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Authors
Onsrud, Harlan J.
Pinto, Jeffrey K.
Azad, Bijan

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Testing Technology Transfer Hypotheses in GIS Environments Using a Case Study Approach

Edited by

Harlan J. Onsrud* & Jeffrey K. Pinto**
National Center for Geographic Information and Analysis
*Department of Surveying Engineering, University of Maine, Orono 04469-5711
**College of Business Administration, University of Maine, Orono 04469-5773

and

Bijan Azad
Department of Urban and Regional Planning
Massachusetts Institute of Technology, Cambridge, MA 02139

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Chapter One
Introduction

In late 1990 and early 1991, a methodological framework was developed for testing technology transfer hypotheses within GIS operational environments. The paper reporting this work was titled "Case Study Research Methods for Geographic Information Systems" (Onsrud, Pinto, and Azad 1992) and drew upon concepts developed by Alan Lee and predecessors and reported in a paper titled "A Scientific Methodology for MIS Case Studies" (Lee 1989).

The "Case Study Research Methods" paper was used subsequently as the basis for a call to researchers around the country to participate in a coordinated and cooperative case study research effort to test a series of prespecified technology transfer hypotheses. The call was first issued at the 1991 annual conference of the Urban and Regional Information Systems Association (URISA) as a joint project of NCGIA Initiative 4 on the Use and Value of Geographic Information and the URISA Special Interest Group on Education and Technology Transfer. Preliminary results from several studies were reported in an organized session at the 1992 URISA conference. Participants in that session included Zorica Budic and David Godschalk of the University of North Carolina at Chapel Hill who reported on the use of the methodology in a study of four government agencies in Cumberland County, N.C. Steven Ventura of the University of Wisconsin followed with a report on a case study of the Town of Middleton in Dane County, Wisconsin and Steven Frank of the University of Maine finished the session with a report on use of the methodology in a study of the GIS operations of a large paper company in Maine.

This report gathers together (1) the original foundation paper used as the basis for the case study research project, (2) the call for participation that includes a listing of the thirty hypotheses for which "control conditions" were sought in each case study, and (3) reports from two of the case studies. The two case studies incorporated into this report were selected for inclusion because they most closely adhered to the methodology presented in the original Onsrud, Pinto, and Azad paper and they provided constructive criticism of the methodology. Some of the diversions from the methodology established for the project may be attributed to differences in the objectives and interests of the participating researchers from those of the original authors, shortcomings in the methods and principles when applied in practice, shortcomings in the principles from a theoretical perspective, limitations in the resources or understanding of the researchers, or a combination of these factors.

Most case work seen to date in the GIS community has been directed at deriving theory. The intent of this project was to spur work in which pre-derived theory would drive the direction the case study work would take and to use case study methods as a means of testing theory. The methods and results that follow are offered as additional tools for gaining greater understanding of the factors and processes involved in implementing and using geographic information systems.

References


Chapter Two
Case Study Research Methods for Geographic Information Systems

Harlan J. Onsrud & Jeffrey K. Pinto
National Center for Geographic Information and Analysis
University of Maine
Orono, Maine 04469
and
Bijan Azad
Boston Redevelopment Authority &
Massachusetts Institute of Technology

Abstract

Although they are perhaps the most commonly-used and popular research methods, case studies and other qualitative forms of social science research have long been criticized for their lack of generalizability to the larger population and lack of sampling controls. These criticisms may be aptly addressed and solutions constructed by evaluating the rules of scientific method within case research environments. By using more logically consistent, rigorous, and systematic approaches, some of the shortcomings of case study methods may be overcome. This article draws from the management information systems (MIS) and organization behavior (OB) literature to make some suggestions on how to conduct and evaluate GIS case study research. It reviews the requirements of natural science research models, particularly as described by Lee (1989), and provides examples of how the substance of those requirements may be met in the context of GIS case studies.

Introduction

Case study methodologies have been suggested within the GIS community as appropriate for researching a range of GIS implementation, utilization, and diffusion issues (Zwart 1986, Niemann et. al. 1988, NCGIA 1989, Craig 1989, Azad 1990). These issues include identifying the determinants of adoption outcomes; isolating critical adoption factors and processes for particular classes of users; investigating the stages at which change agent, opinion leader, and champion influences are most critical; assessing use success; determining levels in the organizational structure where GIS products are used and to what extent; identifying the forms of decision making which have utilized GIS; identifying factors and processes leading to rejection of previously embraced GIS; and identifying organizational and societal consequences of GIS (Onsrud and Pinto, 1991).

Case studies examine phenomena in their natural settings and typically involve collection of data by several different means from a range of sources. When used as the sole research heuristic device, case studies have been criticized for their limitations in terms of generalizability to the larger population and lack of sampling controls (Piore 1979, Bariff and Ginzberg 1982, Bonoma 1985). It is generally acknowledged in the social science research community that no single research methodology is most appropriate for all research applications (Williams, Rice & Rogers 1988). In addition, it is generally agreed that using multiple forms of research to investigate an issue leads to better and more reliable results than using a single methodology (Yin and Heald 1975, Cook and Campbell 1979, McClintock, Brannon & Maynard-Moody 1979, Kaplan and Duchon 1988). Case studies are often included and occupy a lead position in the suite of methods used by researchers to evaluate intervention strategies within organizations. However, there is a need to clarify the explicit methodological means by which case studies within GIS application environments should be carried out.

For purposes of this paper, a case study is an examination of a phenomena in which the primary purpose of the observer has been to carry out research rather than to implement a system or improve an operational environment. That is, since the techniques suggested in this article are intended for individuals testing theories relating to the efficacy of intervention strategies, they will be less useful to practitioners who are implementing systems. Of course, the overall intent of investigating various case study techniques is to aid researchers in building a relevant body of knowledge which eventually will aid practitioners in their system implementation and improvement efforts.

Let us assume that the general GIS practitioner community is confronted with an implementation issue in which the most appropriate intervention strategies to use in addressing that issue are difficult to determine. For instance, organizations throughout the general GIS community currently are involved in determining which processes they should follow and which factors they should consider to ensure that their GIS systems are used to their greatest benefit over time. Another example is determining which policies

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Utility of Case Study Approaches

The traditional phases of accruing knowledge within "learned" settings are often expressed as exploration, hypothesis generation, and hypothesis testing (Glaser & Strauss, 1967). In the exploration phase, researchers descriptively study how organizations have dealt with the constraints imposed upon them. These knowledge capture studies form the basis for developing theories regarding phenomena and for hypothesizing prescriptive strategies. After deriving the theories and generating hypotheses in support of them, the researcher proceeds to the hypothesis testing phase.

Conventional thinking in the MIS literature indicates that case study approaches are highly appropriate for the exploration and hypothesis generation phases but are generally ill-suited to the hypothesis testing phase (Roethlisberger 1977, Bonoma 1983, Benbasat 1984). The argument made is that, although disconfirmation of a hypothesis might be shown by a single case, reasonable confirmation of a hypothesis requires analytic deductive testing of a representative and substantial sample (Benbasat, Goldstein & Mead 1987). By this reasoning, data must be gathered in a form suitable for quantitative processing and must be gathered for a significant number of cases to evidence confirmation of a hypothesis reliably (Bariff and Ginzberg 1982, Dickinson, Benbasat & King 1982, Kauber 1986).

A recent article by Lee (1989) challenges the conventional wisdom with regard to the use of case studies in the hypothesis testing stage. He argues that the data or results generated from case studies need not be quantitative, statistical, or mathematical in order to be analytically rigorous or "scientific." We believe the application of his approach to the evaluation of GIS implementations could provide a useful and practical means for the GIS community to better isolate those factors and processes which are critical for inclusion in prescriptive implementation and improvement strategies.

Croswell (1989) lists numerous obstacles to successful GIS implementation and categorizes them into eleven major groups: apathy/fear of change; funding availability or justification; planning/management support; organization coordination and conflicts; training/understanding of technology; staffing availability/recruitment; software complexity/maturity of technology; data communication/networking; data structure and source materials; data and software standards/data integration; and miscellaneous. The obstacles listed in each group were identified from a wide range of GIS literature extending from 1985 through 1988. From the diffusion of innovations literature and GIS tracer case studies, Onsrud and Pinto (1991) developed a similar list of factors potentially critical to successful adoption of GIS.

Typical questions which arise in regard to such lists include the following: Which of the factors cited may be most critical for a particular class of users or for particular forms of organizational structure? To what extent is it necessary to consider each item? Are there items on the list which might be "perpetuated myth" rather than actual requirements for success? Are there items on the list which may improve the likelihood of initial acquisition but be counterproductive to long term success or vice versa? Appropriate application of case study approaches could aid in finding the answers to these and similar questions.

Lee's Scientific Case Study Methodology

"Few propositions in science are directly verifiable as true and none of the important ones are" (Copi 1986 as reported in Lee 1989). Thus, most theories, whether in the natural or social sciences, may be tested only indirectly. The indirect testing of a theory consists of deriving one or more suppositions capable of being tested directly from the theory and then comparing the actual outcomes against those which were predicted. In addition to making this comparison, the scientist must also provide evidence that the outcomes are attributable to the supposition being tested and not to other causes.

Lee argues that a single case study meets the requirements of scientific method if it adequately addresses four methodological problems; making controlled observations, making controlled deductions, allowing for replicability, and allowing for generalizability. The discussion which follows draws heavily from Lee (1989) and, with the exception of the additional references noted, paraphrases extensively from his work.
In natural science research models, controlled observations are typically achieved by regulating the test environment through laboratory controls (e.g. control groups along with treatment groups) or statistical controls. Neither of these controls is readily available to the GIS case study researcher. GIS implementation issues by their very nature must be observed in real world settings and therefore setting up or finding a case study control group for comparison purposes is very difficult. Similarly, the study of a single case generates more variables than data points and as such is inappropriate for evaluation through statistical methods. A GIS case study must necessarily identify and take advantage of natural controls.

Glaser and Strauss’s (1967) study of "grounded theory" research argues for a comparative model where practicable. Their approach suggests that the case study method should be supplemented by the selection of another, comparable research site. These two case sites should possess similar goals (e.g., expanding the use of GIS in the organization) but have dissimilar characteristics in other aspects. For example, a comparative model to test the effects of top management support for expanded use of GIS would select two similar municipalities: one with strong top management support for GIS and another with little support. It could then be argued that the use of a comparative model has allowed the researcher to set up a form of controlled observation allowing for generalizable theory development. (See Meckstroth (1975) and Lijphart (1975) for more precise definitions and refinements of the comparative model.)

Deductive reasoning is typically controlled for in natural science models through mathematical propositions. Since GIS case studies are qualitative in nature, the convenience of mathematical logic and mathematical tools are unavailable to us. However, we are not precluded from using the formal rules of logic from which those mathematical tools derive. "Mathematics is a subset of formal logic, not vice versa." (Lee 1989, p. 40) The expression of logic through verbal propositions is certainly possible and seems an appropriate and valid alternative for making controlled deductions within GIS use environments. Ragin’s (1987) pioneering work in application of Boolean logic to qualitative comparative method and his subsequent development of a computer-based package for such analysis has proven beyond doubt that the use of logic in case study research is attainable and appropriate.

Replicability is controlled for in natural science models by testing an observed phenomena numerous times under the same set of conditions to determine whether the results remain constant. In evaluating GIS implementations the same set of technical, organizational, and social conditions are unlikely ever to be replicated in natural settings. However, it is possible to carry a constant theory from one case study to another. The concept of replicability can be satisfied in GIS case study work by testing the same theory in new environments. Switching environments to test the same theory may involve deriving new predictive outcomes for the testable hypothesis or may even involve completely new testable hypotheses. Regardless, the new observations will either continue to support the theory or falsify it. Thus, GIS researchers may replicate the results of their peers through testing of the same theory even though conditions under which the theory is tested will change; that is, their results in a variety of environments will show that either the theory continues to be supported or is falsified.

Allowing for generalizability of research results is little different in a GIS case study environment than in a natural science environment. Generalizability is a quality measure which indicates the extent to which a theory is applicable to a range of settings. In a natural science setting, one test or experiment under a single set of circumstances is not generalizable. Only when a theory has been repeatedly tested across a range of circumstances and not falsified can it be reasonably said that the theory is generalizable through that range of circumstances.

Even though a case study may meet the four requirements of scientific methodology, Lee suggests that a case study investigation remains inadequate without inclusion of an evaluation of the extent of its analytic rigor. He suggests that the extent of analytic rigor may be evaluated by addressing the questions which are paraphrased and summarized in Table 1. Rather than discussing the concepts and reasoning behind the questions, we illustrate by example in the next section how GIS implementation theories might be tested using a case study approach. For those desiring a more indepth discussion of underlying concepts, we commend the Lee (1989) article to you.

**Application of Scientific Methodology to a Hypothetical GIS Case Study**

Let us presume that XYZ Corporation is a large company generating most of its revenue from the sale of lumber and other forest products from its extensive land holdings. XYZ Corporation acquired GIS technological capabilities several years ago but use of the system has been largely limited to its automated mapping capabilities. Management seldom calls upon the analysis capabilities of the system. Personnel in other divisions of the corporation occasionally request hard copy and digital products from the GIS Division but in general other divisions have been reluctant to use products generated from the GIS or to contribute data to the system.

By referring to the "lessons learned" in case histories documented in the GIS literature (e.g. URISA Proceedings) and MIS literature, numerous theories may be postulated in an attempt to explain why a GIS has not been used more extensively within a particular organizational setting. A small sample of the competing theories we might consider in this single case are as follows:
1) Relative Advantage Theory: If the relative advantages of using the GIS over the procedure or system the GIS replaces is small, even though benefits to the overall organization might be great, the GIS's intended users will resist its use.

2) System Complexity Theory: If the complexity in using a GIS over the procedures or system the GIS replaces is great, even though advantages to individuals, groups, or the organization as a whole may be substantial, the GIS's intended users will resist its use.

3) Communication Networking Theory: If the degree of interpersonal communication networking in the organization is low (i.e. few informal and formal opportunities to talk with others at all levels and across divisions), resistance to expansions of use or improvements in use of the GIS will be great.

4) Interaction Theory: If the patterns of information flow and control prescribed by using the GIS are incompatible with the information control patterns prescribed by the organizational structure, those individuals and groups losing power in the organization will resist its use.

Each of the above theories has been phrased in terms of resistance to GIS use or improvement efforts. The first two theories relate primarily to characteristics of the technology, the third theory relates to a characteristic of the user organization, and the fourth theory focuses on the relationship between the technology and the organization. Numerous additional theories attempting to explain why technologies are being underutilized are suggested in the literature (e.g. Greer 1981, Wellar 1988, Croswell 1989, Obermeyer 1990, Onsrud & Pinto 1991) but those stated here are merely a sample for illustrative purposes.
Each of the theories involve phenomena which are very difficult to observe. Nebulous factors upon which the theories are dependent include "... human nature, cognitive styles, personality traits, factors internal to the person, user friendliness, technical deficiency in (the) system, ergonomics, horizontal and vertical dimensions of organizational power, power in terms of symbolism, and ... the distribution of power implied in the design of (the) information system" (Lee 1989, p.37). As a result, none of the above theories can be directly verified as being true. From each of the theories, however, we may predict outcomes for various scenarios which are directly observable and which, if they are observed, will either imply that the theory is true or will evidence the theory as false. (See Table 2)

One prediction leading from the "relative advantage theory" is that providing increased advantages to the intended users of the GIS in those divisions which are not using it will reduce resistance to its use. For instance, management has determined that incorporating the thousands of survey measurements made by its surveying division into its GIS database each year would be extremely beneficial to the long term efficacy of the corporate database. However, a case study researcher observes that personnel in the surveying division of the corporation continued to resist all efforts to contribute to or use data from the GIS until an automated survey measurement management system was installed. This system allowed surveyors to carry out their typical daily tasks much more efficiently and provided them with capabilities they never had before, such as the ability to automatically detect and isolate blunders in their work and the ability to efficiently incorporate GPS observations in their adjustment networks. The system also allowed convenient file transfer back and forth with the GIS.

The observation that resistance to working with the GIS by the surveyors was greatly decreased by providing means to do their jobs more effectively lends support to the "relative advantage theory." Of course, other theories might just as reasonably explain the overcoming of the resistance. At this point we can say only that the particular theory being evaluated has not yet been falsified.
<table>
<thead>
<tr>
<th>Theory</th>
<th>Predicted Outcome</th>
<th>Description of Natural Controls (i.e. Events which occurred naturally without any intervention by the observer)</th>
<th>Observed Outcome</th>
<th>Evidence of Support or Falsification of the Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Relative Advantage Theory</td>
<td>1) Providing technical solutions which increase capabilities and efficiencies in carrying out surveying division tasks should decrease the division’s resistance to use of the corporate GIS.</td>
<td>1) Technical solutions were provided in the surveying division with no changes to personnel, management structure, or corporation communication patterns.</td>
<td>1) Resistance Decreased</td>
<td>Support</td>
</tr>
<tr>
<td>2) System Complexity Theory</td>
<td>1) Improving the user friendliness of the surveying interface with the corporate GIS should decrease the surveying division’s resistance to use of the GIS.</td>
<td>1) Technical solutions were provided in the surveying division with no changes to personnel, management structure, or corporation communication patterns.</td>
<td>1) Resistance Decreased</td>
<td>Support</td>
</tr>
<tr>
<td></td>
<td>2) Pulpwood division personnel will continue to resist use of the GIS until the complexity in using the GIS is less than the complexity of using traditional computations.</td>
<td>2) Technical option providing functionally similar results was provided to the pulpwood division with no changes to personnel, management structure, or corporation communication patterns.</td>
<td>2) Personnel chose to use the GIS technology.</td>
<td>Falsification</td>
</tr>
<tr>
<td>3) Communication Networking Theory</td>
<td>1) Providing increased opportunities for the disease control manager to communicate with personnel in those divisions fully embracing the GIS, should decrease that manager’s resistance to contributing data to and using the GIS.</td>
<td>1) During the several month time frame of the study, weekly meetings were instituted for technical staff from all divisions involved with GIS to discuss GIS progress, problems and solutions. Disease control manager regularly attends. Also attends weekly meeting of all the division managers with the Vice-President for Engineering.</td>
<td>1) Resistance to contributing data and using the system continues.</td>
<td>Falsification</td>
</tr>
<tr>
<td>4) Interaction Theory</td>
<td>1) Reforestation program manager will resist use of GIS as long as managers of other divisions and upper level management can access planting program data and potentially analyze it without his involvement or consent.</td>
<td>1) GIS offering substantial operational improvements for the reforestation division was provided. Corporate rules allowing lateral and top down open access remain unchanged.</td>
<td>1) Resistance Continues</td>
<td>Support</td>
</tr>
<tr>
<td></td>
<td>2) The Vice-President for Finance will continue to resist use of the GIS by her division as long as accounting division information is being input and maintained in the GIS by real estate division personnel who report to the Vice-President for Engineering.</td>
<td>2) The accounting division and real estate division were realigned in the corporate structure to both report to the Vice-President for Finance. No significant changes to technical capabilities of the GIS, input or maintenance procedures, or corporation communication patterns occurred during this time.</td>
<td>2) Resistance Eliminated</td>
<td>Support</td>
</tr>
<tr>
<td></td>
<td>3) (example omitted)</td>
<td>3) ...</td>
<td>3) Resistance Eliminated</td>
<td>Support</td>
</tr>
<tr>
<td></td>
<td>4) (example omitted)</td>
<td>4) ...</td>
<td>4) Resistance Continues</td>
<td>Support</td>
</tr>
<tr>
<td></td>
<td>5) (example omitted)</td>
<td>5) ...</td>
<td>5) Resistance Continues</td>
<td>Support</td>
</tr>
</tbody>
</table>
Note that the researcher here took advantage of natural controls. No personnel or organizational changes occurred during this time. This tends to suggest that competing theories involving organizational factors or people factors were not the cause of decrease in resistance by this group of individuals. In GIS case study observations, there is a need to formally analyze the causes of changed conditions as well as analyze continued resistance despite changed conditions.

A "system complexity theory" might also be evaluated through the facts presented. The automated measurement management system now being used by the surveying division in conjunction with providing data to the GIS is far easier to use in several ways than the previous software and procedures. One prediction from the system complexity theory is that improving the user friendliness of the surveying measurement interface with the GIS would decrease resistance to use of the GIS. Thus the system complexity theory is also supported by the facts presented. Both the relative advantage theory and the system complexity theory appear to be at least as explanatory as the other. The observed scenario fails to distinguish which of the theories, if either, is most critical in explaining the change in resistance. However, both theories have passed attempts made at their falsification and knowledge has been gained in the context of a formal conceptual framework.

Let us assume that the case study researcher observes also that personnel within the corporation’s pulpwood division are often requested to provide yield estimates for various land parcels. For a typical request, personnel can provide within an hour’s notice an accurate estimate of the pulpwood yield for a typical parcel through use of conventional maps, airphotos, and a hand held calculator. Estimates with approximately the same accuracy and requiring approximately the same lead time can be made using far more complex procedures by one of the division’s employees trained to use the GIS. The system complexity theory predicts that employees within the pulpwood division will resist use of the GIS. This prediction is compared with that which is actually observed. In this instance, the GIS is almost always chosen to make such estimates and the prediction is falsified. This result supports the contention that the underlying theory upon which the prediction is based can not be generalized to the circumstance observed.

Regardless of whether the prediction holds true or false under the facts stated, the researcher has eliminated many other potential explanations for the results by searching out an instance where the results achieved by using the new procedures were functionally equivalent to those using the old procedures. That is, the results cannot be explained by theories dependent on changes in personnel, alterations in management structure, or changes in communication patterns because these all remained constant in the setting observed. By using this "natural control" situation, the researcher provides evidence, although not conclusive, that the observed phenomena is due to the proposition being tested and not attributable to other factors.

Through the methodology outlined, the case study researcher explores one theory after another by generating one or several predictions for each theory and then actively searching for natural control situations to test those predictions within the organization being studied. The study of a single organization might provide results similar to those summarized in Table 2.

The table shows that in this particular case study four theories were evaluated. In testing the third theory, a situation was observed in which the disease control manager's resistance to cooperating with the new innovation could not be explained by the communication networking theory. The observer was unable to isolate control conditions to explain the resistance of this particular manager or of the personnel within his division such that predictions relative to the other three theories could be tested. However, if we consider the four theories to be competing with each other in explaining the cause of resistance to greater use of the GIS throughout the organization, the overall results of the case study suggest that evaluation of the relative advantage theory or the interaction theory may be more fruitful in developing a successful intervention strategy for lessening resistance by the disease control manager and his personnel than providing yet more formal and informal opportunities for communications by that division with others in the organization.

**Analyzing the Rigor of the Case Study**

The extent to which the case study described satisfies the four requirements of scientific methodology may be analyzed by evaluating the degree of confirmation of each theory addressed. Confirming a theory by successfully testing it against several of its predictors is more rigorous than testing it against a single predictor. Thus, for this single case, the "interaction theory" is more rigorously supported than any of the others because the observer was able to identify five control conditions in which predictions could be tested and all five observations supported the theory. Although the "relative advantage theory" was also supported by the case study, it was tested against only one of its predictors. The case study supplied at least some evidence of falsification of the other two theories but likewise the limited number of predictions against which those theories were tested makes that evidence less rigorous than it might be.

The degree of logical consistency of a theory is also improved by increasing the number of predictors for the theory. Logical consistency requires that a theory must be tested against at least two independent predictors so that their outcomes may be compared with each other for consistency. Thus, in our example, minimal rigor in logical consistency in testing the "relative advantage theory" and the "communication networking theory" has not yet been supplied. That rigor may be supplied by testing the same theories in
other case study settings. Minimal requirements for testing the "system complexity theory" have been supplied but the results are inconsistent as shown. Therefore, that theory fails the logical consistency test. However, the generalizability of the conclusion that the theory has been falsified is highly questionable until the same theory has been tested repeatedly in other case study settings. The "interaction theory" is the most rigorously supported in its logical consistency because it was tested against the largest number of predictors and the five outcomes were entirely consistent with each other.

Contending that one theory is more predictive of outcome than competing theories may be more rigorously supported by increasing the number of theories against which the theory of interest is tested. In the illustrated case study a total of four theories were tested. A few other rival theories were considered but left untested because no control situations could be found within the organizational setting with which to test those theories. Other theories were unconsidered because they were not hypothesized prior to the study or were left untested because of limited resources for the study.

The requirement that a theory must survive attempts at its falsification may be more rigorously supported by increasing the number of predictions through which the theory may be proven wrong. Thus, increasing the number of predictions for a theory also increases its degree of falsifiability.

Another way of viewing the scientific rigor of a case study is to evaluate the degrees of freedom encompassed by the study (Campbell, 1975). In statistics, the number of independent random variables that constitute a statistic indicates the degrees of freedom. The larger the degrees of freedom, the more statistically reliable the results. If we make an analogy with the case study approach outlined, the degrees of freedom in testing a theory can be evaluated in terms of the number of predictions, the number of organizational settings, and the number of rival theories against which the theory of interest has been tested. High numbers in each of these three categories suggest more reliable confirmation of a theory than lower numbers.

Table 3 shows the degrees of freedom for each of the four theories evaluated in our single hypothetical study. Although it is inappropriate to add the numeric values shown in the table across columns, the degrees of freedom approach may be a convenient and appropriate means of compiling the results of numerous independent case studies and a convenient means of gauging the reliability of behavioral and institutional theories against competing theories.

As shown in Table 3, our hypothetical example has focused on a single organizational setting. Reliance on a sole data source confounds the evaluation or compensation for observation effects and biases by the investigator. This threat to internal validity may be substantially reduced by evaluating a cluster of cases. McClintock et. al. (1979) describe the "case cluster" concept. Since the cluster approach highly supports and complements Lee's approach, case study designs should comport with its underlying precepts if attempts will be made at extracting generalizable principles from the resulting case data.

<table>
<thead>
<tr>
<th>THEORY</th>
<th>Number of Predictions</th>
<th>Number of Organization Settings</th>
<th>Number of Rival Theories Against Which Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Advantage Theory</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>System Complexity Theory</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Communications Networking Theory</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Interaction Theory</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

It is important to note in Table 3 that the observer did not "invent" five predictions for the interaction theory and only one or two for the others. The observer thoroughly searched for "control situations" within the organization and was able to find only the
number indicated for each theory. To increase the number of predictions for each theory, the researcher would need to observe additional settings since presumably all control situations in the organization investigated already have been exposed.

One issue relative to generalizability not addressed by the research procedure outlined is how a researcher might be able to identify the bounds within which a theory applies. As stated previously, a theory cannot be considered generalizable through a range of circumstances unless it has been tested across that range and not been falsified. This, however, requires gathering consistent background information for all cases which would be used later in comparative analyses (e.g., multi-function vs. single function systems, low budget vs. large budget organizations, engineering vs. planning applications, transactional processing vs. project focused systems, etc.). The case study methodology outlined above does not address this issue because it is the intent of this research process to test the validity of generally applicable theories rather than those which are constrained to narrow circumstances. In addition, we contend that although case study research can provide hints and evidence of the limits of applicability of a theory, large scale surveys and multivariate statistical analysis are far more suited for accomplishing comparative analyses than are case studies. Surveys make possible the testing of much larger samples.

**Quantifying Benefits and Assessing Impacts**

In attempting to maximize the use of GIS within an organization, it might be argued that it is necessary to measure or otherwise gauge the extent of use in the organization in order to determine when the maximum has been reached. Although quantifying performance, use, and the benefits of use are important research areas (e.g., Goodchild & Rizzo 1987, Raymond 1987, Brown & Friedli 1988, Dickinson & Calkins 1988, Rivard & Huff 1988, Igbaria & Nachman 1990), they are not the subjects of the research suggested by this article.

The set of problems addressed by this article and their relation to quantification issues may be illustrated by example. Let us presume an organization has already acquired GIS operational capabilities. The executive for that organization is interested in maximizing use of the GIS by having the five divisions within the organization all contribute data to the GIS and share the data and products generated from it. The executive knows from experience and observation of successful GIS operations (or, alternatively, from a quantified analysis of projected operations) that if these five groups begin to cooperate and work with each other, substantial and numerous benefits will occur. She is little concerned with explicitly identifying or quantifying those benefits, whether tangible or intangible, because she is already convinced benefits will accrue (or, alternatively, time and motion studies or some other quantitative approach has already projected positive results).

The executive's primary interest is in getting the five divisions of the organization to cooperate with each other and support the common GIS. In accomplishing this goal she needs to know which organizational and behavioral theories are relevant to her situation, which intervention strategies are likely to work, and on which strategies and theories should she focus her efforts (e.g., in order to improve and expand uses of the GIS in her organization should she currently concentrate on relative advantage theory issues, system complexity theory issues, some other set of issues, or what combination of issues?) Thus, the research suggested by this article focuses on understanding the applicability of competing theories of individual and organizational behavior in GIS environments. Although it is a related research need, quantifying the benefits and impacts of GIS should not be construed as a goal of the research methods set forth.

In testing competing theories by the processes outlined in this article, the observer looks for changes in behavior or looks for continued behavior despite attempts at intervention. Because the observer is not attempting to "measure" anything, the very substantial problem of finding a common unit for measuring benefits or other effects is not a major issue in the theory testing procedures outlined.

**Conclusions**

Numerous maxims have been suggested regarding what allows institutions to acquire, implement, and successfully employ GIS. The problem for researchers and practitioners is that many of these maxims either contradict each other or are so situation-specific as to be non-generalizable to a larger population. As a result they may be of little use in providing practical guidance for gaining a greater understanding of the issues involved in successful GIS implementation and use.

In the GIS community to date, we have seen very few theory-focused empirical studies on issues of acquisition and use of GIS. Rather, the literature is more typically dominated by ad hoc application descriptions from past successes and failures. In other words, many of the studies reported in the literature could be more properly labeled "case histories" rather than case studies. The distinction between the two approaches is profound. Case histories are reported in a post hoc manner, after the effects of the GIS implementation have made themselves felt. The result is often an unconscious bias (due to the effect of time or outcome) interjected into the researcher's report.
A scientific approach to case studies, however, offers tremendous challenges as well as the potential for impressive results. Scientific theory must be falsifiable, logically consistent, be at least as explanatory as any competing theory, and the theory, while falsifiable, must survive attempts made at its falsification. The criteria for scientific application of case study analysis are rigorous. Adhering to the criteria can, however, result in better-grounded theory as well as greater confidence on the part of other researchers and practitioners that the results obtained are supportable and can be used as the basis for additional research and theory-building.

Multivariate statistical analyses are likely to remain a predominant heuristic in confirming theories because they make use of larger data bases, employ more rigorous controls, and lessen the likelihood of reporting significant findings where none actually exist (Kraemer and Thiemann 1987, Lipsey 1990). However, case studies can make an important contribution to the research process in a number of ways. First, case studies are an extremely useful tool for early theory development. They offer the researcher the opportunity to explore phenomena of interest in their natural setting, subject to the wide variety of organizational and behavioral factors that can have an impact on desired outcomes.

As a second benefit, case studies can provide a "richness" to the research process that is impossible to find in most quantitative methodologies. Survey research is generally conducted in an artificial environment, often through mailings of questionnaires to a pre-selected sample. The benefit of case studies is that they allow researchers to gain insight into the organizational environment within which the study is conducted. Further, they offer the advantage of providing additional qualitative information to complement the statistical analysis.

Finally, as case study research methodologies gain in sophistication and popularity in the GIS community, the compilation of such studies in a consistent fashion will have the effect of confirming or falsifying theories over time. In other words, as we build up a data base of case studies using a consistent research approach, meta analysis will allow researchers to develop additional theory based on the contributions of each individual case example.

To conclude, we would offer an invitation to other academics and researchers within the GIS community to test the methodological framework set forth in this paper in one or more active GIS use settings. Until we are able to develop a unified method for case analysis, many of the studies reported will remain of minimal use to the field due to the highly idiosyncratic nature of the methodologies employed. It is our own goal to begin using the methodological framework set forth in this article in evaluating a series of GIS use settings during the second half of this year. By compiling the case study work of a variety of researchers in a consistent manner, we believe a lasting contribution can be made to the profession.

Acknowledgements

Many of the foundation ideas contained in this article are drawn from Lee, 1989.

References


Chapter Three
Call to Participate in Testing Thirty Technology Transfer Theories: A GIS Case Study Research Project

Theories to be Tested

The following pages contain a sampling of technology transfer lessons, hypotheses, and theories derived from the GIS, MIS, and organization theory literature. You are invited to test these hypotheses within operational GIS settings. Through your case study, attempt to isolate reasonable control situations which tend to evidence support or falsification of any or all of the following theories. No attempt has been made to arrange the theories in any order.

The proposed case studies to be carried out under this project involve observations of ongoing GIS operations. Therefore, we have tried to incorporate theories in the following list which may be more relevant to improving and expanding the uses of GIS in an organization than to initially acquiring and implementing a GIS.

Some of the hypotheses in the list of thirty address broad theories while others test rather narrow concepts. Many of the theories overlap and conflict with each other and some might be considered subsets of others. Many of the hypotheses reflect "lessons" or "rules of thumb" expressed in the literature and do not cover concepts of sufficient breadth to be labeled as "theories" in a formal sense. For instance, the models developed by McCardle (1985) or Mayo (1985) to explain an organization’s decision to adopt an innovation are more appropriately classified as "theories" than most of the statements on the list which follows (see previous chapter for references). Regardless, the term "theory" is used for all items in our listing for convenience. Through the process of testing the full range of these and similar hypothesized statements, the ultimate goal is to derive broad-based theories which are supportable and useful.

Each hypothesized theory on the list has been worded in terms of "resistance" to GIS use. We chose to do this because in practice, after a GIS has been initially implemented in an organization, there is typically a need to identify and address the additional impediments which are keeping the GIS from reaching its maximum use throughout the organization. A consistent focus on resistance for every hypothesis should also ease later comparative analyses. However, most of the hypotheses listed also may be reworded readily in a positive sense. For instance, although "lack of strong executive and management support is a likely impediment to expanded use of the GIS in an organization," a reciprocally-related hypothesis would state that "strong management support acts as an incentive to the intended users of the GIS to overcome interpersonal and organizational impediments to enable their expanded use of the GIS."

In selecting items for inclusion in the following list, we also tried to keep a focus on potential technological, organizational, and personal impediments without attempting to speculate on the most appropriate means for overcoming those impediments. Strategies for overcoming verified impediments (e.g. altering the technology, organization structures, management arrangements, implementation processes, and personal characteristics) are thus only peripherally considered in this list.

Theory 1 - Relative Advantage: If the relative advantages of using the GIS over the procedure or system the GIS replaces is small, even though benefits to the overall organization might be great, the GIS’s intended users will resist its use

Theory 2 - System Complexity: If the complexity in using a GIS over the procedures or system the GIS replaces is great, even though advantages to individuals, groups, or the organization as a whole may be substantial, the GIS’s intended users will resist its use.

Theory 3 - Opportunity to Experiment: If prior to making substantial commitments of their time and resources, opportunities to try out and experiment with the GIS technology in their organizational setting and to view operational applications of the technology in similar organizational settings are low, the GIS’s intended users will resist use or expanded use of the GIS.

Theory 4 - Internal Communication Networking: If the degree of interpersonal communication networking in the organization is low (i.e. few informal and formal opportunities to talk with others at all levels and across divisions), resistance to expansions of use or improvements in use of the GIS will be great.

Theory 5 - Standard Operating Procedure Compatibility: If the standard operating procedures of an organization are incompatible with the transactional processing prescribed by the GIS technology, those whose procedures are altered or disrupted will resist use or expanded use of the GIS.
Theory 6 - Extent of Change in Standard Operating Procedures: If the degree of change in standard operating procedures necessary to accommodate the GIS is great, resistance by those whose procedures are altered or disrupted by use of the GIS will be great.

Theory 7 - Management Framework Rigidity: If the ability of an organization to restructure its chain-of-command or alter its mid-level management structure is low, resistance to expansions of use or improvements in use of the GIS will be great.

Theory 8 - Internal/External Cooperation: If an organization or division within an organization does not operate internally in a way that facilitates cooperation, the GIS’s intended users within the organization or division will resist cooperating with those external to the organization or division in networking or using a common GIS.

Theory 9 - Personal Differences: If the degree of segregation of professional disciplines and educational backgrounds among the divisions of an organization is great, resistance to expansions of use or improvements in use of the GIS will be great.

Theory 10 - Executive Support: If strong executive or management support is lacking or management fails to treat and protect its GIS assets (e.g. personnel, database, hardware, software, & GIS-derived products) as a strategic organizational resource, resistance to the continued or expanded use of the GIS will grow over time.

Theory 11 - Manager/Technocrat Team: If an organization does not have in its management structure at least one key manager who is a GIS advocate and at least one GIS administrator who is highly competent technically, resistance to the continued or expanded use of the GIS will grow over time.

Theory 12 - Personal Attitudes: If an organization does not have creative and positive individuals leading and moving forward the use of GIS in several of the organizations critical divisions, resistance to the continued or expanded use of the GIS will grow over time.

Theory 13 - Interaction: If the patterns of information flow and control prescribed by using the GIS are incompatible with the information control patterns prescribed by the organizational structure, those individuals and groups losing power in the organization will resist its use.

Theory 14 - Personal Advantage: If the personal benefits to individuals resulting from use of the GIS in an organization are low, even though benefits to the overall organization might be great, the affected individuals will resist use or expanded use of the GIS.

Theory 15 - Personal Risks: If the perceived or real negative ramifications to individuals who fail in their attempts to use a GIS are not far outweighed by the rewards possible by risking and achieving success, the intended users will resist use or expanded use of the GIS.

Theory 16 - Technological Opportunity: If the technological sophistication of the intended GIS users in the organization is low but through expansion of GIS use to their area of responsibility they are given the opportunity to learn and advance themselves, resistance by such individuals to using the GIS will be low.

Theory 17 - Technological Threat: If the technological sophistication of those who are unlikely to use the GIS is low, these individuals will resist use or expanded use of the GIS by the organization.

Theory 18 - Education: If GIS technologies are unable to be appropriately and effectively applied by mid-level managers and technical staff due to their inadequate familiarity with the technical details of the technology (i.e. database, software, and hardware concepts), resistance to the use or expanded use of the GIS will be great.

Theory 19 - Memory of Past Failures: If past failures in incorporating technological innovations in the organization have been recent, severe or extensive, resistance to the use or expanded use of the GIS will be great.

Theory 20 - Early Involvement: If key decision makers, line managers, technical staff and intended users in the organization are not consulted and allowed to contribute early on in the planning of a GIS acquisition, implementation or expansion, they will resist its use or expanded use.
Theory 21 - Unrealistic Expectations: If key decision makers, line managers, technical staff and intended users in the organization have an unrealistic view of the resources and time required to maintain or expand use of the GIS, resistance to the continued or expanded use of the GIS will grow over time.

Theory 22 - Consensus Building: If the strategy for implementation or expansion of use of the GIS is by executive directive rather than by team building and consensus, the intended users will resist its use.

Theory 23 - Inertia: If the use or expanded use of GIS is optional for intended users or the GIS is implemented other than through a project mandate, the intended users will resist its use.

Theory 24 - Committee Management: If the strategy for implementation or expansion of use of the GIS is through "committee decision making" rather than by executive directive or program mandate, committee members will resist change and resist use or expansion of use of the GIS.

Theory 25 - Fair & Rational Consultant: If recommendations regarding technical, operational, and management structure changes necessary to accommodate the GIS technology are made by individuals internal to the organization rather than by or with the involvement of "independent, knowledgeable, and unbiased" consultants, resistance to suggested changes will be great.

Theory 26 - External Communication Networking: If the degree of interpersonal communication networking by external GIS consultants and/or GIS developers with the organization's intended users and key decision makers is low, resistance to expansions of use or improvements in use of the GIS will be great.

Theory 27 - Goal-Oriented Plan: If active expansion of GIS use does not follow a well-structured and logical plan with clearly focused end goals, the intended users of the GIS will resist its use.

Theory 28 - Project Progress Reporting: If the degree of reporting on progress and provision for feedback is low during active expansion of GIS use, those intended users not adequately involved will resist its use.

Theory 29 - Extensive Time Lapse: If the primary advantages in using a GIS will not become evident until a time which is distant, successful and visible applications must be accomplished in the interim or managers and the intended users of the GIS will resist its use.

Theory 30 - Inadequate Time Allowance: If the pace of expansion of the GIS is such that the time allowed for thoughtful feedback is inadequate for the intended users and for those in the organization otherwise affected by the conversion, resistance to the use or expanded use of the GIS will be great.

References

The primary references used in developing the above list are the same as those contained in the reference list of the attached paper entitled "Case Study Research Methods for Geographic Information Systems." The concepts reflected in the list can typically be referenced to numerous sources and therefore references were not provided on an item by item basis.
Chapter Four
An Investigation of Technology Transfer Theories at the XYZ Paper Company

Steven Frank
stevef@mecan.l.maine.edu
Department of Surveying Engineering /-NCGIA
University of Maine

Abstract

Case study methods have been suggested as a tool for testing GIS technology transfer theories indirectly. The goal of the research reported in this paper was to identify and analyze control situations which would allow testing of pre-specified technology transfer hypotheses within a GIS organizational environment. The organization chosen for study was the XYZ Paper Company (fictional name for an actual company), a New England forest products concern which has used GIS technology since 1980. The organizational and policy settings of the company were examined through interviews with company employees, documents provided by the company, and by personal observation. The results of hypotheses testing are provided.

Introduction

Case study research methods are often used to study phenomena in their natural settings. Onsrud, et al. (1992) have suggested using case studies to investigate technology transfer theories involving geographic information systems. They recommend using case study methodology proposed by Lee whereby theories may be indirectly tested: "The indirect testing of a theory consists of deriving one or more suppositions capable of being tested directly from the theory and then comparing the actual outcomes against those which were predicted (Onsrud, et al. 4)." The integrity of such comparisons is determined by the ability of the researcher to isolate other possible causes for the observed behavior through the identification and observation of control situations within the ongoing operational GIS setting. Repeated success of a theory across a range of circumstances leads to the conclusion that said theory can be generalized over that range of circumstances (Onsrud, et al. 6).

Background

The XYZ Paper Company is a large paper and wood products company located in New England. Approximately three million acres of forest lands in New England and eastern Canada are managed by the XYZ Paper Company and an affiliated wood products company using Intergraph GIS software on a VAX/VMS computer. The GIS Section is located within the Lands Division of the XYZ Paper Company, one of three major divisions within the company. XYZ personnel estimate that less than one percent of the company’s annual budget is used for system maintenance and upgrade.

The Lands Division at the XYZ Paper Company is charged with managing company forest lands holdings for the purposes of supplying wood fiber to its mills. After benchmark studies involving three different vendors, the Division acquired Intergraph hardware and software in 1980 for use as an automated mapping system. The system was upgraded in 1985 when, after more vendor comparisons, the present system was installed. The system contains approximately 10 million acres of base mapping compiled primarily from USGS quad sheets at 1:24,000 scale. Three million of these acres -- lands actually managed by the XYZ Paper Company -- are mapped into the system in greater detail, primarily keeping track of forest cover types and growth information. The system is interfaced through two workstations.

The automated mapping capacity of the system has been used to supply map products throughout the company since implementation of the system. The analysis capabilities of the GIS are little used except in the Lands Division. Among the tasks performed by the GIS Section are:

- prepare annual maintenance reports for tax purposes;
- prepare current inventory reports for tax purposes;
- provide support for silviculture programs (i.e., planting, nurturing, and harvesting of trees) by maintaining classified forest coverage records and data;
- assist in long term analysis and planning for wood fiber supplies;
- assist with various land management problems;
- assist with special projects as needed;
- archive historical spatial records.

The 3 million acres managed by the XYZ Company contain additional detail which were originally compiled and digitized from existing paper-based company maps. Forest cover data is updated by combining ground "cruise" information (gathered by company foresters) with digitized and scanned 1:63,360 aerial color infrared photography taken on an annual basis. Classified forest coverages obtained from aerial photography are supplied by private contractors and verified in-house before being entered into the system. Additional spatial information is collected from ground surveys performed by private surveying firms. The system is updated as needed or as new information becomes available.

The only current access to the system is directly through the GIS Section. Some routine analyses are handled as part of the everyday workload. Those wishing nonroutine analyses consult with GIS Section personnel about the feasibility of their requests. Users seem to be generally satisfied and minimally restricted by the current system access priorities. However, some users have complained that certain analyses cannot be performed due to scale and data structure restrictions within the system. Company management and GIS Section personnel feel that it would not be cost effective to collect the necessary data or to restructure the database to satisfy these complaints at this time. Plans are under way to expand the system to desktop personal computers located in field offices, which already have personal computers in place and are using them for some GIS-related record keeping. These personal computers will lack the full analytical abilities of the VAX/Intergraph located in the GIS Section office (these limits are technological and cost related). GIS Section personnel and company management believe this expansion will relieve the GIS Section of many low-level automated mapping requests.

The organization of the XYZ Paper Company has undergone several structural changes since the system was installed in 1980. High-level corporate maneuvering has tied the company to another local paper and wood fiber company, the ABC Company. Because the ABC Company does not have a GIS, its forest holdings coverage has been added to the XYZ Paper Company GIS. The ABC Company is currently acquiring its own GIS. When the ABC Company GIS is installed, the XYZ Company will stop maintaining this data.

The current economic recession and the need to become "lean and mean" have also affected the Company, reducing manpower within the GIS Section by half. The GIS Section appears to have weathered these changes without major damage. However, current system expansion has slowed almost to a standstill during these cutbacks.

**Study Method**

Seven employees of the XYZ Paper Company were interviewed for this study. Interviews were conducted at the XYZ Paper Company offices during normal working hours. The interviewing process consisted of a series of open-ended questions regarding each interviewee's experiences and opinions about the system. Observations were made at several workplaces and the accessibility of each workplace to the GIS section was observed. The organizational structure of the company was reviewed by studying charts provided by XYZ Paper Company and organization policies related to the GIS operations were reviewed through documents provided by the company and by interviewing personnel.

Of the persons interviewed, only two had direct access to the system GIS workstations. Another was responsible for data collection and quality control, but normally lacked access to the system. Three persons regularly request or are provided with analytical services from the system. The seventh person interviewed was a high level manager in the Lands Division. All had college degrees related to the forestry industry and had worked for the company for periods ranging from ten to thirty one years.

**Theory Testing Observations**

Thirty technology transfer theories were hypothesized based on case histories drawn from the GIS literature and various technology transfer studies reported in the GIS literature. This process was accomplished by GIS Case Study Research coordinator Dr. Harlan Onsrud. The thirty hypotheses were studied prior to the interviewing and observation processes. Upon familiarization with the theories, the goal was to search for unique control situations which might allow testing of one or several of the prespecified hypotheses. Within the organizational setting studied, I was able to isolate control situations for only four of the hypotheses. However, for some of the hypotheses several control situations were identified. Situations were observed which allowed the following subset of theories to be tested:
Theory 3 - Opportunity to Experiment: If prior to making substantial commitments of their time and resources, opportunities to try out and experiment with the GIS technology in their organizational setting and to view operational applications of the technology in similar organizational settings are low, the GIS’s intended users will resist expansion.

Theory 4 - Internal Communication Networking: If the degree of interpersonal communication networking within the organization is low (i.e., few formal and informal opportunities to talk with others at all levels and across divisions), resistance to expansions of use or improvements in use of GIS will be great.

Theory 10 - Executive Support: If strong executive or management support is lacking or if management fails to treat or protect its GIS assets (e.g. personnel, database, hardware, software, and GIS-derived products) as a strategic organizational resource, resistance to continued or expanded use of the GIS will grow over time.

Theory 12 - Personal Attitudes: If an organization does not have creative and positive-thinking individuals leading and moving forward the use of GIS in several of the organization's critical divisions, resistance to the continued or expanded use of the GIS will grow over time.

Opportunity to Experiment

Situation 1: The XYZ Paper Company examined two major GIS systems in 1979. Benchmark tests were conducted to compare a Comarc system against an Intergraph system. Since they had the ability to experiment with promising systems within their own operational setting, the "opportunity to experiment" hypothesis suggests that there would be less resistance by users than if the system had been forced on the users by the management without the ability to experiment. After benchmark tests the intended users supported the purchase of one of the systems and the XYZ Paper Company did in fact purchase an Intergraph system in 1979. The result tends to evidence support of the theory.

Situation 2: The XYZ Paper Company again examined two major GIS systems in 1985 with the thought of upgrading its current Intergraph system. Benchmark tests were conducted again to compare Intergraph against Arc/Info. The "opportunity to experiment" leads to the prediction that the users would not resist an upgrade to their system. In 1985, the company indeed purchased new Intergraph hardware and software for their GIS. The result again tends to evidence support for the theory.

Situation 3: Around 1987, personnel in the Taxes Section of Lands Division visited a wood products company in California. It was observed that the California company was using its GIS to prepare tax documents and records for local government agency requirements with great success. The XYZ Paper Company then experimented with preparing tax documents and records on its system. The "opportunity to experiment" again leads to the prediction that the system users would support the expansion of GIS operations to include tax document and record preparation. In 1987 or 1988, this expansion did occur at the request of users. The result once again tends to evidence support for the theory.

Situation 4: As a result of high-level corporate maneuvering, the XYZ Paper Company became affiliated with another local paper and wood processing company. The Lands Department within the affiliated company lacked a GIS. The Lands Department of the affiliated company observed the GIS of the XYZ Paper Company and had a major project performed on the XYZ Paper Company's GIS. The predicted outcome would be the lower user resistance to acquiring a GIS by the affiliated company. The affiliated company is in the process of purchasing a GIS. Meanwhile, the land holdings of the affiliated company are now included in the GIS of the XYZ Paper Company. The result once again evidences support for the theory.

Rival theories: In situations 1 and 2 a strong GIS champion was credited by many in the department as being instrumental to acquisition and upgrading of the system. This person left the XYZ Paper Company in 1986, shortly after the GIS was upgraded, but before situations 3 and 4 arose. This provides evidence that the opportunity to experiment may have been a factor in each of the described situations regardless of the presence of a strong champion. Executive support for the GIS Section appeared to be at the same level throughout the situations described, although the number of personnel in the GIS Section was much higher in situations 1 and 2 which occurred before situations 3 and 4. Internal communication networking remained relatively constant throughout the time period described.

Internal Communication Networking

Situation 5: Personnel within the Lands Division of the XYZ Paper Company responsible for particular duties within the company (i.e., management of pest infestation, road construction, taxes) or with particular tracts owned by the company are encouraged to deal directly with personnel within the GIS Section to determine possible methods of analyzing problems using the system. Theory application would predict that because of this ready access, resistance to use or expanded use of the GIS within the
Lands Division is likely to be smaller than if these communication channels did not exist. While the foresters lack direct access to the GIS, they seem to have little hesitancy in consulting with the GIS Section about new problems that arise. No evidence was gathered to determine if foresters with better opportunities for communication made more frequent use of the GIS. However, this behavior and the overall increased GIS use by foresters tends to evidence support for the theory.

Situation 6: Personnel within other Divisions of the XYZ Paper Company, such as the Recreation Division and Pulpwood Processing Division, have almost no low-level communication with the Lands Division. The predicted outcome of such behavior would be that greater resistance to the expansion of GIS use would occur within these divisions. Although these divisions do receive GIS products, there has been no change of the basic nature of those products since they were first introduced in 1980. Although no direct evidence from those divisions was gathered, there appears to be very little enthusiasm for expanding GIS use in the divisions. The result again tends to evidence support for the theory.

Rival theories: There are many opportunities for personnel within the Lands Division to experiment with system applications, leading us to believe that internal communication networking was not the only critical factor in the above described situations. However, lack of low level communication with other divisions of the XYZ Paper Company coupled with the lack of expansion of the GIS to those divisions does give this theory much credence. The personnel within the Lands Division have remained relatively the same over the years of system operation, as has the level of executive support. Thus theories which might be affected by changes to personnel or management do not seem to be relevant to the outcome of situations 5 and 6.

Executive Support

Situation 7: The XYZ Paper Company GIS expanded at a rapid rate from 1980 to 1988, requiring a system upgrade in 1985. Corporate alliances and economic conditions have forced many changes in the system since 1988. New management policy seems to focus on company survival rather than on company growth. While still highly valued within the Lands Division, the GIS Section is seen by higher level management as a part of the organization which must operate under the same limitations and budget constraints as the rest of the company. GIS Section personnel were reduced from six to three persons. A former policy of cycling GIS personnel through field offices was halted. The "executive support" theory argues that since executive support has decreased, resistance to the expanded use or growth of the GIS would increase. However, the system has expanded within the Lands Division and has grown to include coverage of an affiliated paper company's forest holdings in 1989. Plans are under way to expand the system to personal computers located in field offices within the Lands Division. The evidence seems not to support this theory.

Rival theories: Opportunities to experiment, internal communications networking, and personal attitudes are difficult to relate to this theory. It would appear that each of these theories can be valid without strong executive or management support being evidenced.

Personal Attitudes

Situation 8: The person in charge of special woodlands monitoring and coordinating general forest activities, who holds a Master's Degree in Forestry, is held in high regard by her coworkers. While she professed to some disillusionment and frustration with the system's technological and accuracy limits, she appears to use the GIS more than any other individual outside of the GIS Section. (It must be noted that this person has an office in the same building as the GIS Section, unlike several other users of the system.) Most of those with whom she works are located in field offices. "Personal attitude" theory application would indicate that resistance to GIS use would decrease among those with whom she worked. And, in fact, there is continued use and expansion of use of the GIS among the foresters with whom she coordinates activities. This outcome tends to evidence support for the theory.

Situation 9: The person in charge of database management in the GIS Section is also highly regarded by his coworkers. This person also holds a Master's Degree in Forestry. He is not only responsible for the conceptual evolution of the system (while delegating many of the technical aspects to others in the Section), but he is also responsible for developing or coordinating new applications for the GIS. Coworkers feel that they can consult with him on any problem that has the potential to be solved with help from the GIS. Recent personnel cutbacks in the GIS Section have caused this person to spend less time with new developments and assist more with the day-today maintenance of the GIS. Theory application would again indicate lower user resistance to the continued or expanded use of the GIS. GIS use has continued and expanded within the Lands Division of the XYZ Paper Company, although new applications appear to be occurring at a much slower rate in recent times. Again, the outcome appears to evidence support for the theory.

Rival theories: Again, the opportunity for others to experiment cannot be ruled out as a critical factor in GIS expansion. The internal communication networking at the XYZ Paper Company must also still be considered as a reason for the pattern of expansion
in the company. Executive support has seemed to be constant over the period these two people have been with the company and does not seem to affect the outcome of our predictions for this theory.

Conclusions

The objectives of this research were twofold. The first objective was to use the methods set forth by Lee (in Onsrud, et al. 1992) and expanded by Onsrud, et al. (1992) in a GIS setting to test the utility of the case study methods proposed. The experience gathered from this single case suggests that the indirect case study research process can be a useful and valid method for testing theories. However, there were tendencies by both the observed and the observer to bias responses and/or predictions. Continued experience in indirect case study methods should allow the observer to recognize possible biases and improve his or her research techniques. By extension, I believe that the validity of the results generated by this method are substantially dependent on the researcher’s ability to make thoughtful observations. This skill may be gained only through experience. Experience may be gained by: 1) observation and analysis; 2) personal and peer review of observation and analysis techniques; and 3) repetition of observation and analysis with new cases. This iterative process should allow the observer to hone the skills necessary to produce credible and useful results. A thorough technical understanding of GIS is also highly useful to enable the observer to distinguish behavioral and organizational issues from technical issues and to observe their interplay.

The second objective of this study was to gather actual evidence which would help to support or falsify technology transfer theories which might be generalizable and useful across a range of GIS organizational settings. Control situations were isolated in the organizational setting of a private paper company which allowed the testing of four technology transfer theories. Evidence supporting or falsifying the theories was gathered using indirect case study research methods. The results are summarized in table 1. A measure of the degrees of freedom of the situations observed are tabulated in table 2.
<table>
<thead>
<tr>
<th>Theory</th>
<th>Predicted outcome</th>
<th>Rival theories tested against</th>
<th>Observed occurrence</th>
<th>Evidence</th>
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<tbody>
<tr>
<td>Opportunity to experiment</td>
<td>1) Examination and bench tests of two GIS systems in 1979 would lead to lower user resistance to GIS purchase.</td>
<td>1) Personnel constant, management support constant, internal communications networking constant.</td>
<td>1) The XYZ Paper Company purchased a GIS in 1979.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td></td>
<td>2) Examination and bench tests of two GIS systems in 1985 would lead to lower user resistance to GIS upgrade.</td>
<td>2) Personnel constant, management support constant, internal communications networking constant.</td>
<td>2) The XYZ Paper Company upgraded its GIS in 1985.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td></td>
<td>3) Observation &amp; experiments with tax record preparation would lead to lower user resistance to GIS expansion.</td>
<td>3) Personnel constant, management support constant, internal communications networking constant.</td>
<td>3) The XYZ Paper Company expanded GIS use to tax record preparation in 1987 or 1988.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td></td>
<td>4) Observation &amp; experiments by an affiliated company with the XYZ Paper Company's GIS would lead to lower user resistance to GIS purchase.</td>
<td>4) Personnel constant, management support constant, internal communications networking constant.</td>
<td>4) The affiliated company purchased a GIS in 1991.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td>Internal communication networking</td>
<td>5) Strong interpersonal communication within the Lands Division would lead to lower user resistance to GIS expansion.</td>
<td>5) Personnel constant, management support constant, opportunity to experiment may be a factor.</td>
<td>5) GIS expansion has occurred in the Lands Division of the XYZ Paper Company.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td></td>
<td>6) Weak interpersonal communication between the Lands Division and other divisions would lead to user resistance to expanded GIS use in those divisions.</td>
<td>6) Personnel constant, management support constant, opportunity to experiment may be a factor.</td>
<td>6) GIS expansion has not occurred in other divisions of the XYZ Paper Company.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td>Executive support</td>
<td>7) GIS Section cutbacks by management would lead to user resistance against GIS expansion.</td>
<td>7) Personnel constant, internal communication constant, opportunity to experiment constant.</td>
<td>7) GIS expansion has occurred in the Lands Division of the XYZ Paper Company.</td>
<td>Falsifies theory.</td>
</tr>
<tr>
<td>Personal attitudes</td>
<td>8) A positive GIS attitude by the person in charge of special projects in the Lands Division would lead to lower user resistance to GIS expansion.</td>
<td>8) Personnel constant, management support constant, opportunity to experiment and communication networking may be factors.</td>
<td>8) Lands Division personnel working with this person have expanded their use of GIS.</td>
<td>Supports theory.</td>
</tr>
<tr>
<td></td>
<td>9) A positive GIS attitude by the person in charge of the GIS Section in the Lands Division would lead to lower user resistance to GIS expansion.</td>
<td>9) Personnel constant, management support constant, opportunity to experiment and communication networking may be factors.</td>
<td>9) Lands Division personnel working with this person have expanded their use of GIS.</td>
<td>Supports theory.</td>
</tr>
</tbody>
</table>
As stated above, the primary limitations to the validity of the results appears to be the experience of the observer, not the case study procedures. There appear to be very few people in the GIS community with the requisite theory-focused case experience to test methods set forth by Onsrud, et al. (1992) against other methods. Experience and the results of many case studies are required to build the evidence base that will provide meaningful results over time. Although this single case study makes only a very small incremental contribution to actually testing theories, building scholastic-based case study expertise within the GIS community would be valuable and should be stressed.

Acknowledgments

I would like to thank all those at the XYZ Paper Company who agreed to be interviewed and observed for this study. In particular, I would like to thank the head of the GIS Section whose enthusiasm and cooperation made this study possible.

This study represents work related to research being carried out at the National Center for Geographic Information and Analysis and was partially supported by a grant from the National Science Foundation (Grant No. SES-88-10917). The research was conducted under the auspices of the GIS Case Study Research Project coordinated by Dr. Harlan Onsrud of the University of Maine.

References


<table>
<thead>
<tr>
<th>Theory</th>
<th>Number of Predictions</th>
<th>Number of Settings</th>
<th>Number of Rival Theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opportunity to Experiment</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Internal Communication Networking</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Executive Support</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Personal Attitudes</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 2. Degrees of Freedom
Chapter Five
Human Factor Determinants of GIS Implementation Success: Perception, Experience, Attitude, and Communication Behavior

Case Study of Four Governmental Agencies in Cumberland County, NC

by

Zorica D. Budic
David R. Godschalk
Department of City and Regional Planning
University Of North Carolina At Chapel Hill
INTRODUCTION

This research focuses on the human factor as a determinant of successful implementation of GIS technology. It examines the relationship between people and GIS technology as a foundation of decisions to adopt the technology. More specifically, the question this research poses is:

**How do perceptions, experience, attitudes and communication behavior related to GIS technology influence adoption of the technology by individuals within local government agencies?**

The question is explored through a multiple-case study of four agencies within a county government setting in North Carolina. In-depth analysis of the four cases provides a basis for testing eight propositions (Table 1) derived from theory and previous research on diffusion of innovations and management of information systems.

The eight variables cover most aspects of the human factor indicated as significant in previous research. All aspects are rooted in the subjective realm of individual perceptions, experience, attitudes and communication behavior in relation to GIS technology. These aspects are the basis for individual positions with regard to the technology, which influence decisions to use or not to use GIS technology.

Our conceptual framework illustrates the influence of these variables on GIS adoption within an overall setting that includes GIS management and organizational context (Figure 1). Organizational factors and management activities are considered in this research as control variables while testing the theoretical propositions concerning human factors.

DEFINITIONS

For purposes of this research, adoption of GIS technology is defined as *the successful outcome of GIS implementation.* A decision to purchase a technology is only "the beginning of an often prolonged process of diffusion within the organization" (Leonard-Barton 1987), that may or may not end with adoption.

Possible adopters of the technology are: organizations, organizational units, organizational subunits and individuals. Diffusion may start at any level and may take diverse paths. The ultimate and the most important adopters of GIS technology are the individual users. Reaching the end-users should be the final goal of GIS implementation. Individual users often make their own decisions about engaging in GIS activities. Those personal decisions can determine the success of GIS implementation, and are cumulatively reflected in the organizational adoption of the technology.

Adoption, therefore, results from successful diffusion of GIS technology toward individual employees. Organizational adoption is defined as utilization of the technology for performing organizational tasks. GIS technology is adopted if internalized into organizational processes and functions. Individual adoption is identified through level, type and intensity of utilization of the technology by staff members for organizational purposes. The factors influencing the diffusion of GIS technology to the individual-user level, i.e., influencing individual decisions to adopt or reject the technology, represent the main focus of this study.

---

1 Implementation encompasses installment of GIS technology, database development, system maintenance, and utilization of the technology. Implementation is preceded by an initiation phase, which may or may not lead to a decision to acquire GIS technology.
Table 1
Factors Determining Individual Decisions
About Adopting GIS Technology: Corresponding Theoretical Propositions and Their Sources

<table>
<thead>
<tr>
<th>Factor 1: PERCEIVED RELATIVE ADVANTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If the relative advantage of using GIS technology over the procedure or system it replaces is small, even though benefits to overall organization might be great, the intended users of GIS technology will not adopt it (Downs and Mohr 1979; Zaltman et al. 1973; Rogers 1983; Leonard-Barton 1987; Rivard 1987).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 2: COMPATIBILITY WITH PERSONAL VALUES, BELIEFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If implementation of GIS technology is inconsistent with potential adopters' values and beliefs about computerized technology, the intended users of GIS technology will not adopt it (Zaltman et al. 1973; Rogers 1983; Danziger and Kraemer 1986; Leonard-Barton 1987; Igsbria and Nachman 1990).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 3: COMPATIBILITY WITH COMPUTER EXPERIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If implementation of GIS technology is inconsistent with potential adopters' past experience with computerized technology, the intended users of GIS technology will not adopt it (Zaltman et al. 1973; Ives et al. 1983; Rogers 1983; Danziger and Kraemer 1986; Leonard-Barton 1987; Raymond 1987; Rivard 1987; Baroudi and Orlikowski 1988; Croswell 1991).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 4: PERCEIVED COMPLEXITY OF GIS TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If the perceived complexity of using GIS technology over the procedures or system it replaces is great, even though advantages to individuals, groups, or the organizations as a whole may be substantial, the intended users of GIS technology will not adopt it (Zaltman et al. 1973; Ives et al. 1983; Rogers 1983; Danziger and Kraemer 1986; Leonard-Barton 1987; Raymond 1987; Rivard 1987; Baroudi and Orlikowski 1988; Croswell 1991).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 5: EXPOSURE TO GIS TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If prior to making substantial commitment of their time and resources, opportunities to try out and experiment with GIS technology in their organizational setting and to view operational applications of the technology in similar organizational settings are low, the intended users of GIS technology will not adopt it (Ives et al. 1983; Rogers 1983; Raymond 1987; Baroudi and Orlikowski 1988; Carey 1988).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 6: COMPUTER/GIS-RELATED ANXIETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If the intended users of GIS technology are anxious when confronted with GIS technology and computers in general, they will delay the adoption of the technology (Raub 1981; Danziger and Kraemer 1986; Peterson and Peterson 1988; Igsbria and Nachman 1990).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 7: ATTITUDE TOWARD WORK-RELATED CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If the intended users of GIS technology have negative attitudes toward change, they will delay the adoption of the technology (Mohr 1969; Zaltman et al. 1973; Rogers 1983; Leonard-Barton and Kraus 1985; Leonard-Barton 1987; Rivard 1987; Robey 1987; Carey 1988; Peterson and Peterson 1988; French and Wiggins 1989; Raghavan and Chand 1989; Campbell and Masser 1991; Croswell 1991).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 8: NETWORKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition: If the degree of interpersonal communication within the organization is low or the messages about GIS technology are negative, the intended users of GIS technology will not adopt it (Zaltman et al. 1973; Ives et al. 1983; Rogers 1983; Danziger and Kraemer 1986; Leonard-Barton 1987; Raymond 1987; Baroudi and Orlikowski 1988; Kearns 1989; Campbell 1990; Croswell 1991).</td>
</tr>
</tbody>
</table>
RESEARCH METHODOLOGY

Case study methodology has been recognized by the GIS research community as the appropriate approach for studying issues related to diffusion of GIS technology (Zwart 1986; Niemann et al. 1988; NCGIA 1989; Craig 1989; Azad 1990; Onsrud et al., 1992). It is particularly suitable at this state of limited knowledge, experience and previous research on GIS implementation.

This study followed guidelines developed by the National Center for Geographic Information and Analysis (NCGIA) Initiative 4 leaders (Onsrud et al., 1992). They call for rigorous and systematic case study research aimed at theory testing rather than description of situations and phenomena (Yin 1984; Benbasat et al. 1987; Lee 1989a; Lee 1989b).

We conducted a multiple case study of four local government agencies located in Cumberland County, North Carolina. The study site was selected from a set of local governments in North Carolina which had an operational GIS. The agencies within the Cumberland County government have been implementing GIS technology for over 3 years in a variety of applications related to diffusion of GIS technology (Zwart 1986; Niemann et al. 1988; NCGIA 1989; Craig 1989; Azad 1990; Onsrud et al., 1992).

Interviews were the main data collection technique. A research protocol and a questionnaire with structured, semistructured and open-ended questions were developed to guide the research and ensure a systematic elicitation of relevant factors and issues. During the research period (from October 1991 through June 1992) we interviewed:

1. Key informants within each agency at two points in time (4);
2. All employees within those agencies, whether or not they used GIS technology (27; 2 of them in GIS management position); and
3. Higher level administrators who were in position to make decisions regarding GIS technology, and to initiate and support its implementation (5).

The study was conducted with dual unit of analysis, individual employees and organizational units. While the individual perceptions, experience, attitude and communication behavior related to GIS technology were of major concern, the individuals also were observed with regard to organizational context. Conclusions about falsification or corroboration of the theoretical propositions were reached through qualitative analysis. Pattern-matching, a powerful method that can be used in case study research (Yin 1984), was the major technique for data analysis. Three bases for composing the pattern associated with each individual and agency, and for evaluating the significance of the factors were: (a) cumulative scores on a set of closed questions; (b) information elicited from open-ended questions (comments, statements, explanations, and reasoning about issues); and (c) direct observation of the individual employees and their environments. None of the three sources was given an a priori precedence over the other two.

DIFFUSION OF GIS TECHNOLOGY AMONG THE FOUR AGENCIES

The study was conducted on four organizational units located in Cumberland County, North Carolina:

1. Transportation Department of the City/County School System;
2. Mapping Section of the Tax Assessor's Office;
3. Community Assistance Section of the Joint City/County Planning Department; and
4. Comprehensive Planning Section of the Joint City/County Planning Department.

2 The case study was conducted as one phase of Budic's doctoral dissertation research. Details of the research design as well as other elements of the case study research will be available in the thesis.
3 The local governments were identified in a 1990/91 mail survey of GIS use among Local governments in the Southeast (Budic, forthcoming). The choice of site was based on three criteria: (a) Length of involvement with GIS technology; (b) diversity of GIS applications; and (c) proximity of the study site.
4 Other sources included: documentation (minutes from meetings, memoranda, GIS acquisition and implementation related documents); archival records (organizational charts, financial records, personnel listings and job descriptions); direct observation of people and field environment; and physical artifacts (computer equipment and outputs, i.e., maps).
5 The protocol devised for the case study served as a basis for designing a structured questionnaire to be used in a survey of about 500 individuals employed in local governments in North Carolina. The survey represents the second phase of the dissertation research. Data elicited through the survey will be used for testing the same eight propositions through statistical analyses.
6 The technique is based on comparing empirically observed patterns with predicted patterns deduced from theory, and on employment of natural control situations. Coincidence or contradiction between the two patterns formed the ground for confirming (corroborating) or rejecting (falsifying) the theoretical propositions.
All four local government agencies were directly or indirectly engaged in GIS technology. By 1988 all three departments within which the agencies were located had acquired the technology and started to implement it. By the time of this study (1991/1992) the technology was used in a variety of applications. The four agencies varied in the level of utilization of their GIS, from an indirect and occasional use of maps generated with the technology as was the case of the Comprehensive Planning Section, to a full incorporation of GIS technology into daily organizational functions as was the case of the Transportation Department.

Based on information about GIS-related knowledge and system utilization, staff members within each agency were grouped in two or more categories: GIS users (employees who personally operate GIS technology); prospective GIS users (employees who will be direct users of GIS technology in the near future); indirect GIS users (employees who use products generated with GIS technology, but do not operate the technology personally); GIS non-users (employees who do not use GIS technology either directly or indirectly); and higher level administrators (GIS non-users in organizational positions able to initiate and support GIS implementation, e.g., department heads). Designation of main GIS-user[s] and main GIS non-user[s] was crucial for testing the propositions. While data on the eight variables were elicited for all employees, the values found with the main GIS-user[s] and non-user[s] were given more weight in evaluating the significance of individual attributes on GIS-related behavior because the patterns were clearest at these extreme ends of the adoption/nonadoption continuum.

Transportation Department, City/County School System

In 1986 the Transportation Department volunteered to be a pilot user of the Transportation Information Management System (TIMS), a GIS software specifically designed to help with school bus routing. The idea to incorporate TIMS was generated by the Operations Director and Transportation Department Director and was seen as an opportunity to provide more efficient service.7

Implementation started in 1987. The initiative had full political support and intensive and diverse GIS management activities (available funding, training, technical support, user involvement, system documentation, system maintenance and upgrade, etc.). After one year of initial database development TIMS was introduced into departmental daily activities and since than, it had been intensively utilized for bus routing.8 The system had become an essential tool for the Department’s operation.

Overall, implementation of TIMS has been a path of continuous progression. Hardware and software were replaced or upgraded as necessary to meet expanding needs. The database has been regularly and meticulously maintained and updated.

TIMS diffused successfully within the Transportation Department. It was fully adopted by people who were expected to work with it. Until 1991 TIMS was operated exclusively within a single office by two assigned employees, one cost clerk - TIMS Operator and one transportation supervisor - TIMS Manager (the two main TIMS users). In addition, one more transportation supervisor became an indirect but limited user of TIMS.9

In 1991 a decision was made to introduce employees from the main departmental office to the system, in order to broaden the user-base in case of absence of one or both main TIMS users. The GIS-related behavior of nine individuals was explored in this study:

1. Two main TIMS users: TIMS Operator (clerk) and TIMS Manager (transportation supervisor);
2. Two prospective TIMS users: a clerk and a transportation supervisor;
3. One indirect TIMS user: transportation supervisor;
4. Two non-users of TIMS (clerks); and
5. Two higher level administrators: Operations Director and Transportation Department Director.

Diffusion of TIMS to individuals within the Transportation Department was controlled, driven by executive decisions about staff members to be assigned to operate TIMS. Other employees were neither expected to engage in direct use of the technology, nor were conditions present for them to do that. Despite the lack of a spontaneous diffusion process, it was possible to make observations about the role of personal factors on TIMS-related behavior.

In relating the diffusion history to human factors found during the interviews, only two of the research propositions corroborated: Perceived Relative Advantage and Compatibility with Computer Experience. The outcomes for the Transportation

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7 The City/County School System is the third Largest in North Carolina, consisting of about 45,000 students, of which 26,000-27,000 are transported on daily basis. The Transportation Department operates 441 school buses.
8 At the time of this study, more than 90 percent of the area was in the database.
9 This individual used general maps generated by TIMS, but never made a move for more direct utilization for own operations.
<table>
<thead>
<tr>
<th>THEORETICAL PROPOSITION</th>
<th>DESCRIPTION OF FINDINGS THAT WARRANTED CORROBORATION/FALSIFICATION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELATIVE ADVANTAGE</td>
<td>The main TIMS user (TIMS Operator) had the highest expectations of all employees in terms of personal benefits (primarily intangible).</td>
<td>C</td>
</tr>
<tr>
<td>VALUES, BELIEFS</td>
<td>No association was found between the pattern of individual involvement with TIMS and expressed attitudes toward technology. No difference between TIMS users and non-users.</td>
<td>F</td>
</tr>
<tr>
<td>COMPUTER EXPERIENCE</td>
<td>Current and prospect TIMS users had more experience with computers than the other employees. Exception: TIMS Manager.</td>
<td>C</td>
</tr>
<tr>
<td>PERCEIVED COMPLEXITY</td>
<td>Trend reversed from expected. GIS technology (TIMS) was seen as more complex by users than by non-users of TIMS.</td>
<td>F</td>
</tr>
<tr>
<td>EXPOSURE TO GIS</td>
<td>Two main TIMS users (TIMS Operator and TIMS Manager) were not exposed to GIS technology prior to making decision to engage in using TIMS.</td>
<td>F</td>
</tr>
<tr>
<td>COMPUTER/GIS ANXIETY</td>
<td>No substantial anxiety or apprehension about TIMS was discovered. Results were opposite from expected. Generally, more intensive anxiety was associated with GIS technology than with computers.</td>
<td>F</td>
</tr>
<tr>
<td>ATTITUDE TOWARD CHANGE</td>
<td>Resistant behavior was encountered with one indirect TIMS user and on non-user. Failure to use TIMS could not be clearly attributed to the attitude toward work-related change.</td>
<td>F</td>
</tr>
<tr>
<td>NETWORKING</td>
<td>Amount and nature of communication among the employees was associated with the employees’ decision to use or not to use TIMS.</td>
<td>F</td>
</tr>
</tbody>
</table>

### RELEVANT CONTEXTUAL ELEMENTS

1. State mandate for the use of TIMS;
2. Availability of funding from sources outside the agency;
3. Extensive management activities (support, training, user involvement, etc.);
4. Good history of automation;
5. Stable organizational environment.
Mapping section, Tax Assessor's Office

The idea to use GIS technology for cadastral mapping and land records management in Cumberland County originated in the early 1980s. Implementation of GIS technology was to be the last phase of a long-term project to modernize land records. The project was endorsed by the County Board of Commissioners. By 1988 all phases of the project were completed except the incorporation of GIS technology.\textsuperscript{10}

In 1988, unlike the previous phases, there was no political support for acquisition of GIS technology due to changed membership and beliefs of the County Board of Commissioners. The head of the Land Records Department, who was seen as the major advocate of the County GIS, decided to purchase Arc/Info software and a PC. The acquisition was made with the Departmental funds and with permission from the County Manager. In one employee's words, this initiative was "to get GIS technology in the back door."

Implementation of the technology proceeded very slowly, one step at a time. Commitment and support from the Head of the Land Records Department continued, but only conceptually, i.e., without concrete action. There was no planned or organized GIS implementation. Arc/Info was there to experiment with. The most computer-literate employee was put in charge of the system. Although this staff member received some basic training in the Arc/Info program, self-training was the main learning approach. This method implied a flat learning curve and a lot of frustration on the student's part. There was no user involvement, or any further appropriation of funding to support the implementation process.

In 1989, as a result of a political conflict the Land Records Department was merged under the Tax Assessor's Office as the Mapping Section. The head of the Land Records Department resigned. Although the conflict was not about GIS technology, GIS implementation in the Tax Assessor's Office was halted. In 1992, after three years of stagnation, a move was made toward reviving the process. The main GIS user had the position title changed to GIS coordinator and was charged with developing a county GIS and with facilitating communication on GIS-related matters between the County and the City of Fayetteville. The change was not accompanied with any other concrete measure to advance the implementation of GIS technology.

GIS technology was used throughout this period but never developed further and recognized as a tool for the county land records management. It was only sporadically used for performing the major organizational function - cadastral mapping and analyses related to taxation of property. Employment of GIS technology remains low to this day, although with some progression.\textsuperscript{11}

Despite the difficulties encountered during the GIS implementation, and consequently rather weak organizational adoption of the technology, there was a notable diffusion process to observe. On an individual level the study revealed a clear diffusion pattern among the staff members of the Mapping Section. The source of diffusion was the employee initially assigned to operate (i.e., experiment with) Arc/Info. The diffusion was intensive in terms of number of individuals involved, but not in terms of the amount of knowledge transferred. New GIS users achieved only limited use of GIS, mainly confined to digitizing and data retrieval tasks. Nevertheless, they all directly engaged with the technology. Out of six mappers who were present in the Section since Arc/Info was acquired in 1988, there was only one staff member that had not at least attempted to use the technology. There was also a discernable difference among the users of GIS technology in terms of the extent of their involvement, interest, motivation, and achievement. The following groups of individuals were identified in the Mapping Section with regard to their GIS-related behavior:

1. The main GIS user: GIS Coordinator;
2. Two medium-level GIS users: mappers;
3. Three low-level GIS users: two mappers and the Supervisor;
4. Two GIS non-users: both mappers, one of them joined the agency in 1991; and

\textsuperscript{10} The county was reflown for new base maps in 1983, new parcel identifiers were assigned, cadastral maps updated, and soil and topographic maps obtained.

In addition, in 1986 the County acquired a state of the art computerized system, on-line Assessment Information System (OASIS). It was a mainframe based system, designed to help keep track of properties for the purpose of assessment and taxation. The OASIS database was accessible throughout the County Courthouse offices and associated remote posts, via distributed terminals.

\textsuperscript{11} The major GIS-related activities were: "cleaning" the County base map and soil map which were in digital form provided by a contractor that flew the County for aerial photos in 1983; digitizing of zoning coverage in coordination with the joint city/county Planning Department; and occasional employment of analytical capabilities of Arc/Info to service clients from other departments within the County government.
Table 3
Mapping Section of the Tax Assessor's Office
Corroboration (C)/Falsification (F) of Propositions

<table>
<thead>
<tr>
<th>THEORETICAL PROPOSITION</th>
<th>DESCRIPTION OF FINDINGS THAT WARRANTED CORROBORATION/FALSIFICATION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELATIVE ADVANTAGE</td>
<td>Significant difference in perceived personal benefits between GIS users and a non-user. The main GIS user had stronger motivation to engage in using GIS technology than the other GIS users.</td>
<td>C</td>
</tr>
<tr>
<td>VALUES, BELIEFS</td>
<td>The main GIS non-user was concerned about the influence of computerization on jobs, social interaction, and power sharing.</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER EXPERIENCE</td>
<td>The main GIS user, who was the first to engage in GIS technology, used computers in a variety of applications, and was very knowledgeable about them.</td>
<td>C</td>
</tr>
<tr>
<td>PERCEIVED COMPLEXITY</td>
<td>Results were opposite from expected. GIS non-users saw GIS technology as less complex and difficult to use than GIS users.</td>
<td>F</td>
</tr>
<tr>
<td>EXPOSURE TO GIS</td>
<td>Extent of exposure to GIS technology was associated with the level of involvement with the technology. The main GIS non-user was the least exposed.</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER/GIS ANXIETY</td>
<td>The main GIS non-user was very anxious about using GIS technology.</td>
<td>C</td>
</tr>
<tr>
<td>ATTITUDE TOWARD CHANGE</td>
<td>Variation in attitudes between GIS users and GIS non-users was not substantial.</td>
<td>F</td>
</tr>
<tr>
<td>NETWORKING</td>
<td>Intensity of GIS-related communication was associated with adoption of the technology and with the level of engagement with it.</td>
<td>C</td>
</tr>
</tbody>
</table>

RELEVANT CONTEXTUAL ELEMENTS
1. Organizational restructuring resulting from a political conflict;
2. Hierarchical and conflicting organizational environment;
3. Lack of political support for GIS;
4. Few GIS management activities (i.e., no commitment of funding, no official training provided);
5. Good history of automation (OASIS).
started to use the technology for overlaying and plotting the addressing information downloaded from OASIS on Large scale (1:100) to get into overlay type analysis.

During Planning Department staff meetings, there were no more pronounced and conscious efforts for diffusing the use of GIS technology. The idea of using GIS technology was initiated by the Head of the Transportation Section, who was a strong believer in the utility of computerized technology for increasing efficiency in task performance and for freeing up planners’ time from data collection for more creative activities. Responsiveness and support from the Department’s management (i.e., Planning Director and Deputy Director) was very good.

Although management support was present throughout this period, there were no more ambitious plans for implementation of GIS technology. Political support was never explicitly sought from the County Board of Commissioners or Planning Commission for a more comprehensive approach to incorporating the technology. Finances for acquisition of GIS technology were available through state funding and federal grants for transportation planning. Consequently, the implementation of the GIS was very much application-oriented. Specifically, transportation planning was driving the utilization of the technology.

One element of the implementation strategy was to rely primarily on existing databases. Other formal elements of GIS management were missing. The implementation of the technology was tied to one person, who was self-trained. Technical support from vendors was not utilized.

While, throughout the four-year period (1988-1992) there was notable progress in terms of both upgrade of equipment and the system’s use, to this day the GIS technology has not been employed to its full capability. The GIS was directed primarily toward economic and population study as a basis for revision of the City/County thoroughfare plan. The study was completed in 1991.12 Since then, GIS technology was used for several small projects, but again, not to its full potential.13 The main GIS user has recently started to get into overlay type analysis.

GIS technology diffused modestly within the two sections (both the Transportation Section as the initial location of the technology and the Community Assistance Section as the current location). Except for few demonstrations of the system and its capabilities during Planning Department staff meetings, there were no more pronounced and conscious efforts for diffusing the use of the technology. Staff members - potential users of the technology were not actively involved in the GIS implementation.

Interested employees were introduced to the technology and had free access to the equipment. But, neither extensive help nor organized training were provided to them. No additional time was allocated to this activity, except for the transportation-related projects. As a result, in addition to a newly hired GIS specialist and the main GIS user, only one staff member got directly involved with the technology. The involvement of this employee was self-initiated and spontaneous.14

In summary, the following staff members were identified with regard to adoption of GIs technology:

1 Three GIS users: the Community Assistance Section Head (Planner III), GIS specialist (Planner II) hired in 1991, and the Street Naming and Addressing Section Head (Planner III);

2 Two indirect users of GIS: the Transportation Section Head initiator of GIS acquisition and implementation, and Annexation Planner (Planner I);

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12 Initial use of MapInfo software was confined to overlaying parcel centroids downloaded from the OASIS over origin-destination (OD) zones, and to deriving values for a number of variables by each zone. This information was then fed into a spreadsheet-based program to do actual population and economic forecasts.

13 Water and sewer service re-evaluation, an area plan.

14 In January 1992 when the Street Naming and Addressing Section was formed, this employee became the section Head and started to use the technology for overlaying and plotting the addressing information downloaded from OASIS on Large scale (1:100) county maps.
### Table 4
Community Assistance Section of the Joint Planning Department
Corroboration (C)/Falsification (F) of Propositions

<table>
<thead>
<tr>
<th>THEORETICAL PROPOSITION</th>
<th>DESCRIPTION OF FINDINGS THAT WARRANTED CORROBORATION/FALSIFICATION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELATIVE ADVANTAGE</td>
<td>Strong consensus among GIS non-users and indirect users about absence of any sort of tangible personal benefits from getting to use GIS technology.</td>
<td>C</td>
</tr>
<tr>
<td>VALUES, BELIEFS</td>
<td>While the main GIS non-user was concerned about the consequences of extensive computerization, the manager (supporter of GIS) was unreserved about it.</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER EXPERIENCE</td>
<td>Employees with most computer-related experience were the proponents and/or the first users of GIS technology.</td>
<td>C</td>
</tr>
<tr>
<td>PERCEIVED COMPLEXITY</td>
<td>No difference was detected on this issue between GIS users and GIS non-users. Generally, the technology was not perceived as complex.</td>
<td>F</td>
</tr>
<tr>
<td>EXPOSURE TO GIS</td>
<td>Extensive exposure to GIS technology by the main GIS user and one indirect user (the supporter of GIS) relative to other staff members (mostly non-users).</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER/GIS ANXIETY</td>
<td>GIS non-users felt less anxiety and apprehension about the technology than GIS users. Trend reversed from expected.</td>
<td>F</td>
</tr>
<tr>
<td>ATTITUDE TOWARD CHANGE</td>
<td>The main GIS non-user displayed rigid behavior regarding work related change. The promoter of GIS technology (indirect GIS user) was open to change, particularly computer-related.</td>
<td>C</td>
</tr>
<tr>
<td>NETWORKING</td>
<td>Low communication with regard to GIS technology coincided with failure to adopt the technology.</td>
<td>C</td>
</tr>
</tbody>
</table>

### RELEVANT CONTEXTUAL ELEMENTS
1. Unstable organizational environment with frequent restructuring and internal reassignment of staff members;
2. Conflicting, and segregated organizational environment;
3. Lack of political support for GIS (not sought);
4. Few GIS management activities (funding the acquisition of equipment, but no official training provided, no user involvement);
5. Low level of computer use in the organization (Planning Department).
(3) Three GIS non-users: Historic Preservation Planner (Planner II), Planner II, and Planning Assistant; and
(4) One higher level administrator (Planning Department Director).

The GIS-related behavior observed within the Community Assistance Section resulted in corroboration of six of eight propositions. Those were: Perceived Relative Advantage; Compatibility with Personal Values, Beliefs; Compatibility with Computer Experience; Exposure to GIS; Attitude Toward WorkRelated Change; and Networking. The results are displayed in Table 4, along with a list of contextual elements relevant for implementation of GIS technology in the agency. Fragmented and unstable organizational environment affected the diffusion of the technology within the agency.

Comprehensive Planning Section, Joint City/County Planning Department

The Comprehensive Planning Section never acquired GIS technology, but it had the GIS developed within the Planning Department at its disposal. Staff members of the Comprehensive Planning Section were exposed to the technology acquired in the Transportation Section, currently located in the Community Assistance Section. Beyond responsiveness of the main GIS user to GIS-related inquiries, there was no pronounced effort to diffuse GIS technology toward the Comprehensive Planning Section, neither by the Planning Department leadership nor by the Section Head. While GIS-related service was available from both the Community Assistance Section and the Mapping Section of the Tax Assessor’s Office, these agencies were limited in time they could devote to others, due to their obligations and ongoing projects.

Financial resources were not available for training or hiring additional personnel to operate the GIS for projects undertaken in the Comprehensive Planning Section. Also, employees of this Section were not involved in the process of GIS acquisition and implementation. They were informed about GIS-related matters in staff meetings and through informal contacts.

The Comprehensive Planning Section was included in the study because it was the most prominent unit toward which the diffusion could have occurred. The Section had a clear opportunity to apply the technology through their update of the Comprehensive Plan. The project started in 1986, and, by 1992 was moving from data collection and analysis to plan-making. Maps generated with the GIS were first used in 1991, when through an informal contact an employee from the Comprehensive Planning Section learned that it might be possible to use some of the maps created in the Mapping Section of the Tax Assessor’s Office. Even though the necessary layers for several overlay-type analyses were available in digital form, GIS technology was used only indirectly through hard copy outputs that were further subjected to a traditional manual processing.15

The behavior encountered with the Comprehensive Planning Section was a clear example of unsuccessful implementation of GIS technology. The adoption failed on both organizational and individual levels. None of the four employees of the Comprehensive Planning Section got into using GIS technology directly. They all remained sporadic indirect users of the technology.

The Comprehensive Planning Section along with the Community Assistance Section offered a good environment for testing the theoretical propositions related to individual factors influencing the adoption of GIS technology. Unlike in the Transportation Department of the School System, the diffusion process was not controlled. Rather, its unforced and spontaneous nature created excellent conditions for individual reasoning to surface in the decisions to engage or not to engage with the technology.

The findings within the Comprehensive Planning Section led to corroboration of all eight propositions (Table 5). This was the only agency where it was possible to relate results on Perceived Complexity with the predicted pattern. Similarly to the Community Assistance Section, Comprehensive Planning was part of a conflicting and segregated environment, with low interorganizational communication.

The history of GIS acquisition and implementation in the four agencies is outlined in Table 6. The summary covers a period from 1986 to 1992, from the time when the first move was made in the Transportation Department of the City/County Schools System to introduce GIS technology (TIMS) to most recent GIS-related activities in the four agencies.

The agencies pursued different approaches in their implementation of GIS technology. Planned and controlled implementation in the Transportation Department led to a successful, fully operational system. Experimental approach of the Mapping Section prevented incorporation of GIS technology into organizational functions and operations. Incremental approach in the

15 A prime example of the Limited employment of GIS technology was the process of producing two maps in a series of maps compiled as input for the Comprehensive Land Use Plan. The maps displayed the areas suitable for development, one with regard to septic tank construction, another with regard to the quality and type of farmland. Both maps were generated with Arc/Info software by reclassifying the soil map. Lines from the soil map were manually traced onto the base map using the Light table, and then the map was colored with markers. The base map was also available in digital form. At the time a color plotter was available at the Planning Department (Community Assistance Section).
Community Assistance Section yielded a semisuccessful, partially-utilized GIS. Finally, for a number of reasons, the Comprehensive Planning Section deferred its utilization of GIS technology.

**SUMMARY OF FINDINGS ON PERSONAL FACTORS**

An in-depth examination into the patterns of adoption of GIS technology among employees of the four agencies resulted in patterns both matching and conflicting those predicted in the propositions. only two propositions, Perceived Relative Advantage and Compatibility with Computer Experience, were confirmed across all cases (Table 7). Other propositions corroborated in three or less cases. While the Mapping Section, Community Assistance and Comprehensive Planning Section display rather uniform findings for most of the eight propositions, the findings for the Transportation Department of the City/County School System differ from the others. The fact that this was the only agency with extensive GIS management activities may contribute to its exceptional status among the cases.

**Relative Advantage (CORROBORATED IN 4 CASES)**

Perception of personal benefits emerged as the most essential factor for adoption of GIS technology by individual employees in all four agencies. GIS users said that tangible benefits, such as salary raise and advancement in position, had precedence over other personal benefits.

Among the intangible benefits from learning and using GIS technology, personal satisfaction and improved professional prestige were more readily recognized, but did not offer as powerful a stimulus as the tangible ones. A few individuals, who were identified as major points of resistance to GIS technology, were neutral or pessimistic even about those aspects.

Organizational benefits from implementation of GIS technology were recognized by all agencies and individuals within those agencies, except the Comprehensive Planning Section where GIS technology was not incorporated at all. The doubts about the advantages from relying on the technology expressed in this agency were conditioned by the current situation in the agency and the awareness about the time and effort needed to compile a GIS database.

The perception about organizational benefits did not appear crucial for individual adoption of GIS technology, but it was important for effective organizational involvement with the technology.
### Table 5
Comprehensive Planning Section of the Joint Planning Department
Corroboration (C)/Falsification (F) of Propositions

<table>
<thead>
<tr>
<th>THEORETICAL PROPOSITION</th>
<th>DESCRIPTION OF FINDINGS THAT WARRANTED CORROBORATION/FALSIFICATION</th>
<th>RESULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELATIVE ADVANTAGE</td>
<td>Very low perceived benefits among all employees, particularly tangible benefits (salary raise and opportunity for position advancement).</td>
<td>C</td>
</tr>
<tr>
<td>VALUES, BELIEFS</td>
<td>The main GIS non-user was concerned about possible influence of computerized technology on job security and distribution of power.</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER EXPERIENCE</td>
<td>Very limited experience with computers among all employees. In addition, strong feeling of frustration with computers introduced in the agency, particularly by the main GIS non-user.</td>
<td>C</td>
</tr>
<tr>
<td>PERCEIVED COMPLEXITY</td>
<td>The main GIS non-user felt strongly that GIS technology was hard to understand and use.</td>
<td>C</td>
</tr>
<tr>
<td>EXPOSURE TO GIS</td>
<td>Limited exposure to GIS technology by all staff members, particularly by the main GIS non-user. Rather negative opinion about the products generated with GIS.</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER/GIS ANXIETY</td>
<td>High computer/GIS related anxiety and apprehension expressed by the main GIS non-user. Consciousness about avoiding the use of the technology.</td>
<td>C</td>
</tr>
<tr>
<td>ATTITUDE TOWARD CHANGE</td>
<td>The main GIS non-user expressed negative attitude toward work-related change.</td>
<td>C</td>
</tr>
<tr>
<td>NETWORKING</td>
<td>Low GIS-related communication. Isolation from other sections.</td>
<td>C</td>
</tr>
</tbody>
</table>

**RELEVANT CONTEXTUAL ELEMENTS**

1. Unstable organizational environment with frequent restructuring and internal reassignment of staff members;
2. Conflicting, and segregated organizational environment;
3. Lack of political support for GIS (not sought);
4. No GIS management activities (no management support, no funding for technical support staff member, training, or acquisition of equipment, no user involvement in the Departmental GIS implementation);
5. Low level of computer use in the organization (Planning Department).
<table>
<thead>
<tr>
<th>Agency</th>
<th>TRANSPORTATION</th>
<th>TAX MAPPING</th>
<th>COMMUNITY ASSISTANCE</th>
<th>COMP. PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planned GIS/</td>
<td>Experimental GIS/</td>
<td>Incremental GIS/</td>
<td>Deferred GIS</td>
</tr>
<tr>
<td></td>
<td>Fully operational</td>
<td>Underutilized</td>
<td>Partially-utilized</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>Acquired TIMS software &amp; equipment; TIMS Manager hired &amp; Operator assigned</td>
<td>OASIS Implemented</td>
<td></td>
<td>Started the Comprehensive Plan update</td>
</tr>
<tr>
<td>1987</td>
<td>Database development in progress; Software upgrade; First use of TIMS for school bus routing</td>
<td></td>
<td>Acquired Atlas Graphics &amp; equipment; Digitized OD zones</td>
<td>Data collection activity</td>
</tr>
<tr>
<td>1988</td>
<td>Continuous progression in database and use; Software upgrade; Current TIMS Operator hired</td>
<td>Acquired Arc/Info software &amp; equipment; Experimentation with GIS</td>
<td>Acquired Mapinfo; Hardware upgrade; Continued work with CD zones and information from OASIS</td>
<td>Data collection activity</td>
</tr>
<tr>
<td>1989</td>
<td>Hardware &amp; software upgrade; Continuous use of TIMS</td>
<td>Merger of Land records under Tax Assessor's Office; Resignation of the Head</td>
<td>Continued work on the Thoroughfare plan update and population/economics study</td>
<td>Sporadic use of information from GIS; Continued data collection</td>
</tr>
<tr>
<td>1990</td>
<td>Continued database development; Software upgrade; Steady use of TIMS</td>
<td>Stagnation (experimentation continued); Cleaning soil and base map</td>
<td>Acquired Arc/Info</td>
<td>Sporadic use of information from GIS; Continued data collection</td>
</tr>
<tr>
<td>1991</td>
<td>Continued database development &amp; update; Software upgrade; Continued use of TIMS; Diffusion toward other staff members started</td>
<td>Started to digitize zoning; A few small projects completed (for Tax Office and other departments)</td>
<td>Installed Arc/Info; Hardware upgrade; Finalized Population and Economic Study; Started other projects</td>
<td>Indirect use of GIS (traced over hard copy maps generated with GIS); Completed draft of Land Use Element of the Plan</td>
</tr>
<tr>
<td>1992</td>
<td>Hardware upgrade (LAN - workstations); Full utilization of TIMS</td>
<td>The main user title change to GIS Coordinator; Continued small projects</td>
<td>Plans for further hardware &amp; software upgrade; Small projects continued</td>
<td>Deadline for the Plan</td>
</tr>
</tbody>
</table>
Compatibility with Computer Experience (CORROBORATED IN 4 CASES)

There was a clear pattern in all four agencies that the people who were on the forefront of GIS utilization had stronger computer background and experience than GIS non-users or other GIS users who either adopted the technology subsequently or were indirect users of the technology.

Exposure to GIS Technology (CORROBORATED IN 3 CASES)

This factor was in three cases definitely related to the individual adoption of GIS technology. More exposure to the technology coincided with earlier and more intense involvement with it. The main GIS users in Mapping, Community Assistance, and Comprehensive Planning had an opportunity to observe official demonstrations of the technology. Few of them, however, had an opportunity to try out the technology before deciding to learn and use it.

Subsequent adopters of GIS technology and GIS non-users were exposed to the technology primarily in-house from the main (and usually first) GIS users. Impressions about the main GIS user's experience and about the quality of GIS products (maps) also contributed to varying results of GIS diffusion. This factor was especially clear in the case of the Planning Department where low diffusion corresponded to low communication within a section, as was the case with Community Assistance, or between the sections, as was the case with Comprehensive Planning, due to a fragmented organizational structure. Strong drafting/design background and pride in aesthetic quality of their products contributed further to the delay of GIS use by the employees of the Comprehensive Planning Section.

In the case of the School System's Transportation Department the pattern was opposite from expected and led to falsification of the proposition. Two main TIMS users (TIMS Operator and TIMS Manager) had no prior exposure to GIS technology and no knowledge about it until they interviewed for a new position which entailed operation/management of TIMS. While at the time the technician was familiar with computers, the manager was not even a computer user. The implementation of TIMS was very successful, and both staff members adjusted and mastered the technology very well. This case points to other factors that were more relevant for the individual decision to adopt the technology than an exposure to it, such as: provision of training, political and financial support for GIS, openness to change, and readiness to learn new things.

In comparison to computer experience, exposure to GIS technology appeared as slightly weaker determinant of individual decisions about adopting GIS technology.

Networking (CORROBORATED IN 3 CASES)

Communication behavior was a significant factor in distinguishing between GIS users and non-users in three agencies. Active networking generally led to higher likelihood of using GIS technology. The general communication pattern and amount of contacts were not as crucial determinants of GIS-related behavior as were the frequency and nature of communication with the main GIS users or other sources of GIS-related information.

Negative messages or conflicting personal relationships were found to distract from the contribution of this factor to adoption of GIS technology. Particularly discouraging was a display of frustration with a system, usually due to lack of knowledge or time to devote to experimentation. A few employees within the Planning Department referred to the main GIS user's "struggle" to get the system to work.

Communication behavior was very closely associated with exposure to GIS technology, and a similar pattern with regard to individual employees' standing on the use of the technology was exhibited by all four agencies.

Compatibility with Personal Values, Beliefs (CORROBORATED IN 3 CASES)

In three of the four agencies studied there was at least one individual, lagging in the use of GIS technology (referred to as the main GIS non-user), that expressed a significantly different view on computerized technology from other employees who were either GIS users or were not in position to directly use the technology. Major concerns expressed by those individuals were: (a) possible negative impact of computers on the processes of socialization and power sharing; and (b) endangered job security due to incompetency.

Generally, a majority of employees within the four agencies did not demonstrate a fatalistic or mystical attitude toward computerized technology. Most subjects agreed about the importance of technological advancements and benefits that accrue with their utilization. A few staff members, however, mentioned the problem of keeping up with them because of the fast changes.
**Computer/GIS-Related Anxiety (CORROBORATED IN 2 AND FALSIFIED IN 2 CASES)**

Testing of this proposition resulted in two corroboration and two falsifications. This factor showed as probably the most sensitive area of inquiry. Many employees offered responses that were reversed from expected. Surprisingly, the GIS non-users presented themselves as less anxious, apprehensive and fearful of the technology than GIS users. The majority of staff members described their anxiety in positive terms (such as being interested, active, enthusiastic, curious, etc.).

In two cases where the proposition was corroborated, instances were found of two main GIS non-users, one in the Mapping Section, the other in the Comprehensive Planning Section, who expressed an extremely high computer and GIS-related anxiety. This high anxiety could have contributed to their resistance to adopting GIS technology.

Finally, no significant difference was found among the employees with regard to their anxiety and apprehensiveness about computers in general.

**Attitude Toward Work-Related Change (CORROBORATED IN 2 AND FALSIFIED IN 2 CASES)**

Results on this factor were mixed. In two agencies there were instances of main GIS non-users who showed a negative attitude toward work-related change, i.e., showed a preference for a rather static work environment. A variety of reasons, however, could have simultaneously contributed to their failure to adopt GIS technology. For instance, in case of the main GIS non-user within the Mapping Section those factors were: passive communication behavior, low exposure to GIS technology, high computer anxiety, lack of perceived personal benefits, lack of computer experience, and concern about the consequences of computerization.

In the Comprehensive Planning Section the causes of resistance also could not be exclusively attributed to the main GIS non-user’s negative attitude toward change, but could be traced to the factors such as: low appreciation for products generated with GIS technology, low perceived personal benefits, computer and GIS related anxiety, and perception of GIS technology as complex and difficult to learn.

**Perceived Complexity of GIS Technology (FALSIFIED IN 3 CASES)**

In the Comprehensive Planning Section, the only agency which did not incorporate GIS technology, two crucial staff members (the Section Head and the main GIS non-user) viewed GIS technology as more complex and difficult than their current practice and approach to doing their tasks. This was the only agency where sufficient evidence was found to corroborate the proposition.

In three remaining agencies that had implemented GIS technology and used it even to a limited extent, the technology was not seen as complex to understand and use by either GIS users or non-users. Because the difference in statements between those two groups was not significant, the perceived complexity of GIS technology could not be proved to determine the process of individual involvement or restraint from the technology.

The responses were in some cases reversed from expected, i.e., before engaging with GIS technology the current GIS users saw it as more complex than the current non-users of GIS.
Table 7
Corroboration (C)/Falsification (F) of the Propositions by Agency

<table>
<thead>
<tr>
<th>THEORETICAL PROPOSITION</th>
<th>TRANSPORTATION DEPARTMENT</th>
<th>MAPPING SECTION</th>
<th>COMMUNITY ASSISTANCE</th>
<th>COMPREHENSIVE PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELATIVE ADVANTAGE</td>
<td></td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER EXPERIENCE</td>
<td></td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>EXPOSURE TO GIS</td>
<td>F</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>NETWORKING</td>
<td>F</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>PERSONAL VALUES, BELIEFS</td>
<td>F</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>COMPUTER/GIS ANXIETY</td>
<td>F</td>
<td>C</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>ATTITUDE TOWARD CHANGE</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>C</td>
</tr>
<tr>
<td>PERCEIVED COMPLEXITY</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>C</td>
</tr>
</tbody>
</table>
CONCLUSION

This study of the diffusion of GIS technology in four local government agencies: (1) confirmed the complex, situational and selective nature of the process of diffusion of GIS technology within organizations; (2) isolated Perceived Relative Advantage and Compatibility with Computer Experience as two major determinants of individual decisions to start using GIS technology; and (3) found association between individual behavior with regard to GIS technology and contextual elements.

(1) Diffusion of GIS technology in public organizations is a complex, selective and situation-bound process

Once GIS technology is acquired by an organization, its pattern of diffusion toward the organizational units and/or individual staff members is unique for that organization. Engagement with GIS technology is not uniform across all staff members. Differences arise with regard to type, time, and level of involvement with the technology.

Employees vary in their (perceived) need for GIS technology. Diffusion among them depends on the type of function and operations performed by an agency, as well as the particular staff member's current involvement in different projects, imposed deadlines, supervisor's tolerance for experimentation with new task approaches, expectations about his/her performance, knowledge, experience, and personal history.

If the diffusion of GIS technology is uncontrolled, i.e., left to spontaneous processes and voluntary participation, engagement with the technology is driven by opportunity, immediate circumstances, and personal initiative for action. This kind of situation offers excellent conditions for surfacing of subjective factors in the decision about using GIS technology, i.e., the human factor that was the focus of this research.

Testing of the theoretical propositions could not be achieved through aggregation or averaging of findings on an agency level. Each individual had to be approached as a separate entity with a unique set of situational elements that needed to be considered in order to assess the employees: (a) level of involvement with GIS technology; (b) opportunity to express interest and learn about the technology; and (c) conditions for fulfillment of the interest (access to equipment, provision of training, availability of time, etc.).

(2) Perceived Relative Advantage and Compatibility with Computer Experience - the most significant determinants of GIS adoption by individuals

Among the individual factors perceived personal benefits and previous computer experience were the most important determinants of individual adoption of GIS technology in all four agencies.

Most GIS users had higher expectations in terms of personal benefits from starting to work with the technology then the rest of employees. Individuals identified as the main GIS non-users stated that they anticipated no personal gain from making the effort to learn the technology. Perceived organizational benefits were not significantly related to individual adoption of GIS technology, but were a possible important factor in the organizational-level decision to use the technology, and a source of indirect influence on the individual decisions.

Computer experience was another major factor determining the individual engagement with GIS technology. All employees who were on the forefront of using GIS technology were already intensive computer-users. The fact that they were familiar with computers contributed clearly to their early adoption of GIS technology. The main GIS non-users, were on the other hand, the least computer-literate, and, in few cases, did not use computers at all.

Values and beliefs about computerized technology, exposure to GIS technology, and communication behavior were also significantly related to individual decisions to use the technology. Results about influence of computer/GIS related anxiety and attitude toward work related change on individual adoption of GIS technology were mixed. Finally, responses about perceived complexity of the technology were not associated with the pattern of adoption in most individuals.

(3) Importance of contextual factors

Diffusion of GIS technology toward both organizations and individuals was affected by a number of contextual factors. The case studies showed that all three elements of the research conceptual framework that were expected to define the context were relevant in the adoption of GIS technology: GIS management activities, organizational internal context, and organizational environment. Differences among the four agencies in testing the eight propositions, as well as overall differences in the success of implementing GIS technology, were heavily conditioned by contextual factors.
LITERATURE


