Contents

Refereed

7 Is There a Role for High-Performance Computing in GIS?
   Marc P. Armstrong

11 A Methodology for Reporting Uncertainty in Spatial Database Products
   Gary J. Hunter, Mario Caetano and Michael F. Goodchild

22 Justifying Automated Mapping Systems in Small Communities
   Colin O. Benjamin and Adel Fadel

35 Information Systems: A Labor Market Adaptation
   Linda Y. de la Viña and Ronald Ayers

Features

43 The Dream of GIS for Albania
   Helen M. Schutten

45 Building a Useful GIS Directory: Snohomish County, Washington
   Jeffrey S. Anderson

53 Staffing a GIS
   Rebecca Somers

58 Photo CD: A Digital Solution for Storing and Using Aerial Photos
   Brian Huberty

63 GIS and Neighborhood Planning: A Model for Revitalizing Communities
   James A. Myers, Michael Martin and Rina Ghose

68 1995 Exemplary Systems in Government: Achievement and Excellence
    in the Public Sector
   Edward U. Graham

Feature Map

75 A Dash of Art, Pinch of Science, and Plenty of Elbow Grease
   William S. Burgess

Reviews

Books

78 Managing GIS: A Review of Two Recent Books
   Rebecca Somers
    Eric K. Fisher

Software

86  GeoApplication Tools: Geographic Calculator 3.0; Geographic View 1.0;
    Geographic Transformer 2.0; and Geographic Tracker 1.0
    Jay Lee

91  Author Index

95  Subject Index

101 Guidelines for Manuscript Submission

Cover: The cover aerial photograph shows downtown Seattle, Washington, with the
Kingdome sports arena at left center. Puget Sound is in the upper left (northwest) corner of
the image. It was taken in April, 1995 by Aerial Image Technology (Portland, Oregon) from
a Cessna 172 aircraft flying 12,000 feet above sea level. The image was used for a U.S. Army
Corps of Engineers wetlands project.
Aerial Image Technology used a Nikon F3 35mm camera, a 28mm lens, and Kodak
Ektachrome 100 film. The slide was then scanned by Northwoods Personally Yours in
Woodruff, Wisconsin. They used Kodak's PIW (Photo CD) computer system to scan and
write the image onto a Photo CD, a process which is described in the article on page 58.
The Photo CD disc was supplied by Kodak Aerial Systems.
In this issue ...

Marc Armstrong provides an overview of trends in high-performance computing that may impact GIS in coming years. He points out that many geographic applications are potential parallel-processing problems and can benefit from high-performance computing.

Gary Hunter, Mario Caetano, and Michael Goodchild develop a general model of spatial data uncertainty. The approach allows uncertainty to be modeled and visualized, and its effects on the results of analysis to be simulated and evaluated.

Colin Benjamin and Adel Fadel describe a methodology for evaluating investment in automated mapping systems in small communities. The approach includes financial and economic analysis, and assesses risk and uncertainty by sensitivity and risk analysis.

Linda de la Viña and Ronald Ayers describe the theoretical foundations, design and implementation of the San Antonio Labor Market Information System (SALMIS). SALMIS addresses the effects of incomplete information by providing employment and training officials with up-to-date data and forecasts relating to specific segments of the labor market.

Editorial Intent

The refereed section of URISA Journal strives to share new knowledge in the technical, social, economic, and institutional subject areas that support information systems technology. It is the intent that this section of the Journal contain papers that are representative of URISA's membership and the broader information systems community. We encourage the participation of system designers, implementors and users as well as the educational and research community.

We hope that the refereed section will provide reliable information and new insights resulting from experience, research and scholarship. We also hope that this section will link academia, industry and the user community through the sharing of critical investigations and organized knowledge. To this end, we are seeking three forms of work: (1) Reports of current research and development pertinent to the overall information systems community; (2) systematic literature reviews of research for the research and development community; and (3) systematic reviews of applications which explain successful systems and procedures to the overall information systems community.

The refereed process consists of a "blind review." After receiving a manuscript from an author, we send it out for review to three or more persons who have been identified as being knowledgeable in the topical area. The name and affiliation of the author are removed from the paper so the reviewers can give it an impartial review; likewise, the names of the reviewers are not revealed to the author. We ask the reviewers to respond to the following: (1) Is the thesis or purpose stated early and clearly; (2) is the significance of the paper stated explicitly; (3) is the thesis argued persuasively; (4) is the writing clear, concise, straightforward, interesting, and in the active voice, where possible; (5) is the paper tied in appropriate ways to relevant literature; (6) is the paper illustrated appropriately; (7) are the methods sound and appropriate to the paper; (8) are the methods explained clearly; and (9) is the paper interesting to many different types of URISA Journal readers?

If the manuscript is accepted and does not need revising, it is sent to the managing editor for comments and final editing. If the manuscript needs revision, assistance is provided by the editors. If the manuscript is not accepted, it is returned with an explanation by the editors. (For complete guidelines regarding the preparation of manuscripts and illustrations, see pp. 101–102.)

Kenneth J. Duker
Is There a Role for High-Performance Computing in GIS?

Marc P. Armstrong

The conventional wisdom held by many GIS users and researchers is that high-performance computing (HPC) environments are costly and difficult to use. However, improvements in hardware and software have changed the complexion of HPC during the past several years. Researchers and analysts who routinely use GIS and spatial analysis software can exploit these changes, and thus improve their ability to address computationally complex urban and regional problems. In this paper, I provide an overview of some trends in high-performance computing that have the potential to significantly impact GIS during the next few years. To realize this potential, GIS vendors and the GIS research community will have to adapt to computational challenges.

High-performance computers (HPC) are normally applied to problems that require large amounts (hours, and sometimes, days or weeks) of computer time on commodity-class (e.g., Pentium- or SPARC-based) workstations. In fact, a widely-adopted approach to solving a computationally burdensome problem is to "run it overnight." Consequently, many users are eager to upgrade their computer systems because of the perceived inadequacy of existing systems when performing selected tasks. In some instances, especially when complex models are part of a GIS-based analysis, users may send problems through an HPC system for quick turn-around. Note, however, that HPC is a fuzzy, mutable concept; technology is continuously improving and the size of the problems we wish to solve is also constantly increasing.

During the past 15 years, high-performance computers, such as those sold by Cray, have excelled at solving repetitive arithmetic calculations, especially when the calculations were performed inside of loops, by "pipelining" the execution of instructions (Patterson and Hennessy 1994). Since most high-level operations, such as adding or multiplying two numbers together, actually require the completion of several lower-level instructions before a result is produced (Karpus 1989, pp. 7-8), a pipeline sequences these low-level instructions in a loop so that several of them overlap and can be executed simultaneously. Because of this simultaneity, pipelining can yield an improvement in overall system performance, and is especially valuable for numerically intensive computations. In addition to pipelining, manufacturers of high-performance computers have focused on components that work at very high speeds. Together, pipelining and increased clock speeds led to the successful construction of ever-higher-performance supercomputers through the 1980s. And these same basic principles are also now widely used in the superscalar architectures used by the current generation of high-performance workstations (see, for example, Ryan 1994). In fact, the newest generation of processors typically contains several different pipelines that are optimized to perform tasks such as integer and floating point arithmetic.

Pipelines, however, cannot be extended to great lengths because of data dependencies and because they cannot handle the conditional branches that occur in many application programs (Patterson and Hennessy 1994). These branches normally contain different code blocks that are conditionally executed based on the result of a logical operation (e.g., if . . . then constructs). As a consequence, the instructions that need to be loaded into the pipeline are unknown before the logical expression is evaluated, and this restricts pipeline performance. Clock speeds also cannot be increased indefinitely to improve performance because some component-fabrication barriers are proving to be difficult and expensive to overcome. Consequently, computer manufacturers who formerly relied on pipelining and increased clock speeds to maintain dominance in high-performance computing markets have turned to architectures that are more explicitly parallel. For exam-
ple, new scalable systems, such as the IBM SP-2, are built from networked processors that are functionally identical to those used in RS/6000 workstations.

Parallel HPC architectures considerably extend the notion of processing simultaneity observed in pipelined systems. In addition, recent improvements in hardware and software have led to easy-to-use parallel processing environments. And with the promulgation of standard versions of high-level languages such as C*, Fortran 90 and High-Performance Fortran (Loveman 1993), application codes can now be ported across a variety of parallel HPC platforms. In fact, Fox et al. (1994: 29) assert that High-Performance Fortran is likely to become a de facto standard during the next several years.

What does the Future Hold?

The business of making high-performance computer systems is a risky one with a history of innovative ideas that have led down dead ends of commercial viability. Despite this uncertainty, broad trends can be discerned; and these trends point to the use of at least limited parallelism in GIS applications. These trends are evident not only in GIS, but in business computing as well. Consider, for example, a recent issue of Information Week, a weekly magazine with a target audience of business and technology managers. In the September 26, 1994 issue (p. 27), an advertisement touts the performance of one parallel database management software product over two others. The important point here is that there are several major database software vendors with existing parallel-processing strategies. Additionally, on page 56 of the same issue, a news article describes the changing corporate scientific computing strategy of Atlantic Richfield Co. (an oil company that uses geological analyses to support oil exploration) as it has moved from the use of “traditional” IBM 3090 and Cray Y-MP computers to a parallel, 16 processor Cray CS6400. Though these examples are admittedly anecdotal, it is now easy to see that parallelism has entered into the business computing world. Such stories are reported with increasing regularity and, consequently, parallelism is no longer considered to be esoteric in many sectors of the business data-processing community. As parallelism gains widespread acceptance in commercial applications, the GIS community must be prepared to respond.

Patterson and Hennessy (1994) define a continuum of advances in computer architectures that is bounded on one end by evolutionary developments, such as pipelining and caches, that require little change to algorithms when they are implemented. On the other end of the continuum, they define revolutionary developments, such as parallel processing, that may require algorithms to be rewritten to achieve optimal performance. Because of differences in both the relative capacity of individual processors in parallel computing systems as well as the types of interconnections among them, at present, application programmers must concern themselves with these characteristics if they are to use these systems efficiently.

Despite these challenges, parallel architectures can be applied readily to the types of problems that are normally faced by researchers using GIS and urban and regional models. During the past few years I have been involved in several projects that have evaluated the use of parallel computers in geographically-based applications ranging from locational modeling (Armstrong and Densham 1992) and spatial statistics (Armstrong, Pavlik and Marciano 1994a; 1994b; Armstrong and Marciano 1995) to spatial interpolation problems (Armstrong and Marciano 1993; 1994). Other researchers have also reported on the performance of GIS operations when parallel architectures are applied to vector-based polygon overlay (Franklin 1989; Hopkins and Healey 1990; Wang 1993), terrain triangulation (Puppel et al. 1994), intervisibility analysis (Mills, Fox and Heimbach 1992; DiFiori, Montani and Scopigno 1994), neighborhood (focal) operators (Li 1994), cartographic name placement (Mower 1993) and line simplification (Li 1993a). In addition, graphical applications often require substantial amounts of rendering time, especially those that require the use of realistic (e.g., lighting models and hidden surface removal) three-dimensional graphics. Consequently, researchers have begun to explore the use of parallelism in polygon rendering and shading in general purpose settings (Ellsworth 1994; Whitman 1994) as well as in GIS-based terrain representation (Ding and Densham 1994).

The general consensus that has emerged from this growing body of work is that many geographical problems can be decomposed and recast so that they can be efficiently executed in parallel HPC environments. Indeed, many of the geographical problems reported in the literature are almost "embarrassingly parallel" (Fox, Williams and Messina 1994) and straightforward translations of sequential codes to their parallel counterparts can be performed. Consider an example problem from the work reported above, that of calculating interpolated values for a regular grid from an irregular distribution of control points (Armstrong and Marciano 1994). In this example, the value of each cell in the interpolated matrix can be calculated independently of those for other cells, and consequently, all of the available parallel processing elements can be used very efficiently. Many other types of geographical problems exhibit similar characteristics that make them well-suited to parallel environments.

In addition to the use of dedicated, and often expensive, parallel computer systems, other significant trends indicate that it is now possible to implement parallel
processing environments on a “shoestring budget” by using collections of networked workstations. Several strategies have been suggested in the literature to accomplish this goal, but two conceptually similar approaches, Linda (Carriero and Gelernter 1990) and PVM (Beguelin et al. 1991; 1993), are in broad use. They work by establishing a virtual computer that is built from processing nodes (workstations) connected by a conventional network. Though very little work on the application of this distributed, message-passing model of computing has been done in GIS (see Li 1993b), Rokos and Armstrong (1996) describe a Linda implementation of an algorithm that calculates a measure of spatial autocorrelation for polygon data. The results indicate that this particular geographical problem, which is decomposable into coarse-grained parallel processes, can be adapted to a distributed parallel environment. If this finding is more generally applicable, this means that distributed parallelism is well within the economic and technical grasp of many GIS researchers who have access to networked workstations. However, additional work needs to be performed to determine the general effectiveness of this distributed approach to GIS-based computing.

One additional trend in high-performance computing is also linked to the availability of networks. A fundamental flaw in the historical development of computers has been the implicit assumption that all types of computing can best be accomplished using a single architecture. However, complex problems often contain a mix of computation types that each can best be executed using a different architecture. The goal of heterogeneous computing is to divide a problem into a set of subproblems that are not only executed using different processors, but different architectures as well (Freund and Siegel 1993). A heterogeneous collection of computers must be tied together by a high-speed network to form a virtual, or meta-computer (Smarr and Catlett 1992). It is possible that many GIS-based analyses can be computed efficiently using a heterogeneous approach to computation. Densham and Armstrong (1994), for example, discuss the application of heterogeneous processing to location-allocation analysis. Because many geographical problems can be easily converted into a parallel form, a first step in heterogeneous processing has already been demonstrated. The remaining difficult task of assignment of sub-problems to particular architectures will require a deeper theory of geographical computing as well as considerable research to uncover empirical regularities in the computational characteristics of GIS-related problems.

GIS software is used by groups. Because many public policy issues are resolved by committees and task forces, new types of “groupware” or collaborative spatial decision-making environments must be developed. A hallmark of group decision-making is the generation and evaluation of multiple scenarios. When several individuals simultaneously begin to generate different scenarios, this may induce a substantial computational burden on the system. The magnitude of this burden may be especially critical because most meetings have a finite (and often brief) duration (e.g., one hour). Consequently, required analyses must be computed quickly to permit discussion about relevant alternatives during the course of a meeting. Distributed parallelism can be applied to GIS-based analyses to improve performance with the important secondary effect of providing time to discuss the merits and limitations of a broader range of alternative approaches to problem-solving.

Conclusions

GIS has been transformed during the past decade by the widespread availability of low-cost computing resources. The current generation of workstations is now able to manage, process and display the large volumes of data that are routinely encountered in GIS applications. Nevertheless, there remain significant computational impediments to the timely analysis of large, detailed and complex GIS problems. These impediments can be overcome through the use of HPC. Recent software developments now make it possible to create low-cost parallel-programming environments that are built from collections of networked workstations. These linked computers are harnessed by software that searches for idle machines, and then assigns a portion of a computational load to them. In this way, the collections of workstations that are becoming commonplace in many offices can be used to solve computationally complex GIS problems. Before such activities become routine, however, researchers must investigate ways to decompose geographical problems for parallel computers, and GIS software vendors must follow the lead of database management software vendors and begin the development of commercial GIS software that is designed to exploit the opportunities presented by parallel-computing environments.

Acknowledgments

This research represents part of Research Initiative 17, “Collaborative Spatial Decision-Making”, of the National Center for Geographic Information and Analysis, supported by a grant from the National Science Foundation (SEP 88-10917). Support by NSF is gratefully acknowledged.
References


A Methodology for Reporting Uncertainty in Spatial Database Products

Gary J. Hunter, Mario Caetano and Michael F. Goodchild

The term ‘uncertainty’ is used to refer to differences between the information provided by a spatial database, and the corresponding information that would be available to someone able to observe and measure the real world directly. It includes the effects of errors made during creation of the database, as well as those of the information loss that occurs during generalization. A general model of spatial data uncertainty is presented, and examples of its applications are described. The model forms the foundation for a general approach to handling uncertainty in the application of spatial databases and GIS. The use of the model is illustrated with a simple example of the analysis of a wildfire in a remotely sensed image. The approach allows uncertainty to be modeled and visualized, and its effects on the results of analysis to be simulated and evaluated.

We experience difficulties in articulating the quality of information represented in a database principally because we don’t understand how to analyze data based on information about its qualities. Even if a database were to provide us with a feature’s quality attributes along with its shape and topology, our prevailing tools are usually incapable of modeling most of its properties, and these procedures we do have are pathetically crude...

(Dutton 1984, p. 276).

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Dr. Michael Goodchild is a professor of geography at the University of California, Santa Barbara, and director of the National Center for Geographic Information and Analysis. He was editor of Geographical Analysis for several years and currently serves on the board of six journals and book series. He is well known for his interest in quality and accuracy issues in GIS, and is editor of the book Accuracy of Spatial Databases.

While researchers have invested considerable resources examining the modeling and communication of uncertainty in spatial database products, the results of their labor will not be recognized until the user community can apply the techniques in everyday, operational situations. Thus, the debate about uncertainty has now reached the stage where there is a critical need for tools to be developed to assist users in better understanding the outputs derived from their systems, as acknowledged in the quotation given above by Dutton (1984). Through such knowledge they will be placed in an improved position to make data quality assessments, by comparing the quality of their products against the requirements of the tasks for which the products are to be used.

Before discussing the various options available for dealing with this problem, some explanatory remarks are required regarding the use of the term “uncertainty.” In general terms, uncertainty denotes a lack of sureness or definite knowledge about an outcome or result, and synonyms include “doubt” (a lack of certainty witnessed by the inability to make a decision), “dubiosity” (a vagueness or conceptual confusion), “skepticism” (implying a lack of faith or trust in the reliability of something), and “mistrust” (a genuine belief based upon suspicion).

In the context of spatial databases, the authors suggest there is a clear distinction to be made between “error” and “uncertainty,” since the former implies that some degree of knowledge has been attained about differences (and the reasons for their occurrence) between the results or observations and the truth to which they pertain. On the other hand, “uncertainty” conveys the fact that it is the lack of such knowledge which is responsible for hesitancy in accepting those same results.
or observations without caution, and often the term "error" is used when it would be more appropriate to use "uncertainty."

It is well known that there are many potential sources of error in spatial databases (Hunter and Beard 1992), but because so little is understood about the way in which those errors (either singly or in conjunction with each other) affect the outcome of the final products (be they displays, maps, graphs or reports), there is a resultant uncertainty concerning the level of trust which should be placed in them. In some ways, the distinction between error and uncertainty is analogous to the legal belief that a person is "innocent until proven guilty," since in many cases conceptual models of spatial database error simply do not exist. It is suggested that until that situation improves, "uncertainty" offers a more appropriate means of describing such lack of proof. This does not mean that uncertainty should always be substituted for error, as there already exist several well-established and accepted error models for given spatial operations. They are properly described as such, however in situations where there is little knowledge of the actual errors involved—as in the case study described—it is uncertainty which will be referred to by the authors.

One of the largest sources of uncertainty in spatial databases is a byproduct of the process of cartographic generalization. For example, a map may show an area as having a uniform land cover class, even though it is known that the land-cover class in the area is not in fact uniform. This leaves the user of the database uncertain as to the actual land-cover class to be found at a specific point within the area. A very naive user who is unaware of the nature of cartographic generalization might see such a difference between database contents and ground truth as error.

At this time, there are three options available (Goodchild, Lin, and Leung 1993) for dealing with uncertainty in spatial databases, and communicating such information to users, viz.:

1. omit all reference to it,
2. attach some form of descriptor to the output,
3. show samples from the range of possible maps.

The first option ("do nothing" approach) treats the problem by ignoring it; undoubtedly the easiest solution to adopt, but one which potentially places at risk the reputations of decision-makers (and their agencies) who have to act on the basis of such information. The second option would see the use of descriptors such as epsilon bands, misclassification matrices, reliability diagrams, and root mean-square error estimates. In effect, these are a caveat to users and while they give warnings about product uncertainty, they provide little assistance in showing how the resultant output might vary spatially. Although, with further development they can be more usefully interpreted, as Hunter and Goodchild (1995a) have shown in the case of the root mean-square error estimate for digital elevation models (DEMs). Finally, different versions of the same map might be presented to users to illustrate the uncertainty to which their products are subject due to the particular combination of data, error estimates, algorithms and process models which have been chosen for the task.

This latter approach is the one preferred by the authors, since it would appear to have the greatest potential benefit in both communicating uncertainty and at the same time educating the user community in the significance of this issue. Accordingly, this paper presents a methodology which permits uncertainty reporting for certain types of spatial database products. By presenting the level of uncertainty which resides in an output, such a methodology might assist agencies in determining the degree of uncertainty they are willing to tolerate before it either changes the decisions made on the basis of that information, or else (in the worst case) causes the benefits of spatial database usage to be lost. In the reverse role, the methodology could provide advance testing of different combinations of data, error estimates, algorithms and models to assess which ones are most likely to suit a user's needs.

At this stage, the methodology is restricted to the study of grid-cell data and, specifically, the outputs derived from the use of DEMs; however, even in this limited role it has considerable relevance to natural resource and environmental applications where the raster data model has greater suitability for representing inherently continuous variation. In addition, the raster model more easily accommodates simulation techniques such as those used in this research. The paper discusses:

1. the underlying model of uncertainty employed,
2. its potential applications,
3. how the model can be integrated into an overall methodology to handle uncertainty, and finally
4. a case study of its use relating to the adjustment of remotely sensed data for topographic effects, as applied to the detection of burnt land in mountainous areas of central Portugal.

The Underlying Model of Uncertainty

The basis of the approach is a model of the uncertainty present in a spatial database. While the database may indicate that a point has some characteristic value, such as its elevation or land cover class, in general it is clear that the value recorded in the database may not be the true value. The amount of uncertainty is sometimes known—for example, producers of DEMs often publish estimates of root mean square error, and producers of
land cover maps may provide information on misclassification probabilities. In such cases it is possible to model uncertainty and its effects by introducing random variation. Where the amount of uncertainty is unknown, it is possible to introduce different amounts of random variation to explore their effects. However, the spatial nature of the data requires that the random variation be spatially autocorrelated, and thus demands the use of specialized techniques.

An error model can be defined as a mechanism for introducing random variation in order to represent error or uncertainty. Any one execution of the mechanism creates one pattern of distortion, and thus one sample from a population of possible patterns of distortion. The term for such a single execution of the mechanism is a 'realization' of the error model. One realization might represent the errors introduced by one person's effort to digitize a map, or the uncertainty generated by one cartographer's generalization. A sample of realizations might represent the variability due to different foresters' interpretations of the same aerial photograph. When several realizations are displayed rather than a single map, the effect is to convey a sense of uncertainty. In addition, realizations can be used to investigate the effects of uncertainty on the results of GIS analysis due to error propagation. One error model for categorical spatial data has been described by Goodchild, Sun and Yang (1992).

The traditional Gaussian model (where the standard deviation is a measure of error or uncertainty) is useful for modeling variation in single measurements, but cannot be used to deal with the spatial case where errors display strongly correlated patterns. The error at one point in a DEM, for example, is likely to be strongly correlated with errors at neighboring points. In a previous paper, Hunter and Goodchild (1995b) argued that while it is possible to perturb a data set according to an error descriptor (such as an RMSE value for a DEM) without consideration of spatial autocorrelation between point sample elevations, the process may be stochastic but nevertheless lacks 'truthfulness'—since adjacent elevations can be severely distorted creating large pits and peaks which do not intuitively occur at the resolution of a 30m × 30m grid. This approach produces what are known as 'random maps'.

On the other hand, assumption of complete spatial dependence between neighboring points produces realizations of the DEM which are "truthful" but not stochastic, since elevations are constrained to maintain their relative differences to each other and the introduction of a noise value has the effect of moving all DEM elevations up or down by a constant amount. Hence, there is a need to find the appropriate pattern of spatial dependence for any particular application. For the model used in this paper, and by Goodchild, Sun and Yang (1992), spatial dependence is described by a single parameter $r$ in the range $0 < r < 0.25$, which meets the dual requirements of being stochastic as well as "truthful." The limit of 0.25 arises because a raster is used, and spatial dependence is defined by the relationship between a cell's value and those of the four neighbors with which it shares a common edge (Cliff and Ord 1981, p. 147). This is perhaps the simplest possible model of spatial dependence. If additional information were available about the actual spatial dependence between errors in a given application, this simple model could be replaced by a more accurate version.

By producing distorted versions of the DEM for different $r$ values, and by studying the change in differences between the realized data and the original DEM, it is possible to make reasonable deductions as to what the appropriate $r$ values may be, or at least to place limits on the range, and to gain insight into the effects of various levels of spatial dependence on the outcomes of GIS analysis. Hunter and Goodchild (1995b) derived separate realizations of slope gradient and aspect values from a DEM with the latter, in particular, showing a marked change in response at approximately $r = 0.24$, while slope gradient only started to vary significantly from $r = 0.20$ onwards.

Of course, the realization process need not stop there, as the different slope gradient and aspect maps can be input to, say, hydrologic models to produce alternative realizations of drainage basin parameters, which in turn can be used to derive realized runoff characteristics. At any stage, the differences between the realized maps and the original (as produced from the source data without any consideration of uncertainty) can be analyzed to assess the resultant effects. The attractiveness of this approach is that even though we do not know how error is being propagated, its effects are nevertheless displayed.

A Methodology to Handle Uncertainty

The methodology to handle uncertainty embodies the model previously described (Figure 1). It consists of four steps, with the first one requiring the user to combine whatever data, processes and models are needed to generate the desired output-in other words, applying the spatial database as would normally be done without any consideration of uncertainty. From the beginning of the procedure, a log or watch file is kept of the commands used which will later be applied in producing the realizations.

In the second step, the parameters necessary for the realization process are determined. By reading system variables associated with the source data file, the num-
number of rows and columns in the data file, the cell size, and the geo-referencing details of the data can be ascertained. These will be required later when the noise files are to be transformed to agree with the actual data sets used. An error estimate for the source data will also need to be identified, and this can take the form of either a global value for the file, or else a separate field in the database which may be subject to spatial variation.

At this stage, the watch file of commands may need to be edited by the user to include only those which were finally applied in the procedure. Any constraints applied during processing will also be embedded in this file, such as in a viewshed computation where cells immediately surrounding the viewing point are usually masked out or held fixed (and therefore assumed to be always seen) so that their elevations are not perturbed, thereby possibly obscuring large areas of the viewshed.

While not a direct step in the realization procedure as such, the noise files to be employed would usually be previously computed and then permanently stored in the system for future use. The way in which they are generated has already been described by Hunter and Goodchild (1995b). To date, it has been considered sufficient for most applications tested for about ten files to be held for each \( \rho \) value, although users would have the option of creating a greater number of noise files for specific tasks in the final module of the methodology. The default \( \rho \) values chosen for the noise files are 0.0, 0.05, 0.10, 0.15, 0.20, 0.21, 0.22, 0.23, 0.24, 0.245, and 0.249.

Again, the user has the option of producing noise files with other \( \rho \) levels in the final module. As for the maximum value of \( \rho \) offered (0.249), experience has shown there is little to be gained from using \( \rho \) values higher than this since the realization process becomes so constrained that there is no discernible difference between the realized maps and the original product. In Step 3 of the methodology, it is expected that users will want to see a small number of initial trial realizations and the default range of \( \rho \) values listed above is applied. A single realization for each value is performed by first applying the parameters derived from Step 2 to georeference and transform the coordinates of the noise grid. Next, the error estimate (usually an RMSE for DEMs) is applied to map the noise values from a Normal distribution of \( N(0,1) \) to \( N(0,\text{RMSE}) \). This adjusted noise file is added to the source data to produce a realization to which the commands employed to create the original database product are applied. The realized maps and
the differences between the realizations and the original outputs can be displayed in map or graph form.

Finally, in Step 4 of the procedure the user may choose one or more approaches for more detailed investigation of product uncertainty, as discussed in the previous section, and with a greater variety of reporting output products available.

A Case Study in Assessing Uncertainty

The case study to be discussed relates to mapping areas burnt by forest fires through the use of remotely sensed Thematic Mapper (TM) imagery. In rugged areas in particular, many researchers have reported the problem of confusion between shadowed and burnt regions as they both appear the same in most of the bands. Similarly, if terrain corrections are not applied, it is difficult to discriminate between differing degrees of fire severity since a given area may seem darker not because the fire was more intense, but because it lies on a slope that receives less light by area unit.

Traditionally, DEMs have not been used as part of the assessment for fire severity mapping, but research at the University of California, Santa Barbara, is underway to determine how consideration of topographic effects on the satellite signal may be used to counter this problem, which requires a radiance model to be applied to correct (or normalize) the radiance data for terrain differences (Caetano 1993, personal communication). Normalized radiance values are already commonly used in other applications of remote sensing in mountainous areas, and once derived may be used with traditional image-analysis techniques such as supervised and unsupervised image classification, and density slicing.

The test site lies in central Portugal near Pampilhosa da Serra, and a DEM with a cell size of 30m x 30m was used as the basis for normalization of the TM imagery. Figure 2a shows a hill-shaded view of the DEM covering the test site, while the same area is also delineated on the unclassified TM Band 4 scene in Figure 2b in which the effects of fire clearly show in the middle of the image as regions of dark gray/black color. The portion of the DEM used for this research measures 353 rows by 272 columns (or about 10.6 km by 8.2 km), with elevations ranging from 287m to 1020m. Unlike DEM data supplied by the U.S. Geological Survey, an estimate of the elevation error for the DEM is not available, and so on the advice of researchers familiar with the Portuguese digital mapping program the standard deviation for elevation error has been estimated to be 10m.

The traditional procedure used by image analysts is to calculate the slope gradient and aspect for each cell in the DEM and then combine them with the sun’s zenith and azimuth angles at the time of image capture (taken
from the file header or else calculated for the time of day and the latitude and longitude of the site). This information is used to compute the cosine of the incidence angle, which has values in the range -1.0 to +1.0. Thus, a cell with an aspect equal and opposite to the sun’s azimuth (in other words, facing the sun), and a gradient equal to the sun’s zenith angle (that is, perpendicular to the sun’s rays), will receive the maximum amount of radiance and have an incidence angle of 0° with a cosine of +1.0. The formula for the cosine of the incidence angle is given by Equation 1:

\[
\cos(i) = \cos(\text{sun zenith}) \times \cos(\text{cell gradient}) + \sin(\text{sun zenith}) \times \sin(\text{cell gradient}) \times \cos(\text{sun azimuth-cell aspect})
\]

(1)

Cells which have an incidence angle cosine equal to or less than zero either lie in a plane parallel to the direction of the sun’s rays or else are on reverse hill slopes (Figure 3). These cells are deemed to be in ‘self shadow’ and are not operated on in the traditional research procedure due to the difficulty of working with diffused light. There is a further process which identifies cells that are in ‘cast shadow’ from larger features which obscure them from direct sunlight, and these cells also are usually excluded from further calculations.

The incidence angle cosines for all cells in the DEM are then used as a means of normalizing the radiance values of pixels in the TM image, given that radiance is affected by the nature of the terrain to which it applies. At this point it should be noted that corrections will have already been made to ensure that both the DEM and the TM images have the same georeferencing and cell/pixel size. The radiance values, being the raw signals from the image in the range 0 to 255, are then normalized by computing the value they would have if each pixel was horizontal, as in Equation 2:

\[
L_{\text{rel}} = \frac{L}{\cos(i)}
\]

where \(L\) denotes the radiance value, and \(L_{\text{rel}}\) is the normalized radiance value.

Having discussed the analysis’s traditional procedures for deriving normalized radiances values for each pixel, it is clear there is considerable potential for applying the realization methodology to assess the uncertainty present in the final output, which would include any effects arising from the DEM elevation error, the algorithms used to calculate slope gradient and aspect, and the formulae applied to determine the incidence angle cosines and the normalized radiance value. In this example we focus on dealing with the uncertainty associated with normalization, since that was the primary concern of the researcher conducting the major study; however, there is no reason why the process outlined here could not continue through to the next stage of analysis of the effects of uncertainty on fire-severity modeling.

The difference between the traditional approach to calculating the terrain-corrected \(L_{\text{HI}}\) values and the proposed approach permits their uncertainty to be assessed (Figure 4). The latter technique applies elevation noise files, with varying levels of spatial autocorrelation, to the original DEM to establish corresponding sets of slope gradient and aspect files for the test site. Pairs of gradient and aspect realization files (for each given \(\rho\) value) are then taken in turn and used to calculate the corresponding incidence angle cosine file, which is applied to the original TM radiance file (\(L\)) used for the analysis. The process results in the creation of a family of realized \(L_{\text{HI}}\) files whose outputs can then be analyzed. The entire process was automated by using a macro command script and applied using the ARC GRID software (ESRI 1992).

The adopted procedure resulted in a set of 10 realized \(L_{\text{HI}}\) files for each of the \(\rho\) values 0.0, 0.05, 0.10, 0.15, 0.20, 0.21, 0.22, 0.23, 0.24 and 0.245. For the purpose of analysis, the 96,016 grid cells in every realized file were subtracted from their corresponding cells in the original \(L_{\text{HI}}\) file to provide a “difference” file. This difference represents the amount by which the final \(L_{\text{HI}}\) value might be expected to vary under terms of uncertainty due to variation in the elevations of the original DEM and the subsequent series of spatial operations that were performed on the data.

The mean and standard deviations of each set of 10 difference files were then calculated for the range of \(\rho\) values applied. The results are shown in Figures 5a and 5b, with a gradual increase noticeable in the mean and standard deviation of the differences as \(\rho\) varies from 0 to 0.20, followed by sudden decreases as \(\rho\) approaches 0.25. Figures 5a and 5b therefore represent the results of 96,016 x 10 x 10 (or 9,601,600) individual calculations.

At this stage, analysis of the results shows that the average greatest difference that might be expected in \(L_{\text{HI}}\) values is about 2.5 units with a standard deviation of

**FIGURE 3.** Variation in the incidence angle (i) with cell position.
approximately 13 units. These extremes occur around $\rho = 0.20$. However while such global statistics are useful in their own right, they say nothing about the spatial variation of the differences and, accordingly, further analysis was made of the realizations made at $\rho = 0.20$.

Taking the 10 realized $L_{41}$ difference files at $\rho = 0.20$, a composite file was calculated and displayed such that cells with an $L_{41}$ difference within $\pm 2$ standard deviations of the overall mean for the file were shaded as gray color, while cells with an $L_{41}$ difference greater than $\pm 2$ standard deviations were shaded as white and black color respectively. The result is shown in Figure 6a where it can be seen that the white and black cells, representing outlying values or those most susceptible to the spatial operations applied, tend to occur on west-facing slopes of north-south ridgelines when compared with a hill-shaded view of the test site DEM with contours overlaid at an interval of 100m (Figure 6c).
The file used in Figure 6a was then hill-shaded from the northeast to communicate both the size and spatial variation of the differences, and cell values beyond the ±2 standard deviation threshold show as a highly disturbed pattern while cells with differences within the threshold display as relatively smooth gray color (Figure 6b). One site in particular, in the top northeast corner of the image contains a significant $L_{II}$ difference witnessed by its long shadow extending to the southwest. Given that this file represents the mean difference value occurring after 10 independent realizations, there is the suggestion of either an anomalous DEM elevation or TM radiance value present which warrants closer inspection of the original data.

Having illustrated the spatial variation in the uncertainty of the $L_{II}$ values, further explanation was sought.

FIGURE 6a. Showing the mean $L_{II}$ difference file after 10 realizations at $\rho = 0.20$, with cells below and above the ±2 standard deviation threshold shown as black and white color respectively.
as to the reason for the apparent correlation between significant differences in $L_{41}$ and west-facing slopes. This can be explained by the location of the sun at the time of the TM image capture, which was at an azimuth of 117° and a zenith angle of 36° (during the middle of the northern hemisphere summer). From this position, the pixels in shadow are clearly affected the most, which confirms the problems encountered when working with pixels in diffused light. It was for this reason that cells found to be in shadow (and thus having an incidence angle cosine < 0) were not removed from the realization process, but instead deliberately retained to demonstrate any likely susceptibility to variation. Thus, the masking of such pixels during traditional analysis may be considered a valid approach to the problem.

At the same time, it was seen that for the remainder of the image the greatest mean difference in $L_{41}$ that might be expected is about 2.5 units with a standard deviation of some 13 units. It is left to the user of the data to decide whether this variation is acceptable for the task at hand, and this assessment of product quality (or fitness for use) forms part of the management approach which needs to be adopted in such cases. If the variation is acceptable, then the methodology proposed has confirmed that the particular combination of DEM and TM imagery; the algorithms for gradient, aspect and incidence angle cosine; and the model for terrain correction of the $L_{41}$ value are suitable for the purpose intended.

On the other hand, if these differences are unacceptable then uncertainty reduction methods will need to be employed, such as:

- choosing more accurate DEM data;
- selecting alternative algorithms and models;
- taking certain areas shown to be most susceptible to the effects of uncertainty out of the analysis; or
- employing TM imagery from other epochs.

To this end, the realization process may be repeated using different combinations of data, algorithms, and models to determine which one produces the least uncertainty in the final product. At the time of writing, work is already underway using external funding to develop a simple software toolbox which will embody the procedures described, in order that users may more easily automate the modeling and analysis procedures applied in this research.

Potential Applications of the Model

The potential applications of the model lie in four areas. First, the realization process may be used to highlight areas of a map that are susceptible to changes in parameter values. For instance, Hunter and Goodchild (1995b) demonstrated that the calculation of slope aspect from a DEM was particularly susceptible to variation in terrain elevation in relatively flat regions, while large hillside slopes remained relatively stable. While such a conclusion is already fairly well established, this may not always be necessarily so; where complex process models are applied, their effects may still be largely unknown. In other applications, the observed differences might be used as input to subsequent sensitivity analysis to understand how changes in parameters impact upon the decision-making process, such as in land use suitability and capability studies.

Secondly, the technique can be useful in cases where differences per se are not as important as assessing the likelihood of a cell's membership of a particular class. An example of this can be found in viewshed computations where cells are computed as being either seen or not seen from a viewing point, and similar requirements may be made in calculating the extent of drainage basins. Sets of realizations taken at different $p$ values can be added to compute a “score” for each cell (together with a mean and standard deviation), which in turn may be used to calculate the probability of a cell satisfying the criteria associated with the operation, thereby overcoming the “in or out” Boolean responses normally associated with spatial databases. Users can thus nominate a confidence level to be met when assessing the re-
sults of the process. Hence, cells must have a 90 percent probability of being seen).

Another example occurs in soil classification which is often dependent in part upon slope-gradient estimates, in which realizations of a soil map can be produced based upon previous realizations of the slope-gradient map, enabling users to select cells on the basis of having a given probability of belonging to a defined gradient range. At the same time, cell class counts (and therefore area estimates) may be made for a set of realized maps with the mean and standard deviation of the area being reported to users.

Thirdly, a user might want to display several realizations of a map to understand the degree of variation associated with the processes involved. For example, instead of interpolating contours from a DEM just once, several realizations might be made to assess not only the impact of elevation uncertainty on the process, but also the variation due to the interpolation procedure itself. This could also be applied to other raster-to-vector conversion procedures when class polygons or linear features such as stream patterns are required, thus producing a family of possible boundaries or linear features.

Finally, simulations can be undertaken to study the effect on map products where competing data sets, error estimates, algorithms, and process models are available. This 'reverse engineering' approach might also be applied by users who, having already studied several possible realizations of a desired map, and having identified areas exhibiting levels of uncertainty considered unacceptable, wish to see how different uncertainty reduction options (for example, recollecting data at a higher accuracy) would affect the final outcome—before returning to the field site or purchasing alternative data sets.

Conclusions

In this paper the authors have presented a methodology that allows uncertainty to be reported for certain types of spatial database products. The work recognizes the critical need for tools to be developed to assist users in improving their understanding of the quality of the outputs from their systems. The methodology has been applied to communicate the uncertainty associated with using digital elevation models to correct remotely sensed imagery for terrain effects when assessing mountainous areas burnt by fire in central Portugal. The results of the study show that given the particular combination of DEM data, algorithms, models and imagery employed, the normalized radiance values of pixels in some locations are highly susceptible to variation in the input parameters. As such, the procedures that have been applied permit users to study the uncertainty associated with the analysis, identify where its effects are most severe, study its impacts on the final spatial database product derived, and offer the opportunity for alternative data and algorithms to be tested to determine which combinations yield uncertainty levels that are acceptable for the task at hand. We believe the result will be an analysis that is better informed with respect to the effects of uncertainty. On the other hand, we cannot avoid the need to involve the user in any ultimate decision about whether the analysis meets its objectives—in that sense the technique remains partially subjective.

While the basis of the approach lies in statistical error modeling, the results can be visualized readily within a GIS, and the paper has demonstrated techniques that can be employed by users lacking any great depth of statistical knowledge or training. In this sense, the visual, intuitive nature of GIS analysis and modeling holds the key to novel, practical approaches to the management of uncertainty in spatial data. The methodology outlined in Figure 1 can be implemented in many existing GISs using scripting or macro languages, hiding most of the computation from the user, and exploiting visual techniques for eliciting the key information needed to implement the model.

On the other hand, the basis of the technique is complex and it will probably never be possible to package them in a form that is fully understandable by all GIS users, given the diversity of backgrounds common in this field. For that reason we suggest that the toolbox containing these techniques be operated by the analysts in an organization who can in turn feed the results to users. Readers interested in obtaining the toolbox and an associated tutorial manual should contact the first author.

Acknowledgments

The authors gratefully acknowledge the support received for this research from the Australian Key Center for Land Information Studies (AKCLIS), and the National Center for Geographic Information and Analysis (NCGIA). The NCGIA is supported by the National Science Foundation, Grant 89-10917 and this research constitutes part of the Center's Research Initiative 7 on Visualization of the Quality of Spatial Data.

References


Justifying Automated Mapping Systems
In Small Communities

Colin O. Benjamin and Adel Fadel

Abstract: In this paper, we describe a methodology for evaluating capital investment in automated mapping (AM) systems in small communities. A microcomputer-based spreadsheet model used to conduct traditional financial and economic analysis incorporates considerations of risk and uncertainty via sensitivity analysis and Monte Carlo simulation. Also, a multi-criteria decision model using the Analytic Hierarchy Process (AHP) is used to consider qualitative benefits and assess their impact on the investment decision. Field validation was done using small communities in the United States as case studies. The methodology received favorable evaluations from practicing city engineers and academicians.

In February 1988, the National Council on Public Works Construction released its final report to the President and the Congress, entitled, “Fragile Foundations: A Report on America’s Public Works.” In this report, the Council strongly encouraged all levels of government to upgrade the quality and quantity of basic public works management information so as to measure and improve system performance (NCPWI 1988). In large cities, such as Anchorage, Alaska (Mann 1987), Miami, Florida (Roddy 1988), and Seattle, Washington (Haley 1987), automated mapping/facility management (AM/FM) systems have proven to be cost effective in meeting the information needs for good infrastructure management. The payback period for an AM/FM project is generally three to 10 years and is influenced by factors such as the amount and methods of data capture, computer hardware and software used, the degree of accuracy required, and source documents used (Chenoweth 1987).

The demand on small cities to maintain quality infrastructure and services is no less than that on large cities. In the United States, small cities own and operate nearly 85 percent of all public works systems (Tomaselli 1988) and face a more difficult task since they typically have a smaller tax base. Although there are several references to AM technology being applied to small communities (Ismail 1990; McCravy 1990; Tomaselli 1988; Klein 1987) with population less than 10,000, the justification for acquiring AM systems is not clear. In this paper, we describe the development and testing of a methodology to facilitate the systematic evaluation of investments in AM systems to improve infrastructure management in small cities.

Applications of AM/FM/GIS Systems
Technologies such as computer-aided drafting (CAD), geographic information systems (GIS), and automated mapping/facility management AM/FM (McCravy 1990), which store, draw, manipulate, analyze, or capture information, can be used by small communities to better manage their infrastructure. The need for these systems and their various applications have been heavily researched in recent years [Moreno and Heyendahl 1992; Robison 1988; Cowen and Shirai 1989; Miller 1988; Cowen, Mitchell, and Meyer 1989; Eichelberger 1988; and White 1989]. In a marketing survey of GIS users, Hanigan (1990) grouped applications into nine general areas:

- Geographic Data Collection
- Facility and Asset Inventory
- Map and Chart Publishing
- Resource Allocation

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• Simple Network Analysis
• Complex Network Analysis
• Site Location Planning
• Sub-Surface and Surface Assessment
• Tracking and Monitoring.

All communities have needs in these areas and can fulfill them using either manual or automated techniques. Laudon and Laudon (1988) assume that all organizations, including small municipalities, perform the same basic functions and therefore have the same basic needs. Some applications by small communities of AM/FM/GIS systems include infrastructure management, city planning and emergency services.

AM/FM/GIS Justification

Although several researchers (Diaz 1986) report on the justification of new technology projects and GIS projects (Korte 1991; Aho 1989; Reeve and Smith 1986; Devine and Field 1986; Allen 1986; Silbovitz and Jolls 1989), few articles deal specifically with the justification of AM Systems. Lamie and Wang (1991) use the water and sewerage districts at the city of Auburn, Maine as an example of how water and sewer agencies can leverage their investment in AM/FM/GIS systems. They concluded that the district found that to leverage its investment in automated mapping, the most attractive solution was an integrated system which could provide automated mapping, database management, and facilities management capabilities.

Berger (1989) discussed the cost and benefits of AM/FM projects. He mentioned that while the cost side of the cost-benefit equation was very real, the savings side needed more investigation. To accomplish this, the author surveyed 20 electric and gas utilities users of AM/FM systems. The results of the survey identified four general categories of benefits/savings:

1. Reducing staff
2. Improving functional performance
3. Considering the intangible benefits
4. Part of doing business (to improve efficiency and remain competitive)

In the Joint Nordic Project (1987), a study that focused on GIS applications in large Canadian cities, it was reported that a system used only for mapping would yield a benefit-cost ratio (BCR) of 1:1. However, for cities with populations of 90,000 and above, a typical GIS investment would realize a BCR of 4:1. However, the literature contains few references of the technology being applied to small communities (pop. less than 10,000). Tomaselli (1988) reported on developing a low-cost microcomputer GIS for planning in Anoka, Minnesota with a population of 16,000 people. Klein (1987) used a PC-based CAD system to establish an automated mapping/facility management system for Mill Valley, California with a population of 13,000 people.

One problem facing small communities is the absence of a replicable methodology to justify the purchase of hardware and software required for AM Systems. Benefits are often difficult to identify and to quantify in monetary terms. Shoval and Lugasi (1987), in discussing the evaluation of computer systems, highlighted the problem of measuring the nonquantifiable benefits, and suggested the use of multicriteria techniques. Many alternative approaches have been proposed in the literature to assess the risks associated with investment in new technologies. These include sensitivity analysis, risk-adjusted discount rate (RADR), decision analysis, simulation, analytic hierarchy process (AHP), expert systems (ES), and artificial neural networks (ANN). The literature also suggests the use of a spreadsheet program to model cash flows in new technology projects, to input the probability estimates into the model to incorporate the range of risks involved and determine the effect of such assumptions on the return of the project (Hundy and Hamblin 1988; Kexel 1988).

However, for AM projects, the evaluation needs to be extended to incorporate the assessment of intangible benefits. The analytic hierarchy process (AHP) (Saaty 1982) can be used to provide a flexible, generalizable, and structured framework for quantifying these intangible benefits.

In this research program, a framework will be developed to enable the comprehensive analysis and evaluation of a proposed investment in an automated mapping system in a small community. The framework will integrate a simple spreadsheet-based economic model, a Monte Carlo Simulation extension to incorporate considerations of risk and uncertainty, and a multi-criteria decision model utilizing the analytic hierarchy process to permit examination of the intangible benefits.

Proposed Methodology

The methodology proposed for the economic evaluation of AM systems in small communities is outlined in Figure 1. The most important steps in the proposed systematic procedure are:

- Identify all costs and tangible benefits.
- Conduct financial analysis and sensitivity analysis to obtain the financial indices.
- Conduct a simulation analysis to consider risk and uncertainty associated with the cash-flow variations.
- Consider the intangible benefits and use the analytic hierarchy process (AHP) to quantify these benefits in dollar values.
- Repeat financial analysis, sensitivity analysis, and simulation analysis using dollar values of the intangible benefits obtained from the previous step.
FIGURE 1. Framework for small communities to evaluate prospective capital investment in an AM/FM/GIS system.
TABLE 1. Classification of Cases Included in Study

<table>
<thead>
<tr>
<th>Development Approach</th>
<th>Population Density (Person/Acre)</th>
<th>Cuba, Missouri</th>
<th>Plattsburg, Missouri</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-House Development</td>
<td>Low &lt;1.0 0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Consultant</td>
<td>Medium (1.0 → 2) 1.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High &gt;2.0 2.59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Make final decision based on the results of the previous steps.

A spreadsheet model will be used to compute economic indices such as the net present value (NPV), internal rate of return (IRR), benefit-cost ratio (BCR), and payback period (Newnan 1991). Simulation analysis will be used at the second stage of evaluation to consider the risk and uncertainty associated with the variations in the cash flow estimates. The inputs to the simulation analysis are probabilistic values for each cost and benefit element and the outputs are the expected net present value and the probability of negative and positive results. If the economic indices are positive and the degree of risk is acceptable to the decision-maker, then the process is completed and no further analysis would be required. On the other hand, if the financial indices are negative or the degree of risk is unacceptable to the decision-maker, then the AHP would be used to assign monetary values to the intangible benefits. These monetary values will then be used as input to the spreadsheet model and the process repeated to compute new economic indices. The AHP methodology would typically proceed as follows (Saaty 1982):

- Define the problem.
- Decompose the problem into a hierarchical structure.
- Construct a questionnaire comprised of pair-wise comparison matrices using a scale 1 through 9.
- Administer the questionnaire to elicit expert judgment.
- Analyze the data obtained in the previous step using the expert choice software.
- Determine the group rankings using the geometric mean.

This approach involves spiral cycles of interaction between the creation and the evaluation of the methodology by its application to real-life cases.

An action research approach was used with multiple-cases to determine whether the proposed framework methodology was effective and could be generalized. Based on the experience and insights derived from the application of the methodology to one case, refinements were made to the methodology before applying it to another case.

Three small, midwest communities in the state of Missouri—Cuba, Plattsburg and Branson—were selected as cases for this study according to (1) city area per person, and (2) whether the system (map automation) would be done in-house or by an external consultant. Table 1 shows the case classifications. Figure 2 shows these three cases superimposed on the action research cycle. Brief outlines of the three community profiles are summarized in Table 2.

Results

A microcomputer-based economic model was developed to incorporate all monetary costs and benefits. Details of the general model are summarized in Appendix A and the analysis for the city of Cuba described in Appendices B and C. The Lotus 123 spreadsheet was used and the financial indices were computed. The results of the financial analysis for each city are summarized in Table 3. If the financial indices are negative, the analysis is extended to incorporate qualitative benefits using the AHP technique to assign relative monetary values to the intangible benefits. The hierarchy of benefits of the proposed AM system was developed after extensive consultation with industry experts (Figure 3). Table 4 summarizes the responses provided by four industry experts to a questionnaire administered to ascertain the relative significance of the various groups of benefits associated with the introduction of AM systems in small communities.
Although there was some divergence among the subjective judgments provided by the four experts, their responses show a high degree of consistency. The inconsistency ratio provides a measure of the violation of numerical and transitive consistency (Saaty and Kearns 1985). In this case, the inconsistency ratios were all less than 0.1. The subjective judgments of the four experts were therefore considered acceptable, and the geometric mean used to consolidate these responses.

Based on the forecast value of savings of printing new maps and in updating maps, and on the relative significance assigned to each group of benefits, monetary values for the qualitative savings were estimated as follows:

Example: Case # 3—Branson.

Savings in printing new maps = $21,934/year
The relative significance of the benefits associated with printing maps = 0.116
The relative significance of the benefits associated with locating and repairing facilities = 0.125
Estimated monetary value of benefits associated with locating and repairing facilities =

\[
\frac{21,934 \times 0.125}{0.116} = 23,636\text{ /year}
\]

Estimates for monetary values for other groups of qualitative benefits were obtained using the same procedure. This information was used as input to the financial spreadsheet model developed for Branson. The financial analysis can then be revised to incorporate those intangible benefits. The sensitivity analysis and risk analyses are also revised. These revised results for the city of Branson are summarized in Table 3.

Discussion of Results

The results obtained by applying the model to the cities of Cuba, Plattsburg and Branson are summarized in Table 3. In the first case, the city of Cuba acquired a low-cost system. No training costs or consulting fees were involved. The whole process was performed by the Director of Public Works, an expert in the field. As a result, all economic indicators are positive; the payback period and the discounted payback period are less than two years, and the IRR is more than 36 percent.

The sensitivity analysis as shown in the spiderplot (Eschenbach 1992) in Figure 4 indicates that the financial indices are highly sensitive to changes in the number of maps, and the conversion cost saved, moderately sensitive to new and updated map time saved, and insensitive to discount rate. Also, the sensitivity analysis shows that the NPV is negative if the number of maps is less than 12. The simulation analysis, shows an expected mean NPV of $4176 with a standard deviation of $435 as against an NPV of $9319 obtained in the case of the deterministic model. The probability of negative results was insignificant indicating a minimal investment risk. Thus, in the case of Cuba, an AM system represented a cost-effective method of maintaining and mapping public works facilities.

In the second case, the city of Plattsburg did not purchase hardware or software systems. Instead, the city contracted the automation process to an external consultant. The area of the city is 1.5 square miles as against
### TABLE 2. Community Profiles

#### City Profile: Cuba, Missouri

<table>
<thead>
<tr>
<th>Population</th>
<th>Area (Acres)</th>
<th>Number of Utilities to Map</th>
<th>System Specifications</th>
<th>Consulting Fee $</th>
<th>Training Cost ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2700</td>
<td>2560</td>
<td>Two (water and sewer)</td>
<td>IBM 386/33 Computer</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Digitizing Tablet (24-36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>printer/plotter</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Cost $10000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The system is used 50%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>of the time for mapping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### City Profile: Plattsburg, Missouri

<table>
<thead>
<tr>
<th>Population</th>
<th>Area (Acres)</th>
<th>Number of Utilities to Map</th>
<th>System Specifications</th>
<th>Consulting Fee $</th>
<th>Training Cost ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2488</td>
<td>960</td>
<td>Three (water, sewer and gas)</td>
<td>N/A</td>
<td>5292</td>
<td>N/A</td>
</tr>
</tbody>
</table>

#### City Profile: Branson, Missouri

<table>
<thead>
<tr>
<th>Population</th>
<th>Area (Acres)</th>
<th>Number of Utilities to Map</th>
<th>System Specifications</th>
<th>Consulting Fee $</th>
<th>Training Cost ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3700 and approx. daily tourists of 50000 in summer</td>
<td>6400</td>
<td>Three (water, sewer and gas)</td>
<td>Apple Mac II Cost $4000 is used 100% of the time for mapping</td>
<td>100,000</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ComGrafix Cost $5000</td>
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<td></td>
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<td>FoxBase Cost $5000</td>
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<td>Apple Mac II Cost $6000 is used 10% of the time for mapping</td>
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<td>ComGrafix</td>
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<td>FoxBase</td>
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<td></td>
<td>Cost $5000</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Apple Mac II Cost $4000 is used 10% of the time for mapping</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

four square miles in the case of Cuba; the number of maps was eight compared with 20 maps in the case of Cuba. The contract was valued at $5,292 for the conversion process, and the cost of updating any map was $10 per map. It was expected that no more than three maps would need updating every year according to the city’s Director of Public Works. As a result, all economic indicators were positive. The payback period was less than three years while the IRR was more than 20 percent.

The sensitivity analysis showed results similar to those obtained for Cuba. The NPV is negative if the number of maps is six or less. Also the NPV is negative if the conversion cost saved is $12 per hr. or less. The simulation analysis, showed an expected NPV of $1,542.
TABLE 3. Summary of Financial Indices for the Three Cities

<table>
<thead>
<tr>
<th>Financial Indices</th>
<th>Payback Period (Years)</th>
<th>Discounted Payback Period (Years)</th>
<th>Net Present Value ($ (i=10%))</th>
<th>Internal Rate of Return (%)</th>
<th>Benefit/Cost Ratio (i=10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuba</td>
<td>1.62</td>
<td>1.92</td>
<td>9,319</td>
<td>36.28</td>
<td>1.77</td>
</tr>
<tr>
<td>Plattsburg</td>
<td>2.64</td>
<td>3.32</td>
<td>1,768</td>
<td>24</td>
<td>1.32</td>
</tr>
<tr>
<td>Branson</td>
<td>8.74</td>
<td>14.45</td>
<td>-54,222</td>
<td>-23.84</td>
<td>0.5</td>
</tr>
<tr>
<td>Branson</td>
<td>0.32</td>
<td>0.35</td>
<td>232,851</td>
<td>374</td>
<td>3.2</td>
</tr>
</tbody>
</table>

with a standard deviation of $142, as compared with $1768 in the case of the deterministic model.

The third case examined Branson, a tourism-centered city. Approximately 50,000 tourists visit Branson daily during the summer. The city is expanding very quickly, so city officials decided to use an automated mapping system to better manage the infrastructure. The city paid $100,000 as consulting fees in addition to the purchase of a relatively expensive system. Because of the higher development costs, the financial indices were negative. When the intangible benefits were evaluated using the analytic hierarchy process (AHP) procedure

FIGURE 3. The benefits hierarchy of using an AM system.

MISSION

Benefits from AM Systems

OBJECTIVES

Printing/Plotting
Record Keeping
Record Search
Locating & Repairing Facilities

CRITERIA

Cost Reduction
Accuracy
Capability
Mgmt. Planning & Control
TABLE 4. Judgement on the relative significance of groups of AM Benefits

<table>
<thead>
<tr>
<th>Automated Mapping Benefit</th>
<th>Inconsistency Ratio</th>
<th>Printing/Plotting</th>
<th>Record Keeping</th>
<th>Record Search</th>
<th>Locating and Repairing Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert No. 1</td>
<td>0.002</td>
<td>0.070</td>
<td>0.368</td>
<td>0.368</td>
<td>0.193</td>
</tr>
<tr>
<td>Expert No. 2</td>
<td>0.000</td>
<td>0.167</td>
<td>0.667</td>
<td>0.083</td>
<td>0.083</td>
</tr>
<tr>
<td>Expert No. 3</td>
<td>0.061</td>
<td>0.075</td>
<td>0.041</td>
<td>0.530</td>
<td>0.354</td>
</tr>
<tr>
<td>Expert No. 4</td>
<td>0.070</td>
<td>0.210</td>
<td>0.092</td>
<td>0.655</td>
<td>0.043</td>
</tr>
<tr>
<td>Geometric Mean</td>
<td></td>
<td>0.116</td>
<td>0.174</td>
<td>0.320</td>
<td>0.125</td>
</tr>
</tbody>
</table>

(Saaty 1982) and a dollar value assigned to intangible benefits, the revised financial indices improved to positive values. Table 3 shows a comparison of the financial indices with and without the inclusion of intangible benefits. It indicates that in the case of Branson, significant improvements were observed in all financial indices when intangible benefits were considered. The results of the simulation analysis for the extended model show an expected NPV of $73729 with a standard deviation of $4875. The probability of negative results was insignificant showing a minimal investment risk.

System Evaluation

The goal of this evaluation was to assess the methodology from the perspective of potential users. Adelman (1992) highlighted the importance of incorporating feedback from potential users in evaluating a proposed deci-

FIGURE 4. Spiderplot for sensitivity analysis for Cuba, Missouri.
sion-support system. A major concern in this evaluation, therefore, was determining whether the framework supported the users' decision-making needs. The system was evaluated by two groups comprised of practi-
ing experts in the field of automated mapping systems and professors of economics and finance at the University of Missouri-Rolla. Ratings were provided on the fol-
lowing factors:

Cost: The cost for small communities to apply the proposed framework to evaluate their capital investment in an AM sys-
tem.
Usefulness: The usefulness of applying the proposed framework in small communities to evaluate their capital investment in AM systems.
Ease of use: This attribute refers to the ease of use or difficulty of using the proposed framework by small community engineers.
Efficiency: The efficiency of the framework to use the available knowledge, data, hardware and software to evaluate capital investment in AM systems in small communities.
Clarity: How well the proposed framework avoids ambiguities in its application in small communities.
Soundness: The quality of the sources of information used in developing the proposed framework.

Figure 5 summarizes the ratings obtained. These show that the proposed evaluation framework received ratings much higher than the average acceptable level from both groups of evaluators.

Conclusion
Developing a systematic framework for evaluating capital investment in AM systems in small communities should be regarded as another small step in the ef-
tort to improve the quality of engineering management decision-making in small communities throughout the United States. As was seen in the cases of Cuba and Plattsburg, limited cost-benefit studies that utilize relatively easy-to-measure tangible benefits may be ade-
quate to justify AM investments. However, as the case of Branson illustrates, justification of AM systems may require the conduct of a full cost-benefit study incorpo-
rating quite difficult to measure intangible benefits.

The proposed framework is generalizable and can be used to evaluate proposed capital investment in an AM system in any small community in the USA. This research should be regarded as providing preliminary "proof of concept" of the effectiveness of the framework in providing a systematic process for evaluating proposed capital investments in AM systems in small communities.

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FIGURE 5. Summary of the ratings of framework attributes by practicing experts and faculty members.
Even though the proposed framework was successfully tested using data from three small midwest communities in Missouri, further research is needed to evaluate the suitability and applicability of the framework to a wider range of small communities in other regions. Researchers can also expand this framework to incorporate a knowledge-based system (KBS) as part of a larger intelligent decision-support system (IDSS) to help directors of public works of small communities decide whether or not to adopt an AM system to improve a particular community's infrastructure management. The proposed IDSS could be developed to utilize a community database with area, population, number of utilities, and other data used to determine the investment risk. A KBS can be developed to help identify and estimate savings and intangible benefits associated with a proposed investment in an AM/FM/GIS system. The IDSS should be user-friendly and easily maintained so that it can be readily accepted by engineers in small communities.

Acknowledgements

We wish to acknowledge the financial support for this research provided by the Center for Technology Transfer, University of Missouri-Rolla, and the helpful comments submitted by several anonymous reviewers.

References


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APPENDIX A

ECONOMIC MODEL

For year t,

\[ C_t = \text{Total Costs} = C_1 + C_2 + \ldots + C_6 \]

\[ B_t = \text{Total Benefits} = B_1 + B_2 + \ldots + B_5 \]

Net Benefits = \( B_t - C_t \)

Net Present Value (NPV) = \( \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1 + i)^t} \)

where i = discount rate (%); n = study period (years)

Explanatory Notes:

Costs:

- \( C_1 \): Hardware Investment
- \( C_2 \): Software Investment
- \( C_3 \): Consulting Fees
- \( C_4 \): Training Costs
- \( C_5 \): Map Conversion
- \( C_6 \): Database Conversion
- \( C_7 \): Hardware and Software maintenance
- \( C_8 \): Operating Costs

Benefits:

- \( B_1 \): Savings from new mapping
- \( B_2 \): Savings in updating maps
- \( B_3 \): Savings in location facilities
- \( B_4 \): Savings in repairing facilities
- \( B_5 \): Other benefits
## APPENDIX B  Financial Analysis - Cuba, Missouri

<table>
<thead>
<tr>
<th>Yr.</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs $</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_1$ Hardware</td>
<td>5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_2$ Software</td>
<td>3600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_3$ Consulting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_4$ Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_5$ Map Conversion</td>
<td>2192</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$C_6$ Database</td>
<td></td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
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<tr>
<td>$C_7$ System Maint.</td>
<td></td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>$C_8$ Operation</td>
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<td></td>
<td></td>
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<tr>
<td>$C_9$ Total costs</td>
<td>8600</td>
<td>2621</td>
<td>420</td>
<td>420</td>
<td>420</td>
<td>420</td>
</tr>
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<td></td>
<td>420</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits $</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_1$ Sav. from New Maps</td>
<td>8768</td>
<td>4384</td>
<td>4603</td>
<td>4833</td>
<td>5075</td>
<td></td>
</tr>
<tr>
<td>$B_2$ Sav. in updating Maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_3$ Sav. in Record Keeping &amp; Search</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_4$ Sav. in Locating &amp; Repairing Fac.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$B_5$ Other Benefits</td>
<td></td>
<td>8768</td>
<td>4384</td>
<td>4603</td>
<td>4833</td>
<td>5075</td>
</tr>
<tr>
<td>$B_6$ Total Benefits</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Benefits (Bt-Ct)</td>
<td>(8600)</td>
<td>6156</td>
<td>3964</td>
<td>4183</td>
<td>4413</td>
<td>4655</td>
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<tr>
<td>Cumulative Benefits</td>
<td>(8600)</td>
<td>(2444)</td>
<td>1520</td>
<td>5703</td>
<td>10116</td>
<td>14771</td>
</tr>
<tr>
<td>Present Value ($=10%$ pa)</td>
<td>(8600)</td>
<td>5596</td>
<td>3276</td>
<td>3143</td>
<td>3014</td>
<td>2890</td>
</tr>
<tr>
<td>Cumulative value</td>
<td>(8600)</td>
<td>(3004)</td>
<td>272</td>
<td>3415</td>
<td>6429</td>
<td>9319</td>
</tr>
</tbody>
</table>

### Input Data

- Population: 2700
- Number of Utilities to Map: 2

### Results (Economic Indicators)

- Payback period: 1.62 Yrs
- Discounted Payback Period: 1.92 Yrs
- Net Present Value: $9319
- Internal Rate of Return: 36.28%
- Benefit Cost Ratio: 1.77
APPENDIX C  Results of Simulation Analysis - Cuba, Missouri

A. Input Data for Risk Analysis:

<table>
<thead>
<tr>
<th>Description</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁ Hardware Cost</td>
<td>@Triang (4500, 5000, 6500)</td>
</tr>
<tr>
<td>C₂ Software Cost</td>
<td>@Triang (3240, 3600, 4680)</td>
</tr>
<tr>
<td>C₃ Map Conversion</td>
<td>@Triang (1973, 2192, 2850)</td>
</tr>
<tr>
<td>C₄ Maintenance Cost</td>
<td>@Uniform (270, 390)</td>
</tr>
<tr>
<td>C₅ Operation Cost</td>
<td>@Uniform (108, 156)</td>
</tr>
<tr>
<td>B₁: New Map Savings</td>
<td>@Triang (6138, 8768, 9645)</td>
</tr>
<tr>
<td>B₂: Updating Maps Savings</td>
<td>@Triang (3069, 4384, 4822)</td>
</tr>
</tbody>
</table>

B. Output after 1000 iterations:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The expected mean NPV</td>
<td>4176.03</td>
</tr>
<tr>
<td>Probability of negative results</td>
<td>0%</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>434.766</td>
</tr>
</tbody>
</table>
Information Systems: A Labor Market Adaptation

Lynda Y. de la Viña and Ronald Ayers

Abstract: This paper describes the theoretical foundations, design and implementation of the San Antonio Labor Market Information System (SALMIS). The SALMIS is a fully automated, microcomputer-based metropolitan labor-market information system, the only locally based labor-market information system of its type. Issues raised by the economics of imperfect information motivated the development of SALMIS. The central problem created by the absence of labor market information is an inefficient labor market. SALMIS is designed to remedy the effects of incomplete information by providing employment and training professionals with up-to-date, easy-to-use data and forecasts relating to specific segments of the labor market. The importance of SALMIS in the local labor market is demonstrated by the continuing use of SALMIS in both the public and private sector since its creation in 1981. A brief summary of the results from the most recent annual user survey documents the significance of the system.

Following the publication of Stigler’s seminal 1961 paper, economists began to probe for insights into the behavior of economic agents when information available to them is incomplete or imperfect. Stigler’s concern was with “uninformed buyers” who make purchases, given an “unknown true state of the world.” Other economists followed with extensions and applications of the analysis. For example, Hirschleifer and Riley (1979) elaborated upon problems created by conditions of market uncertainty that result from imperfect information. They cited cases such as sellers who are unsure of the prices that buyers are willing to pay, banks unsure of the solvency of potential borrowers, and employers uncertain of the productivity of job applicants.

Information Search and SALMIS

The economics of imperfect information focuses upon information asymmetries. Stigler’s buyers would like to know the prices of a good offered for sale by various sellers. Therefore, they are motivated to engage in a search across sellers in order to find an acceptable price. Because search costs may be substantial, the search for a lower price will stop when the expected gain from continuing a search becomes less than the incremental search costs. This elementary logic regarding the value of information to market participants, and the price they will pay for such information, is applicable to labor markets in numerous ways. Hirschleifer and Riley’s case of the employer who is uncertain of job applicants’ productivities suggests the asymmetric nature of information. The applicant knows more about his or her productivity than the employer. The employer might be willing to incur costs to ascertain more about such productivity, by administering a test to the applicant, for example. But applicants who can supply more favorable data about their productivity than can be ascertained from test results will be more likely to be hired.

Job-training specialists typically perform their duties under conditions of incomplete and imperfect information. Evidence suggests that the most widely used method of information search by job trainers is ad hoc, unstructured and unplanned. Examples include the use of newspaper reports about labor market conditions, telephone calls and conversations with friends about job openings, and information gleaned from classified advertisements. The San Antonio Labor Market Information System (SALMIS) incorporates insights from the economics of imperfect information into the design of a database that offers the possibility of supplanting informal methods of augmenting information stocks, and which would actually be used by labor market professionals.

Planners and trainers would be expected to utilize such information because of its potential to ameliorate a

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Dr. Ronald Ayers is an associate professor in the College of Business at The University of Texas at San Antonio. Dr. Ayers received his Ph.D. in economics from Tulane University. Major areas of research are labor economics and managerial economics.
variety of problems. The most attractive aspect of SLMIS is its promise to balance labor supply and demand in various occupations and industries. SLMIS thus provides a means to increase the efficiency of resource allocation in the metropolitan area labor market. Efficiency gains can be achieved at relatively low cost because of economies of scale associated with providing data to numerous subscribers within the area.

SLMIS was commissioned under the auspices of the Job Training Partnership Act (JTPA). Preexisting labor market data did not report information linking occupational supply and demand at the sub-state level. As a consequence, labor market planning and decision-making that dealt with training fund allocations was not feasible. The Private Industry Council, charged with the responsibility of allocating training funds to area employment and training programs, sought to rectify this problem through the implementation of SLMIS.

Problems of Incomplete Information

In the process of designing and developing SLMIS, the ultimate goal has been to furnish a tool for planners, labor market analysts, and employment and training specialists. When implemented, this tool would address problems possessing a common thread—incomplete information. Hence, it is worthwhile to briefly examine the notion of signaling, an idea central to the theory of incomplete information, which provides insight into the role that a labor market information system can play in improving the workings of a labor market.

Spence pioneered the work on signaling in the marketplace in the book Market Signaling (1974). Job signaling, as defined by Spence, occurs when job applicants possess attributes that an employer is able to interpret. Prior job training, or a diploma, are signals indicating higher capabilities. Thus, education and training perform a signaling function which separates the more capable individuals from the less capable ones. When the employer's beliefs about the meaning of market signals are confirmed, there exists a signaling equilibrium.

Signaling by applicants, and the reading of signals by employers is rooted in the lack of information about an applicant's true productivity. Employment and training professionals also lack information. The problem is that professionals who seek to plan and shape the labor market must be wary of sending the wrong signals. Misleading signals are costly. For example, the setting aside of funds in a training budget to train people to become aircraft mechanics signals trainees that such jobs are available. If there are, in fact, no openings of that type, funds and trainees' time have been wasted. A labor market information system can help prevent the sending of such false signals.

An efficiently functioning labor market which is in equilibrium will be characterized by the following conditions: 1) no involuntary unemployment, and 2) no underemployment of labor. A corollary to the latter condition is that all workers will have received their personal, optimal amount of training. Different workers will receive different amounts of training depending upon their individual abilities.

It is difficult to make a labor market function efficiently so that equilibrium is attained. Mismatches occur as a consequence of information lags. If the number of slots in training programs is based upon outdated information, surpluses or shortages of workers in specific labor market segments are more likely. Labor market demands are in a constant state of flux, and the number of trainees in specific fields must be continually adjusted up or down as market conditions dictate. Furthermore, as skill requirements in occupations change over time in response to technological change, information lags can result in trainees enrolling in programs which are a poor match for their abilities. SLMIS is predicated on the principle that the right information made available in a timely manner can bring about more efficient outcomes.

It is useful to expand on Spence's formulation of the job market to illustrate how a labor market information system can contribute to efficiency (Figure 1). The flow of the labor market process is from the top down: funds are allocated during the planning process to training agencies, which are then spent on training; trainees then supply their labor to the job market upon the completion of training.

Spence's focus is limited to the two bottom rungs of the ladder—the interaction between trainees and employers. Planners and trainers, however, have power over the flow of trainees, and the type of signals that trainees send to employers. Therefore, the two top rungs of the ladder influence the employment of labor, as shown in the two bottom rungs.

Signaling also occurs between each rung of the ladder (Figure 1). The double arrows in the figure indicate the possibility that signaling may be a two-way street. In other words, any party may both send and receive signals. For example, trainers may send signals to planners that they are capable of providing high-quality training. The signals might include highly credentialed staff, extensive equipment, or references. But planners may also receive signals from trainers. Spence defines signals as any activity or action conveying information which is subject to interpretation by the party on the receiving end of the signal. Conferences, memos, and other communications between planners and trainers present opportunities for the sending of signals by planners regarding the future direction of budgets and training efforts.

SLMIS enters the labor market process at the two top rungs of the ladder. The arrows in the figure indi-
The objective of SALMIS is to disseminate detailed demand and supply data to the economic agents directly involved with the allocation of labor resources in the metropolitan economy. The matching of demand with supply at the micro level permits trainers to have more confidence in the decisions made by planners, and permits planners to have more confidence in the proposals made by trainers.

**Designing SALMIS: Rationale and Data Sources**

SALMIS is an automated microcomputer-based system designed as a comprehensive labor market database and as a system for analyzing demand and supply trends in the San Antonio MSA labor market. The focus of this information system is on the estimation and projection of the demand attributable to job openings, occupational characteristics, job skill transferabilities, and industrial trends, as well as the supply status of vocational and technical occupations in the San Antonio Metropolitan Statistical Area. The system has been implemented by the Institute for Studies in Business at the University of Texas at San Antonio under an initial grant awarded by the San Antonio Private Industry Council in cooperation with the Texas Employment Commission and the City of San Antonio. The system came to fruition as a result of a regional concern regarding the uniqueness of the area industrial base and the need to have timely and accurate information specifically developed to address local economic trends in the labor market. SALMIS is divided into ten distinct modeling segments (Figure 2):

1. Industry Projections Module,
2. Occupational Distribution Module,
3. Industrial Composition Module,
4. Occupational Employment Module,
5. Occupational Market Profile Module,
6. Occupational Training Module,
7. Occupational Supply Module,
8. OES-CIP Code Match Module,
9. Occupational Traits Module, and
10. San Antonio Firms Module.

The tutorial and utilities modules complete the twelve basic system modules.

The modular approach offers flexibility to users. For example, the San Antonio Area Firms module is the only listing of all area employers. It is complete in regard to company name, address, census tract, phone number, name of director of Human Resources or person in charge of employment, current full-time employment, current permanent part-time employment, minority, and/or woman-owned businesses, and definition of service or product. Embedded searches can be opera-
tionalized at every variable end. When a job trainer is searching for job leads, a few strokes of the keyboard can quickly and easily provide a list of contacts.

**Employment Data**

The primary source of the demand data is the Current Employment Survey 790 series which consists of 168 months of historical employment data summarized at the two-digit Standard Industrial Classification (SIC) level. The 790 series is benchmarked by the ES-202 Report of Covered Employment and Wages. The ES-202 series, required by federal and state law as part of the Social Security Act, represents 97 percent of the working population. The two-digit level of aggregation represents a compromise between the need for specificity and forecast feasibility in terms of time, cost, and human resource constraints as well as disclosure problems.

**Forecasting**

The forecasting procedure utilizes a Box-Jenkins ARIMA Forecasting Model. The ARIMA model is a type of stochastic time-series analysis that is considered appropriate for use when forecasting from a univariate series of data. The result of this process is 75 individual industry forecasts which are further disaggregated to a 3-digit SIC level. This was accomplished by obtaining the 3-digit percentage composition within 2-digit industries and applying it to the 2-digit totals. The 3-digit factors are available from the Texas Employment Commission (TEC). Through this factoring procedure, each of the industry forecasts were reallocated to a 3-digit level.

**Industrial/Occupational Matrix**

The next procedure utilizes the Industry/Occupation (I/O) Matrix, which is created through survey activity
jointly processed by the National Occupational Information Coordinating Committee (NOICC). A validation study comparing the matrix with a microdata sample of the Census was undertaken and resulted in confirmation of the reliability of the I/O Matrix. From the survey data, an occupational profile is developed for each 3-digit industry in the metropolitan area based on Occupational Employment Survey (OES) Codes.

By taking the industrial employment levels and applying Industry/Occupational profiles to them, one may obtain occupational employment patterns for each industry. The Industry/Occupation Matrix contains 1567 occupations for 368 industries. By processing 3-digit SIC employment data through the matrix, it becomes possible to obtain an estimate of employment by occupation in the San Antonio MSA. This process was accomplished for each of the employment forecasts to provide current and projected growth levels of vocational and technical occupational employment in the MSA. Furthermore, projected openings due to growth are then coupled with projected openings due to replacement. The replacement projections are accomplished by analyzing occupational separation rates as developed by the TEC. Separation rates are applied to current employment figures in order to project future replacement openings. Ultimately, projected openings are composed of a disaggregation into openings due to growth plus openings due to replacement.

**Supply Model**

Occupational supply data come from seven sources:

1. Secondary Educational Institutions,
2. Post Secondary Educational Institutions,
3. Proprietary Schools,
4. individuals seeking employment,
5. Rehabilitation Programs,
6. JTPA Training Programs, and
7. Apprenticeship Programs.

In-migration and out-migration, which affects occupational supply, is not currently estimated. Thus, the system assumes a closed economy on the supply side. Secondary and post-secondary data are obtained from school program completions, which are reported through the Vocational Education Data System (VEDS). These completions are recorded by the U.S. Office of Education program code—Classification of Instructional Programs (CIP). Proprietary schools data are collected by surveying all local proprietary schools. Data on individuals seeking employment are obtained from the State Automated Management System of Texas. These data summarize applicants and job openings by occupational codes. Data are also obtained from JTPA and from the Bureau of Apprenticeship Training.

**Linking Supply and Demand**

All data are coded in terms of the CIP codes through crosswalk techniques. The crosswalks include SIC to OES and OES to CIP (Figure 3). All crosswalks are summarized at the training program code level. The linkage between supply and demand, therefore, is provided by establishing a crosswalk between occupational codes and the appropriate training codes. This procedure provides a convenient level of analysis for those making decisions regarding the budgeting and resource allocation to training programs.

This abbreviated description of the procedures employed in collecting a large volume of data from many diverse sources in order to create the SALMIS is proof of the economies of scale inherent in the provision of a labor market information system such as SALMIS.

**Application and the Economics of Information: Cases and Examples**

The SALMIS has been developed to serve the information needs of a wide variety of users. Pop-up computer screen menus via a Windows environment permit users

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**FIGURE 3.** Environmental Factors Map

![Environmental Factors Map](image)
easy access to the specific information they need, which is presented in an easy-to-understand format. Furthermore, the SALMIS is updated each year in an effort to provide users with the most current data available.

The inherent high quality of the SALMIS is illustrated by considering several kinds of information problems which the system is capable of addressing. The case of a school district which is engaged in budget planning is informative. Suppose a vocational director is asked to make a recommendation for increased/decreased funding for the training program for electronic technicians. In the absence of the system, the recommendation will fall into the category of "educated guess." However, the SALMIS will permit the acquisition of information on the current status of the occupation, the projected growth of the occupation, programs that train for the occupation, actual numbers of completers and enrollees in the current program, the projected growth of those industries that employ the occupation, and a listing of firms within these industrial categories in the San Antonio MSA.

Consider next the case of an economic or employment developer who is asked to determine the labor market conditions for a new industry contemplating the possibility of locating in the area. The system permits an industrial simulation which depicts those occupations, and their percentage figures, that comprise this industry. Furthermore, the generally prevailing entry-level wages (weighted averages) are provided for certain occupations in the industry. Also, current competition by other employers requiring the same labor pool is listed for further analysis. Moreover, training facilities and programs for an industry's key occupations can be easily determined.

Career counseling contributes another example. Suppose a city employment counselor is asked to recommend a type of occupation for a high school graduate with no vocational training and no work experience. If the student is interested in occupations that require no more than 12 years of education and three months of training, and which are expected to exhibit 10 percent annual job growth, then SALMIS can access this information instantly. Furthermore, the counselor can extract data from SALMIS which can show the applicant that, with more training, the job alternatives expand considerably. Thus, the counselor can help convince students of the importance of vocational and technical training.

To fully monitor the utilization of SALMIS, to assess the effectiveness of SALMIS, and to plan SALMIS update modifications, an annual survey of SALMIS users was instituted. The results of the 1994 survey show that 13 agencies responded with a total of 20 surveys returned by agency personnel. The agencies were all of the funded 1994 fiscal year JTPA agencies. Examples of larger agencies include the Alamo Community College District, Bexar County Opportunities Industrialization Center, Communities in Schools, City Department of Community Initiatives, Edgewood Independent School District, Goodwill Industries, and San Antonio Lighthouse for the Blind.

Sixty percent of the respondents reported they accessed the SALMIS at least once a month, or more. Forty percent stated that SALMIS was "easy" to "very easy to use," with 35 percent stating that it was somewhat easy. The survey also included questions about the purposes for which SALMIS is employed. Users report that SALMIS is useful for a wide variety of labor market analyses (Table 1). Questions about the frequency of use of each module were also asked. With the exception of the industrial composition module, all modules were used by a majority of agencies (Table 2). The surveys also queried users about possible modifications to SALMIS. Responses included the addition of Holland Topology; a separate module on wages; and an OES to DOT crosswalk. The feasibility of such modifications have been investigated but are not yet feasible because of funding limitations.

The data for SALMIS reflect the result of comprehensive research and complex statistical analysis to arrive at a body of information tailored to the specific needs of the region. User insights and needs are paramount to the continued evolution of the system. The only other labor market information system available is a state-based system. The state system (SOCRATES) was developed from the SALMIS prototype but was created as a macrosystem to assist in broad-based regional and state labor market planning using aggregated data. The state system is useful, however, to areas in Texas that do not possess a local system. The State Occupational Information Coordinating Committee (SOICC) has stated that a localized system is preferable to the state system in terms of customization of data and accuracy of results.

Conclusion

SALMIS was conceived as a response to the problems of imperfect information in the labor market. It is currently the only locally based labor-market information system of its type. It continues to provide a mechanism to promote timely and accurate metropolitan labor-market data and has filled a void by collecting, creating, and providing pertinent labor information to assist planners, labor market analysts, and program-training specialists in the San Antonio area.

Acknowledgements

We wish to thank the Alamo Private Industry Council for their support of the SALMIS effort. We would also like to thank the
staff of the Institute for Business Studies; without their dedicated work, the SALMIS would not be a reality.

References


In this issue...

A diverse assortment of features: Helen Schutten provides a glimpse of the garbanzuan task that lies before the eastern European country of Albania. This newly democratic country is looking to GIS to help resolve land policy issues and to sort out ownership rights and infrastructure problems.

Helpful how-to articles offer guidance in structuring and staffing an organizational GIS. Jeffrey Anderson describes how Snohomish County in Washington state is developing a comprehensive, county-wide directory system. Rebecca Somers offers strategies for how to best set up and organize a GIS staff.

Next, a technological solution for archiving the mounting millions of slides and photographs in agencies throughout the United States. Brian Huberty describes the quick and efficient Photo CD system for digitally storing and manipulating photographs.

In “GIS and Neighborhood Planning,” Jim Myers and Michael Martin describe a hands-on program that puts the power of GIS in the hands of those who are most invested in seeing communities revitalized—the residents themselves.

Finally, Edward Graham provides an excellent overview of this year’s Exemplary Systems in Government award winners.

Editorial Intent

In this Features section, we welcome material that is serious or not so serious; visionary or pragmatic; domestic or international; public or private sector; high or low tech; far-fetched or down-to-earth; managerial or technical; vocational or educational; qualitative or quantitative; GIS or non-GIS. In short, we are open to different ways the world can be explored, described, understood.

Norman Cousins has said “No one really knows enough to be a pessimist.” Assuming further that no one can ever know enough to be a pessimist, the pursuit of knowledge must therefore be an optimistic (or, at worst, realistic) endeavor. Torturing the logic a bit further, an optimistic endeavor is joyful and therefore—ah ha!—contributing material to the Features section is pleasurable. So, please do so.

We ask only that you submit material you genuinely believe will interest URISA’s members, and of which you are truly proud.

Lynne Wiggins
Gene Roe
The Dream of GIS for Albania

Helen M. Schutten

Albania, a country the size of the state of Maryland, has undergone radical social and political change in the last four years. Like other eastern European countries such as Romania, Hungary and the former Soviet Union, Albania is struggling to transform its centrally planned economy into one that is market-oriented. In terms of land ownership, that means bringing private control and developing real property markets on land that was formerly centrally owned. Prior to 1991, private property in agricultural land was not possible in Albania; according to the country's 1976 Constitution, all land belonged to the state.

Today, Tirana—the capital—and other major cities in Albania are experiencing extensive land development pressure as a result of:
1. new commercial businesses,
2. expanded infrastructure and public service needs,
3. large population shifts from country to cities, and
4. residential relocations as a result of individual initiative.

Modifications in land arrangements are apparent everywhere. And many land policy questions have arisen that relate directly to parcel formation: ownership rights, title registration, dispute settlement, compensation of owners before the Communist takeover, and authority of the state to retain or reclaim land needed for public purposes.

The Land Tenure Center at the University of Wisconsin-Madison is assisting Albania in developing a parcel-based land record system. Computerizing the registry will establish an automated land information system (LIS). Implementing the GIS will begin when maps and registration of land are completed.

The day-to-day operation of the project is under the guidance of the Project Management Unit (PMU), made up of government policy-makers. To date, Albania's PMU has identified the structure of the mapping and has adopted the regulations to administer property registration. Members of the PMU and the Albanian Ministry have traveled to Austria, Hungary and the United States to study LIS and GIS systems. Other European countries have invited Albania to join in an organization of adjoining countries to share in the process of automating land records. One day these countries hope to use GIS in wide-ranging applications: for farming, surveying, utilities, real estate, and especially in marketing strategies.

Some History

Three hundred years before Christ, the Illyrian kingdom covered much of what is now Albania. Greece also had colonies in Albania then, and Greek civilization influenced the Illyrians.

When the Roman Empire split in 395 A.D., large parts of Albania became part of the Eastern Roman Empire. The invading Goths, Bulgarians, Slavs, Normans, and Serbs brought change for the next 1,000 years. By the 1300s, much of Albania was part of the Serbian Empire ruled by Tsar Dushan.

In the 1400s, Skanderbeg—Albania's national hero—resisted Turkish attempts to take over the country. After his death, the Turks conquered Albania and it became part of the Ottoman Empire. Throughout this period, the Albanian chiefs controlled most local matters particularly in the villages and towns. This form of local governing still exists today.

Several times during the 1800s Albanians tried to throw off Ottoman rule. Finally in 1912, during the First Balkan War, Albania became independent. In 1913, the great European powers established Albania's borders and the country became a self-governing principality. However, this was not to last; by 1939 World War II began and Italy occupied Albania, making it a part of the Italian Empire. When Italy surrendered to the Allies in 1943, German troops took over Albania.

FIGURE 1. Albania and Eastern Europe

Helen Schutten works on the Albania Privatization of Land Records Committee through the University of Wisconsin-Madison. She was the Racine County, Wisconsin Register of Deeds from 1980-1994.
The Soviets took control in 1948, followed by the Chinese in 1961. In 1991, Albania regained freedom from Communism and began to establish a democratic form of government. Considering its tumultuous history, it is easy to understand the huge challenges Albania faces in bringing order to their land-market system.

The Geography

Albania consists of three geographical/topographical regions: the Mediterranean coastal lowlands, the hilly region with large plains, and the cool mountainous zone. Total arable land is approximately 706,000 hectares, nearly twice the amount of arable land available in 1950. Most of this new arable land has been obtained by draining swampland in the coastal region and extending irrigation systems; the rest has been gained by terracing hillsides.

From the Ground Up

The transition since 1991 from structured farming under Communism, and the forming of cooperatives, to the personal enterprise of individual farms has brought about abrupt change. Basic decisions, such as what and how much of a certain crop to grow, not to mention how to market them, faces farmers and administrators. Economically, no formal marketplace existed. Supply and demand in a competitive marketplace did not exist. The recent redistribution of farmland has required a whole new structure for buying and selling in the marketplace.

Albania could not establish an organized plan rapidly enough to offset the problems they are experiencing today. Property owners found themselves with small pieces of fragmented property often far from their homes. Farming is difficult. Farm equipment is not affordable so much of the land is tilled and harvested by hand.

An automated LIS/GIS system could help ease their struggle. GIS can aid them in combining parcels into spatially compact blocks for better productivity and access. GIS tools can help farmers identify optimal crop types, and amounts of fertilizer or herbicide applications for the greatest yield. Soil types, elevation and crop yield can be overlaid on maps to display a wide range of valuable information.

Urban infrastructure problems in Albania also loom large. Many farm families desiring a better life choose a parcel of land near a city. They plot out parcels by placing large stones in the four corners of the intended parcel of land they are claiming. They tap electricity from a neighbor, water is carried in; often there is no road or public access. Such random construction with no planning threatens the health and welfare of the people. Designing an infrastructure from such chaos is a huge task.

In the modern world, GIS helps protect and facilitate infrastructure maintenance; in Albania, it can help plan and locate infrastructure elements. All districts (similar to U.S. counties) are now mapped in Albania. The maps contain building footprints, roads, streams and various political boundaries. An analysis of the maps will help planners locate sewer, water and electricity. The challenge is to rapidly draft a plan for the necessary infrastructure around the existing homes. Laws must be passed to halt illegal construction.

Albania is a country blessed with sandy beaches, mountain views and the bright blue waters of the Adriatic Sea. In another time, perhaps, an ideal vacation destination. With the help of GIS and some sound planning, that time may once again not be far off.
Building a Useful GIS Directory: Snohomish County, Washington

Jeffrey S. Anderson

Every GIS, no matter how simple or complex, must have a directory structure system. By no means does this guarantee that the system is conceived and implemented with any coherent plan behind it. Having no plan usually results in a spontaneous and chaotically organized directory. For a small GIS organization, this may not pose any problem at all. But for a large and/or growing organization, the problems will multiply as time passes. Time and labor will be wasted looking for misplaced material, coordinating programs and applications which reference the database, training new personnel, and managing the system. To compound the dilemma, the longer that nothing is done about the problem, the more difficult it is to fix through reconfiguration and reorganization.

Snohomish County in Washington state, now in its second phase of a three-phase program to implement a countywide GIS, is developing a simple, yet comprehensive directory which can be adapted to fit most any governmental GIS. In Snohomish County, Sun (Unix) workstations are connected together on a local area network (LAN); ARC/INFO software has been installed in the GIS Division. Other stand-alone satellite workstations have been installed in many of the departments and divisions in the county system. The three main goals of the program during Phase II and Phase III over the next five years are to:

1. assemble and build an extensive lower-accuracy (1:24,000 and 1:100,000 scale) and higher-accuracy (1:2400 scale) countywide database,
2. install workstations, PCs, plotters, and GIS capabilities throughout the county running on a single network, and
3. develop a wide array of GIS applications which lead to the automation and integration of county business functions.

This is the environment for which the GIS directory structure will serve Snohomish County now and into the 21st century.

Directory Structure Requirements

To be considered successful, a directory system should be standardized. This will make it easier to use and will help manage the database efficiently. Among the structure requirements, it should:

Be easy to learn and use

The directory structure system must be easy to learn and use for novices and experts alike. The hierarchy and naming conventions must provide an easy-to-understand frame of reference for the GIS neophyte to relate to. It must also provide shortcuts for the GIS expert to encourage him/her to use the system as well. And it must have a shallow learning curve for new GIS Division employees so they can become productive as quickly as possible. To meet these requirements, the structure must be logical, consistent and intuitive to all end users. It must be transparent. In other words, the structure must appear identical to every user regardless of whatever workstation they log on to, be it a machine connected to the LAN or a stand-alone. In a nutshell, the directory structure should be as easy and intuitive to use as the common phonebook.

Serve the needs of a multi-departmental user community

It is important to anticipate all of the different types of GIS activities on the system now and in the future, and then incorporate these activities into the directory structure design. Each department and division in the county will have their own unique set of GIS projects and activities. The directory structure design must anticipate, accommodate and provide a systematic storage place for all the data, programming, and other material associated with these activities.

Support incremental implementation and expansion

At present, the GIS Division has plans to install additional workstations and PCs in other departments and divisions around the county. We also plan to install a networking infrastructure among all workstations and many PCs in the indef-
nite future. Yet in these tight budget times, it is difficult to predict where and when expansion and network installation will next occur. The directory structure design must support as many combinations and permutations as possible.

**Support database management and system administration functions**

The directory structure must provide the means to manage the database, update common directories on satellite stand-alone workstations, and to set access privileges and permissions. Particularly in the case of access protection, the design must provide the flexibility to set permissions based on entire departments, entire divisions, or any subset of people in a division working on a project, a data-layer maintenance activity, or within any particular workspace on the system.

**Reinforce the concept of a commonly shared and integrated system**

The promoters of GIS often stress the idea and the philosophy of GIS as an integrating technology that can link dissimilar governmental functions and departments together based on the management and use of commonly shared geographic information. The directory structure is one of the visible aspects of the GIS that can illustrate how integrated a particular system really is. Just as it’s important for everyone on the system to be using the same GIS software, it is also important for everyone to be using the same directory structure system with its associated concepts, terms and procedures.

**Directory Structure Components**

Five basic components make up the directory structure. Each performs a unique set of functions within the context of the entire countywide GIS.

**Common geographic database**

The geographic database is the central storehouse for all commonly shared and referenced countywide GIS data sets and layers. Many of the data sets stored here are designated to be updated and maintained by specific county departments and divisions (i.e., data custodians). All data stored here are subject to some minimum level of quality-control checks and quality-assurance standards.

Because the data here will be referenced by the entire system, the GIS database must be stable and secure. System users have read-and-execute access. Only the system and database administrators have write access. Both workstations (operating with Unix) and PCs (operating with DOS) will reference the database component of the structure. Because of the DOS naming standard, all directories, files, data sets, and coverages here will comply with the 8.3 file naming convention.

At Snohomish County we have elected to divide the database into three subdirectories according to map scale and spatial accuracy. We have also subdivided each map scale directory into further subdirectories according to type or class of data. All countywide coverages, layers, and data sets are located in these standard class subdirectories. Figure 1 shows a schematic of the Snohomish County GIS database directory structure. Table 1 contains a list of the standard class subdirectories and the type(s) of data each contain.

**Common libraries**

One aspect of GIS, sometimes overlooked, is the fact that there exists a considerable wealth of common resources and tools on the system.
TABLE 1. Standard Data Class Subdirectories and Descriptions

<table>
<thead>
<tr>
<th>Subdirectory Name</th>
<th>Data Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>admin</td>
<td>Political and Administrative Districts</td>
</tr>
<tr>
<td>capital</td>
<td>Capital Facilities and Public Services</td>
</tr>
<tr>
<td>census</td>
<td>Census Geography and Associated Statistical Files</td>
</tr>
<tr>
<td>control</td>
<td>Survey Control</td>
</tr>
<tr>
<td>environ</td>
<td>Environmental Conditions</td>
</tr>
<tr>
<td>index</td>
<td>Geographic (Spatial) Indexes</td>
</tr>
<tr>
<td>land</td>
<td>Land Records</td>
</tr>
<tr>
<td>pilot</td>
<td>Pilot Study Data</td>
</tr>
<tr>
<td>planning</td>
<td>Planning Data</td>
</tr>
<tr>
<td>plantopo</td>
<td>Planimetric/Topographic Features</td>
</tr>
</tbody>
</table>

above and beyond the data. Libraries provide the vehicle through which these resources may be centrally stored, managed and referenced. Through proper administration, libraries present real opportunities for GIS programmers and system users to save time, trying to find and maintain common resources and applications. There are five different types of libraries in the Snohomish County design. It is envisioned that these libraries will be maintained by GIS Division personnel and designated department and division representatives from around the county.

- **Tool libraries** (toollib) contain AML programs, Unix scripts, and GIS applications common to one or more groups on the system. At the system level (see next section), the tool library also serves as an ARC/INFO ATOOL directory housing custom built ARC/INFO commands intended for use system wide. Material in the tool libraries must adhere to conventional programming coding standards.

- **Map libraries** (maplib) contain graphics files, plot files, ARC/INFO map compositions, and ARCVIEW files.

- **Table libraries** (tablelib) contain ASCII flat files, key legend files, feature selection files, file templates, INFO tables, lookup tables, and standard INFO datafile templates.

- **Symbol libraries** (symbolib) contain custom symbol sets, fonts, logos, and other map symbology.

- **Documentation libraries** (doclib) contain standard documentation about data, files, projects, and other activities on the system. At the system level (see next section), the document library will be the eventual storage place for the County’s online data dictionary.

**Department / Division directories**

In large part, the Snohomish County GIS is composed of its contributing county departments and their participating divisions. Much of the county’s GIS work will be done by departments and divisions that have custodial responsibility for one or more countywide GIS data layers. Each department and division with a GIS workstation will have its own dedicated branch set up in the directory structure.

**GIS software repository**

There is a standard dedicated place, “/gis/esri”, in the structure set up for holding the county’s GIS software, programs, executables, samples, tutorials, and demos from Environmental Systems Research Institute (ESRI—Redlands, CA).

**Individual user home directories**

In keeping with the standard Unix convention, each individual user on the system will have his/her own dedicated home directory established with sole ownership and writing privileges (e.g., /home/dis/gis/ander). Home directory paths will be composed of the following elements strung together: the standard home directory designation “/home”, the department the user belongs to (e.g., /dis), the division the user belongs to (e.g., /gis), and the user’s account name (e.g., /ander). This path naming scheme parallels that established under the system “/gis” directory (see next section).

Individual home directories are intended to be used for personal work and for individual GIS, Unix, and system training. Work which is a part of a regular GIS project or some other GIS activity should be done under the system “/gis” directory.

**Directory Levels**

There are four standard directory levels in the Snohomish County GIS directory structure design. Each directory level has its own set of libraries and/or standard subdirectories. Each level has its own unique purpose and function in the structure as a whole. All four of these levels, with their accompanying libraries and subdirectories, are system standards which can only be altered by the county’s database or system administrators.

**The system level**

The top level of the structure, one step down from the root, is the system “/gis” directory level. This directory is called “gis” to designate it as the master directory which contains the countywide geographic information system. The subdirectories...
be stored, managed and referenced from its respective system level library.

The department level
One level down from the system level is the department level. As stated earlier, each contributing department in the county with a GIS workstation will have its own departmental branch within the structure. Subdirectories at the department level include the various divisions within the department which have satellite GIS workstations (one directory for each division), and the standard set of five libraries. Figure 3 illustrates our Public Works department-level directory structure. In Snohomish County, our Public Works Department currently has three divisions with workstations: Design/Construction, Engineering Operations, and Surface Water Management. The libraries at this level are intended exclusively for the storage and referencing of resources common to two or more divisions within the department. When there is only one division in the department with GIS capabilities, the libraries at the department level will always be empty. Obviously, department libraries serve a much more useful purpose in departments where many divisions participate in the GIS.

The division level
The next level down from the department level is the division level. Division level subdirectories include the database reserve (e.g., "/gis/pw/swm/reserve"), the maintenance work area (e.g., "/gis/pw/swm/maint"), the project work area (e.g., "/gis/pw/swm/proj"), the demonstration work area (e.g., "/gis/pw/swm/demo"), and the standard set of five libraries (e.g., "/gis/pw/swm/maplib", etc.). Figure 4 illustrates our Public Works
Department / Surface Water Management Division directory and its subdirectories. At this level, the five libraries are dedicated to the storage and management of any resources common to many different projects or activities within the division.

Division Work Areas and Subdirectories

The final standard level down in the structure is the division work-area level. Since most of the actual GIS work performed in the county will be done by the divisions, and since there is a need (for inventory and organization purposes) to separate this work out into different categories, the following standard four work areas were created: the database reserve, the maintenance work area, the project work area, and the demonstration work area. Each of these work areas is explained and diagrammed below.

The database reserve

Each division will need to maintain its own particular set of data for its own purposes. This data may include raw data from other sources, historical data which are frequently referenced, data which are being converted from original source format to county standard format, subsets of countywide data, or any other data which serve the specific needs of the division. The database reserve serves as a central storehouse of data for the division. Data in the reserve differs from data in the central countywide database in that they need not meet any minimum quality-assurance standards. If any data set developed by a particular division crosses the threshold where it becomes of interest to the county as a whole, then the data set becomes a candidate for inclusion into the centrally shared database. Figure 5 illustrates an example of the database reserve.

The basemap maintenance work area

Certain divisions will be designated as custodians of specific countywide data layers. Maintenance and update work on these layers will take place in "gis workspace" (see next section) subdirectories under the division "/maint" directory. Separate and unique workspaces will be established for each countywide layer which the division is responsible for. Security will be in place to ensure that only authorized personnel have write access in these directories. All applications and programs residing in these workspaces will adhere to GIS programming coding standards. Maintenance work areas will be relatively stable and permanent.

The GIS project work area

All divisions in the county will have their own unique set of projects which they will be undertaking. These projects will range in duration from relatively short time periods (i.e., one week) to very long time spans (i.e., years). The common trait that all projects have is that they are temporary. The division project work area is the designated place for these projects to be housed. Each project (or phase of a project) will have its own separate "gis workspace" (see next section). When projects are completed, the data, tools, and other useful material produced will be moved to another area on the system. Data will go to the common database, the reserve, or the demo area. Useful tools will go into a tool library, etc. The remaining material which is determined to be worthless, and the workspace as a whole, will then be deleted from the system. Hence, workspaces in the project work area are relatively volatile and unstable.

The GIS demonstration work area

In Snohomish County, GIS demos will play a critical role in the coming years showing the potential of what the technology can do. Hence, complex demos, or demos with their own special databases, will be stored in separate workspaces un-
der this directory in the structure. Figure 6 is a specific example of a GIS projects work area. The basemap maintenance and GIS demos work areas are virtually identical in structuring.

**The GIS Workspace**

The standard Snohomish County workspace used in the maintenance, projects, and demos work areas is similar to a conventional ARC/INFO workspace, with a few exceptions. There are four additional subdirectories called "tools", "maps", "files", and "docs". These standard subdirectories may be used as bins to hold work material related to the particular activity. The "tools" subdirectory may also serve as a local ARC/INFO ATool directory. A
system ATOOL program, called "CREATEGIS/WORKSPACE" has been written to create such a workspace on demand. Figure 7 illustrates the county's standard GIS workspace.

Benefits and Limitations

There are a number of advantages, and some constraints, associated with this particular design. On the positive side, the directory structure:

- establishes standards that help everyone in the organization understand the system better. Once users understand how the directory system works in their own divisions, they will understand how the entire system works countywide.
- accommodates all different types of GIS activities in an organized way. Administrators have maximum flexibility in setting permissions and controlling access systematically.
- enables users to think and communicate in terms of standard places on the system.
- supports convenient and easy pathname management within macros and programs.

On the negative side, the directory structure:

- is only as stable as the organization is as a whole. If departments and divisions within the organization change frequently, this directory structure will be just as unstable.
- may be perceived as too deep and having too many levels. This can be circumvented with the use of logicals and prudent management of work area subdirectories.
- requires an investment of time for administration, education, and training. However, any system requires some amount of time invested into it to work.

Guidelines, Considerations and Lessons Learned

Much has been learned in the last six months while engineering and implementing this directory design. A few of these lessons are listed below. We hope that other GIS organizations, both established and newly forming, will be able to benefit from Snohomish County's experience.

- Listen and learn from user's requests, needs, and work habits. Use this feedback to guide the development of the structure and system standards. It is relatively easy to design a standards system for a GIS. However, it is an art to develop and implement standards which will work and which people will actually use.
- In concert with a directory structure system, try to implement a basic system of file and data naming conventions.
- Try to implement your directory structure plan early on during your overall GIS implementation. The longer that any directory structure is in use, the more difficult it will be to restructure and migrate to any other one.
- Try to keep directory depths as shallow as possible.
- Use short, pronounceable directory names which make sense.
- If you have an existing set of users who are accustomed to a system already in place, prepare for a potentially rocky transition period to your new structure. Change is sometimes a hard thing for people to swallow.

Conclusions

Snohomish County's GIS program is well underway and is due to expand and grow substantially in the future. We are just beginning to implement this particular directory structure plan, and so far it is working well. With this plan in place, and with an administrator to help manage and guide the system's growth,
we anticipate that there will be no significant database organization problems at any time in the future.

Selected Reference

Acknowledgements
Thank you to Brent Rolf, Rick Pourroy, and the San Bernardino County (CA) GIMS and OMS programming staff members for planning, writing and sharing their directory-structure design. Thank you to Kirsty Burt for sharing her insight into the art of developing and implementing system standards. Thank you to Jim Smith, Jason Henderson, Jim Box, and Don Eginton for their contributions and feedback during the course of designing this system. Finally, thank you Kim for your wonderful support on the home front.
Staffing a GIS
Rebecca Somers

Editor’s Note: In the last issue, the author discussed organizational strategies for designing and implementing a GIS. In this issue, she discusses strategies for designing a GIS staff.

Hundreds of organizations are now implementing GIS and facing GIS staffing issues. To many of them, GIS staffing means figuring out how to write job descriptions and hire trained people. They focus on job titles, job descriptions used by other organizations, prevailing pay scales, specific software and hardware skills and recruitment. This focus on the need for people with training and experience in specific GIS software and hardware environments deflects attention from the basic issues of GIS staffing.

The goal of GIS is to provide a work tool that helps people do their jobs. To accomplish this goal, an organization needs people with different specific GIS-related skills who can design, implement, manage and use the GIS. But hiring pre-trained people is not necessarily the best route for developing a competent staff. In fact, jumping straight to this step can introduce problems that include: additional expense, increasing staff size, paying GIS people out-of-scale, losing existing staff, introducing inequities in positions and pay, causing dissension in the organization, and wasted effort.

The most effective approach to GIS staffing simply involves deriving a staffing plan from the organizational GIS design-and-implementation plan. The only trick is that a GIS staff implementation plan takes time and must be started early—on the same day that an organization begins its technical implementation plans. Hiring trained staff at the last minute is not the silver bullet that will save a project, but it is often the last resort of those who delayed their staff planning and implementation activities until the last minute.

The main goal in designing the GIS staff is to provide support of GIS development and operations. Using this goal as an underlying principle provides guidance while developing the GIS staffing plans.

GIS Support Functions

While many GIS position titles have emerged over the past ten years, any organization approaching the development of a GIS staff plan should look first at their own functional needs and derive their own position titles and descriptions from those GIS support requirements. These requirements generally fall into five functional areas:

Management and Coordination

The GIS staff provides the project and organizational management for developing and operating the GIS. Coordination among GIS participants and users, and their related activities, is handled by the GIS staff.

Key aspects of the GIS to be managed include planning, requirements analysis, technical design, database design, data acquisition, hardware and software acquisition, application development, acquisition and performance of contractors and consultants, database management, staffing and organization, budgeting and funding, training and communication with the user community and management.

System Support

The GIS staff provides the necessary skills and services to ensure that the GIS software, hardware and databases are properly developed and implemented, that they operate as expected by the users.

Database Support

The GIS staff provides data administration and database management for the system and the user community. These activities include development, documentation and enforcement of data standards, metadata and related operations (such as update and maintenance), quality control and oversight of data conversion and maintenance activities. This area of responsibility may also involve coordinating and cooperating with the database management functions related to other databases within the organization.

User Support

The GIS staff must support the user community’s activities in the use and development of their applications. This responsibility includes technical assistance, special project production, training, and assistance.

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in the development of new applications and databases. The latter responsibility requires the specific ability to recognize when a new application and/or database may be beneficial and to act as a user advocate in its development.

Production

In some organizations, it is appropriate, and in fact advisable, that the production of critical databases or the provision of standard services fall under the responsibility and control of the GIS staff. Data sets that may be appropriate for centralized production are those that are used by everyone, critical in the maintenance cycle or technically complex, and may include the landbase or the cadastral base. Comparable services may include standard map production. When this is the case, two types of production support are generally needed. The first is the operation of the GIS—the input, maintenance, output, or accessing of the database. The second is the preparation of the data—research, verification, problem resolution, etc.

Positions and Staff Organization

An organization's specific requirements for GIS positions will flow naturally from their GIS requirements analysis when viewed in light of the GIS support functions described above. Likewise, position descriptions should be derived from the organization's needs (not from another organization's staff plan.) Inserting the right terminology and creating the right titles is a minor detail. It should be done at the end, as an activity in fine-tuning the plan to fit the overall organization staffing standards. A general organization model for the GIS staff is outlined in Figure 1. This model organized the functions above.

The GIS manager, project leader, or coordinator is the key position for a project or a program. The role of GIS manager may involve varying levels of effort. The Manager may be one person devoting only part of his or her time to the planning of GIS, the operation of the technology or the supervision of consultants. On the other end of the spectrum, the GIS manager may direct an internal staff of dozens. The GIS manager must have both strong management skills and GIS experience.

The person filling the role of GIS manager and the organization itself are interdependent. He or she must fit the organization's requirements and culture, management's needs and style, the technical expertise required, and management experience and style required. The manager must also fit or be able to mold the appropriate management climate for the the types of GIS people and resources available. The establishment of the proper person in the proper position in the proper role in the organization requires management skill, expertise, foresight, understanding of the organizational context and goals, and flexibility. Then the organization must empower the GIS manager to do his or her job and, in turn, must empower the staff and users to do theirs. The decision whether to hire a GIS manager from the outside or develop one from the inside is another matter of organizational culture. In some organizations, only an insider would have the knowledge, connections, and support necessary to make a GIS successful. In others, only an outsider could bring the credibility necessary to gain the required attention and action.

Under the GIS manager, there are generally three sets of positions: one handles system support; the second provides user support; and the third, if applicable, provides production or service functions.

The system support personnel provide the systems and database skills necessary to implement and run the GIS. The various responsibilities include system management, network management, system maintenance, trouble shooting, backups, capacity planning, database design, technical aspects of data conversion and database building management, data administration, data management, applications development, other interface development, documentation, and programming.

Depending on the size of an organization's GIS and its available resources, these responsibilities may be divided among several positions or all rolled into one. Obviously, the latter situation presents the greatest
challenges in terms of training and/or filling the position, but if the responsibilities are individually isolated and examined, it does not represent an insurmountable obstacle. Depending on the particular positions involved, these individuals should have strong system skills and strong GIS skills (preferably in the organization's own GIS brand). If a choice had to be made, however, it would be better to start with an individual with strong system skills and teach them GIS, rather than try to teach computer science to a GIS operator.

The user support and production positions relate to the organization's applications and data. These positions involve the use of the GIS to produce the organization's products and services. The responsibilities related to these areas include the content aspects of database design and data conversion, quality control, database maintenance, data research and resolution, database and product production, and service provision. The user-support personnel help people use the GIS—through training, answering questions, doing special projects for users and analyzing users' needs that lead to new applications and databases. The production staff consists of highly-trained, efficient GIS operators who use the system to provide production and access services, if applicable. For complex data input and maintenance operations, data technicians may be required to research, reconcile and prepare data and maps for input into the system.

Depending on the particular organization's situation, these responsibilities may be shared by a staff of dozens or handled by one person. The most important aspect of these jobs is that the individuals must understand the organization's operations and data. Unlike the technical positions, the preferable candidates would have a knowledge of the organization's operations and data, or would be in that profession. They will then be trained to use GIS as a tool. Ideally, filling these positions will simply involve providing GIS training to existing personnel, who are already doing the production and applications functions in a non-GIS environment.

Most organizations have implemented variations on this basic GIS staffing concept. Variations are dependent on the function of the GIS within the organization, the types of applications and users involved, the role and location of the production and service functions, the location of the GIS in the organization, the size and extent of the GIS, and the GIS resources. As with the position definitions themselves, the pay scales will work out if they are derived within the context of the GIS's role within the organization. Currently, GIS pay scales are an issue of some concern because of market conditions. Particular GIS skills appear to command high pay and fees, and there are also great discrepancies in salaries for most positions. Some of this variation is due to regional differences, market sectors, particular GIS software popularity, applications and fields, and differences in job content. Most attention seems to be drawn to the high salaries and fees for certain GIS skills in certain markets. However, these pay levels are often out of scale for many organizations hoping to establish GIS

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**Staffing is not necessarily, and in many cases should not be, primarily a hiring issue.**

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In addition to developing the GIS staff organization and related positions to meet the specific needs of the GIS, a number of other matters are involved in developing a staff design. Position classes must be designed so that there is differentiation, equity, mobility and career potential. These issues are common to the design of a staff and organization plan for any area of the organization. GIS complicates the matter somewhat by introducing a new technology, a long-term ever-changing implementation environment, new work processes and new relationships between organizational entities. Attention to these issues, however, is the key to establishing a solid plan, ensuring that the GIS staff and individuals fit the overall organization and retaining the individuals within the organization.

Positions. This causes a problem in many organization because of two incongruities:

- If an organization looks to the outside for guidance on GIS positions and pay scales without working out its own needs, it may be misled into pre-supposing which skills it needs in order to implement GIS, what it should pay for them, and where it should get them.
- GIS expertise is often viewed as an added skill. However, in an age where automation is the norm, this may not be an appropriate viewpoint. For example, an organization must determine whether it wants to pay an engineer for an upgrade to GIS skills. Does it, or will it, pay a higher salary for every new skill a professional learns, or is this just part of on-the-job training?

The answer to the pay issues, again, lies in establishing GIS within the context of the organization.
Staffing the Positions

Staffing the GIS positions involves ensuring that properly qualified and trained individuals occupy the appropriate positions. Staffing is not necessarily, and in many cases should not be, primarily a hiring issue.

Training

Training is not just an event that occurs when the system is installed. Training is a critical element throughout the process of GIS planning, development and operation. Different types and groups of people will need different training at different times.

For an organization that plans to implement GIS as an integral part of its operation, the GIS staffing problem actually becomes a GIS training problem. Training is also key to retaining staff. No organization wants to run a GIS training shop—it wants its professionals to develop GIS skills as part of their professional toolkit, and thus enhance its workforce. Many organizations, unfortunately, have experienced the revolving door syndrome — they hire and train GIS staff, who then leave for higher-paying GIS jobs. Some of this is due to temporary demand and supply imbalances in the market place, and can’t be remedied. The key to avoiding unreasonable training costs and losses, however, lies in the original staff planning strategies. Staff retention depends on training, career opportunity and job satisfaction.

Hiring

Hiring should be a last resort. GIS is a tool for the users and staff within an organization. It represents a new technology for doing existing work (even if the work process is "re-designed"). Therefore, existing personnel should be trained to use the GIS within the course of their work — whether that is cadastral mapping, utility design and drafting, permits processing, planning, marketing or any other function.

If the implementation of GIS causes an increase in workload, it would seem to follow that additional hires are called for. The problem with this reasoning, however, is that the cost/benefit justification for implementing GIS was that it would save staff time. Therefore, in most cases, what is needed is a shift in staff resources. This shift, however, is difficult to accomplish in most organizations. Recent work in reengineering work processes and redesigning organizations based on new processes is just beginning to show results. It appears that this is the model that GIS users should be following — not the traditional one of bringing in GIS technology and then "staffing up" to accommodate it.

Even if additional manpower is called for, in many cases careful analysis would reveal that the positions needed are professional, not strictly technical GIS. Some organizations hope that they can accelerate their GIS implementation by hiring outside GIS expertise. The problem with this approach is that they then have to train these people in their applications, data, organizational procedures, and perhaps profession. This training task is more formidable than training professionals in the use of GIS.

If the organization is performing a short-term GIS project, particularly a one-time and/or short-deadline effort, then hiring GIS expertise is probably the best route. Depending on the duration of the project, either hiring trained staff or renting consulting resources may be best. Through this approach, an organization usually pays less than it would to develop expertise in-house, but more significantly, they can get the job done on time and do not have to support the GIS personnel when the work is over.

Most organizations, however, are looking at supporting some level of continuing GIS effort within their organization. Given that GIS was supposed to make operations more efficient and cost effective, the GIS staffing process should be preceded by the work design incorporating GIS and the resulting position descriptions.

Designing a GIS Organization and Staffing Plan

While the models outlined in this article have proved successful for many organizations, this is not an indication that they should be adopted as-is, or that one organization's GIS organization and staffing plan should be entirely transplanted to another organization. While the basic concepts of the models remain relevant, each organization is unique. The basic concepts inherent in a model may be used, but a model is just a model, not a complete solution.

Many of the issues involved in the development of a GIS staffing and organization plan are common to the human resources and organizational design methodologies inherent in the development of a staffing plan for any organizational function. GIS, however, does present a few unique challenges.

Evolution of GIS in the Organization

The most challenging aspect of GIS staffing concerns the evolution of GIS development and use within the organization. The tasks, and therefore, the personnel requirements, will vary widely over the duration of the effort from initial inception and design, through design and data conversion and into ongoing operation and applications. Individuals who performed the initial database design or data conversion might not be suitable for applications support and production.
There is a wide spectrum of staffing alternatives over the course of GIS development and operations. Staffing requirements, and thus available skills, will change. The challenge is to design and implement a staffing plan that will evolve with the system. This could result in a fluid staffing plan or one that has fixed configurations for specific stages of the system development. Potential solutions include contracting out design tasks; contracting or short-term hires for data conversion; training positions for data conversion that then become full-time applications support; full-time positions only for the operational stage, etc. An organization may go through many staff arrangements throughout the life cycle of the GIS. And these changes affect people as well as the positions in the organization chart.

Another way to look at it is as the rise and fall of a GIS staff — organizing a highly visible GIS staff for development, and then integrating the operational responsibilities into positions in line units of the organization. In many cases, if a GIS implementation has been done correctly, the GIS will virtually disappear into the organization over time.

Obviously, in order to design your target organization, you have to know what your target needs are. This points again to the need to plan the GIS staffing activities early.

Conclusions
While there are no simple formulas for successful GIS organization and staffing, solid, useful models and valuable experiences have arisen from many organizations' GIS implementation experiences over the last two decades. In addition to the models presented here, some key principles include the following:

- An organization must understand its GIS staffing and use requirements in an organizational context, including short- and long-term goals and visions.
- A GIS must be fit into an organization through the positions it involves. Staffing is an important vehicle for GIS integration.
- Organization and staffing plans are an integral part of the GIS planning and implementation effort. An organization should begin its GIS organization and staffing plans at the same time it begins its GIS concept planning. Waiting too long has been the root of many organizations' problems.

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PHOTO CD: A Digital Solution for Storing and Using Aerial Photos

Brian Huberty

For the last 20 years, United States Department of Agriculture (USDA) agencies have been acquiring 35mm slides. Lots of slides. There are probably close to one million 35mm aerial photo slides archived throughout the Wisconsin Consolidated Farm Services Agency (CFSA—formerly the Agriculture Stabilization and Conservation Service) field offices. They are the result of the CFSA’s Supplementary Aerial Compliance (SAC) program. Across America, it is estimated that the number of archived slides is close to a billion.

The USDA Natural Resources Conservation Service (NRCS—formerly the Soil Conservation Service) uses these slides to map and monitor agriculture, soils and other natural resource features. This relatively large, unknown aerial photo program has proven to be cost-effective by substantially reducing the time required for expensive field checking. SAC also demonstrated the utility of 35mm aerial photography as contrasted to traditional, expensive large format (9x9-inch) aerial photography or even more expensive coarse-resolution satellite imagery. The images are used for a host of purposes:

- to evaluate crop-compliance programs,
- for the National Resources Inventory,
- windbreak surveys,
- wetlands mapping, and
- other farmland conservation projects.

Because of the large number of slides, accessing these images in a timely, cost-efficient manner is a necessity. The NRCS Wisconsin State Office has developed a program to digitally scan these slides using the Photo CD system. It is a quick and efficient means for scanning SAC slides at a very high resolution.

Plus, the full-color images are stored in a compact, lossless, standard format on CD-ROMs. Ultimately, these images will be directly geo-referenced for easier access by USDA geographic information systems (GIS).

Image Access

Quick and easy access to information is becoming mandatory in a world where information generation increases exponentially every day. The manual method of pulling and using SAC slides over a particular farm from year to year requires massive amounts of time and energy. For example, if you want to compare crop types and acreage patterns over a ten-year period for a farm, it would require:

1. finding the slides,
2. enlarging the slides onto prints at a nominal, working scale,
3. cutting and mosaicing prints to cover an entire farm,
4. identifying and measuring crop types and tracts,
5. assembling different years to show trends, and finally
6. printing a report and map depicting farming patterns.

This process can literally take weeks to accomplish. Some parts may not even be possible given the current tools available to USDA offices. However, it is possible to complete this example in a couple hours with a Photo CD system.

Photo CD

Recently, professional photographers were looking for ways to store and manipulate photographs digitally. Eastman Kodak created the Photo CD system to help solve this problem. Kodak wanted to come up with a system which can scan 35 or 70mm slides quickly and store them efficiently without using large amounts of computer disc space. (When one doubles the film-scanning resolution from 500 to 1000 dots per inch (dpi), for example, the computer information storage requirement quadruples!). Kodak uses the Photo CD disc (physically similar to music CDs) because it is inexpensive ($3.00/disc), a standard (ISO 9660), and holds a large amount of images per disc (over 100). The Photo CD format can be read into DOS, Windows, Macintosh, and UNIX-based computer systems provided you have a multi-session CD-ROM reader.

Compared to other methods of scanning photos into a computer, Photo CD uses a faster, higher resolution (2048x3072) scanner with a large capacity feeding mechanism for either slides or negatives. It also uses a compression format (PCD) which does not lose image informa-

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tion during image compression and decompression like JPEG or other image compression formats. (For more detailed information on the PCD format, refer to the 1994 John Larish book titled, *Photo CD*.)

The Photo CD images can be displayed on both televisions (with a Photo CD-compatible or multi-media player) and computers (with a multi-session CD-ROM drive) without the need for conversion or frame grabbing. This feature was incorporated into the image-storage compression structure on the Photo CD. This means images can be quickly displayed and manipulated by users at home or at the office with the proper equipment.

The Photo CD system consists of two parts: the scanning system and the user system. Film or slide scanning is performed in a production environment at your local photo...
FIGURE 2. An enlargement of University of Wisconsin-Madison's Camp Randall football stadium. Produced on a Hewlett-Packard 4M continuous-print printer at 600 dpi.
dealer. This eliminates the need for the user to buy expensive scanners, color printers, computer workstations, and scanning software. It also saves time because the user does not have to waste time scanning or maintaining the Photo CD scanning computer system. Cost is roughly $6.50 to $15.00 per slide depending on who does your work and how they do it. The user system consists of any Macintosh, Windows or Unix computer with a multi-session CD-ROM drive and software to read Photo CD (JPCD) format images. To the best of my knowledge, Adobe Photoshop, Aldus Photostyler, Corel Draw, Hijac Pro, Kodak Photo Edge, Kodak Shoebox, and Kodak Access software will read the Photo CD format. There are probably others as well. As with any software, they all have a variety of features which may or may not suit your needs.

Here’s an example of how well Photo CD works: If I were to hand you two 8x10-inch color photo enlargements—one made from the original slide, the other from the Photo CD disc—you could not tell the difference unless you had a magnifying glass. That’s how good the Photo CD system is compared to others (See cover). Remember, Photo CD images are much better if printed on full-resolution, photo-quality color printers.

Figure 1 shows a SAC slide that has been scanned onto a Photo CD and printed using a Hewlett-Packard 4m laser printer at 600dpi. The photo shows the University of Wisconsin-Madison campus. Figure 2 is an enlargement of Figure 1 centered over the football stadium in the center of the picture. With this image, you can start to discern the individual pixels. Pixel size and quality will vary depending upon the original SAC photo scale, season, film type and camera.

Photo CD/GIS Link

Currently, Kodak Shoebox is the database software being used to make a ‘crude’ geo-link between the scanned aerial photo and its location. This geo-link is nothing more than connecting user-defined fields of section, township, range, county, date-of-photography, etc., within Shoebox to each unique scanned slide number and Photo CD identification number. Obviously, this is a weak link in today’s GIS environment, but it’s affordable and it works.

Since the Photo CD system is so new, only one GIS system (TNTmips) is planning to develop the means to read this format directly. However, the Photo CD images can be translated into TIFF, TGA, Bitmap or whatever file format your GIS can read. Realistically though, with a million SAC slides for Wisconsin alone, Photo CD format conversion to another type is not feasible.

Progress

The idea of getting better access to CFSA slides started here in Wisconsin in the early 1990s, when Dane County (WI) acquired a video camera-based system to ‘capture’ slides onto a large video disc. Columbia County followed by getting a digital version with an in-house scanner and WORM CD-ROM drive mated to a 486 computer system. Both systems worked quite well and are still in use today.

In 1993, this author was asked to review the two existing systems to see if NRCS should use one of them for the rest of the Wisconsin NRCS offices. After extensive research, the newly emerging Photo CD system had the best overall features. Five pilot counties (Fond Du Lac, Jefferson, Kewaunee, La Crosse, Rusk) scattered throughout Wisconsin were chosen to demonstrate the tool’s utility. About 10 continuous years of slides were scanned during the summer in 1994. The total scanning cost for these five counties was about $25,000. Half the cost was shared by each county Land Conservation Department. Another five counties will be chosen for 1995. Michigan State University has taken a similar approach. They are having 55,000 slides covering the entire state scanned onto Photo CDs, but just for the year 1991.

Conclusion

The Photo CD system is rapidly becoming a standard for photo capture and storage thanks to high-resolution scans and lossless compression. These are some of the advantages:

- fast scan rate
- very high resolution: 2048x3072 dpi
- tv or computer display
- scanning by film shops
- many software tools
- low-cost CD-ROMs
- duplication of CD-ROMs
- easy-to-use database
- fast display time
- multiple resolutions
- portable
- Windows, UNIX, Macintosh compatible

The GIS component will eventually mature. In the meantime, the immediate goal of faster access to 35mm photos has been met by using the Photo CD system. The result: USDA personnel can do their job faster, more efficiently, and at a lower cost.
Acknowledgements

Special thanks to all the participating Wisconsin County Land Conservation Departments that have foreseen the tremendous impact of this new 'mapping' tool. These departments have stepped forward to fully fund the computer hardware and software (due to federal limitations) necessary to use the scanned aerial slides efficiently in addition to sharing the scanning costs with Wisconsin-NRCS. Because of this foresight, the slide scanning program is a success.

Note

Trade names are used solely to provide specific information. Mention of a trade name does not constitute a guarantee of the product by the U.S. Department of Agriculture, nor does it imply endorsement by the Department or the Natural Resources Conservation Service over comparable products that are not named.

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GIS and Neighborhood Planning: A Model for Revitalizing Communities

James A. Myers, Michael Martin and Rina Ghose

Neighborhood planners in cities need a process that includes citizens, in particular low-income and minority residents of older urban neighborhoods, in public planning and decision-making. Citizens’ knowledge, experience, creativity and participation are essential to creating successful solutions to existing urban problems. Their unique perspective as residents is a critical missing element of the public data and discourse available today.

Two years ago, in Milwaukee, Wisconsin, a team of graduate students developed a proposal for applying GIS to neighborhood planning. The students, working in an applied GIS course in the Department of Urban Planning at the University of Wisconsin-Milwaukee, approached the Metcalfe Park Residents Association, an inner-city neighborhood group, with their proposal: Would the residents be interested in using and learning a tool that could help them more easily access, view, and use public information? Would the residents be interested in learning GIS?

Presenting the Proposal

Their proposal would allow residents to more fully participate in decision-making over how public and private resources are allocated within their neighborhood. The process would use GIS to visually display spatial data, making public information more accessible to them. Residents with no prior computer experience would be able to quickly and easily search city-created data files and view this information in tables or on maps. The GIS computer software would make this public information more usable by providing tools for analyzing the data.

Through this analysis, spatial relationships highlighting housing problems and other neighborhood issues could become highly visible where previously they went unnoticed. Equipped with new insights into the problems and GIS maps to display their findings, neighborhood residents could more effectively and convincingly communicate with other residents (insiders) and non-residents (outsiders) about what had happened and what is happening in their neighborhood. They could then communicate their plans for what should happen by including their diverse wants, needs, assets and constraints in addition to their unique knowledge and experience as residents of the neighborhood.

The Metcalfe Park Neighborhood

Metcalfe Park is a mixed residential and industrial neighborhood in central Milwaukee (Wisconsin). The neighborhood is bisected by an industrial corridor. It includes a public library, several churches and not-for-profit community-based organizations. The dominant land use is residential, consisting of mostly detached duplex and single-family dwellings. The poverty rate in this neighborhood is 54 percent. The resident population is majority African-American. Most of the residents are renters rather than homeowners. This neighborhood, like many older central-city neighborhoods in America, has experienced serious problems: unemployment, industrial relocation, commercial and retail-business decline, residential disinvestment, increased crime, poor schools, aging infrastructure and old residential structures that contain hazardous asbestos and lead-based paints.

In 1990, the city of Milwaukee departments and agencies focused their efforts within this geographic area. The planning department named the neighborhood Metcalfe Park and created the Metcalfe Park Residents Association. The Association consists of a board of directors and subcommittees on housing, crime, and sanitation. The residents

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participating in this project were members of this housing subcommittee. They had been working on neighborhood housing problems as a subcommittee for over a year. This resident group consisted of two women and six men, of which seven were African Americans and one white. Seven were homeowners and one a long-term renter.

A goal of the project was to include and train the community organizer, who is a paid staff person of the residents’ association, in using GIS so that the project would continue beyond this limited course project.

Setting up the Process

This project was designed to progress from low-technology planning activities to those requiring high-technology computer systems. The residents began with field surveys, paper maps and paper lists of data; then the students introduced a computer and a database, and finally the computer system for putting the data and the maps together.

This paper-to-computer method, based on William Huxhold’s GIS County exercise (see Huxhold 1991, p.142), helped introduce the residents to GIS through a gradual and logical process. It allowed them to focus on learning the concepts, rather than the technology. With access to public information and a good understanding of the concepts, even without computers, the residents could manually collect data, map it and analyze it.

This paper-to-computer process provided the residents with new skills, confidence and independence. By receiving training in the use of ArcView™ GIS software they were less dependent upon others to do their planning. Technical experts using advanced technology still played a critical role, however. Several students working in ARC/INFO® created the GIS for the Metcalfe Park Neighborhood making the training in ArcView™ feasible.

Step 1: Needs Analysis

The students and residents first met in Metcalfe Park to discuss the scope of the project and to determine the residents’ data needs. The residents described the neighborhood’s housing problems and the work they had been doing. The residents’ experience and knowledge of these problems was both extensive and impressive. They identified the information they needed such as ownership, building code violations, abandoned properties and zoning requirements. Fortunately, the Milwaukee Master Property File (MPROP) database, the city’s data on each parcel of land within the city, had most of the data they needed. Data on vacant lots and boarded-up properties were not included in the MPROP; a field survey of these properties was needed. The residents, describing the work of their sanitation subcommittee, suggested also identifying sanitation problems when conducting this field survey.

Step 2: Field Survey

The students and residents went through the neighborhood collecting data on boarded-up properties, vacant lots and sanitation problems.

Survey information was transferred to a paper map of the neighborhood, using colored dots to represent various property conditions: different colors for owner-occupied homes, for investor-owned properties, for boarded-up properties, and for vacant lots (Figure 1). With this paper simulation of a GIS, the residents were introduced to the concept of spatial analysis. Colored dots allowed them to see property patterns they had not seen before.

Step 3: Introduction to Database and Data Center

Next, at the Milwaukee Associates for Urban Development (MAUD) Data Center, the residents were introduced to a paper form of MPROP consisting of numerous boxes of computer printout. Each resident looked up his or her address in the printout. A user-friendly computer interface to the MPROP allowed the residents to see how the computer simplified and sped up the research process. They could see how presenting data spatially made analysis easier and how computers reduced the time needed to gather information.

Step 4: The GIS Training Sessions

Training sessions were conducted in the GIS computer lab of the Univer-

![FIGURE 1. Metcalfe Park Vacant Lots 1993](image-url)
sity of Wisconsin—Milwaukee, School of Architecture and Urban Planning. The students trained the residents in the use of ArcView™ software. This software uses a windows interface making it easy to use for computer novices. Four training sessions were organized, each a little more advanced than the last. Previous sessions were reviewed at each new session to reinforce the skills already learned.

One of the computers was connected to an overhead screen so that the residents could follow all the steps on their computer terminal (Figure 2). A student instructor shared a computer with two residents. The training incorporated an interactive instruction method based on hearing, seeing and doing. The residents would hear a description of the lesson, see it demonstrated, and then try it themselves.

The first two sessions covered the basics: how to perform computer functions and some simple analysis in ArcView™, such as color, legends, and class values. These sessions opened up possibilities for using GIS capabilities.

By the third training session, residents were learning how to use GIS to analyze a problem specific to their neighborhood and how to work around the limitations of the database. The residents decided to use this session to gather information about properties owned by problem landlords. The students demonstrated the various names and methods landlords can use to confuse ownership records and how to work around that problem. What interested the residents the most was the ability to get a visual record of these properties within minutes (Figure 3). They were able to identify properties that they had not known were owned by a particular landlord. By the end of the session, the residents were building their own queries covering topics from problem landlords to building-code violations. They were gathering the information they had identified in their earlier needs assessment. The residents were pleased with how quick and easy this was compared to time-consuming visits to City Hall to track down information on a property or owner.

The fourth training session was structured differently. The resident's compared their queries and computer-generated maps to the paper maps and surveys they had created at the project's beginning. The comparison helped them understand and reinforce the connection between public information, GIS and neighborhood planning.

They also clearly saw that, while technology and computer skills were powerfull tools, it was their own knowledge, experience, creativity and participation that would ultimately make a difference in creating successful neighborhood solutions. Their insights and unique perspective as residents of this neighborhood were critical. Not only could they identify what was old or inaccurate in the public data-base, they could collect additional data at the street and block level that would improve the public data.

The data collected in the sanitation survey were separated into distinct waste categories: old automobile tires, abandoned vehicles, household trash, hazardous waste, old appliances and yard waste. With the location and type of waste identified, the residents were able to notify the specific city departments responsible for pick-up or enforcement of that waste. In addition, they had a record of the sanitation problems on a specific date; therefore they could monitor changes and the city's response. This simple analysis brought out other ideas. On blocks where sanitation problems were concentrated, garbage dumpsters were ordered from the city and block clean-ups organized by the residents.

A Model for Citizen Participation

There is a growing need for decision-making processes that involve citizens—in particular low-income and minority residents of older urban neighborhoods. People of color,
renters, youth, elderly and the poor are groups that too often have been left out of traditional planning and community development. This project is a model for a newer, more visionary planning process needed in our inner cities. It can help put the power of resource allocation into the hands of the people who need the resources—the residents (See Note 2). In short, the model can help create a civic environment where participation and planning are more constructive, proactive and informative.

At the core of this model is GIS. Its powerful concepts, mapping and visual display capabilities, its capacity to integrate many different layers of data, its user-friendly windows interface and speed make public information accessible and usable for neighborhood residents. John Landis, a professor at the University of California, Berkeley recently suggested the beginning of a new phase in the use of GIS called the "Era of Modeling," where "GIS will be used to improve and democratize public and private decision-making." (Landis 1994)

The Role of Universities

Applying this model to neighborhood planning as described in this paper, provides a model for urban colleges or universities as well. It demonstrates the role these institutions can play in community revitalization. Urban universities have a responsibility towards improving the communities in which they are located. And often, these universities possess significant human and other resources that can be applied to community development. To encourage universities in taking a more active role in community revitalization, the government is providing financial incentives. For example, HUD has been awarding grants to San Francisco Bay Area universities for this purpose (Oakland Tribune 1994). Recently, HUD together with SEEDCO announced a competition for $14 million in financing to establish "Centers for Community Revitalization." In this announce-

ment, HUD Secretary Henry Cisneros stated, "A university's considerable store of knowledge and expertise is a resource that should be put to use by the community. This program is a great way for colleges and universities to show that they're a part of the neighborhood and the city, not a walled off preserve whose location is almost a coincidence."

While this funding is needed and appreciated by those within the university who want to meet this challenge, the structure of universities has traditionally discouraged faculty and students from active involvement in the neighborhoods that are most in need of revitalization. Today, universities need models that provide a process for their involvement in, rather than study of, community revitalization.

Increasing the access and use of public information is a critical role for universities in revitalizing community. By applying GIS to neighborhood planning, students and faculty at universities can provide the expertise and training necessary to help residents achieve their goals and help revitalize the surrounding community.

Acknowledgements

The project participants thank Professor William E. Huxhold and Mark Roth of the UVM School of Architecture and Urban Planning, Professor Michael Barndt and Chris Wenders of the Milwaukee Associates in Urban Development (MAUD) Data Center, and the Environmental Systems Research Institute, Inc. (ESRI) for their generous assistance.

Also thanks to:


Student Team Members: Kurt Davis, Rina Ghose, Ernest Hafner, Dale Mohr, Dave Morek and Brenda Werner.
1. The Police Department in Oakland, California is using GIS to map drug activity. "And there is an added advantage of being able to take these maps to community meetings and showing the people what is going on," he (police officer) said (McLeod, 1995). While this is a more limited use of GIS with neighborhood residents than the model described in this paper, the fact that Oakland has the GIS in place and is beginning to see the potential for citizen participation with GIS is encouraging. The project described in this paper can be used as a model for community participation in Community Policing efforts not just in Oakland, but in other cities as well.

2. Meaningful citizen participation results in improving the decision-making about resource allocations by making it more fair and effective. "In 1981, Madison's Community Block Grant Commission took a hard look at patterns of neighborhood funding. It realized that most city assistance was going to those neighborhoods that were the best organized, not the most needy." (Bewitz, 1994). A process for meaningful participation of those citizens that have been traditionally excluded due to income, race, gender, age, geographic location, etc. is essential and urgently needed.

Some communities, like the City of Madison and City of Milwaukee are starting to recognize this. The City of Milwaukee is now requiring neighborhood planning as part of neighborhood groups' requests for city CDBG funds. While this is a positive step forward, it appears that the planning taking place does not include the most needy residents in any meaningful way. Therefore without a good neighborhood planning model, these efforts will likely result in the same outcome observed in Madison.

Neighborhood residents are "empowered" when they are able to plan and make decisions about the allocation of resources within their neighborhood and community. The term "resident empowerment" is used often in community development projects, but rarely are these residents afforded the power to decide where and to whom resources are allocated.

Selected References


Guidebook for Community-Based Strategic Planning for Empowerment Zones and Enterprise Communities." U.S. Department of Housing and Urban Development, HUD-1443-CPD.


1995 Exemplary Systems in Government: Achievement and Excellence in the Public Sector

Edward U. Graham

Each year, URISA honors deserving governmental agencies for excellence in automation through its Exemplary Systems in Government (ESIG) Awards. The ESIG awards program is a showcase for systems that are both highly effective and well designed and implemented. The traits that characterize ESIG winners include knowledge, vision, teamwork, perseverance and skillful management. Since its inception, the ESIG awards program has recognized more than 75 public sector agencies for their successful projects.

The ESIG awards recognize systems that have cut costs, solved a nagging operational problem or improved services, while sustaining both user and budget support. This year, from a highly competitive field, the winners are: Small Municipality Systems category: Barry County, Michigan (USA), for the Barry County GIS;

Operations Automation Systems category: Albuquerque, New Mexico (USA), for the Site Environmental Audit System (SEA); and

Corporate Systems category: City and County of San Diego, California (USA), for the Regional Urban Information System (RUIS).

Several entries received honorable mention. Three counties earned an honorable mention in the Operations Automation category. They are Mecklenburg County, North Carolina (USA) for GIS Precinct Splitting Application; Pinellas County Florida (USA) for Land Information Management System (LIMS), and Prince George's County, Maryland (USA) for GIS-Based Flood Management Simulation Model. Queensland (Australia) earned an honorable mention in the Corporate Systems Category for Geographic Information for Public Safety (GIS). In addition, the Department of Natural Resources Canada received an honorable mention for the Delta-X system in furthering the goals of the National Spatial Data Infrastructure (NSDI).

The ESIG Competition
The ESIG Awards competition is one of URISA's key annual events. All URISA members are encouraged to nominate a potential applicant or apply themselves. Each attendee at the Annual Conference receives an ESIG nomination form. In the fall, URISA mails ESIG application forms to all nominees and the full URISA membership. Applications are due in February and distributed to the ESIG Review Committee (see table) for consideration.

The Committee uses five criteria to evaluate each application:

- The degree to which the system is exemplary;
- Quality of design;
- Quality of implementation;
- Organizational impact; and
- Effective use of resources.

The winners are notified in May. The award ceremony is part of the opening program at the annual URISA Conference. ESIG winners are also featured at Project Showcase.

1995 ESIG Winners
As in the past, ESIG '95 recognizes winners in three categories:

- Small Municipality Systems, where the system has produced exemplary results in a jurisdiction with a population less than 100,000;
- Operations Automation Systems, where the system has automated a specific set of operations or procedures resulting in substantial improvements in efficiency, service or cost-effectiveness; and
- Corporate Systems, where organizations have implemented comprehensive systems crossing a wide variety of functions producing broad improvements in service.

In addition, ESIG '95 introduced a new category for systems that promoted the goals of the National Spatial Data Infrastructure.

Small Municipality Systems: Barry County GIS
Barry County, Michigan earned its ESIG award by showing that a small jurisdiction with limited resources can develop an effective GIS. Barry County mixed the right proportions of vision, perseverance and support to produce a system expeditiously and at low cost. The
county quickly exceeded the original goal of accurate, up-to-date parcel maps and now supports many users, ranging from police detectives to school districts.

Through the 1980s, map users throughout Barry County had to contend with outdated, hand-drawn maps covering the County’s 27,000 parcels. This violated a state mandate and impeded the work of many county and township departments. The drive to automate began in late 1989. The early success of a small pilot parcel-mapping project and a central dispatch 911 service map was enough to justify creating a mapping department and helped ensure financial support from individual townships for data conversion.

The mapping group now supports over a dozen departments with a variety of applications. In one case, an engineering firm with a county contract was able to lower their fee by several thousand dollars because of the availability of good quality maps. The planning department makes routine use of the system in notifying property owners who may be impacted by impending land use changes. The county’s 911 program is heavily dependent on the GIS.

Barry County has shown that it is possible to accomplish a lot with limited resources. The system revolves around three IBM compatible PCs. The system’s database software is FOXPRO. Spatial manipulations are performed using Michigan State University’s C-Map, but is being replaced by MapInfo. Raster needs are met by IDRISI from Clark University. The total hardware and software costs to date are under $25,000. The system is supported by two dedicated staff.

For more information, contact David Shinavier, GIS Coordinator, Mapping Dept., 220 W. State St., Hastings, MI 49058.

Operations Automation Systems: SEA
The city of Albuquerque earned its award with a well-conceived and executed system supporting environmental assessments of sites involved in real estate transactions. The Site Environmental Audit (SEA) system provides greatly improved service and is self-supporting.

The Superfund law added a new dimension to many real estate transactions. The purchaser of a contaminated site risks assuming a major cleanup liability, despite lack of responsibility for the original contamination. Since Superfund, environmental site audits have become standard procedure for most commercial and industrial real estate transfers. These audits are typically performed by environmental consultants and generally involve searching the records of numerous governmental agencies.

Albuquerque’s Health Department faced a growing demand for services while coping with severe budget constraints. They teamed up with the city’s GIS staff and conceived of a GIS application that effectively combines site information from various agency databases and produces an easy-to-use site report. Before SEA, consultants spent up to four days researching and preparing a site report. Today, they receive the finished product within 24 hours of placing the order.

After an initial pilot test, the city worked with its customers to modify the product to meet ASTM environmental audit standards and reduce the cost to an average of $130 to $160 per site. The improved product, reduced cost and effective marketing resulted in increased revenues. The standard report includes three distinct maps, each displaying appropriate known or potential contamination information.

The system hardware includes a Sun S690 fileserver and a Sun Classic workstation. The software components include ARC/INFO and dBase III. In addition to the set of databases available from the city’s GIS, SEA accesses six environmental databases that contain a wide variety of contamination information.

For more information, contact Gloria Cruz, Environmental Services Information Team Leader, PO Box 1293, Albuquerque, NM 87103.

Corporate Systems: RUlS
Over ten years ago, the city and county of San Diego produced a vision for a strong, multiparticpant GIS. This vision, the consistency of their support and an innovative approach to system management, earned the ESIG award. The Regional Urban Information System (RUlS) also deserves credit for the public-private partnership that substantially reduced costs and the adaptation to changing technology.

The concept for RUlS emerged in 1984. Officials from the city and county recognized the potential for GIS to address growth management, environmental problems and a range of other issues. They also were aware of the value of cooperation. The conceptual design model identified 24 generic applications from environmental management to emergency dispatch. The conceptual design step was critical in that it validated the integrated approach and helped identify the sequence for implementation.

A key milestone in database conversion was the 1990 agreement between RUlS and San Diego Gas and Electric Company (SDG&E). Under this agreement, RUlS licensed SDG&E’s base map at no cost while SDG&E gets all base map updates and enhancements for ten years. By late 1991, base map conversion, in-
cluding quality control, was complete.

Building and sustaining user support was anticipated from the beginning. Given the long period for complete implementation, a few early "successes" were planned for early stages. A joint city-county building permit system was implemented in 1987, followed soon by a Road Information Module. These also helped maintain the essential support of elected officials.

Particularly noteworthy is the organizational structure. The city of San Diego owns the San Diego Data Processing Corporation (SDDPC), a not-for-profit entity that provides the hardware, software and telecommunications required by RUIS. SDDPC employs 25 GIS analysts and 22 data conversion technicians. This is complemented by a variety of technical and administrative committees and appropriate liaison with the wide range of users.

RUIS has had an increasingly large impact. Eleven of the original 24 applications are fully implemented. Ten more are either partially implemented or are under development. One estimate projected a $165 million savings of savings. Much of this is attributable to the elimination of many expensive manual drafting processes.

RUIS is a client-server GIS, using UNIX workstations and personal computers. The central file server is an IBM RS/6000 Model 950 with 30 gigabytes of memory. There are a total of 40 workstations at 12 sites. RUIS depends on ARCGIS for its GIS capabilities and Ingres for database management. RUIS cost $9.9 million to develop. Annual operation and maintenance costs are $3 million.

For more information, contact William J. Bamberger, Manager, GIS Services, San Diego Data Processing Corporation, 5975 Santa Fe Street, San Diego, CA 92109.

Honorable Mentions in 1995

Operations Automation Systems:

GIS-Based Flood Plain Simulation Model

Prince George's County, Maryland has created a powerful and effective environmental tool by integrating a set of stormwater management models with its GIS. The GIS-Based Flood Management Simulation Model is particularly useful because its graphical user interface makes it accessible to planners and engineers without detailed knowledge of GIS. Its marketing agreement with the consultant who supported the county, ensures that the system will continue to be enhanced and provides royalty revenues.

Prince George's County lies in the coastal plain and is a rapid-growth area. Watershed flood-management studies are particularly important for regulating new development, identifying potential flooding problems and evaluating alternative solutions. The county recently completed a 15-year watershed modeling effort, at considerable expense. Further, developers are required to conduct flood management studies for their development sites.

Considerable resources, public and private, are devoted to flood management studies. The county had a real need to develop a system that would provide faster and more accurate watershed flood management studies, reduce cost to developers and more accurately predict the cumulative impacts of all development activity.

The system has benefited internal and external users. The county estimates that a county-wide update of the watershed studies could be reduced from 12 to two years. For developers, a typical floodplain study can cost $25,000. With the system, this can be reduced to several thousand dollars.

The system integrates widely used water resources models with the county's GIS. It operates on a Sun Sparc-station configured with 32 MB of memory and 1 GB local disk storage. The computer is networked to other workstations and microcomputers. The system software includes ESRI's ARC/INFO, Network and GRID products and Innovative System Developers' GEOGUIDE graphic user interface. The models are FORTRAN executable code from the USDA and the Corps of Engineers.

For more information, contact Stan Wildeson, Manager, Watershed Protection Branch, Dept. of Environmental Resources, 9400 Peppernut Place, 6th Floor, Landover, MD 20785.

Operations Automation Systems: GIS Precinct Splitting Application

With yet another example that GIS applications can dramatically improve a well-established government function, Mecklenburg County, North Carolina earned recognition for its GIS Precinct Splitting Application. The process of adjusting election precinct boundaries is long, tedious and prone to error. However, when population densities change, precincts have to be created or adjusted.

Mecklenburg's Board of Elections was the first department to request development of an entire system running under GIS. The motivation was clear. The manual process required six persons working five to six months, and was done only when necessary. The cost-effectiveness and productivity benefits are clear. The total development effort took one GIS programmer analyst 26 hours at a cost of $728. A precinct split can now be analyzed and completed in less than 30 minutes.
This application has produced a number of benefits. In addition to improved accuracy and internal productivity, the county reports reduced congestion and lines at polling places and shorter travel time to the polls.

The County's GIS uses ARC/INFO running on a Sun IPX workstation.

For more information, contact Marsha Hinde, Application System Manager, Data Processing Department, Charlotte-Mecklenburg Government Center, Charlotte, NC 28202.

Operations Automation Systems: LIMS

Pinellas County, Florida's LIMS system is an example of a comprehensive, unified land management system. While it has taken a number of years to realize the original vision, LIMS' success derives from the strength of that vision and the quality of the implementation process.

The county's rapid growth and the desire to foster responsible development led to the concept of an automated and integrated Land Information Management System (LIMS). Phase I called for the automation of various permitting functions. A key objective was to better understand the critical relationships between land use, zoning, transportation, infrastructure and development. The essential function was to provide systems that would promote coordination, validation and proper sequencing of land development processes and to bridge the gap between geographic and non-geographic information.

Development of LIMS followed a systematic progression. Needs assessment identified seven primary systems for development, including GIS and infrastructure management. System acquisition reflected the desire for a single hardware platform. Application development was based on the idea of zero redundancy. Implementation Phase I included co-locating all departments with permitting responsibilities, with applications designed to support this one-stop shopping environment. LIMS provides services to a wide variety of users from Public Works to private sector developers. A recent example illustrates the value of the system. A manual search to locate and distribute notification letters for a road project took three man-weeks. A comparable search by LIMS took four minutes.

LIMS is built around seven IBM RS/6000 servers and 35 DEC, SUN and HP workstations; 250 PCs are also tied into the system. LIMS' GIS software is VISION. Oracle is the database management software. The initial cost was about $42 million. Annual costs, including personnel, are about $1 million.

For more information, contact Donald Lord, GIS Applications Manager, 400 S. Ft. Harrison Ave., Clearwater, FL 34616.

Corporate Systems: GIPS

The state of Queensland, Australia is as large as Great Britain and Western Europe combined. It has a coastline of 7,400 km. Its population of 3.2 million is mostly concentrated around Brisbane and the coast, but much is widely dispersed in small rural settlements. In addition to normal urban emergency problems, Queensland confronts a wide range of natural hazards, including cyclones, storm tides, floods, droughts and bushfires.

All of this presents a huge challenge to police and emergency-service providers. Effective public-safety work requires access to appropriate geographic information. Prior to the development of the Geographic Information System for Public Safety (GIPS), public safety staff depended on local knowledge and paper maps of widely varying quality and coverage.

GIPS has changed all that. In 1990, Queensland decided to view their emergency and police service providers as a corporate entity for purposes of managing geographic information. GIPS is as much a philosophy of information management as it is a widely disbursed GIS. In a 1992 report, "Emergency Services Mapping and Analysis Program (ESMAP) - Strategic Concepts and Direction" was accepted by top management and implementation moved beyond the pilot stage.

To gain support, GIPS had to become accepted at all levels of management and emergency-service operations. It had to function across a wide range of hardware (Mac, PC and UNIX). It had to meet the needs of the rural and metropolitan users.

The result is a low-cost ($1.5 million), easy-to-use system that relies heavily on MapInfo for its applications. Its success depends on its value to users. While there are only two dedicated staff, there are nearly 300 trained users throughout the state. Key applications include analysis of crime statistics, optimum routing of emergency vehicles, reconfiguring of service areas, preparation of hazard risk maps and development of a Rural Road Directory.

The key factor that makes GIPS so exemplary is that state-wide coverage was achieved expeditiously, with efficient use of resources while achieving both user and management support.

For more information, contact Ken Granger, Scientific Advisor, GPO Box 1425 Brisbane, QLD 4001, Australia.

National Spatial Data Infrastructure: Delta-X

The National Spatial Data Infrastructure, or NSDI, is a concept of huge proportions. Its success depends on unprecedented cooperation and coordination, involving multiple levels of government on a...
national scale. By all accounts, interest at all levels of government and in the private sector has increased remarkably since the earliest discussions and the NSDI Executive Order. There is also a substantial interest in NSDI principles and concepts on an international scale. Thus, the ESIG Committee was pleased to get an NSDI application from the Department of Natural Resources Canada, for their Delta-X System.

Delta-X is a code name for a federated spatial information management system. It is an approach to providing interoperability in a network of heterogeneous GIS databases. It traces its roots to the late 1980s when the Geographic Information Systems Division of Geomatics Canada was established within the Department of Natural Resources Canada. One of their early goals was to develop the technology required for building a spatial information infrastructure within the division.

In short order, the division established a heterogeneous GIS environment involving a wide variety of GIS software running on a wide variety of platforms, interconnected through a local area network. The operational problems encountered reflected the wide range of GIS, hardware, database management systems and data structures.

Delta-X was conceived to bring order out of chaos. It sets out to achieve interoperability between DBMSes that have been specialized for three distinct data types: spatial data (i.e., vector and raster), structured text and free text. Its design provides an integrated access to data stored in relational databases, object-oriented databases, simple file systems and information retrieval and document management systems. One of the key features of Delta-X is the Metacistro/GIS Spatial Browser. It provides a convenient interface for users to search through metadata, information about databases and for locating datasets for GIS application development.

The structure of Delta-X is a loosely coupled network of Delta-X servers and Delta-X clients. LAN-based clusters are combined to form a WAN, which forms the backbone of the Delta-X system. Any client in system can request a transaction from any server in the “federation.”

The Department of Natural Resources Canada has earned its recognition by showing how unity can be established among heterogeneous systems. The concepts and design offer ideas worth pursuing for those involved in implementing NSDI.

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For more information, contact
Mosad Allam, GIS Division, Geomatics Canada, Natural Resources Canada, 615 Booth Street, Ottawa, Ontario, Canada, K1A0E9.

ESIG in 1996
The interest in ESIG is strong and growing. Winners report that an ESIG Award means both personal satisfaction and enhanced recognition for their program. ESIG helps affirm the value of automation in improving governmental services. ESIG winners often get requests for information and advice, indicating
that the ESIG program is succeeding in providing guidance and support.

There are several emerging trends. There has been a steady increase in the number and diversity of ESIG applications. More engineering and public works systems are being submitted for consideration. There are also more systems that reflect maturing geographic information systems, those where the database development is largely complete and the users have understood the capabilities and value of GIS.

The ESIG Committee is planning to introduce a new “Public Works and Engineering” award category for ESIG ‘96. This is in response to the growing number of such applications and reflects URISA’s increasing emphasis on automation in support of public works programs.

URISA anticipates a strong ESIG program in Salt Lake City in 1996. Many governmental systems are good candidates for ESIG recognition. Journal readers are invited to nominate their favorite systems for an ESIG award.
In this issue...

Photographs give us a realistic, detailed view. Where our mind may have difficulty recalling the details of a scene, a photograph offers us a precise memory. Similarly, photographs from above provide us a recognizable and lasting view of the earth’s surface.

Aerial photographs have been used in mapping applications for decades. In recent years, advances in aerial photography technology for applications in mapping and geographic information systems have become nothing short of amazing.

The dramatic changes in aerial image use have been largely driven by the scientific development of digital orthophotography. For many organizations, digital orthophotos have become the standard source of base geographic information. The state of Maryland’s Department of Natural Resources was one of the first state agencies to develop and use high resolution digital orthophotos for both statewide and local applications. The images displayed in this issue on pp. 81–82 provide us a glimpse of Maryland’s orthophoto images, and how they are used as a base to electronically integrate and display other information.

Editorial Intent

Many of us derive great pleasure from viewing maps. Often we feel that the enjoyment maps bring us is something we have felt for a long time, something we grew up with. It may be difficult for us to pinpoint the precise appeal that maps hold, but often they may provide new understandings and stir our imaginations.

Even though well-designed and informative maps have existed for decades, the growth of computer mapping, and geographic information systems has allowed us to experiment and develop new and exciting ways of analyzing and displaying data in a map context. Computer mapping and geographic information systems play a key role in URISA’s mission to help local, regional and state/provincial governments make the best use of information system technologies. Because computer-generated maps have become an important part of URISA’s domain, the URISA Journal showcases the efforts of map-makers by featuring an exceptional map product in each issue. The word “map” is used in a very broad context and can include remotely sensed images or other graphics.

Our intent is to feature a wide variety of maps, hoping to inspire others to learn and apply good ideas and techniques. We look for maps that are easy to read, have a pleasing appearance and clearly communicate the map’s purpose. New methods of analyzing and presenting phenomena through mapping techniques are also desirable, as is presenting a map that is particularly pleasing or attractive.

If you have produced a map or know of one you believe should appear in the URISA Journal, please contact the editors.

Ted W. Koch
Mother Nature has aptly managed the artistic development of Maryland's varied landscapes. Map-makers and others smile as they watch her creations appear on their computer screens. Forested hills rise directly from farm fields as they turn into larger tracts that are managed as parks, forests and recreational areas. The Chesapeake Bay moves in and out of expansive marshes that balance the transition from man's activities on land to shallow waters where our prized Rockfish prows in search of its next meal.

Digital orthophoto maps allow humans to see and better understand Mother Nature's work. As map-makers, we provide the elbow grease and manage the scientific end of the business. There is no magic in this part of the job. Digital orthophoto map production is a well-documented science. Even the airborne GPS technology our contractor has used for two years will soon be considered "old hat." The staff works with our contractor to produce, use and distribute 928 maps covering the entire state. To date, we are 56 percent complete. Maryland's digital orthophoto quarter quad (DOQQ) mapping program will generate more than 360 gigabytes of color infrared DOQQ data, the equivalent of 525 CD-ROM disks. This includes a working copy, an archive copy, and a copy in a generic distribution format. We have a ground resolution of 16 square feet per pixel that causes me to reflect on Maryland's relatively small size. It is actually the 8th smallest state, with approximately 12,186 square miles including our abundant inland water and beloved Chesapeake Bay. Working with color maps generates four times more data (3 bands plus a composite raster) than panchromatic mapping programs. Therefore, the volume of panchromatic DOQQ data that may be generated by GIS programs in larger states may not exceed the volume of Maryland's data.

In 1989, our decision to begin production of color DOQQ maps was considered somewhat odd. We were supported by an effective image-processing and GIS system (TNTmips from MicroImages, Inc.), faith that hardware and software would get better, and a belief that natural resource management techniques can be implemented more effectively on photographic base maps than planimetric maps. The later point considers that we have a history of using photo-based regulatory maps dating back to 1971. We know that our customers can easily relate to aerial photographs.

Production of the DOQQ maps began in 1991 with approval of a contract to a Maryland-based photogrammetric firm (Photo Science, Inc.). Until this year, NOAA's Coastal Zone Management Grant and the EPA's Chesapeake Bay Implementation Grant programs provided all of our funding. With strong support from the Maryland State Government Geographic Information Coordinating Committee (MSGIC), we obtained a budget enhancement to finish the maps by the end of 1996. The acceleration of this program is in direct proportion to the increasing number of uses for these maps and how well they work with the other MSGIC base-map systems. The other systems include Landsat TM imagery for small-scale applications from the Maryland Office of Planning (MOP) and Towson State University, scans of the USGS 7.5' topographic quads from the Department of Housing and Community Development, and the infrastructure base maps produced by MOP, the State Highway Administration (SHA), and the Department of Assessments and Taxation (DAT). The last system combines a joint state and private effort to produce enhanced "TIGER" files using SHA's 124,000 road, stream, land/water boundary, and political boundary files. The infrastructure base maps also include binary raster scans of the tax parcel maps, with vector updates for new parcels, and vector centroids of each parcel which are linked to DAT's database. These data become a more powerful tool when displayed over the DOQQ map base. Some people have trouble relating to systems based entirely on vector technology and can easily visualize the uses of vector data when they are displayed over the image base.

Of the 13 counties for which the DOQQ maps are complete, nine county governments are using them in various GIS systems. The order of
production is determined by several factors including cost-share form local government agencies. Applications vary widely and include support for regulatory, planning and enforcement staff in state and local government agencies. The public benefits by having spatial data provided on image maps that are more easily understood and by having products readily available to their consultants.

Bart Matthews, the GIS coordinator for Carroll County, has worked with the state-produced DOQQ maps since 1992. They are the base maps for the county’s GIS system and have been used for various purposes including an NPDES mapping project that saved the county over $100,000. Working with local engineering firms is part of Bart’s daily routine. He provides them with paper and digital products to conduct their development projects. Kelly Shanahan is a planner in Worcester County. He has also used the maps since 1992 to manage land planning and population growth associated with development along Maryland’s Atlantic coast. Among other applications, he occasionally works with a local consultant who finds the maps useful for forest management plans. Queen Anne’s County and St. Mary’s County have both used the maps to assist in planning efforts and development of their E911 house-numbering systems. Each presentation we give on the maps brings a new use and user.

Today is representative of how we spend our time using the DOQQ products. Pat Page is working in the Permit Service Center to screen permit applications on a GIS. His efforts will improve the quality, speed, and coordination of the permit process. Deb Uhlthoff continues work on a demonstration CD-ROM that will show all of MSGIC’s base maps. It features a variety of thematic data layers on the DOQQ map base. This disk will eventually find its way into every school in the state to teach Maryland’s youth about GIS. Jennifer Gillis creates 1:7,200 scale paper products that show wetland locations; she also prepares copies of digital data for distribution to our customers. Ken Miller, Division Chief for the Geographic Information Services Division, meets with representatives of the State Highway Administration to talk about delivery of digital wetlands data that were created on the DOQQ maps to improve the accuracy of our inventory. They are trying to develop environmentally sensitive alternatives for two new bypass roads and are anxious to obtain the data. At the end of the day, Ken takes an order from a company that will locate cellular phone equipment in our state while I take an order from Salisbury State University (SSU). This sale is significant to me because our program began in 1986 when I first contracted with Dr. K. Peter Lade at SSU. He is an anthropologist with a special talent for GIS and image processing.

These maps have made a significant change in our lives. What we once envisioned as a simple tool to make our jobs easier has now become our master. It took nine days to properly document the DOQQ data using the federal Metadata Content Standard. Two weeks were spent devising a CD-ROM distribution method that would work for a small shop. Hours are occupied each day to fill data orders, fix problems that are not addressed by existing standards, and work with our customers to help them better understand our products.

Maryland’s digital landscape has been paved to accept the information superhighway. The members of MSGIC have worked hard over the past three years to prepare the route. We accept responsibility for a few bumps along the way, but always give Mother Nature credit for the natural beauty of the scenery.
In this issue...

Two book reviews, covering three books, and one software review. The first book review relates to GIS management issues, and the second addresses a specific GIS technical issue. Managing Geographic Information Systems and Managing Geographic Information Projects are two recent books that address different aspects of GIS management. We have long needed some texts in this area and these books represent significant contributions to the documented knowledge base of GIS implementation. Rebecca Somers' review summarizes these books and highlights their differences and the roles they can play in assisting GIS practitioners.

ArcView (in various versions) has become a prevalent GIS software tool, and many users are looking for the best way to get training on it and on related products. Eric Fisher's review of the ArcView Developer's Guide provides an evaluation of the book and a perspective on how it's best used. The review also provides valuable insight regarding the emerging area of books that address specific GIS technical issues.

In the software review, Jay Lee reviews GeoApplication Tools—a set of tools for processing various types of geographic information. Used individually or together as a suite, Geographic Calculator, Geographic View, Geographic Transformer, and Geographic Tracker are easy to use and efficient in supporting a wide variety of tasks for information systems professionals.

Editorial Intent

The Reviews section of this journal provides critical reviews and information concerning publications, information sources, and software in the field of urban and regional information systems.

General review categories include: Books, Publications, Information Resources, Videos and Software. Software reviews are of three types: “In-Depth,” “Head-to-Head,” or “From the Inside.”

In addition to submissions of book, publication, video and software reviews, we welcome suggestions and insights pertaining to the identification, critical review, and recommendations of all information sources in the field of urban and regional information systems.

For complete submission guidelines, see pp. 101–102.

Rebecca Somers
Jay Lee
Book Review

Managing GIS: A Review of Two Recent Books

Managing Geographic Information Systems,

Managing Geographic Information System Projects,

Reviewed by Rebecca Somers

In all the GIS literature, there have been no books devoted substantially to the issues of GIS management. Now there are two. Despite their nearly identical titles, these books are very different.

The Context of GIS Management

Managing Geographic Information Systems, by Obermeyer and Pinto, is intended to provide a theoretical framework for understanding the issues that relate to managing GIS. Their dual goal is to advance further research and development on GIS implementation, evaluation and methodologies, and to create a theoretical and practical basis for effectively developing and using an organization’s GIS. The authors bring perspectives related to their own work in political science, public administration, business and organization theory.

For the past few years, it has been a commonly repeated adage that organizational issues are more important to the success of a GIS than are the technical issues. This book also makes this assertion, and then goes on to explain why—drawing from a large and wide-ranging body of literature regarding organizations, bureaucracies, management, work organization, adoption and diffusion of technological innovations, business and public administration. GIS practitioners have known this material is out there, but have explored and applied it rather haphazardly. Obermeyer and Pinto use their expertise in these fields to select and summarize the relevant literature and explain how it relates to GIS. The book is not so much about GIS, as it is about the issues related to GIS implementation, management, use and proliferation—from both a systems and database perspective.

The first sections of the book establish the context for evaluating what we know today about GIS management. The book begins by explaining why literature on GIS management has emerged later than that on technical matters, and where we currently stand on understanding management issues. In discussing the GIS management literature available to date, the authors point out the shortcomings of generalizing from single-case studies, and discuss the alternatives for assessing GIS implementation, measuring “success,” and developing models and theory.

The bulk of the material is organized into chapters that address various aspects of implementing, managing and using GIS in organizations. The topics are diverse, but follow a semblance of a progression from understanding GIS within an organization to the role of GIS in a democratic society.

“The Role of Geographic Information within an Organization’s MIS” discusses the responsibilities, activities and interests of management and the role that information and information systems play, particularly in managerial decision-making. GIS is mentioned only by extension, focusing on what it adds to the environment in its ability to catalog and analyze spatial information.

The next chapter, “Why Geography Matters,” stresses the importance of geographic and cartographic principles in GIS implementation and illustrates how GIS puts the capability to create maps and manipulate data into the hands of those who may not have adequate knowledge to do so correctly. The authors recommend a three-point approach to maximize an organization’s chances for success in implementing a GIS: 1) substantive expertise in the field of application; 2) knowledge of GIS techniques; and 3) understanding the basic principles of geography and cartography. These principles might seem obvious, but it is discouraging to see the number of GIS failures in or-

Rebecca Somers is president of Somers-St.Claire, GIS Management Consultants in Fairfax, Virginia. She has been active in GIS for over 18 years, and has taught seminars on GIS management for 11 years.
ganizations that have not addressed these issues. In particular, the authors cite the tendency that "for organizations thinking about implementing a GIS, their first thought is to acquire a system and hire a technician."

The chapter, "Bureaucratic Factors in the Adoption of GIS," examines how the features of bureaucracies hamper the adoption of GIS. The authors discuss bounded rationality and satisfying behavior in decision-making, and how these phenomena, among others, cause a bias against the search for geographic information and the adoption of GIS. The conclusion of this discussion is only that these factors must be recognized and addressed.

Issues of GIS adoption segue into the next topic, "Economic Justification for GIS Implementation." This chapter provides a lecture on public sector economics and discusses briefly the basic concepts behind benefit-cost analysis for GIS and the difficulties encountered in applying the methodology in the public sector.

The chapter on "Sharing Geographic Information Across Organizational Boundaries" discusses the origins, implications, and persistence of fragmented operations and, thus, information, in bureaucracies. The authors suggest a theory regarding the most suitable alliances for different situations and a conceptual model to promote information sharing.

"GISs and the Strategic Planning Process" is confined to explaining strategic planning and merely offering that GIS provides relevant information and useful analytical capabilities to enhance this ongoing process.

"Ensuring the Qualifications of GIS Professionals" lays out the issues involved in the current discussions and debates concerning "the GIS Profession," certification, and accreditation. Everyone seems to agree that "there is a growing need to guarantee the competency of GIS professionals," but disagrees on the best method and the form of emergence, if any, of a GIS profession.

The last two chapters, "Policy Conflicts and the Role of GISs" and "GIS in a Democratic Society," address the consequences of the proliferation of GIS. The authors theorize that instead of reducing conflict by providing "better" information, GIS will create conflict by presenting more ammunition to bolster conflicts of interest. Furthermore, they believe that the conflict will eventually even out, but at a higher level than before GIS. Finally, they point out that such conflict proves democracy is working. They develop these arguments, as they do all others in the book, by presenting relevant differing points of view on the basic issues, and then applying them to GIS.

Then the book simply ends. That's fine, because the authors' conclusions have been stated many times throughout the book: they repeat that they have only laid out the problems and proposed some theories and models, and identified areas where further research and development are needed.

This book does not tell you how to manage a GIS. It describes the problems, not the solutions. Understanding the problems, however, is the first step to finding solutions. In this way, the book serves two purposes: it identifies the areas where researchers' efforts are needed, and it provides a basic education for students and practitioners.

The information in this book is a prerequisite to even thinking about managing GIS. If you're already familiar with the concepts presented, the book provides a good organization of this information and direction on its applications to GIS. If you are like many GIS practitioners, however, and have come to GIS management with little background in the issues represented in this book, it serves as a good primer to bring you up to speed.

The book is organized along the lines of "tell them what you're going to tell them, tell them, and then tell them what you told them." This approach results in repetition, but it provides for a very organized presentation of the material. Abstracts preceding each chapter provide an excellent preview of the structure of the chapter. This highly organized style makes it possible to read the entire book very quickly.

I agree with Will Craig's comment on the back jacket, "This book is a wonderful summary of a wide range of literature on this important topic. It is necessary reading for anyone interested in management issues in GIS." In past years, I've researched this wide range of literature myself, and I wish this book had been around to save me the time. Now every GIS student and practitioner can pick up the basics in a few hours.

The Practice of GIS Management

Having found the Obermeyer and Pinto book interesting and easy to read, I cracked open Managing Geographic Information System Projects by Huxhold and Levinsohn and felt like a student assigned several thousand pages of summer reading. The book appears long and dense, and it's full of extensive diagrams and lists. But that's just the nature of GIS management issues vs. GIS management practice. Everyone likes to discuss and debate issues, but sooner or later you have to roll up your sleeves and do the work. Managing a GIS is long and full of lists.

Managing Geographic Information System Projects presents a realistic picture of detailed tasks that must be addressed in order to successfully manage a GIS. Before the authors do this, however, they philosophize for a while on the organizational context of GIS.
The first two chapters set the stage by establishing a perspective for considering GIS, management and the organization. "The GIS Paradigm" discusses the relationship of GIS and the organization. The GIS paradigm is described as the "application of the fundamental geography to organizing and using information." It deals with GIS as the "application of information technology, data management principles and organization theory to the geographic information needs of an organization." This perspective is important because it places GIS within the larger context, and emphasizes integration of the key elements. "Fundamentals of GIS Management" intermingles discussion of basic management, organizational and information systems issues with GIS.

The third chapter discusses "Strategic Planning for GIS", but also spends a lot of time reverting back to discussions of the organizational setting. Strategic planning is a very important first step in GIS implementation, but this discussion is not well focused. It talks more about strategic planning in general than how to proceed specifically with strategic planning for GIS.

At this point the book is one-third gone, and the authors have only talked about managing GIS projects, not how to manage. Things pick up, however, and the discussion becomes more focused and gets down to process and details. While digressions still occur, the rest of the book is more direct than the first three chapters. These authors are better at explaining the processes they know well than they are at discussing theory.

The next two chapters deal with planning tasks. "Implementation Planning" begins to lay out the more specific tasks involved in implementing and managing GIS. "Systems Design Methodology" presents approaches and tools for determining an organization's requirements and developing the appropriate data model to meet them. This chapter begins with an important warning that the first step in proceeding with GIS implementation is not to turn your attention to the commercial products available, as so many organizations do, but to determine your needs and functional model.

In "Implementation Management," the discussion moves from planning to "applying that knowledge to the creation of a working system." This section covers the transition from system planning to construction, technology and service procurement, and applications implementation. Data acquisition and conversion and database implementation are glossed over and subsumed in the above discussions. The material dwells on personnel issues for quite a while (probably too long—it seems to be a pet topic).

"Managing the System" addresses the issues and tasks associated with GIS operation. Although this is the point to expect explanation of the various responsibilities involved in system and data management, this discussion is brief. The bulk of the material relates to organizational structure and personnel issues (back to the pet topics).

The book ends with an appendix that contains some miscellaneous material from case studies regarding its purpose and relevance. Huxhold and Levinsohn present some excellent ideas, conceptual frameworks, principles, guidance and experience. They both have significant backgrounds as practitioners, though Huxhold is now associated with a university. The nuggets of information they offer, however, are sometimes buried in rambling text. Maybe the problems arose in the editing process. The result, though, can be frustrating reading. More importantly, topics are given uneven treatment. While some are discussed extensively, more important ones are glossed over.

When the authors do make significant points and describe processes, they do it well. The conceptual organization described in the preface is excellent, but loses something in the follow-through. Many important topics are covered well; however, several important ones are missing.

Probably the most serious omission is discussion of the issues and tasks related to data acquisition and development. The database is the most important component of a GIS—often comprising up to 80 percent of the development and operational resources—yet these issues are given only two pages. Granted, this is not a technical text, but there are important management issues that should be covered in this book. Furthermore, there are many more sources of data than the authors mention—notably, digital orthophotos and commercial databases—and they are becoming important components of most GISes today. The data acquisition, conversion and development stage of GIS implementation can be very complex, but this book treats data conversion as a simple event, or one that can be wholly turned over to vendors.

There is little discussion of private sector cases and issues. Most examples are from the public sector—local government in particular. While many of the same principles apply to the private sector, explicit discussion as to how they are adapted would help. Sometimes the authors seem unfamiliar with private sector GIS interests, as when introducing a "typical business operation." They are not so vague with their public sector examples.

The authors assume a "big systems" approach to GIS implementation—large numbers of users, scores of applications, large budgets and long timeframes. Increasingly, this is not the route that many organizations take to GIS. While the tasks and issues covered in this book also apply to smaller, GIS installations,
Feature Map 1

This image shows a portion of the Princess Anne SW quarter quad map which surrounds the Eastern Correctional Facility. The map is shown at 1:9,600 scale with Maryland's wetland inventory applied in yellow. The digital ortho-photo maps are produced in color infrared to facilitate production of a more precise wetlands inventory. Wetlands have been photo-interpreted on the same 1:40,000-scale color infrared photography used for production of the maps. Interpretations are performed in accordance with the procedures of the National Wetlands Inventory using the Cowardin et al., 1979 classification system.
Feature Map 2

This image shows a portion of the Frederick NW quarter quad map displayed at 1:7,200 scale. A binary scan of the state's parcel map (white) has been applied with vector nodes (green) for each parcel. The nodes are linked to Maryland's assessment database. A vector road map (yellow) has also been applied. The unaltered data on this map were produced at scales ranging from 1:7,200 to 1:24,000. They are from the individual efforts of the Department of Natural Resources, Office Of Planning, Department of Assessments and Taxation, and the State Highway Administration. Integration of these maps is facilitated through the Maryland State Government Geographic Information Coordinating Committee (MSGIC). The data can be used in a variety of GIS systems because each is available in a generic format.
the authors do not address this point, let alone discuss how.

Another area that presents some problems is that outdated or marginally relevant studies and examples are frequently used. Likewise, some of the authors’ research and review of relevant literature is spotty. Important literature is ignored. Many examples do not seem to be the most relevant material, but rather what the authors had on hand. While this situation hinders the discussion in some respects, it does not overshadow the important points.

Despite its shortcomings, this book is the only one to date that substantially addresses the tasks involved in GIS management. As John Antenucci comments in the book’s forward, it is “a long-needed contribution.” The book is a good compilation of some of the most significant GIS management knowledge, covering many common issues. It could serve well as a teaching text, but the rambling background discussions and gaps in practical matters make it a little frustrating as a practical guide for GIS managers and implementors.

How to Use These Books

Both books provide valuable material regarding GIS management—each from a different perspective. Therefore, comparing them is not the issue. The only relevant comparison may regard overall impressions, and these relate mostly to scope: Managing GIS is a big topic to bite off—especially when you include all related topics, as both teams of authors did. Obermeyer and Pinto stated their scope, limited their discussion and met their goal. They only sought to set a framework for further development and understanding of GIS management issues.

Huxhold and Levinsohn were perhaps a bit too ambitious. They sought to apply all relevant literature, examine the state of GIS in organizations and provide a complete guide for implementing and managing GIS. In this respect their book falls short of its goals, but still presents a wealth of valuable information.

GIS management is a very broad topic, but together these two books cover a significant portion of it. Although neither book provides much new information, they represent a compilation of much of the current knowledge regarding GIS management. The Obermeyer and Pinto book provides the background information needed to understand the issues involved in managing a GIS. In addition to summarizing the relevant information, it provides a guide for more in-depth reading. The Huxhold and Levinsohn book provides a discussion of the tasks directly involved in managing a GIS.

Even if you read both books, however, you are left on your own to fill in the gaps on some important topics—particularly those that would have been expected to be covered in the Huxhold and Levinsohn book. But these books form a good starting point; they are a significant contribution to the documentation of the growing amount of information regarding managing GIS.
Here is the problem: You are using Environmental Systems Research Institute's ArcView 2.1 desktop mapping software and you like the results. However, you need to take the package further in order to get your job done. You know that ArcView can be customized through the use of an object-oriented programming language called Avenue, but the documentation never seems to be enough and you're unsure how to get started.

If you have this problem, you are not alone. Recent message traffic on Internet discussion lists like “esri-l” reflects this dilemma. When trying to learn new software, your options are limited: Option one: a formal training class which probably will not be appearing in a city near you and often not at a price within your budget. Option two: struggle and invest a lot of time at the keyboard learning trial-by-fire. Option three: find a book to follow on your own. This last option is common with mainstream software like word processing or spreadsheets but uncommon with specific software in a field such as GIS. That is until now.

ArcView Developer's Guide ($49.95) by Amir Razavi is a good solution in the struggle to learn Avenue. The book is well-written and it does an excellent job of helping ArcView users gain an understanding of Avenue and its use in application development and the customization of ArcView. The book is not a ‘programming tutorial,’ but rather a guide to using Avenue. Prior programming experience is beneficial, as is an understanding of GIS concepts. When the book was written, Avenue was sold separately from ArcView 2.0; however, with the release of ArcView 2.1 in July 1995, Avenue is now bundled with ArcView 2.1 at no extra cost.

Razavi's introduction sets the stage by briefly describing Avenue, object-oriented programming, and what benefits object-oriented programming brings to the table. He continues with a section entitled ‘How to read this book,’ a great help in guiding readers of varying backgrounds and abilities along the quickest path to learning Avenue.

Chapter 1 describes structured application development and presents a four-step methodology for developing ArcView applications. You may already have a preferred application-development methodology, but for the sake of discussion, these stages are: the requirement study, prototyping, construction, and structured testing. Razavi explains this process by presenting a hypothetical scenario of a bank wanting to perform demographic analysis to ensure fair lending practices. His scenario has a happy ending and encounters few problems along the way. Not exactly the real world, but then again Razavi does not want to scare the reader this early with stories from the trenches.

In Chapter 2, ‘Customizing the Interface,’ Razavi shows how the existing graphic user interface (GUI) of ArcView can be customized by the user. A point lost on many ArcView users is that the GUI is customizable from the interface itself. In other words, without knowing Avenue, the user can use the default menu system to customize said same menu system and save the changes. Chapter 2 outlines this process and includes illustrations of the actual menus being explained. Razavi describes in a detailed way the options and the processes the user must follow when reworking the existing control bar (a combination of the pulldown menu bar, the pushbutton bar, and the tool bar) of ArcView.

The third chapter entitled ‘Avenue Building Blocks,’ introduces the user to Avenue and lays the foundation needed to actually program in Avenue. While not a long section, this basic information is essential to understanding Avenue and object-oriented programming. The chapter also covers how to create, compile, and run Avenue programs or ‘scripts.’ This entire process occurs through ArcView's graphic-user interface as well, and the steps in the book illustrate this procedure.

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Chapter 4, 'Avenue Programming Language,' presents the meat of programming with Avenue. Variables, structures, file interaction, input, output and, every programmer’s nemesis—commenting, are all covered here. Even though I have programmed in FORTRAN and currently use C, this chapter was beneficial to me because, as with any programming language, Avenue and object-oriented programming have a flavor all their own. Razavi’s scripts are well commented and explained. Indentation of the scripts would improve readability, but I understand this problem was the printer’s and not Razavi’s original intent.

With the fundamentals covered, Chapters 5 through 11 cover how the specific elements of ArcView are ‘assessed and programmed using Avenue.’ These elements and ‘documents’ should be very familiar to current users of ArcView 2.0 and above. Individual chapters are devoted to the Project Window, Views, Tables, Charts, and Layouts as well as to the subjects of themes and accessing databases. Each chapter’s topic is explained well with the use of how-to examples, illustrations of menus, and sample scripts.

Chapter 12, ‘Application Installation,’ is very brief but covers what comes after the application is finished (if any application is ever finished). Your end product can be protected by encryption. This process is explained, but remember this is a one-way process, so be sure to save a copy before encryption. Single-user installations of the final application are explained in detail. Network installation is also discussed, but that is beyond the scope of this single text.

The final two chapters are advanced topics which may be beyond the interest or capability of beginning Avenue users. Chapter 13, ‘Address Matching,’ explains the concepts of geocoding addresses with Avenue and includes examples of typical business applications. Razavi also includes and describes several scripts, two of which prepare a theme for address matching and create the final address events theme. Chapter 14, ‘Integration,’ deals with several topics. Among them: Utilizing the clipboard and system variables, issuing system commands, and using Remote Procedure Calls (RPC’s) and Dynamic Data Exchange (DDE), and interaction with ARC/INFO AML’s. Because these topics are platform and operating-system dependent, and this is only an introductory-level book, the high-level programmer will not have all questions answered. But then, isn’t that why programming is so much fun?

Razavi includes two appendices to aid the Avenue programmer. The first is an organizational chart of the Avenue class hierarchy. The second is a list of reserved words and phrases for Avenue that should not be used as variables names.

I found ArcView Developer’s Guide to be helpful in starting to work with Avenue. I recommend the book highly. Razavi has succeeded in presenting the topics at an understandable level and in an easy-to-follow fashion. This book is part of a series from OnWord Press focusing on GIS and specific software packages from ESRI. I look forward to reading the other books from OnWord Press as well as any future texts by Amir Razavi.

Fisher/URISA Journal 85
GeoApplication Tools: Geographic Calculator 3.0, Geographic View 1.0, Geographic Transformer 2.0, and Geographic Tracker 1.0.

Reviewed by Jay Lee

Information systems professionals often find themselves handling geographic information from various sources in various formats. Land cover/land use maps may come from printed paper maps at various scales. Land use updates may come from aerial photographs at different scales; zoning maps from yet another source at another scale. Bringing all geographic information into an integrated database can be a daunting task. To this end, it would be nice to have tools that were developed specifically for tasks applying geographic information.

Under a concept of building component software for professionals in geographic applications, Blue Marble Geographics (Gardiner, Maine) has released a suite of software tools, known as GeoApplication Tools. These tools include the Geographic Tracker, the Geographic Calculator, the Geographic View, and the Geographic Transformer. All of these tools are Windows-based and executable on a personal computer platform. They can be used individually or linked with each other. The GeoApplication Tools offer practical, versatile functions and are easy to use.

In brief, here’s how they work: Linked to a GPS receiver, the Geographic Tracker records and organizes the received coordinates into industry standard file formats. With the Geographic Calculator, conversions of coordinates between projections can be easily carried out by either converting one point at a time or by converting many points in batch. The Geographic View allows users to view or print scanned maps interactively. The Geographic Transformer offers an integrated environment—from scanning and registering to tiling images of paper maps, aerial photography, or satellite imagery. In concert, the tools cover almost all of the needs of preparing geographic information for most mapping systems.

We tested these products on an EPS 486 personal computer with 20 MB of RAM and VGA running Windows 3.1. Overall, the GeoApplication Tools are easy to install and simple to use. Since map projections or computation algorithms are not fully explained in the manuals, users need to have an understanding of various map projections to take full advantage of these tools. Within the Windows environment, Tools are configured with easy-to-use graphic user interfaces; however, they are limited by the speed and capacity of PCs. Vendor technical support was responsive and efficient. Although the learning curve for experienced professionals could be relatively short for using GeoApplication Tools, expanding the manuals by adding tutorials or sample data would assist first-time users significantly.

Hardware Requirements

The GeoApplication Tools run on IBM or compatible personal computers with Microsoft Windows 3.1 or later, running in enhanced mode. To use all four software components, a minimum of 8 MB of RAM (16 MB recommended) are needed. A mouse or other pointing device is required to use the graphic interfaces in the GeoApplication Tools.

Geographic Tracker

The Geographic Tracker allows real-time global position system (GPS) positioning, navigation and data logging. Linking with a GPS device through local or modem connections, the Geographic Tracker records coordinates received via GPS, and converts them into speci-

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Vendor Information

Blue Marble Geographics, 46 Water Street, Gardiner, Maine 04345, U.S.A.
Telephone: (207)582-6747, FAX: (207)582-7001. Prices for the reviewed products are Geographic Tracker (US$395), Geographic Calculator (US$295), Geographic View (US$149), and Geographic Transformer (US$795). Technical support is provided via telephone, mail or FAX.

Coordinate Systems. Users can interactively transform coordinates or process coordinate files in several formats, including ASCII, NGS Blue Book, AutoCAD DXF, ARCHINFO Generate, Kork Systems PTLIST and the SEG P1 coordinate file formats. The Geographic Calculator implements horizontal datum transformation algorithms such as the Molodensky, DMA Multiple-Regression Equations, Seven-Parameter Bursa/Wolfe, NGS High-Accuracy Reference Network (HARN) and NGS NADCON methods.

Conversions of coordinates by the Geographic Calculator can be carried out in three modes: interactive processing of individual coordinates, coordinate data file processing, and batch processing from the command line. Users may direct the results of conversions to computer screens or to ASCII data files. The Geographic Calculator can be operated by using the pull-down menu or by clicking any of the buttons in the tool bar for direct actions. In Version 3.0, the Geographic Calculator has a two-sided window that records the input coordinates on the left side and gives the converted coordinates on the right side. A number of options are available to customize output according to the user’s preference, including coordinate formats, operation formats, and output formats.

As shown in Figure 1, the Geographic Calculator uses a window interface that allows users to pick options from listings. On the left side of the window, a coordinate of the northwest corner of Portage County, Ohio was entered in State Plane projection units. The coordinate was converted to UTM projection units on the right side of the window. Conversions of coordinates are done seamlessly with a click of the mouse button. Ease of use is the biggest advantage of this tool. However, Geographic Calculator assumes that users possess a sufficient understanding of various map projections because the selections of appropriate data units, datum, and zones are critical to correct results.

The Geographic Calculator

The Geographic Calculator converts geographic information from one coordinate system to another. It is capable of performing geodetic forward and inverse calculations. When used with any GPS, surveying, engineering, or mapping packages, the Geographic Calculator provides accurate geographic coordinate transformations and geodetic calculations.


Geographic View

The Geographic View allows users to navigate around a map, such as a scanned paper map, a scanned aerial photograph, or a satellite image. It also provides the convenience of printing any section of the map as viewed on screen. Any portion of the map can be copied to Windows Clipboard to be integrated with other text-editing or graphic programs.

The Geographic View supports map file formats in TIFF, ERDAS LAN and GIS, NOAA Raster Nautical Chart Image format, Targa TGA, Zsoft PCX, CompuServe GIS, Windows Bitmap BMP and DIB, JPEG, Encapsulated Postscript EPS and Windows Metafile. As a map is being viewed, Geographic View allows users to determine the geographic coordinate of any location within a map if the map is geodetically referenced.

Figure 2 shows a screen of the Geographic View used to navigate an image of Portage County, Ohio. A pull-down menu allows users to choose operations. There are also buttons for direct-command operations. Buttons are available to open, print input images, to re-center images (hand button), and to re-scale images (magnify lens). When activated, a ‘Thumbnail’ option, pictured in the upper left corner of the graphic area, shows a sketch of the
FIGURE 1. The Geographic Calculator.

```
| Name: Portage NW | Name: Portage NW |
| Nothing: 614607 | Nothing: 4577290.69 |
| Easting: 2304217 | Easting: 467204.86 |
| System: United States State Plane 1927 | System: Universal Transverse Mercator |
| Datum: 107 NAD 1927 - CONUS | Datum: 2 North American Datum 1927 |
| Zone: 3401 - Ohio North | Zone: Zone 17N - 84°W to 78°W |
```

The Geographic Transformer has an integrated scanner interface that allows users to use any TWAIN-compatible scanner to create source images without the need for other 'scanning only' software. It also includes a reference component that allows users to create a relationship between a source coordinate system and a reference coordinate system. This is useful when 'registering' an image to fit other digitized layers in a GIS or CAD system. The mosaic-tiling component of the Geographic Transformer allows users to bring together scanned images from sections of a bigger map or image.

The Transformation component of the Geographic Transformer can take the referenced 'image map' and transform it into the coordinate system and projection of the other data set(s) or to any one of the many coordinate systems and projections supported in the Geographic Transformer. The capability to 'tile' the transformed image map into multiple files of smaller uniform areas is also possible. The mosaic component creates a composite-image map from multiple-input image maps sharing a common coordinate system and pixel resolution.

Referencing an image map in the Geographic Transformer begins with issuing information about control points. Source X and Y control points can be picked interactively from 'Point Pick Window'. X and Y coordinates of the reference system are then entered and added to the list of control points. The example shown in Figure 3 is a transformed image of Portage County, Ohio. The Geographic Transformer gives errors of map registration in graphs that are layouts corresponding to the relative location of control points within the image. Transformation is configured by defining the left and right sides of the Geographic Calculator that are linked to the Geo-
FIGURE 2. The Geographic View.

FIGURE 3. The Geographic Transformer.
FIGURE 4. The Geographic Transformer.

The Geographic Transformer. With output file name, dimension, resolution, and border colors specified, the transformation proceeds with a click of the Transform button (Figure 4). The Geographic Transformer also can easily put together multiple adjacent images with the mosaic component. The resulting composite image can be viewed or printed directly.

While registering a scanned image into a geographic coordinate system has become a daily routine for most mapping professionals, the Geographic Transformer offers a simple way to perform geographic referencing and map-joins without having to rely on more sophisticated mapping or GIS packages. Advantages of the Geographic Transformer are that it accepts a wide range of file formats and operates in an integrated environment of scanning, transforming, tiling and printing functions. Possible improvements: enhance the manual to include sample data and demonstrations so that first-time users, especially those who are not experienced, can use the software more efficiently.

Summary

The components in the suite of GeoApplication Tools released by Blue Marble Geographics, when tested on one of our 486-based personal computers, worked well in accordance with their designed uses. The Tools were easy to manipulate and, in most cases, straightforward. They are not demanding for computation resources unless larger image files are being processed. They worked well together to complement each other's functions. While useful for planning and mapping professionals, we feel that users of coordinate-conversion software packages should have sufficient background knowledge in various map projections to use the Tools effectively. The GeoApplication Tools package could benefit from including some sample data files and/or tutorials for new users.
Author Index

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Books


Publications


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Software


Video

# Subject Index

## REFEREED

### Analysis and Planning

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td>6.1: 11</td>
<td>Chen</td>
</tr>
<tr>
<td>Economic analysis</td>
<td></td>
<td>3.2: 50</td>
<td>Tomaselli</td>
</tr>
<tr>
<td>Forecasting</td>
<td></td>
<td>2.2: 35</td>
<td>Watterson</td>
</tr>
<tr>
<td>Location/spatial analysis</td>
<td></td>
<td>2.2: 26</td>
<td>Gimblett</td>
</tr>
<tr>
<td>Modeling</td>
<td></td>
<td>5.1: 40</td>
<td>Armstrong</td>
</tr>
<tr>
<td></td>
<td>2.1: 26</td>
<td>Kjerne</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2: 35</td>
<td>Buyong</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2: 35</td>
<td>Denkers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2: 26</td>
<td>Peng</td>
<td></td>
</tr>
<tr>
<td>Routing</td>
<td></td>
<td>7.1: 6</td>
<td>Chenoweth</td>
</tr>
<tr>
<td>Site selection/analysis</td>
<td></td>
<td>7.1: 20</td>
<td>Peng</td>
</tr>
<tr>
<td>Small area forecasting</td>
<td></td>
<td>7.1: 38</td>
<td>Brown</td>
</tr>
<tr>
<td>Statistics</td>
<td></td>
<td>2.2: 35</td>
<td>Watterson</td>
</tr>
<tr>
<td>Surveys</td>
<td></td>
<td>6.1: 11</td>
<td>Chen</td>
</tr>
<tr>
<td></td>
<td>5.1: 4</td>
<td>Budic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.1: 53</td>
<td>Jeffress</td>
<td></td>
</tr>
</tbody>
</table>

### Applications

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision support</td>
<td></td>
<td>4.1: 56</td>
<td>Beroggi</td>
</tr>
<tr>
<td>Environ. assessment/analysis</td>
<td></td>
<td>3.1: 6</td>
<td>Chenoweth</td>
</tr>
<tr>
<td></td>
<td>5.2: 44</td>
<td>Ventura</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6.2: 11</td>
<td>Felleman</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.1: 38</td>
<td>Brown</td>
<td></td>
</tr>
<tr>
<td>Land use planning</td>
<td></td>
<td>2.2: 26</td>
<td>Gimblett</td>
</tr>
<tr>
<td></td>
<td>3.1: 6</td>
<td>Chenoweth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2: 50</td>
<td>Tomaselli</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.1: 20</td>
<td>Bishop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.2: 3</td>
<td>Lee</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.1: 56</td>
<td>Beroggi</td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
<td>7.1: 26</td>
<td>Peng</td>
</tr>
<tr>
<td>Water resources</td>
<td></td>
<td>3.2: 12</td>
<td>Armstrong</td>
</tr>
<tr>
<td></td>
<td>5.2: 44</td>
<td>Ventura</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.1: 38</td>
<td>Brown</td>
<td></td>
</tr>
<tr>
<td>Natural resources</td>
<td></td>
<td>4.1: 24</td>
<td>Denkers</td>
</tr>
<tr>
<td>Policy analysis</td>
<td></td>
<td>3.1: 6</td>
<td>Chenoweth</td>
</tr>
<tr>
<td></td>
<td>2.2: 7</td>
<td>de Neufville</td>
<td></td>
</tr>
<tr>
<td>Hazardous waste/materials</td>
<td></td>
<td>4.1: 56</td>
<td>Beroggi</td>
</tr>
<tr>
<td>Redistricting</td>
<td></td>
<td>5.1: 40</td>
<td>Armstrong</td>
</tr>
<tr>
<td>Real Estate</td>
<td></td>
<td>5.1: 53</td>
<td>Jeffress</td>
</tr>
<tr>
<td></td>
<td>6.2: 11</td>
<td>Felleman</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.1: 7</td>
<td>Simons</td>
<td></td>
</tr>
</tbody>
</table>

### Databases

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database design/development/management</td>
<td></td>
<td>1.1: 17</td>
<td>Parent</td>
</tr>
<tr>
<td></td>
<td>2.1: 2</td>
<td>Hintz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.1: 26</td>
<td>Kjerne</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2: 2</td>
<td>Grady</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2: 16</td>
<td>Langran</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2: 12</td>
<td>Armstrong</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.1: 14</td>
<td>von Meyer</td>
<td></td>
</tr>
<tr>
<td>Data processing management</td>
<td></td>
<td>1.1: 17</td>
<td>Parent</td>
</tr>
<tr>
<td>Data sharing/exchange</td>
<td></td>
<td>1.1: 17</td>
<td>Parent</td>
</tr>
<tr>
<td>Education and training</td>
<td></td>
<td>4.2: 59</td>
<td>Blinn</td>
</tr>
<tr>
<td>Feasibility analysis</td>
<td></td>
<td>2.1: 11</td>
<td>Epstein</td>
</tr>
</tbody>
</table>

### Hardware

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributed Systems/Networks</td>
<td>6.1: 37</td>
</tr>
<tr>
<td>New technologies</td>
<td>3.1: 6</td>
</tr>
<tr>
<td></td>
<td>1.1: 7</td>
</tr>
<tr>
<td></td>
<td>2.2: 7</td>
</tr>
</tbody>
</table>

### Issues

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy/data quality</td>
<td>1.1: 17</td>
</tr>
<tr>
<td></td>
<td>2.1: 2</td>
</tr>
<tr>
<td></td>
<td>2.2: 2</td>
</tr>
<tr>
<td></td>
<td>2.2: 16</td>
</tr>
<tr>
<td></td>
<td>4.2: 32</td>
</tr>
<tr>
<td></td>
<td>6.2: 25</td>
</tr>
<tr>
<td>Benefit/cost methods</td>
<td>4.2: 20</td>
</tr>
<tr>
<td></td>
<td>2.1: 11</td>
</tr>
<tr>
<td></td>
<td>3.1: 33</td>
</tr>
<tr>
<td></td>
<td>6.2: 63</td>
</tr>
<tr>
<td>Cost analysis</td>
<td>3.2: 50</td>
</tr>
<tr>
<td>Cost recovery</td>
<td>4.1: 45</td>
</tr>
<tr>
<td>Data dissemination</td>
<td>2.1: 38</td>
</tr>
<tr>
<td>Data lineage</td>
<td>6.2: 25</td>
</tr>
<tr>
<td></td>
<td>2.2: 2</td>
</tr>
<tr>
<td></td>
<td>2.2: 16</td>
</tr>
<tr>
<td></td>
<td>6.2: 25</td>
</tr>
<tr>
<td>Data processing management</td>
<td>4.1: 24</td>
</tr>
<tr>
<td>Data sharing/exchange</td>
<td>1.1: 27</td>
</tr>
<tr>
<td>Education and training</td>
<td>4.2: 59</td>
</tr>
<tr>
<td>Feasibility analysis</td>
<td>2.1: 11</td>
</tr>
<tr>
<td>Volume</td>
<td>Lead Author</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td>2.1: 11</td>
<td>Epstein</td>
</tr>
<tr>
<td>3.1: 14</td>
<td>von Meyer</td>
</tr>
<tr>
<td>3.1: 43</td>
<td>Croswell</td>
</tr>
<tr>
<td>4.1: 32</td>
<td>Onsrud</td>
</tr>
<tr>
<td>4.2: 59</td>
<td>Blinn</td>
</tr>
<tr>
<td>5.1: 18</td>
<td>Onsrud</td>
</tr>
<tr>
<td>6.2: 35</td>
<td>Pinto</td>
</tr>
<tr>
<td>2.1: 38</td>
<td>Roitman</td>
</tr>
<tr>
<td>2.1: 2</td>
<td>Hintz</td>
</tr>
<tr>
<td>3.1: 14</td>
<td>von Meyer</td>
</tr>
<tr>
<td>4.1: 45</td>
<td>Dando</td>
</tr>
<tr>
<td>2.2: 7</td>
<td>de Neufville</td>
</tr>
<tr>
<td>6.2: 35</td>
<td>Pinto</td>
</tr>
<tr>
<td>6.2: 35</td>
<td>Pinto</td>
</tr>
<tr>
<td>2.1: 38</td>
<td>Roitman</td>
</tr>
<tr>
<td>4.1: 75</td>
<td>Information systems development</td>
</tr>
<tr>
<td>4.1: 45</td>
<td>Dando</td>
</tr>
<tr>
<td>2.1: 38</td>
<td>Roitman</td>
</tr>
<tr>
<td>1.1: 7</td>
<td>Craig</td>
</tr>
<tr>
<td>4.1: 32</td>
<td>Onsrud</td>
</tr>
<tr>
<td>1.1: 39</td>
<td>Clapp</td>
</tr>
<tr>
<td>4.2: 47</td>
<td>Hazleton</td>
</tr>
<tr>
<td>2.1: 11</td>
<td>County government</td>
</tr>
<tr>
<td>2.1: 2</td>
<td>Local government</td>
</tr>
<tr>
<td>5.1: 18</td>
<td>Urban government</td>
</tr>
<tr>
<td>2.2: 35</td>
<td>Systems evaluation</td>
</tr>
<tr>
<td>4.2: 32</td>
<td>System Concepts</td>
</tr>
<tr>
<td>4.2: 47</td>
<td>Dynamic modeling</td>
</tr>
<tr>
<td>2.2: 26</td>
<td>Geographic information systems</td>
</tr>
<tr>
<td>2.2: 2</td>
<td>Grady</td>
</tr>
<tr>
<td>2.2: 7</td>
<td>de Neufville</td>
</tr>
<tr>
<td>3.2: 3</td>
<td>Lee</td>
</tr>
<tr>
<td>3.2: 50</td>
<td>Tomaselli</td>
</tr>
<tr>
<td>5.1: 4</td>
<td>Budic</td>
</tr>
</tbody>
</table>
### FEATURES

#### Analysis and planning

<table>
<thead>
<tr>
<th>Location/spatial analysis Surveys</th>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.2:77</td>
<td>Van Demark</td>
</tr>
<tr>
<td></td>
<td>5.2:73</td>
<td>Craig</td>
</tr>
<tr>
<td></td>
<td>5.2:78</td>
<td>Miller</td>
</tr>
<tr>
<td></td>
<td>6.2:92</td>
<td>Sprecher</td>
</tr>
<tr>
<td></td>
<td>7.1:60</td>
<td>Kuhlman</td>
</tr>
</tbody>
</table>

Demographics

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1:69</td>
<td>Strasma</td>
</tr>
</tbody>
</table>

#### Applications

<table>
<thead>
<tr>
<th>Disaster relief</th>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.1:73</td>
<td>Hale</td>
</tr>
<tr>
<td></td>
<td>4.1:66</td>
<td>Johnson</td>
</tr>
</tbody>
</table>

Environ. assessment/monitoring

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2:48</td>
<td>Robinette</td>
</tr>
<tr>
<td>6.1:57</td>
<td>Kuhlman</td>
</tr>
</tbody>
</table>

Facilities/infrastructure

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1:66</td>
<td>Long</td>
</tr>
<tr>
<td>6.1:57</td>
<td>Johnston</td>
</tr>
</tbody>
</table>

Land use planning

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2:48</td>
<td>Robinette</td>
</tr>
<tr>
<td>3.2:70</td>
<td>Koeppel</td>
</tr>
<tr>
<td>6.1:63</td>
<td>Beulac</td>
</tr>
</tbody>
</table>

Natural resources

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1:69</td>
<td>Wellar</td>
</tr>
</tbody>
</table>

Policy analysis

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1:57</td>
<td>Wieland</td>
</tr>
</tbody>
</table>

Water resources/systems

<table>
<thead>
<tr>
<th>Volume</th>
<th>Lead Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1:81</td>
<td>Mordian</td>
</tr>
</tbody>
</table>

#### Databases

<table>
<thead>
<tr>
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<th>Volume</th>
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### Feature Map

#### Analysis and Planning
- **Site selection/analysis**
  - Volume 4:1; 93
  - Lead Author: Crowell
- **Surveys**
  - Volume 6:1; 87
  - Lead Author: Strasma

#### Applications
- **Environmental assessment/analysis**
  - Volume 3:1; 85
  - Lead Author: Riggle
  - Volume 4:2; 91
  - Lead Author: Walker
  - Volume 6:2; 96
  - Lead Author: Mckai
- **Facilities/Infrastructure**
  - Volume 7:1; 69
  - Lead Author: Johansen
- **Water resources/systems**
  - Volume 3:1; 85
  - Lead Author: Riggle
  - Volume 4:1; 93
  - Lead Author: Crowell
  - Volume 7:1; 69
  - Lead Author: Johansen
- **Site design**
  - Volume 3:2; 103
  - Lead Author: Foster

#### Databases
- **Database design/development/management**
  - Volume 2:2; 68
  - Lead Author: Flynn
- **Digital Mapping**
  - Volume 4:2; 91
  - Lead Author: Walker
- **TIGER**
  - Volume 2:1; 74
  - Lead Author: Cooke

#### Hardware/Software
- **Multimedia**
  - Volume 5:1; 95
  - Lead Author: Yap
- **New technologies**
  - Volume 6:2; 96
  - Lead Author: Mckai

#### Level of Government
- **Rural/small municipalities**
  - Volume 2:2; 68
  - Lead Author: Flynn
- **State/provincial**
  - Volume 6:1; 87
  - Lead Author: Strasma

#### Regional Concerns
- **Australia**
  - Volume 5:1; 95
  - Lead Author: Yap

#### System Concepts
- **Multi-purpose systems**
  - Volume 2:2; 68
  - Lead Author: Flynn
- **User interface**
  - Volume 5:1; 95
  - Lead Author: Yap
- **Visualization**
  - Volume 4:2; 91
  - Lead Author: Walker
REVIEWs

Analysis and Planning

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Applications

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Desktop Computing

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Hardware/Software

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Level of Government

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<th>Volume</th>
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