic contributions. First, it documents a comprehensive review of the literature on GIS implementation. It can be used as an easy-reference to the Guiding Literature. It organizes the proposals from several sources by subject, enabling comparisons. In other words, it answers the first set of questions stated in Section 1: What does the literature say about GIS implementation? What are the alternative approaches? A second basic contribution of this report is concerned not with the adequacy of the theories themselves but with their organization. By analyzing the coverage, the theoretical consistency, and the theoretical diversity of the Guiding Literature this report addresses a second set of questions from its introduction: Are the proposals compatible among themselves or are they contradictory? Are the ideas organized in a comprehensive guide for practitioners?

Several of the publications analyzed in this report include reviews including or even emphasizing the study of literature from other fields such as theory of innovations and implementation of information systems in a general sense. This report differs from those publications because it does not address the literature from other fields at all , but only the literature explicitly directed to the implementation of GIS. Other proposals presented a review restricted to the GIS field but in a limited scope. For example, Onsrud and others [ONSRUD93b] review a sample of academic studies on GIS implementation in U.S. local governments (such as those proposals classified as Research Findings, described in Section 7 of this Report) and do not review non-academic proposals on GIS implementation (such as some of those described in Sections 4, 5, 6 and 8). This report is unique in that it presents a comprehensive literature review documenting what the (GIS) literature says about GIS implementation.

This report does not contradict any proposal, it does not state what alternative approach is appropriate for specific situations, and it does not present any new idea. All these activities are beyond its goals and scope. We understand that documenting what the literature says was a first necessary step toward the development of a comprehensive guide for GIS implementation - our long-term goal.

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