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APPENDICES
A: Overview of NCGIA Research and Education Missions
B: Specialist Meeting Agenda
C: Post-Conference Position Papers
D: Bibliography

We would like to acknowledge the patient and diligent assistance of several graduate students, who kept a record of the Initiative 4 Specialist Meeting. They are:

Holly J. Dickinson, SUNY-Buffalo
Gary Jeffress, University of Maine
Phil Parent, University of California at Santa Barbara
Kerry Kreiton, University of Maine
Victor Wu, SUNY-Buffalo
1. Introduction

The Specialist Meeting for Initiative 4, "the use and value of geographic information," was held in Tenants Harbor, Maine from May 6 through May 10, 1989. The meeting brought together a group of roughly thirty academics, government officials, and representatives of private firms along with NCGIA researchers to develop an agenda for research on the use and value of geographic information. The meeting participants represented a variety of disciplines, including geography, surveying engineering, sociology, economics and law relevant to the use and value of geographic information.

One of the greatest challenges in organizing a specialist meeting such as this one is to identify a group of specialists who, as a group, can represent a broad perspective on the research topic within the constraints of limited space and schedule conflicts. Beginning with a rather large group of potential specialists, about twenty specialists outside the NCGIA ultimately participated. Through a series of large- and small-group meetings, characterized by an open exchange and critique, the group achieved its goal of developing an agenda for research on the use and value of geographic information in decision-making. This agenda includes surveys, taxonomy development, research on economic measures of value, and the diffusion of innovations.

2. Specialist Meeting Goals

The goal of geographic information research is to uncover basic knowledge that will facilitate the use of geographic information in decision making processes and will allow or aid the use and diffusion of geographic information technologies. The goals of the Specialist Meeting to discuss the Use and Value of Geographic Information are several:

1. To provide a forum for an interdisciplinary discussion of the use and value of geographic information in decision-making, focusing on impediments to use.

2. To identify impediments to the diffusion of geographic information innovations among users and potential users of geographic information.

3. To gain social knowledge which may be used to aid and direct the adoption of geographic information innovations.

4. To identify existing models that are appropriate for assessing the economic value of geographic information.

5. To identify shortcomings in existing models to assess the value of geographic information.

6. To develop, refine or modify current models and methodologies to assess the value of geographic information.

7. To identify a research program on the use and value of geographic information to be implemented by the NCGIA over the coming two-year period.

3. List of Specialist Meeting Participants

One of the greatest challenges, as previously noted, was to identify a group of experts to participate in the Specialist Meeting. On the one hand, we recognized a core of individuals larger than our accommodations and the format of the meeting would allow. On the other, we faced the difficulty of meshing the schedules of busy people with the schedule for the specialist meeting. The final list of participants reflects compromises on both counts. The list of specialists follows, in alphabetical order.

Specialists:

Vince Barabba
Executive Director for Marketing Research & Planning
General Motors Corporation
Detroit, Michigan

David Brusegard
Executive Director, The Institute for Market and Social Analysis
Toronto, Ontario, Canada

Tom Duchesneau
Chair, Department of Economics
University of Maine
Orono, Maine

Earl Epstein
Professor, School of Natural Resources
Avijit Ghosh, editor, Journal of Retailing
Assistant Professor, Department of Business Administration
New York University
New York, New York

Ann Greer
Professor, Department of Sociology
University of Wisconsin-Milwaukee
Milwaukee, Wisconsin

William Huxhold
MIS Project Director, City of Milwaukee
Milwaukee, Wisconsin

Mike MacDougall
Chief of The Information Management Branch
US Environmental Protection Agency
Boston, Massachusetts

John Moeller
Deputy Assistant Director of Support Services
U.S. Bureau of Land Management
Washington, D.C.

Peter Morgan
Professor, Department of Economics
University of Michigan
Ann Arbor, Michigan

David Moyer
Executive Director, Institute for Environmental Studies
Madison, Wisconsin

Allan Schmidt
Internal Consultant, Prime-Wild GIS, Inc.
Natick, Massachusetts

Carl Shapiro
Economist, U.S. Geological Survey
Reston, Virginia

Roger Tomlinson
President, Tomlinson Associates, Ltd.
Ottawa, Ontario, Canada

William Ubbens
Computer Specialist, Geographic Information Systems
USDA Forest Service
Washington, D.C.

Lisa Warnecke
Director of Research & Development, School of Information Studies
Syracuse University
Syracuse, New York

James Wells
Senior Policy Analyst, Center for Health Affairs
Project HOPE
Chevy Chase, Maryland

NCGIA Personnel:

Univ. of California - Santa Barbara

David Simonett
Professor, Co-Director of NCGIA
4. Pre-conference Materials

In order to help focus the Initiative 4 Specialist Meeting on the Use and Value of Geographic Information in Decision-Making, the NCGIA sent the participants several items. Perhaps the most important among them was the outline of objectives for Initiative 4, which was taken directly from the NCGIA Research Agenda. We asked the Meeting participants to consider these objectives, and to respond to them in the form of a pre-conference position paper, in which they would present their own ideas on the use and value of geographic information. Both the Initiative 4 objectives and the participants’ pre-conference position papers follow.

4.1 Outline of Use and Value Issues

USE AND VALUE OF GEOGRAPHIC INFORMATION IN DECISION-MAKING OBJECTIVES

1. Identify problems of dealing with uncertainty and risk associated with decision-making.
2. Develop and test models of the decision-making process regarding land use, focusing on the role of information.
3. Identify primary and subsequent users of spatial information, and determine the value of such information.
4. Evaluate the direct and indirect benefits of GIA/GIS.

A Specialist Meeting to discuss and explore different perspectives on the topic began the initiative. Concepts of use and value of information are common to all information-producing activities and must be judged within a broad definition of the social, economic, and legal impacts of those activities.

THE USE AND VALUE INITIATIVE WILL EXAMINE THE FOLLOWING SUBTOPICS

- UNCERTAINTY AND RISK ASSOCIATED WITH DECISION-MAKING
  - the economic concept of utility applied to information;
  - the role of information in uncertainty reduction;
uncertainty reduction and absorption;
- limits to the search for information.

- DECISION MODELS
  - the decision-making process;
  - the role of information;
  - information as a product;
  - the distinctions between data, information, and knowledge.

- DEMAND FOR INFORMATION
  - value as a demand-initiated concept;
  - identification of primary and subsequent users of information;
  - the contrast between supply/push and demand/pull in the development of information systems;
  - public good aspects.

- BENEFITS
  - direct and indirect benefits;
  - uncertainty reduction;
  - uncertainty absorption;
  - expanded opportunity;
  - avoided cost model.

The initiative will result in guidelines for GIS design, especially regarding which data to include and what benefits can be expected. It also will form a starting point for investigations regarding data quality and how it affects the quality of decisions. Initiative 4 will provide some design criteria for Initiative 7 ("Visualization of the Quality of Spatial Information") by identifying those aspects of data quality most important to decision-makers. Initiative 4 will provide foundation knowledge and a common ground for Initiative 9 ("Institutions Sharing Spatial Information"). Results of this research will be discussed at a conference in conjunction with a suitable professional meeting.

4.2 Pre-conference Position Papers

4.2.1 Kate Beard, University of Maine Dimensions of Use and Value of Geographic Information

Introduction

Better design and wider adoption of geographic information systems can benefit from a better understanding of the use and value (or non-value) of geographic information. The value of geographic information depends largely on the adequacy of the information relative to need. In this context adequacy refers to content as well as timeliness. It is a common assumption among advocates of GIS that these systems enhance the value of data by creating information products more efficiently, improving access to information and generating new information products. Notions that such systems may diminish the value of data are less often considered, yet this is a distinct possibility. High quality data can be input into a system and manipulated in ways such that they become meaningless. GIS must be consciously designed and costs expended not only to enhance value, but also to assure that value is not diminished. Discussions of enhancement or degradation, however, must be prefaced with a better understanding of value as a whole.

As a starting point for grappling with value, we might codify uses of geographic information and relate these to different dimensions of decision making. Following is a first attempt at a list of generic uses of geographic information with some examples. This categorization is intended to be exhaustive and mutually exclusive, but could benefit from some refinement.

Categorization of Uses of Geographic Information

- Siting: finding an optimal location for structures or activities (e.g., siting a fire station, a McDonald’s, a sanitary land fill, a prison, a high level nuclear waste site)
- Logistics: movement or distribution of persons or objects within a space (e.g., emergency response, military troop movements)
- Routing: (optimal) movement of things through a known network (e.g., school buses, garbage pick up, express mail, hazardous materials)
- Navigation: way finding, may or may not involve a prescribed or known network. (e.g., ground, sea, air)
• Inventory (of spatial objects): count and location of objects for a specified time period (e.g., tax roll, census)
• Monitoring and analysis: examination of processes over space and time
  - Socio-psychological: migration studies, territorial behavior studies
  - Zoological: migration, habitat selection
  - Ecological: deforestation and environmental degradation
  - Geological: plate tectonics, seismic observations
  - Pedological: erosion
  - Hydrological: precipitation, water quality monitoring, flooding
  - Atmospheric: weather forecasting
  - Epidemiological: incidence and diffusion of disease
  - etc.

The above uses require certain types of geographic information, but it is the nature of decisions and actions with respect to these uses that serve to define the quality of the information needed. Investigating the nature of decisions may therefore be a lucrative path to follow. Decisions can be seen to have several characteristic axes, some of which might include:

Routine ----------------------- > Non-routine
Non-Political ---------------- > Political
Minimal Risk ---------------- > High Risk
Non-Controversial ---------- > Controversial
Indefinite ------------------ > Immediate
Local Implication ------------ > Global Implication

With these different decision axes we can create a decision space and plot the different uses within this space. Clusters of uses within the decision space may share similar information needs and reflect similar components of value.

![Figure 1. Decision space for routing](image-url)
The essential components of geographic information which may lend it value are positional accuracy, attribute accuracy, currency, completeness, and consistency. The relative weight that each of these component contributes to value will depend on the use of the information and the decision framework. For example, with express mail delivery, the geographic information must be sufficient to assure that a package is delivered to the correct location, to the correct person and within a prescribed time. Consistency is important here as well since it will be disconcerting if the indicated address does not match with the indicated recipient. Completeness of the information, however, is not critical. On the other hand, with inventories, such as the census, attribute accuracy (who is counted) and completeness (whether all were counted) are critical, while positional accuracy is less important.

Each component of value has an associated cost incurred in data collection and processing. Attempts to optimize all five components can be very expensive. Some framework is needed to optimize data collection and processing efforts with respect to use and decision making.

4.2.2 David Brusegard, The Institute for Market and Social Analysis

Research Progress in the Use and Value of GIS Information

Most factual information used in any form of decision-making is tacitly or explicitly geo-referenced to some location, be it North America, or as specific as X/Y coordinates. So what’s the real question being asked here?

There is a school of thought in information theory that to have meaning is to have a value as a bound variable, and analogically, that to have value as a piece of information is to be an element in an inference ticket. Since different users wish to make different inferences in their daily work and mandated responsibilities, information has value if it is required to fit into some train of inferential thought or inferentially licensed action. The addition of “geographic” before “information” serves, it seems, only to restrict the application to the domain of the spatially referential.

The simplest response to the broad query regarding the value of geographic information is that geographic information is enormously useful and valuable to any agent requiring knowledge of the spatial distribution of any object attribute, or the spatial relations between objects with attributes.

Agents require knowledge to carry out certain tasks and to make the requisite decisions. Thus, a mapping of the basic tasks/decision types, the main informational elements by area of interest would seem to permit the creation of a useful matrix. This matrix would essentially permit the benchmarking of any GIS system with respect to the degree to which it could accomplish the core set of tasks inherent in the major decision processes of defined subject area, e.g., municipal management, market research, crop management, emergency service management and so on.

What drives the value of information is the ability of the agent to alter conditions that alter attributes. Marketers, for example, have been using geographic information for decades and know the uses and value well. The uses are to target and to analyze, the value is in the ability of these information laden activities to permit the change in attributes/behaviors of clients, and the attributes/product types of goods and services.

Look, for example, at the following train of information of increasing specificity and increasing value growth:

1. The number of cars sold by General Motors (GM) in North America this year.
2. The number of cars sold by GM in Toronto.
3. The number of cars sold by GM through dealer A in Toronto.
4. The number of cars sold by GM through dealer A in Toronto to individuals living within three miles of the dealership.
5. The number of cars sold by GM through dealer A in Toronto to individuals living within three miles of the dealership who have purchased a GM vehicle from that same dealership within the last ten years.
6. The number of cars sold by GM through dealer A in Toronto to individuals living within three miles of the dealership who have purchased a GM vehicle from that same dealership within the last ten years, and whose workplace is within one mile of the dealership.

Information about car purchases becomes more and more valuable as geographic location, and associated attributes become more and more disaggregated. The law of diminishing returns sets in at some point depending upon the particular uses to which the information is to be put.

The distribution of sufficiently disaggregated information then becomes extremely valuable since it forms an input-output system capable of use in modeling and prediction of the interaction between individuals, organized units, and objects.

Geographically referenced data permit the analysis of data to determine spatial relationships, and the use of location to find existing or similar objects (in the case above, the highest probability customer leads). Analysis permits the consideration of, for example, do individuals buy GM cars from the closest dealer and with what frequency? Does workplace location play a role? Are there more of these individuals? What is unique about them if anything? And where do we find them and their like? How many are there? And can we generate a listing by address or postal district or marketshed? From a marketing perspective, some of this is useful geographic information.
How do you test whether geographic information has value and how do you quantify that value?

- Value derives from use. To do research on the value of information, do research on uses of information. This sounds very much like the familiar concepts of functional requirements, data models and cost-benefit analyses.

And why do we want to know this?

- Likely to determine functionality of GIS systems
- Standards for basic georeferencing files
- Standards for basic subject-specific georeferenced data sets or users of types A,B, ..., N

This whole area of investigation of the value and uses of geographic information is less than obvious. We might ask ourselves some basic questions. For example:

- What is the value of
  - The unemployment rate for the United States ± 1 % ?
  - The unemployment rate for the SMSAs ± 1 % ?

The latter is likely more expensive to collect than the former, but is it more valuable? A data series may have five users or five million users. Is one more valuable than the other?

Large governments often determine the value of information in broad terms and on the argument of societal good; municipalities on the basis of management needs. Businesses use other yardsticks. Are there common yardsticks for different domains or is each so separate so as to require separate analysis?

Are we really trying to answer the question of what is the most useful information? This is more than a daunting task. What kinds of uses are there for information is also a very long string to begin to pull.

What was the question again?

4.2.3 Hugh W. Calkins, SUNY-Buffalo

Position Paper on the Use and Value of Geographic Information in Decision-Making

Historically, it has been assumed that geographic information, made available to decision makers through the use of a geographic information system or other means, will "improve" the decision-making process (i.e., it will lead to "better" results). The notions of "improved decisions" and "better results" have not been defined or examined in detail, particularly for geographic information. Much of the effort to date to produce geographic information, either as mapped data, a GIS, or through some other means, has been focused on simply providing the information. It has been assumed that the utility of the information will be self-evident and therefore that the GIS information products will have sufficient value to justify the whole activity.

These assumptions are now being called into question, partly because GISs are very expensive and partly because of the increasing complexity of "systems" to supply geographic information. Early GISs were often single-use or application-oriented, but the current approach to providing such information looks towards integrated systems meeting the needs of a broad range of users. The early GISs were often justified on rather simplistic grounds. Larger, more complex GISs serving a multiplicity of disparate uses pose a much greater justification problem. Commonly, a benefit/cost analysis encompassing the entire range of GIS uses is attempted. The disparate nature of the proposed uses makes such analysis very difficult, if not impossible, given the level of knowledge we have regarding the use of geographic information.

The study of economics of a GIS (or other process providing geographic information) must consider three factors:

1. The use(s) of the geographic information;
2. The costs of providing the geographic information; and
3. The benefits obtained from using the geographic information.

Benefits will be a function of how the resulting information is used, by whom, and the marginal performance attributable to using the geographic information. The problem occurs when benefits of a very different nature must be defined, measured, and evaluated. In an organizational setting, this problem can be exacerbated by the need to involve multiple departments or agencies in the provision of the geographic data, such as in a multi-purpose cadastre (LIS). Table 1 is a generalized attempt to identify some of the major categories of demand for geographic information associated with various levels of GIS functional capability. Each cell in the table contains an indication of our present ability to define adequately the use of geographic information, our ability to measure the cost of providing the information, and our ability to assess the benefits.
In viewing the use of GIS or geographic information, from the perspective of a single organization (implying a more limited set of uses), a sequence of steps can be defined which trace the geographic information from initial field observation through to products designed to support decision-makers (Figure 1, below). Each step in the process involves activities that impact use (and

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<td>For Information Use</td>
<td>Record</td>
<td>Graphic</td>
<td>Display</td>
<td>And</td>
<td>Display</td>
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<tr>
<td>Protect health and safety</td>
<td>undefined</td>
<td>undefined</td>
<td>undefined</td>
<td>undefined</td>
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<tr>
<td>welfare of public</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Disseminate data and information</td>
<td>use: low</td>
<td>use: low</td>
<td>use: low</td>
<td>not yet</td>
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<tr>
<td>Freely decision-making</td>
<td>ben.: low</td>
<td>ben.: low</td>
<td>ben.: low</td>
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<tr>
<td>Ad hoc or unstructured</td>
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<td>use: low</td>
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<tr>
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<tr>
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Table 1: The Ability to Define Use, Measure Costs and Determine Benefits of Geographic Information Within a GIS Context
therefore value or benefit) and that incur costs. There is a need to understand this set of steps (or transformations) for each single use of geographic information. After describing single uses in this fashion, it may be possible to generalize, or combine, these transformations across several (or all) uses to gain insight into the overall use and value of a particular set of geographic information.

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**Figure 1: Organizational Use of Geographic Information for Decision-Making**

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4.2.4 Paul Densham, SUNY-Buffalo

GIS as a Decision Support System

**Introduction**

Geographic Information Systems (GISs) often are implicitly designed to assist decision-makers in their deliberations; many systems, however, do not perform effectively. There are two reasons for this. First, insufficient attention is given to the process and context in which decisions are made; second, many GISs do not support the analytical and statistical modeling required by many decision-makers. Similar shortcomings in management information systems led to the development of decision support systems (DSS) by operational researchers and management scientists. Geoffrion (1983) identifies six distinguishing characteristics of DSS:

1. They are used to tackle ill or semi-structured problems - these occur when the problem, the decision-maker’s objectives, or both, cannot be fully and coherently specified.
2. They are designed to be easy to use, the often very sophisticated computer technology is accessed through a user-friendly front end.
3. They are designed to enable the user to make full use of all the data and models that are available, so interfacing routines and data base management systems are important elements.
4. The user develops a solution procedure using the models as decision aids to generate a series of alternatives.
5. They are designed for flexibility of use and ease of adaptation to the evolving needs of the user.
6. They are developed interactively and recursively to provide a multiple-pass approach which contrasts with the more traditional serial approach - involving clearly defined phases through which the system progresses."

**Spatial Decision Support Systems (SDSS)**

My research focuses on the development of spatial decision support systems, particularly for locational planning. Combinatorial locational planning problems form a continuum between the extremes of structured and ill-structured problems. Structured problems can be addressed appropriately by using the traditional serial approach of locational analysis: the formulation of an objective function to reflect the decision-maker's preferences, an optimizing analysis using location-allocation techniques, and the presentation of the solution to the decision-maker for implementation. This approach is not suitable for semi-structured problems because locational planning models, including hybrid formulations, cannot capture all the important dimensions of locational planning problems (Dear, 1978), especially qualitative decision criteria. There are two reasons for this. First, decision-makers are not incorporated into the solution process, and thus cannot change their decision criteria or preferences in response to learning more about their problem; and second, the "user-groups" often are excluded from the decision-making process. Thus, the chosen location set does not reflect collective "user-group" preferences, and therefore generates conflict when the quality of the solution is evaluated in terms of the decision-making process that generated it (Densharn and Rushton, 1988).

**Optimality: A Definition of Process, Not of Outcome**

Keen (1977) discusses the shortcomings of optimizing analysis from the stance of a management scientist, using Simon's three-stage model of the decision process: Intelligence, Design, and Choice. Intelligence is the stage of recognizing that a problem exists and then defining it; design is the generation of alternative solutions to the problem; and choice is the selection of one solution to be implemented. Keen agrees with Simon (1972) that "The mainstream of optimization science has focused on Choice" (p. 52), largely ignoring Simon's two preliminary decision stages, intelligence and design. To improve the quality of the decision-making process, it is necessary to develop methodologies that "shift the emphasis to Intelligence and Design - the definition of relevant alternatives - and leave the Choice stage under the control of the decision-maker's subjective judgment. Optimality is then a characteristic of the process rather than the solution and the role of the Operations Research/Management Science analyst is to provide a supportive and interactive methodology" (p. 52).

To support an interactive methodology, the SDSS decision-making process must be iterative, integrative, and participative. It is iterative because a set of alternative solutions is generated which the decision-maker evaluates, and insights gained (Schwenk and Thomas, 1983; Schwenk, 1984) are input into, and used to define, further analyses. Consequently, value judgments that materially affect the final outcome are made by decision-makers who have expert knowledge that must be integrated with the quantitative data in the models. This participation also serves to return control over the decision-making process to decision-makers, ameliorating criticism about the quality of that process.

**Research Issues**

Many of the issues raised in the assigned literature are pertinent to the development of SDSS. As Dickinson and Calkins (1988) note, the products of an SDSS cannot be known in advance because of its adaptive process of evolution (Keen, 1980). Research has concentrated on improving optimizing and heuristic solution methods per se, rather than investigating how these techniques can be used to generate good alternatives that help the decision-maker explore the solution space (Simon, 1972). The organizational context in which decisions are made often results in a solution being evaluated on the basis of the decision-making process that generated it rather than on its narrowly-defined, technical efficiency (March and Olsen, 1976).

In addition, there are other factors that directly affect the design and use of SDSS. For example, the literatures on human factors and psychology show that decision-makers exhibit a variety of cognitive styles. Research has shown that users with differing cognitive styles demand different capabilities from a decision support system and want to use different types of information; moreover, systems that do not support a particular user's cognitive style cannot be used effectively. This finding has ramifications for the preliminary needs assessment for an SDSS and for the types of data made available, employing both the user's perception of its effectiveness and usefulness and formal measures as well.

**References**


4.2.5 Holly J. Dickinson, SUNY-Buffalo
The Value of Geographic Information and GIS

Understanding the benefits of geographic information and GIS requires understanding how geographic information and GISs are actually (and potentially) used. This is complicated by the fact that quite often the product of a GIS is not an end product, but rather an input into some decision-making process. At present, GISs are being used by organizations in the decision-making process; however, it is unclear how the information is specifically used in decision-making, and where the GIS fits into the overall process.

Referencing the diagram of organizational use of GIS by Hugh Calkins (see position paper above), we see that a number of transformations may occur to the information extracted from a GIS before the actual decision-making occurs (i.e., before the actual use). A key research objective in Initiative 4 should be to understand the actual processes that occur during these transformations. Understanding what happens with the extracted GIS information should enable us to begin to determine the costs and value of the products of a GIS. This, however, assumes that the information is used to provide "better" decision-making (e.g., decreased uncertainty in the decision-making process) and thus, gives "value" to the information. Knowledge of information use should also be helpful in guiding future GIS design as well as successful organizational implementations.

Some of the specific questions to be addressed include:

1. "What are the specific transformations performed on extracted GIS information before the information is used in a decision-making process?"
2. Can these transformations be categorized into processes, such as those presented by Calkins (extraction and formatting, analysis and problem recognition, and prediction and projection?)
3. Are these processes application-specific?
4. Do certain levels of decision-making complexity warrant different or more transformations?
5. Could the information output from each transformation be viewed as value-added information?
6. What are the results from decision-making and how can we measure the value of these results?

The above questions suggest an empirical (rather than theoretical) approach to the research. This would consist of user surveys to determine the use of geographic information and GIS actually occurring at the present time. Potential use should also be documented.

4.2.6 Thomas Duchesneau, University of Maine
Earl Epstein, The Ohio State University Development of a Methodology for Determination of Use and Value of Geographic Information System Products and Services

Hypothesis: The introduction and use of the products of GIS technology proceeds according to the following path:

GIS Technology --- > Adoption of Technology --- > Implementation, and generation of GIS products
and diffusion of the products

The *adopting unit* (the unit that adopts the GIS technology) may be one of the following:
- a government jurisdiction
- a private company or organization.

The *using unit* is the specific agency or sub-agency within a government or a specific department in an organization that relies on the GIS products for execution of its substantive responsibilities.
Assumptions

- The products of GIS technology diffuse throughout the using units as the products become accessible and as awareness of their utility develops.
- Diffusion to units will occur regardless of whether the adopting unit provides a centralized or decentralized source.
- The impact of GIS technology for the using units is to enhance or alter the attributes of geographic data and information.
- The impact of GIS is evolutionary, depending for its nature more on the perceptions among users of the enhanced information attributes than the desire of system designers.
- Perceptions about those who first adopt a new technology are frequently different from the perceptions of those who eventually use its products.
The Adoption Diffusion Processes are represented as follows:

The $A_n$ are the primary using units within a jurisdiction or organization.

The $B_n$ are secondary using units. They are often removed from the system designers, generators, assemblers, and distributors.
Research Questions

• By what processes do the GIS products diffuse among the using units after adoption?
• Can a theory or model of the process be developed based on rational criteria and be made applicable to a variety of adoption and implementation circumstances?
• How do the enhanced information products from a GIS alter the substantive activities of the informed and uninformed user?
• What feedback mechanisms are available from the users to provide guidance to the system designers?

Specific Choices

• We will study a large, public jurisdiction. This will likely be a county with a large area and population with several cities and many local agencies. The local agencies may be repeated in the various cities.
• There will be a single case study of the jurisdiction that considers several (if not all) cities and many agencies. The repeated aspect of agencies will provide a statistical basis for a time-dependent study.
• The case study will rely on interviews and analyses. Relevant variables will be sought from the mass of anecdotes.
• The adoption process at time two will be considered. Baseline data on patterns of use and non-use will be established. Buyer, consultant, and primary user perspectives will be considered. The diffusion process will be examined based upon the timing and actual use of products that evolve and are used.
• Feedback mechanisms from users to designers will be identified.

4.2.7 Andrew U. Frank, University of Maine
Assessing the Use and Value of Geographic Information

At the outset, we must recognize the difference between studies to assess the economics of geographic information systems (GIS) and studies to assess the use and value of geographic information independent of the system that produces it. In the past, a number of studies determined the cost-effectiveness of geographic information systems by showing that computer-based systems can process data more economically than manual systems and that GIS can produce the same spatial information products with less effort. Typically, one compares the cost of producing the spatial information using the existing system (manual or first-generation GIS) with the projected cost of the new system. After a GIS is installed, new and unanticipated uses of the spatial information products are discovered; indeed, the improved availability of spatial information is the major benefit of a GIS. Thus, typical cost/benefit analyses of GIS fail to assess fully most of the benefits of GIS due to the discovery of new uses. This occurs because of the difficulty in making such assessments.

In order to evaluate GIS properly, we must expand our scope and concentrate on the use and value of geographic information in an organization. A GIS is cost-effective if the value of its products, measured as a contribution to the overall value of the organization's products, is larger than its cost, independent of the technology used or the cost of the existing system.

This begs the question, how to assess the value of geographic information. I assume that we must consider the organization and its goals and assess where and how spatial information improves the organization's decision-making process. Spatial information can improve the decision process in two ways:

1. By reducing the cost of performing the same services by improving the efficiency of the operations; and
2. By providing higher quality services, that is, services that have higher value to the users. (This effectively extends the boundary of the system included in the assessment.)

The special problem we face is to assess the contribution that information makes to an organization's procedures. The general assumption seems to be that more information improves the decision and thus contributes value. This may not always be correct, as more information may extend the duration of the decision-making process and thus increase the cost of making the decision without necessarily creating or adding value. The problem is further exacerbated by the fact that most GISs are used in the public sector, where other factors in addition to economic considerations are important, if not essential (e.g., equity in decisions). One means to evaluate public sector use of GIS is to measure the value of geographic information in a private enterprise environment (e.g., forest management or real estate management) and then use the same value in the public sector. Finally, I am interested to see if we can
identify classes of use of geographic information. Can we categorize the decision-processes that may potentially use spatial information into a few classes which would, among other things, simplify research?

4.2.8 Mason J. Hewitt, U.S. Environmental Protection Agency
Use and Value Issues

Most of my current research and interests lie in the area of information usage. An example from the EPA would characterize how many large organizations utilize information. The EPA has been gathering environmental data for fifteen years and archiving it in vast computer data bases in a central location. A good deal of this data was related to lake and stream parameters. Yet, when asked by Congress if acid rain was affecting our lakes and streams, the Agency was unable to answer. In response, the EPA proposed and undertook a massive field operation to gather new data.

With the introduction of GIS into the Agency within the last three years, perhaps a new perspective will emerge. The Acid Deposition Program is supported by GIS in the hope that being able to "see" the data will increase our understanding of status, cause, and effect.

Below I pose the many questions we are seeking to answer in order to utilize fully GIA techniques. The references cited do not always contain the answers; sometimes, they just pose the question. For the sake of brevity, I have confined my key points to summaries with references at the end of this paper.

1. My own experiences are related to site-specific or species-specific uses of GIA for reducing uncertainty in decision-making. I have used GIA to accomplish the following tasks:
   • Assess alternatives at hazardous waste sites (Hewitt and Dulaney, 1989; Hewitt and James (in draft)); what needs to be removed; where; how much; what removal route poses the least exposure to humans and ecosystems; which removal scenario is more economically feasible?
   • Characterize problems (Hewitt and James (in draft); Hewitt and Stone (in draft); Hewitt, et al., 1989; Pickus and Hewitt, 1989; Stout et al., 1989); what is the problem; what information is needed to make a decision; who or what is at risk?
   • Reduce decision risk (Hewitt and Stone (in draft); Fitzsimmons et al., 1988; Mynar and Hewitt, 1989); how accurate does spatial data need to be; how do you decide task priorities by risk priorities; how do you decide with uncertain data; how do you decide who is at risk?
   • Identify responsible parties (Hewitt and Stone (in draft)); can you use GIA to track contaminants to sources and therefore to identify the responsible party; can you use GIA to build a body of evidence that will support litigation?
   • Determine trends (Hewitt, 1989); where is the loss/gain; how much is lost or gained, can cause be determined?
   • Resource utilization (Hewitt, et al., 1986; Young, 1987; Hewitt, 1989); how much is there?

2. With every decision there are risk extremes to be calculated. When reviewing data, there is always the possibility of Type I and Type II errors. One keystone of decision-making is a knowledge of the quality of available data. There is much research to be done on techniques to characterize and control error in spatial data bases (Boyle and Hewitt, 1989).

3. Project planning is critical to design a system to support decision-making (Hewitt and Koglin, 1987). The first step in decision-making is to clearly define objectives that will serve as a blueprint for the system design.

These key points and questions are drawn from my own experiences and will probably overlap with others at the meeting. The questions will be used at this facility to drive a research plan relevant to the needs of the EPA. The results of our program will be made available to NCGIA.

References
Hewitt, M.J. and James, D.E. In draft. Decision support at a very large hazardous waste site. EMSL Las Vegas.
In researching the use of geographic information and its value to an organization for decision-making, one must first review the progress of the data processing industry as a whole in the addressing the issue of the value of information. Whereas thirty years ago the value of data processing was based upon the efficiencies that it brought to the processes within an organization, now its value is based upon the use of information for improving the effectiveness of the organization. The switch from individual processes to corporate performance is significant in evaluating today’s information systems. Two publications should be reviewed for this perspective: Martin’s Principles of Dam-Base Management, and Strassmann’s Information Payoff.

1. Managers are becoming more dependent upon information systems and view their value in terms of their flexibility in responding to their changing needs. According to Martin:

   The same data can be processed in a variety of ways to produce different pieces of information which are useful in different circumstances. The key to making computers useful to management is learning how to present the right information in the right way, and this is no simple matter (Martin, 1976: 292).

   Similarly, Strassmann suggests that:

   As the workforce shifts from the production of objects to the production of services based on information, the ability to enhance effectiveness becomes far more important than the question of whether or not one can measure efficiency (Strassman, 1984: 117).

2. An effective geographic information system must be used in applications that are directly linked to the strategic goals of the organization in order to have value beyond the efficiencies associated with automated mapping. As Strassman notes (1984: 116), “Driving a car that gets 100 miles per gallon is not effective if you are driving around without a purpose.” Strassman goes on to say:

   Information’s raison d’être lies in its dissemination, whereas goods are produced to be possessed. For instance, the more people share information, the more its importance will increase. Information which nobody uses diminishes in value (Strassman, 1984: 117).

   Data Modeling and Information Engineering methodologies of system design in the data processing industry address these issues and should be incorporated into geographic information systems design and implementation.

3. Gaining support for implementing a geographic information system in an organization is a matter of selling the product, that is, it means creating a market for its services. If decision-makers accept the potential benefits as better than other alternatives for meeting the goals of the organization, then its value is determined at the time that funds are appropriated. According to Martin (p. 293):

   "Some computer systems can be cost-justified in tangible terms. It will be increasingly difficult in future systems to find tangible justification. For that matter the telephone systems of a corporation, and many other services, cannot be justified tangibly. The justification of a computer doing payroll depends on the number of clerks it replaces. The justification of an information system depends of the value of the information it provides. It becomes necessary to assess this value, rather than merely to assess cost reductions or displacements. The value of the information must exceed the cost of providing it.

   "Can we measure the value of information?

   "The answer to that question depends on what the information is used for. If it is used in an "operations system," the value of the information can usually be estimated, at least approximately. If it is a general-purpose information system, the
value may be impossible to estimate in any other than the most subjective terms. It would be exceedingly difficult to estimate
the value of having your telephone. Information systems will be evaluated equally subjectively.

"To have the maximum likelihood of being valuable to its potential users, computer-provided information must have
a number of characteristics, which are listed [below].

1. It must be accurate. The worst criticism of some information systems is that the information is inaccurate.
2. It must be tailored to the needs of the user.
3. It must be relevant to what he requires at that time.
4. It must be timely. Often it must be given in response to a user’s request. If it is given to him a day late, he may not use it in
some cases.
5. It must be immediately understandable. Some computer printouts are remarkably unintelligible.
6. Its significance must be immediately recognizable. This is often a function of the method or format of presentation.
7. It helps if it is attractively presented.
8. It should be brief. The lengthy listings characteristic of batch processing often conceal rather than reveal information.
Single significant facts should not be camouflaged by the inclusion of other less relevant data.
9. It should be sufficiently up-to-date for the purpose for which it will be employed.
10. It should be trustworthy. Management is often suspicious of computerized information sources. Management will soon
lose confidence in them if occasional errors in the data are found.
11. It should be complete. The user should not be left feeling that he has received only part of the information he really needs.
To obtain complete information, it may be necessary for the user to browse in the files or ask certain types of questions
relating to the information. Man-machine dialogue then becomes a vital part of the information-finding process.
12. It should be easily accessible. If a terminal is difficult to use, or confusing, it will not be used.

A manager who is given information lacking in these qualities should not accept it passively. He should discuss the matter
with the data-processing manager or systems analyst.

And Strassman (pp. 129-130) says:

"Information is not a privilege. Its value must be determined by its users.
"For benefits to be greater than price, which is a part of our inequality for determining effectiveness, there must be a
way customers can exercise meaningful choices in obtaining information service. This rarely happens because most
information work allows little or no choice of supplier. There are exceptions, however. For instance, there is a great deal of
competition in the travel business, in advertising, in entertainment, in publishing, in stock brokerage, and in consulting. Still,
I estimate that less than 50% of all information work in the United States involves any significant user options....

"As long as customers have no alternatives, it is possible to compute only the efficiency of suppliers, not their effectiveness.
A government agency, whose actions are regulated by law, and whose budget is a share of tax revenues, can
improve only its efficiency. However, even in the absence of a market mechanism, it is possible to develop benchmarks to
measure relative efficiency by comparison with acknowledged examples of excellence. For instance, it is possible to develop
multi-variate statistical methods for comparing the performance of all fire departments in a state with those few which are
most successful. Constructing such benchmarks of excellence requires much more effort and much more data than what a
competitive marketplace accomplishes through a small number of customer pricing choices. The special advantage of the
market mechanism, then, lies in its low-cost information efficiency in channeling resources to where they are of greatest
value."

4. The value of a GIS should be measured by the effectiveness of the organization as a whole because the contribution of the
GIS to that effectiveness is difficult, if not impossible to segregate from the whole. It is a function not only of the reduction in time to
perform manual tasks, but also the value of the impact of using the information. Often, the latter is an order of magnitude larger than
the former. Allow me two examples from my work at the City of Milwaukee:

**Example 1: Workload Balancing**

The Building Inspection Department of the City of Milwaukee, among other responsibilities, inspects properties to ensure
that their electrical work is safe, in accordance with established building codes. The properties to be inspected are identified through
the building permit process. In a year, Milwaukee could conduct over 30,000 electrical inspections as a result of permit applications.
With such a sizeable amount of work, the electrical inspectors are assigned to geographical subunits of the City (electrical inspection
districts), and at the City of Milwaukee, each inspector is assigned to one district -- twelve, in all. Since, over the years, the number
and size of buildings within each district changes (because of demolitions, new construction, renovations, etc.), the number of
inspections an inspector must conduct also changes, causing an imbalance of workload among inspectors. One inspector, it was found,
had three times as many inspections to conduct as another. In order to balance the workload among inspectors, the district boundaries are periodically changed, based upon the number of permits in each district.

Without a GIS, and using manual methods, adjusting inspection district boundaries in order to balance workload among Milwaukee’s inspectors required one full week with all twelve inspectors together in a room, trading cards (one for each permit) until there were twelve even stacks and each stack defined one contiguous geographic area. Since this process was very labor-intensive (480 work-hours), and took the inspectors away from their primary responsibilities, it was not conducted very often. As a result, inspector workloads were usually out-of-balance, causing morale problems in the department.

When a GIS was employed to balance the workload, the polygon processing of computerized permit data took only four hours -- a savings of 476 work-hours.

That quantitative benefit of the GIS was 476 work-hours, but is that the only value of this GIS application? Since the workload balancing could be done so easily, it could also be done more frequently, keeping the workload constantly in balance. What is the value of constant workload balance? Surely, the Building Inspection Department would not perform this process as often under the manual method as it would with a GIS method, so the 476 work-hours could not be considered a benefit more often than the actual frequency of the manual method. After five years, as Milwaukee population declined and development waned, the number of permits (and thus, inspections) was reduced to a point where the redistricting process, using the City’s GIS, resulted in eleven districts -- one less than before. This reduced the department’s operating expenses by one work-year, a considerable savings of 1900 work-hours per year.

To what extent does the GIS get credit for the savings of 1900 work-hours per year? Without it, the reduction of one district (and thus, one inspector) could have been done manually and one may conclude that the value of doing it with a GIS could only be the 476 work-hours saved in the actual redistricting process itself -- not in the hours saved by eliminating one inspector. One might counter that, since the GIS allows the redistricting process to be performed more often, the elimination of the position was realized sooner than if the manual method had been used. (If the manual method, because of its labor-intensiveness, was done only once every five years and the GIS method allows it to be done every year, then the GIS method allowed the department to reduce its operating expenses four years earlier than the manual method would have. Thus, the GIS could produce 7,600 work-hours of savings -- four years times 1,900 hours per year -- that would not have been realized under a manual method.)

Example 2: State Shared Revenue

The City of Milwaukee receives revenue from the State of Wisconsin each year from a portion of State income tax revenue which is based upon the City’s population as a percentage of the State’s entire population. Since the U.S. Census Bureau provides population figures only once every ten years, the State uses surrogate data for estimating population annually (registered motor vehicles, income tax returns, etc.).

In 1985, the City of Milwaukee, feeling that the annual State estimates underestimated the City’s actual population, challenged the State’s estimates in hopes of increasing its portion of the shared revenues. State law, however, provided for a correction in the State estimates only if new population figures were obtained from a special enumeration and only if that enumeration were performed by the U.S. Census Bureau. Since the Census Bureau charges cities for special enumerations at the rate of fifty cents per person, Milwaukee policy-makers had a decision to make: would the cost of a special census be less than the increase in the City’s portion of State shared revenue?

The decision to go ahead with a Census enumeration was difficult. The only certainty that the correct decision had been made would come after the special census and thus, after the cost had been incurred. To make the decision more difficult, State law further required that, if a special census were conducted, the resulting figure would be used as a basis for estimates in all future years until the next decennial census. Thus, if the special census resulted in a population figure that was less than the state estimate, the City would not only lose its case (and the cost of the special census), but would also realize reduced shared revenues in each of the next five years because the state estimates in those years would be lower than if the special census had not been conducted at all.

Fortunately, the City of Milwaukee had a GIS that contained accurate data and maps that were structured in a flexible manner so that analysts were confident that the City’s population was considerably greater than what the State estimated. (The GIS contained data on housing unit counts from tax records and building permits, land use maps that identified residential units, school enrollment records, birth and death records, and so on.) The policy-makers decided to contract with the Census Bureau to conduct the special census and incur the cost of fifty cents per person. The resulting population figure from the special census was 18,310 more than the State estimate and the City of Milwaukee realized over $15.4 million more in State shared revenue over the next five years because the State estimates were adjusted upwards. The cost of the special census was $318,000, resulting in a net increase in revenue over the five year period of more than $15 million.

Can this value ($15 million) be attributed to the use of a GIS? Some argued that the correct decision (paying the cost of the special census) could have been made without using the GIS and, therefore, the benefit of $15 million could not be attributed to the GIS. The greatest benefit that could be attributed to the GIS was the reduction in work-hours required to amass the data used to estimate the City’s population. GIS protagonists, on the other hand, argued that the use of the GIS increased the confidence of the policy-makers in making the correct decision by reducing their uncertainty in the decision-making process (because computer-
processed data is considered more accurate than manually processed data). Thus, they argued, the GIS should be credited with some of the benefit of increased revenue in addition to the savings in the cost of obtaining the data needed to make the decision.

These two case histories show that a GIS can be proven to be a benefit by reducing the cost of processing and using geographic information in the decision-making process. What has yet to be proven, or at least accepted by non GIS-oriented professionals, however, is what its value is in a much larger context -- that of making good decisions in a timely manner. While it is clear that geographic information itself is critical to good decision-making, it is not clear to what the value of the information in a GIS is to the decision-making process.

References


4.2.10 Gary A. Jeffress, University of Maine
The Use and Value of Geographic Information: Position Outline

"What is the use and value of geographic information?" This question is asked when organizations are faced with social or financial decisions dependent on geographically referenced data. The amount of time, money and effort invested in geographic information is proportional to the reduction of uncertainty or risk in making these decisions.

GIS technology is a tool that enables decision-makers to improve the quality and quantity of geographical information. This improved information retrieval will enhance the day-to-day operations of organizations dealing with geographic information and allow sophisticated analysis of data that would have been prohibitive using manual techniques. Thus, an organization whose business is concerned with geographically referenced data and information stands to benefit from improved operations, management, and policy making with the introduction of GIS.

There are numerous documents reporting the high costs of the introduction of automated GIS. To achieve GIS implementation, financial, organizational and interpersonal barriers must be breached. An understanding of the use and value of GIS products is desired as a justification for the introduction and diffusion of GIS technology.

There is a need for research into the decision making process that constitutes GIS justification and the assessment of use and value of geographical information products. Many of the benefits of GIS are long term, intangible, or unforeseen. The reliance of traditional financial investment justification may not prove valid for GIS as these techniques usually rely on short term payback, do not take into account intangibles, and are based on management by numbers rather than strategic corporate concerns.

4.2.11 John Moeller, Bureau of Land Management
The Impact of Geographic Information on Levels of Uncertainty Associated with Decision-Making

Introduction

• Information must be viewed as an asset of the corporate body, not of individuals.
• For a land and resource manager, the primary use and value of information is for decision-making.
• Geographic information must be organized so it can be integrated and meet a multiplicity of needs.
• Degrees or levels of uncertainty are a reality in decision-making and must be accepted and managed.
• In order for public agencies to perform their respective missions effectively, information will need to be shared between and among them.

Issues

• To what extent should uncertainty be eliminated in order to foster public confidence in land related decision-making?
• At what point does the incremental cost of achieving a higher level of refinement of data and information exceed the added benefits?
• When integrating information from a variety of sources, are there any models to determine the weakest link in the information being used?
• What are effective methodologies to assess social value or demographic information in land and resource decision-making?
• How should determinations be made regarding which data should be automated and to what level of accuracy?
• How are institutional and economic barriers between and among agencies addressed?
• How do managers measure the degree to which decision-making has been improved?
Demand for Geographic Information

- Land and resource information that is oriented to land parcels and legal boundaries or ownership has been in high demand and will increase in demand as it becomes more readily available in automated formats.
- In the Bureau of Land Management (BLM), information needs come from a wide variety of users of public land resources and interested groups and individuals.
- Examples of entities with needs for information related to public lands include:
  - Local governments (counties and towns);
  - State governments;
  - Federal agencies;
  - User groups such as recreationists, hunters, hikers, and campers;
  - Industry users: timber, minerals, ranching and utilities;
  - Environmental organizations; and
  - The general public.

Issues

- How can the public benefit of information be maximized in a shared environment?
- What criteria should be used to determine the amount of standardization needed for effective sharing of data and information?
- How can future user demands be projected with greater confidence than at present?
- Are there any models to estimate the unknown applications backlog as new or modernized systems are developed?

Decision Models and Their Relation to Spatial Information

- Effective land and resource management requires balancing economic, environmental, and social needs of the public for both the present and the future.
- The Bureau of Land Management's multiple-use management mission calls' for the consideration of all of the land's values and characteristics, and for managing to provide a mix of development, use, protection and preservation.
- A key decision process is Resource Management Planning (including the preparation of environmental statements), which lays out land use decisions for a geographic area.
- Information from a wide variety of sources including public comment is considered in Resource Management Plan decision-making.

Issues

- What kinds of land and resource management decisions can most effectively be supported by decision models?
- How do we find the best mix of professional judgment and interpretation and scientific information to reach sound, defensible decisions?
- Should research efforts be focused on providing decision support models rather than decision models given the complex dynamics of interrelationships of man and the environment?
- What are the most effective methodologies for interpreting social and economic information so it can be used by managers in land and resource decision-making?

Benefits

- Man is dependent upon land and its resources as a life support system.
- Better management and utilization of our land and its resources are enhanced by better management of the information about them.
- The barriers to better management are not technological, but include institutional, economic, legal, managerial and other social issues.
- Neither costs nor benefits for a total land information management program have been fully explored.
- Given the frequent need for cost/benefit justifications for LIS/GIS efforts, there is a need to look at the total costs including equipment, training, personnel, data, and organizational preparation.
Issues

- Techniques to improve explanation and quantify the benefits of:
  - Better decisions;
  - Avoidance of poor or incorrect decisions;
  - Improvements in the presentation of data and decisions;
  - Improvements in organizational coordination;
  - Reduction in duplication or overlapping work;
  - Identification of value added benefits of sharing information and managing it as a corporate asset; and
  - Intangible employee and organizational benefits.
- Models to assess and make present-day comparisons of the large up-front expenditures of money for hardware, software, and data vs. long-term benefits.
- Benefits of using GIS capabilities in day-to-day operations of an organization as opposed to project-oriented work as is generally the case now.

4.2.12 Peter Morgan, University of Michigan

Two Thoughts on Geographic Data Collection and Usage

I am unfamiliar with the bulk of geographic research initiatives and my comments should be interpreted in the light of this admitted ignorance. Nevertheless, I would like to advance two thoughts and run the risk that neither are novel to geographers.

First, it seems often to be the case that, when research into an applied area of study begins, databases are amassed without a great deal of thought being given to the statistical parameters of interest. Yet it is well known that the majority of those estimators that have good sampling properties under various data generation conditions are sensitive to these conditions; few are "robust" estimators. As a consequence, there commonly ensues a litany of complaints that the data were not collected with due regard to the forms of statistical analysis used for their analysis and that, as a consequence, it is often hard to select a "good" estimator or that precision is lost. This is as true of spatial statistics as it is of any other class of statistics. It seems prudent, therefore, to consider the end uses to which the statistics might be put and the statistical techniques that might be used when designing the experimental techniques to be used to amass the database.

Second, the maintenance of any database is a resource-consuming activity, and the available resources are often scarce. Hence, the managers of the database are typically confronted with questions of how to reallocate their resources as time goes by to meet changes in demands for the various types of statistical data contained in the database. (This issue is not independent of the one raised above.) As a paradigm, think of the gathering of a year's new data for the database as a sampling of a set of vectors, one for each data type, where in any year the length of the vector (the number of observations within the year) is decided by the database management. How should management decide the length of each vector for the current year? This decision should be guided by the overall objective of tying to make the value of the entire database as great as possible to its users. Thus a variable which is of small value and which is reasonably expensive to observe should be observed only a few times within the specified period. Yet a variable which is of small value but which is almost costless to observe might sensibly be observed many times in the same period. These choices are themselves affected by the resources consumed by observing other variables -- none of these choices are independent of the others. How, then, should the management allocate their overall scarce resources? To complicate matters a little further, note that decisions taken concerning the data gathered this year will often affect the value of gathering similar data in future years. The management problem is an intertemporal allocation problem, which requires the establishment of a well-defined resource allocation algorithm that takes proper account of the relative costs of gathering different data types, their end values, and the year-by-year flow of resources for maintaining the database.

4.2.13 Nancy J. Obermeyer, University of Maine

Organizational Perspectives on the Use and Value of Geographic Information in Decision-Making

Introduction

How and why organizations make decisions are questions that have been asked over the years. In response to these questions, a variety of models of organization decision-making have arisen. Among them are models that examine decision-making within the context of organization structure, mission, procedures and personnel. I find these models of particular interest because of their efforts to look inside the "black box" of decision-making: the organization itself, taking it apart and examining it thoroughly.

Below are three different directions in the area of organization decision-making models that could comprise a small part of research into the use and value of geographic information within the category of institutional issues.
The Search for Information by Organizations

In particular, models of the organization's search for information as input into its decisions (Douglas, 1986; Steinbruner, 1974; Cyert and March, 1963) suggest a systematic bias that favors the familiar over the novel. This may have implications for expansion of the use of geographic information systems to organizations that have little experience with geographic information. Empirically, the earliest adopters of GIS have been organizations whose missions emphasized natural resources and land use and management, and that have historically used maps as a means of collecting, maintaining and conveying information. More recently, social service agencies have become interested in geographic information systems.

Geographic Information and Organizational Legitimacy

Another potentially useful avenue of research within this general area relates to the organization's sources of authority and legitimacy: the expertise of the bureaucrat; the professionalism of specialist-bureaucrats, including their ability as a group to develop and protect a unique body of knowledge; and finally, the organization's relationship with its clients (Weber 1978). Expertise in the use of geographic information generally and familiarity with GIS in particular may result in the use of geographic information by an individual to advance within an organization, or by an organization to gain an edge relative to others with which it may share organizational turf. Similarly, as GIS continues to grow as a professional specialty (note the establishment of the International Journal of GIS), there is potential for related professions (geographers, for example) to use their knowledge of geographic information and GIS to increase their professional visibility and stature. Finally, organizations may find that by using geographic information in the interest of their clients, they may consolidate, maintain, or increase their authority and legitimacy. This potential use of geographic information is especially relevant to public sector organizations, given their reliance on maintenance of legitimacy as a condition of their continuing existence. In short, geographic information and GIS may have value as means to assure organizational and professional survival through their potential contribution to organizational authority and legitimacy.

Geographic Information as Communication

The use of geographic information in a graphic presentation may also be examined as a means of communication, particularly within the context of legal requirements for public hearings and input on land use and planning issues. The use of a variety of CAD and GIS systems in conjunction with screening technologies that permit the visual alteration of known spaces has been used successfully as a means to help achieve consensus on local land use issues. Habermas's theory of communicative action could provide a starting point for research in this area, which should discuss both legitimate and illegitimate uses of geographic information as communication.

References


4.2.14 Harlan J. Onsrud, University of Maine
Initiative 4 - The Use and Value of Geographic Information
Position Paper & Some Personal Observations

Some predicted trends for GIS include:
- smaller capital investments required for hardware to establish useful limited-purpose local level GIS (i.e. microcomputers)
- small databases collected locally for specific purposes
- networking of databases to allow utilization of data collected by others
- automated methods and generally much more efficient means of collecting geographic data are forthcoming
- more efficient means of analyzing and managing geographic data are forthcoming
- small system users are likely to call upon government agencies ( or other centralized sources) to supply generic data sets or provide overall management functions

These trends appear to be driven primarily through technological advances which are for the most part being developed to respond to marketplace demands.
In such an environment, will a typical GIS be used primarily as a generator of information products or as a communication device? GIS currently act primarily as generators of information products. However, over time, much more of a GIS’s value will be as a communication device (i.e. movement is towards networked GISs accessible from multiple users; up and down and among government levels and private concerns).

It appears that it is extremely difficult to place a value on a communication capability. Valuing a GIS through the value of the products generated from the GIS seems to be an extremely limited approach. To obtain a more realistic estimate of the value, secondary and tertiary users should be identified and some component of the value they gain from the technology also attributed to the information system value. The process is complex and probably not warranted in most instances in view of the trend towards smaller distributed systems. (For example, in considering whether or not to buy a fax machine or photocopy machine a business does not typically analyze how much money they will make from the investment. Decision-makers in business typically buy because the technology is proven, they can immediately communicate better today than they did yesterday, and they have a strong hunch that the time saved by the device will more than pay for the service in a very short time. Attempting to attach a monetary value to an increased communication capability doesn't make sense for most individuals in a distributed information network.) Going through a comprehensive economic analysis is more appropriate for centralized large-based systems.

If the vast majority of future data bases are likely to be collected on relatively inexpensive micro-computer based systems with most processing also carried out on micro-computers, decisions to buy or not to buy such systems will be local-based and made by independent individuals. Traditional cost/benefit analysis seems to be more than an adequate economic tool to justify purchase of such GIS capabilities. Independent buyers have little need or desire to look at secondary and tertiary uses of information and then attempt to place a value on those more remote uses of the information. The decision to purchase will be made based on the primary uses.

Only if there is a reason to value an entire and growing networked system does there appear to be a need to utilize more sophisticated economic theory. However, placing a realistic value on the overall network seems to be little needed since the network will be built through thousands of independent purchase decisions based on primary use considerations.

The more relevant research questions seem to consist of taking a close look at those uses which, if available through a GIS, would vastly increase the numbers of decisions that could be better made through application of GIS technology. What uses/data capabilities would vastly increase the numbers of people wanting to get their hands on a GIS? What data would they like to feed into a GIS to carry out their jobs more efficiently or expand the services they currently offer? These questions may be answered by looking at the uses of geographically-related information which individuals make use of in their business structures.

For instance, if GIS in a micro-computer based environment could reliably tie physical objects on the earth’s surface to legal ownership interests in those same objects, I contend that the number of users and uses of GIS would increase tenfold. This critical societal information is missing in almost all GIS databases being compiled today, or is provided with little indication of the information’s reliability (i.e., GIS derived information is currently of very little value with respect to decisions requiring significant legal evaluations). How may this contention be tested? What are other data sources, which if available, would significantly increase the usefulness of GIS products and the demand for GIS services by broad classes of potential users?

Using the example of lack of strong legal foundations in current GIS, is the marketplace the limiting factor on progress; is it the state of technology; or are other factors more crucial? Studies of technology diffusion in other computer-based information fields may provide some clues for part of the answer.

4.2.15 Phil Parent, University of California - Santa Barbara

The Use and Value of Geographic Information in Decision-Making

Introduction

Linking information to a specific location on the Earth’s surface is a key element in the definition of a Geographic Information System. As databases are built, consolidated, and amended, more and more information about locations becomes available. In fact, spatially ordered information is beginning to be seen as a corporate asset potentially more valuable as an end-product than for the purposes for which the data were originally gathered.

"Value-added" GIS is an area that can best be described as underdeveloped at the present time. But with the increasing trend toward multi-agency consortiums; on the municipal, county and regional levels, the interest in marketing various combinations and permutations of selected aspects of the participants' databases is beginning to heat up. Participants could include utilities who might want to share billing and late-payment data among themselves, assessors who have mortgage information, police with their crime statistics, and public works agencies with infrastructure data. There is a definite need to explore the ramifications of database sharing, processing and marketing by public and quasi-public agencies.

Areas of specific study include the following:
Public Access

Must the consortium provide adequate viewing facilities for the public to inspect their records? Is an agency required to reformat data at public demand? Can a consortium put constraints on the purposes for which the data are to be used? What are the legal constraints to reselling information? This area would require a compilation and interpretation of the various state and federal laws regulating access to information, especially spatial information.

Liability

Is the generating agency or the consortium liable for errors in the database? Must the generating agency document the "lineage" of the database and will that be passed on to the consortium and end users? A look at contractual procedures would be necessary for study in this area.

Cost-Effectiveness

At what point does it "pay" to set up a semi-private agency to market databases and products? Should such practices be promoted as a cost-recovery strategy? Economic theory and cost projections would need to be applied before making any recommendations.

An apparent trend in the near future is the proliferation of regional multi-agency consortia. A strategy for research in this area would be to undertake a survey of existing projects and examine how each approaches the issues of marketing "value-added" GIS. Included with such a survey would be an investigation of the specific legal and contractual arrangements that define the approach. Since each case would vary, efforts should be focused on common elements that are successful and common drawbacks. Results of this research would be valuable for information managers contemplating setting up such a project, current practitioners who would like to further utilize their systems, politicians interested in clarifying the legal environment for increased productivity, and the public who would be informed of their rights and privileges. Such research would result in guidelines for GIS design and implementation.

This also presents the Initiative with an interesting case study in technology transfer. How should research results be diffused? As the Initiative agenda is set, a series of workshops designed to instruct as well as to exchange information among the attendees might be held to involve outside specialists in investigating the issues. Such and approach would promote inter-agency dialogue and serve as a medium for disseminating NCGIA research results. In addition to the workshops, I would propose a specific set of papers that would address some of the above issues. The need is to focus specific resources on certain problems to produce tangible results. In both instances, the case study approach would be one way of pursuing the research.

Another idea I would like to explore a bit in - (but don't really see it as a research issue per se) is the role of GIS as a catalyst for intra- and inter-agency cooperation. For instance, in a University setting, we now have geographers talking with computer scientists, talking with anthropologists, talking with geologists all about spatial information. In fact, the very NCGIA is an example of different groups of people getting together due to a shared interest in spatial information. In some of the multi-agency consortia, we have the same phenomenon on a larger scale. For the first time, the assessors are working with the police who are talking to the health care people. Again, the shared spatial database is the common denominator. This could be one of the more overlooked but potentially important indirect benefits of instituting a GIS: the need to cooperate with other agencies for the common good, in this case a spatial database.

For the Japanese, reaching a consensus on such issues as the color the fire hydrants should be or at what scale the maps should be drafted is nothing new. However, for fifteen different city, county, and quasi-public utilities to agree on any of those issues is a giant step forward. But in order to implement a regional GIS, consensus on a multitude of questions is a vital requirement. The tying of information to a location on the Earth's surface can be viewed as an equalizer among the competing viewpoints. It gives the impression that we are all Earth residents and must cooperate to survive. If GIS can bring about this need for cooperation (which comes naturally to the Japanese who find the same respect for the Earth in the Shinto religion), so much the better.

4.2.16 Allan H. Schmidt, Prime-Wild GIS, Inc.
The Need for Research Related to GIS Data-Sharing

Geographic Information Systems (GIS) allow for information to be provided at a scale, of a data type, and in an administrative setting not previously widely available. GIS versus AM/FM (Automated Mapping/Facilities Management -engineering mapping) are primarily a difference of (1) small-scale versus large-scale phenomena, (2) data regarding the natural (environmental, socio-economic, and administrative) environment versus the built environment, and (3) multiple versus specific uses and users of the information system.

In terms of benefit/cost analysis, the most important difference appears to be the last, i.e., multiple users and uses of a GIS. For example, the Joint Nordic Project Study (1987) of sixteen existing mapping systems reported that when a digital mapping system was used to automate an organization’s map-making operations, the resulting benefit/cost ratio tended to be 1:1.
If the organization was able to use the resulting data for planning and analysis as well as engineering operations, the benefit/cost ratio tended to be 2:1. However, if an organization was able to develop a map data base that was used by multiple organizations within a governmental jurisdiction, then the benefit/cost ratio averaged 4:1 and in some cases was greater than 10:1. These findings suggest that GIS technology can be of greatest benefit when it can meet the needs of multiple agencies within a governmental jurisdiction, e.g., a multi-purpose land data system. The associated requirements for data sharing, i.e., adoption of common data standards, issues related to data control and maintenance, are critical issues. An improved understanding of such issues should lead to better design and more importantly should be of value in the operation of a GIS.

The issues of greatest importance likely will not be technical, but rather administrative and political barriers to be overcome as GIs strive to realize their maximum potential. As such, it may be that the changes a multiple agency GIS introduces into the operational procedures between organizations will equal in significance the economic benefits within any one of the organizations. It also suggests that benefit/cost ratios for a GIS that supports multiple agencies may justify GIS usage for organizations whose independent development and operation of GIS would be marginal or uneconomical. GIS operations are likely to be overhead-intensive and such costs can be minimized when a GIS is incorporated and operated as part of an administrative information resource between multiple government agencies rather than a technical specialty within a single governmental organization.

The above observations suggest that benefit/cost studies for a potential GIS may have their greatest economic return as well as their greatest administrative and political challenges in multi-agency systems. As a result, it would be desirable for the NCGIA to examine:

(1) the validity of the above assumptions;
(2) the administrative and political issues related to data sharing; and
(3) the policies and procedures that can foster data sharing.

Reference


4.2.17 Carl Shapiro, U.S. Geological Survey
Issues Relating to Benefits of Geographic Information

Introduction

There are many issues that are important to address while examining the benefits of geographic information. Three issues that I believe are especially important for our discussion are:

1. Identification of applications;
2. Measurement of benefits vs. cost savings; and
3. Methods of benefit measurement: survey vs. modeling.

Identification of Applications

The task of measuring the benefits of geographic information is difficult in part because the information itself has very little intrinsic value. The benefits of the information are directly and indirectly derived from the applications that are supported by the information. Thus, before any measurement of benefits can be initiated, it is necessary to identify the applications associated with the information. This task becomes difficult in many cases because new applications become possible with the introduction of new or more accurate information. As a result, a comprehensive understanding of the benefits of geographic information requires knowledge of how the information may affect existing as well as new applications. In addition, the benefits in many cases may be dynamic. Witness the effect of advanced technology (geographic information systems) on applications using spatial information.

Measurement of Benefits vs. Cost Savings

Discussions of the advantages of geographic information can be divided into basic categories: (1) benefit estimates and (2) cost savings estimates. Because it is much easier to measure the cost savings made possible with the availability of new geographic information, many analyses that attempt to estimate the benefits of information are in fact, measuring the cost savings. That is, how much less expensive will it be to accomplish a task with the information than without it?

An understanding of the economic benefits of geographic information, however, requires a broader analysis. Measurement of the economic benefits of information do include cost savings in accomplishing current applications. However, it is also necessary to include the benefits to society of new applications made possible with the information as well as the benefits of better decisions made possible with more current or precise information.
Methods of Benefit Measurement: Survey vs. Modeling

There are two general approaches to measuring the benefits of geographic information. The first and more traditional method of benefit-cost analyses involves modeling the applications and the importance of the information to the accomplishment of the application. This method requires an understanding of both the benefits of the application as well as the part that the information plays in the application. In addition, the application in many cases causes a chain of events that may affect the benefits of the geographic information. As a result, modeling in benefit analyses can become extremely complicated, time consuming, and expensive, with a very high risk of error.

A simpler method of benefit measurement involves the development of a survey to determine the willingness to pay for geographic information. This method is still application-specific; very few users would pay much for the information unless potential applications existed. The survey approach, however, does not require the development of complex models to determine the importance of the information to the application and the importance of the application to society.

This approach is not, however, without problems. Perhaps the most important obstacle to overcome is to develop a method to deter strategic responses to the survey. If the respondents realize that their answers may have an impact on the production of a public good, such as geographic information, they may respond in a fashion that distorts their needs. Because information (at least information produced by government organizations and many universities) has characteristics similar to a public good, the natural inclination of users is to wait until somebody else produces the information. The fact that many users can use the same information simultaneously and that government-produced information is not subject to a copyright means that if somebody else produces the information first, it becomes very inexpensive for subsequent users to benefit from it. As a result, the incentive is to act disinterested if somebody else is about to produce the information needed.

4.2.18 William C. Ubbens, U.S. Forest Service
Issues, Concerns, and Opportunities Affecting the Use and Value of Geographic Data -- a Perspective from the USDA-Forest Service

The Forest Service, in order to be more responsive to its mission and to the public, will demand better (not necessarily more) geographic data, and make substantially more use of that data in responding to resource management issues, concerns, and opportunities. By better data, we mean more accurate, more timely data without duplicity in location, i.e., that data are stored in one and only one place and are fully accessible and sharable to anyone who needs them. The storage and maintenance of the data need to be done where the data are used most --- resource data are site-specific. What we have in the Forest Service is a federation of many local, site-specific resource databases to support one common mission of the organization. The ability to effectively manage and conveniently share data among the nearly 1,000 local resource databases is vital to the Agency.

We see in the future the need to provide more confident, sharper, and defensible resource management decisions based on more quantitative and qualitative improvements in analyzing management alternatives, and having those decisions hold up under public and legal scrutiny. To do this, we must move much more vigorously into a standards-based environment -- standards in hardware, software, telecommunications, and most importantly, in data.

Standards for data definition and units of measure must be established within localized resource databases; and standards for data exchange, both internally among the federation of local resource databases and externally beyond the Agency, must be developed and implemented to share data and information. In addition, standards should be developed to better define resource database metadata that go beyond traditional data dictionaries to more of an information "atlas," i.e., information about data. Finally, standards need to be established for data storage so that eventually standard storage technology will be available to facilitate the use of data anywhere, anytime.

Mechanisms need to be established to communicate information about resource data sources, applications, decisions, etc. This might be done through the establishment of a national GIS library or information service.

Finally, data collection remains the most time-consuming, costly, and error-prone aspect of GIS operations. This has a profound impact on resource management decision-making. New or improved technologies for data capture and editing must be developed to better respond to the decision processes and reduce system costs.

In summary, the use and value of geographic data can be greatly enhanced if certain developments come to pass in both technology and data management arenas. Technology innovation in data collection and storage, and in telecommunications are needed to reduce data costs substantially (cost avoidance); and the development and implementation of standards for data definition and exchange are needed to increase the value-added benefits of more accurate, timely, and sharable data suitable for resource management decision-making and public participation in the decision-making process.

4.2.19 Lisa Warnecke, Syracuse University
Comments Submitted

The following are some general ideas regarding the "use and value" of geographic information (GI).
Information in general and information technologies are being studied in many different fields today. It seems that we can access and build upon this work, and concentrate on that which is uniquely geographic information and its related technologies (GITs), including geographic information systems, remote sensing, Global Positioning Systems (GPS) and so on. It would help to define GI within the broad information field. To me, referencing information by location creates a foundation, framework and link between and among various types and sources of information -- it is as much a perspective as anything, as well as a way to increase the value of information by using it in ways other than for those which it was originally designed and developed. Focusing on the public sector, it is often stated that eighty percent of all local government information can be referenced by location. Is this true? Regardless of the percentage, to what extent is this referencing of information useful? Further, what is unique about GI and GITs, compared to other information and technologies, that can help determine the use and value of geographic information?

From a public sector perspective, it seems that to try to understand the use and value of geographic information, it would be helpful to identify the functions and priorities of government, and the actual and potential uses and applications of geographic information and geographic information technologies to meet public needs. Uses and applications are important to identify for other entities as well, such as the private sector. The functions of government can be cut in various ways, and the main issues and priorities may vary in time and by top officials. Essentially, we have seen geographic information and related technologies grow in programs within the single functional areas of natural resources and infrastructure management. Current challenges in both fields offer increasing applicability and usefulness of geographic information and geographic information technologies. In addition, we are seeing emerging applications in other functions of government, such as public safety, disease control, human service delivery and so on. It is potentially more difficult to "crystal ball" these uses. Further, we are seeing applications for truly multi-purpose needs, such as economic development and emergency management, which often require information from many other functions to be of greatest value.

In trying to measure benefits, the direct/indirect, tangible/intangible breakout is useful. A complementary way to consider benefits is to identify those that are helpful in improved operations, those that are helpful from a management perspective, and finally, those helpful from a policy standpoint. It seems we have learned to justify GIS/LIS-related investments from an operational and tangible benefits standpoint alone. Quantification of these benefits always seems helpful. Benefits in terms of cost and mistake avoidance seem to be of increasing significance regarding geographic information and related technologies. Beyond the use of GIS to improve efficiency, how can we determine and measure the benefits that will improve the effectiveness of the organization, i.e., improving the way decisions are made, business is conducted, and services are delivered? Some additional benefits include improved intergovernmental and inter-organizational communication, cooperation and coordination, as well as development of processes to address common problems and needs, but these benefits are also difficult to measure. How much should we attempt to ascertain benefits beyond those that are tangible?

Widespread diffusion and development of geographic information and related technologies, as well as information and information technologies in general are growing, especially in the last few years. However, it is estimated that there is a lag of ten years or more between the development of an information technology and its widespread adoption in the public sector. In addition, it is increasingly concluded that adoption of information technologies is more strongly influenced by institutional conditions than by the technology itself. I believe that GITs in particular, are influenced even more directly by these conditions because their improved usefulness, and the development of geographic information, are dependent upon governments and others working together. It is helpful to review the Chorley report on "Handling GF" which identifies many of the barriers to geographic information development in the United Kingdom. These institutional barriers are generally greater in this country. In addition, it seems there are a number of other conditions and trends influencing this field, including those regarding information and information technologies in general, government and its needs and priorities, public and private sector consciousness, severity of environmental, infrastructure, and fiscal problems, globalization of the planet, and others. It would be helpful to identify some of the conditions, trends, and barriers that influence, help to determine, and will potentially increase the use, value and development of geographic information and geographic information technologies.

Reference


5.0 Meeting Format

The I-4 Specialist Meeting was designed as a series of small group discussions of specific topics leading to a report to the full group, followed by discussion among the participants. Vince Barabba, Director of Market Research at General Motors Corporation and a member of the NCGIA Board of Directors, opened the meeting. Mr. Barabba's keynote address provided an overview of the meeting discussion, couched in terms of the contrast between supply/push and demand/pull concepts in the development of information systems as a means to understand the use and value of geographic information. His address is included in the appendix of this report. Other introductory addresses were given by David Simonett, NCGIA Director; Andrew Frank, Associate Director of the NCGIA; and Initiative 4 co-leaders Harlan Onsrud and Hugh Calkins.
During the ensuing days, the participants broke into small (5-7 people) pre-assigned groups with specific discussion questions: what are the impediments to assessing the use and value of geographic information? and what are the methods to assess use and value? Later small group discussions focused on researchable problems within the general topic, assessing the use and value of geographic information, and prioritizing the problems identified. The final small groups were self-selected, as participants discussed specific research projects to be carried out under the auspices of Initiative 4 over the coming two years.

The assignment of specific topics to the small groups was designed as a step-by-step process culminating in the development of an integrated research agenda for Initiative 4. Each small group work sessions contributed to a large group discussion. These discussions in turn formed the starting point for the succeeding small group work sessions, which once again achieved a consensus in a large group meeting. In this way, the process established a common foundation on which the participants then were able to add the building blocks to form an integrated research agenda.

Over the course of the Specialist Meeting, several of the participants made short presentations in conjunction with the tasks assigned in the small group meetings and reported to the group as a whole. The wide variety of disciplinary training and experience of the participants made it necessary to provide a common foundation for later discussion. The informational presentations ranged in length from one-quarter to one-half hour.

6.0 Vince Barraba, Executive Director for Marketing Research and Planning General Motors Corporation Keynote Address

The breadth of the objectives we wish to accomplish in this conference is indeed impressive as is the pool of assembled intellectual capacity and practical experience. To the person who is supposed to provide the opening address to this distinguished group by reflecting on the topics to be discussed, and, to do so in thirty minutes or so, the list of topics not only seems impressive -- it poses a formidable, if not impossible, challenge. While struggling to come up with an approach for this assignment, I was reminded of a graduate course at UCLA when the professor, Leo Grebler, opened the seminar by pointing out that it was not his responsibility to cover everything that was associated with the topic, but to uncover an aspect of it that would have meaning to the class. With that good advice in mind, let me identify my objectives for the next thirty minutes and what it is that I plan to uncover.

First, given the rich set of advanced materials prepared by our hosts, I do not plan to cover areas which, in my judgment, were sufficiently covered in the advanced materials. Second, as the person in this room who is least familiar with what has happened to Geographic Information Systems in the last decade, I will address the subject by relating my general understanding of the "use and value of geographic information in decision-making" based on my experience in government and business. Given the conference objectives, I do not plan to cover everything on our agenda, but instead to highlight subjects for which I hope I might be able to uncover something of meaning.

The first item I’d like to pursue is related to the contrast between the supply-push and demand-pull concepts in the development of information systems. In discussing this subject, I’ll also touch on information as a product.

Let me provide you with my perspective on this issue by discussing how the issue is being explored at General Motors -- which will require a few minutes to describe how the Market Research function is positioned at GM. Additionally, I believe you might find some interesting comparisons between the Market Research function and the concept of Geographic Information Systems, both of which provide information to customers or users who want to make decisions.

First, we treat the Market Research function at General Motors as a business within a business -- a business that must produce, sell, and deliver its own product. That product is market information that is accurate and usable and produced early enough in the product development cycle to aid all market-based decisions within the firm.

Second, we also view the market research business as being conducted with the goal of improving total customer satisfaction. When we speak of customers at GM, we include both those who buy cars and those who buy stock in the company. We operate using a very simple model.

Everyone, on an as-needed basis, has equal access to what we call the "Voice of the Market," as they prepare their arguments to support their own points of view. Now, what do we mean by the "Voice of the Market?" We define the Voice of the Market as "what the market indicates it wants and is willing to pay for." (In this definition, "Voice of the Customer" is a specific component within the Voice of the Market. Other components would include the Voice of Competition, the Regulator, the Public, and so on.) To understand how all of this fits into the push-pull context, we need two more definitions. The "Voice of GM" is "What GM is capable of and willing to present to the marketplace.” Market-based GM is determined by the extent to which management effectively and efficiently reconciles any differences between the Voice of the Market and the Voice of GM. The relationship of the three concepts is identified in the following illustration.

The important point to uncover is that neither the supply/push nor the demand/pull approach is the optimum solution to designing vehicles, nor any other product or service, for that matter. Though we can find examples where either of the approaches has been successful, there are many more examples where they have been abject failures. The key is to reconcile the differences between them.

For example, the Market may express itself by saying it needs and is willing to pay for a V8 engine. GM may find it necessary (for example, to accommodate styling considerations, government regulations, and so on) to provide a V6 engine. Indeed,
GM may even have a V6 engine that meets the needs the market believes only a V8 can provide. How effectively GM presents this alternative to the market will determine its success with those customers -- particularly against a competitor who is capable of and willing to provide a V8.

Phil Parent might provide a GIS example of push-pull reconciliation by comparing the "Voice of the GIS-Builder" for a multi-agency consortium with the "Voice of the Participant Agencies" with "various combinations and permutations of selected participant data-bases" (Parent, - Position Paper). He would also indicate that the reconciliation might take place across the three dimensions of

1. public access;
2. liability; and
3. cost-effectiveness.

Next, I'd like to discuss the decision-making process, and in doing so, I will touch on the role of information and the distinctions between data, information and knowledge. In discussing the decision-making process, I'll provide my judgment on the environment in which decisions are made, and some of the belief systems that underlie the models we use in decision-making; I will try do this in the context of the value of Geographic Information and Analysis.

First, let's discuss the environment in which decisions are being made. Today, we live in an era in which the allowable margin for error in both public and private decision-making is smaller than ever before. Partly, this is because of the following factors:

1. We are confronted by the realities of a real world of limited resources, rather than the theoretical one that we all studied.
2. There is increased societal and market complexity.
3. There is greater economic and political interdependence in both domestic and international sectors of activity.

These realities demand that we set priorities in areas that we used to approach simply by doing everything that was "needed." For example, in the Fifties, Sixties and Seventies, businesses sometimes made product decisions that did not match actual demand. In these cases, the strength of the marketplace was generally so great that these firms could market their way out of the problem through price of promotional activities. In the same way, government could launch new programs to solve problems that old programs had failed to alleviate.

Additionally, impactful events like the energy crisis of the Seventies, the current economic plight of many industrial firms and public utilities, and the interaction between the different national stock exchanges during last year's stock market plunge all show just how narrow the allowable margin of error has become. Additionally, we have discovered that decisions by business and government can have irreversible ecological impact.

As it relates to Initiative Four and our attempt to understand the use and value of geographic information in decision-making, it would be of value to address two relatively simple questions -- simple to ask, but not necessarily simple to answer.

1. What can Geographic Information and Analysis do relative to the production and dissemination of information that will aid in policy development and decision-making for our society?
2. And how can Geographic Information and Analysis effectively and efficiently perform this role?

But before we address either of these very important questions, we need to better understand how we, as a society, use information in our decision-making process.

Recently, a distinguished group of scholars reported to the White House Office of Science and Technology Policy and the National Science Foundation their findings on decision-making and problem-solving (1986). Among other things, the panel reported that,

"The work of managers, of scientists, of engineers, of lawyers -- the work that steers the course of society and its economic and governmental organizations -- is largely work of making decisions and solving problems. It is work of choosing issues that require attention, setting goals, finding or designing the suitable courses of actions. The first three of these activities -- fixing agendas, setting goals, and designing actions -- are usually called problem solving; the last, evaluating and choosing, is usually called decision making."

The group took the position that improving our problem solving and decision-making ability was among the most promising and important targets for further research.

In dealing with this issue of improving the decision-making process, the panel focused considerable attention on what it refers to as the theory of "subjective expected utility" (SEU), which they identify as "central to the body of knowledge about decision-making." The panel points out that this sophisticated mathematical model, and all of the assumptions under which it operates, underlie the basis for most contemporary economics, theoretical statistics and operations research. Some of the critical assumptions underlying SEU surfaced in the panel's description of what SEU attempts to do:
"SEU theory defines the conditions of perfect utility-maximizing rationality in a world of certainty or in a world in which the probability distributions of all relevant variables can be provided by the decision makers."

Furthermore, the panel, given its earlier distinction between problem solving and decision-making, makes it clear that the SEU theory is associated with decision-making and has nothing to do with the components of problem solving -- how to frame problems, set goals, or develop new alternatives. The panel goes further to point out that:

"Prescriptive theories of choice such as SEU a complemented by empirical research that shows how people actually make decisions... and research on the processes people use to solve problems... "

It is also important to point out that this empirical research has led to a descriptive theory that raises significant questions about the limitations of the prescriptive theory.

"What chiefly distinguishes the empirical research on decision making and problem solving from the prescriptive approaches derived from SEU theory is on human rationality. These limits are imposed by the complexity of the world in which we live, the incompleteness of and inadequacy of human knowledge, the inconsistencies of individual preference and belief, the conflicts of value among people and groups of people and the inadequacy of the computations we can carry out, even with the most powerful computers."

To which we could add the most powerful Geographic Information Systems. Of specific interest to this group, the panel points out:

"The descriptive theory of problem solving and decision making is centrally concerned with how people cut problems down to size; how they apply approximate, heuristic techniques to handle complexity that cannot be handled exactly. "

Of course, to anyone who does problem solving or decision-making, this is not news. What is of interest, however, is the extent to which most of society’s problem solving and decision-making tools are based on SEU theory. If I had to guess, it would be of least news to Peter Morgan who could tie research in this area back to 1948 under the concept of "search for learning" (Morgan, - Position Paper).

Interestingly, basic questions about information and society have been addressed by other interests for some time now. In 1934, the poet T.S. Eliot demonstrated that he knew something about the relationship between information and knowledge by asking very simply:

Where is the wisdom we have lost in knowledge?  
Where is the knowledge we have lost in information?

Let me develop the notion of a hierarchy of knowledge use from Data to Wisdom by being so bold as to add two more lines to Eliot's poem:

Where is the INFORMATION we have lost in data?  
Where is the DATA we have lost in ignorance?

Then there is the issue of relevance of all this to those who make decisions. In 1971, C. West Churchman, in his book, The Design of Inquiring Systems, pointed out that:

"Inquiry is an activity which produces knowledge... [By] 'produces' we mean 'makes a difference in and of itself.' In other words, for an activity to be said to produce a result, it must really matter.. "

In other words, information collections simply stored in libraries, file drawers or computers -- unless and until they are used - - are useless.  
This is an essential point. Churchman offers a pragmatic imperative in defining knowledge (and one which Bill Huxhold would support; Huxhold, - Position Paper) -- and that is, to be knowledge, it must be used! It must make a difference to the user! And its value is determined by the extent of use, not its mere presence!

More recently, psychologist Robin Hogarth (1983) has also touched on the subject by referring to what he calls the second industrial revolution -- a revolution that is propelled by information, rather than steam. To quote Hogarth, "The new revolution is being propelled by information. And, as in the first revolution, relative success will be determined by the ability to handle the propelling force... There can be little doubt that the need today is for conceptual skills, that is, the ability to process information and make judgments."

Out of Hogarth's work comes the notion that the real problem is to design organizational information systems that compensate for or can be adapted to the fallibilities of human decision-making. I agree with Hogarth about this, particularly as it
relates to the distortions that occur because of the fallibility in dealing with the collection, processing, and use of information relative to our predispositions in the decision-making process.

Both Churchman and Hogarth, then, remind us that the effort required to develop information makes sense only if that information is accessible, relevant to the ultimate users and is used. This requires, of course, that information providers acquaint themselves with the needs and practices of the users. In this case, the users are not only government policy makers, but also business organizations, research institutes, public interest groups and interested citizens and voters. I believe Paul Densham would also agree, particularly if we were talking about the user’s cognitive style being incorporated into a spatial decision support system (Densham, - Position Paper).

So my answer to the first question relative to Geographic Information and Analysis and the production and dissemination of information, is that we should first really get to know our users: not only who they are, but what it is they need to know and in what form they prefer to receive it. In essence, we need to be equally concerned that we have procedures that ensure we collect the “right data” as well as procedures that ensure we collect and present the “data right:” data that leads to information; that leads to knowledge; that leads to wisdom; that leads to meaningful policy development and decision-making.

As it relates to the second question, “How can geographic information efficiently and effectively perform its role,” let me make the point that the answer is not found solely in technology by relating the story of the Yir Yoront that opened the article I wrote for a colloquium celebrating the 75th year of the Harvard Business School (1985), called “Steel Axes for Stone Age Men.”

“\[There once was a tribe of Australian aborigines called the Yir Yoront. The central item in the Yir Yoront culture was the stone ax, which tribe members found indispensable in every activity -- from producing food to constructing shelter. For the elders, the stone ax was a symbol of masculinity and respect. The men owned the stone axes, but the women and children were the principal users. Thus, according to a prescribed social system, the tools were borrowed from fathers, husbands, or uncles.\]

Enter some well-intentioned missionaries. They distributed steel axes to the Yir Yoront to help them improve their living conditions. There was no important resistance to the shift to the new tool; the aborigines were accustomed to obtaining their tools via trade with others. Moreover, the steel axes were more efficient for most tasks, as a result, the stone axes rapidly disappeared among the Yir Yoront.

The missionaries had distributed the steel axes to men, women and children, old and young alike. In fact, the younger men were quicker to adopt the new tool than were their elders, who maintained a certain distrust. The result was a major disruption of sex and age roles among the Yir Yoront. Elders, once highly respected, now became dependent upon women and younger men and often were forced to borrow steel axes.

In addition, the trading rituals of the tribe were undermined because stone axes had previously formed the basis of trade. Ties of friendship among traders broke down. Overall, the religious system and social structure of the Yir Yoront became disorganized as a result of an inability to adjust to the innovation.

Naturally, the steel ax alone did not cause all these changes among the Yir Yoront. But researchers concluded that it was central to most of the cultural disorders.”

I first ran across this story while studying the seminal work of Everett Rogers when, as a student, I was vying to understand why some innovations were adopted faster than others. Rogers defined an innovation as:

"An idea, practice, or object perceived as new by an individual. It matters little, so far as human behavior is concerned, whether or not an idea is 'objectively' new as measure by the lapse of time since its first use or discovery. It is the perceived or subjective newness of the idea that determines his reaction to it. If the idea seems new to the individual, it is an innovation."

The important point is that innovation need not be truly new in the sense that it has never existed before in order for it to be perceived as new.

In 1976, a little over ten years after initially reading his works, I had the opportunity to provide Rogers the opportunity to test out his concepts on what I believed, according to his definition, was a real innovation -- the Geographic Base File/Dual Independent Map Encoding System (better known, at the time, as GBF/DIME and the precursor of today's TIGER system.

Let me quickly point out that this was not an academic exercise. Then, as now, a comprehensive and accurate geographic information system was at the heart of the conduct of a modern day census. Also, it was the belief, as it is now, of the Bureau of the Census that the system should be designed to support public and private organizations at the local and national level as well as the conduct of the census. The reason the Census Bureau took this position was straightforward -- the more value the public and private agencies at the local and national level saw in the GBF/DIME system, the more they would support it through the allocation of resources to keep it up to date. Therefore, we decided we needed to understand why the system was, or was not, being used. And, in those cases where it had not been adopted, we wanted to find out why it was, or was not, being fully utilized.

With the support of the National Science Foundation (interestingly, the sponsor of this conference), Rogers set out to find out how to understand what facilitated and what inhibited the diffusion of the GBF/DIME system in state and local organizations. In the
context of this study, the term diffusion referred to the spread of an innovation from one person to another, from one agency to another, or from one department in an agency to another. Basic to Rogers’ concept of adoption was a model that recognized four phases -- knowledge, persuasion, decision, and confirmation.

The knowledge phase is where the individual is exposed to the innovation’s existence and gains some understanding of how it functions. The critical point here is that the innovation doesn’t get any further unless the individual defines it as it relates to him or her. The innovation will get no further if the individual does not become adequately informed so that he or she can be persuaded.

During the persuasion phase, the individual forms a favorable or unfavorable opinion about the innovation. He or she becomes more psychologically involved as his or her knowledge of the innovation increases. A key point is that both knowledge and persuasion can move only as fast and only as effectively as the channels of communication allow. And, as the risk of adopting the innovation grows more apparent as the individual gains knowledge, he or she may seek reinforcement of his or her own attitude from his or her peers. Kate Beard might raise a concern that the individual might not look into the possibility that the GIS could diminish the value of information (Beard, I-4 Position Paper).

During the third phase, the decision stage, the individual undertakes activities that will ultimately lead to adoption -- or rejection -- of the innovation. The decision phase calls for a real commitment, and innovations that lend themselves to trial or test generally are adopted more readily. Harlan Onsrud might make the point that a distributed GIS might make trial or test easier for each individual adopter (Onsrud, I-4 Position Paper).

In the confirmation phase, the individual seeks reinforcement for the decision he or she has made by further direct application of the innovation. Hugh Calkins might concur that because of the increasing complexity of some GISs, initial positive decisions to adopt might be reconsidered (Calkins, I-4 Position Paper). On the other hand, Allan Schmidt might remind us that the cost/benefit ratio is likely to increase when multiple agencies utilize a common, but possibly more complex, GIS (Schmidt, I-4 Position Paper).

Rogers’ study was conducted in two parts. In the first phase of the study, Rogers carried out a general analysis based on a mail survey of the 257 agencies that had, at that time, been designated by the Census Bureau as coordinators for the GBF/DIME System for their geographic areas.

The first portion of the study identified that the Census Bureau was by far the most important source of information about this innovation for the 257 regional agencies that were surveyed. Additionally, it has found that there was very little communication between the agencies. This observation relates to Nancy Obermeyer’s interest in how organizations search for information (Obermeyer, I-4 Position Paper) and supports Allan Schmidt’s observation that administrative and political barriers are greater barriers to adoption than technical ones (Schmidt, I-4 Position Paper).

In the study, the dominance of the Census Bureau relative to that of the innovation’s did not allow the researcher to explain much of the variance in the innovation’s adoption, use and implementation with independent variables like the agency’s characteristics, the region, or contact with the Census Bureau.

The second part included a “tracer” study of the innovation process for GBF/DIME in eight selected regions. These more qualitative data indicated that a wide range of applications of the innovation had taken place across a wide range of community functions. I believe this is the type of study from which Holly Dickinson (Dickinson, I-4 Position Paper) might expect to identify how geographic information is actually being used -- as well as how it might potentially be used. It also sounds as though the kind of study Tom Duchesneau and Earl Epstein envisage (Duchesneau and Epstein, I-4 Position Paper).

Of most importance to this group, the tracer studies uncovered an understanding of the innovation process that was quite different from previous studies that had used cross-sectional, correlational analyses of survey data. In Rogers’ mind, a new model of the innovation process emerged.

The model consisted of five stages in the innovation process: agenda-setting, matching, redefining, structuring, and interconnecting. The researchers reported,

"As these decisions are made, the innovation is gradually specified; that is, its ambiguities are removed and its realm of possibilities is restricted. In this framework, an innovation is seen as a specific version of a general idea. It is these general ideas that are diffused, and each organization must define for itself exactly what the innovation is to mean in its own context.”

In later papers, Rogers and his colleagues identified their findings from the GBF/DIME project as reinvention. They defined their finding as follows:

"Reinvention is the degree to which an innovation is changed by the adopter in the process of adoption and implementation after its original development. Reinvention may involve both the innovation as a tool and in its use. Thus, the same technological innovation may be put to a different use than originally intended; alternatively, a different innovation may be used to solve the same problem. In addition, the intended or potential consequences of an innovation may be changed through reinvention."

They further described the concept by pointing out,
"The concept of reinvention also recognizes that an innovation is often really a bundle of components; it is possible to adopt some components and change or reject others. Typically, diffusion studies assume the existence of technical experts who ultimately make the decision to adopt or reject a monolithic, prepackaged innovation. In fact, there may be a fair amount of groping for a solution by concerned individuals, leading to alterations of and later correction to, the original invention."

I imagine that Lisa Warnecke would agree with this finding and specify that government agencies in public safety, disease control, human service delivery and so on are ready to reinvent some existing GISs to meet their specific needs. Andrew Frank would also point out that reinvention (he might use the word discovery) makes it difficult to conduct a traditional cost/budget analysis.

The last substantive area I'll discuss is the identification of primary and subsequent users of information. I'll do this in the context of an exercise we've just completed at GM related to our Quality Network.

As we have struggled to improve customer satisfaction, dealing in the complexity of our market environment and the multiplicity of functions at GM, we have found it helpful to have an overarching framework to coordinate our quality assurance efforts corporate-wide.

We have developed a set of principles, agreed on by all of our people, union and management alike -- principles that define how we're going to do business from now on to ensure quality. It's called the Quality Network.

The concept begins with the premise that customer satisfaction is the master plan. And that customer satisfaction is achieved through people, teamwork, and continuous improvement. Of specific interest to this conference is the effort to identify the "customer" -- not only the customers who buy our vehicles, but the internal customers of the manufacturing, engineering or staff services within GM as well.

A part of the effort to communicate the purpose of the Quality Network was a cascading briefing process at which the concept of the Quality Network was presented to every organizational entity and person within GM. At the close of each of these meetings, employees were given a brochure that described the essence of the presentation and that contained an exercise designed to encourage employees to start thinking immediately about how they could improve their own work to increase customer satisfaction.

The exercise simply asked everyone to answer five questions:

1. Who are my customers?
2. What are their requirements?
3. Who are my suppliers?
4. What are their requirements?
5. What can I do right now to improve my job and measure the results?

This morning, I'd like to share with you an analysis of my GM market research colleague's answers to the first two questions of that exercise. First of all, the responses indicated that the customers of market research could be described generally as anyone who needs support or assistance in the collection or understanding of consumer-based information about the marketplace as measured by research. Further, the customers of market research may be either internal or external to the corporation. External customers include:

1. Suppliers to the firm who are in need of market information so that they can fulfill their responsibilities to GM efficiently and effectively.
2. The ultimate customers who purchase the product. These people eventually benefit from the conduct of market research by having made their views, preferences, and level of satisfaction known through the survey process. Given GM's beliefs and values -- that we will achieve customer satisfaction through people, teamwork and continuous improvement -- the product will have improved because of their input.

But, most importantly, and not surprisingly, my colleagues and I identified the majority of customers within the company and categorized them as follows:

<table>
<thead>
<tr>
<th>Analysts</th>
<th>Economists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasters</td>
<td>Management</td>
</tr>
<tr>
<td>Marketing Staff</td>
<td>Planners</td>
</tr>
<tr>
<td>Product Researchers</td>
<td>Sales Staff</td>
</tr>
<tr>
<td>Service Staff</td>
<td>Designers</td>
</tr>
<tr>
<td>Product Engineers</td>
<td>Lawyers</td>
</tr>
<tr>
<td>Manufacturing Engineers</td>
<td>Purchasing Agents</td>
</tr>
<tr>
<td>Product Reliability Staff</td>
<td>Research Labs</td>
</tr>
</tbody>
</table>

Of course, this is a General Motors market research list and is not offered as a definitive list of market research customers for all firms. My purpose in presenting the list, is to note that the "traditional" customers of market research, the Analysts, Economists,
Forecasters, Management, Marketing Staff, Planners, Product Researchers, and Sales and Service Staff, are augmented by Designers, Product Engineers, Manufacturing Engineers, Lawyers, Purchasing Agents, Product Reliability Staff and Research Labs.

At GM, this reflects the growing role of market research as we make the transformation to a market-based firm and a recognition on the part of these "new customers" that it is important for them to understand the market. This leads to the question of whether, given my earlier comments about the narrowing margin of error facing society's decision-makers, users of graphic information have similar attitudes.

What have I tried to uncover this morning? We need to understand those who will use the information we plan to develop through geographic information and analysis. Given the complexity of the world in which our users will soon find themselves, they will come to realize that competitive advantage is found not in how well you collected information, but rather competitive advantage is found in using better information better than anyone else.

Let me close with two stories and a poem.

As I was developing my first company which attempted to bring electronic data processing systems into political campaigns, an Iowa county chairman said, "Developing a political electronic data processing system is much like walking through a mine-field blindfolded. I guarantee," he said, "as you attempt to establish such a system you will soon realize that:

1. You cannot afford it.
2. Your first program will be unsuccessful.
3. You will be personally embarrassed.
4. You will try to save a sinking ship.
5. Fifty percent of what you finally develop will be: a. not timely; b. not needed; c. too expensive."

On the more positive side, I offer the story of a cave man who, staring out at the moon one night noticed on his horizon a giant tree silhouetted against the sky by the moon light. As he sat there contemplating the silhouette, he noticed that only a small gap existed between the top of the giant tree and the edge of the moon. The gap appeared so small that he thought if he could climb to the top of the giant tree he could actually touch the moon.

Excited by that thought, he raced to the tree, quickly climbed to the top, and reached out to touch the moon. When he realized that he could not actually touch the moon, he said to himself, "well at least I'm closer now than I've ever been before."

I noticed from some of the promotional literature that Edna St. Vincent Millay was born nearby. About the same time that T.S. Eliot was taUng about data, information and ignorance, Edna St. Vincent Millay wrote:

"Upon this gifted age in its dark hour,
Rains from the sky a meteoric shower
Of facts-they lie unquestioned, uncombined:
Wisdom enough to leech us of our ill
Is daily spun;
But there exists no loom
To weave it into fabric..."

Though I'm sure Edna St. Vincent Millay did not have a GIS in mind when she wrote the poem, she certainly described the need for it in fairly direct terms.

References
This initiative, Initiative 4, is so complex and involved that it might even be unnecessary as a stand alone initiative. It permeates all the others. There are three major RFPs currently circulating that deal with this topic and conferences abound. There is a definite hierarchy of users, each of whom has a different perspective on the use and value of information. Should there be new designs?

These use and value issues will be ongoing throughout the life cycle of the technology, but they will be most important right now as the technology is taking off. Each one of the research areas identified by the Center will have its own set of problems. As we support multiple data structures, as we develop a theory of spatial relationships, as we develop more algorithms, the questions of the use and value of the information produced by the new spatial data handling will emerge. They are embedded in all the issues. The integration of GIS and remote sensing will be no different, especially as we enter a multi-national phase.

As in all new research, there is paramount concern about data quality and the character of error. We are moving into an environment where information is becoming more important in directing many of the things that we do. Because of the computer, we must be sensitive to public perceptions about the decision-making process. This technology can provide a greater ‘citizen oversight’ of the decision-maker. Information will take a more pro-active role as we develop multiple uses for the databases generated. We must be sensitive to the measurement of error. We must be able to track error as it moves through a system and propagates. This error will impact all users, whether they are politicians or environmentalists. The risks become greater and greater for people as the issues become more complex and more expensive. We are reaching the point where we cannot afford to make big mistakes. The consequences will be too dire.

In a sense, the heart of the use and value question is the issue of risk reduction. Strict cost/benefit analysis glosses over risk. It doesn’t look far enough ahead. Did the people behind Love Canal do a cost/benefit analysis of dumping toxic waste? Would it have made a difference? Can performing a cost/benefit analysis reduce the probability of future liability? There are issues that we must come to grips with, and this workshop will, hopefully, start us on the pathway to meeting the challenge.

7.2 Harlan Onsrud, Co-Leader of Initiative 4, University of Maine
GIS Overview From a Use and Value Perspective

In order to study the issues of the Use and Value of Geographic Information, we have invited experts from a variety of disciplines: economics, geography, engineering, law and sociology. Everyone in attendance has considerable expertise in dealing with or using geographic information. Although you are experts in your respective disciplines, several of you have very little knowledge concerning geographic information system technologies and an introductory review is appropriate.

What is a GIS? A GIS provides an automated environment for pulling together information from a variety of sources. Data from these various sources is stored in a digital database by means of different data layers to provide a model of the real world. These different layers might contain zoning districts, ownership parcels, measurements, soils, and so on.

There are many ways to enter data into the system. Data might be entered by digitizing off existing maps or entering data such as measurements via the keyboard or by file transfer from a digital data collector or GPS receivers. Other sources of data might include imagery from remote sensing platforms in space (e.g. SPOT & LANDSAT), digital photogrammetry, analytic photogrammetry, and file transfers from existing agency databases such as those maintained by USGS, EPA, BLM, and NGS. Documents, photos, and images may also be scanned.

What’s the difference between a GIS and a computer-aided drafting (CAD) or automated mapping system? In a GIS, topological structuring is accomplished so that data files can be associated with each entity within the layer. That is, attributes associated with an entity may be stored in a database management system. A GIS allows comparisons between layers to show, say, how much soil of a certain type exists in certain parcels between certain elevations. A GIS allows queries. For instance, if you were a real estate agent, you might query the system for all parcels within 15 miles of Tenant’s Harbor, having coastal frontage, having less than 15 acres, with a creek running through the parcel, priced at less than $50,000. The GIS system would display the qualifying parcels for the user. Then you could ask additional queries such as current owners, existence of dwellings, property taxes paid last year and so forth.

Primary limitations of currently available commercial GIS include the great expense and effort to transfer data into the GIS so that it may be queried and the lack of fully automated or user friendly query methods.

8.0 Uses of Geographic Information by Government Agencies

This section provides a brief summary of short presentations made by some of the participants.

8.1 Bureau of Land Management (John Moeller)

The Bureau of Land Management (BLM) is responsible for several different functions, including the public land survey system, the collection and maintenance of land and mineral records, and resource management. The agency therefore has significant need for a land information system (LIS) to facilitate the performance of its duties. Such a system must be multi-purpose and must make provisions for a geographic coordinate data-base; tie in land boundaries, records information and authorizations; and standardize and categorize resource information. The BLM is currently preparing a study for submission to the U.S. Congress that will address the
questions of cost-benefits analysis as applied to geographic information systems and the maximization of data for use by two or more agencies.

8.2 U.S. Forest Service (William Ubbens)

The U.S. Forest Service has three major missions: management of national forests; state and private forestry; and research. Currently, the Forest Service is developing a GIS that it expects will be operational in about two years. The system currently under development will be required to handle several functions, including managing resources for multiple use and sustained yield, balancing conflicting interests, and analyzing complex multiple use processes. Data to be included in the Forestry Service GIS will detail timber, wildlife and recreational resources. These data still must be automated.

8.3 Environmental Protection Agency (Michael McDougall)

The U.S. Environmental Protection Agency (EPA) has a broad mandate and works in an intergovernmental environment, delegating many duties to its state partners. Data collection and processing are among the duties the federal EPA delegates to the states. GIS technology came to the EPA in 1987, and current efforts in the area of geographic information systems emphasize the multi-disciplinary nature of data collection and analysis. Using a prototype strategy, the EPA’s current pilot projects begin with existing data sources, then modify the data to add to their value as information before passing it along to the states, or develop new applications before exporting the information products to the states. Among the issues the EPA is most aggressively exploring are hazardous waste site privatization and wetlands evaluation.

8.4 Other Agencies

As the meeting progressed, the perspectives of other government agencies were adequately addressed during the small and large group discussions. Thus, formal presentations for those other agencies were not necessary. Additional federal agency perspectives were provided in the group discussion by Carl Shapiro, U.S. Geological Survey, and David Moyer, National Geodetic Survey. William Huxhold, City of Milwaukee, provided insightful comments on local government uses of geographic information.

9.0 Processes for Evaluating Use and Value Issues

One of the objectives of the 14 Specialist Meeting was to identify methodologies and processes that will help the NCGIA to gain insight into the use and value of geographic information in decision-making. In support of this objective, several of the participants in the meeting provided information on research methodologies or insights designed to help lay the groundwork for an ongoing research effort on the use and value of geographic information. Their comments follow below.

9.1 James Wells, Center for Health Affairs, Project HOPE
Methodological Questions for Studies of the Use and Value of Geographic Information

Assessing the use and value of geographic information presents investigators with a variety of questions regarding the following:

• demand for information;
• the implementation of geographic information systems;
• organizational response and individual use of these systems;
• the diffusion of new systems in the population;
• the impact of systems on productivity and user satisfaction; and
• the benefit or efficacy of these systems.

The broadest array of research designs and techniques may be applied to this set of questions. However, a few methodological questions are standard in every case. What are the units of analysis? Are they people, networks, organizations, or episodes of using information systems? How are the units selected? Is the universe selected or is a sample selected? Is the sample random? Is it stratified by one or more relevant targeting variables? Or, is it a convenience sample? What data are to be collected? The conceptual model and hypotheses largely will guide the choice of data elements. However, one must also determine which data are available and which data can be conveniently and cost-effectively collected.

What design is to be used? The conceptual model and hypotheses again should guide this decision. Several designs are possible. Incidence and prevalence designs, for example, include the cross-sectional survey, the prospective follow-up or panel design, or the retrospective time series. Cause-effect designs include prospective cohort designs, case-control designs, quasi-experimental designs, and experimental designs. Cause-effect designs also feed back on how units will be selected. That is, how are units for the comparison groups selected? Will they be a matched sample; will they be a random sample; or will they be a convenience sample?
Finally, how will the data be collected? Will it be through face-to-face interview? If so, will it be structured or unstructured? Will it be a telephone interview, a questionnaire, observational or ethnographic techniques, or will data be collected from administrative records?

Furthermore, with any design there are things that can go wrong to invalidate study conclusions. One of these is inappropriate concreteness or the wrong units of analysis. Of particular concern in this area is the difficulty in ascribing influences to organizations rather than to people or, conversely, taking into account contextual organizational effects on the individual. Another problem is selection or recruitment bias. A particular problem is self-selection into using or implementing a program. In a design that compares a group of users or adopters to a group of non-users or non-adopters, outcomes may be related to whatever characteristics caused people to differentially become adopters in the first place. Such an effect may confound inferences about the presumed intervention. Another form of biased selection is refusal to participate in the study or loss to follow-up in a longitudinal study. A third problem is unavailable data. Sometimes data are unavailable because the conceptual model is not correctly specified, so the data are never collected. On occasion, they are unavailable because of incomplete records or item non-response in a data collection instrument. Sometimes proxy variables may be used for unavailable data, but these may be inadequate.

A fourth problem is an inappropriate design. The most common instance of this is the use of a cross-sectional or weak longitudinal design to test a cause-effect hypothesis. In addition, there is the inability to control the nature of the intervention. It is common for researchers to overlook effects of differences in the implementation of a program. Furthermore, especially in cause-effect designs, the problem of a biased control group often arises. Sometimes an investigator will use different criteria for selection of controls than for selection of the treatment group. This selection bias leads to non-comparability of the groups. A fifth problem is the inappropriate use of data collection techniques: for example, a face-to-face interview to collect sensitive data or a self-completed questionnaire to collect very complex, detailed information. The final set of problems have to do with the statistical analysis of the results. Often measures are invalid or unreliable. Unreliable measures lead to observed associations that are small compared with the true association. Sometimes, cause-effect research designs employ measures that are not sensitive to changes in the cause, even if they are generally valid and reliable. Additionally, an insufficient number of cases precludes drawing a statistical conclusion with confidence.

References


9.2. Ann Greer, University of Wisconsin - Milwaukee

Innovation and Technology Transfer

The adoption of an innovation tends to be a slow process. In many instances, people distrust new ideas and technologies. Developers of innovations have a very different perspective from that of potential users; this may impede adoption of the innovation. "Opinion leaders," tuned in to both the user community and the outside world, can influence others to adopt an innovation. In general, the judgment of opinion leaders is well-respected. However, opinion leaders tend to be careful in their rate of adoption of an innovation, gathering enough information about the innovation to reduce their uncertainty about the innovation to a tolerable level. Thus, the adoption process can still be very time consuming.

Following initial adoption of an innovation, the innovation's users often adapt or re-invent the innovation to make it more valuable to them. Following such adaptation or re-invention, the improved innovation may be more readily adopted among potential users. In essence, the early adopters of an innovation help work out any remaining bugs in the innovation.

There is not that much difference between the Geographic Information and non-geographic information in the sense that both support decisions. Based on my experience and research, many people face the decision either to adopt or not to adopt this new way of generating information. Most of the people who do adopt the new technology think it is valuable and a good thing. However, by and large, technology transfer is a very slow process. Ordinarily, organizations must reach some sort of consensus on methods, standards, and so on before they fully utilize an innovation. Organizations are very slow to change, especially if the impetus for change is to improve a system that seems to work as opposed to fixing one that is obviously broken.

A good way to understand these issues is to look at the literature from related disciplines, which suggests that people are often distrustful of an innovation. For instance, physicians are reluctant to put medical records into a computerized data base for a number of reasons. Perhaps a physician does not type well and fears making a mistake on the computer in front of the patient and perhaps losing the patient's confidence. Or, a doctor may think it takes too long to enter new data into a data base. Or a physician may simply fail to recognize any benefits from implementing a new system.
People who develop computerized data bases and information systems have a different perspective from those who actually use the products, especially if the products are used in a wide range of applications. Often, the developers of a new technology are too involved to be objective, especially in an academic setting, and may in fact become promoters of their own creation.

Potential users of an innovation are often resistant to adoption of new technologies. Rather than boldly adopting an innovation, people often wait for someone else to take that all-important first step. Ordinarily, literature touting a new product will fail to persuade a large number of people to adopt the product. This is particularly true within the medical community. It is said, for example, that for medical science to advance, a patient must die. But the physician wants a live patient, so he or she will probably be resistant to trying new techniques or technologies, especially if the physician perceives them as involving potential risk to his or her patients.

Similarly, organizations are resistant to innovation. One reason for this is the unanticipated repercussions of an action. For example, a hospital in the United Kingdom decided to change the times they wakened patients in the hospital from 4:30 am to 5:00 am, causing several major unanticipated problems. This change forced the nurses to change their schedules, which created the need for a change in the local bus schedule. These schedule changes upset other workers and caused a general uproar. Eventually the hospital reverted to its original schedule. This example illustrates the real need for consensus and an understanding of the effects of change if change is to be successful. Moreover, change dictated from a high level to lower levels can lead to non-use or, even worse, sabotage of the innovation. Finally, the memory of past failures (such as the one described above) can cause an organization to reject innovations out-of-hand, without even considering the potential benefits.

So new ideas, even very good ones, tend to diffuse rather slowly. They cannot be applied immediately. There is new equipment to be developed, distributed, and operated. There is a new set of knowledge to be learned. And there must be back-ups developed in case something goes wrong. Ordinarily, only one or two people in an organization will adopt and promote an innovative technique or technology.

One way to promote an innovation to attend special interest meetings. There are, of course, the meetings and paper sessions, but such meetings also offer the opportunity to meet and interact with vendors of innovative technologies to discuss concerns about the technologies and products. Professional meetings also offer the opportunity for informal talks and information-sharing among colleagues who face similar problems.

There are several types of people who typically promote the diffusion of new technology in an organization. The first are called opinion leaders. Opinion leaders are usually attuned to both the community and the outside world. One of the keys to promoting a new technology is to identify opinion leaders and enlist their support. The most effective opinion leaders are those who have both technical knowledge about the technology as well as the respect of their colleagues. Such people are often cautious in their support of new technologies, choosing to promote only those in which they have a great deal of confidence. It is partly because of their caution in evaluating new technologies that they have earned the respect of their peers: these opinion leaders rarely back a loser.

When an organization adopts new idea, it is generally re-invents or adapts the technology to meet its own needs at the user level. At this stage, re-inventors play an important role. The re-inventor is generally skilled and knowledgeable in the technology adopted. The most successful re-inventor, of course, is someone who has had a hand in the actual product development. The role of the re-inventors is to modify the product fit to the local needs. Moreover, re-inventors help their less-knowledgeable colleagues to understand the technology. The re-invention phase produces a snow-ball effect in the technology adoption process by making the technology increasingly accessible to the average user.

Another person who may advance the diffusion process is the champion. The champion pushes for adoption and does not take "no" for an answer and re-proposes to encourage the organization to adopt the innovation. If the champion holds a high-level post, his or her activities in support of an innovation can be crucial to the ultimate adoption of the innovation.

In summary, the most important influence in diffusion is the interaction of small groups of users who will relate the benefits of adoption to their peers and colleagues in the organization. Understanding the role of individuals and small groups in the adoption of an innovation is necessary to building an understanding of how GIS may diffuse in the future.

9.3. Peter Morgan, University of Michigan
Economic Valuation of Information

Introduction

The basic paradigm is that extra information leads to "better" allocations of scarce resources. These better allocations yield higher "value." The increase in value so achieved is defined to be the value of the extra information. The value of a data set should be carefully distinguished from the value of a resource allocation.

The central problem facing the NCGIA is one of trying to maximize the value, to end-users, of the resources given to it by society. The NCGIA is, in a real sense, a firm whose products are a set of information types and the supply of information acquisition and delivery systems. Such a problem is a resource allocation problem.
Allocation Under Certainty: The basic allocation problem is to solve

\[
\max_{x_1, \ldots, x_n} f(x_1, \ldots, x_n), \quad \text{where } (x_1, \ldots, x_n) \in C.
\]

\(f\) is the decision-maker's objective function. \(C\) is the set of available choices.

For example, \(C\) might be:

\[
C(B) = \{(x_1, \ldots, x_n) \mid 0 \leq x_1 + \cdots + x_n \leq B\}
\]

where \(B\) is the budget available for sampling data, \(x_i\) is the number of observations in variable \(i\), and \(c_i\) is the cost of each such observation.

The sample size vector \(x_1(B), \ldots, x_n(B)\) solving the above problem is the "optimal" allocation of the budget \(B\), the scarce resource. The optimal sample size vector depends upon the costs of sampling, the available budget, and the decision-maker's objectives as expressed by \(f\). The value of the optimal allocation, and thus of the budget resource that makes it feasible, is:

\[
V(B) = f(x_1(B), \ldots, x_n(B)).
\]

Informational Assumptions

(i) The form of the objective function \(f(\cdot)\) is known.
(ii) The dimension, \(n\), is known.
(iii) The position of the (feasible) choice set \(C\) is known.
Allocation Under Uncertainty

Uncertainty can intrude on the above "certainty" problem in at least three ways—namely, violations of any of the three above informational assumptions. In every case, however, it is assumed that the decision-maker is always able to form expectations, conditional upon any possible information set that might arise, about the value of allocations he or she must make after some uncertainty is resolved, either partially or completely. Should valuable resources be expended now to gather data that will augment the decision-maker's information set? If so, then how?

Let $I$ denote the information set possessed by the decision-maker. At some cost, $c(D)$, he or she can acquire a data set, $D$, that will augment his or her information set from $I$ to $I \cup D$.

Suppose that, as in the search theoretic context, the uncertainty is over the value of $\theta$. Let $\phi(\theta \mid I)$ denote the probability density function (PDF) for $\theta$ when no additional data are collected and let $\phi(\theta \mid I \cup D)$ be the PDF conditional upon the data augmented information set. The expected informational value of the data set $D$, given the information set already in hand, $I$, is:

$$EV_\theta[D \mid I] = E_\phi[V(B) \mid I \cup D] - E_\phi[V(B) \mid I].$$

It is "economically rational" to collect the data set $D$ if $c(D)$, $EV_\theta[D \mid I]$.

Notice that the economic value of the data set $D$:

(a) depends upon the information already possessed, $I$;

(b) is derived from the value of the end-uses to which the data are put;

(c) depends upon the range of data types that can be generated (represented here by the value of $n$); and

(d) depends upon the resource costs of the technologies available for data generation and dissemination (represented here by $\{1, \ldots, n\}$).

Variations in the Uncertainty Model

The above basic model of information acquisition describes the choice of a single (one-time) optimal sample size vector. But the model can be extended in many valuable ways.

(a) Selecting the Set of Data Types

Suppose that $n$ is the number of all possible data types. Then sample data

* of type $i \in \{1, \ldots, n\}$ only if $x_i (\theta, B) \geq 1$. 

(b) Intertemporal Decision-making
Suppose there is a sequence of points, dated by $t = 1,2,\ldots$, at which sampling can take place. Let $I_t$ denote the information set at hand at date $t$. Let $B_t, B_{t+1}, \ldots$ be a sequence of budgets, with possibly only the current budget $B_t$ known for certain. Let $x_{t1}, \ldots, x_{tn}$ be the vector of per observation resource costs at time $t$. Future such vectors may be uncertain at $t$. The problem now, at date $t$, is to decide upon the sample size vector which solves:

$$\max_{x_{t1}, \ldots, x_{tn}} f_t(x_{t1}, \ldots, x_{tn}) + \operatorname{E}_y[V(X_{t+1}, B_{t+1}) | I_t \cup X_t],$$

where $0 \leq x_{t1} + \cdots + x_{tn} \leq B_t$.

$X_t$ is the data collected at $t$, and $V(\cdot, B_{t+1})$ is the optimized value of the budget resource $B_{t+1}$ at $t+1$ when $t+1, \ldots, t+1, m B_{t+1}$, and $X_t$ are known.

This is a stochastic dynamic programming problem, the solution to which is an algorithm that tells how to allocate the next period's resources conditional upon the realization of sampling funded by the current period's resource allocation. The recursive nature of the problem allows us to compute the value at time $t$ of the budget resource $B_t$, given the current information set $I_t$, the current sampling cost vector $x_t$, and the sequence of known objective functions $f_t(\cdot), f_{t+1}(\cdot), \ldots$.

(c) Investing in Alterations to the Allocation Problem's Parameters
What can be done to improve further the value of the budget resource $B_t$? Can we do better by diverting some of the current budget $B_t$ from data acquisition now (and so lower the highest achievable value for the current payoff, $f_t(\cdot)$) towards initiatives that are expected to improve future payoffs (improve $\operatorname{E}[V(\cdot, B_{t+1}) | I \cup X_t]$) so as to increase the overall value of $B_t$?

1. Invest some of $B_t$ in order to reduce some elements of future vectors? For example, should a new data formatting system be introduced so as to make it easier for customers to retrieve data in useful forms?
2. Invest some of $B_t$ in order to enlarge $B_{t+1}$? For example, should we pay now for advertising designed to attract additional future resources?
The problem of implementing an economically efficient resource allocation algorithm is obviously difficult and yet many firms appear to do rather well at solving similar problems. What is their secret? Many firms are profit-seekers. Such a goal defines the firm’s objective function, f. The NCGIA needs to define its goals in order to define its objective function.

How does a firm elicit end-use values for its products? Through the price mechanism. The firm then uses these values to decide how to allocate its productive resources. The price system is part of an implementation mechanism for the firm.

What is an “implementation mechanism?” It is a strategy used by the decision-maker (NCGIA) both to elicit information from end-users about product values and to allocate the available productive resources. An efficient mechanism is an implementing strategy that maximizes the value of the currently available resources –B, for example. Can such a mechanism be designed for the NCGIA?

Should the NCGIA be a profit-seeking entity? Or should it be a supplier of a “public good?” What is the goal set of the NCGIA? The answer greatly affects the choice of an appropriate implementation mechanism. Note, however, that the availability of implementation mechanisms also affects the feasibility of achieving various goals and, therefore, the value of any data gathering activity that may be undertaken.

The main point is that, for an economist, the issue of squeezing maximum added value from scarce resources for data acquisition and dissemination is an implementation issue.

9.4. Paul Densham, SUNY - Buffalo
Spatial Decision Support Systems

Spatial Decision Processes

Management scientists and operations researchers are moving towards a new concept of an optimal decision process. Simon’s three stage model of decision-making is at the core of this approach: intelligence in the recognition that a problem exists and formulated a definition; design in the generation and evaluation of a review of alternative solutions; and choice in the selection of one alternative for implementation. Optimizing analysis emphasizes choice, in an optimal decision process the emphasis is on intelligence and design in an iterative process. Such a process is at the core of Spatial Decision Support Systems.

Two schools in experimental psychology have diverse opinions about the role of decision aids in the decision-making process. The first school of thought holds that decision aids bias the process and therefore should be avoided. The second school believes that, without decision aids, decision-makers will make poor choices; therefore, decision aids are essential.

<table>
<thead>
<tr>
<th>Structured</th>
<th>Ill-structured</th>
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<tr>
<td>Garbage Dump</td>
<td>Fire Stations</td>
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In the above table suggests that as the problem features greater dimensions, the problem becomes increasingly unstructured. Many decisions are evaluated on the quality of the process that generated them, with public participation viewed as an improvement in the overall quality of the decision. As more groups participate in the process, the problem becomes increasingly unstructured and complex. Therefore, we need a new approach to address the task of decision-making. Adoption of Spatial Decision Support Systems (SDSS) is one such approach.

The SDSS approach can be very helpful in the decision-making process because it provides the following:
1. a more general solution process in which optimizing models play an important role;
2. an iterative process that both generates and evaluates alternatives;
3. an integration of both analysis and expertise; and
4. participative solutions which are advantageous because they tend to build wide public support.

The major benefit, overall, of spatial decision support systems, is that they encourage the decision-makers to challenge assumptions, thus clearing the path for new approaches to problem-solving which should ultimately result in better decisions.

10. Impediments to Assessing the Use and Value of Geographic Information

As a means to encourage discussion and debate on Initiative 4, the use and value of geographic information in decision-making, the specialist meeting participants were asked identify impediments to assessing the use and value of geographic information. Meeting first in small groups, then coming together as a whole, the specialists carried out their task. What follows below is the question as posed to the specialists, followed by their responses.

10.1 What are the impediments to assessing the use and value of geographic information?

Please consider the following subtopics:

• UNCERTAINTY AND RISK ASSOCIATED WITH DECISION-MAKING
  - the economic concept of utility applied to information;
  - the role of information in uncertainty reduction;
  - uncertainty reduction and absorption;
  - limits to the search for information.

• DECISION MODELS
  - the decision-making process;
  - the role of information;
  - information as a product;
  - the distinctions between data, information, and knowledge.

• DEMAND FOR INFORMATION
  - value as a demand-initiated concept;
  - identification of primary and subsequent users of information;
  - the contrast between supply/push and demand/pull in the development of information systems;
  - public good aspects.

• BENEFITS
  - direct and indirect benefits;
  - uncertainty reduction;
  - uncertainty absorption;
  - expanded opportunity;
  - avoided cost model.

The Initiative 4 Specialist Meeting should result in guidelines for GIS design, especially regarding methods to use in determining the data to include in a GIS and determining what benefits can be expected. It also will form a starting point for investigations regarding data quality and how it affects the quality of decisions. It will provide some design criteria for Initiative 7 by identifying those aspects of data quality most important to decision-makers. Initiative 4 will provide foundation knowledge and a common ground for Initiative 9 ("Institutions Sharing Spatial Information").

10.2 Group Consensus on Impediments to the Use and Value of Geographic Information

The small group discussions identified a wide variety of impediments concerning the use and value of geographic information. These impediments were then discussed by the entire group. The impediments have been grouped into four categories as follows:
A. Impediments Related to Methodology

1. The lack of a taxonomy of the many and varied uses of geographic information has made difficult the task of developing testable hypotheses about the value of various uses of geographic information.
2. The methodology used to assess the use and value of geographic information influences the outcome of the assessment. The exact nature and extent of such influences must be examined.
3. The traditional emphasis on price-based analyses (such as cost-benefit approaches) has inhibited the development of a fuller range of methods to assess the use and value of geographic information.
4. To date, there have been insufficient numbers of test cases to examine the use and value of geographic information empirically.
5. There is a lack of adequate survey design to support case studies for determining the use patterns of geographic information and the associated economic values of such use.

B. Impediments Related to Use of Geographic Information

1. There is a gap between expectations and reality with respect to the capabilities Of GIS. This gap affects the overall assessment of the use and value of geographic information.
2. The differences in the needs of the developers of GIS as compared with those of users of geographic information have not been adequately explored and documented. Inasmuch as the value of geographic is dependent on its use, the needs of users must be thoroughly explored.
3. There has been insufficient research on the variations in decision-making processes from one organization to another and their relationship to organization-specific the use and value of geographic information.
4. The assumption that better information leads to better decisions in the real world has not been confirmed. This has been taken as a given in assessing the use and value of geographic information in decision-making in spite of its lack of confirmation.
5. Researchers have identified difficulty in identifying uses of geographic information: current, anticipated and unanticipated. This difficulty is exacerbated in multiple-use and multiple-user environments.
6. The lack of taxonomy to identify new ways to use geographic information that have arisen from the implementation of GIS has created a gap in our understanding of the value of speculative or unanticipated uses of geographic information.
7. Lack of understanding of the motivations for developing GIS, along with the contradictory objectives of users of geographic information has limited our understanding of the uses to which geographic information is put, along with the ultimate assessment of the value of the information.

C. Impediments Related to the Value of Geographic Information

1. The self-interest versus the public interest in the use of geographic information is not well understood. Given the wide variety of applications of geographic information in the public sector, existing gaps in our knowledge about assessing the value of public goods in general and the value of geographic information as a specific public good must be bridged.
2. The public goods aspects of information increase the difficulty in assessing its use and value. It is sometimes difficult to discover the true desire, and thus the willingness to pay, for a specific public good. The consequence is that less than the optimal level of supply of the good can be achieved by a simple system of individual levies for the good.
3. The lack of procedure(s) to assign monetary value to the benefits of new ways to use geographic information that have arisen from the implementation of GIS makes it difficult to estimate use and value.
4. The unmet need to assess the utility of geographic information prior to assigning economic (monetary) value must be addressed. Lack of realistic valuation methods is substantially hindering the adoption of geographic information systems by local, state, and federal agencies.
5. Time lags between the use of geographic information and the full manifestation of benefits increases the difficulty in assessing the value of the information.

D. Impediments Related to Organizational Issues

1. Incomplete understanding of the impact of the rate of technology improvement on the use of the geographic information products of the technology inhibits our ability to understand and assess the role that technology such as GIS plays in adding value to information.
2. Incomplete understanding of the role that information and its use play in reshaping the organization make difficult an understanding of the iterative process that results in the use of geographic information and the refinement of geographic information systems.

4. Incomplete understanding of the role that the organization plays in producing benefits through the use of geographic information neglects the importance of specific uses of geographic information to its ultimate value.

5. There has been insufficient research on organization-specific use of geographic information and the value of such use.

11.0. Methods to assess use and value of geographic information

Building on the work of the first small group discussion as well as on the consensus reached in the large group follow-up discussion, the charge during the second small group meetings was to identify methods to assess the use and value of geographic information. In implementing methods to make such assessments, it is necessary first and foremost to make a distinction between geographic information and GIS. It is the geographic information itself that is the primary focus of this initiative.

The small groups identified several potential methods to assess the use and value of geographic information. They are listed below.

1. Survey of users and uses of geographic information
   - cross-sectional surveys over time
   - longitudinal surveys

2. Case studies
   - study users with varying lengths of experience using geographic information
   - study users with varying perspectives in use of geographic information
   - study decision-making processes

3. Taxonomies
   - users of geographic information
   - uses to which geographic information is put

4. Explore the history of GIS and the use of geographic information to see what hypotheses they might yield

5. Explore and analyze the literature and methods relevant to the use and value of information generally, and geographic information explicitly (for example, traditional and refined cost-benefit analyses)

6. Conduct experiments to learn how people integrate and synthesize information presented in a variety of formats, both geographical and non-geographical (tabular and prose formats, for example)

7. Method development through a process of study, contemplation, and reflection

There was considerable overlap in the methods suggested by the five small groups. In most instances, the groups suggested several complementary methodologies for implementation. Several groups noted the value of complementary methodologies along with the need for an iterative process to develop and test hypotheses related to the use and value of geographic information.

12.0. Initiative 4 Research Agenda: Prioritization of research topics

There was considerable consensus among the participants about the prioritization of research topics. The general perception was that we are still at a very early stage in exploring the use and value of geographic information; much basic work must be done to develop and test hypotheses about the use and value of geographic information. In the small group settings, and during the subsequent large group meeting, the participants agreed upon a general research approach designed to expose and address the priority use and value issues. (See Figure I on the following page.)
The participants broke into groups to provide more detailed direction on the three initial components of the agreed upon research process which are:

1. Developing a taxonomy(s) of users and uses of geographic information
2. Carrying out a preliminary survey to test the validity of the taxonomies and the initial case study directions
3. Designing case studies to address the range of use and value issues
These three initial components are intended to proceed contemporaneously with each other and continue in an iterative cycle until a well developed case study design likely to provide significant and relevant results has been arrived at. Only after this thorough evaluation process should detailed case studies be attempted.

Although numerous use and value research questions may be addressed through the diagrammed approach, the following two areas of concern were designated priority topics:

**Priority Topic: Study A**

One of the research topics of great concern to attendees at the specialist meeting was the need to develop a methodology for assessing the value of geographic information. There was a general consensus among GIS users and economists that current methods of valuation of geographic information are highly inadequate; particularly in institutional settings where no market exists to establish value (i.e. public goods) and the geographic information is used by many users for many purposes. Lack of realistic valuation methods is substantially hindering the adoption of geographic information systems by local, state, and federal agencies. Thus, valuation issues and methods will be evaluated and tested through the iterative method outlined above.

**Priority Topic: Study B**

Another priority research area is evaluating technology adoption and diffusion. Adoption studies in other fields, particularly the medical field, have shown that definable and consistent factors may typically be identified which are crucial in the decision by private individuals or institutions to embrace a particular technology. For instance, although economic justification is a critical factor in the decision to buy into a technology by a public agency, innovation diffusion studies to date suggest that other factors are even more critical in the decision to finally embrace a technology. This is true for both public agencies and private businesses. With the prevalent GIS trend toward decentralization, networking, microcomputers, and database sharing, the relevant factors affecting adoption of geographic information technologies by individuals, private enterprises, and individuals within public agencies should be identified and verified through the iterative research process applied to Study B.
**Objective:**

Obtain basic knowledge which will aid the use of geographic information in decision making and will allow or aid the use and diffusion of geographic information technologies.

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<thead>
<tr>
<th>Priority Topic: Study A</th>
<th>Priority Topic: Study B</th>
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<tbody>
<tr>
<td>Towards a methodology for assessing comprehensively and realistically the value of geographic information</td>
<td>Determining crucial factors in the adoption and diffusion of geographic information technologies</td>
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<thead>
<tr>
<th>Tendencies of the Framework Focus in the Initial Phases of Study A</th>
<th>Tendencies of the Framework Focus in the Initial Phases of Study B</th>
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<tbody>
<tr>
<td>public &lt;-&gt; private</td>
<td></td>
</tr>
<tr>
<td>agencies (institutions) &lt;-&gt; individuals &amp; businesses</td>
<td></td>
</tr>
<tr>
<td>users of large systems/databases &lt;-&gt; users of small systems/databases</td>
<td></td>
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<tr>
<td>-interfacing to small systems -interfacing to large systems</td>
<td></td>
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<tr>
<td>detailed case study (micro view) &lt;-&gt; macro view of many users</td>
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<td>geographic information &lt;-&gt; geographic information technologies</td>
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<td>analytical/quantifiable &lt;-&gt; observation/contemplation/reflection</td>
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<td>current users of &quot;geographic information&quot; &lt;-&gt; current users and potential users of &quot;technology&quot;</td>
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<td>-retrospective observations -experimentation &amp; prospective observation possibilities</td>
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Table 1. Comparison of Two Priority Research Thrusts
Both of the above priority studies take an in-depth look at "uses" of geographic information but from different approaches. By initially concentrating on these two research questions a wide range of issues and research methods may be addressed as illustrated by the table on the following page. The two research thrusts shown in the table are highly complementary. Although particular points of stress and characteristics are listed in the table in two columns, each study will address the characteristics listed under the complementary study as the studies progress. Thus, the two proposed research studies will result in greatest knowledge advancement if carried out at the same time. The studies will be carried out by two separate but closely cooperating research teams. Cooperation will be particularly important in the taxonomy development phases of both studies.

The intent of NCGIA personnel involved with Initiative 4 is to begin the iterative case study design process on both topics to the greatest extent possible with the resources available to us. The steps likely to pay the highest dividends in new useable knowledge must be financed through other than NCGIA funds (i.e. the actual in-depth case studies). It is our intent to solicit such funds.

13.0 Products of the Proposed Research

The primary goal of Study A is to derive a methodology for assessing comprehensively and realistically the value of geographic information. The primary goal of Study B is to determine and investigate those factors which are crucial to the adoption and diffusion of geographic information technologies.

Deliverables arising out of Studies A and B as the research progresses and evolves are reported in an accompanying and regularly updated document. The complete and final list of deliverables will be contained in the scientific report to be published at the completion of the initiative.

From the combined results of Studies A and B and extensions of their primary goals, additional products of the research are likely to include the following:

1. a comprehensive procedure(s) to identify the demand for geographic information in support of decision making; e.g., this might involve developing models of the contribution of geographic information to decision making and identifying the operands and dam necessary to support those models.
2. knowledge of human behavior and perception which is likely to be important in guiding applied technical research
3. insights on establishing data collection priorities
4. insights on public awareness of the uses of geographic information and how best to provide public education
5. insights on training requirements for those using geographic information in their decision making or potentially using it in their decision making
6. functional innovation adoption methodologies which could be used by those desiring to promote the adoption and diffusion of geographic information technologies
7. insights on those GIS capabilities and operational characteristics most likely to encourage the embrace of the technology by any particular class of geographic information users

Experience with Study A and Study B is likely to suggest specific and more narrowly focused use and value studies with appropriate research methods for those studies, suggest additional important case studies, provide direction for the technical design and human interface of GIS, and provide a foundation for the later NCGIA research initiative on the institutional sharing of geographic information.

The NCGIA is funding several people specifically to undertake research on the use and value of geographic information. Directing the research are Harlan J. Onsrud (University of Maine) and Hugh W. Calkins (SUNY-Buffalo), Co-Leaders of Initiative 4. A post-doctoral Research Associate, Nancy J. Obermeyer (Maine) will also pursue research under the auspices of Initiative 4, along with Ph.D. candidates Holly J. Dickinson (SUNY-Buffalo) and Gary Jeffress (Maine).

Early efforts (summer, 1989) will focus on preparing a proposal for joint submission to several federal agencies. It is anticipated that literature reviews on diffusion of innovations, taxonomy, and assessing value developed for the proposal will also be adapted as articles for submission to refereed journals. As the results of the studies become available, they, too, will be prepared as journal articles.

For further information on Research Study A, contact Dr. Hugh Calkins at State University of New York at Buffalo. For information of a general nature regarding this initiative or for further information on Research Study B, contact Dr. Harlan J. Onsrud at the University of Maine.
APPENDICES

APPENDIX A.

Overview of NCGIA Research and Education Missions

NCGIA SUMMARY

There is a growing need to examine a large class of difficult questions concerning both geographic information and analysis (GIA) and geographic information systems (GIS). GIA/GIS technology offers an untapped potential for increasing our understanding of the world and for applying such understanding in ways that are valuable to society. It can provide basic tools for solving common problems and can provide vital decision-making aids for the public and private sectors.

For the technology to realize its full potential, it must significantly increase its capacity to handle very large spatially-indexed databases, and incorporate more powerful capabilities for modeling and analysis. The technology will attain its greatest value only if there exist both a sufficient number of individuals educated in its use and a sufficient body of knowledge concerning its availability and applicability. The demand for systems that can analyze and model complex spatial phenomena is increasing, but systems that are fully operational are currently not available.

The National Science Foundation (NSF) has recognized the need to investigate the field of GIA/GIS in order to discover, explore, and disseminate sound concepts for improving our technologies and our understanding of geographic information. In its call for proposals, NSF identified five major areas needing further investigation:

1. Spatial analysis and spatial statistics;
2. Spatial relationships and database structures;
3. Artificial intelligence and expert systems;
4. Visualization; and
5. Social, economic and institutional issues.

The consortium of the University of California-Santa Barbara, the State University of New York-Buffalo and the University of Maine has been designated as the National Center for Geographic Information and Analysis (NCGIA). It has developed a research agenda and an education and outreach program that respond to the areas listed above.

RESEARCH PLAN

Research will be undertaken by means of initiatives, or projects designed to investigate fully the impediments to the more widespread implementation of GIS. These research initiatives involve interaction not only among academic researchers but also among industrial and government researchers and those applying GIS technology to aid in decision making.

For each initiative, there will be specialist meetings to define precise research objectives, working groups that will address problems for one to two years, and national and international conferences to present research findings. Specialist meetings will bring together individuals from different disciplines with expertise in particular aspects of the research problem. Working groups will then carry out specific research tasks as outlined by the specialist meeting.

Initiatives may naturally lead into long-term single-investigator projects of greater depth and specificity. The involvement of graduate students in research initiatives will have considerable educational impact; dissertation research will be a very important part of this outgrowth research. Many initiatives will also lead to applied research relevant to federal agencies, state and local governments, and the private sector. Initiatives will usually conclude with descriptions of new problems which have been exposed, and thus influence the Center's long-term research plan.

The objectives of the proposed initiatives, in summary, are:

1. **Spatial accuracy**
   - Assess statistical models of spatial data.
   - Evaluate techniques for interpolation and estimation to overcome problems of variable reporting zones and missing values.
   - Develop indices of data uncertainty and confidence for GIS products.
   - Conduct studies of the effects of aggregation on spatial modeling.

2. **Languages of Spatial Relations**
   - Identify formal cognitive models of spatial concepts and relations in natural languages.
   - Develop methods for determining reference frames for spatial language.
   - Construct formal mathematical/logical models of spatial concepts and relations based on topology and geometry.
• Integrate the mathematical and logical models into a general theory of spatial relations.

3. **Multiple Representations**
   • Examine the relation of the geometry of geographic features to the scale of representation.
   • Develop models for digital descriptions of features.
   • Examine problems associated with scale changing.
   • Develop a database organization for dealing with multiple representations of the same objects.

4. **Use and Value of Geographic Information**
   • Identify problems dealing with uncertainty and risk in decision making.
   • Develop models of the decision-making processes regarding land use, focusing on the role of information.
   • Identify users of spatial information and determine the value of this information.

5. **Architecture of Very Large Databases**
   • Assess requirements for very large databases.
   • Identify functional components for very large databases.
   • Build prototypes and test components.

6. **Spatial Decision Support Systems**
   • Design GIS data structures to support decision systems.
   • Develop methods to improve spatial search algorithms.
   • Produce and test prototypes.

7. **Visualization of the Quality of Spatial Information**
   • Develop methods for displaying the quality of spatial information.
   • Evaluate these methods in real world situations.

8. **Expert Systems for Cartographic Design**
   • Develop an expert system to design cartographic displays.

9. **Institutions Sharing Spatial Information**
   • Document policies regarding inter-agency and agency-citizen information exchange.
   • Investigate information sharing among public sector agencies.
   • Explore liability aspects of sharing data.
   • Develop models for political support for shared databases including aspects of privacy and public access.

10. **Temporal Relations in GIS**
    • Understand the modeling of time.
    • Compare models of states with models of incremental change.
    • Study the problems of building temporal GIS databases.

11. **Space-Time Statistical Models in GIS**
    • Systematically document characteristic scales of spatial and temporal variation.
    • Develop a taxonomy of space-time statistical models to help select appropriate database structures.
    • Develop algorithms for efficient data refreshing.
    • Develop and apply efficient methods of multiple representation in the time domain.

12. **Remote Sensing and GIS**
    • Improve methods for data acquisition and processing.
    • Develop principles for identifying appropriate data structures for remotely sensed data.
    • Extend GIS applications in scene classification, contextual classifiers, and expert systems.

**EDUCATION AND OUTREACH**

There is a shortage of individuals trained in geographic data management and analysis. Many federal, state and local governmental agencies are finding the lack of such personnel to be a major limitation in developing their own systems. One of the Center's primary objectives is to alleviate this shortage by expanding the nation's supply of experts in GIS. The Center's educational program will include the following:
Development of a one-year model curriculum of basic GIS concepts, techniques, and applications;  
Education of undergraduate, graduate and post-graduate students at the three NCGIA sites; and  
Extensive workshops, summer seminars, conferences, educational publications, and related outreach activities for the GIA/GIS community.

The Center will also act as a "research clearinghouse" of GIS information and will provide a multi-disciplinary link among the many disparate users of the technology. Specific outreach programs will be developed to promote more widespread use of GLA/GIS in the public and private sectors.

The educational and knowledge dissemination functions of the Center are of critical importance because the production, analysis, management, presentation, and use of geographic information involves the complicated interaction of theory, technology and practice. The gaps between theory and technology, technology and application, and application and theory in GIA/GIS are too wide; the Center will work toward integrating education and knowledge dissemination with research.
The value of a geographic information system has been identified as the combination of the efficiency in performing information-related tasks and the effectiveness, or quality, of those tasks in both individual and in organizational performance. Clearly, efficiency can be recorded by the traditional (and accepted) method of comparing costs with and without GIS in tasks utilizing geographic information (the Cost/Benefit Study). Effectiveness, on the other hand, is much more elusive, having no simple formula that can be used to quantify value -- except, perhaps, in the private sector where it may be possible to link the use of a GIS directly to: increased sales, realization of sales earlier than expected (as in the case of siting a new commercial establishment), or improved product or service quality (perhaps, even the creation of new products or services). Public organizations, however, have a much more difficult time with the effectiveness associated with using a GIS, as was well-discussed at the Initiative Four meeting. (What can a citizen do? -- go to a different government if the one they have isn’t effective?)

Virtually every organization that has implemented a GIS has gone through the motions of performing a Cost/Benefit Study that identifies the dollar savings that can be associated with anticipated efficiencies. At the end of the Study comes the "non-quantifiable benefits," which is a list of all the improvements that a GIS can bring to the organization to make it more effective. This list, as we all know, is the real value of the system, which no one has yet been able to quantify. And many of these benefits (such as "improved decision-making," "more accurate information," improved response to the needs of the public," etc.) are necessarily generalized because of all the uses that can be achieved which are not known at the time of the study. ("GIS has the answer -- what’s the question?) These arguments, we know through experience, are often the ones that make sense to decision-makers who have the choice of promoting or defeating the GIS project.

The initial question at hand is: how do you measure the effectiveness of an organization? If that is possible, then it is merely a matter of comparing the effectiveness of an organization that uses a GIS to one that does not. All other things being equal, the determination of effectiveness proves the value of the GIS. We may not be able to answer that question, but we may be able to perform research that can answer other questions that, collectively, serve as a surrogate for the question. I suggest that a good start on the list of such surrogate questions relating to effectiveness include:

1. Can an individual who uses a GIS make more accurate decisions than one who does not, or can he or she be only more efficient in making decisions?
2. Given two people with access to a GIS and who have the same job, why does one use the GIS and the other not?
3. Given two similar organizations that perform the same function (land management, dispatching vehicles, etc.), is the one that uses a GIS in that function more effective?
4. Which professions in organizations could use a GIS in performing their functions if they knew the answers to the above questions?

The attendees of the Initiative Four specialist meeting were, I think, unanimous in their opinion that, whatever the list of questions, they cannot be answered by a research agenda consisting of experiments, case studies, surveys, or literature searches without a means to simplify the research -- a taxonomy of uses of geographic information. A taxonomy would:

1. Establish an accepted structure for measuring the extent of use and growth of GIS.
2. Set a basis for evaluating the use of GIS over long periods of time.
3. Understand the different influences on one individual or organization over another in acceptance of GIS (why does a public agency planning function use GIS for siting public facilities and a private developer not use it for siting a new development?).
4. Establish standard terminology for communication with professions which could use GIS but do not.

A proposed taxonomy was presented at the meeting. This taxonomy was multi-faceted because of the various environments in which the technology has already taken hold. Six approaches to a taxonomy were presented -- not as a hierarchy of classifications as in the Standard Industrial Classification (SIC) scheme so widespread in business -- but as a layering of different "user views" of the many different uses of GIS by so many different people, from the simple users to the complex institutional environments.

The proposed taxonomy is:

**Primitives:** Those cartographic objects that represent geographic features, about which information is collected and upon which manipulations are made. Examples include points, lines, areas, volume, and time.
Operands: Algorithms, analytical processes and other manipulations on geographic data that provide information needed to complete a task or make a decision. Examples include spatial query, nearest neighbor, and optimum path.

Applications: Tasks and procedures of an individual or organization that uses geographic information. Examples include map updating, siting, routing, flow analysis and so on.

Functions: The reasons for the existence of organizations that use geographic information, expressed in profession-specific missions that identify not only the type of information used, but also why the functions are performed. Examples include natural resources, land management, public safety, health, marketing, infrastructure, and insurance.

Levels: Those locations within the organizational hierarchy in which geographic information and analysis are used. Examples include operations, management and policy.

Institutions: The legal and economic constraints on organizations that can influence their actions. Examples include eleemosynary, public, public consortium, quasi-public, private, illegal and so on.

This structure of "user views" of a taxonomy of geographic information and analysis and use allows flexibility in analyzing the use of GIS. It allows paths to be defined for determining all possible uses of GIS and how those uses are constructed in designing a system or in developing specifications for a system. Below are a few examples of how such a taxonomy is useful.

Institution: eleemosynary, public, consortium, quasi-public, private
Level: operations, management, policy
Application: map updating, siting, routing, flow analysis
Operand: spatial query, nearest neighbor, optimum path
Primitive: point, line, area, volume, time

1. What are the uses of a GIS in public safety and what are the software requirements and data structure needed?
2. In what kind of organizations can optimum path algorithms be used? (Maybe I want to develop one and sell it.)
3. What limitations would there be if areas were not defined in my GIS project?

Institution: Public
Level: Operations
Mission: Public safety
Application: Routing
Operand: Optimum path
Primitive: Point, line

What are the uses of a GIS in Public Safety and what software requirements and data structures are needed?

Institution: Eleemosynary, public, consortium, quasi-public, private
Level: Operations, management
Mission: Natural resources, public safety
Application: Routing, flow analysis
Operand: Optimum path
Primitive: Point, line, area, volume, time
In what kind of organizations can Optimum Path algorithms be used?

(Maybe I want to develop one and sell it.)

Institution: Eleemosynary, public, consortium, quasi-public, private
Level: Management, policy
Mission: Natural resources, land management, public safety
Application: Siting
Operands: Spatial query, nearest neighbor
Primitive: Area

What limitations would there be if areas were not defined in my GIS project?

D. David Moyers: Post-Meeting Position Paper

Following the discussions at the Initiative 4 meeting in Maine, I remain convinced that this initiative, on the Use and Value of Information in Decision Making, is THE most important of all of the research initiatives identified by the NCGIA staff. The long run value of output and support for further work of the Center will be closely linked to the success with which we deal with this initiative.

I concur with Vince Barabba (Opening Address, Tenants Harbor, May 7, 1989), that one major focus must be on the users, that is:

- Who they are;
- What they need to know; and
- Form they want information in.

This focus would provide us with important insights as to the demand for information, which will in turn help to identify many of the benefits of GIS/GIA.

A second, and almost equally important focus should be on the supply side, looking at the stream of technological innovations that serve as the base for the GIS/GIA field.

I would suggest that the model proposed by Mayo, and modified by Niemann, et al., provides a useful way to assess GIS/GIA systems, given the above supply and demand relationships. Please see figure on the following page.

This model helps answer questions such as:

- What is it that makes this system successful?
- Or, what keeps it from becoming successful?

This model includes the demand or "pull of society," as well as the supply or "push of technology" that affect the flow of innovations into society. Two major gates, the social gate and the technology gate, have major impacts on these innovation flows.

The flow of innovations through the technology gate depends on a number of factors, including: research and development experience, supporting management infrastructure, a resource base to support technology development, and the proper sequencing of standards.

The flow of innovations through the social gate is affected by such forces as: survival, increased comfort, and ability to deal with increasing complexity. Therefore, if innovations are to move successfully through the social gate, they must increase efficiency, meet an economic need, be recognized as significantly contributing to the common good, and not perceived by the public to be detrimental nor restricted by law.
The Technology/Social model can serve as a framework for the evaluation of the use and value of geographic information. A preliminary survey should be conducted as soon as possible. This survey should then be repeated at specified time intervals. The resultant longitudinal data will be extremely important in evaluating which jurisdictions adopt GIS, why they adopt them, and how the systems measure up to expectations over time.

The preliminary survey sample should be structured to include:
- Jurisdictions with GIS;
- Jurisdictions considering GIS; and
- Jurisdictions without GIS.

These jurisdictions should be asked specific questions such as:
- What are you doing now
- What are you spending to do it?
- What alternatives, if any, have you considered?
- If they have considered GIS:
  - Have you made a decision as to GIS?
  - If yes, and accepted, why?
  - If yes, and discarded idea, why?

The Symbiotic Relationship Between Technology and Society
(after Mayo, 1985)

The Technology/Social model can serve as a framework for the evaluation of the use and value of geographic information. A preliminary survey should be conducted as soon as possible. This survey should then be repeated at specified time intervals. The resultant longitudinal data will be extremely important in evaluating which jurisdictions adopt GIS, why they adopt them, and how the systems measure up to expectations over time.

- Jurisdictions with GIS;
- Jurisdictions considering GIS; and
- Jurisdictions without GIS.

These jurisdictions should be asked specific questions such as:
- What are you doing now
- What are you spending to do it?
- What alternatives, if any, have you considered?
- If they have considered GIS:
  - Have you made a decision as to GIS?
  - If yes, and accepted, why?
  - If yes, and discarded idea, why?
- What projects are competing with, and considered in a similar time frame as GIS?
  - Of those that have been accepted:
    - What are they?
    - Why were they accepted? (list reasons)
  - Of those that have been rejected:
    - What are they?
    - Why were they rejected? (list reasons)

Throughout the survey effort, attention should be given to whether the availability of GIS improves the results of the decision-making process. It is important to note that there are a number of equally important factors in the Technology/Social model, in addition to economics. Natural sequencing, standards, public receptivity and regulations also need to be considered as well. A broad view of this Initiative will help to answer such questions as why utilities and title insurers are willing to use less cost effective single purpose land information systems, compared to multipurpose systems, and what barriers to interagency cooperation are related to such factors as possession, control, and trust of the data base. Therefore, the key to success in this initiative will be to keep the evaluations broad enough to include consideration of all of these major factors.

Finally, longitudinal studies are critical since information itself changes the organization's perception and use of information, as well as changing the organization itself. Also, the work necessary for this initiative cannot be done for $400,000 ($200,000 per year for two years). Therefore, additional resources are necessary if the objectives laid out by the NCGIA staff are to be met.

References


**APPENDIX C: SPECIALIST MEETING AGENDA**

*AGENDA*

Initiative 4 – Use and Value of Geographic Information Specialist Meeting

**SATURDAY, MAY 6**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00-7:30 pm</td>
<td>Dinner</td>
<td>I – Dining Room</td>
</tr>
<tr>
<td>8:00-10:00</td>
<td>Welcome/Introduction by Initiative 4 Leaders</td>
<td>MH – Large Meeting Room</td>
</tr>
<tr>
<td></td>
<td>Self-introductions of participants</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Review agenda, Questions &amp; Answers</td>
<td></td>
</tr>
</tbody>
</table>

*Overview of NCGIA Research and Education Missions* - Andrew Frank,
NCGIA Associate Director, Maine
SPECIALIST MEETING AGENDA
Initiative 4 – Use and Value of Geographic Information

SUNDAY, MAY 7

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30-8:45</td>
<td>Breakfast</td>
<td>I – Dining Room</td>
</tr>
<tr>
<td>9:00-9:30</td>
<td>Opening Address – Vince Barabba</td>
<td>MH – Large Mtg. Room</td>
</tr>
<tr>
<td>9:30-10:00</td>
<td>Importance of the NCGIA Initiatives Directed at Social, Economic, and Institutional Issues – David Simonett, NCGIA Director</td>
<td></td>
</tr>
<tr>
<td>10:00-11:00</td>
<td>Purpose of Use and Value Meeting</td>
<td></td>
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<tr>
<td></td>
<td>Administrative Details</td>
<td></td>
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<tr>
<td></td>
<td>Small Group Assignments</td>
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<tr>
<td></td>
<td>– Harlan Onsrud and Hugh Calkins</td>
<td></td>
</tr>
<tr>
<td>11:00-12:15</td>
<td>Small Groups: What are the impediments to assessing the use and value of geographic information?</td>
<td>A - MH, large room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B - MH, Rm 30 (apt)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - MH, living room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - I, dining room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E - I, Rm 1 (suite)</td>
</tr>
<tr>
<td>12:30 pm</td>
<td>Lunch</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>1:30-2:00</td>
<td>Small Group Sessions Continue</td>
<td>(Same Locations)</td>
</tr>
<tr>
<td>2:00-3:30</td>
<td>Reports by each small group to the large group - Compilation of impediments</td>
<td>MH - large room</td>
</tr>
<tr>
<td>3:30-4:30</td>
<td>Users' Perspectives: Uses of geographic information by federal agencies, state and local governments, and private business</td>
<td>MH - large room</td>
</tr>
<tr>
<td>4:30-5:30</td>
<td>Small Groups: What are the methods to assess use and value?</td>
<td>(Same Locations)</td>
</tr>
<tr>
<td>6:00-7:30</td>
<td>Dinner – Lobster Bake</td>
<td>(Travel by vans to other side of the bay)</td>
</tr>
<tr>
<td>8:00-9:00</td>
<td>Overview: Presentation and Discussion of Research and Survey Methods</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Leader: James Wells</td>
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</tbody>
</table>

Note: Coffee and tea are generally available throughout the day starting at 9:30 in the break room. Pastries or snacks available in the break room at approximately 10:00 to 11:00 and 2:30 to 3:30 each day.
SPECIALIST MEETING AGENDA
Initiative 4 – Use and Value of Geographic Information

MONDAY, MAY 8

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
</tr>
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<tr>
<td>7:30-8:45</td>
<td>Breakfast</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>9:00-9:30</td>
<td>Small Groups (Continued)</td>
<td>(Same Locations)</td>
</tr>
<tr>
<td>9:30-11:00</td>
<td>Reports by each small group to the large group</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Compilation of Opinions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assignment of new small groups</td>
<td></td>
</tr>
<tr>
<td>11:00-11:30</td>
<td>Overview: Innovation and Technology Transfer</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Leader: Myles Boylan / Ann Greer</td>
<td></td>
</tr>
<tr>
<td>11:30-12:00</td>
<td>Overview: Value of Information Theories</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Leader: Peter Morgan / Tom Duchesneau</td>
<td></td>
</tr>
<tr>
<td>12:30 pm</td>
<td>Lunch</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>1:30-2:00</td>
<td>Overview: Spatial Decision Processes</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Leader: Paul Densham</td>
<td></td>
</tr>
<tr>
<td>2:00-3:30</td>
<td>Small Groups:</td>
<td>F - MH, large room</td>
</tr>
<tr>
<td></td>
<td>* Identify those problems with assessing use and value which are researchable.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Which are the priority topics?</td>
<td>G - MH, Rm 30</td>
</tr>
<tr>
<td></td>
<td>* On which priority topics can significant progress be made within one year time frame?</td>
<td>H - MH, living room</td>
</tr>
<tr>
<td></td>
<td>* Which segments of the priority topics require a longer time frame?</td>
<td>J - I, dining room</td>
</tr>
<tr>
<td>3:30-5:30</td>
<td>Large Group: Identification of four or five lead topics by consensus</td>
<td>K - I, Rm 1 (suite)</td>
</tr>
<tr>
<td></td>
<td>Breakdown into Topic Groups - Choose the topic you wish to participate with</td>
<td></td>
</tr>
<tr>
<td>6:00-7:30</td>
<td>Dinner</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>8:00-9:00</td>
<td>Topic Group: For the high priority researchable topic</td>
<td>1 - MH, large room</td>
</tr>
<tr>
<td></td>
<td>* Develop a detailed outline of a sample research plan</td>
<td>2 - MH, Rm 30 (apt)</td>
</tr>
<tr>
<td></td>
<td>* Identify potential cooperating researchers</td>
<td>3 - MH, living room</td>
</tr>
<tr>
<td></td>
<td>* Identify potential funding sources</td>
<td>4 - I, dining room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - I, Rm 1 (suite)</td>
</tr>
</tbody>
</table>
SPECIALIST MEETING AGENDA
Initiative 4 – Use and Value of Geographic Information

TUESDAY, MAY 9

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
</tr>
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<tbody>
<tr>
<td>7:30-8:30</td>
<td>Breakfast</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>8:45-9:30</td>
<td>Topic Groups (Continued)</td>
<td>(Same Group Locations)</td>
</tr>
</tbody>
</table>

Recovery and Relaxation

a. Sunny Weather:
   Excursion to Monhegan Island ($18/person)
   One hour ferry ride each way, bring warm
   clothes and hiking shoes, hiking paths and
   lobster fishing, 11000 acres, no vehicles on
   island, nothing open on island, box lunches
   provided.
   10:30 Ferry leaves Port Clyde Pier for Monhegan
   3:00 Ferry leaves Monhegan to return to Port Clyde

b. Rainy/Cold Weather:
   Transportation Museum (Owlshead)
   Farnsworth Art Museum (Rockland)
   Camden wanderings

9:30          | Leave in vans for Ferry or sights                                      | I - Dining Room           |

5:30-7:00     | Dinner                                                                 |                           |

7:30-8:30     | Topic Groups (Continued)                                                 | (Same Group Locations)    |

8:30-9:30     | Report by One or Two Topic Groups to Large Group - Primary purpose is to
   receive comments from other specialists |                           |
SPECIALIST MEETING AGENDA
Initiative 4 – Use and Value of Geographic Information

WEDNESDAY, MAY 10

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30-8:45</td>
<td>Breakfast</td>
<td>I - Dining Room</td>
</tr>
<tr>
<td>9:00-11:00</td>
<td>Reports by Topic Groups Continued</td>
<td>MH - large room</td>
</tr>
<tr>
<td></td>
<td>Submission of Written Documents</td>
<td></td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>Shuttles leave for airport</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

USE AND VALUE
OF GEOGRAPHIC INFORMATION

A Bibliography

UNCERTAINTY AND RISK ASSOCIATED WITH DECISION-MAKING


DECISION MODELS


DEMAND FOR INFORMATION


BENEFITS OF GEOGRAPHIC INFORMATION

GENERAL BACKGROUND ARTICLES ON
GEOGRAPHIC INFORMATION SYSTEMS (since 1987)

1. General Introductory Papers (Particularly introduction to GIS)

2. Introduction to LIS

3. Obtaining Data

4. Introduction to DataBase Structure
5. Applications


6. Access to Public Information


7. Diffusion of Innovations


Infotech Ltd.
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8. References from Specialist Meeting Position Papers

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----------; Eby, J.R.; Brewer, L.W. 1986. The role of Landsat multi-spectral scanner data in the analysis of Northern Spotted Owl
----------; and James, D.E. In draft. Decision support at a very large hazardous waste site. EMLS Las Vegas.
----------; and Sierra, J.A. 1989. GIS implementation in the U.S. Environmental Protection Agency: the role of management and
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Conference. ESRI, Redlands, CA.
Conference. ESRI, Redlands, CA.
Schwenk, C.R. 1984. Effects of planning aids and presentation on media performance and affective responses in strategic decision -
making. Manazement Science, 30, 263.
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Stout, K.K.; Slonecker, E.T.; Sitton, M.D.; Peroutky, J.D.; Carter, J.A.; and Hewitt, M.J. 1989. The Old Southington Landfill: hazardous waste site investigation using a geographic information system. Proceedings HAZMAT Central '89. EHM Institute, Durham, NH.


9. Readings suggested by I-4 Specialist Meeting Participants


Patterson, V. 198 1. The Cost and Value of Information (from: Proceedings of the American Society for Information Science); v. 18.


10. Taxonomy