01 Jan 1993

Decision-support Tools For Transferring AM/FM/GIS To Small Communities

Steven W. McCrary

Colin Othniel Benjamin
Missouri University of Science and Technology

Peter J. Schmidt

DECISION-SUPPORT TOOLS FOR TRANSFERRING AM/FM/GIS TO SMALL COMMUNITIES

By Steven W. McCrary,[1] Member, ASCE, Colin O. Benjamin,[2] and Peter J. Schmidt[3]

ABSTRACT: This paper examines several decision-support tools for transferring AM/FM/GIS technology to small communities. The term Computer-Assisted Spatial Information Systems (CASIS) provides a basis for a systematic categorization and definition of AM/FM/GIS systems that will serve to enhance small communities' understanding of these technologies for future decisions. The acronym CASIS includes such areas as database-management systems, automated mapping/facilities management/geographic information systems (AM/FM/GIS), and computer-aided drafting (CAD). Further, this paper reports the highlights of a survey that assesses the theory-practice gap in AM/FM/GIS usage among very small local government agencies. The survey uncovered an existing theory-practice gap: A slow rate of system usage among very small local governments due to a lack of awareness of these technologies and their benefits. Finally, this paper identifies several decision-support strategies necessary for bridging that theory-practice gap. The CASIS project life cycle provides a framework for discussing these issues.

INTRODUCTION

Geographic information systems (GIS), and automated mapping/facilities management (AM/FM) packages, with their capacity for improved information storage, retrieval, updating, and reporting, offer considerable potential for improving infrastructure management (Al-Naqi 1988). Many large and medium-sized cities, but few small cities, have adopted these systems for more effective management of many of the services they provide (e.g., water supply, sewage collection and treatment, pavement repair, tax assessment, city planning, police and fire dispatching and routing, and facilities location). The American Public Works Association (APWA) published its study entitled *Good Practices in Public Works* (1988), recommending the use of pavement management systems (PMS) and management information systems (MIS) for improving the management and quality of infrastructure. The National Council on Public Works Construction released its final report to the President and the Congress titled *Fragile Foundations: A Report on America's Public Works* (1988), which strongly encouraged all levels of government to upgrade the quality and quantity of basic public-works management information in order to measure and improve system performance.

This paper provides a summary and categorization of the technologies in this field and reports the highlights of a survey to assess the theory-practice gap in AM/FM/GIS usage among very small communities in the state of Missouri. Finally, this paper summarizes the decision-support literature on AM/FM/GIS as it applies to small local communities and provides decision support for small local communities in the consideration and use of these

[1]P.E., Asst. Prof., Dept. of Civ. Engrg., Louisiana Tech Univ., Ruston, LA 71272.
[2]Assoc. Prof., Dept. of Engrg. Mgmt., Univ. of Missouri-Rolla, Rolla, MO 65401.
[3]Asst. Prof., Dept. of Engrg. Mgmt., Univ. of Missouri-Rolla, Rolla, MO.

Note. Discussion open until May 1, 1994. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on June 15, 1992. This paper is part of the ***Journal of Planning and Development***, Vol. 119, No. 4, December, 1993. ©ASCE, ISSN 0733-9488/93/0004-0173/$1.00 + $.15 per page. Paper No. 4229.

J. Urban Plann. Dev., 1993, 119(4): 173-188

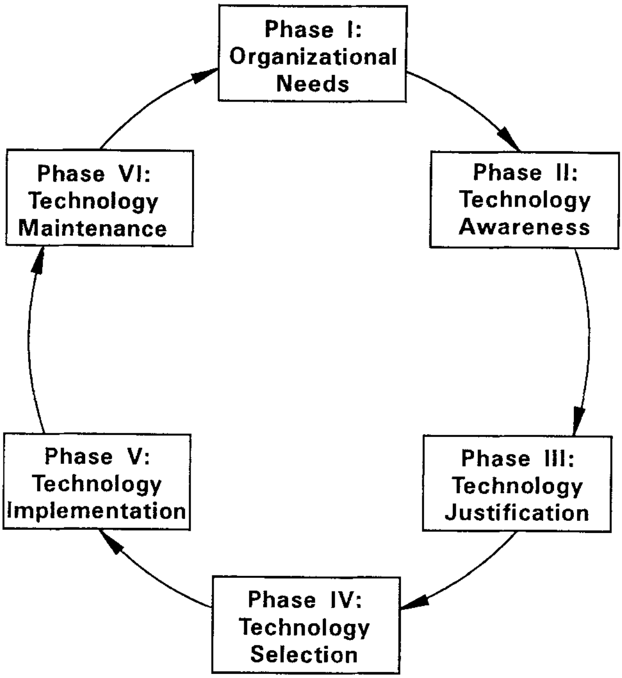

FIG. 1. CASIS Life Cycle

systems. The paper follows the project life cycle, shown in Fig. 1, as a framework for discussing these issues.

The six phases of the Computer-Assisted Spatial Information System (CASIS) life cycle, shown in Fig. 1, are further explained as follows.

Phase I—Organizational Needs

This is the point at which an organization realizes that a need exists and that something needs to be done about it.

Phase II—Technology Awareness

Here, an organization seeks to find out how to meet the needs of phase I. This involves discovering what technologies, if any, can fulfill that need, how these technologies fill that need, and how much each costs. If the appropriate technologies cannot be found, then the process stops.

Phase III—Technology Justification

Organizations attempt to justify obtaining new technology using analytical tools that compare benefits and costs of the technology. If the technology cannot be justified then the process stops.

Phase IV—Technology Selection

During this phase the organization attempts to select the technology that best fulfills their needs.

Phases V and VI—Technology Implementation and Maintenance

Once a new technology is selected, the organization commits itself to taking the appropriate measures for successful implementation and maintenance.

COMPUTER-ASSISTED SPATIAL INFORMATION SYSTEM

We prefer to think of CADD, AM/FM, and GIS as some of the software tools in the Computer-Assisted Spatial Information System (CASIS) subset of the information system set. Fig. 2 illustrates the information system set hierarchy.

By definition, an information system is a set of processes used to convert raw data into information useful for decision making. An information system does not have to be a computer; it can include a manual system for storing and manipulating data. An information system contains at least four elements: (1) A set of rules and procedures (manual or computer-based) for data collection, storage, and retrieval; (2) analytical capabilities (again manual or computer-based) to interpret the data; (3) the data; and (4) an organization of people within which the system operates. [Note: A vast amount of literature exists on information systems, see Laudon and Laudon (1988) for a start.]

A computer-assisted spatial information system (CASIS) is defined as an information system implemented in a computer environment (as opposed

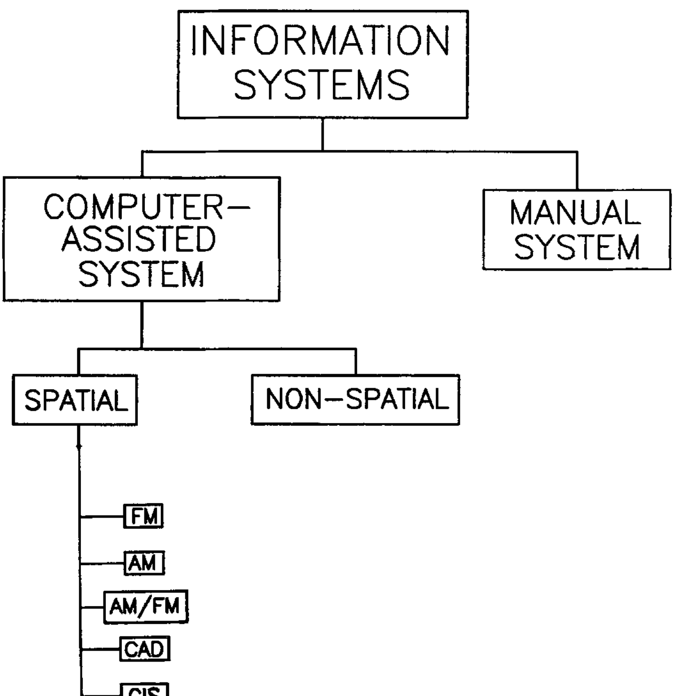

FIG. 2. Taxonomy of Computer-Assisted Spatial Information Systems (Carter 1989; McLaughlin and Nichols 1987)

J. Urban Plann. Dev., 1993, 119(4): 173-188

to manual) based on a spatial reference system. The parts of a CASIS include the hardware, software, data, procedures, and people. The hardware could be a DOS-based, UNIX-based, or other type of machine. The software could be computer-aided drafting and design (CADD), AM/FM, GIS, and so on. The data usually (but not necessarily) include a graphic element, such as a map, and nongraphic elements, such as names, types, and sizes. The procedures include formal names of data types, data-security issues, and methods of data collection. And the people are managers, computer-scientists, computer-hackers, planners, and engineers. Some examples of CASIS include a computerized map, a computer-aided drawing, a computerized database of addresses or property owners, a computerized asset-management system, a computerized work-order-management system, a traffic-incident report, and a police summary of theft location.

Some Confusion

The reader may find other definitions of these systems as provided by other authors, including Dueker and Kjerne (1990), Korte (1991), Cowen (1988), "Geoprocessing" (1990), Carter (1989), and Huxhold (1991). Few of these definitions provide a clear, comprehensive, systematic categorization. Those definitions usually present a confusing categorization of systems, which fails to provide a comprehensive understanding of these systems, leading to a failure in proper usage.

The main source of confusion is the failure to settle on a common, all-encompassing term to refer to these technologies. Most professionals advocate and use GIS as the all-encompassing term to describe these technologies. One problem with the term "GIS" is that many of the full-function GIS software packages should not be lumped with software having considerably less or different function, e.g., CAD systems.

Another problem with the term "GIS," is that it is sometimes used to refer to the software component of the system and other times used to refer to the total system. This is especially confusing when someone must distinguish between a "GIS" system and "GIS" software. It is most constructive to think of the GIS in terms of software only, and CASIS in terms of the total system.

Often, discussions on these systems cover the topic by discussing the types of software tools available. This approach can also mislead the novice since software tools tend to be disjointed, i.e., there are no obvious relationships interconnecting them. A better insight can be gained through a historical discussion of CASIS's software evolution, as follows.

Some Disconfusion

In the past, various scientific and engineering practices have emerged as separate, segmented disciplines. Despite the segmentation, a characteristic common to many of them was (and continues to be) graphic communication through the medium of maps and drawings. Since the emergence of the computer these various disciplines used the computer in their own unique way. Because of the segmentation of disciplines, the early development of computer tools for spatial processes became segmented. For that reason, there exists today several different types of computer-assisted spatial information systems, each designed to service a specific part of the market.

In hindsight, the result is that several disciplines have worked separately on the common topic of maps and drawings. Burrough (1986) says, "Many disciplines are attempting the same sort of operation: namely to develop a

J. Urban Plann. Dev., 1993, 119(4): 173-188

TABLE 1. CASIS Technologies by Activity Types

CASIS technology (1)	Activity Type A (2)	B (3)	C (4)	D (5)	E (6)
Photogrammetry, surveying, scanners, digitizers	x	—	—	—	—
Database-management algorithms	—	x	x	—	—
Spatial-analysis algorithms	—	—	—	x	—
Terminals, plotters, computer graphics	—	—	—	—	x
Commercial DBMS FM packages	—	—	x	x	x
CAD system	x	x	—	—	x
Automated mapping system	x	x	x	—	x
AM/FM system, LIS, GIS	x	x	x	x	x

powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular purpose."

Therefore, in this study CADD, AM/FM, and GIS are used in reference to the computer software tools only; and CASIS is used to refer to all the tools needed to operate the system: people, procedures, data, hardware, and software. We define CASIS software tools as those that either store, draw, manipulate, analyze, or capture data having a relationship to the earth's surface. These tools perform one of the following activities:

Activity type A—to capture graphic and/or nongraphic data having a spatial relationship to the earth's surface. This technology includes capturing data from remote and photogrametric sensors, surveys, scanners, and digitizers.

Activity type B—to store and retrieve only graphic data in an efficient manner for viewing, correcting, or modifying. This technology includes computer-aided drafting and computer cartography.

Activity type C—to store and retrieve only nongraphic data in an efficient manner for viewing, correcting, or modifying. This technology includes database systems.

Activity type D—to analyze and manipulate the stored information. This technology includes a large number of spatial and nonspatial analysis techniques and algorithms that answer questions about the stored information.

Activity type E—to report and display all or part of the spatial and/or nonspatial data. This technology includes visual display terminals, printers, plotters, and magnetic media.

Table 1 provides a systematic summary of CASIS technologies with their activity types. Appendix I is an abridged glossary of the terms in Table 1.

SURVEY OF LOCAL GOVERNMENT COMMUNITIES

A survey of local government communities in Missouri was conducted to determine the characteristics of communities' current mapping systems, the level of familiarity with computer automated systems, and the potential for purchase of a system in the future. A complete report of the survey is contained in McCrary (1990). In-depth interviews were conducted with four city administrators to obtain additional insights.

The survey results reveal that small cities (population less than 30,000) are dissatisfied with their current mapping systems, which is heavily utilized by many different users to manage daily activities. But, they are so unfamiliar with automated technologies that they cannot see the benefits of using

J. Urban Plann. Dev., 1993, 119(4): 173-188

them. Small cities may also find it difficult to evaluate system alternatives, because of the lack of expertise needed to make that evaluation. Therefore, small cities are not using automated systems, and do not plan on using them in the future.

BRIDGING THEORY/PRACTICE GAP: LIFE-CYCLE APPROACH

In *Megatrends*, Naisbitt (1982) describes the shifts that shape our times, one of which is the shift from an industrial society to an information society. This information shift has found its way into public-works infrastructure. The usefulness of information systems is just now coming to be fully realized by cities as communities begin using these systems to successfully manage all aspects of their information.

Small-community applications include infrastructure management, city planning, emergency protection. This paper uses the project life-cycle model in Fig. 1 to examine the challenges of bridging the theory-practice gap. This can be accomplished by providing at each stage of the life cycle the decision-support tools for using these technologies in very small communities.

PHASE I. ORGANIZATIONAL NEEDS

The determination of organizational needs can be achieved by conducting a formal needs, or requirements, analysis. The results of that analysis should define the functional and informational requirements to be placed on a system by the user.

One of the decision-support tools needed by communities is in the area of determining these organizational needs. Information to support this decision can be obtained by asking questions, analyzing data on existing systems, and/or determining ideal system characteristics. Generally, GIS experts use these same techniques for determining information requirements, and usually ask the following critical questions of both the user and top management.

What are the project's goals and objectives?
Who are the potential users of the system?
What is the data flow in the current system?
What are the data that will be captured, processed, and used?
What are the products to be generated by the system?
What technology is available to perform the work?
What types of people are available to use the equipment?

One approach to determining information needs is suggested by Dangermond and Freedman (1984), who approach needs analysis from the standpoint that municipalities all perform the same basic, or generic, functions and, therefore, have the same basic needs and potential applications. The system and information requirements result both from looking inside the organization and from looking at other organizations.

A study completed by Hanigan (1990) was based upon a method similar to this approach. That study revealed nine general and common application areas across the current user community. Communities can begin to discover their needs by looking in these nine areas for system requirements: Geographic data collection, facility and asset inventory, map and chart publishing, resource allocation, simple network analysis, complex network analysis,

J. Urban Plann. Dev., 1993, 119(4): 173-188

site-location planning, subsurface and surface assessment, and tracking and monitoring (Hanigan 1990).

This approach contributes to a successful and reliable needs analysis and should be used by small communities in their decision process for several reasons: (1) The approach uses the successes and failures of other organizations as a basis of analysis; (2) it recognizes the existence of common needs and characteristics across organizational boundaries; and (3) it takes advantage of several types of information-analysis techniques, combining the advantages of each technique.

PHASE II. TECHNOLOGY AWARENESS

In the second phase of the project life cycle, technology awareness, a lot of information is needed about appropriate technologies and their functionality. The discussion given in the previous sections provides a much-needed source of the information needed during this phase of the life cycle. It is the communities' responsibility to obtain the education needed about these technologies. However, universities, professional societies, and technology-transfer agencies play a key role in making high-quality and affordable information available to these entities.

Another piece of information needed about the technology is the cost for purchase, installation, and usage of a system. In this phase, information on cost is needed to provide an initial order-of-magnitude estimate for use in early decision making. However, the level of cost detail needed will gradually increase throughout the life cycle of the project. In this phase, the technology needs of small communities will be on the order of $30,000–50,000 and more, although initial costs for hardware and software only (without data) could be as low as $15,000.

Discussions about software, hardware platforms, vendors, consultants, etc., is beyond the scope of this paper. Those interested in learning more in this area should refer to other sources *1993 International GIS Sourcebook* (1993), the annual issue of *Software Reference Guide*, published by the International City Management Association, Washington, D.C.; or the annual April issue of *Public Works* magazine.

PHASE III. TECHNOLOGY JUSTIFICATION

Having become aware of its needs and the available technologies, a community should purchase a system that will best fill its needs. Typically, a community should justify the new system's ability to provide more benefits than the existing system, and these benefits should exceed the cost of the new system. Some cities may not be ready to purchase CASIS; in these cases they should purchase not CASIS but a manual spatial information system.

There are several decision-support tools available for justification. The following discussion focuses on one of these tools, benefit-cost analysis (BCA), since it is the method of choice in public agencies.

Justification of CASIS Using BCA

The literature discussing the justification of CASIS systems is sparse. However, two studies provide outstanding decision support ideas in dealing with a BCA in CASIS. [Dickinson and Calkins (1988) provide a general discussion and framework for conducting a BCA.]

The first is a study by American Public Works Research Foundation

(*Good* 1988). The other study, done by the Joint Nordic Project (*Digital* 1987), identified several benefits, looking at several public agencies, the smallest of which had a population of 90,000. These two studies listed the following benefits of computerized mapping.

- Flexibility: Information can easily be adapted for multiple users; individual departments no longer need to maintain their own records.
- Productivity: The benefits of faster access to information and ease of maintaining records ultimately outweigh the initial outlay of time and money.
- Centralization: Data are stored in a single database, allowing better communication and more-efficient updates.
- Decision making: Allows presentation of nongraphic data on a map. Abstruse concepts become concrete; computerized mapping and records become an information resource. Managers, planners, and engineers can make better decisions in less time.
- Updating: Up-to-date information can be accessed in a timely and efficient manner.
- Analysis: More information and analysis tools are available.

Justification of CASIS in Small Communities

Justification for using new technology in an organization is not a new issue, although it is new to small communities using CASIS. For decision-support tools to be useful and effective, it is important to know both economic and noneconomic benefits of these systems, specifically to small communities. If a net benefit does not exist, small communities should not purchase these systems.

Cities realize the importance of having a complete and updated atlas of their facilities. The question is whether the decision to automate can be supported by demonstrating real benefits to mapping the community's atlas. The benefits of using automation is an elusive topic. It is widely believed that the benefits for communities exist, but they are usually difficult to demonstrate. The Joint Nordic Project (*Digital* 1987) demonstrated a 1/1 B/C ratio for mapping in large communities. And Korte (1991) provided a benefit-cost analysis for a medium-sized city (definition of size not specified). Previous studies have been done for relatively large communities (greater than 90,000) with large budgets (over $100,000). The question for small communities is they will also see these benefits.

In an effort to provide better information for the process of deciding to purchase CASIS, net present value data from the Joint Nordic Project was extrapolated for cities smaller than 90,000 (Fig. 3). Fig. 3 shows that communities as small as 2,500 population may realize a net benefit when using automated mapping technology. Although the potential for a net benefit exists, it is important to remember that Fig. 3 is based on extrapolated data. More research and information are needed to substantiate the assumptions behind Fig. 3.

The information contained in Fig. 3 falls well short of providing potential users of CASIS with the justification needed to implement a system. There is a tendency by CASIS vendors and consultants to paint a rosy scenario for the use of this technology; the present study does not with to fall into that category. Although many users have justified their systems and have realized both economic and noneconomic benefits, research is still needed—

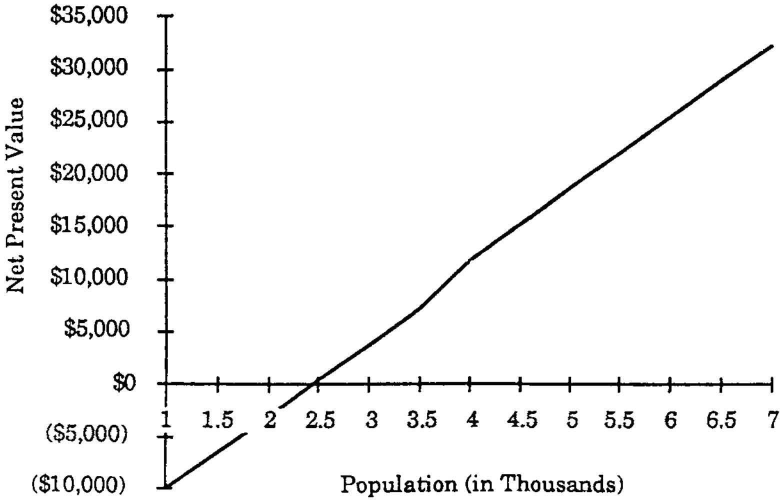

FIG. 3. Variation of Net Present Value of Automated Mapping System with Population

and is ongoing (NCGIA: "Use" 1989)—on the use and value of geographic information, especially for small communities. Craig and Moyer (1990) also emphasize the need for more research in this area.

PHASE IV. TECHNOLOGY SELECTION

If a community has identified its needs, becomes aware of available technologies, and justified the purchase of a system, it is ready to move to the next decision point: selecting a system. According to *GIS World 1993* (1993), there are over 270 commercially available GIS—or closely related—systems on the market. Today, the challenge facing many city administrators, engineers, and planners is that of selecting the appropriate system from among the many alternatives. For various reasons, many small communities have not accessed the expertise needed to properly select a system. An expert system or a knowledge-based system that can capture the knowledge of GIS and infrastructure-management experts in a computer program can be of considerable benefit in providing much-needed decision support during the technology-selection phase.

The process of selecting a computer and computer software is well documented. Literally scores of articles and books exist on the subject [see for example Shoval and Lugasi (1988)]. These references all document four steps in the selection process:

1. Determine user needs and/or requirements
2. Learn technologies and their features
3. Match requirements to technologies
4. Select the appropriate system.

The information needed to complete the first two steps was covered in previous subsections of this paper. The decision-support strategies and logic

J. Urban Plann. Dev., 1993, 119(4): 173-188

needed in steps 3 and 4 are complex, and are beyond the scope of this paper. These issues are fully covered in McCrary (1990). However, this section discusses the major issues of selection discovered in the development of a knowledge-based decision-support tool called EXGIS (expert system for GIS selection). This system, when complete, will assist communities in the selection of a software package appropriate for their needs. This system is also more fully reported in McCrary (1990).

To properly design an automated decision-support tool for technology selection, the following major issues must be addressed.

Define Objectives and Needs of User

It can be summarily stated that selection is a process based on how well various technologies fulfill certain objectives of the user. The entire process depends on how well this first step is done.

Differentiate Absolutely Essential from Less-Essential Needs

Technologies are evaluated first based on using the absolutely essential needs of the user; failure to meet this requirement drops the technology from further consideration. Only technologies passing the first evaluation go through a second evaluation, which is based on how well they fulfill the less-essential objectives of the users.

Divide User's Objectives among Four Subobjectives

Selection is usually on four major subobjectives: functional, technical, vendor, and price. First, functional objectives are those tasks and needs of the user that the software features can functionally perform. Second, technical objectives include such ideas as the "friendliness," "speed," and "modularity" of the software. Third, the vendor objective attempts to categorize the quality of the software vendor in terms of experience and reliability. The fourth objective, price, is the cost of the software.

Multiattribute Utility Theory

Multiattribute utility theory (MAUT) approaches are by far the most reported decision-support tool used in the selection of software. The essential idea behind MAUT is that decisions can be decomposed into a decision hierarchy and then appropriately aggregated to form the basis of a decision. A general example of a decision hierarchy is shown in Fig. 4.

A hierarchy is composed of objectives, subobjectives, and attributes, used to break down a problem into its logical parts. An objective is the desired direction or goal of the decision maker or organization. The objective is placed at the top of the hierarchy. Detailed objectives, also called lower-level objectives, form the breakdown of the broad objective. A hierarchy is created, with broad objectives at the top and detailed objectives near the bottom. At the bottom of the hierarchy are attributes. An attribute characterizes or defines the (sub) objective it is associated with. Attributes are quantifiable and, if constructed properly, are additive with other attributes.

Several studies have established the value of using MAUT for decision making. These studies demonstrate that MAUT is superior to human judgments because of its robust ability in combining information (Wainer 1976).

Automating MAUT Using Expert Systems

Decision-support systems use decision-science techniques to provide a computerized model of the decision process. One of the newest decision-automation tools is the knowledge-based or expert systems (ES).

J. Urban Plann. Dev., 1993, 119(4): 173-188

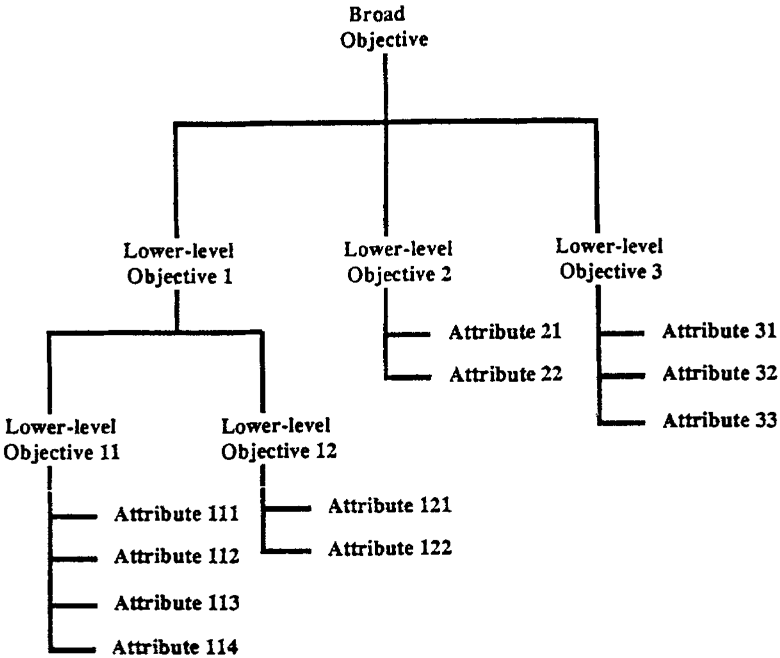

FIG. 4. Example of Multiobjective/Multiattribute Hierarchy

Expert systems use artificial-intelligence (AI) tools to mimic the selection process of human experts. Keller (1987) defines an expert system as "a computer system whose goal is to make decisions or plans as well as, or better than, experts in a particular domain" (page 234). Expert systems capture the decision-making process in a computer-storage device called a "knowledge base" using a series of "if-then" rules. Several studies document the use of expert systems in the selection of decision-support systems. Masud and Kolarik (1987) use an expert system for CAD software selection. In construction engineering, Mohan (1990) developed an ES to select the most appropriate type of ready-mix concrete—a system that recommends the appropriate concreting technique and the admixtures to be used. In computer engineering, IBM's Financial Marketing Expertise (FAME) (Griesmer 1989) is an ES that selects the optimum computer-system configuration for a particular customer's needs. In manufacturing engineering, Benjamin and Hosny (1990) describe EXSEMA, an ES prototype, to advise on the simulation software best suited for a particular manufacturing application.

PHASES V AND VI: IMPLEMENTATION AND MAINTENANCE

Assuming that the technology has been justified and the appropriate technology selected, the next phase is implementing the technology. Although the actual implementation technique used will vary from one organization to another, certain procedures and attitudes can be established as maxims for successful implementation. Croswell (1991) provides one of the best summaries of these maxims, analyzing 39 elected articles on the

J. Urban Plann. Dev., 1993, 119(4): 173-188

experiences and observations of system-implementation efforts. For the organization, Croswell identifies the following issues.

1. Evaluate the organization's readiness to accept and use technology. If the organization is not ready, do not adopt the technology.
2. Get commitment from top management.
3. Assign a project manager early in the project.
4. Adopt a structured approach to system development. This step includes a needs analysis to determine information flow, requirements, detailed implementation strategy, and so on.
5. Involve users in the system design.
6. Formulate a plan and schedule for project.
7. Encourage cooperation and consensus on the project.
8. Allocate sufficient time and proper staff to the project.
9. Provide education and training at all implementation stages.
10. Modify the organization's structure to take advantage of GIS technology.

To properly use CASIS technology, at a minimum, small communities should follow the 10 suggestions just enumerated. But there are some additional recommendations that are important for small communities to consider as follows.

Of the enumerated issues, item numbers 1, 2, and 10 are the most important. Small communities are entrenched in their current organizational structure. Without the support of management, including the council/board and mayor, the project is doomed to failure. Potential users should attempt to determine their organizational readiness for using CASIS technology as the very first step of implementation.

Since most communities have a limited budget, they should consider taking a phased approach to using CASIS. The technology needs of small communities require major capital outlays, as mentioned before, on the order of $30,000–50,000 and more. Most small communities hesitate at spending this much money. A phased approach allows the technology to be used at a slower pace. [By a phased approach we mean purchasing a system a little at a time. For example, it is possible to purchase inexpensive hardware and software (for less than $6,000), and establish a rudimentary database (for less than $5,000). Next, the user could buy a large digitizing tablet, large plotter, and eventually could upgrade to higher-end hardware, software, and data, all as money becomes available.]

In developing an implementation plan, the following items should also be considered:

- Type of computers
- Use of external expertise
- Software implementation priority
- Funding

CONCLUSION

This paper looked at the CASIS literature in an attempt to provide some clarity to the wide variety of published information available on the topic. The review was made especially for those in small communities to assist

J. Urban Plann. Dev., 1993, 119(4): 173-188

them in the decision process at every phase of the CASIS life cycle. This paper used a life-cycle perspective to discuss the critical information and decisions needed by small communities to fill the theory-practice gap in CASIS technology.

Our studies show that the following recommendations will help small communities make better decisions in the CASIS life cycle. Under technology selection, this study recommends that communities conduct a careful needs analysis of their organization. Communities will find the needs analysis of other organizations very helpful as a starting point. This paper provides a point of beginning for communities to become technologically aware, by introducing a new term—CASIS—that provides a clearer distinction between the various systems. A brief and systematic discussion of several technologies was also given. Justification should be done using, for example, a benefit-cost analysis. However, further information and research are needed to verify that the benefits claimed for these systems are real and positive for small communities. At this point in time, because of the lack of clear, unbiased, justification studies in the literature, justification should be done on a case-by-case basis at the local level. Noneconomic benefits are important to the justification process and should be included in the justification analysis.

Selection of these systems is often problematic, requiring the involvement of a CASIS expert to ensure a project's success. However, selection decisions can be made without a CASIS consultant if the community is willing to commit to the time needed to make a well-informed decision. Ultimately, artificial intelligence and MAUT should be able to assist a community in this decision. Finally, implementation issues should be thoroughly understood before the system is purchased.

From the material presented in this paper, this work makes the following comments regarding the CASIS project life cycle:

First, communities should view the CASIS project as a serious and demanding undertaking. From the beginning, the project will demand a lot of deep creativity and resourcefulness.

Second, it is proposed that the term "CASIS" become the overarching term for these technologies. However, it is more probable that this community will continue to use such terms AM/FM/GIS and CAD. It is therefore good advice for potential users to learn what distinguished these systems from each other to the point that the user can recognize these systems. The term GIS is so overused by the vendors that the user community should become especially educated regarding any system using that label.

Further research is still needed on the use of CASIS in small communities. Small communities must be educated on these systems and their proper use. Novel and creative ways of spreading these technologies should be designed and tested. Universities, governments, and the private sector should all be looking at how to use these systems on a small scale. Several small communities around the country are beginning to use these systems. Their experience will benefit those who follow. Finally, the literature is weak in its presentation of the economic benefits for small communities. More research is needed to quantifiably demonstrate these benefits, if they exist, for small communities.

ACKNOWLEDGMENTS

We wish to gratefully acknowledge the financial support provided by the Center for Technology Transfer and Economic Development, and the Small Business Development Center, both at the University of Missouri-Rolla.

This research was partially funded by the U.S. Small Business Administration under Cooperative Agreement Number SB-2M-00147-02. The support given by the U.S. Small Business Administration through such funding does not constitute an express or implied endorsement of any of the Co-Sponsor(s)' or participants' opinions, findings, conclusions, recommendations, products, or services.

APPENDIX I. ABRIDGED GLOSSARY OF TERMS

Automated mapping/facilities management systems. AM/FM technology evolved from the need to link stand-alone automated mapping systems to stand-alone facilities management systems. Basic functionality includes the ability to assign attribute data to graphic elements, to assign positions to facilities, and to produce planimetric or topographic maps. Other functionality includes network connectivity and analytical capabilities unique to the particular application, such as materials lists or work-order creation.

Automated mapping systems. Automated mapping can be defined as a system that focuses on map design, creation, and maintenance. Although mapping can be done with CAD software, AM packages are true mapping packages since they include such mapping algorithms as map registration and map-projection transformations.

Computer-assisted spatial information systems. CASIS are tools that use a computer to store, draw, manipulate, analyze, or capture information having a relationship to the earth's (terra) surface. Some examples of CASIS include a computerized map, a computer-aided drawing, a computerized database of addresses or property owners, a computerized asset-management system, a computerized work-order management system, a traffic-incident report, and a police summary of theft location.

Computer-aided drafting systems. CAD is unique because it traces its roots to computer graphics, not to geography as do some CASIS technologies (e.g. GIS), accounting for its emphasis on graphic modeling. CAD packages capture graphic data, store and retrieve graphic data, and report and display data. CAD packages differ from geographic information system(s) in that CAD systems can only create displays and cannot process the base data since they have little or no analytic capability.

Database management system. DBMSs are software packages used to create and manage a computer file of data. They allow the user to extract or retrieve specific data in the format desired. Computer-mapping and computer-drafting packages use database technology to manage graphic data.

Facilities management systems. FM packages can be distinguished from other packages mainly by their lack of a graphic interface. They are specially designed DBMS packages usually used in: (1) Work-order management, including facility inventory, historical tracking, preventive maintenance, and customer-complaint tracking (Hansen 1989); (2) field inspection and testing; (3) cost management; and, (4) repair, rehabilitation, and placement.

Geographic Information Systems. The term GIS has many synonyms: spatial-information system, geographic data system, land-information system, and geographical information system. It is widely considered to be a collection of computer hardware and software capable of doing four things: (1) Creating and editing geographic data; (2) linking locational and attribute data; (3) performing spatial analysis; and (4) displaying collected information. This definition allows a variety of software packages, with

varying degrees of functionality, to be considered as GISs, but it says nothing about the ability of the software to perform these functions.

APPENDIX II. REFERENCES

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