A FRAMEWORK FOR A MULTI-PARTICIPANT GIS PROGRAM

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(ABSTRACT)

The objective of this paper is to develop a well-defined and sound framework for the implementation of a multi-participant GIS program and to illustrate the developed framework by its application to the Departments of the Town of Blacksburg.

A multi-participant approach to implementing GIS technology faces greater challenges than a single-participant GIS project, due to the unique culture, structure, policy, decision-making rule and expectations of participants from implementation of GIS technology. So a successful program depends upon aligning different characteristics of the program's structure to those of participants, individually and collectively. Maximizing the system's potentials necessitates a well-defined implementation framework that can help manage changes and integrate the technology in organizations. Therefore, the paper focuses on the implementation aspects of multi-participant GIS programs.

The paper achieves its objective by exploring various issues involved in the implementation process of GIS technology and multi-participant GIS programs, develops a framework for implementing a multi-participant GIS program and applies the framework to the Departments of the Town of Blacksburg to achieve successful implementation. The illustration of the Town of Blacksburg identifies various constraints for multi-participant GIS program for which recommendations are provided to achieve successful implementation.

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Chapter 1. Introduction

The demands for better management of the Earth's resources require management of spatial data and information. Geographic Information Systems (GIS) refer to the broad collection of Information Management Techniques, which store and analyze such information to contribute to the needs for planning and resource management.

A Geographic Information System has two basic components, Geography and Information System. Geography focuses (in part) on the spatial relationship between man and earth. An Information System is a system consisting of a chain of operations ranging from planning of observation, collection, storage and analysis of data to the use of derived information in some decision-making process. The use of GIS has produced remarkable changes in the way and rate at which georeferenced data are produced, updated, analyzed and disseminated, making production and analysis of geographic information very efficient. Furthermore, it is characterized by diversity of applications and can be effectively used in urban planning, natural resource management, and other land use fields. In the past three decades, this potential has led to rapid developments in both theory and technology resulting in increasing technical capabilities and decreasing hardware and software costs. As a result GIS has become an extremely powerful tool in both public and private sector organizations.

1.1 Purpose of the Paper

The unique characteristics and capabilities of GIS technology have led to its widespread adoption and implementation. But in addition to its technical and information handling capabilities, GIS is capable of numerous organizational and economic opportunities, which have emerged during the last few years. This potential of GIS has led to emergence of the multi-participant approach for GIS. However, a multi-participant approach of implementing GIS technology faces greater challenges than a single-participant GIS project. In multi-participant program each participant has a unique culture, structure, policy, decision-making rule and expectations from implementation of GIS technology. So a successful program depends upon aligning different characteristics of the program's structure to those of participants, individually and collectively. Maximizing the system's potentials necessitates a well-defined implementation framework that can help manage changes and integrate the technology in organizations.

This paper focuses on the implementation aspect of multi-participant GIS programs in organizations. The main objective of this paper is to develop a sound framework for implementation of a multi-participant GIS program. The paper achieves this by exploring various issues involved in the program, develops a framework for implementing a multi-participant GIS program, and applies the framework to the Departments of the Town of Blacksburg to achieve successful implementation of GIS technology. The aim of application of the implementation process framework is only to illustrate the proposed framework.

1.2 Organization of the Paper

This major paper consists of six chapters. Chapter 2 deals with the importance of the implementation process for GIS technology in organizations, followed by the different perspectives on the implementation process. The next chapter includes an introduction of the multi-participant approach to GIS technology with its characteristics, potential benefits and examples. Chapter 4 deals with the implementation process framework for multi-participant GIS programs, to achieve successful outcome. Then, the proposed framework is applied to the Town of Blacksburg in Chapter 5. Finally, the conclusions of this study are outlined in Chapter 6.

Chapter 2. Implementation Process for GIS Technology

With increasing use of GIS technology, organizations have come to expect improvement in productivity, efficiency and effectiveness.

- **Improved productivity and efficiency means,**
  producing more results with same or fewer resources
  deriving greater benefits from staff activities and better utilization of staff time
  reducing expenses for data maintenance and data updates

- **Improved effectiveness means,**
  improving the information flow between staff members and departments
  improving the decision-making process of the organization

However, despite the claims about the potential opportunities that would result from the introduction of GIS, many unforeseen problems and complete abandonment of the technology is a common occurrence than its successful utilization. Organizations can realize the benefits from GIS, if the technology is used in daily activities and becomes an integral part of the organizations' decision-making process. Thus, simply the purchase of the technology will not lead to effectiveness and profits (Huxhold, Levinsohn, 1995). It is the process of implementation that helps innovations to become integral parts of organizations and increase the effectiveness of GIS in these organizations.

2.1 Definition of Implementation Process

Implementation process is defined as a "fundamental process that involves the transfer of an innovation into an organization to become a daily part of the lives of the people of the organization" (Campbell and Masser, 1996, p. 4). Therefore, GIS implementation can be defined as "the entire technology transfer process from when an organization becomes aware of the technology through to when the technology is incorporated into its operations and is regularly utilized where appropriate in its daily activities" (Aronoff, 1989, p. 251). The implementation process can be thought of as an umbrella concept encompassing the following steps -- **initiation, acquisition, adoption and utilization.**

2.2 Importance of the Implementation Process to GIS Technology

The implementation of GIS occurs when technology and people come together. It is the people in the organizations that have to adopt and use the new technology. In doing so, GIS technology changes the organizations in ways that cannot be predicted entirely. The challenge during implementation is to manage these changes and the implementation process acts as a "means through which such adaptations are transmitted to the members of the organizations" (Campbell and Masser, 1995, p. 7). Thus, implementation process is responsible for managing changes, integrating GIS into organizations and thereby leading to its effective utilization.

Implementation problems have often inhibited the success of GIS and other Information Systems throughout their history. So, the entire process from when organizations become aware of GIS through to when GIS is fully operational is very critical to its success in organizations (Aronoff, 1989). An understanding of the implementation process and the affecting variables can help provide guidance to users to accrue the benefits that GIS can offer.

2.3 Implementation Success for GIS Technology

GIS technology has to be internalized into organizations and utilized by potential users to be successfully implemented. The three criteria used to judge implementation success are:

- **User satisfaction:** User satisfaction leads to widespread acceptance and use of the system.

- **System Usage:** This indicates use of the system for daily activities of organizations. This criterion is critical, as introduction and acquisition of GIS technology are not sufficient conditions to imply utilization of the technology.

- **System Performance:** System performance refers to effectiveness and efficiency. GIS technology cannot be said to be implemented if it does not lead to an increase in productivity, profits and environmental effectiveness for the organizations (Budic and Godshalk, 1994).

Shultz and Slevin (1979) suggest technical validity and organizational validity as two other criteria for measuring implementation success. Technical validity indicates that the selected GIS system is the right solution to the organizations' problems. Organizational validity is a "measure of congruence between the organization and the system" (Obermeyer and Pinto, 1994, p. 17). This criterion similar to the user satisfaction criterion emphasizes the notion of gaining acceptance and use of the system to be important in the equation of implementation success.

These criteria suggest that numerous factors are involved in the implementation of GIS. Depending on which factor is considered critical; there are different opinions on how GIS can be successfully implemented. Due to this, interpretations regarding the significance and complexity of the process vary greatly leading to different perspectives on implementation process.

2.4 Perspectives on Implementation Process

There are basically four perspectives on the implementation process for technological innovations: technological determinism, economic determinism, managerial rationalism and social interactionalism. Advocates of each have different views about the process.

2.4.1 Technological Determinism Perspective

The technological determinism perspective is based on the utopian concept of the power, technical aspects and capabilities of technical innovations. It proposes that the technical merits of an innovation would be so apparent that they would inevitably lead to the acquisition of the innovation. Another concept that technological determinism theory believes in is that acquisition of innovation implies utilization and therefore, purchase is considered to lead to effective utilization. This suggests that processes of adoption and implementation are purely guided by technical capabilities of the innovation and, are rational responses of the users (Campbell, 1996). The human and organizational components are considered to be irrelevant to successful implementation and the only constraints for effective utilization are attributed to be technical failures or incompetence of users. Therefore, a failure is considered to be a temporary setback and, implementation, a matter of technical refinements of the innovation. This places emphasis on conceptualization of the technology to be a set of machines in isolation from its context (Cullis, 1996). In conclusion, the theory believes that all that is needed for a prosperous, effective and efficient society is improvements and advancements in technical fields.

2.4.1.1 Economic Determinism Perspective

Economic determinism perspective represents the same views put forth by the technological determinism perspective. In addition, it stresses the importance of technological innovations as essential for achieving economic progress. On realizing that an innovation can lead to economic prosperity, it will be absorbed by organizations inevitably. Thus, the technical imperative emphasized by technological determinism is taken a step further by the economic determinism theory by linking economic development to technology (Campbell, 1996).

2.4.1.2 Limitations of the Technological and Economic Determinism Perspectives

The key premise of technological and economic determinism theories that innovations will be utilized solely on the basis of their technical powers and resulting economic benefits leads to a linear and one-dimensional approach to implementation process. Research and evidence indicates that the process is far more complex and it is necessary to take into account social, political and organizational factors to achieve success. Thus, the arguments and assumptions underlying the technological and economic determinism theories fail to measure up to real world challenges when embedded in organizational settings.

2.4.2 Managerial Rationalism Perspective

The managerial rationalism perspective takes a slightly different approach than the earlier perspectives. The theory does not believe that implementation of innovations in organizations is purely technical in nature. Proponents of the theory are convinced that the implementation process is a combination of both, rational management and inherent technical qualities.

The theory is based on the concept that individuals and organizations act rationally and logically. The technical merits of the innovation coupled with the new work practice of management will lead to successful implementation. Therefore, a scientific management process involving pre-planning and strategy formulation, consisting of sequences of steps is perceived to lead to an unproblematic implementation. However, the theory still considers implementation to be dominated by technical factors rather than organizational and proposes a single management strategy for implementation in all organizations. The only factors that would lead to a failure are considered to be technical incapability and, failure to identify and follow steps in the management process. Thus, managerial rationalism perspective defines implementation process to be simple, but involving a set of specific rules and procedures (Cullis, 1996). Unlike the earlier theories, this theory acknowledges that in addition to the technical merits, an innovation has to be managed to realize its full potential.

2.4.2.1 Limitations of Managerial Rationalism Perspective

The managerial rationalism perspective acknowledges the need of a management strategy for effective implementation, but it does not go beyond the concept to consider organizational factors. Being indifferent to the social and political factors, it assumes that a single management strategy will work for all organizations and believes the process to be linear and unproblematic. Thus, the managerial rationalism theory when implemented in organizations does not hold true creating a need for social interactionalism perspective (Campbell and Masser, 1995).

2.4.3 Social Interactionism Perspective

The social interactionalism perspective is based on the conception of how organizations operate in "real world" situations and attempts to understand the issues of “real world.” The theory contradicts and points out the drawbacks of previous theories. Studies have shown that innovations introduced solely on the basis of technical potential rarely have a positive outcome. Also, individuals do not always, perform rationally and follow management strategies. Evidence also shows that the results of implementing the same innovation vary so greatly, which implies that innovations alone do not determine the success of implementation.

The social interactionism theory believes that technologies are not isolated from the context in which they are introduced and, adoption and effective utilization is a result of interaction between the technology and potential users. The theory suggests that the implementation process is far more complex and problematic due to organizational, social and political factors. Therefore, the basic aim of the theory is to gain organizational and user acceptance rather than creating a technically operational system. This places emphasis on the needs and capabilities of users and on their participation to achieve success (Campbell, 1996). However, the theory does not deny the technical component of innovations, but does not place too much emphasis on it. In conclusion, the theory does not provide a cook book approach but proposes that the right approach is dependent upon the available potentials, needs and resources.

2.4.3.1 Implications of Social Interactionalism Perspective for GIS Technology

Today, when technology has become sophisticated, users have realized that success of GIS technology is influenced by the context and is not solely dependent upon the development of a perfect technical tool. The advocates realize that organizations have certain sets of assumptions regarding nature, purpose and mission and are places in which people having different values and professions come together. The assumptions help in the formulation of rules that guide the actions of members and help to fulfill the missions of the organizations. While the missions remain constant, driving forces inside and outside the organizations change, leading to changes in their goals. To achieve their missions, organizations need to adjust their structures and procedures. Introduction of new technology in such environments affects organizations in ways that cannot be anticipated (Huxhold and Levinsohn, 1995). Therefore, the three critical factors that the theory emphasizes and believes will lead to effective utilization are:

a. **Information Management Strategies to identify needs of users, existing resources and settings of organizations:** GIS technology will be utilized in daily operations only if it produces valuable information to all users in organizations.

b. Commitment, participation of potential users at all levels: It is vital that strategies that facilitate participation and secure commitment from all stakeholders and users are devised.

c. Ability of organizations to cope with the changes due to GIS technology: Change is inherent in organizations that introduce and adopt GIS. To achieve successful implementation, organizations must accommodate and cope with the effects of GIS technology (Campbell and Masser, 1995).

However, social interactionalism theory emphasizes that identification of needs, gaining acceptance and consideration of change will not alone guarantee success, but failure to consider them would affect the integrity of the GIS project. The theory also acknowledges that without the technical abilities implementation is impractical, but implies that the organizations in which technology is well connected with the requirements can only lead to successful systems.

2.5 Summary and Conclusions

GIS technology is not a discrete entity from the environments in which it is imbedded. So the implementation of a GIS system is as social and political in nature as it is technical. Its introduction changes organizations' existing information systems, which are both familiar to staff and reflect the current structures and values of organizations. GIS introduction often requires changes in the organizational structures to satisfy the organizations' mission. These changes have to be managed to be able to provide a smooth transition to GIS technology. Attention is focused on obvious changes but there are numerous subtle and significant ones that go unnoticed. The ability of organizations to sustain changes plays an important role in the implementation success.

So, an implementation process that identifies changes and develops a plan that can help minimize their effect is essential to technology success in organizations. But, the process should give equal importance to social and technical aspects to achieve successful implementation. Such a process will be able to develop a system that will be integrated and utilized in the organizations' decision-making processes. This implementation framework attains much more importance when dealing with the new trend - **multi-participant GIS program**. The next chapter discusses multi-participant programs and the importance of an implementation framework to these programs.

Chapter 3. Multi-Participant GIS Programs

In the past decade, organizations have developed GIS facilities resulting in single-purpose/single application solutions to the needs of individual departments and organizations. This has sometimes resulted in the creation and maintenance of digital databases separately by each department/organization, leading to redundancy of data and efforts. This duplication led to interests in database sharing and construction, which resulted in formal and legal relationships between departments and organizations, leading to new spatial handling associations called multi-participant GIS programs (Savage, 1991). Though multi-participant GIS programs are in their infancy phase today, their approach to GIS technology promises numerous benefits. The realization of benefits from the approach has caused organizations with single purpose/single-participant GIS projects to turn towards multi-participant programs (Somers, 1990). Today, numerous GIS projects are being initially designed as multi-participant programs.

3.1 Definition of Multi-Participant GIS Program

A multi-participant GIS program is a “project which involves more than one user, each of whom has a different reason for implementing a GIS” (Huxhold and Levinsohn, 1995, p.75) with responsibilities shared among all. The multi-participant system is designed to perform applications and satisfy requirements of all participants. The involved participants consist of a wide range of legally separated entities, all bound by common GIS needs. These participants are:

- One or more Government departments and agencies
- Planning Commissions
- Utility departments (i.e. gas, telephone, electric, water, cable etc.)
- Private sector agencies
- Many combinations of the above (Montgomery, 1990c)

Thus, a multi-participant GIS program implementation crosses established organizational, departmental boundaries and involves cooperative efforts amongst all participants. Also, these programs involve participants, each with his own set of goals, functions, data requirements and reasons for implementing a GIS. They differ in their management philosophy, culture and stage of technology use. Multi-participant GIS programs thus, involve diverse entities, which come together with unique motives and work together to achieve individual missions (Huxhold and Levinsohn, 1995). A few years ago, these programs were considered impractical and infeasible, both politically and technically. Today several factors have contributed to their acceptance and they are being conceptualized and implemented at increasing rates.

3.1.1 Types of Multi-Participant GIS Programs

Multi-participant GIS programs can be operationalized in the following two ways:

Multi-departmental GIS program: This is a most common model of GIS, especially in local government, which develops diverse applications for all participants. The program is normally managed by a separate team, which ensures compliance with standards and communication among all users. Many large cities and counties find it difficult to implement a multi-departmental GIS program due to internal differences and cost of a jurisdiction-wide GIS.

Multi-agency GIS program: Agencies participating in multi-agency GIS programs may have different policies and decision-making rules making the program a greater challenge than a multi-departmental one. Still more agencies are participating in multi-agency programs due to the potential they offer in providing quality information and services (PTI and ICMA, 1991).

These multi-participant GIS programs are of two types:

- **Temporary / Permanent program:** A temporary program is a single purpose project, i.e. once the goal is achieved the program is reconstituted for different purposes. While, a permanent program is one in, which there is an ongoing need to coordinate efforts among the entities. These programs are established with large organizations or corporate-wide jurisdictions.
- **Coordinated / Joint program:** A coordinated multi-participant GIS program focuses on the development of separate systems for separate projects, keeping the existing one intact. The driving force behind coordinated multi-participant programs is primarily data sharing. These programs are less formal in structure than joint programs. A joint multi-participant program, is one in which participants come together to achieve a specific objective, that cannot be funded by any single agency or department. These programs are more formal agreements involving contracts to be signed by participants (Huxhold and Levinsohn, 1995).

3.2 Characteristics of Multi-Participant GIS Programs

Multi-participant Information Systems programs are similar to multi-participant GIS programs in the aspect that they involve several participants and aim to satisfy all stakeholders. However, the primary reason for the initiation of the program is what differentiates the two. The focus on geography to create a comprehensive database acts as a principal motivator and is a distinguishing characteristic of multi-participant GIS programs. A shared geographical database brings entities together in multi-participant GIS program. Typically, though the convenience of common geography brings diverse participants together, it is not the only unifying force. Some other driving forces that lead to the creation of a multi-participant GIS are:

- Declining budgets
- Increased efficiency and cost-effectiveness
- Data interdependence
- New technology and systems integration
- General awareness, demand and mandates among Government organizations
- Reduced costs and increasing profits (Huxhold and Levinsohn, 1995)

In addition to the above factors, programs are designed to facilitate sharing of responsibilities and funding. The major motivators include cost and data sharing. All these driving forces motivate the participants to come together to achieve their objectives.

3.2.1 Criteria for Participation in A Multi-Participant GIS Program

Determination of initial participants in a multi-participant GIS program is a difficult task. Evidence indicates that restricting participants to a manageable number is sometimes essential for successful implementation. Initial selection of "realistic" participants should be broadly based on the following criteria:

- Common geographical location to help develop a common land database
- Interest in the program
- Ability to fund the share of the program cost if required
- Ability to cooperate and work constructively (Montgomery, 1990c)

3.3 Potential Benefits from Multi-Participant GIS Programs

The multi-participant approach to GIS technology provides benefits in addition to those usually obtained from a single-participant approach to GIS. Some of the benefits that can be obtained from a multi-participant GIS program include the following:

- The concept behind a multi-participant approach to GIS is to share technology, costs, and responsibilities. This helps participants obtain a fully operational system at a lesser cost than if they each had to develop the system individually. This is an important benefit for small organizations not capable of developing an operational system because of financial constraints.

- The development of a comprehensive database, a difficult and expensive task, can be achieved through the multi-participant approach. The comprehensive database provides participants with data for carrying out functions and performing analyses that were not possible, as data was unavailable. The centralized database ensures consistency in accuracy, scales and format, and provides a central location to organize, store and maintain data for the area. It eliminates redundancy of efforts and funds for collection, development and maintenance.

- The most important benefit from a multi-participant approach is in terms of increased efficiency, productivity, profits and reduced costs for all participants. The benefit in terms of costs can be highlighted by a comparison between a single-participant and multi-participant approach. The next section discusses the financial benefits through a hypothetical example.

3.3.1 Financial Justification of a Multi-Participant GIS Program

There are four general types of costs associated with the implementation of a GIS:

- Services: These include services such as consulting, training of users etc.
- Hardware and software purchases: These include purchase of workstations, data storage devices, printers, plotters, data communication networks and software packages.
- Database creation: Database creation is the largest of all the implementation costs in a GIS program and deals with collection of data and creation of database.

- Ongoing costs: Ongoing costs include costs for system development, hardware/software maintenance, data management etc (Korte, 1997).

In many GIS projects the costs for implementation of the technology in a single organization are distributed in the following manner:

Table 1: Proportion of Implementation costs

Implementation tasks	Costs
Services	6%
Hardware/software purchases	19%
Database creation	69%
Ongoing costs	6%

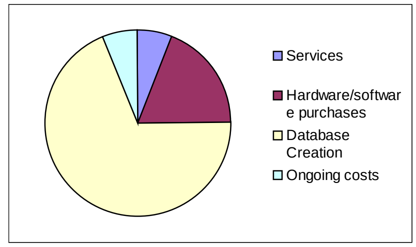

Figure 1: Proportion of Implementation Costs (Korte, 1997)

A hypothetical example is used to highlight the cost savings obtained through a multi-participant approach. This hypothetical example has two scenarios:

- **Scenario 1** has four organizations implementing GIS technology through the single-participant approach. Each organization is considered to be of the same size, having 15 employees each. The total cost for implementing GIS for four organizations is four times the cost for one organization.

- **Scenario 2** deals with the same four organizations implementing GIS technology through the multi-participant approach. The four organizations are treated as a single entity and costs are calculated. Database creation costs are considered for a database that will be shared among the participants.

The costs are calculated for each scenario based on the costs for hardware/software purchases (personal workstation with software licenses, large disk drive and plotter) and distribution of costs as explained in Figure 1. In Scenario 1, the cost for the first workstation is $20,000 and each additional workstation is considered to be $10,000 (Korte, 1997). It should be noted here that the hypothetical example is provided to illustrate the cost savings in a multi-participant approach as opposed to a single-participant approach to GIS. The following table compares the two scenarios to highlight the financial benefits from a multi-participant approach:

Table 2: Comparison of Costs in Scenario 1 and Scenario 2

Implementation Tasks	Costs for Scenario 1	Costs for Scenario 2
Services	50,500 x 4 = 202,000 $	202,000 $
Hardware/software purchases	160,000 x 4 = 640,000 $ (60 computer workstations)	210,000$ (4 servers-30,000$ + 60 PCs- 1500$)
Database Creation	580,000 x 4 = 2,320,000 $	580,000 x 2 = 1,160,000$
Ongoing costs	50,500 x 4 = 202,000 $	151,500
Total Costs	**3,364,000 $**	**1,723,500 $**

The comparison between the two scenarios clearly indicates that implementation costs for a single-participant approach are approximately two times higher than the costs for a multi-participant approach. Thus, the hypothetical example reinforces the notion of cost savings and increased efficiency obtained through the multi-participant approach.

3.4 Potential Disadvantages of Multi-Participant GIS Programs

Although the multi-participant approach to GIS technology provides numerous benefits, it is necessary to acknowledge that it also has a few disadvantages. A multi-participant GIS program usually leads to the development of a centralized database for the participants. The centralized database can lead to loss of power, control and flexibility that the individual organization/department has in a single-participant project. Unlike the multi-participant program, in a single-participant project the organization/department has complete authority over the database and therefore has powers and control over the database. The power and control enable the organization/department to deal with the data as needed leading to flexibility. The centralized database in multi-participant GIS program results in storing and maintaining the database at a centralized location and therefore leads to the loss of control over the data, power and flexibility.

These disadvantages can overshadow the benefits of multi-participant GIS programs and can even lead to the rejection of the concept by organizations and departments.

3.5 Examples of Multi-Participant GIS Programs and their Benefits

This section provides examples of multi-participant GIS programs while exploring the benefits of the new trend.

a. Ontario Municipal GIS Applications Program: The Ontario Municipal GIS Applications program has indicated that small organizations that come across challenges in terms of database design, hardware/software acquisition, funding etc. are capable of implementing GIS and can benefit from it. The multi-participant approach taken by Ontario Municipal GIS Applications Program involving private and public agencies helps make full use of the potential of GIS.

The main challenge for participating organizations was the creation of a comprehensive database. Data existed in digital formats, but was scattered around. Therefore, the main aim of the program was to collect data and build a comprehensive database that could be used by all participants. Using the set of data translators developed by Hunter GIS (a consulting firm) data from various sources was converted to the required format and developed into a comprehensive database. The development of a regional database opened up unlimited application opportunities for the participants. Hunter GIS worked together with the participating organizations, defined needs, tailored the database to support applications and performed the required analyses. Due to the multi-participant approach, the participating organizations did not need to acquire a fully operational GIS system at their facility, but obtained the benefits of the technology at nominal expense. Thus, the benefits of sharing and exchanging of data among the private and public organizations is evident from the Ontario Municipal GIS Applications Program (Parent, 1991).

b. Milwaukee County Automated Mapping and Land Information Systems (MCAMLIS): The MCAMLIS multi-participant program involving the Government and Utility companies is an example of what can be achieved through cooperation. Earlier, the Government and Utility companies worked separately collecting data and providing services to the community. However, these uncoordinated efforts resulted in redundancy of data, data collection efforts, incompatible scales and formats in addition to making the taxpayer pay twice for the same information. The realization of drawbacks led to the establishment of MCAMLIS, a multi-participant program.

Several utilities, viz. Wisconsin Gas, Wisconsin Electric etc. paired up with the county to start the program. In addition the Southeastern Wisconsin Regional Planning Commission assisted the efforts of participants. The main aim of the program was development of a shared land information system, which would make information readily available to all. This would reduce duplication of efforts and help utilize the taxpayers' money in other productive ways. The integrated LIS would also help bring about economic development in the community because of the advantage over other cities, which did not have a comprehensive database. Also, Wisconsin would be able to attract businesses and create jobs in the community, driving the state's economic competitiveness. Thus, the multi-participant program proved to be beneficial not only to the participants, but also to the community (AM/FM International Staff, 1992).

c. Edmonton's GBIS: Edmonton's GBIS multi-participant program, in addition to the benefits of the approach, is an example that indicates the importance of an implementation framework for successful implementation of the technology. Edmonton was faced with problems related to land and mapping activities. These problems led to the recognition of the need for an integrated approach to collecting and storing land information. This resulted in the conceptualization of GBIS, a multi-participant program, a "integrated network of computer systems for mapping design graphics, facility management planning and management support functions" (Somers, 1990c, p. 84). The objectives of the program were:

- Integrating of land and property information
- Integrating of municipal and utility applications
- Increasing drafting productivity
- Reducing cost of conversion of city map to metric system (a new regulation)
- Providing users with uniform, high quality land-related data
- Accessing all city information from one terminal

- Allowing for development of decision-support functions related to land information

The multi-participant GIS program helped achieve these objectives through cooperation and sharing of data, funds etc. among participants. The major participants of the program included the City departments of Planning and Development, Parks and Recreation, Public Works, Finance and Transportation; City Utility departments of Power, Telephones, Environmental Services and the private company of Northwest Utilities Ltd. However, the first phase of the program, development of primary databases, faced serious problems. A study indicated lack of project management as the primary cause of problems. Identification of the problem led to the development of implementation framework, which helped gain cooperation, support and trust from all participants and led to a successful Phase I of the program. On completion of the primary database, productivity increase ranged from 2:1 to 26:1, indicating the success of multi-participant GBIS approach as well as the implementation framework (Somers, 1990c).

d. GeoMap: GeoMap is a multi-participant GIS program initiated in 1984, involving the counties of Montgomery and Prince George and the Washington Suburban Sanitary Commission (WSSC). Other participants included Maryland National Capital Park and Planning Commission (MNCPPC) and Maryland State Department of Assessments and Taxation. GeoMap was aimed at providing a wide range of applications, such as mapping, report generation, assessment support, planning and infrastructure management etc. Before the initiation of the multi-participant approach, agencies had limited geo-processing capabilities. The multi-participant approach brought about steady progress in the capabilities of all participating agencies. The cost of the program was shared evenly among the WSSC and MNCPPC and the two counties. The multi-participant approach was expected to reduce the mapping effort by sharing data and elimination of redundant activities among participants. In addition to the expected cost savings from reduced mapping efforts, GeoMap provided benefits to facility management and emergency response (Somers, 1989).

Thus, these are a few of the numerous multi-participant GIS programs that are underway today. The following table provides an overview of the examples of multi-participant GIS programs explained above:

Table 3: Summary of Multi-Participant GIS Programs

Program	Type of Program	Type and No. of Participants	Reason for Implementation
Ontario Municipal GIS	Multi-agency, permanent, joint	Local Govt., Private companies	Comprehensive database creation
MCAMLIS	Multi-agency, permanent, joint	Govt., Utility companies, Planning Commission (5)	Shared land information system to serve residents
Edmonton's GIS	Multi-agency, permanent, joint	City Departments, Private companies (9)	Improve land and mapping activities
GeoMap	Multi-agency, permanent, joint	County offices, Planning Commission (6)	Elimination of mapping efforts, cost savings

These examples indicate that multi-participant GIS programs can be successfully implemented in diverse organizations. The principal motivators of database creation and cost effectiveness make participants to implement the technology through the multi-participant approach. But to achieve successful implementation, it is necessary to develop an implementation plan, as indicated by Edmonton's GIS program.

3.6 Importance of Implementation Framework for a Multi-Participant GIS Program

In a multi-participant GIS program, the differences among requirements and goals necessitates aligning the characteristics of the program's structure to participating organizations, both individually and collectively. Also, with many participants involved, managing activities and maintaining communication among all becomes a difficult task. In addition, introduction of GIS in organizations leads to changes in all of them, which need to be managed for successful implementation. Therefore, an accompanying trend with the multi-participant approach is an increased level of difficulty in introducing and implementing the technology.

This indicates that a multi-participant approach is even more complex than a single-participant project and faces greater implementation challenges. This level of difficulty in implementation necessitates a well-defined implementation framework to maximize the system's potential. Therefore, an implementation process that deals with managing changes, integrating GIS in organizations and thereby, leading to its effective utilization becomes critical and essential to the successful implementation of multi-participant GIS programs. The next chapter, Chapter 4 presents a general implementation framework for a multi-participant GIS program.

Chapter 4. Implementation Process Framework For A Multi-Participant GIS Program

The implementation process for a multi-participant GIS program involves four phases. The process starts with an initiation phase when a department/organization/individual considers incorporating GIS through the multi-participant approach. Although, a single-participant GIS project also involves the same four phases and starts with initiation phase, the contractual requirements and coordination issues set multi-participant program apart from single-participant project. As participants in a multi-participant program are entities, each having unique needs, it necessitates contractual considerations among participants to provide a solid foundation for successful implementation. Also, developing healthy relationships among participants is very crucial in a multi-participant program. The following flow chart describes the entire implementation process:

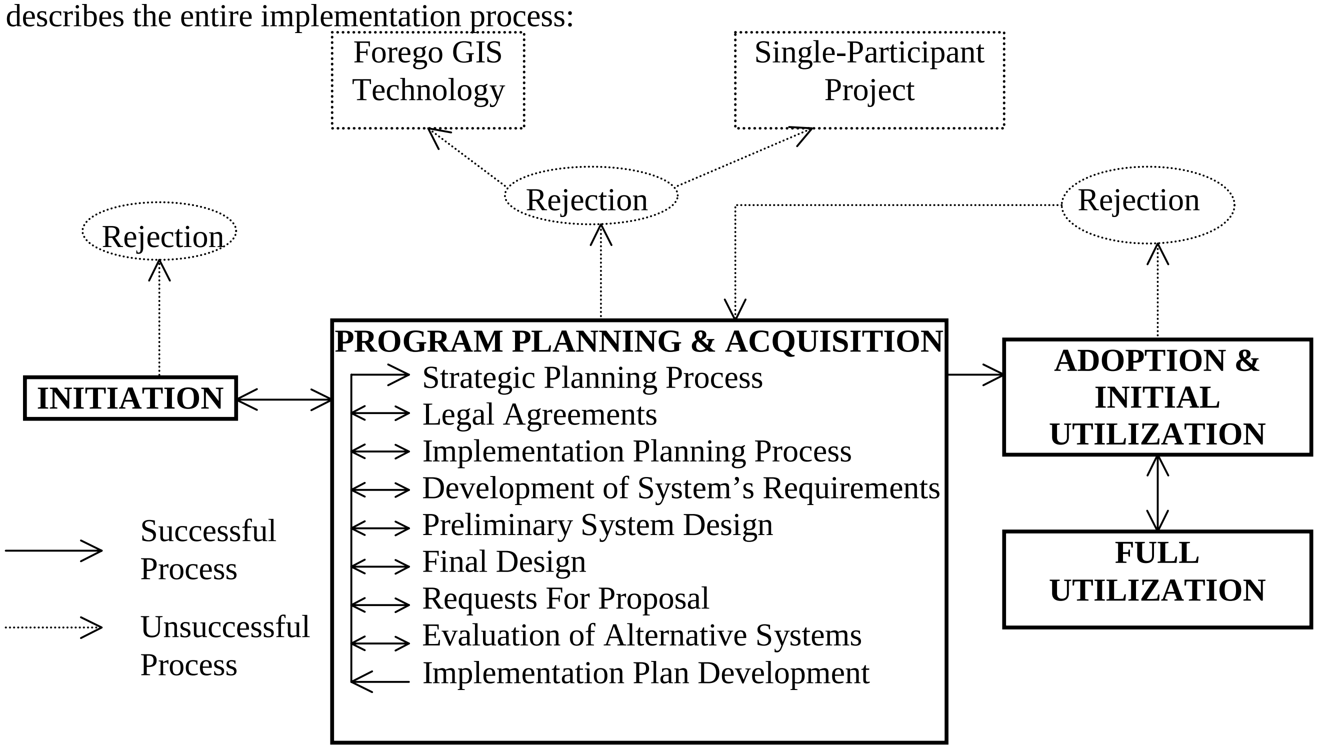

Figure 2: General Implementation Process Framework

While the process is shown as sequential, it is also iterative in that users can revert back to previous phase, step and decision points as they gain new information. At every phase and step in the implementation process, numerous decisions regarding the implementation have to be made by the involved participants. In addition to the lead agency director and staff and interagency teams (policy and technical) whose aim is to achieve efficiency in performance and costs, each participant has a set of people who are involved in the decision-making process of the multi-participant program. These actors involved in the decision-making process may differ in private and public sector agencies due to the difference in the goals and structures of the agencies. The goal of a private agency is increased profits and efficiency, while the goal of providing better services and cost effectiveness makes the public agency weigh the benefits against the costs needed to acquire

GIS. This difference in goals and actors involved in the decision-making process makes the multi-participant program complicated. The following is a description of the phases and tasks involved in the implementation process.

4.1 Phase I: Initiation of Multi-Participation GIS Program

Normally, it is a department/organization or an individual who initiates the multi-participant approach to GIS. This impetus for incorporation of the multi-participant approach can be fueled by mandate, recognition of problems in the current Information System (need), self-interest of department/organization or individual and awareness of benefits of the multi-participant approach. The department/organization, which initiates the concept, is a "lead agency" and the individual a "project champion".

Consideration of the criteria for participation (section 3.2.1), technical and economic practicality should help the lead agency/project champion to identify initial participants and secure interest for the multi-participant approach in those organizations. This should be followed by the introduction of GIS concept and contractual considerations among the interested participants (Montgomery, 1990f).

4.1.1 Introduction of GIS Technology

The introduction of GIS among participants should be done by the lead agency/project champion, and should involve a "a general overview of GIS and its benefits and issues. The following activities should be undertaken during the introduction of GIS technology:

- Discussion of various GIS uses and functions
- Awareness of the differences between computer-aided design and GIS
- Operation, staffing, cost and personnel requirements
- Performance expectations and general implementation time frames
- Questions raised by the technology" (Flagg, 1993, p. 48).

4.1.2 Contractual Considerations for A Multi-Participant GIS Program

A multi-participant GIS program involving diverse agencies necessitates some type of a formal written agreement among interested entities. This agreement called the "memorandum of understanding" unites participants to jointly conduct a feasibility study. Normally participants need to commit some funds for this study. However, the memorandum does not bind participants to implement GIS technology (Wright, 1992).

Another issue during initiation is ensuring that all affected groups are involved in all aspects from start of the program. So, the initiation phase should be directed towards all participants to ensure commitment and participation during the entire process.

4.2 Phase II: Program Planning and Acquisition

A successful initiation phase proceeds to a feasibility study, which helps participants, make decisions regarding acquisition of the technology. The desire to acquire GIS leads to adoption and initial utilization and successful adoption and initial utilization ends with full utilization of the technology (Budic and Godshalk, 1994). Phase II involves the following steps:

4.2.1 Step 1: Strategic Planning Process

The main objective of the strategic planning process is to formulate a strategic plan for the program. The introduction of GIS in each organization creates uncertainty and instability. A strategic plan that aligns the existing organizational structures and expectations of participants can help identify changes and manage their impacts effectively. It also helps participants research the feasibility of the multi-participant approach, individually and collectively. The formulation of a strategic plan involves the following tasks:

- **Situational Analysis:** The situational analysis carried out by the lead agency or specially appointed team should identify the characteristics and needs of every participant. The analysis helps to develop an understanding of the existing situation of the participants by identification of their missions, objectives and plans, both in present and future. Management styles and cultures of participants should also be identified. Analysis of information products and data requirements for each organization should also be carried out. In addition, the available financial, human resources and technological maturity of all participants should be determined. Analysis of implementation success risk, which provides a probability of successful GIS implementation, should also be undertaken.

The individual analyses should be aggregated to form a situational analysis, which will help identify the institutional, structural, technical and economic situation. The results will guide the development of the best approach to planning for multi-participant GIS program. Thus, situational analysis is not a technical analysis but, helps understand participants, and is based on the perspective of social interactionalism (Huxhold and Levinsohn, 1995).

- **Creation of strategic vision:** Strategic vision is a general plan that outlines a direction for GIS development. Strategic visions for individual organizations should be developed into a collective strategic vision for the multi-participant program. The development of a strategic vision, which applies the results of a situational analysis, would help foster commitment, align the direction of the implementation process with other institutional aspects of the organizations and guide planning and development of GIS technology (Huxhold and Levinsohn, 1995).

- **Determination of Feasibility of the program:** Determination of feasibility of the program is a valuable step involving the alignment of strategic vision with "real world". Feasibility should be determined in terms of financial, technical and institutional factors. Financial feasibility involves a general cost-benefit analysis and provides an estimate of the required resources to warrant expenses and justify GIS (Montgomery, 1989c). Technical feasibility deals with available resources and technology required for carrying out the organizational functions. This helps determine training and technical support required for an operational system. Institutional feasibility deals with administrative policies, budgeting and planning processes of participants to determine their capacity to manage changes (Clarke, 1991).

Funding Strategies: The financial feasibility study should also research funding methods. Every program being different in terms of participants, financial environment and processes needs different methods to achieve success. "Some creative funding techniques are:

- Enterprise funds
- General obligation bonds
- Sales tax
- Dedicated fund loans
- Lump sum payments
- User fees
- Improvement
- District funds
- Special assessment funds
- Ongoing operation cost" (Montgomery, 1990d)

- **Development of the Scope for the Program:** The constraints determined in the feasibility studies should be aligned with the collective strategic vision to develop a scope for the program. Thus, having identified a concrete scope for the program will help ensure that expectations of all users are met and guide GIS development in the multi-participant program.

Thus, the strategic planning process helps develop a strategic plan, which records the studies and analyses done to define the scope for the program (Huxhold and Levinsohn, 1995).

4.2.2 Step 2: Legal Agreements and Obligations

The strategic planning process helps organizations make decisions regarding participation in the program. The decision to participate necessitates a legal agreement among the participating organizations. The agreement called "master agreement"; a formal and detailed written agreement should put forth each participant's commitment and responsibilities during implementation of the program. The "master agreement" should address the following issues:

- Identify participants
- Define organizational structure: This involves setting up project teams and committees for various tasks and establishing operating procedures.
- Define cooperation among participants
- Define participants' responsibilities and rights (what they would get for their investment)
- Define cost allocation share of participants over a specified period of time. Separate cost allocation shares should be established for database development, maintenance etc.
- Define data sharing specifics, security and confidentiality

- Define financial and administrative details of adding new participants to the program
- Define prospective partners' or dropouts' role and rights
- Identify the entity that will house the "master" GIS database. This could be a participant, a contractor or a third party created for the specific purpose
- Define maintenance procedures and data quality standards
- Define sale of data issues (Montgomery and Schuch, 1993)

Additional attention should be paid while considering the following issues:

a. Developing Cost Allocation Strategy: For developing a cost allocation strategy, it should be recognized that each participant in the multi-participant program receives different benefits and therefore, should pay according to the benefits received. The strategy should also depend upon the characteristics of the program. A final cost allocation strategy should be decided through consensus among participants and should be agreed to in writing. The cost allocation strategy should be fair and equitable to all. The common cost allocation methods utilized are:

- "Cost related to legal responsibility to provide information
- Cost related to required level of accuracy, specific database element and access needs
- Cost related to participant usage as associated with miles of road, number of parcels etc.
- Cost related to number of customers, taxpayers etc.
- Cost related to direct benefit, ability to pay
- Cost divided by number of participants" (Montgomery, 1990d, p. 81)

b. Database Sharing Specifics: The actual contents of the shared database should be established before proceeding with acquisition of technology. Since, different organizations will have different data needs and ways of representing information this issue should be an important consideration. Data sharing specifics issues should be documented and signed by all participants.

c. Data and Non-data Ownership issues: In multi-participant program, data is not necessarily owned by those who pay for it, but depends on database contents. So, database ownership should be clearly spelled out in the agreement along with the non-data assets ownership. Although, non-data issues are easier to resolve, they should be given attention along with data ownership issues.

d. Data Maintenance: Data maintenance, a big legal issue, has significant impacts on all participants. Questions such as which participants have responsibility for maintenance, information currency, distribution of updates of data, what happens if the responsible entity does not perform the task properly etc. should be addressed in the "master agreement."

e. Liability: Information generated by the computer is believed to be extremely accurate, but "accuracy of GIS database is only good as the data used to create it" (Montgomery and Schuch, 1993, p. 174). A disclaimer regarding the accuracy should be included to protect the multi-participant organizations from any liabilities. Also, a copyright law should be issued so that the multi-participant organizations solely retain the rights to its use.

It is essential that all above mentioned issues be addressed and agreed upon through a contractual form in the agreement, before starting implementation of the program. Since, each multi-participant GIS program will have its own unique requirements, issues regarding the program should be solved and documented. Also, provisions should be made in the agreement to accommodate any other future changes. Organizations signing the master agreement are then contractually and financially committed to build GIS (Montgomery and Schuch, 1993).

4.2.3 Step 3: Implementation Planning Process

The signing of "master agreement" leads to implementation planning process. This step involves the development of a start-up plan (an interim plan) and provides a schedule of tasks leading to implementation of GIS. The start-up plan involves the following tasks:

- **Organization of stakeholders and users into teams to guide the implementatio process:** As GIS technology spans across numerous functional areas and organizations, all have to be adequately represented to achieve effective utilization. A team approach involving all major stakeholders and users encourages consensus, comprehensive solutions and fosters cooperation and participation among all participants (PTI and ICMA, 1991). However, a right team has to be assembled to help make the right decisions. The strategic plan, which identifies the following groups in organizations, should be consulted during the formulation of teams:

- Sponsors: These include the management level of organizations and possibly outside organizations that provide funds for the project.
- Clients
- Project management: This team includes people who are responsible for managing planning and implementation of the technology.
- System Designers: This team determines the needs of organizations and individual users and translates them into technical specifications needed to purchase the system.
- System Implementers: These include people who participate in the acquisition process and carry out certain implementation tasks. (Huxhold and Levinsohn, 1995)

Also at this stage, policy and implementation teams, consisting of a combination of participants and representing all participants should be created.

Policy Team: The policy team involves management level people to define key issues, allocate resources, approve the implementation plan, and provide management support and guidance to the technical team. The team also resolves issues regarding funding and data ownership.

Technical Project Team: The technical project team should include technical and direct user representatives. The main aim is to develop an operational GIS that can be utilized by all. Issues such as database content and construction, data transfers and maintenance procedures should be defined. Depending upon the requirements, steps in implementation, required skills and expertise for the tasks, different members will be involved in different tasks (PTI and ICMA, 1991).

In addition to the two teams, a project manager should be appointed to coordinate and manage the entire program. Evidence has indicated that an efficient project manager is a key to success, especially for multi-participant programs. He should have a good understanding of the participating organizations and excellent communication skills. He should manage the functions of the program, coordinate between teams, represent all participants fairly and efficiently manage vendors and consultants of the program (Montgomery and Schuch, 1993).

- **Schedule of workshops and general group meetings:** It is very critical to develop bonds among teams to help achieve consensus and commitment. Group discussions and work sessions that involve all participants/stakeholders can help achieve this goal. So, a tentative schedule of work sessions should be prepared to foster participation (Huxhold and Levinsohn, 1995).

Thus, the start-up plan provides a general overview to all participants of the upcoming tasks, how participants fit into the implementation process and what is expected of them and helps to ensure commitment of all participants to GIS implementation.

4.2.4 Step 4: Development of System's Requirements

The development of system's requirements is also known as User Requirement Analysis or Functional Requirement Study (FRS). The main objective of this step is to identify and determine user's needs in detail. This step involves the following tasks:

- **Identification of existing functions and processes:** Identification of existing functions and processes of each participant will provide a better understanding of information flow, its use and users (Montgomery, 1989c).

- **Identification of the potential users:** Identification of potential users in each organization helps identify people affected by the incorporation of GIS. These users include users from clients (end-product users) to people who collect data (Clarke, 1991).

- **Definition of the information products and the analysis of data requirements:** Since, data form the most important part of GIS and database development results in 69% of the technology costs, identification of existing data and existing and anticipated data requirements for each entity forms an important step in the implementation process (Aronoff, 1989). A "geographic information needs" inventory provides a systematic way of identification of currently used data and anticipated data needs of organizations. For this, each department in each organization must be surveyed to obtain the required information.

A "geographic information needs" inventory should be followed by a "map inventory". The "map inventory" of each organization should identify all maps and drawings used by staff in the organizations. The inventory should also identify features, geographic coverage, scale, accuracy and updating methods of each map. This survey will help determine both digital database and hardware/software requirements. An effective way to summarize this information into a usable format would be to aggregate the information into a collective "information needs matrix" for the multi-participant GIS program. The matrix will help graphically identify interrelations and common needs of all participants (Huxhold and Levinsohn, 1995).

- **Definition of Application Requirements:** Applications provide an understanding of how data are used to accomplish functions and processes of the organizations. To ensure that the organizations' missions and goals are reached, GIS applications should be integrated with the functional needs of organizations. So, the application requirements definition involves identification of functions organizations perform, data inputs, use and outputs. Inventories of the functions and needs of participants will help define application requirements of the program.

- **Estimation of Workloads:** Estimation of workloads can be calculated from data analysis, database requirements and potential users. This information is useful during system design and selection process for adoption of GIS technology (Clarke, 1991).

The above tasks in the development of system's requirements will help recognize constraints and provide a basis for hardware/software requirements to enable the capabilities of GIS to satisfy the needs of all participants. These requirements should be determined at all levels of each organization to achieve successful implementation (Aronoff, 1989).

4.2.5 Step 5: Preliminary System Design

The preliminary system design step is a direct translation of the development of system's requirements step into a description of system components. Database contents define data storage components, functional requirements define hardware components, and the software components can be identified from the application needs. The tasks involved in this step are:

- **Preliminary design development:** This step involves the design of database, functional specifications and system models. The development of database specifications is guided by the system's requirements study of existing and anticipated data needs and the information needs matrix. Functional specifications should define functions and processes required to enable database development while, the system model should identify the aspects such as hardware, software, communication and organizational arrangements needed to develop an operational GIS. The training needs of users should also be identified. Finally, a market survey to identify systems available in the market should be undertaken to determine whether the proposed preliminary design can be realized by existing technological abilities (Clarke, 1991).

- **Cost-Benefit Analysis:** A thorough cost-benefit analysis of the system should be performed to guide the decision-making process for acquisition of GIS. The analysis should be carried out for participants individually and, collectively for the program. The analysis should decide:

a. Costs, which include costs for purchase, maintenance of the technology, data development, training for all users etc.

b. Benefits, which include increased efficiency, elimination of duplicate efforts, new non-marketable products (sophisticated output and presentation products, better decisions etc.) and, other intangible benefits (better public image, better communications etc.).

The cost-benefit analysis should assess the economic value of benefits, impact of the technology on organizations and risks involved in implementing GIS. Identification of risks that the technology may not actually fulfill expectations in terms of benefits, time and costs is very crucial (Aronoff, 1989 and Korte, 1996). Thus, the analysis helps weigh costs and benefits of acquiring GIS with the alternative of maintaining the existing information system. A positive outcome of the cost-benefit analysis will lead to the decision of acquisition of the technology.

4.2.6 Step 6: Final Design

The final design step is an extension of the preliminary design step. The main objective of this step is to develop a design document for the Requests For Proposal step. The results of development of system's requirements and preliminary system design steps are developed into specifications, necessary to request proposals and to evaluate the received responses. The final design is a crucial step towards the acquisition of GIS and involves the following tasks:

- **Finalize database specifications:** The results obtained during the preliminary database specification and cost-benefit analysis should be utilized to develop and finalize the database specifications required by vendors for designing the required system.

- **Finalize functional requirements:** The functional requirements study and preliminary functional requirements results should be used to finalize the functional requirements This should identify essential and desirable needs for the operation of GIS in organizations.

- **Finalize performance specifications:** The performance specifications should specify minimum and optimum workloads identified during the estimation of workloads step in the development of system's requirements phase.

Also, in order to enable vendors to design a realistic system, constraints of existing hardware, software, communications, training, maintenance etc. should be put forth during the final design step. At this stage, an evaluation committee consisting of representatives from policy and technical fields should be appointed for the evaluation of proposals (Clarke, 1991).

4.2.7 Step 7: Requests For Proposals (RFP)

Requests For Proposals (RFP) document clearly spells out the "needs of the participants, requirements for responding for bidders, evaluation methodology, criteria used for evaluation" (Huxhold and Levinsohn, 1995, p. 185). It combines final design and contractual requirements to solicit bids for an operational system. A typical document should consist of:

- Background information: This section should include information regarding previous studies, results of various analyses, participants and stakeholders of the program.
- Description of the organizations in terms of staff, structure and population etc.
- Existing information system description and needs analysis document
- Evaluation process description: This section should include and explain the evaluation criteria, which will be used by the selection committee.
- System acceptance standards and requirement definition should include criteria for system acceptance to help bidders in proposing a system and define and describe a general solution required in terms of functionality, reliability, productivity and delivery of results.
- Contractual requirements: The contractual issues that must be addressed should include terms and conditions under which organizations will purchase the system. In addition, it should include scope of work, contract administration and performance standards.
- Format: The desired format of the RFP response should be stated (PTI and ICMA, 1991).

The RFP document requests bidders to apply themselves to the technical, organizational and contractual requirements. Each respondent should provide a statement explaining how the response corresponds to the requirements of the proposal. Preparation of the RFP should be followed up by its release, allowing some period for bidders to respond.

4.2.8 Step 8: Evaluation of Alternative Systems

The evaluation step following the release of RFP involves identification of an appropriate system from the received responses. The evaluation is based on the criteria mentioned in the RFP document, followed by a cost-effectiveness evaluation. This step consists of the following tasks:

- **Shortlisting:** A complete review of responses will lead to rejection of non-responsive offers and help obtain a shortlist of qualified candidate systems based on the responses of bidders.

- **Benchmark testing:** Benchmark testing provides a systematic method to compare performances of candidate systems. It also provides participants with better knowledge and judgment of how the system would perform under the required conditions. The benchmark testing first involves designing the benchmark which, establishes the tasks to be performed, data input and output requirements. The data used should be a sample of data used by participants and new to the vendor (Clarke, 1991). The evaluation of benchmark testing should consider system performance as indicated in the response by the bidder and cost-effectiveness evaluation. The test conducted under the surveillance of an evaluation committee would help identify unexpected difficulties and demonstrate the capabilities of the system. An analysis of the test results will help the evaluation team in selection of one best system (PTI and ICMA, 1991). The evaluation can be taken a step further by conducting a more expensive pilot study.

- **Pilot study:** A pilot study in addition to using a real data set, involves direct participation of users. A pilot study helps provide a "real world" view of the system. Though an expensive endeavor, a pilot study is considered a most effective way for evaluation. The direct involvement of users will enable to understand how a fully operational system would work and whether it would be capable of satisfying their needs. Thus, a pilot study "provides direct experience, look and feel of using a GIS, handling problems, exercising the system's capabilities and evaluating its performance and products" (Aronoff, 1989, p. 258). The evaluation of alternative systems should conclude with a report that identifies the best-suited systems, financial and human resources needed to support the implementation of GIS.

4.2.9 Step 9: Implementation Plan Development

The implementation plan is a document that ensures smooth implementation and early benefits from GIS technology. Development of the plan should be started either during or after the system evaluation and agreed upon by all participants and stakeholders. The following tasks should be undertaken when developing the implementation plan:

- **Identification of priorities of products and data:** A prioritization process should be conducted in consultation with all users of the system. Identifying priorities can help realize early benefits from the implementation of GIS, which will ensure commitment from users towards the long-term implementation process and help judge the progress, than a plan that does not result in benefits until late in the implementation process.

- **Define and schedule tasks:** Depending upon the priorities, the implementation plan should define and schedule all tasks, to provide participants with an overview of the entire process.

In addition, a budget and management plan should be prepared to take into account the unexpected setbacks and provides for funding until the completion of the project (Clarke, 1991).

To bring about a smooth implementation of GIS technology, it is necessary to bring together the four components of GIS technology- hardware, software, data and people. The implementation plan should provide a framework of how these components can be brought together into an operational system. The identification of priorities, definition and schedule of tasks and development of budget and management plans will guide and help develop a successful implementation plan resulting in an effective operational system. The implementation plan should consider the following components of GIS:

a. Technology: The strategies used to acquire an operational GIS technology are:

- "Big Bang" approach leads to a sudden change from the existing Information System to GIS.
- "Parallel Running" approach involves working of old and new technologies side by side.
- "Phased Running" approach involves purchase and introduction of GIS technology in phases that lead finally to a fully operational system.
- "Trials and Dissemination" approach consists of small-scale implementation and helps identify problems and needs by a trial and error method.

Each of the above approaches requires a well-defined plan for technical and organizational aspects (Budic and Godshalk, 1994). The implementation plan should identify the right approach to acquire GIS for the program depending upon the identified requirements and constraints.

b. Data: Database development consists of conversion of existing data into a digital format for use in GIS. The prioritization of data and definition of tasks will provide guidance for database development. Depending upon the proposed strategy for the purchase of technology, database development can be achieved in-house or contracted out.

c. People: People form an important component of GIS technology. The success of GIS heavily depends on people who implement the technology. The responsibilities of the process can either be assigned to an existing team or a separate team can be created and assigned the responsibility to carry out the implementation process. The plan should develop an appropriate approach and identify teams responsible for implementation and operation of GIS (Aronoff, 1989).

However, it is important to recognize that a negative outcome at any step during program planning and acquisition may require the participants to go back to the earlier steps to again assess the feasibility of the approach for the participants and program.

4.3 Phase III: Adoption and Initial Utilization of GIS Technology

The third phase, adoption and initial utilization of GIS consists of the following steps:

- **System Selection:** System selection should reflect the numerous analyses and studies undertaken during the process and should be based on the report developed during the system evaluation and implementation plan.

- **Contracting and purchasing the system:** Contracting involves aligning RFP, vendor's responses and implementation plan to develop a legal contract. The participants should carefully review and negotiate the terms of the contract before committing to the purchase of the system. Contracting conditions such as training of staff, documentation, installation and maintenance, in addition to hardware/software purchases should be negotiated. Guarantees, warranties, upgrade options, delivery schedules, payment methods, penalty clauses, responsibilities etc. should be explicitly expressed in the contract (Clarke, 1991). The contract should be reviewed by a lawyer, to ensure that the system will be delivered as per the requirements of the participants.

An acceptance test should be performed after installation of the system to determine whether the delivered system meets the requirements of functionality, reliability and performance, expectations of participants and claims of vendor (PTI and ICMA, 1991).

- **Start-up:** A start-up basically involves training users and staff in handling and operating the system. Guidance can be obtained from consultants and vendors on problems during the start-up. Thus, the start-up step is an initial utilization step and can help staff gain confidence in operating the system as well as to develop in-house expertise (Aronoff, 1989). The successful adoption and initial utilization of GIS technology should lead to a fully operational GIS.

4.4 Phase IV: Full Utilization of GIS Technology

The full utilization of GIS technology phase is reached when users start utilizing GIS effectively in their daily operations and decision-making processes. Once the system is operational, organizations must develop a plan to keep up with the current developments in the GIS field. All members should be provided with regular updates regarding the status and benefits realized from GIS to maintain the financial and political support for the system. A fully operational GIS that fulfills expectations of all participants is successfully implemented system.

Thus, such a system would help organizations realize the potentials of Geographic Information System, a powerful spatial handling tool. The next chapter deals specifically with the Town of Blacksburg and the implementation process framework if the Departments in the Town decide to incorporate the multi-participant approach.

Chapter 5. Multi-Participant GIS Program and the Town of Blacksburg

The Town of Blacksburg has been implementing GIS technology since 1989 through the single-participant approach by Department of Planning and Engineering. A study of current activities and future plans of the Planning and Engineering Department indicates that a multi-participant approach to GIS technology would help realize the potential and benefits of the technology. This chapter applies the proposed implementation process framework to Blacksburg's Planning and Engineering Department and other departments.

5.1 Overview of GIS Activities in the Planning and Engineering Department

The Engineering Division of Public Works, which has been using AutoCAD for its engineering applications since 1989, realized the potential of GIS for their applications and initiated GIS introduction. In 1993, the Engineering Division was integrated with the Planning Department and was named the Planning and Engineering Department, which is in the process of developing an operational GIS.

The development of database started with aerial photographs in 1978. But lack of accuracy in the aerial photographs resulted in a contract with Benatec Associates, Inc. to supply current aerial photographs and planimetric topographic maps of the Town in 1990. These maps showed information on topography, structures, roads, water features etc. This information provided a basis for database development of GIS in the Planning and Engineering Department. In 1993, software was upgraded from automated mapping (AutoCAD) to a full-scale GIS with Environmental Systems Research Institute's Arc/Cad. Arc/Cad was selected from various programs due to its link to AutoCAD, which the department already had. Arc View was also purchased to work directly with Arc/Cad. Database development, the first step towards a functional GIS was started using Arc/Cad. In 1995 an implementation plan developed by Duane Hyde (Hyde, 1995) suggested a schedule for implementation, depending on the requirements, financial, technical and staffing capacity of the Department. The plan is being used and has proven to be useful for implementation of GIS technology in the Department.

5.1.1 Current Status of GIS Technology in the Planning and Engineering Department

So far, a large number of paper maps have been converted into digital data for use in GIS. However, the Department is still in the process of completing the database, needed to perform simple analysis. Two programs, Version 14 of AutoCAD and Arc View 3.0 are used for developing geo-referenced digital data. AutoCAD is used to get maps into digital format and Arc View to register/geo-reference the maps into GIS. The attribute data, which is being developed by the Finance Department, will be linked to the spatial data using 'street address' as a primary key, to form a complete database. According to the GIS Coordinator, the database will take a few years to get completed. Database development is thus, being coordinated between the two Departments. However, maintenance of the digital database is proving to be a great challenge to the GIS coordinator. To tackle the problem of accuracy and to keep database current, the Department has now purchased a GPS unit. Today, a planning intern and an engineering technician help the GIS coordinator in database development (Smith, 1997).

5.1.2 Future Plans of the Planning and Engineering Department

Some of the future plans of the Planning and Engineering Department are as follows:

- Complete the initial database development in a year’s time (approx.).
- Replace paper maps system by digital maps on completion of the comprehensive database.
- Make information available and accessible to public through terminals using GIS technology.
- Buy ARC/INFO software to enhance GIS potentials in the Department.
- Provide the Finance, Police, Public Works, Transit and Parks and Recreation departments with GIS applications, but not coordinate efforts nor hold any responsibility for maintaining the applications.
- Provide a GIS workstation with Arc View software on every person’s desk, to enable simple GIS point queries to be performed (Smith, 1997)

5.2 Multi-Participant GIS Approach Benefits for Planning and Engineering Department

The Town of Blacksburg is a typical local government agency consisting of the Departments of Planning and Engineering, Finance, Police and others. Each department deals with its own data separately to carry out its functions. Although the use for which data is put may differ, all departments require the same geographical data. This has led to duplication of efforts and costs for data collection, maintenance and differences in data format, accuracy and scale.

The Planning and Engineering Department is developing a digital database for its department through the single-participant GIS approach. However, having realized the benefits of coordinated efforts among departments for database creation, it is working with the Finance Department to develop a complete data set. The realization of the potential that GIS can offer to the departments, has resulted in a plan for development of applications for the departments (see section 5.1.2) by the Planning and Engineering Department. However, this approach will not eliminate the initially identified problems. A better solution would be a multi-participant GIS approach for departments, which would help develop a comprehensive database of Blacksburg, reduce duplication of effort and costs for developing a database and GIS technology etc. Also, one of the objectives of the Department of making information available to residents can be achieved better through a comprehensive database. Thus, the multi-participant GIS program among the departments of the Town of Blacksburg would provide more benefits from GIS than the present single purpose, single-participant GIS approach. Thus, a **multi-participant permanent and joint GIS program** is recommended to help realize the full potential of GIS.

5.3 Implementation Process Framework for the Planning and Engineering Department

The implementation process framework suggested in this section follows the generic framework put forth in Chapter 4 and suggests a few modifications along the way. This framework is very brief and should be considered only as a base tool for a more detailed implementation process plan that should be prepared by the participants. The implementation framework process involves the following phases:

5.3.1 Phase I: Initiation of Multi-Participant Program

The Planning and Engineering Department should act as a "lead department" and initiate the multi-participant approach for GIS program in the Town of Blacksburg. Since the Planning and Engineering Department plans to develop GIS applications for other Departments, these Departments should be considered as initial participants. Other agencies can also be approached to identify more participants if needed depending upon the participating criteria. The following diagram shows the hierarchy of participants in the multi-participant program for the Town.

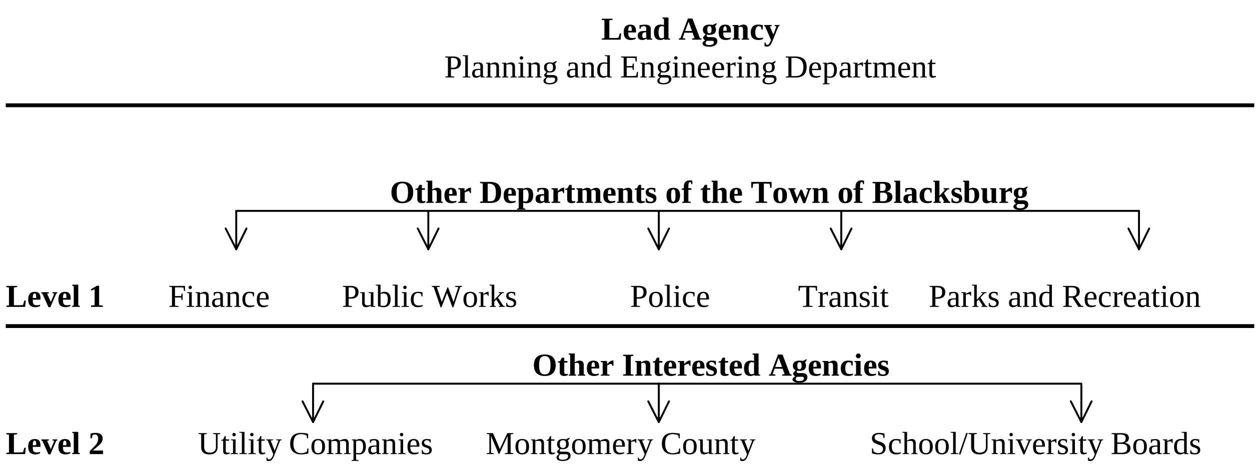

Figure 3: Hierarchy of Participants in the Multi-Participant GIS Program

The GIS concept should be introduced to interested participants and a "memorandum of agreement" should be signed to research feasibility of the program. However, an interview with GIS coordinator, Planning and Engineering Department, identified that the perceived lack of immediate need for multi-participant GIS for Town wide GIS may act as a constraint to get Departments involved and interested in the approach.

- **Recommendations**

The constraint of perceived lack of immediate need places more emphasis on introduction of the multi-participant concept to the Departments of the Town of Blacksburg. The Planning and Engineering Department should:

a. Emphasize the benefits from the incorporation of the approach to GIS. The WHIP program

(Netscape) should be used to introduce and educate the Departments of the benefits obtained from digital and centralized database (Smith, 1998). To encourage interest in the multi-participant approach, the different ways that each department could use the developed system should be emphasized. The following gives examples of GIS applications in various departments:

Planning and Engineering Department: The common database would help in the decision-making process of site selection for various land uses in the Town. The developed system would also improve the mapping capabilities and through overlay analysis aid in the development of the Town's Comprehensive Plan.

Transit Department: Network analysis (routing) to identify the efficient routes in the Town in terms of fuel usage and optimum distance.

Police Department: Network analysis (routing) to identify the location of an accident/emergency and the quickest route to reach that location. Other applications are crime analysis and neighborhood watch program evaluation.

Public Works Department: Network analysis (tracing) would help to identify the location of emergency and it's connected links in the water and sewer systems.

Parks and Recreation Department: The developed system will be helpful to monitor the maintenance activities in the Department, such as calculation of area for planting etc.

b. Develop relations and associations among the departments

5.3.2 Phase II: Program Planning for GIS Technology and Acquisition

5.3.2.1 Step 1: Strategic Planning Process

A collective situational analysis should be carried out to determine the overall constraints and opportunities for the program. This should be followed by development of collective strategic visions and feasibility in terms of financial, technical and institutional factors. One of the major constraints in the implementation of the multi-participant approach is the lack of education and technical expertise needed to utilize the technology. This factor should help determine the financial resources needed to train staff and/or hire new experienced staff. Finally, the scope should be determined in consultation with the situational analysis, vision and feasibility studies to formulate the strategic plan for the program.

5.3.2.2 Step 2: Legal Agreements and Obligations

Before committing to the program through legal agreements, the participants should carefully consider the decision to participate. Interested departments should sign the "master agreement", which should address all the issues mentioned in Section 4.2.2. The cost allocation strategy should consider the different requirements of departments. The Finance Department requires only attribute data regarding taxes and other payments and does not require graphics for performing their functions while the Planning and Engineering department and the Transit department require graphics to enhance their functions. Issues regarding accuracy of data requirements for each department should also be considered for the strategy. Also, issues concerning data sharing specifics should be carefully resolved.

- **Recommendations:** For issues concerning data sharing, a centralized database center should be formed. A team headed by a database administrator should be given the responsibility of database development, maintenance and accuracy. The allocation of a team to deal with the database issues will help solve the concern of database maintenance and integrity voiced by the GIS coordinator. The technological arrangements to make the centralized database accessible to participants can be achieved through computer networking. The updating of data should be based on the concept of transaction and master files. The participants should have the privileges to edit transaction files, but master files should be read only, with only the database administrator having the privilege to write. The transaction files after being edited by participants and verified for errors and accuracy standards by the database team should be passed on to the database administrator to update the master file. Thus, the master files represent data that is ready to be used for analysis. The following diagram represents the multi-participant GIS program organizational structure with the centralized database.

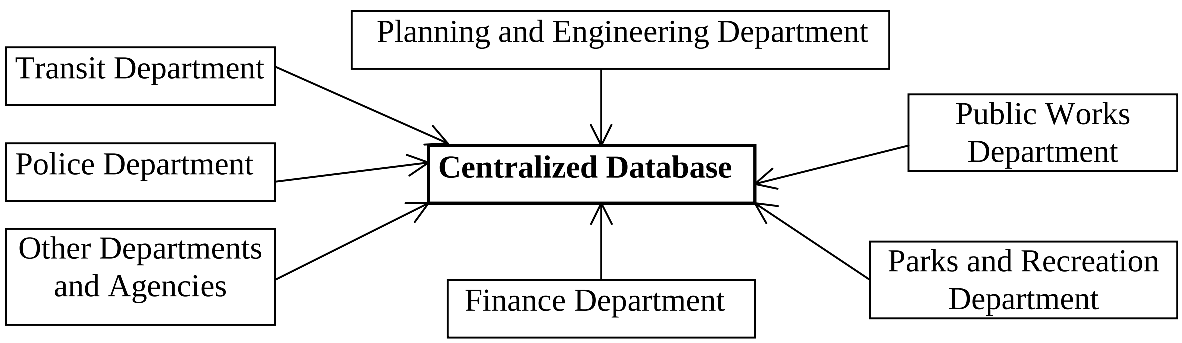

Figure 4: Recommended Centralized Database Model

Constraints: However, the Finance department data is developed and maintained on a system AS400, which is a mainframe IBM system. This system acts as a constraint to the development of the recommended centralized database. To download data for performing queries, it requires converting data into ASCII/text format and then importing into a SQL database. Thus, the system does not have a clean SQL interface required for GIS. The multi-participant GIS program requires a database that has a clean SQL connection and allows downloading data directly into SQL format. Therefore, the constraint of AS400 requires the modification of the recommended centralize database for the Town. The proposed database model for the town would be:

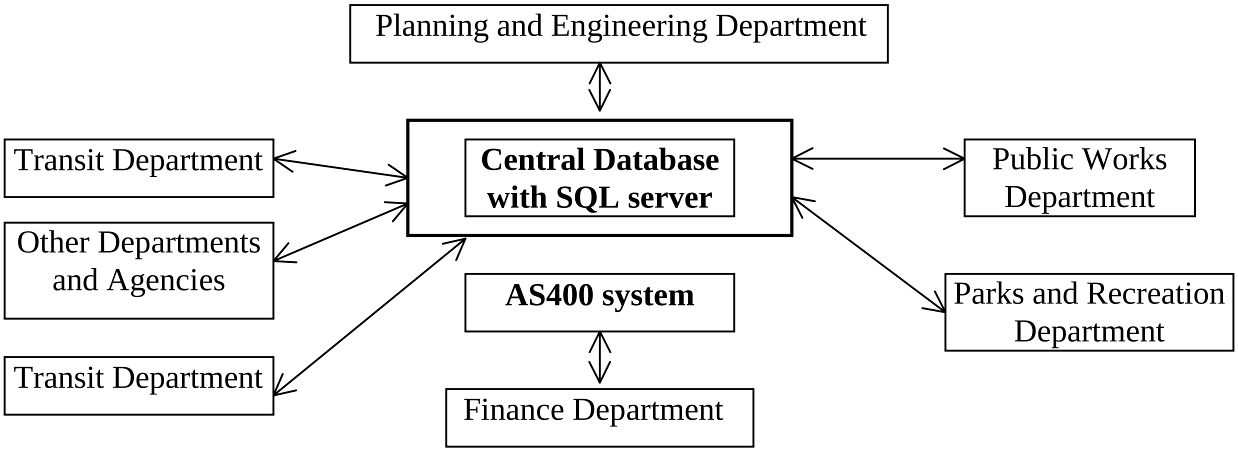

Figure 5: Proposed Centralized Database Model

While this model may not be most efficient of all, it would be efficient to carry out the functions of the Departments under the existing constraints. Also, according to the GIS coordinator, Montgomery County is developing AS400 system and in the long run the AS400 may prove to be beneficial in terms of integrating the Town and County databases (Smith, 1998).

5.3.2.3 Step 3: Implementation Planning Process

The signing of master agreement should be followed by organization of policy and technical project teams. Every department should be represented in the two teams. A project manager should be appointed to oversee the entire process of implementation. Since, the project manager should be someone experienced and well acquainted with the program, if possible should be selected from the Planning and Engineering Department, which is more experienced with GIS than other participants. With hands-on experience this person can help guide the process better. Also, as the town lacks the required technical expertise, new staff should be hired.

5.3.2.4 Step 4: Development of System's Requirements

The development of system's requirements step should help identify and determine the program's requirements in terms of hardware, software, database, training staff that can provide a base for system design. This should be achieved through identification of existing functions, potential users of the system, analysis of data requirements, application requirements and estimation of workloads. The geographic information matrix that helps identify current and priority data layers is a crucial component of this step. Other requirements can be determined through systematic matrices for software systems and computer equipment and peripherals.

5.3.2.5 Step 5: Preliminary System Design

The results of development of system's requirements should be utilized to design a system that meets all technical, functional and organizational requirements of the program. Also, a thorough cost-benefit analysis should be performed of the designed system to guide the decision-making process for acquisition of the system.

- **Recommendations:** The dominant trend of distributed computing system is proposed for data networks and data communication. Each participating department and database center should develop a local area network (LAN) individually, which can be interconnected together to form a Wide Area Network (WAN) for the multi-participant program. Each LAN should be built on a backbone of a single cable that interconnects all devices on the network and transmits data at high transmission rates, which allows for communication and data exchange. Several different types of computers can be attached in a single LAN, such as mainframe/minicomputer, PCs and engineering workstations. Computer peripherals such as printers, plotters and scanners and application software can also be shared in the WAN. This will allow users to access devices and data on LANs other than their own. Thus, this will support the proposal of centralized database development mention in the section 5.3.2.2. This distributed computing system will help reduce hardware and software expenses as it allows users on the network to access all devices.

Constraints: The Town's computer network, which connects each department with the other (Figure 4), acts as a bottleneck for exchange of larger files (maps take hours to download). However, having identified this drawback the Town is working to get the funding necessary to upgrade the network to support data exchange and accommodate increase in the users of the network. The GIS coordinator is confident that this will be achieved (Smith, 1998).

5.3.2.6 Step 6: Final Design

If the preliminary design step favors acquisition of GIS through the multi-participant approach, the final design step should develop a document that finalizes database specifications, functional requirements, performance standards and provides information regarding all technical and organizational constraints. This document should consist of comprehensive information obtained through various tasks undertaken to determine the feasibility of the program.

5.3.2.7 Step 7: Requests For Proposals

The evaluation team consisting of members from policy and technical project teams should prepare the RFP for soliciting bids. The RFP document should consist of detail information regarding the required final design and contractual requirements for an operational system along with the typical items mentioned in section 4.2.7. Constraints in terms of technical, organizational and financial terms should be outlined clearly to provide bidders with information to propose an operational system for the multi-participant program.

5.3.2.8 Step 8: Evaluation of Alternative Systems

From the numerous bids the evaluation team should identify feasible systems for the multi-participant program. These systems should reflect the unique characteristics and satisfy the requirements of participants. A benchmarking test and a pilot study should be carried out to evaluate and identify the best systems that can fulfill all requirements of the program.

5.3.2.9 Step 9: Implementation Plan Development

The implementation plan development step should ensure smooth implementation of the technology. Priorities in terms of data development and output products should be established for realizing the benefits of the system earlier. Depending on the identified priorities, decisions regarding acquisition of the components- hardware, software, data and people should be taken.

- **Recommendations:** A phased approach is recommended for technology acquisition.

Since development of database is the primary objective of the multi-participant approach, technology purchases should be first made for database development team. This would help the team to start on the creation of database. The other departments should be given priority over the Planning and Engineering Department for technology purchases.

5.3.3 Phase III: Adoption and Initial Utilization of GIS Technology

The implementation plan, which identifies priorities, approach to develop a fully operational system etc. should help guide the decision regarding an appropriate system for the program. The necessary equipment should be purchased through a well-negotiated contract. Potential users should test and start with initial utilization of the system after installation on site and its performance should be reviewed before committing to the vendor. This will help get users acquainted with the technology and help identify the drawbacks of the system if any.

5.3.4 Phase IV: Full Utilization of GIS Technology

The successful adoption and initial utilization of the technology will slowly result in its full utilization by all participants. This will fulfill the expectations of participants and would enable them to realize the benefits provided by the multi-participant approach. However, coordination and communication should be maintained among participants even after successful utilization to help achieve the long-term goals of the program. Being a permanent multi-participant program, participants should strive to make improvements to obtain maximum benefits from the technology. It should be noted that the implementation does not end here but is an on-going process and commitment of all participants is necessary to make it successful.

The application of the implementation process framework to the Town of Blacksburg indicates constraints and factors that need to be recognized to improve the chances of successful implementation of multi-participant GIS program. The identification of these limitations will help align the program and expectations of participants with “real world” situations and achieve effective utilization of GIS technology. The next chapter puts forth some specific and general lessons learned from the application of the framework to the Town of Blacksburg.

Chapter 6. Conclusions

6.1 Multi-Participant GIS Programs

Multi-participant GIS programs are based on the concept of sharing costs and resources to create a common operational GIS system among two or more separate departments/organizations. Although there are numerous benefits, sharing of a common database that helps reduce costs significantly acts as a principal motivator for the involved participants along with public demand for service organizations to exchange information.

Since, the principal motivator for organizations to embrace the multi-participant approach is the creation of a common database, a multi-participant program is usually established among organizations within the same geographical area. Factors such as commitment, resources and funding also influence the selection of initial participants in the program for a successful start. Although more participants are good in terms of sharing of costs and responsibilities, the definition of database contents, participant requirements, expectations and standards becomes more complex for a successful implementation of the program. Also, the variety of interests, requirements, schedules, budgets and missions of participants makes a multi-participant approach difficult and complex. These and numerous other facets of multi-participant GIS program (discussed in section 3.5) make the organization and implementation of these programs more challenging than single-participant GIS projects. Therefore, a well-defined and planned implementation process is essential to achieve effective utilization and implementation of GIS.

6.2 Applicability of the Proposed Implementation Process Framework

The general implementation process framework was developed considering the numerous stages and issues that organizations may go through to fully implement GIS technology. The application of the framework will help the Departments of the Town of Blacksburg to achieve successful implementation. The Planning and Engineering department should act as a “lead department” being most experienced with GIS and also as it is performing a similar role in trying to develop relationships with the departments to develop GIS applications. The following diagram can represent the implementation process for the multi-participant program for the Town of Blacksburg.

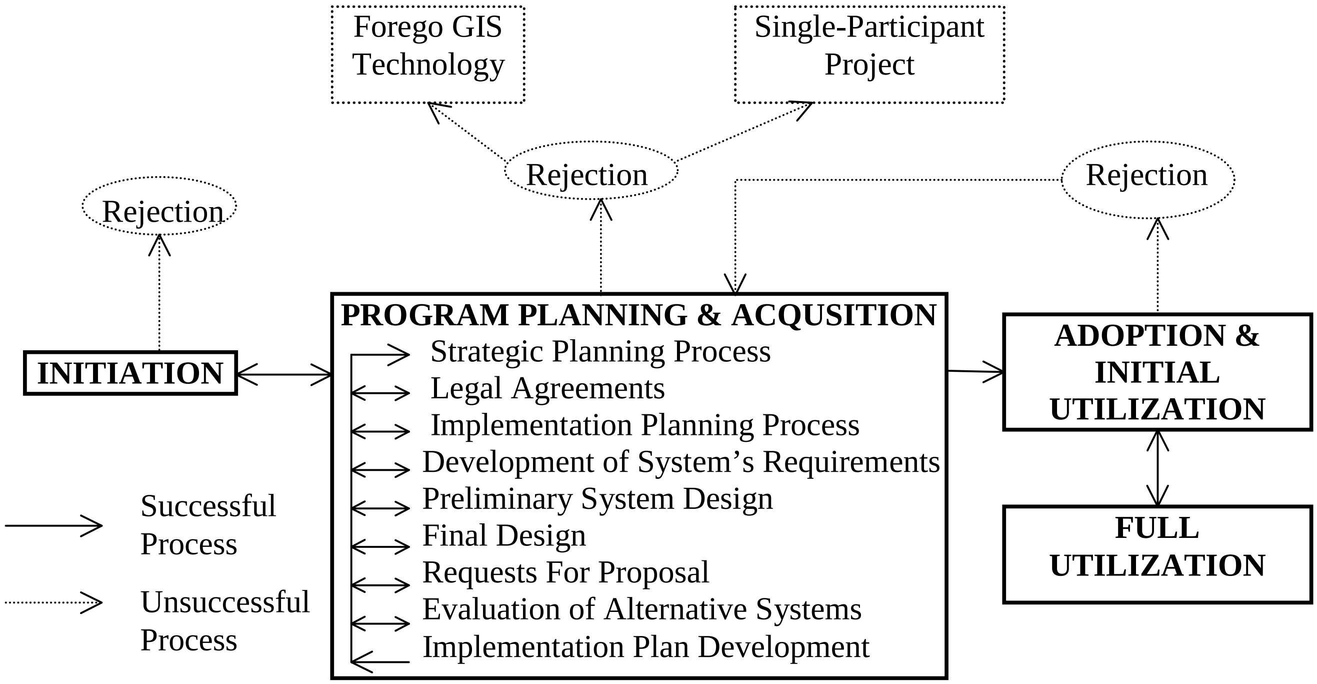

Figure 2: Implementation Process Framework

Although it appears that the general framework would hold true if implemented in the Town of Blacksburg, its application indicates a need for some flexibility to overcome constraints and take advantage of the opportunities that are unique to the situation. For example, the recommended centralized database represents an efficient solution for multi-participant GIS. But Finance department's AS400 system prevents its implementation. Therefore, a database with the SQL file server along with AS400, which feeds data into it, would be the best solution in the existing conditions. Also, this constraint can be turned into an opportunity to develop an interface with County's AS400 system in the future. Since, every multi-participant GIS program is different in terms of participants, their objectives, requirements, funding strategies etc., each program has different issues, which are program specific. Every project team will need to develop its own strategies and plans, which consider these organizational circumstances and requirements.

The lack of funds to upgrade the Town's network will obstruct and delay the effective use of the system. Thus, the unavailability of funds to satisfy the requirements of the program represents a common constraint, which can delay implementation and may require going back to determine the funding strategies for the program. Thus, the phased approach for purchasing the technology starting with the database center will prove to be beneficial to the multi-participant GIS program.

Also, the application and the general framework indicate that the process is long-term, which requires the accommodation of changes that may take place over the time. Today the Planning and Engineering Department is updating its implementation plan to take into account the changes that have occurred over the past few years. However, these issues cannot be planned for and outlined in the implementation process framework. But, if the participating organizations are committed to the approach, develop a solid plan following the steps outlined in chapter 4, and use the experience of others who have done it before, can definitely achieve a successful implementation and utilization of GIS.

6.2.1 Barriers to the Success of Multi-Participant GIS Program

The following are program specific barriers to the successful implementation of a multi-participant GIS program for the Town:

- Perceived lack of immediate necessity to incorporate the multi-participant GIS approach
- Decision pending for the development of the required WAN system
- Inadequate and inexperienced staff required for utilization of the technology
- Inadequate technical expertise for the implementation of the multi-participant approach

Some of the more general barriers to successful implementation are:

- Attempting to accomplish too much in a too short time period
- Insufficient communication among the participants
- Hidden agendas among participating organizations

However, an implementation plan that identifies these factors as barriers to the effectiveness of GIS technology and makes provisions in the implementation process framework, to deal with them will help develop a successful and operational GIS technology for the program.

6.3 Conditions for Successful Multi-Participant GIS Applications

There are numerous factors that go on to make the multi-participant GIS program a success. However, the application of the implementation process framework to the Town indicates the following factors that can improve chances of a successful implementation are:

- Participant recognition of the benefits of GIS and multi-participant approach
- User directed implementation
- Participation/commitment of all participants and end-users
- Identification of constraints/limitations of the participants
- Introduction of simple GIS applications

The multi-participant GIS program implementation should consider the requirements of all potential end-users of the technology in all participating organizations. A user directed implementation technique that considers all users would ensure the necessary commitment, participation and support for the multi-participant GIS program. Participation and commitment of all users is extremely critical at all stages for successful implementation. Identification of the constraints and limitations of participating organizations will help to eliminate the unrealistic expectations of participants from GIS implementation and align the program with “real world” and the introduction of simple GIS applications will help end-users to utilize the technology without much trouble.

Thus, it can be said that the implementation process for a multi-participant GIS program consists of barriers and is more socially and politically oriented than it is technically. These social and political factors represent major obstacles to successful implementation and are the ones that are responsible for the final outcome of the implementation process. Being social and political in nature, the process is situation bound and so the implementation process framework will have to be modified to take into account all the organizational, technical and financial opportunities and constraints of participants and program. In conclusion, the findings of this paper suggest that although the implementation process for a multi-participant GIS program is complex and problematic, successful implementation can lead to improved efficiency and coordination in GIS operations.

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