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16 Managing GI systems

LEARNING OBJECTIVES

After studying this chapter you will understand:

- Return-on-investment (ROI) concepts.
- How to go about choosing a GI system to meet your needs.
- Key GI system implementation issues, including managing risk.
- How to manage an operational GI system effectively with limited resources and ambitious goals.
- Why GI projects fail—some pitfalls to avoid and some useful tips about how to succeed.
- The roles of staff members in a GI project.
- Where to go for more detailed advice.

Much of the material in earlier parts of this book assumes that you have a geographic information (GI) system and can use it effectively to meet your organization's goals. Getting to that happy state is the focus of this chapter. Later chapters deal with how GI systems contribute to the business of an organization.

This chapter covers how to choose, implement, and manage operational GI systems successfully. We deliberately describe a tried and tested approach to procuring large systems because that is the most complex to get right, but parts of our approach can be used for smaller systems. Underpinning our whole approach are two interrelated key success criteria:

- Will risks be managed successfully and catastrophes avoided?
- Will you get a good return on the investment of money and other resources expended (like time of skilled staff)?

Procurement and operational management involves four key stages: the analysis of needs, the formal specification, the evaluation of alternatives, and the implementation of the chosen system. In particular, implementing GI systems requires consideration of issues such as return on investment, planning, support, communication, resource management, and funding. Successful ongoing management of a major operational GI system has five key dimensions: support for customers, operations, data management, application development, and project management.

16.1 Introduction

This chapter examines the practical aspects of obtaining and managing an operational GI system. It is deliberately embedded in the part of the book that focuses on high-level management concepts because success comes from combining strategy and implementation. It is the role of management in GI projects or programs to ensure that operations are carried out effectively and efficiently, and that a healthy, sustainable GI system can be maintained—one that meets the organization's strategic objectives.

Obtaining and running a GI system seems at first sight to be a routine and apparently mechanical process. It is certainly not rocket science, but neither is it simple or without tried and tested principles and best practices. The consequences of failure can be catastrophic, both for an organization and for careers. Success involves constant sharing of experience and knowledge with other people, keeping good records, monitoring the status of risks to the program, and making numerous judgments where the answer is not preordained.

16.2 Managing Risk

Every program has risks, and not all risks can be anticipated. But the identification of significant risks, how to mitigate them, and oversight of the process are critical to program success at every stage. This normally involves at least one risk register (a list of risks, their impacts and likelihood of occurring, and mitigation actions) which is reviewed frequently by those with oversight responsibilities (Figure 16.1).

Good governance processes—defining who is responsible for what and who answers to whom—are also crucial. Thus the program leader and his or

Figure 16.1 Excerpt from a hypothetical corporate risk register.

Risk Number	Risk Description	Owner	Original Risk			Mitigation Plan	Contingency Plan	Progress Against Action	Residual Risk		
			L	I	E				L	I	E
2	New mobile mapping software may not be ready for publicly announced national launch.	Chief Operating Officer	5	4	20	Bring in extra resource, COO to monitor progress weekly and report to Chief Executive Officer, prioritize and action what must be present in first release.	Prepare draft press release explaining why – stress additional functionality, unique features, and define new launch date. Prepare private statement for key partners and licensees for use if needed before problem becomes public. Once emergency is over, review staff contributions to the problem and the solution.	3 staff transferred from project 22. List of 'nice-to-have' but not essential functions identified. Quality Assurance and Quality Control mechanisms reviewed	3	4	12
3	Server scalability may not be sufficient for very large numbers of users.	Head of IT	4	5	20	Use soft launch of service to test likely uptake. Inform product management and release teams.	Work with cloud service provider to allow provision of additional capacity. Alert marketing and communications of need to manage client expectations.	Outline discussions held with cloud service provider, but business negotiations still ongoing.	2	5	10

Key:
L: Likelihood
I: Impact
E: Exposure (=L times I)

Residual risk matrix: all red risks are reported to the Board and the CEO describes actions taken. The status of yellow risks is monitored by senior management, with appropriate actions taken. The Board reviews the entire risk register periodically. For residual risks below 10 tolerate but monitor direction of travel.

		Impact				
		1	2	3	4	5
Likelihood	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Meaning of Likelihood and Impact terms

	Likelihood	Impact
5	Very likely	Very severe/catastrophic
4	Likely	Major
3	Quite possible	Moderate
2	Unlikely	Minor
1	Very unlikely	Insignificant

her team must ensure that tactical, technological, and operational risks are regularly quantified and mitigation strategies deployed. Risks remaining at a very high level after mitigation are reported to the Management Board (Section 16.5.1), which acts as the guardian of the program on behalf of the enterprise. That Board also oversees the strategic risks to the program. Figure 16.1 illustrates part of a simple hypothetical risk register owned by a GI system program leader and the Management Board. In each case risk has two components—the likelihood of coming to pass and the impact on the program if it did. The risk score is computed by multiplying these together. Mitigating actions are then designed for each risk above a level judged appropriate and the residual risk estimated once these have been implemented.

Risk registers are only useful if they are built into the way a whole program is run, treated seriously, updated regularly, and used to steer actions. They must be living documents and reflect careful judgments that are debated by the relevant team(s).

16.3 The Case for the GI System: ROI

The most fundamental question an organization can ask about a GI system is: Do we need one? This question can be posed in many ways, and it covers quite a number of issues (see Maguire, Kouyoumjian, and Smith in Further Reading). The key strategic questions that senior executives will have are likely to be:

- What value will an investment in a GI system have for our organization?
- When will the benefits of a GI system be delivered?
- Who will be the recipients of the benefits?
- What is the level of investment needed, both initially and on an ongoing operational basis?
- Who is going to deliver these benefits, and what resources are required—both internally and externally—to realize the expected benefits?
- What is the proven financial case—that is, does the investment in a GI system provide the financial or other value to make it worthwhile?

For many years GI projects have been initiated based largely on qualitative, value-added reasoning; for example, "if we implement this technology, then we will be able to perform these additional services." However, in recent years there has been greater pressure for financial accountability in both the public and private sectors. Combined with a better understanding of difficulties associated with implementing enterprise IT systems and processes, and a realization that proper project accountability is a key aspect of good management, these have all led to wider adoption of return-on-investment (ROI) methods in project planning and evaluation.

To be successful, GI system strategies must be aligned with business strategies, and GI system processes must reflect business processes. GI systems that exist in a vacuum and are disconnected from an organization's business processes may detract from business success more than having no GI system at all.

Although there are many ways to describe the success or failure of a GI project, the most widely used is return on investment. ROI studies use a combination of qualitative and quantitative measures to assess the utility that an organization will obtain from an investment. Much greater importance is almost always placed on fact-based, quantitative measures given their greater objectivity and persuasiveness as far as senior executives are concerned.

ROI uses a combination of qualitative and quantitative measures to assess the utility that an organization will obtain from an investment.

One ROI method suitable for use in GI projects (see Further Reading) comprises a sequence of ten interrelated steps designed to be performed by a GI professional supported by a small project team. Shown in outline form in Figure 16.2, the method begins with a series of planning and investigation activities that lay the groundwork for subsequent steps. Step 1, preparing for the ROI project, requires a review of an organization's mission statement(s) and an understanding of its past and present GI system landscape. Step 2 comprises a series of interviews with key stakeholders to elicit, with guidance, how a GI system can contribute to an organization's mission, collecting information concerning the high-level business issues and challenges that it faces. These insights are then organized into a series of business opportunities, which are prioritized in Step 3.

The next group of steps is concerned with GI program definition. The information gathered in earlier stages is used to define a program of GI projects in Step 4 and dictates how these projects will be governed and managed in Step 5. The following series of steps form the core of the method and are concerned with business analysis. In Step 6, the defined projects are broken down into constituent parts and

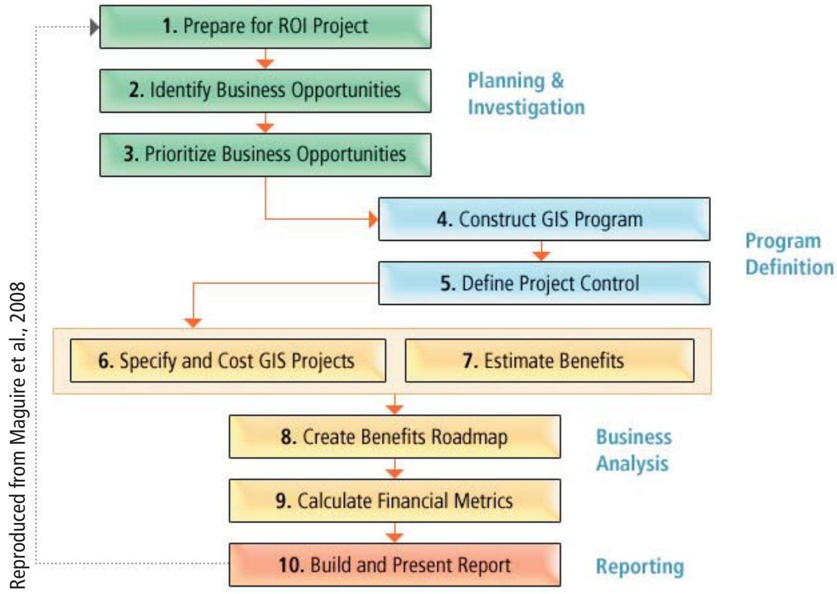


Figure 16.2 Overview of GI system ROI methodology.

the resource costs are determined, from which estimated benefits will be detailed in Step 7. In Step 8, a benefits road map is created that predicts when an organization will realize the benefits. In Step 9, ROI and other relevant financial metrics are calculated in order to demonstrate quantitatively the value of a GI system to an organization. In the final Step 10, a summary report is created by aggregating the information and research completed previously. If the GI system ROI project is to be seen as worth supporting, this report will concisely show how the GI system can contribute value to an organization, including its cost, benefits, time to implement, resources required, governance needed, the risks to be faced and the ROI an organization will realize.

In most IT projects—and GI projects are no exception—it is much easier to measure costs than benefits. Costs can simply be determined by making an inventory of all the goods and services required (hardware, software, data, consultants, etc.). The term *benefit* usually means any type of material value obtained from a GI project. It is useful to distinguish between tangible and intangible benefits. Tangible benefits, also sometimes referred to as hard or economic benefits, are those that can be precisely defined and to which we can assign a specific monetary value. Examples of tangible benefits include cost avoidance (such as increasing the number of valve inspections a water utility engineer can complete per route and therefore decreasing inspection time); increased revenue (e.g., from additional property taxes derived as a result of using a GI system to manage land records); and the value of time saved (for instance by creating essential reports more quickly using a GI system).

Intangible benefits, also sometimes referred to as soft savings or institutional benefits, are those to which we cannot safely assign a monetary value. Examples of intangible GI system benefits include increased morale of employees due to improved information systems, improved citizen satisfaction with government as a result of readily available online access to maps and data, and better customer relationships through more efficient information management. Although it is important to include both types of benefits in a GI system business justification case, executive decision makers are usually much more easily persuaded by tangible, measurable benefits than by those that are intangible.

Table 16.1 describes some examples from the government and utility sectors of the main types of tangible and intangible benefits that have been used in the past to justify GI projects. Because the general principles are common across all these areas, it should easily be possible to extrapolate from the details of government and utility benefits to other sectors and industries. These lists are high level, are by no means exhaustive, and have a degree of overlap between several categories (for example, revenue growth, cost reduction, and cost avoidance). Nevertheless they can be a guide that will help focus the process of researching GI system program benefits. Table 16.1 begins with very tangible benefits and ends with very intangible benefits.

Table 16.1 Examples of tangible and intangible benefit types for public and private organizations. Both tangible and intangible benefits are ordered strongest to weakest.

	Benefit Type	Government	Utility
STRONG	Revenue Growth—how can a GI system generate revenue (strictly speaking profit) for the organization?	Property taxes account for a substantial portion of the income for many local governments. A GI system is used to assess accurately the size of land parcels and keep an up-to-date record of property improvements. This typically results in additional tax revenue. The benefit is the total additional tax revenue that results from using a GI system.	There is great demand for accurate, detailed utility data for emergency management, construction coordination, and other purposes. Utilities sell network data products to other utilities and governments in the same geography for such purposes. The total benefit is the sum of all income.
Tangible	Revenue Protection and Assurance—how can a GI system save the organization money?	A GI system is used to optimize thenumber and location of fire stations and to comply with key government regulations about service response times. By using a GI system to analyze fire station locations, road networks, and the distribution of population, the location of existing or new stations can be optimized. Avoiding the cost of building a new fire station, or saving money by combining existing stations, saves governments millions of dollars a year. The benefit is the amount of money saved by optimizing the location of the fire stations.	Costly reactive and emergency repairs to sewer networks can be eliminated by creating a planned cycle of inspections and maintenance work orders. This enables network infrastructure to be properly maintained. The total benefit is the sum of the average costs of an emergency repair compared with those of planned repairs.
	Health and Safety—how can a GI system save the lives (or reduce injury) of employees or citizens? Although some might take the view that lives are invaluable, it is commonplace to ascribe a monetary value to loss of life in, for example, the insurance industry.	The most important role of governments is to protect the lives of citizens. Police forces are usually tasked with monitoring the security of major public events. A GI system is increasingly regarded as a key component of emergency operations centers where it is used to store, analyze, and visualize data about events. Data about, for example, suspicious packages can be used to help support decision making about the evacuation of surrounding areas. The benefit of a GI system is based on an estimate of the monetary value of lives saved as a result of using the GI system.	Integrated AM/FM/GI system electric network databases and work-order management systems are being used to create map products for use in Call-Before-You-Dig systems that reduce the likelihood of electrocution from hitting electrical conductors. Before-and-after comparison of lives saved multiplied by an agreed value of a life can lead to large benefits.
WEAK	Cost Reduction—this is different from Cost Avoidance because here we are assuming that this is an activity that an organization	Local government planning departments are reducing the cost of creating land-use plans and zoning maps by building	Multiple entry of "as-built" work orders by several departments is reduced by centralizing data entry in a

Table 16.1 (*continued*)

	Benefit Type	Government	Utility
STRONG	has to perform, and the objective becomes how to perform the activity with minimal net expenditure.	databases and map templates that can be reused many times. The benefit is the difference in the cost of manual and GI system-based plan and map creation.	single department. The total benefit is the cost of the as-built work-order entry multiplied by the reduction in the number of work orders entered.
↓	Cost Avoidance—rather than reducing costs, it is sometimes possible to avoid them altogether.	Local government departments issue permits for many things such as public events and roadside dumpsters (skips). By using a GI system, a government department can automate the process of finding the location, issuing the permit, and tracking its status. The benefit is the reduction in the cost of issuing and tracking each permit, multiplied by the number of permits issued. There are often additional benefits of reduced time to obtain a permit and improved tracking.	Forecasting the demand for gas by integrating geodemographic data with a model of the gas network will avoid costly overbuilding of distribution capacity. The benefit is the reduced cost of construction and operation of the unwanted gas facilities.
Tangible	Increase Efficiency and Productivity—how can the organization do more with less resource?	Fire is a major hazard to forests in many drier parts of the world. Firefighters need access in their fire trucks to maps of structures to better fight fires. Field-based GI systems are used to map structures more efficiently. These data are then transferred to a GI database, and map books are produced automatically, thus greatly improving the productivity of the surveyors and cartographers (not to mention the firefighters). The benefit of increased efficiency and productivity can be quantified by comparing manual with GI system-based operations. The hours saved can be converted into dollars based on the hourly rates of workers.	Automating map production improves the efficiency and productivity of staff, freeing them up to perform other tasks and in some cases avoiding hiring new staff. The benefit is equal to the number of person-hours that can be assigned to other tasks, multiplied by their hourly rate.
↓ WEAK	Save Time—if a process is carried out using a GI system, how much faster can it be completed?	Searches are typically performed whenever a property is bought/sold to determine ownership rights and encumbrances (rights of way, mineral rights, etc.). This requires a search to be sent to many departments. Historically this has been a manual, paper-based process taking several weeks. By implementing this	The amount of time it takes to inspect outside plant will be reduced by providing better routing between inspection sites and field-based data-entry tools. The benefit is the additional number of inspections per inspector per day multiplied by the cost of an inspection. There are additional benefits of reduced vehicle use (less congestion,

(*continued*)

Table 16.1 (*continued*)

	Benefit Type	Government	Utility
STRONG		in a GI system, the process can be managed electronically, performed in parallel, and responses automatically produced as a report. The time taken to complete the process can be reduced by several days or weeks. The benefit is the monetary value of the time saved multiplied by the number of searches performed. There are additional benefits of improved service to citizens.	pollution, and gasoline consumption).
Tangible	Increase Regulatory Compliance—if an organization has to comply with mandatory regulations, can it be done cheaper and faster with a GI system?	Various e-government initiatives around the world mandate that federal/central government agencies expand the use of the Internet for delivering services in a citizen-centric, results-oriented, market-based way. A GI system is a cost-effective way to achieve this goal because it is a commercial off-the-shelf system that can be relatively easily implemented across multiple departments. The objective of government is generally to minimize the cost of compliance. This is a cost (a negative benefit), and the benefit derives from minimizing the costs of compliance and avoiding fines for noncompliance.	Telecom utilities are bound by law to comply with several exacting operating regulations. A GI system can be used to maintain a database of the status of resources and to produce timely reports that summarize compliance levels. Given that this is a cost (a negative benefit) to the utility, the benefit derives from minimizing the costs of compliance and avoiding fines for noncompliance.
WEAK	Improve Effectiveness—if a process is carried out using a GI system, how much more effective will it be?	A GI system is used to fight crime using hotspot analysis and thematic mapping techniques to illustrate geographic patterns. The results from this work are being used to catch criminals and as the basis for crime prevention campaigns (e.g., increase police presence on the streets and advise members of the public to lock garages). The effectiveness of the GI system is quantified by assessing the reduction in crime and assigning a monetary value to it.	GI systems for outage management improve the speed and accuracy with which the location of outages (loss of service) can be identified and repair crews can be dispatched. The benefit is the value of total reduction in time for repairing outages, which in turn translates into electricity, water, or gas consumed.

Table 16.1 (*continued*)

	Benefit Type	Government	Utility
STRONG ↓ Tangible ↓ WEAK	Add New Capability—what new activities or services does a GI system make possible, and what value do they add to the organization?	Infection by West Nile virus has resulted in a number of deaths in the past few years. A GI system is a key component of the virus-spread monitoring process because it allows data to be analyzed and visualized geographically. This is a new capability that has allowed medical staff to understand and mitigate the spread of the virus. The benefit is the value of the GI system in terms of reduced medical costs for treating infected carriers.	A GI system allows utilities to create map products that show the status of construction, to facilitate coordination of participating contractors. The benefit is the value of the improved level of coordination.
STRONG ↓ ↓	Improve Service and Excellence Image—in what ways will use of a GI system cast the organization in a better light (e.g., forward looking, better organized, or more responsive)?	A number of government departments have front-desk clerks that respond to requests for information from citizens (e.g., status of a request for planning consent, rezoning request, or water service connection). A GI system can be used to speed up responses to requests, and in some cases access can be provided in public facilities such as libraries or on the Web. The benefit is the value of improved organizational image.	By creating a publicly accessible Web site that shows planned electrical network maintenance and outages, an electrical utility can improve its image. The benefit is determined by the value of a page view, multiplied by the total number of page views.
Intangible	Enhanced Citizen/Customer Satisfaction—can a GI system be used to enhance the satisfaction levels of citizens/customers?	Providing access to accurate and timely information is not only a requirement for governments, but it is also desirable because more information generally leads to higher levels of satisfaction. Changes in the satisfaction of citizens can be measured by questionnaires.	Utilities can enhance their customer care capability by providing access to accurate and up-to-date outside-plant network information. This enables customers to find out about themselves and their services.
↓ ↓ WEAK	Improve Staff Well-Being—can a GI system be used to enhance the well-being and morale of employees?	Staff are generally happier if they can see that an organization is progressive and is improving effectiveness and efficiency, as well as spending public money wisely. A GI system is a tool that can contribute to all these and therefore to worker satisfaction and well-being.	Automating boring and repetitive data-entry tasks can increase staff retention. There is a tangible benefit in reducing recruitment costs and an intangible value in having happy and contented staff.

Biographical Box 16.1

Ross Smith, GI System Consultant

Ross Smith's (Figure 16.3) interest in GI systems started during his undergraduate studies at Wilfrid Laurier University in Ontario, Canada, while working in the Computer Science Department as an internal IT consultant. Upon graduating, Ross went to work for the Ministry of Natural Resources, where he developed GI system applications and digitized massive amounts of data—in those days on VAX/VMS and Tektronix machines.

Recognizing the potential of the technology, Ross pursued his M.Sc. in GI systems at the University of Edinburgh, Scotland, and then embarked on a UK-based consulting career. After several years in the UK, Ross moved to New Zealand, where he worked independently for major utilities, telecommunications providers, and GI system vendors. He then went to Poland, where he helped launch and lead an offshore network broadband design center that was heavily reliant on GI technology. While based in Poland, Ross also became involved in contracts for the U.S. Air Force in Europe, working in Italy and Germany on the Air Force bases and running multiple GI projects that ranged from antiterror/force protection to land-use management. Ross returned to North America in 2003 and joined PA Consulting Group, a global management consulting firm, where he led the Denver-based IT consulting team, as well as the global geospatial consulting team.

Ross is known for structuring and delivering large complex technology programs, and he is recognized as an industry leader in geospatial strategy development and return-on-investment models. His primary focus is on the telecommunication, utilities, and defense sectors and on IT-enabled business transformation. Ross is a coauthor of a GI system business case and strategy book (*The Business Benefits of GIS: An ROI Approach*), and he is also the author of numerous articles on strategic planning, ROI modeling, and organizational design. Ross comments:

> It has become obvious to me that GI projects are not just about technology, although this is clearly important; it is also critical that business and organizational strategies are given due consideration if a project is to be successful and sustainable in the long term.

Courtesy: Ross Smith

Figure 16.3 Ross Smith, GI System Consultant.

The best benefits are specific, measurable, and relevant to an organization (so-called SMART, for specific, measurable, attainable, relevant, and time-bound). Examining the generic benefits in Table 16.1 shows that these textual descriptions are imprecise rather than being expressed in monetary terms, time saved, or processes improved. In real-world cases it is important to avoid generalized statements such as "a GI system will reduce costs" or "with a GI system we can improve operational performance." More strongly tangible benefits should be defined through further analysis. The Further Reading section gives more details on how to achieve that end.

Finally, the implementation of a GI system may lead to costs rising in some parts of the organization but substantial benefits accruing in other parts. Thus it is important that the final analysis takes a holistic, enterprise-wide view of the balance between all costs and all benefits of a major GI system.

16.4 The Process of Developing a Sustainable GI System

GI projects are similar to many other large IT projects in that they can be broken down into four major lifecycle phases (Figure 16.4). For our simplified purposes, these are

- Business planning (strategic analysis and requirements gathering)
- System acquisition (choosing and purchasing a system)

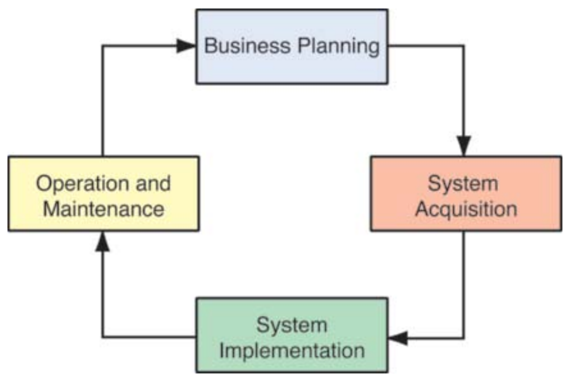


Figure 16.4 GI project life-cycle stages.

- System implementation (assembling all the various components and creating a functional solution)
- Operation and maintenance (keeping a system running)

These phases are iterative. Over a decade or more, several iterations may occur, often using different generations of GI system technology and methodologies. It follows that risks will change and need to be reevaluated accordingly. Variations on this model include prototyping and rapid application development but space does not permit much discussion of them here.

GI projects comprise four major life-cycle phases: business planning; system acquisition; system implementation; and operation and maintenance.

Roger Tomlinson, often regarded as the father of GI systems (see Table 1.4), developed a methodology for obtaining a GI system that is likely to fulfill user needs (see Further Reading). This high-level approach is very practical, easy to understand, and designed to ensure that a resulting GI system will match user expectations. Here we use a variant of that approach.

Table 16.2 The Tomlinson methodology for getting a GI system that meets user needs. (Source: adapted from R. Tomlinson 2007)

Stage	Action	Commentary
1	Consider the strategic purpose	This is the guiding light. The system that gets implemented must be aligned with the purpose of the organization as a whole.
2	Plan for the planning	Because the GI system planning process will take time and resources, you will need to get approval and commitment at the front end from senior managers in the organization.
3	Conduct a technology seminar	Think of the technology seminar as a sort of town-hall meeting between the GI system planning team, the various staff, and other stakeholders in the organization.
4	Describe the information products	Know what you want to get out of it.
5	Define the system scope	Scoping the system means defining the actual data, hardware, software, and timing.
6	Create a data design	The data landscape has changed dramatically with the advent of the Internet and the proliferation of commercial datasets. Developing a systematic procedure for safely navigating this landscape is critical.
7	Choose a logical data model	The new generation of object-oriented data models is ushering in a host of new GI system capabilities and should be considered for all new implementations. Yet the relational model is still prevalent, and the savvy GI system user will be conversant in both.
8	Determine system requirements	Getting the system requirements right at the outset (and providing the capacity for their evolution) is critical to successful GI system planning.
9	Return on investment, migration, and risk analysis	The most critical aspect of doing an ROI analysis is the commitment to include all the costs that will be involved. Too often managers gloss over the real costs, only to regret it later.
10	Make an implementation plan	The implementation plan should illuminate the road to GI system success.

16.4.1 Choosing a GI System: The Classical Acquisition Model

A general model of how to specify, evaluate, and choose a GI system is shown in Figure 16.5. Variations of it have been used by many organizations over the past 25 years so we use this "classical model." It is based on fourteen steps grouped into four stages: analysis of requirements, specification of requirements, evaluation of alternatives, and implementation of the system. Such a process is both time consuming and expensive. It is only appropriate for large GI system implementations (contracts over $250,000 in initial value) where it is particularly important to have investment and risk appraisals. We describe the model here so that those involved with smaller systems can judiciously select those elements relevant to them. On the basis of painful experience, however, we urge the use of formalized approaches to evaluate the need for any subsequent acquisition of a system. It is amazing how small projects, carried out quickly because they are small, evolve into big and costly ones!

Choosing a GI system involves four stages: analysis of requirements, specification of requirements, evaluation of alternatives, and implementation of system.

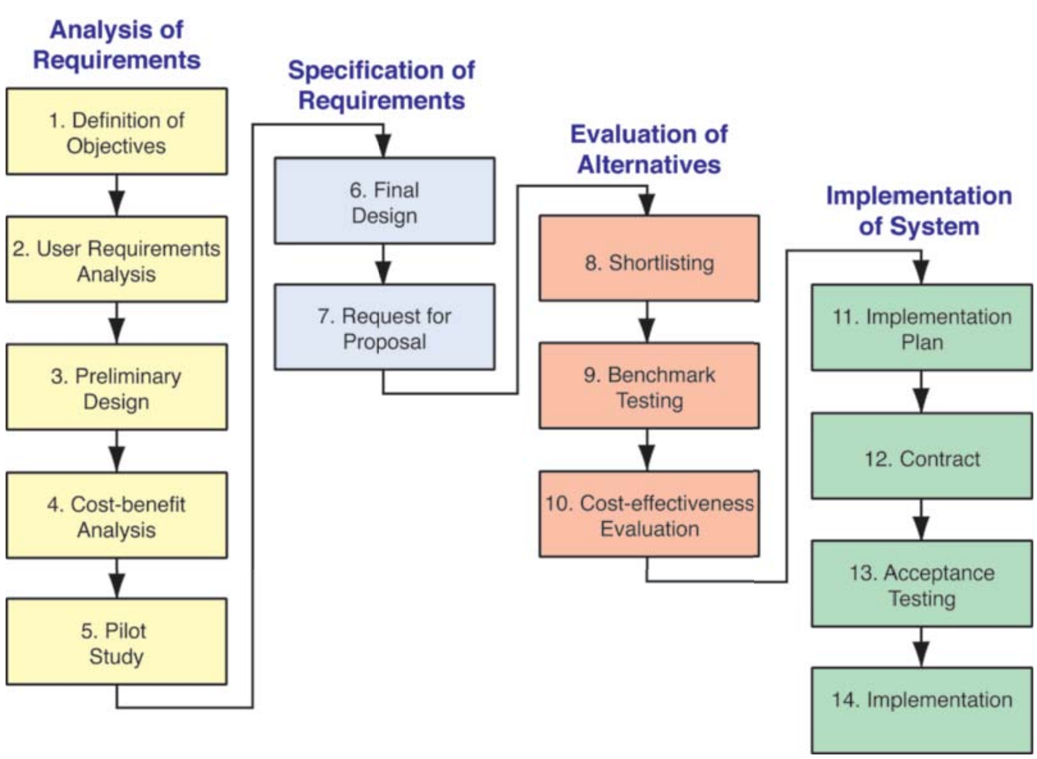
For organizations undertaking acquisition for the first time, huge benefits can be accrued through partnering with other organizations that are more advanced, especially if they are in the same field (see Chapter 18). This is often possible in the public sector, for example, where local governments have similar tasks to meet. But a surprising number of private-sector organizations are also prepared to share their experiences and documents.

Stage 1: Analysis of Requirements The first stage in choosing a GI system is an iterative process for identifying and refining user requirements and for determining the business case for acquisition. The deliverable for each step is a report that should be discussed with users and the management team. It is important to keep records of the discussions and share them with those involved so that there can be no argument at a later stage about what was agreed! The results of each report help determine successive stages.

Step 1: Definition of objectives

This is often a major decision for any organization. The rational process of choosing a GI system begins with and spins out of the development of the organization's strategic plan—and an initial supposition that a GI system might play a valuable role in the implementation of this plan. Strategic and tactical objectives must be stated in a form that is understandable to managers. The outcome from Step 1 is a document that managers

Figure 16.5 General model of the GI system acquisition process.



and users can endorse as a plan to proceed to the next stage; that is, the relevant managers believe there is sufficient promise to commit the initial funding required.

Step 2: User requirements analysis
The analysis will determine how the GI system is designed and evaluated. Analysis should focus on what information is presently being used, who is using it, and how the source is being collected, stored, and maintained. This is a map of existing processes (which may possibly be improved before being replicated by the GI system) or of processes newly designed after a business reengineering exercise. The necessary information can be obtained through interviews, documentation, reviews, and workshops. The report for this phase should be in the form of workflows, lists of information sources, and current operation costs. The clear definition of likely or possible change (e.g., future applications—see Figure 16.6), new information products (e.g., maps and reports—Figure 16.7), or different utilization of functions and new data requirements is essential to subsequent successful GI system implementation.

Step 3: Preliminary design
This stage of the design is based on results from Step 2. The results will be used for subsequent cost-benefit analysis (Step 4)

APPLICATION

Display zoning map information for a user-defined area.

FUNCTIONS USED IN THE APPLICATION:

Review and prepare zoning changes.

DESCRIPTION OF APPLICATION:

This application uses zoning and related parcel-based data from the database to display existing information related to zoning for a specific area that is defined by the user. The application must be available interactively at a workstation when the user invokes a request and identifies the subject land parcel. The application will define a search area based upon the search distance defined and input by the user, and will display all required data for the area within the specified distance from the outer boundary of the subject parcel.

DATA INPUTS:

User defined: Parcel identifier
Search distance

Database: Zoning boundaries
Zoning dimensions
Zoning codes
Parcel boundaries
Parcel dimensions
Parcel numbers
Street names
Addresses

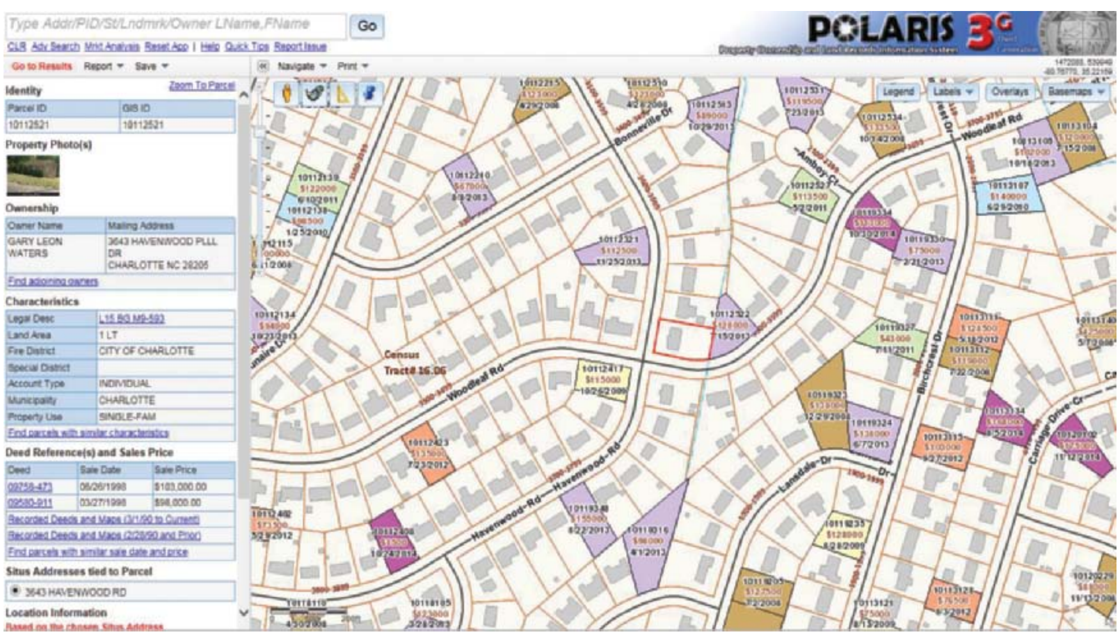
PRODUCTS OUTPUT:

1. Zoning map screen display with subject parcel highlighted, search area boundaries, search distance, all zoning data, parcel data, street names and addresses.
2. Hard copy map of the above.

Figure 16.6 Sample application definition form.

and will enable specification of the pilot study. The four key tasks are: develop preliminary database specifications, create preliminary functional specifications, design preliminary system models, and

Figure 16.7 A report produced by a local government GI system.



Source: Mecklenburg County, North Carolina GI system.

survey the market for potential systems. Database specifications involve estimating the amount and type of data. Many consultants maintain checklists, and vendors frequently publish descriptions of their systems on their Web sites. The choice of system model involves decisions about raster and vector data models and a survey should be undertaken to assess the capabilities of commercial off-the-shelf (COTS) systems. This might involve a formal request for information (RFI) to a wide range of vendors. A balance needs to be struck between creating a document so open that the vendor has problems identifying what needs are paramount and a document that is so prescriptive and closed that no flexibility or innovation is possible.

Whether to buy or to build a GI system used to be a major decision (Section 6.4). This occurred especially at "green field" sites—where no GI system technology had hitherto been used—and at sites where a GI system had already been implemented but was in need of modernization. But the situation is now quite different: use of general-purpose COTS solutions is the norm. COTS GI systems have ongoing programs of enhancement and maintenance and can normally be used for multiple projects. Typically, they are better documented, and more people in the job market have experience of them. As a consequence, risks—such as those arising from loss of key personnel—are reduced.

There has been a major move in GI systems away from building proprietary products toward buying COTS solutions.

Step 4: Cost-benefit analysis

Purchase and implementation of a GI system is a nontrivial exercise because of the expense involved in both money and staff resources (typically management time). It is very common for organizations to undertake a cost-benefit analysis to justify the effort and expense and to compare it against the alternative of continuing with the current data, processes, and products—the status quo. Cost-benefit cases are normally presented as a spreadsheet, along with a report that summarizes the main findings and suggests whether the project should be continued or halted. Senior managers then need to assess the merits of this project in comparison with any others that are competing for their resources. Cost-benefit analysis can be considered a simplified form of ROI calculation (see Section 16.3), and we urge the use of that particular approach.

Step 5: Pilot study

A pilot study is a miniature version of the full GI system implementation that aims to test several facets of the project. The primary objective is to test a possible or likely system design before finalizing the system specification and committing significant resources. Secondary objectives are to develop the understanding and confidence of users and sponsors, to test samples of data if a data capture project is part of the implementation, and to provide a test bed for application development.

A pilot is a miniature version of a full GI system implementation designed to test as many aspects of the final system as possible.

It is normal to use existing hardware or to lease hardware similar to that which is expected to be used in the full implementation. A reasonable cross section of all the main types of data, applications, and product deliverables should be used during the pilot. But the temptation to try to build the whole system at this stage must be resisted—regardless of how easy the "techies" may claim it to be! Users should be prepared to discard *everything* after the pilot if the selected technology or application style does not live up to expectations.

The outcome of a pilot study is a document containing an evaluation of the technology and approach adopted, an assessment of the cost-benefit case, and details of the project risks and impacts. As stressed earlier, risk analysis is an important activity even at this early stage. Assessing what can go wrong might help avoid potentially expensive disasters in the future. The risk analysis should focus on the actual acquisition processes as well as on implementation and operation.

Stage 2: Specification of Requirements The second stage is concerned with developing a formal specification that can be used in the structured process of soliciting and evaluating proposals for the production system.

Step 6: Final design

This creates the final design specifications for inclusion in a Request for Proposals (RFP: also called an invitation to tender, or ITT) to vendors. Key activities include finalizing the database design, defining the functional and performance specifications, and creating a list of possible constraints. From these, requirements are classified as mandatory, desirable, or optional. The deliverable is the final design document. This document should provide a clear description of essential and desirable requirements—without being so prescriptive that innovation is stifled, costs escalate, or insufficient vendors feel able to respond.

Step 7: Request for proposals

The RFP document combines the final design document with the contractual requirements of the organization. These documents will vary from organization to organization but are likely to include legal details of copyright of the design and documentation, intellectual property ownership, payment schedules, procurement timetable, and other draft terms and conditions. Once the RFP is released to vendors by official advertisement or personal letter, a minimum period of several weeks is required for vendors to evaluate and respond. For complex systems, it is usual to hold an open meeting to discuss technical and business issues.

Stage 3: Evaluation of Alternatives

Step 8: Short-listing

In situations where several vendors are expected to reply, it is customary to have a short-listing process. Submitted proposals must first be evaluated, usually using a weighted scoring system, and the list of potential suppliers needs to be narrowed down to between two and four. Good practice is to have the scoring done by several individuals acting independently and to compare the results. This whole process allows both the prospective purchaser and supplier organizations to allocate their resources in a focused way. Short-listed vendors are then invited to attend a benchmark-setting meeting.

Step 9: Benchmarking

The primary purpose of a benchmark is to evaluate the proposal, people, and technology of each selected vendor. Each one is expected to create a prototype of the final system that will be used to perform representative tests. The prospective purchaser scores the results of these tests. Scores are also assigned for the original vendor proposal and the vendor presentations about their company. Together, these scores form the basis of the final system selection. Unfortunately, benchmarks are often conducted in a rather secretive and confrontational way, with vendors expected to guess the relative priorities (and the weighting of the scores) of the prospective purchaser. It is essential to follow a fair and transparent process, maintain a good audit trail, and remain completely impartial. However a more open cooperative approach usually produces a better evaluation of vendors and their proposals. If vendors know which functions have the greatest value to customers, they can tune their systems appropriately.

Step 10: Cost-effectiveness evaluation

Next, surviving proposals are evaluated for their cost-effectiveness. This is again more complex than it might seem. For example, GI software systems still vary quite widely in the type of architectural options and pricing models available; some need additional database management system (DBMS) licenses, some run in a Cloud computing environment with a pay-as-you go business model, customization costs will vary, and maintenance will often be calculated in different ways. The goal of this stage is to normalize all the proposals to a common format for comparative purposes. The weighting used for different parts must be chosen carefully because this can have a significant impact on the final selection. Good practice involves debate within the user community—for they should have a strong say—on the weighting to be used and some sensitivity testing to check whether very different answers would have been obtained if the weights were slightly different. The deliverable from this stage is a ranking of vendors' offerings.

Stage 4: Implementation of System The final stage is planning the implementation, contracting with the selected vendor, testing the delivered system, and actually using the GI system "in anger."

Step 11: Implementation plan

A structured, appropriately paced implementation plan is an essential ingredient of a successful GI system implementation. The plan commences with identification of priorities, definition of an implementation schedule, and creation of a resource budget and management plan. Typical activities that need to be included in the schedule are installation and acceptance testing, staff training, data collection/purchase, and customization. Implementation should be coordinated with both users and suppliers.

Step 12: Contract

An award is subject to final contractual negotiation to agree on general and specific terms and conditions, what elements of the vendor proposal will be delivered, when they will be delivered, and at what price. General conditions include contract period, payment schedule, responsibilities of the parties, insurance, warranty, indemnity, arbitration, and provision of penalties and contract termination arrangements.

Step 13: Acceptance testing

This step is to ensure that the delivered GI system matches the specification agreed in the contract. Part of the payment should be withheld until this step is successfully completed. Activities include installation plus tests of functionality, performance, and reliability. A system seldom passes all tests the first time so provision should be made to repeat aspects of the testing.

Step 14: Implementation

This is the final step at the end of what can be a long road. The entire acquisition period for a major GI system can stretch over many months or even longer. Activities include training users and support staff, data collection, system maintenance, and performance monitoring. Customers may also need to be "educated" as well! Once the system is successfully in operation, it may be appropriate to publicize its success to give recognition to the staff involved and enhance the brand image or political position.

16.4.1.1 Discussion of the Classical Acquisition Model

The general model outlined earlier has been widely employed as the primary mechanism for large GI system procurements in public organizations. It is rare, however, that one size fits all, and although the model has many advantages, it also has some significant shortcomings:

- The process is expensive and time consuming for both suppliers and vendors. A supplier can spend as much as 20% of the contract value on winning the business, and a purchaser can spend a similar amount in staff time, external consultancy fees, and equipment rental. This ultimately makes systems more expensive—though competition does drive down cost.
- Because it takes a long time and because GI technology is a very fast-developing field, proposals can become technologically obsolete within several months.
- The short-listing process requires multiple vendors, which can end up lowering the minimum technical selection threshold in order to ensure enough bidders are available.
- In practice, the evaluation process often focuses undue attention on price rather than on the long-term organizational and technical merits—some at least of which are intangible—of the different solutions.
- This type of procurement can be highly adversarial. As a result, it can lay the foundations for an uncomfortable implementation partnership (see Chapter 18), and it often does not lead to full development of the best solution. Every implementation is a trade-off between functionality, time, price, and risk. A full and frank discussion between purchaser and vendor on this subject can generate major long-term benefits.
- Many organizations—especially those with little previous experience of a GI system—have little idea about what they *really* need. Furthermore, it is very difficult to specify precisely in any contract what a system must perform. As users learn more, their aspirations also rise, resulting in "feature creep" (the addition of more capabilities) often without any acceptance of an increase in budget. On the other hand, some vendors take a minimalist view of the capabilities of the system featured in their proposal and make all modifications during implementation and maintenance through chargeable change orders. All this makes the entire system acquisition cost far higher than was originally anticipated; the personal consequences for the budget holders concerned can be unfortunate.
- Increasingly, most organizations already have some type of GI system; the classical model works best in a "green field" situation.

As a result of these problems, this type of acquisition model is not used in small or even some larger procurements, especially where existing facilities can be augmented rather than totally replaced. A less complex and formal selection method is *prototyping*. Here a vendor or pair of vendors is selected early on using a smaller version of the evaluation process outlined in the preceding part of this chapter. The vendors are then funded to build prototypes in collaboration with the user organization. This fosters a close partnership to exploit the technical capabilities of systems and developers, and it helps to maintain system flexibility in the light of changing requirements and technology. This approach works best for those procurements—sometimes even some large ones—where there is some uncertainty about the most appropriate technical solution and where the organizations involved are mature, able to control the process, and not subject to draconian procurement rules.

Prototyping is a useful alternative to classical, linear system acquisition exercises. It is especially useful for smaller procurements where the best approach and outcome is more uncertain.

16.4.2 Implementing a GI System

This section provides a checklist of important management issues to consider when implementing a GI system.

16.4.2.1 Plan Effectively

Good planning is essential through the full life cycle of all GI projects. Both strategic planning and operational planning are important to the success of a project. Strategic planning involves reviewing overall organizational goals and setting specific GI project objectives. Operational planning is more concerned with the day-to-day management of resources. Several general project-management productivity tools are available that can be used in GI projects. Figure 16.8 shows one diagramming tool called a Gantt chart. Several other implementation techniques and tools are summarized in Table 16.3.

16.4.2.2 Obtain Support

If a GI project is to prosper, it is essential to garner support from *all* key stakeholders. This can entail several activities, including establishing executive (director-level) leadership support; developing a

Figure 16.8 Gantt chart of a basic GI system project. This chart shows task resource requirements over time, with task dependencies. This example presents a straightforward chart, with a small number of tasks.

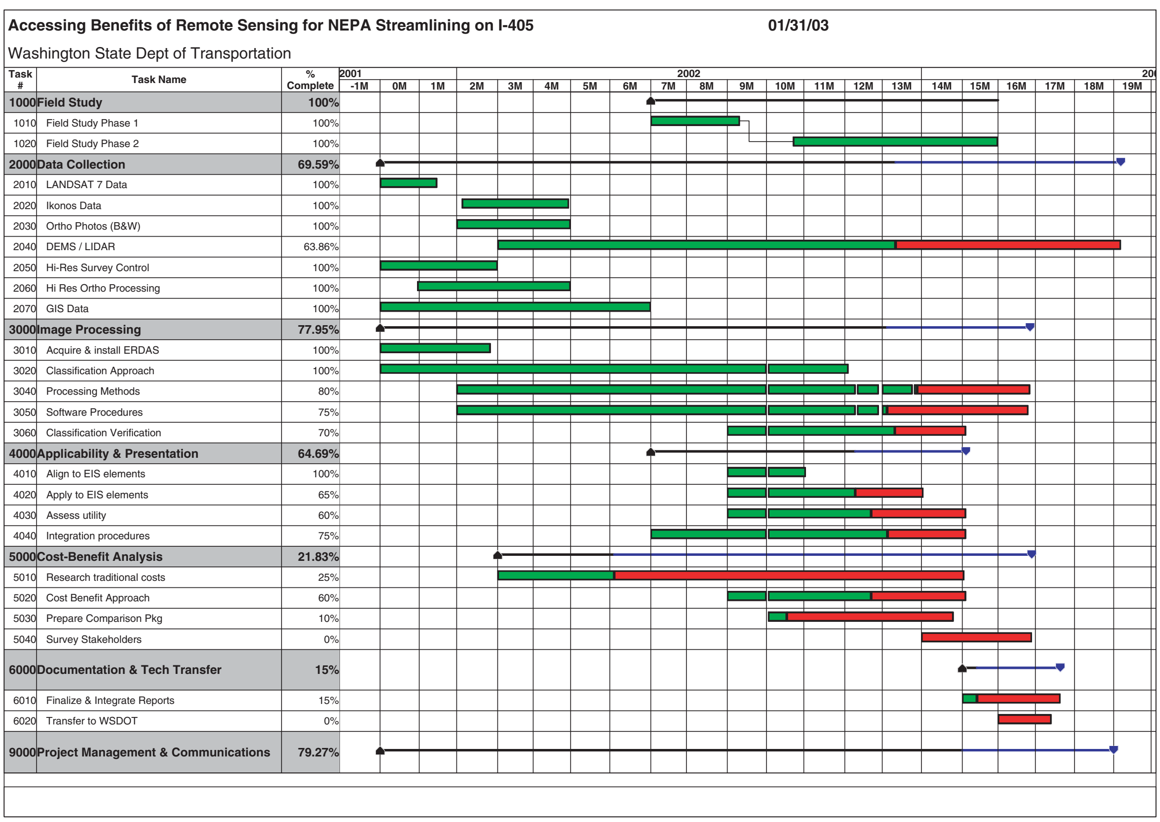


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Table 16.3 GI system implementation tools and techniques (After Heywood et al., 2012, with additions).

Technique	Purpose
SWOT analysis	This is a management technique used to establish strengths, weaknesses, opportunities, and threats (hence SWOT) in a GI system implementation. The output is a list and narrative.
ROI analysis	This methodology is used to assess the value added by comparing outputs with inputs (see Section 16.3).
Rich picture analysis	Major participants are asked to create a schematic/picture showing their understanding of a problem using agreed conventions. These are then discussed as part of a consensus-forming process.
Demonstration systems	Many vendors and GI project teams create prototype demonstrations to stimulate interest and educate users/funding agencies.
Interviews and data audits	These aim to define problems and determine current data holdings. The output is a report and recommendations.
Organization charts, system flowcharts, and decision trees	These are all examples of flowcharts that show the movement of information, the systems used, and how decisions are currently reached.
Data flow diagrams and dictionaries	These are charts that track the flow of information and computerized lists of data in an organization.
Project management tools	Gantt charts (see Figure 16.8) and PERT (program evaluation and review technique) are tools for managing time and resources.
Object-model diagrams	These show objects to be modeled in a GI database and the relationships between them (see, for example, Figure 7.18).

public relations strategy by, for example, exhibiting key information products or distributing free maps; holding an open house to explain the work of the GI system team; and participating in GI system seminars and workshops, locally and—depending on the organization—sometimes nationally.

16.4.2.3 Communicate with Users

Involving users from the very earliest stages of a project will lead to a better system design, reduce some risks, and help with user acceptance. Seminars, newsletters, and frequent updates about the status of a project are good ways to educate and involve users. Setting expectations about capabilities, throughput, and turnaround at reasonable levels is crucial to avoid any later misunderstandings with users and managers.

16.4.2.4 Anticipate and Avoid Obstacles

These obstacles may involve staffing, hardware, software, databases, organization/procedures, time frame, and funding. Be prepared: make your risk register(s) the vehicle for coping with adversity!

16.4.2.5 Avoid False Economies

Money saved by not paying staff a reasonable (market value) wage or by insufficient training is often manifested in reduced staff efficiencies. Furthermore, poorly paid or poorly trained staff often leave through frustration. This situation cannot be prevented by contractual means and must be tackled by paying market-rate salaries and building a team culture where staff enjoy working for the organization.

Cutting back on hardware and software costs by, for example, obtaining less powerful systems or canceling maintenance contracts may save money in the short term but will likely cause serious problems in the future when workloads increase and the systems get older. Failing to account for depreciation and replacement costs, that is, by failing to amortize the GI system investment, will store up trouble ahead. The amortization period will vary greatly—hardware may be depreciated to zero value after, say, four years while buildings may be amortized over 30 years.

16.4.2.6 Ensure Database Quality and Security

Investing in database quality is essential at all stages from design onward. Catastrophic results may ensue if any of the updates or (especially) the database itself is lost in a system crash or corrupted by hacking, and the like. This requires not only good precautions but also contingency (disaster recovery and business continuity) plans and periodic serious trials of them.

There are now many options for securing data, such as Cloud storage. Losing data through lack of a good backup strategy is a very serious matter.

16.4.2.7 Accommodate the GI System within the Organization

Building a system to replicate old and inefficient ones is not a good idea; nor is it wise to go to the other extreme and expect the whole organization's ways of working to be changed to fit better with what the GI system can do! Too much change at any one time can destroy organizations just as much as too little change can ossify them. In general, the GI system must be managed in a way that fits with the organizational aspirations and culture if it is to be a success. All this is especially a problem because GI projects often blaze the trail in terms of introducing new technology, interdepartmental resource and risk sharing, and generating new sources of income.

16.4.2.8 Avoid Unreasonable Time Frames and Expectations

Inexperienced managers often underestimate the time it takes to implement a GI system. Good tools, risk analysis (see Section 16.2), and time allocated for contingencies are important methods of mitigating potential problems. The best guide to how long a project will take is experience in other similar projects—though the differences between the organizations, staffing, tasks, and so on need to be taken into account.

16.4.2.9 Funding

Securing ongoing, stable funding is a major task of a GI system manager. Substantial GI projects will require core funding from one or more of the stakeholders. None of these will commit to the project without a sound business case, risk analysis, and consideration of how much uncertainty they can tolerate (Section 16.5.3). Additional funding for special projects, and from information and service sales, is likely to be less certain. In many GI projects the operational budget will often change significantly over time as the system matures. The three main components are staff, goods and services, and capital investments. A commonly experienced distribution of costs between these three elements is shown in Table 16.4.

16.4.2.10 Prevent Meltdown

Avoiding the cessation of GI system activities valued within an organization is the ultimate responsibility of the GI system manager and his or her superior. According to Tomlinson (see Further Reading), some of the main reasons for the failure of GI projects are as follows:

- Lack of executive-level commitment
- Inadequate oversight of key participants
- Inexperienced managers
- Unsupportive organizational structure
- Political pressures, especially where these change rapidly
- Inability to demonstrate benefits
- Unrealistic deadlines
- Poor planning
- Lack of core funding

You have been warned!

Table 16.4 Percentage distribution of GI system operational budget elements over three time periods (after Sugarbaker, 2005).

Budget item	Year 1–2	Year 3–6	Year 6–12
Staff and benefits	30	46	51
Goods and services	26	30	27
Equipment and software	44	24	22
Total	100	100	100

16.4.3 Managing a Sustainable, Operational GI System

Sugarbaker (see Further Reading) has characterized the many operational management issues throughout the life cycle of a GI project as customer support, effective operations, data management, and application development and support. Success in any one—or even all—of these areas does not guarantee project success, but they certainly help to produce a healthy project. Each is now considered in turn.

Success in operational management of a GI system requires customer support, effective operations, data management, and support for applications development.

Applications Box 16.2 describes a very successful and well-managed GI system in South Korea.

16.4.3.1 Customer Support

In progressive organizations *all* users of a system and its products are referred to as customers. A critical function of an operational GI system is a customer support service. This could be a physical desk with support staff, or, increasingly, it is a Web, email, and telephone service. Because this is likely to be the main interaction with GI system support staff, it is essential that the support service creates a good impression and delivers the type of service users need. The unit will typically perform key tasks, including technical support and problem logging plus supplying requests

Application Box 16.2

Managing Land Information in Korea through a GI System

In South Korea, a complex and rapidly changing society, local government authorities administer the public land through assessment of land prices, management of land transactions, land-use planning and management, and civil services. In many cases, more than one department of a local government authority produces and manages the same or similar land and property information; this has led to discrepancies in the information held across local government. With the large number of public land administration responsibilities and the control of each given to the local authorities, many problems arose in the past. This led to the decision to develop a GI system-based method for sharing the information produced or required for administering land in the public and private sectors (Figure 16.9B).

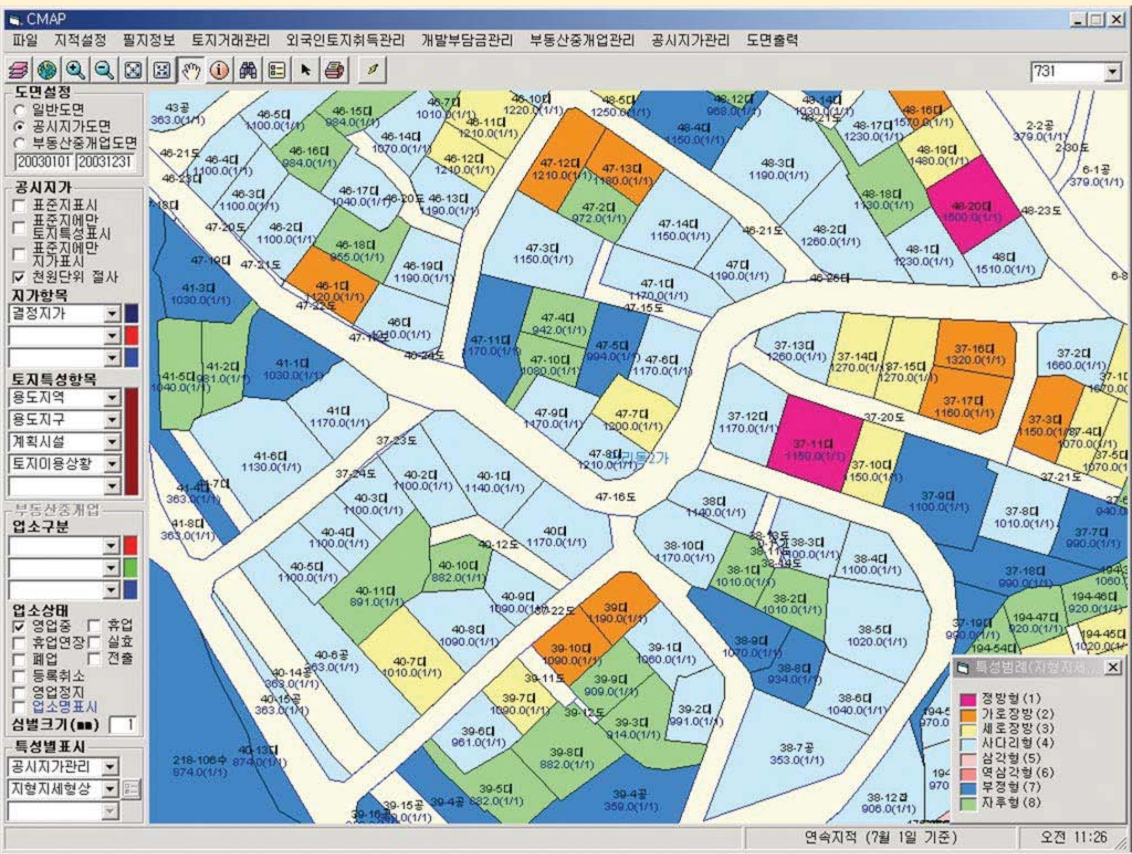
The purpose of this Korean Land Management Information System (LMIS) is to provide land information, increase productivity in public land administration, and support the operation of the land planning policies of the Korean Ministry of Construction and Transportation (MOCT). The LMIS database contains many spatial data layers including topographic, cadastral, and land-use districts.

Hyunrai Kim, vice director of the Land Management Division of Seoul Metropolitan City, summarizes the advantages of this system thus: "By means of the Internet-based Land Information Service System,

(A)

© Sean Pavone/Shutterstock

(B)



Reproduced by permission: Corbis

Figure 16.9 (A) Seoul by night. (B) Land information map for part of Seoul.

citizens can get land information easily at home. They don't have to visit the office, which may be located far from their homes." The system has also resulted in time and cost savings. With the development of the Korean Land Price Management System, it is also possible to compute land prices directly and produce maps of variations in land price. Initially, the focus was mainly on the administrative aspects of data management and system development; however, attention then turned to the expansion and development of a decision support system using various data analyses. It is intended that the Land Legal Information Service System will also be able to inform land users of regulations on land use. In essence, LMIS is becoming a crucial element of e-government. This case study highlights the role that GI systems can play beyond the obvious one of information management, analysis, and dissemination. It highlights the value of a GI system in enabling organizational integration and the reality of generating benefits through improved staff productivity.

for data, maps, training, and other products. Performing these tasks will require both GI system analyst and administrative skills. It is imperative that *all* customer interaction is logged and that procedures are put into place to handle requests and complaints in an organized and structured fashion. This is both to provide an effective service and to correct systemic problems.

Customer support is not always seen as the most glamorous of GI system activities. However, a GI system manager who recognizes the importance of this function and delivers an efficient and effective service will be rewarded with happy customers. Happy customers remain customers. Effective staff management includes finding staff with the right interests and aspirations, rotating GI system analysts through posts, and setting the right (high) level of expectation in the performance of all staff. Managers can learn much by taking a turn in the hot seat of a customer support role!

16.4.3.2 Operations Support

Operations support includes system administration, maintenance, security, backups, technology acquisitions, and many other support functions. In small projects, everyone is charged with some aspects of system administration and operations support. But as projects grow beyond five or more staff, it is worthwhile designating someone specifically to fulfill what becomes a core, even crucial, role. As projects become larger, this grows into a full-time function. System administration is a highly technical and mission-critical task requiring a dedicated, properly trained, and paid person.

Perhaps more than in any other role, clear written descriptions are required for this function to ensure that a high level of service is maintained. For example, large, expensive databases will require a well-organized security and backup plan—perhaps exploiting the Cloud (Section 6.2)—to ensure that they are *never* lost or corrupted. Part of this plan should be a disaster recovery strategy. What would happen, for example, if there were a fire in the building housing the database server or some other major problem?

16.4.3.3 Data Management Support

The concept that geographic data are an important part of an organization's critical infrastructure is becoming widely accepted. Large, multiuser geographic databases use DBMS software to allocate resources, control access, and ensure long-term usability (see Section 9.2). DBMS can be sophisticated and complicated, requiring skilled system administrators for this critical function.

A database administrator (DBA) is a person responsible for ensuring that all data meet all the standards of accuracy, integrity, and compatibility required by the organization. A DBA will also typically be tasked with planning future data resource requirements—derived from continuing interaction with current and potential customers—and the technology necessary to store and manage them. Similar comments to those outlined earlier for system administrators also apply to this position.

16.4.3.4 Application Development and Support

Although a considerable amount of application development is usual at the onset of a project, it is also likely that there will be an ongoing requirement for this type of work. Sources of application development work include improvements/enhancements to existing applications, as well as new users and new project areas starting to adopt GI systems.

Software development tools and methodologies are constantly in a state of flux, and GI system managers must invest appropriately in training and new software tools. The choice of which language to use for GI system application development is often a difficult one. Consistent with the general movement away from proprietary GI system languages, wherever possible GI system managers should try to use mainstream, open languages that are likely to have a long lifetime. Ideally, application developers should be assigned full-time to a project and should become permanent members of the GI system group to ensure continuity (but often this does not occur).

16.5 Sustaining a GI System—The People and Their Competences

Throughout this chapter we have sometimes highlighted and sometimes hinted at the key role of staff as assets in all organizations. If they do not function well—both individually and as a team—nothing of merit will be achieved.

16.5.1 GI System Staff and the Teams Involved

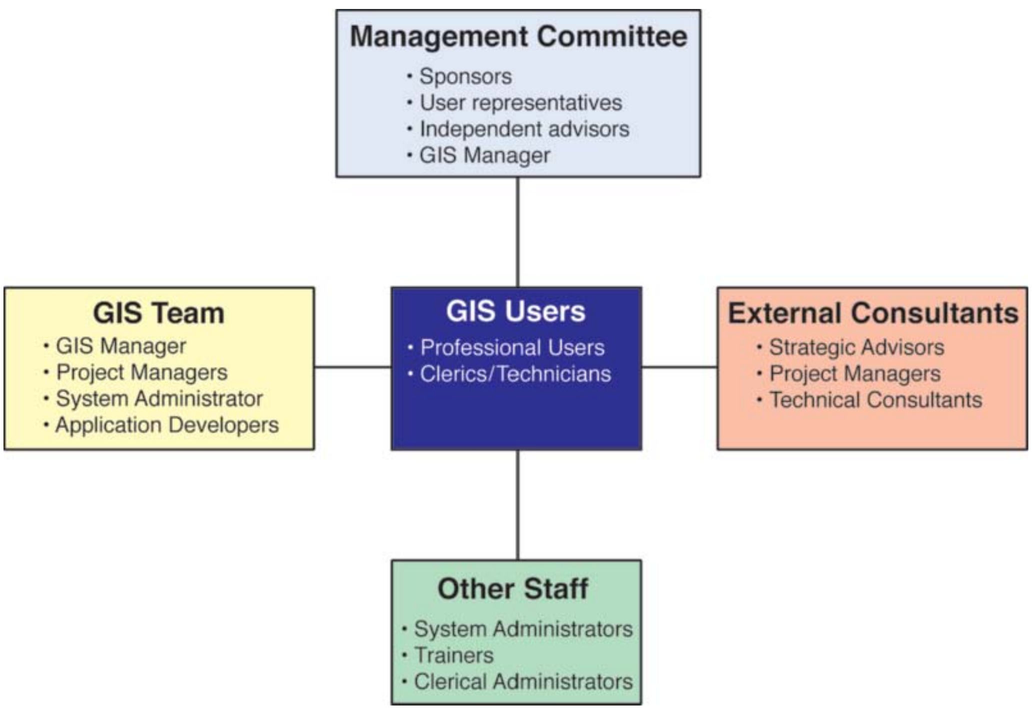
Several different staff will carry out the operational functions of a GI system. The exact number of staff and their precise roles will vary from project to project. The same staff member may carry out several roles (e.g., it is quite common for administration and application development to be performed by a GI system technical person), and several staff members may be required for the same task (e.g., there may be many data compilation technicians and application developers). Figure 16.10 shows a generalized view of the main staff roles in medium to large GI projects.

All significant GI projects will be overseen by a management board composed of a senior sponsor (usually a director or vice-president), members of the user community, and the GI system manager. It is also useful to have one or more independent members to offer disinterested advice. Although this group may seem intimidating and restrictive to some, used in the right way it can be a superb source of funding, advice, support, and encouragement.

Typically, day-to-day GI system work involves three key groups of people: the GI system team itself, the GI system users, and external consultants. The GI system team comprises the dedicated GI system staff at the heart of the project, with the GI system manager designated as the team leader. This individual needs to be skilled in project and staff management and have sufficient understanding of GI technology and the organization's business to handle the liaisons involved. Larger projects will have specialist staff experienced in project management, system administration, and application development.

GI system users are the customers of the system. There are two main types of user (other than the leaders of organizations who may rely on the GI system indirectly to provide information on which they base key decisions). These are professional users and clerical staff/technicians. Professional users include engineers, planners, scientists, conservationists, social workers, and technologists who utilize output from the GI system for their professional work. Such users are typically well educated in their specific field, but may lack advanced computer skills and knowledge of the GI system. They are usually able to learn how to use the system themselves and can tolerate changes to the service.

Figure 16.10 The GI system staff roles in a medium to large size project.



Clerical and technical users are frequently employed as part of the wider GI project initiative to perform tasks such as data collection, map creation, routing, and service-call response. Typically, the members of this group have limited training and skills for solving ad hoc problems. They need robust, reliable support. They may also include staff and stakeholders in other departments or projects that assist the GI project on either a full- or part-time basis—for example, system administrators, clerical assistants, or software engineers provided from a common resource pool, or managers of other databases or systems with which the GI system must interface.

Finally, many GI projects utilize the services of external consultants. They could be strategic advisors, project managers, or technical consultants able to supplement the available staffing. Although these consultants may appear expensive at first sight, they are often well trained and highly focused. They can be a valuable addition to a project, especially if internal knowledge or resources are limited and for benchmarking against approaches elsewhere. But the in-house team must not rely too heavily on consultants lest, when they go, all key knowledge and high-level experience goes with them.

The key groups involved in GI projects are the management board, the GI system team (headed by a GI system manager), the users, external consultants, and various customers.

16.5.2 Project Managers

A GI project will almost certainly have several subprojects or project stages and hence require a structured approach to project management. The GI system manager may take on this role personally, although in large projects it is customary to have one or more specialist project managers. The role of the project manager is to establish user requirements, to participate in system design, and to ensure that projects are completed on time, within budget, and according to an agreed-upon quality plan. Good project managers are rare creatures and must be nurtured for the good of the organization. One of their characteristics is that, once one project is completed, they like to move on to another, so retaining them is only possible in an enterprising environment. Transferring their expertise and knowledge into the heads and files of others is a priority before they leave a project (see also Section 1.2).

16.5.3 Coping with Uncertainty

As we have seen, GI varies hugely in its characteristics, and rarely is the available information ideal for the task in hand. Staff need a clear understanding of the concepts and implications of uncertainty (see Chapter 5) and the related concepts of accuracy, error, and sensitivity. An understanding of business risk arising from GI system use and of how a GI system can help reduce organizational risk is also essential; this presupposes a prior definition of the organization's risk "appetite" or tolerance. This section focuses on the practical aspects relevant to managers of operational GI systems—and hence on the skills, attitudes, and other competences they need to bring to their work.

Organizations must determine how much uncertainty they can tolerate before information is deemed useless. This can be difficult because it is application-specific. An error of 10 m in the location of a building is irrelevant for business geodemographic analysis, but it could be critical for a water utility maintenance application that requires digging holes to locate underground pipes. Some errors in a GI system can be reduced but sometimes at a considerable cost. It is common experience that trying to remove the last 10% of error typically costs 90% of the overall sum. As we concluded in Section 5.5, uncertainty in GI representations is almost always something that we have to live with to a greater or lesser extent. The key issue here is identifying the amount of uncertainty (and risk) that can be tolerated for a given application and what can be done at least partially to eliminate it or ameliorate its consequences. Some of this, at least, can only be done by judgment informed by past experience.

A conceptual framework for considering uncertainty was developed in Section 5.1. This discussion also introduced the notion of measurement error. Some practical examples of errors in operational GI systems are as follows:

- Referential errors in the identity of objects (e.g., a street address could be wrong, resulting in incorrect property identification during an electric network trace).
- Topological errors (e.g., a highway network could have missing segments or unconnected links, resulting in erroneous routing of service or delivery vehicles).
- Relative positioning errors (e.g., a gas station incorrectly located on the wrong side of a divided highway or dual-carriageway road could have major implications for transportation models).
- Absolute errors in the real location of objects in the real world (e.g., tests for whether factories are within a smoke control zone or floodplain could provide erroneous results if the locations are incorrect). This could lead to litigation.
- Attribute errors (e.g., incorrectly entering land-use codes would give errors in agricultural production returns to government agencies).

Managing errors requires use of quality assurance techniques to identify them and assess their magnitude. A key task is determining the error tolerance that is acceptable for each data layer, information product, and application. It follows that both data creators and users must make analyses of possible errors and their likely effects, based on a form of ROI analysis (Section 16.3). And sitting in the midst of all this is the GI system manager, who must know enough about uncertainty to ask the right questions; if the system provides what subsequently turns out to be nonsense, the manager is likely to be the first to be blamed! In no sense is the good and long-lasting GI system manager simply someone who ensures that the "wheels go round."

16.6 Conclusions

Any management function in GI system (and indeed elsewhere) is mostly about motivating, organizing, or steering project teams; enhancing skills; and monitoring the work of other people.

Managing a GI project *is* different from using a GI system in decision making. Normally, managing a GI project requires good GI system expertise and first-class project management skills. In contrast, those involved at different levels of the organization's management chain need some awareness of a GI system, its capabilities, and its limitations—scientific and practical—alongside their substantial leadership skills. But our experience is that the division is not clear-cut. GI project managers cannot succeed unless they understand the objectives of the organization, the business drivers, and the culture in which they operate, as well as something of how to value, exploit, and protect their assets (Section 17.1.2). Moreover, decision makers can make good decisions only if they understand more of the scientific and technological background than they may wish to do: running or relying on a good GI service involves much more than the networking of a few PCs running one piece of software.

So, good management of a GI project requires excellent people, technical and business skills, and the capacity to ensure mutual respect and team working between the users and the experts. And it is underpinned by following management processes proved in other GI projects!

Questions for Further Study

1. How can we assess the potential value of a proposed GI system?
2. Prepare a new sample GI system application definition form using Figure 16.6 as a guide.
3. List ten tasks critical to a GI project that a GI system manager must perform and the roles of the main members of a GI project team.
4. Why might a GI project fail? Draw on information from various chapters in this book.

Further Reading

Douglas, B. 2008. *Achieving Management Success with GIS.* Hoboken, NJ: Wiley.

Heywood, I., Cornelius, S., and Carver, S. 2012. *An Introduction to Geographical Information Systems* (4th ed.). Harlow: Pearson Education Ltd.

Maguire, D. J., Kouyoumjian, V., and Smith, R. 2008. *The Business Benefits of GIS: An ROI Approach.* Redlands, CA: Esri Press.

Sugarbaker, L. J. 2005. Managing an Operational GIS. In Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W. (eds.) *Geographical Information Systems: Principles, Techniques, Management and Applications* (abridged ed.). Hoboken, NJ: Wiley.

Tomlinson, R. 2013. *Thinking about GIS: Geographic Information System Planning for Managers* (5th ed.). Redlands, CA: Esri Press.