Third Edition

Thinking About GIS

Geographic Information System Planning for Managers

Roger Tomlinson

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Excerpts included from *Thinking About GIS: Geographic Information System Planning,* Third Edition are highlighted below.

Contents

Foreword

For a number of years, Roger Tomlinson has been advocating that one of the key ingredients to successful geographic information systems (GIS) is the use of a consistent planning methodology. He developed a methodology that has evolved over the years, and he continues to adapt it through his personal consultation practicum and in association with the evolution of technology. At the ESRI International User Conference and other venues, Tomlinson teaches his method as part of a very popular "Planning and Managing a GIS" seminar. In observing the attendance of these seminars, I notice that they tend to attract two primary groups of people. The first group is composed of senior managers who oversee GIS and other information technologies in their organizations. The second group is composed of more technical managers responsible for the actual implementation of GIS and other information technologies. That these two markedly differing groups come together year after year to glean Tomlinson's wisdom always strikes me as significant and as an excellent starting point for a book on GIS planning.

Roger Tomlinson wrote this book for those two kinds of managers, intending to bridge the communication gap between them. Senior executives in public- and private-sector organizations often have the general idea that GIS would be good for their organization, and they know how to get the resources allocated to make it happen. What they lack is enough understanding about the capabilities and unique constraints of geospatial data technologies to direct their technical managers (the second audience) and ask the right questions. Conversely, these line GIS managers tend to have a solid grasp of the technology and the unique characteristics of GIS but know much less about how the GIS must operate within the broader context of the organization itself. What they need is information that will allow them to anticipate the questions their bosses are going to ask. This book effectively and successfully serves the needs of both groups.

While these are the primary audiences, the book also has value for the student of GIS who wishes to learn how to do the middle manager's job. It is an invaluable source of tuition for students to understand what being a GIS manager in a large organization is all about and what they have to be able to do.

While Roger has rightly become known as the "father of GIS" as a result of his early work in using computers to model land inventories for the Canadian government in the early 1960s, I believe that his greatest contribution to the field is the rigorous method of GIS planning that is described in this book. I hope that you find his work as informative and beneficial as have my colleagues and I at ESRI.

Jack Dangermond
President, ESRI

Acknowledgments

The errors are mine. The methods described in this book have evolved over the years with help from many people. These include the associates of Tomlinson Associates Ltd. in Canada, the United States, and Australia. Many contributions were made by my colleague Larry Sugarbaker as we developed the "Planning and Managing a GIS" seminar together. Deep thanks to Dave Peters for help and careful review of chapter 10 and particularly of the City of Rome case study. Generous input has been received from the staff of our clients worldwide and the staff of the corporations that eventually served our clients. They have been the real-world laboratory in which the ideas were tested. This book exists because Jack Dangermond thought it was a good idea to show the world what we put him through and because Brian Parr and Christian Harder turned the methodology into readable words. Candace Lyle Hogan is responsible for the new face on the third edition. Their support has been patient and constant. None of this would have come about without the continuing work and friendship of my wife Lila. Not only has she read every word and corrected most of my mistakes, but she still smiles. To these I owe my heartfelt thanks.

Roger Tomlinson

Introduction

If you're holding this book, perhaps it's because you've been charged with launching or implementing a geographic information system, a GIS, for your organization. Yours could be the type of organization that has historically used GIS—a local government, a transportation authority, a forest management agency. Or it could be the type of organization—such as a corporation, a political action group, or a farm—that has only recently begun to discover the positive implications of geographically enabled decision making.

The GIS you've been tasked with implementing could be intended to serve a single, specific purpose or to perform an ongoing function. It could even be what's called an *enterprise GIS,* one designed to serve a wide range of purposes across many departments within your organization. (You'll learn as your GIS evolves that a well-planned implementation can start out as a project and grow, or scale up, into a full-blown enterprise system.)

Whatever the mission of your organization or the intended scope of the initial GIS implementation, the good news is that the fundamental principles behind planning for a successful GIS are essentially the same. These principles are based on the simple concept that you must think about your real purposes and decide what output, what information, you want from your GIS. All the rest depends on that.

This book details a practical method for planning a GIS that has been proven successful time and again during many years of use in real public- and private-sector organizations. It is a scalable approach—the methodology can be adapted to any size GIS, from a modest project to an enterprise-wide system.

Why plan?

So why should you plan? What's wrong with just buying some computers and GIS software, loading some data, and sort of "letting things happen"? Can't you simply adapt as things move along, tweak the system, learn as you go? In fact, doesn't all this advance thinking slow things down and create even more work? On the contrary, evidence shows that good GIS planning leads to GIS success and absence of planning leads to failure. Whether you are working with an existing system or creating a GIS from scratch, you must integrate sufficient planning into the development of your GIS; if you don't, chances are you'll end up with a system that doesn't meet your expectations.

Knowing what you want to get out of your GIS is absolutely crucial to your ultimate success. Too often, organizations decide they want a GIS because they've heard great things from their peers in other organizations, or they just don't want to get left behind technologically. So they invest considerable sums of money into technology, data, and personnel without knowing exactly what they need from the system. That's like packing for a vacation without knowing where you're going. You pack everything from your closet just in case, but it turns out that sweater isn't needed in Fiji and you forgot the sunscreen. You've wasted time and energy, and worse yet, you're still not ready. When you try to develop a GIS without first seriously considering the real purpose, you could find yourself with the wrong (expensive) technology and unmet needs.

You must determine your organization's GIS needs from the outset of the planning process. GIS has many potential applications, so it's important to establish your specific requirements and objectives from the beginning. That way you will avoid the chaos that results from trying to create a system with no priorities or ends in mind. The methodology described in these pages will show you how to describe and prioritize what your organization needs from a GIS, so that you can plan a system that meets these requirements.

The key undertaking of managers—and those who plan on their behalf—is to understand their business and identify what would benefit that business. From GIS, the fundamental benefit comes in the form of what we call *information products.* An information product is data transformed into information particularly useful to you—for example, economic data analyzed in relation to a specific location—and delivered to you, via computer, often in the visual form of a map. If it's something that helps you do your work better, faster, more efficiently, then it's an information product.

Your GIS can quickly become a money pit if it's not creating useful products for the organization, ultimately jeopardizing the very existence of the GIS initiative and perhaps your own job. Conversely, a GIS can prove its worth and justify its existence if it manages to help streamline existing workflows and create useful information products. These are the ultimate benefits reaped by any successful information system.

Once you've identified the information products you seek, you can determine what data you need to make them. Then you can deal with the issues of tolerance to error and the concepts of database design on which efficiency will depend. From the type and amount of handling the data requires to make it usable (data requirements), you can specify the system scope, the capabilities you need from software (software functionality), and what your system requires in the way of support from the hardware and the network (hardware and network requirements). From these itemized necessities, you can develop accurate cost models to allow for clear and meaningful benefit–cost analysis. Having laid this groundwork, you can identify issues affecting implementation—institutional, legal, budgetary, staffing, risk, or timing issues—and look at how to mitigate them. The end result is an effective, efficient, and demonstrably beneficial GIS within the organization.

Implementation and maintenance can be expensive, but good planning will make your ongoing GIS efforts cost-effective in the long run. This book will teach you to evaluate the benefits of the system relative to its cost and how to make the case to management in a way that makes them advocates for your own success.

The entire planning process can take some time, and you may find that some of the steps can be minimized or eliminated in certain situations. But it is nonetheless important to think carefully about each step, to really get your head around the subject. You'll be glad you took the time.

GIS means change

Technology changes under us like the swell of a tide. To harvest the immense long-term benefits of GIS, you have to plan ahead in fast-paced times.

Rapid advancements in technology—both in software and hardware—continue to exert their strong effect on the GIS planning process. Your GIS can develop faster and much more iteratively now because of improvements in software usability and advanced off-the-shelf GIS functionality. The hardware that supports this grows ever more affordable—CPU seconds are approaching zero cost. The days when we designed system architecture around the limitations of software and hardware are over.

Now the driving determinants in system design are the location of human and data resources in the organization and the communication between them. Distributed systems and communications are becoming increasingly important. Quite complex applications can be done on the server level now. That's where the technology is going. Follow it, and you won't be left unsupported.

Geospatial data also has become more accessible and plentiful, due in part to the increase in geographic measurement being driven by new technologies (GPS, lidar, etc.) and by real-time sensors capturing data to make it available as Web services. Many standard and commonly used datasets are now readily available in digital form and at a much lower cost than even just a few years ago.

This relative abundance of affordable and reliable spatial data significantly widens the scope of potential GIS applications. Rapid prototyping and development tools such as ESRI ArcGIS Desktop with ModelBuilder, Microsoft Visual Basic, and CASE technology allow for quick exploration and testing of such applications. In other words, you can now explore a greater range of options; you can do targeted planning on selected business areas and build databases incrementally, scaling them up as needed.

These days, most GIS users handle spatial data within one of three paradigms: In the first GIS framework, the traditional stand-alone desktop information system, the user can conduct an integrated set of GIS functions on a wide variety of data types. In the second, the developer environment, software developers can combine a set of application-neutral, individual function components to create new applications. The third is the server environment. Here, a set of standardized GIS Web services (e.g., mapping, data access, geocoding) support enterprise-wide applications. (We see many examples of enterprise GIS now in organizations such as federal agencies, state and local governments, utility companies, national mapping organizations, and transportation agencies.)

These three environments currently interoperate but are moving rapidly toward more unified models and interfaces. The more enterprise systems are in place, the more interoperability standards will be required. Integration is becoming the theme of the future.

Geographic information systems integrate seemingly disparate information quickly and visually, which facilitates communication, collaboration, and decision making. Through GIS, geography is actually becoming an organizing tool. In much the same manner as enterprise-wide financial systems converted the way organizations were managed in the 1960s through the 1980s, now geographic information systems are transforming the way organizations and government agencies manage their assets and serve their customers or citizens.

The focus is shifting from application-oriented architecture to a server-oriented one, making real-time geographic information available to anyone who surfs the Internet. The results of GIS capabilities—quick complex analysis, maps showing statistical connections—used to be limited to the few. Now GIS technology, fully emerging on the Web, offers affordable and direct access to such information products. The combination of new GIS server technology and intuitive, easy-to-use Web clients is opening up the GIS domain to everyone.

We've learned that individual geographic information systems themselves tend to evolve over time, but now we're discovering the value of GIS as a facilitator for a kind of organizational evolution. GIS means change—a new GIS implementation (into an organization that hasn't had GIS before) is a change agent. But once in place, GIS capabilities can be used to help an organization adjust to change, forecast changes ahead, and take advantage of the opportunities incumbent with change.

The ever-widening availability and continual advancements of technology have made it impossible to ignore that we live and work in a perpetual atmosphere of change. Planning is no longer a one-time event, but rather an ongoing process. More and more, organizations and public policy makers have come to identify GIS as important to their objectives. But to harvest GIS's potential requires coordination, collaboration, and an enterprise view of GIS management. GIS planning itself is increasingly important if all these objectives are to be achieved.

GIS: The whole picture

No GIS can be a success without the right people involved. A real-world GIS is actually a complex system of interrelated parts, and at the center of this system is a smart person who understands the whole.

GIS is a particularly horizontal technology in the sense that it has wide-ranging applications across the industrial and intellectual landscape. For this reason, it tends to resist simplistic definition. Yet the first thing we need is a common understanding of what we're talking about when we refer to GIS. A simple definition is not sufficient. In order to discuss GIS outside the context of any specific industry or application, we need a more flexible tool for elaborating: a model.

Figure 1.1 on the next page presents a holistic model of a functional geographic information system, which turns data, through analysis, into useful information. At the center, you can see that GIS stores spatial data, replete with its logically linked attribute information (from the left), in a GIS storage database, where analytical functions are controlled interactively by a human operator to generate the needed information products (shown on the right).

Let's understand the GIS model better by examining its individual components. Spatial data is a term with special meaning in GIS. *Spatial data* is raw data distinguished by the presence of a geographic link. In other words, something about that piece of data is connected to a known place on the earth, a true geographic reference. The features you see on a map—roads, lakes, buildings—are ones commonly found in a GIS database as individual thematic layers. Most can be represented using a combination of points, lines, or polygons. Linked to these geographic features, and usually stored in a table format, is nonspatial information about them, data such as the name of the road, seasonal temperatures of the lake, owner of the building. These various characteristics applied to place are called *attributes* in GIS parlance, and, in fact, it is

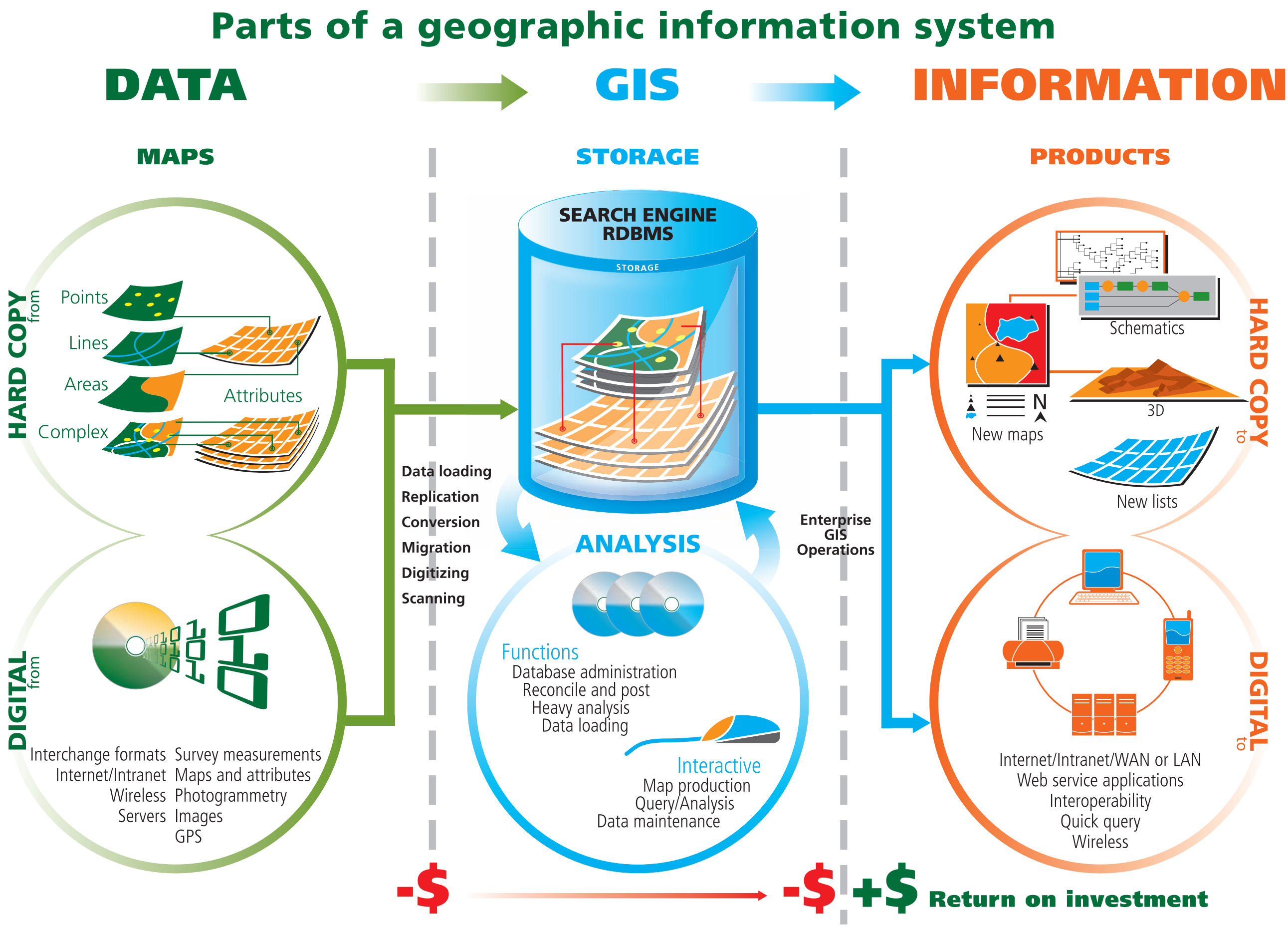


Figure 1.1 **Parts of a GIS**

the range and depth of these attributes that make spatial data such a powerful tool in the hands of a dynamic, working GIS.

So where does this data come from? Not surprisingly, good old-fashioned paper maps and other hard-copy records still supply much of the physical and human data needed for GIS. After all, printed paper maps have been the standard vehicle for conveying geographic information since the earliest recorded history. By scanning or digitizing the features drawn on our organization's paper maps, we mine this rich data source. And by establishing logical links to other digitized hard-copy records in our organization—tables, lists, documents—we further convert data for use in the GIS, doing this until we've digitized and linked all the relevant paper documents at our disposal. More and more, spatial data is available in digital form; you can buy it or acquire it via data-sharing arrangements or over the Web.

Measuring and survey devices, including GPS receivers, photogrammetry images, and survey instruments generate troves of GIS-usable data, which can be shared quickly by means of the Internet and common interchange formats. All these sets of data with logical links—after being systematically integrated under the primary organizing key of geographic location—can be stored and managed as a unit, called a *database.*

Along with all its features and attributes, this linked unit of spatial data—the GIS database—resides in the GIS storage system, where it is available for software functions such as analysis and mapmaking. The power of the computer is used to ask questions of the spatial data, to search through it, compare it, analyze it, and measure it. You use the GIS to do things that would be very laborious or even impossible to do in any other way. These GIS software functions are under the interactive control of the GIS operator, whose job is to create the needed information products.

Identifying the information products your organization needs is central to the GIS planning process, so we do it at the beginning. Information products come in many forms—new maps, new lists and tables, schematics, 3D visualizations, the results of interactive queries presented on-screen, as hard-copy maps and reports, or as transmittable digital information—but they are all intended to improve job performance. And when these end-product reports, which inform your choices, actually lead to better decision making, you know you've planned your GIS well. This is the harvest, the accomplishment that represents the ultimate success of GIS.

Scope of GIS projects

Understanding the scope or range of operation of your project will help you develop an effective plan for GIS implementation. Is it a single-purpose project, a department-level application, or a multi-department—perhaps even multiagency—enterprise system? The same guiding principles of GIS planning apply to all three scopes, regardless of subtle differences between project types, but some of the planning steps may not be needed on small projects or department-level applications.

Most organizations end up testing the GIS waters with a single-purpose project carried out within a single department. The expected result is a project-specific output, such as information needed to make a decision. A site analysis to locate a new landfill is an example of this modest scope: a one-time effort that has an end date, with the project paying the acquisition cost and no long-term support expected.

The second level of GIS implementation is also within a contained scope, but without the limited time frame. With a department-level application, the objective is just as straightforward, but this time the need is ongoing: a department expects output from GIS to support at least one established business objective or function. For example, anytime a change in land-use zoning is proposed, the city planning department must notify all property owners within three hundred feet of the property in question. The business objective is notification of all those owners; GIS supports this by generating the appropriate mailing lists. The GIS is located right there in the department responsible for the targeted workflow, and this department manages the system. For this reason, support from the departmental head is crucial; developing the GIS application depends on it. Funding to cover GIS staff, hardware, software, applications, and maintenance requires corporate approval.

Finally, enterprise-wide systems are the broadest in scope of the three, allowing employees to access and integrate GIS data across all departments of the organization. Here, fully in alignment with the organization's mission, GIS takes its most versatile, active role. The objective is for GIS to boost an already established strategic direction, supporting the entire organization over the long haul. Advocacy from upper management is essential, as is long-term support from multiple departments. Enterprise GIS addresses the business needs of many or all departments, becoming a powerful tool inside the organization as a whole. For example, in a transportation company using multiple GIS applications and huge databases of geospatial data across all departments, GIS is a mission-critical element of the company's operating strategy. Corporate involvement is integral to ensuring data sharing among the many divisions. An enterprise-wide GIS allows the integration of this data with the business functions and processes.

The power of GIS can be leveraged the most at the enterprise level, where there is much to be gained from GIS's adeptness at bringing people and knowledge together: with consistent information available across the organization, decision makers get a clearer picture of reality; data is regularly updated; and more data is shared, reducing duplication of effort.

As GIS software continues to expand more and more into enterprise implementations, other trends lead industry observers to predict that the next step will be society-wide—GIS will become as much a part of our lives as computers are today. GIS servers are already providing the software architecture to enable multiuser access, extending the capability for serving maps and data on the Web in a ready-to-use fashion (through Web clients).

GIS's potential as integrator is only beginning to be tapped, but already GIS-based applications have brought modest changes into the daily life of people, just as GIS has brought major change into the daily business of many organizations. As GIS-based applications become more widespread and available, who knows what societal changes will develop?

Interest in Web services and in service-oriented architecture (SOA) is growing, and with it the public's access to knowledge previously available only to GIS specialists. Thanks to the Internet and technologic advances, GIS is currently evolving from the enterprise to society.

The who, what, when, where, why

Let's borrow a page from the reporter's notebook and set this story up via those famous "W"s of the newsroom: *who*, *what*, *when*, *where*, and *why*?

Who should plan a GIS? You, the GIS manager, must take the lead role in the planning process, but you should never go it alone. You need the senior-level decision makers on board with you, advised and informed throughout the process. Failure to keep these budget keepers apprised can lead to reduced or eliminated funding. To ensure their support, keep them actively engaged in the planning process and educated about the work. You rely on them also to tell you what information products are going to be needed at their level. Include in the planning process those who will be directly using the system as well. If they aren't involved, you'll probably fail to meet their real needs.

A note on consultants: if you decide to hire GIS consultants, have them lead you through the planning steps—never hire a consultant to do the planning for you. You and your colleagues need to do the planning—it's your GIS system, your job, and your reputation at stake. You'll be making decisions as a team throughout the planning process. If you do use a consultant to help you, a GIS team within the organization should still carry out the work, under the consultant's guidance.

In Canada there is a saying: "Consultants disappear like the snow in springtime." The point is, at the end of the process you will be left with the system to implement. If you haven't been totally involved in planning and writing the implementation strategy, you might be in for a very difficult and painful time.

What to plan? GIS is a complex system of interconnected parts. So it will come as no surprise that you must consider six different major components in any GIS plan: information products, data, software, hardware, procedures, and people.

Information products: Information products are what you want (need) from the GIS. This desired output may take the form of maps, reports, graphs, lists, or any combination thereof. Mission critical: identify these products with sufficient clarity early in the planning process.

Data: By knowing what information products you want, you can plan for the acquisition of the needed data. What can you get that already exists? What can you create from existing sources? What levels of map accuracy and scale will you require? And don't forget data format, a factor related to the next component, software. Sometimes data format alone drives the software decision, as in the case of the city municipal government planning a data-sharing arrangement with a county GIS department that already uses a particular software.

Software: Software programs provide the functions needed to perform analysis and create the information products you want. Sometimes customized software sits on top of the main GIS software package. Updates need to be planned to keep the versions current. There are also support and operating system issues related to software.

Hardware: GIS is demanding of hardware. You must take an unflinching look at your organization's computational resources and upgrade accordingly to support GIS. Typically, a few powerful workstations support the heavy lifting and geoprocessing, though in larger systems this is increasingly handled by GIS servers on a network. Simple computers ("thin clients") on the network provide the user access for database query and display purposes. A robust internal network and wide bandwidth ("fat pipe") to the Internet are also required to facilitate file sharing, data acquisition, and reporting.

Procedures: As an important component of GIS planning, *procedures* refers to the way people do their jobs and the changes they will have to make to do their jobs using your new GIS system. You need a migration plan to facilitate this transition from the old way into the new, plus you need to address how the existing ("legacy") systems will coexist (or not) with the GIS.

People: GIS is a thinking process that requires the right people. Will you need to hire or are the right ones already on staff? How will you hire, train, and keep the staff with the specialized skills it takes to build or use your system? Over time, staffing will be your single biggest cost.

When to plan? You plan from the beginning, and the planning process continues after the GIS is installed. Successful GIS projects attract positive attention, which means that before long people will identify other things that they'd like to see from the GIS. This will move you to revisit one or the other of the planning stages. Armed now with the empirical experience of a functioning GIS, each new iteration of the planning process becomes better calibrated to the real world.

Also, you plan in a particular order, each step illuminating where to go with the next. This only stands to reason. How could you plan to acquire the data for a map, for example, unless you'd already identified that map as part of an information product you need?

Where to plan? GIS planning, to be most effective, must be carried out in the business world, not from the vacuum of your office. Because GIS has the potential to create common connections between disparate things, it is inherently a horizontal technology that can touch literally every person in an organization if the company's leaders want it to (and many do). The thorough and diligent GIS planner must meet people in the organization to learn what information they need and how they need to get it. Only by taking the time to witness people doing their work can the GIS planner ever aspire to true understanding of the business processes. And how can a planner create anything of use to anyone without this knowledge?

Why plan GIS? Good planning leads to success and poor planning leads to failure. This is true whether you are starting from scratch or building from an existing GIS. It seems obvious on the surface, but time after time GIS projects fail because of poor planning. Like any complex information system, GIS implementation and maintenance are costly. Every component of the system—the data, the software, the hardware, the staff—cost an organization dearly. But everything exacts a lesser toll if it is considered beforehand and selected carefully.

Would you rather spend a dollar at the beginning on planning or ten thousand later to make up for not planning? The point is, even spending a lot of money is no assurance of getting the right thing. Besides, planning can be interesting: you meet a lot of people, learn a lot about your organization, and you may end up knowing more than the CEO about how the place really runs. Planning is especially rewarding toward the end when you do the benefit–cost analysis and see how much money your organization will be saving over time—and all because you led the implementation of a well-planned GIS.

Overview of the method

Like a good roadmap, an overview of the method lets you know where you are going.

The planning methodology introduced in this book shows you the steps of GIS planning—how to assess what your requirements are and which system will meet those needs—and how to implement the GIS in your organization once your plan is approved.

This ten-stage GIS planning methodology evolved from years of experience in planning large and small implementations in public- and private-sector companies. The size and nature of your organization will determine which of the component stages are most relevant to your situation. A full enterprise-wide implementation almost certainly requires you to undertake all the stages in full, while for a smaller project, you'll be completing some steps quickly or even skipping a few. Regardless of the size of the undertaking, all situations are unique; you will need to understand all of the steps in the process before adapting the methodology to suit your circumstances.

The ten-stage GIS planning methodology

Stage 1: Consider the strategic purpose
Stage 2: Plan for the planning
Stage 3: Conduct a technology seminar
Stage 4: Describe the information products
Stage 5: Define the system scope
Stage 6: Create a data design
Stage 7: Choose a logical data model
Stage 8: Determine system requirements
Stage 9: Consider benefit–cost, migration, and risk analysis
Stage 10: Plan the implementation

The following ten chapters of this book detail each of the ten stages. Let's take a quick tour of the method.

Stage 1: Consider the strategic purpose (chapter 3)

Start by considering the strategic purpose of the organization within which the system will be developed. What are its goals, objectives, and mandates?

This stage of planning ensures that the GIS planning process and final system fit within the organizational context and truly support the strategic objectives of the organization. This stage also allows you to assess how information created by the GIS will affect the business strategy of the organization.

Stage 2: Plan for the planning (chapter 4)

GIS planning should not be taken lightly. Forget about actually implementing a GIS for the moment. Just planning a GIS takes a commitment of resources and people. Before you begin, you need to know that your organization understands the distinction between planning and implementing and that it is prepared to provide enough resources for the planning project.

Making the case means understanding what needs to be done and what it will take to get it done. The result of this stage is a project proposal that makes that case and explicitly seeks approval and funding to launch the formal planning process.

Commitment to the planning process is essential to a successful GIS implementation, especially in municipal government agencies and other bureaucratic public-sector organizations. The project proposal helps secure this political commitment. This is the moment to introduce the GIS planning process to the highest level executives of your organization and to arrange to keep them fully informed of your progress. If you receive approval for your planning project and a commitment of resources at this point, your chances of having a successful GIS are high.

Stage 3: Conduct a technology seminar (chapter 5)

Once your project plan is approved, you can activate the in-house GIS planning team to begin its most important endeavor: identifying exactly what the organization needs from a GIS.

Defining the specific GIS requirements is the primary task of the planning process. You must meet with the customers or clients of the GIS (those who will use the system or its output) to begin gathering specifics about the organization's needs from the user's perspective. A highly effective method of soliciting input is to hold one or more in-house technology seminars.

In addition to its information gathering purpose, the technology seminar is an ideal opportunity for you to explain to key personnel the nature of GIS, its potential benefits, and the scope of the planning process itself. By involving stakeholders at this early stage, you help to ensure subsequent participation in the planning work ahead.

The technology seminar is also the place where initial identification of information products begins.

Stage 4: Describe the information products (chapter 6)

Knowing what you want to get out of your GIS is the key to a successful implementation. And what you want comes in the form of information products: maps, lists, charts, reports, whatever you need to inform your decision making and streamline workflows.

This stage must be carefully undertaken. You will talk to the users about what their job involves and what information they need to perform their tasks. Ultimately you need to determine things like how each information product should be made and how frequently, what data is required to make it, how much error can be tolerated, and the benefits of the new information produced. You will help each person declaring a specific need for such information from the GIS to write an *information product description (IPD).*

This stage should result in a document that includes a description of all the information products that can be reasonably foreseen, together with details of the data and functions required to produce these products.

Stage 5: Define the system scope (chapter 7)

Once the information products have been described, you can begin to define the scope of the entire system. This involves determining what data to acquire, when it will be needed, and how much data volume must be handled, then charting all this on a *master input data list (MIDL).*

You will also assess the probable timing of the production of the information products. Here, you may discover it's possible to use one input data source to generate more than one information product, and you can build this into your development program. Each refinement helps clarify your needs and increase your chance of success.

Stage 6: Create a data design (chapter 8)

In GIS, data is a major factor because spatial data is relatively complicated. In the conceptual system design phase of the planning process, you review the requirements identified in the earlier stages and use them to begin developing a database design.

Stage 7: Choose a logical data model (chapter 9)

A logical data model describes those parts of the real world that concern your organization. The database may be simple or complex but must fit together in a logical manner so that you can easily retrieve the data you need and efficiently carry out the analysis tasks required.

Several options are available for your system's database design. You will review the advantages and disadvantages of each approach at this stage, while considering various issues affecting the design: data accuracy, update requirements, error tolerance, and data standards.

Stage 8: Determine system requirements (chapter 10)

Here, you envisage the system design in its entirety by examining as a whole what you will require of a system: the GIS functions, user interface, communications bandwidth, and core capacity. This is the first time in the planning process that you examine software and hardware products.

You review the information product descriptions (IPDs from chapter 6) and the master input data list (MIDL from chapter 7) in order to summarize and classify the functions needed to make these products. This will enable you to inform vendors of what you require in the way of software functionality. You will consider issues of interface design, effective communications (particularly in distributed systems), and platform sizing in order to determine the appropriate hardware, software, and network configurations to meet your needs.

Stage 9: Consider benefit–cost, migration, and risk analysis (chapter 11)

Following conceptual system design, you need to work out the best way to actually implement the system you have designed. This is where you begin preparing for how the system will be taken from the planning stage to actual implementation.

As part of that preparation, you may need to conduct a benefit–cost analysis to make your business case for the system. To convince management to fund the GIS implementation, you will probably be called upon to show how various risk factors weigh in, such as migration from the old system to the new.

Stage 10: Plan the implementation (chapter 12)

Until now, the focus of the planning methodology has been on what you need to put in place to meet your requirements. The focus at this stage switches to how to

Let each step inform the next

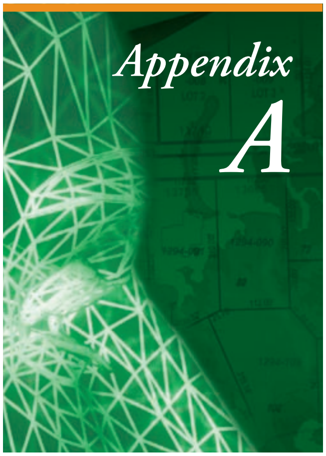
- If you know what information products you need, you can determine what data should go into your GIS.
- If you can determine what data should go into your system, you can also determine what needs to be done to the data to produce your information products.
- If you know what you want to do to your data, you can determine what functions your system needs to be able to perform and begin to design an appropriate technological solution.

put the system in place—acquisition and implementation planning. Now you will address such issues as staffing and training, institutional interactions, legal matters, security, existing legacy hardware and software, and how to manage change. The plan that results from this last stage of the methodology will contain your implementation strategy and benefit–cost analysis. This plan becomes your final report, which can be used both to secure funding for your system and as a guide for the actual implementation of the system.

The final report equips you with all the information you need to implement a successful GIS. It will become your GIS planning book to help you through the implementation process.

Developing the final report should be the result of a process of communication between the GIS team and management so that no part of the report comes as a surprise to anyone. The report should contain a review of the organization's strategic business objectives, the information requirements study, details of the conceptual system design, recommendations for implementation, time-planning issues, and funding alternatives.

The purpose of this GIS planning methodology—and my intention with this book—is to guide you through these stages in your thinking. Use it to give senior executives the context for the questions they must ask about GIS in their organization; let it inform you as a planner or new GIS manager how to answer those questions.



GIS staff, job descriptions, and training

A good GIS staff is an invaluable tool for a manager. Money can buy more hardware and software, but even money cannot create the motivation and enthusiasm essential to a successful staff and a successful GIS implementation. It takes people to build, manage, and maintain a GIS, so part of planning for a GIS is making sure you will have enough staff with the appropriate skills and training.

GIS staff

Consider everyone directly concerned with the design, operation, and administration of the GIS as the GIS staff, including the end users, the management group, and the systems administration team. The core GIS staff, however, is where you expect to find the more specialized GIS skills, and it includes the GIS manager and GIS analysts.

GIS manager

The GIS manager requires skills in GIS planning, system design, and system administration. Ideally, the manager would also possess hands-on, technical GIS skills—most effective GIS managers come from the ranks of GIS doers. The responsibilities of this position vary depending on the type of organization. In smaller organizations, the GIS manager may be the only person involved with the GIS; so the same person who negotiates data sharing agreements with the next county over is also pushing the buttons on the GIS when the data itself shows up. In very large organizations, often the GIS manager is in charge of coordinating the GIS staff, working with multiple departments, and overseeing the development of an enterprise-wide database. An emerging trend is toward the creation of geographic information officers (GIOs), who become the true champions and executors of GIS innovation within an organization.

GIS analysts

GIS analysts are persons with GIS expertise working in support of the GIS manager. In smaller GIS organizations or in a single-department GIS, the GIS analyst may be one person with a broad range of GIS skills; large organizations may need several GIS analysts, among whom you might find titles such as these:

- GIS technology expert—responsible for the hardware and network operations of the GIS
- GIS software expert—responsible for application programming
- GIS database analyst—responsible for administration of the GIS database
- GIS primary users
- Professional GIS users—support GIS project studies, data maintenance, and commercial map production
- Desktop GIS specialists—support general query and analysis studies

GIS end users

It is helpful to think of the end users of your GIS as an important staff component because they affect the design and use of the GIS. They may include the following:

- Business experts—key employees with intimate knowledge of the processes your GIS is attempting to improve; they provide the GIS manager with major input regarding design and management of the GIS.
- Customers—clients of the GIS who are served by it, including business users requiring customized GIS information products to support their specific business needs, as well as the more casual Internet and intranet map server users, people accessing basic map products invoked by wizards or Web browsers.

Once the GIS is implemented, the management group merits special attention as part of the end-user category. The fundamental purpose of a GIS is to provide to management new or improved information for decision-making purposes. At this level then, the managers actually become customers, whereas up until now they have been involved in helping you pass through the hurdles of the organizational bureaucracy. The managers could be the project sponsor, a member of executive management who will be using the application (or its output), or a management representative who can serve as the conduit delivering management's requirements. While not the core GIS staff, they are nonethelss vital to GIS success.

System administration staff

A large organization needs a system administration staff to play an important role in the day-to-day operation of the computer systems supporting the GIS. Staff members may include the following:

- The network administrator—responsible for maintaining the enterprise network
- The enterprise database administrator—responsible for the administration of all databases that interact within the organization
- The hardware technicians—handle the day-to-day operation of computer hardware within the organization, including maintenance and repair

Staff placement

Once you've identified the GIS staff required, you must decide where the positions fit into your organizational structure, a decision that will affect the role and visibility of the GIS department. There are four main levels in which GIS staffs are typically placed:

1. Within an existing operational department: In this scenario, staff is tied to a specific need and budget. It is difficult for staff at this level to serve multiple departments.
2. In a GIS services group: This group serves multiple projects but still has the autonomy and visibility of a stand-alone group.
3. At an executive level: This placement signals a high commitment from management. Staff have high visibility and the authority to help coordinate the GIS project. The downside is when GIS staff at the executive level become isolated, fostering the perception among the rank-and-file of being out of touch with critical stakeholders.
4. In a separate support department: The more old-fashioned notion of IT would place any new information system staff in a centralized computing services department. This is the "systems" group in many organizations.

GIS job descriptions

Clear job descriptions are essential before hiring begins. Outlining GIS roles provides you and your prospective employees with a common understanding about the position and its requirements. Job titles and descriptions will also come into play during job evaluation and performance reviews. Most GIS job descriptions of the same titles are similar; however, they do vary depending on the software used within an organization, size of the system, specific job responsibilities required, and type of agency or company seeking to fill the position.

If your organization is new to GIS, the human resources department will not have suitable job descriptions for the type of GIS personnel you need, so you'll have to write them yourself. Refer to the sample GIS job descriptions here, and be sure to design your own just as realistically. Obviously, you want the best person for the job, but if you require that your digitizing technicians have master's degrees, you will probably never find a digitizing technician.

GIS manager

Provides on-site management and direction of services to develop, install, integrate, and maintain an agency-wide standard GIS platform. This position will be responsible for developing, implementing, and maintaining special-purpose applications consistent with the agency's mission and business objectives. Requirements: must have proven experience in project-design and work-plan development; database system and application design; maintenance and administration of a large Oracle SDE database. Successful candidates must have a B.S./M.S. in geography, planning, or related field and three to five years professional experience implementing in-depth, complex, GIS solutions involving RDBMS and front-end application development. Applicants must also have knowledge of and ability to apply emerging information and GIS technologies (particularly Internet technologies); experience in project management; experience working with Oracle databases; and excellent interpersonal, organizational, and leadership skills. Experience with object-oriented methods and techniques is a plus.

Enterprise systems administrator

This position will provide user support, resolve UNIX- and NT-related problems, perform systems administrative functions on networked servers, and configure new

UNIX and NT workstations. Requirements include a B.S. degree in computer science or other related college degree with experience in computer systems area or three or more years working in systems administration functions in a client-server environment. Must be familiar with multiple UNIX platforms and have high skills with both UNIX and NT commands and utilities. Good problem-solving skills and the ability to work in a team environment are mandatory.

GIS application programmer

The GIS programmer will design, code, and maintain in-house GIS software for custom applications. Position requires the ability to interpret user needs into useful applications. Candidates should have a B.S./B.A. degree or higher in computer science, geography, or related earth sciences. All candidates must have two years or more of programming experience with one of the following: VB, C++, or GIS vendor-specific programming languages. Previous experience with programming GIS applications and knowledge of GIS search engines is a plus.

GIS database analyst

Responsible for the creation of spatially enabled database models for an enterprise GIS. Typical tasks include setup, maintenance, and tuning of RDBMS and spatial data, as well as development of an enterprise-wide GIS database. Position is also responsible for building application frameworks based on Microsoft COM approaches. Position requires at least a B.S./B.A. in computer science or geography. Candidates should have a strong theoretical GIS and database design background and experience with Microsoft COM objects approach. Preference will be given to candidates with experience in modeling techniques used by the enterprise.

GIS analyst

Responsible for the development and delivery of GIS information products, data, and services. Responsibilities include database construction and maintenance using current enterprise GIS software, data collection and reformatting, assisting in designing and monitoring programs and procedures for users, programming system enhancements, customizing software, performing spatial analysis for special projects, and performing QA/QC activities. Requires a B.A. degree in geography, computer science and planning, engineering, or related field or an equivalent combination of education and experience. Candidates should have one to two years experience with GIS products and technologies, especially those currently used by the enterprise. Applicants should have experience with various spatial-analysis technologies, and knowledge of current enterprise spatial server engines is a plus.

GIS technician/Cartographer

Responsibilities include all aspects of topographic and map production using custom software applications, including compilation from various source materials, generation of grids and graticules, relief portrayal, creating map surround elements, digital cartographic editing, text placement, color separation, quality assurance, symbol creation, and cartographic software testing. Successful candidates will have strong verbal and written communication skills and have a B.A./B.S. or M.S. degree (depending on position level) in geography, cartography, GIS, or related field; experience or coursework in GIS software and macrolanguages, Visual Basic, or graphic drawing packages; and familiarity with remote-sensing and satellite imagery interpretation. Candidates should provide a digital or hard-copy cartographic portfolio for evaluation.

Training

Consider how the people within your organization will use the GIS before developing a training program. GIS staff and GIS end users will require different types of training.

Core staff training

The core GIS staff members comprise the cornerstone of your efforts. They are responsible for creating, maintaining, and operating both the data and the system infrastructure. They will require up-front and ongoing training to keep them current on new techniques and methods. (You may need to consider training for system administration staff as well.)

The training program developed for the GIS staff could involve courses in database management, application programming, hardware functionality, or even geostatistical analysis, depending on their relative and collective skill sets. The training your staff receives should complement their job responsibilities. These are the people responsible for maintaining a product for your users. A well-trained staff is crucial for the continual success of a GIS.

End-user training

The training required for GIS end users is understandably much less involved than that for core GIS staff members. Often a single interface or Web application is all that an end user will ever see, meaning the application can be taught in as little as minutes.

Many vendors provide training courses related to their own software, and some even cover basic GIS theory and applications as necessary. Self-study workbooks that include software to practice with provide another flexible learning alternative. GIS is inherently a multidisciplinary endeavor, so training in other areas beyond the actual software continues to play a major role.

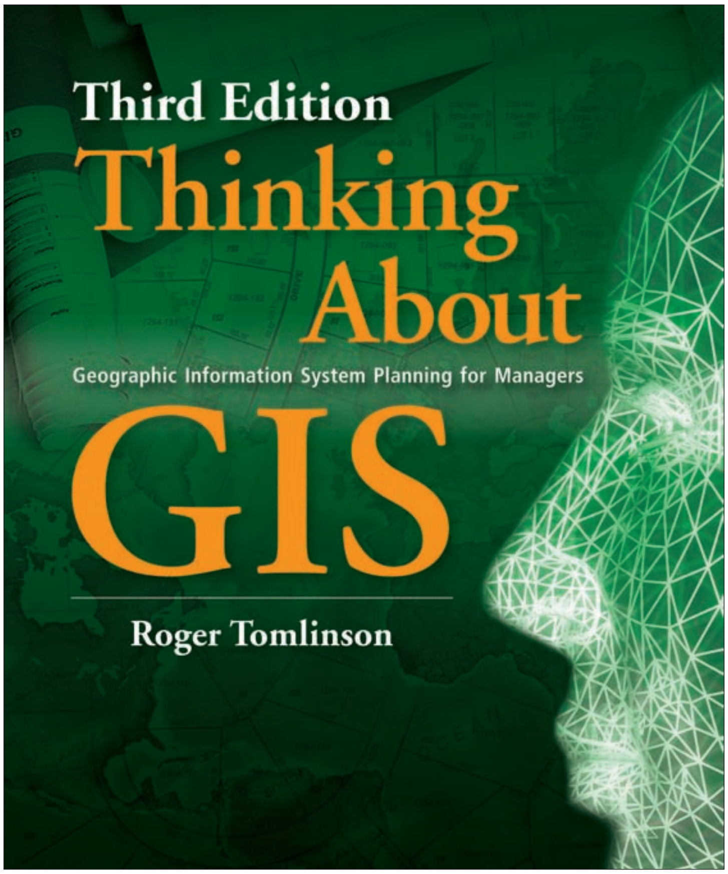
Manager training

Even if, ideally, the person hired as GIS manager has technical competency in GIS, these skills must be continually updated if the manager hopes to give meaningful direction to his or her staff. Also, of course, GIS managers must demonstrate effective management skills—or work to acquire them. Courses designed to help in specific areas such as general management skills, project management, strategic management, and total quality management can all be helpful.

Training delivery

Training can be delivered in many flexible forms these days, thanks to wonders like the Web and cheap air travel. Face-to-face classroom courses are available from vendors or educational establishments, either at their premises or on-site with you. Web-based training, distance learning, and self-study workbooks are all options for training in GIS and related areas. Whatever method is used, sufficient time and resources for training and related activities (travel, preparation of assessment, follow-up reading) must be provided.

Want more Thinking About GIS?



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About the author

Roger Tomlinson is the principal of Tomlinson Associates, a firm of consulting geographers he established in 1977. He has advised an impressive list of clients, from the World Bank to the U.S. and Canadian Forest Services. He holds two bachelor degrees; a master's degree from McGill University in Montreal, Canada; and a Ph.D. from University College, London, England. Commonly referred to as the "father of GIS," he has conducted successful GIS planning seminars worldwide.

About this book

Developed from his decades of global consulting experience and popular GIS seminars, Roger Tomlinson's book helps bridge the communication gap between those with and without technological expertise. By addressing the concerns of both types of managers (specialists and senior executives), Tomlinson's methodology provides a common platform from which to assess exactly what an organization needs from a GIS and to conduct the kind of specific planning that management can support.

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