Zablocki Park Creek

Water Quality Problems
Loss of Habitat
Toxicity
Limited Recreation

Nonpoint Source Pollutants
Metals
Suspended Solids
Nutrients
Pathogenic Organisms
Oil and Grease
Low/High Flow

Observed and Potential Pollutants
Urban Lands
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Cover: The cover map represents a portion of the Kinnickinnic River Priority Watershed in Milwaukee, Wisconsin. This map was one of three parts in a project depicting the use of GIS in nonpoint pollution modeling. The overall project (described in the cover feature article on p. 69) won the Project Showcase “Best Map” award at URISA ’94 in Milwaukee last August.

The Kinnickinnic River Priority Watershed is part of the metropolitan Milwaukee area and extends across six municipal jurisdictions. None of the streams in the watershed are meeting full biological or recreational potential. Water-quality problems include loss of aquatic habitat, low oxygen, high bacteria, toxic levels of metals, oil and other organic compounds. The use of a GIS in conjunction with an empirical model (Source Loading and Management Model: SLAMM) designed to predict pollutant runoff characteristics in an urban area, proved to be an effective way to assess and display urban nonpoint source pollution. The map links pollutants, their sources, and associated water-quality problems to specific streams within the watershed.

The map, which was produced using ARC/INFO, identifies various densities of residential land use (burgundies), commercial land use (purples), open space (greens and blues) in addition to institutional, industrial and transportation uses. United States Geological Survey 1:100,000 digital line graphs (DLGs) served as a base map, saving time associated with digitizing. A new technique was developed to use the DLGs and large-scale photography (1" = 400') to update a 1:24,000 land use map.

The cover map was produced by Kristine Kuhlman at the Land Information and Computer Graphics Facility at the University of Wisconsin-Madison. The SLAMM model was developed by the Wisconsin Department of Natural Resources.
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MANUSCRIPT SUBMISSIONS: URISA Journal is dedicated to sharing knowledge about information systems among managers, users, developers and educators, so that improved systems can be developed and used more effectively and equitably at all levels of government. Manuscripts, correspondence or questions on editorial matters should be addressed to the following section editors: Referreed: Ken Duerer, Portland State University, P.O. Box 751, Portland, OR 97207; (503) 464-4042. Features: Lyna Wiggins, Rutgers University Center for Urban Policy Research, Livingston Campus Bldg. 4161, New Brunswick, NJ; (908) 932-3423. Reviews: Rebecca Somers, Somers St. Claire, 3157 Babashaw Ct., Fairfax, VA 22031; (703) 204-0033. Maps: Ted Koch, Wisconsin State Cartographer, 160 Science Hall, 550 N. Park St. Madison WI 53706; (608) 262-6852.
In This Issue...

Internet, Superhighway, Cyberspace. New words for a brave new world of information technologies. But will these new technologies and a host of support services be an information panacea? Or the next Pandora's box? In Gary Ostroff's opinion piece, he surmises how Gustave Flaubert, a 19th century author and artist, might have viewed yet another technological leap.

Editorial Intent

Consider In My Opinion to be a forum for your thoughts, an opportunity to speak your mind. The only guidelines we suggest are that it:

- Be relevant and well-written.
- Address an issue that is related to URISA.
- Be a topic of current interest or debate, yet not so time-sensitive that the Journal's publication lead-time would detract from its impact.

We invite you to express your opinion. Please send your submission to Kenneth Dueker, David Moyer, or Bernard Niemann.

The Editors
Flaubert on the Internet

Gary Ostroff

It is with a sense of unease that I have read the many (many!) discussions of the imminent information superhighway. It seems that virtually all of the articles are positive, some are just plain corporate boosterism, and they sing the praises of technology and the benefits which it will certainly bestow upon us. To be fair, many people express a keen awareness that the development of the superhighway is approaching a critical phase that could determine whether it is dominated by closed corporate interests that are bent on offering us 500 channels of pabulum or a more open, democratic, and it is hoped, constructive alternative. Nevertheless, outside of the vast money-making possibilities it poses, is the superhighway really something to be so excited about? Is the Internet really the harbinger of a new age of wonderful cyber-communities that many see in it? Is all of this progress? I find myself thinking again and again of that solitary, stoic romantic artist, Gustave Flaubert, creator of Madame Bovary. In his Dictionary of Received Ideas he railed against, to use a favorite phrase of his, all sorts of similar enthusiasms. What would he have made of it all?

In Flaubert’s nineteenth century, when technological progress was deemed synonymous with progress itself, the analog to our revolutionizing computer technologies was the railroad. What miracles would this new mode of transport bring about, and did it not epitomize in its very action the hurtling progress of western civilization itself? Some were not so sanguine. Flaubert, with his ear so painfully and exquisitely attuned to the cadences of intellectual cliches, wrote in his Dictionary:

Railroads. If Napoleon had them he would have been invincible. Talk about them ecstatically, saying: “I, my dear sir, who am speaking to you now—this morning I was at X; I had taken the X train; I transacted my business there, and by X o’clock I was back here.”

He followed with:

Railroad Stations. Gape with admiration; cite them as architectural wonders.

Clearly, Flaubert was not impressed. His controlled ridicule concealed a suppressed rage. To him, the idolatry of the railroad was just another popular delusion. I hear echoes of his sarcastic definitions when I read how computers, and now the information superhighway, are transforming all of our lives—for the better it is claimed. Always the emphasis is on the great increases in productivity, i.e., business productivity, and personal convenience which we may expect, and on the intrinsically wonderful nature of the change the technology will bring. The paperless office, video phones, telecommuting, virtual reality, virtual amusements, and on and on!

As Flaubert remarked in his letters, technological progress without moral progress yields barbarism, and the Franco-Prussian War only confirmed him in his views. Certainly, he would have cited World War I as conclusive proof, had he lived to see it instead of merely predicting it. In his stoical, romantic—and many thought—cynical view, people were swept up in fads, bedazzled by mere technology, technique and machines, that is, without asking about the consequences of such new opportunities. In other words, the short-term view looked marvelous, but who worried about suburban sprawl, air pollution, train wrecks, or simply the effect of a faster pace on the quality of everyday life itself. Who worried about the destruction of the world that made the innocent piety of the characters in his Three Tales possible?

I suspect that the positive effects of our new information/communication technology are not all that certain either, since people have difficulty in evaluating change in its context. Word processors and desk-top publishing, for example, have certainly removed much drudgery from office work. But the standards for commercial texts, business proposals, reports, etc. are now higher. I have compared engineering reports from 25 years ago to contemporary examples and found that the recent ones are slicker, much bigger, and have more varied graphics, but I would hesitate to judge them any better. Change we will certainly have, dizzying change, in fact. Although the information superhighway will certainly get some important data to people who desperately need it, I suspect that its main effect on most people in their everyday lives will be to ratchet even higher the standard for what it means to be informed, competitive, up-to-date, in touch, and au courant. No real progress here! As Flaubert remarked, often ordinary Parisians were convinced that the sophistication of the great me-

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Gary Ostroff works at HydroQual, Inc. in Mahwah, New Jersey in water quality engineering and watershed management. He is responsible for database and GIS project efforts related to urban and rural hydrology. The history of technology is one of his main interests.
tropolis reflected their individual cosmopolitanism, when in fact they were usually urban provincials. Inundated by cataracts of information, we may deceive ourselves into believing that we actually know something.

Now, Flaubert had a rather unpleasant view of life, and he was wont to dwell on the negative and on the frequent displays of human stupidity which always tormented him. Certainly the coming of the railroads was not going to be held up, just as some form of information superhighway will be here soon, and so it should be. Given the nature of our economy and our culture, it is a necessity. But is it good? That is what gnawed at Flaubert, for he felt the changes he observed were not. They merely were, and society would go on being what it was; brutal, corrupt and philistine. We all know that it is too much to blame technology for not making us all virtuous, but we rarely refrain from praising new technology as though it will bring out the best in humanity. Perhaps it's time for a bit of stoical and deadpan appreciation of our new marvel. May I suggest:

Information Superhighway. Large bandwidth communications network facilitating rapid and high-volume transfer of digitally encoded information.

Otherwise, some contemporary Flaubert may write in his dictionary:

Information Superhighway Shake one's head in wonder and say, "I can't believe what computers can do today! Way just ten years ago..." Sure to change the world, a whole new realm of communities. Speak ecstatically, saying, "Just this morning I downloaded 10,000 pages of business data from across the world—I have so much data I can't even look at it!"
In this issue . . .

John Felleman introduces the concept of “deep information” to emphasize integration of environmental and property data, using the state of New York’s environmental regulatory interest in private real property. “Well thought-out, intriguing, and well-presented,” commented one of the referees.

In contrast to the above institutional analysis is the technical analysis in the paper by Jeff Paradis and Kate Beard. They introduce the term, “data quality filter” to visualize and communicate spatial data quality. The paper discusses an important issue in the development, update, and use of GIS databases. It clearly presents a problem and suggests an approach for addressing it.

A paper by Jeff Pinto and Bijan Azad assesses the role of organizational politics in GIS implementation. Their case studies of two state departments of transportation illustrate the importance of organizational political behavior in explaining different paths to GIS implementation.

Last, a paper by Stephen Gillespie attempts to measure the benefits of GIS implementation. The distinction it makes between ‘efficiency’ and ‘effectiveness’ outcomes is well-taken. He uses two transportation case studies to illustrate issues in estimating benefits of GIS analysis.

Editorial Intent

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

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

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

If the manuscript is accepted and does not need revising, it is sent to the managing editor for comments and final editing. If the manuscript needs revision, assistance is provided by the editors. If the manuscript is not accepted, it is returned with an explanation by the editors. (For complete guidelines regarding the preparation of manuscripts and illustrations, see p. 112–113.)

Kenneth J. Dueker
Deep Information: The Emerging Role of State Land Information Systems in Environmental Sustainability

John Felleman

Abstract: Environmental sustainability entails both a complex synergistic process of environmental knowledge-building and proactive pluralistic responsibility. Current disparate real property and environmental regulatory information systems block this process. Deep information, the state-facilitated integration of property and environmental data at the site level, is emerging as the key to this critically necessary transformation.

In recommending that EPA establish a nationwide ecological mapping and monitoring program (EMAP), the SAB (Science Advisory Board) pointed out that, given the regulatory framework of EPA, it was important to know the relationships between environmental stresses and the effects observed. Despite the SAB’s recommendation, it is not clear to what degree EMAP plans to focus on cause-effect relationships.

(Committee to Review EPA’s EMAP 1992, p.8)

The first thing to understand is that the public peace-the sidewalk and street peace-of the cities is not kept primarily by the police; necessary as the police are. It is kept primarily by an intricate, almost unconscious, network of voluntary controls and standards among the people themselves. In some city areas...the keeping of sidewalk law and order is left almost entirely to the people and special guards...such places are jungles.

(Jacobs 1961, p.31)

Deep Information

We can take Ms. Jacobs quote from a period of urban volatility, substitute the words environmental quality for peace/law/order, and regulatory agencies for police, and describe a major issue of the 1990s. Environmental sustainability has emerged as a dominant wisdom-based management goal. How do we go about generating the informed social fabric necessary for its propaga-

John Felleman is a professor of environmental studies and director of the graduate program in environmental science at the State University of New York’s College of Environmental Science and Forestry. He has a bachelor's and masters in civil engineering from Cornell University, a doctorate in public administration from New York University, and is a licensed engineer. Current research and teaching include: environmental decision-making, environmental information policy, and environmental visualization.

In order to make meaningful progress towards this end we will need to achieve two knowledge-building objectives.

First is to admit our continuing endemic ignorance of systems processes and institutionalize broad monitoring-modeling-feedback programs. The EMAP program is a partial step in this direction. Second is to recognize that there are both multiple perspectives regarding systems functionality (plural science), and shared public-private responsibility in perpetuity for environmental stewardship (plural democracy).

Underlying both objectives is the concept of “deep information,” which integrates property and environmental data. Deep information directly links the smallest scale of environmental data collection (in-situ discharge reporting, well sampling, wetland designation, etc.) with society’s fundamental environmentally responsible data unit: the landowner. A “deep information system” facilitates integration of these currently disparate data streams. This would enable both spatial and temporal aggregation for modeling and disaggregation for continuous education, participatory democracy, and police powers control. Such a system would be fully “open,” accessible to all environmental stakeholders.

The need for deep information is not widely recognized. Environmental concerns, which originally were legislated at the federal level, have been delegated in large part to the states for implementation. These have come into direct conflict with the traditional practice of land use planning, which is primarily practiced at the local scale, emphasizes fiscal health, and is dominated by individualized negotiations with developers. While the geometrically increasing complexity of the development process has added significant private and public sector costs, many environmentalists feel their goals are not being achieved. At the heart of their concern is the apparent inability for the regulatory approach to take a systems view of cumulative impacts. Much of this inef-
ficiency and ineffectiveness is due to haphazard information systems, which have been created to respond to the rapid growth in mandated regulations.

This paper reviews the evolution of the environmental-land development information problem, and outlines the emerging form of its resolution. Emphasis is placed on the critical role of state government, while most descriptions are drawn from New York state.

In the two-plus decades since Rachel Carson’s book, *Silent Spring*, and the National Environmental Policy Act (NEPA 1969) catalyzed the modern environmental movement, a fundamental shift of focus has occurred. Initially, energies were concentrated on exposing and halting major projects such as an Everglades Jetport, the broadcasting of DDT, and the massive discharge of raw sewage into the nation’s estuaries. These high-profile problems were addressed by a combination of constraining governmental abuses, outright bans on some practices, new federal regulations of the private and public sector (most notably air and water point “pipe and stack” discharges), and the increased visibility and third-party litigation leverage provided by impact statements. Such approaches together constitute the “modern” program which has spearheaded major gains in slowing environmental degradation and improving public health.¹

In stark contrast, a rapidly growing set of low-profile problems has surfaced over the last decade. From our deepening understanding of environmental systems a new consensus has developed on the primary goal of environmental sustainability.² It has become increasingly clear that the previous background issues—such as wetlands, hazardous materials, nonpoint pollution, sole source aquifers, and radon—are critically linked to the central goal of sustainability. It is also becoming obvious that the modern program of environmental management is a fundamentally inadequate means of achieving and maintaining this goal.

Insights to this lack of effectiveness can be gained by briefly profiling some common functional characteristics of these emergent issues against those of the modern program. The problems are spatially dispersed (in contrast to “point”), and encompass numerous landowners. Frequently, the phenomena of concern manifest over extended periods of time, measured in years, generations, even centuries. The phenomena often involve low levels of harmful attributes with cumulative effects. These disturbances, releases, transports and exposures are a function of the day-to-day operations of the land- (and water) based activities interacting with the locally unique context of biophysical conditions. Finally, the physical transport, ecosystem, and human health dynamics of the affected systems are often poorly understood.

Three key attributes—spatially dispersed private land use, protracted time frames, and process ignorance—constitute a fundamentally new challenge. Each of the three problem attributes represents a set of misfits to underlying management concepts and practices of the modern program.

First, a singular, top-down role of the federal government is not a viable approach for dealing with spatially dispersed private lands. Laws regarding the ownership of land, its records and taxation, and regulation of the use of the land are responsibilities of the states and their designated local governments. Indeed, we can see in problem arenas, such as sole source aquifers and flood plains, an emerging environmental federalism that combines federal policy frameworks with financial carrots and sticks, and with state police powers.

However, there are fundamental flaws inherent in this variant in the modern program. Many states essentially delegated much of their land use regulation to municipalities during the pre-environmental period between the world wars when zoning was sweeping the country as progressive reform.³ States, such as New York, have reinforced this partial autonomy with statutory “home rule.” Since zoning itself is often optional and has a long history of being highly politicized and quite volatile, it provides a dubious foundation for programs designed to create long-term stewardship.

Another problem facing a state police power land regulation management approach is the “taking issue.” This old constitutional challenge is alive and well, as exemplified by recent Supreme Court rulings ⁴ and continuing flow of more scholarly texts.⁵ State regulatory legislation designed to avoid takings are carefully worded as *apriori* compromises with the private sector:

... to regulate use and development of such wetlands to secure the natural benefits ... consistent with the general welfare and beneficial economic, social and agricultural development of the state.

(New York State Environmental Conservation Law Sec. 24-0103)

The result is highly predictable. Even if implemented well they can at best slow the rate of environmental degradation. They cannot sustain systems. Subsequent policies, such as “no net loss” trivialize the complexity of the environment with overly simplistic (but expedient) acreage swaps.

The second attribute—protracted time frames—is the antithesis of the primary traditional management mechanisms of land development/operating permits, often coupled with impact statements. Both of these mechanisms can be classified as “one-stop” decisions, occurring at one point in time. Environmental impact statements are based on the presumption that the important issues can be identified, analyzed and solved prior to
the undertaking of a development project. Wetland, floodplain, septic system and other permit-based approaches take a similarly positivistic view. The one-stop approach has been an adamant position of the real estate and development sector in response to the ever-increasing (often uncoordinated) regulatory obstacle course.

One stop is more often than not an informational dead-end. Impact statements, containing extensive “amendation” proposals, line shelves, then are delegated to warehouses. Permits, issued to developers with extensive “conditions,” are filed in departmental archives. Frequently there is little or no follow-up monitoring. Subsequent land owners, managers and users typically have no knowledge of either potential problems or responsibilities.

The final attribute, process ignorance, is enfolded in the first two. Individual actions collectively modify environmental systems. The systems themselves are stochastic and highly interrelated. Although NEPA was in some ways visionary, its one-stop impact statement focus reinforces a disjointed, incremental approach to management. NEPA’s view of both natural and social systems was and is mechanistic and utilitarian:

Identify and develop methods and procedures . . . which will ensure that presently unquantified environmental amenities and values may be given appropriate consideration in decision-making along with economic and technical consideration.

(NEPA 1969)

At the outset of NEPA, federal agencies such as Departments of Transportation and Agriculture, and the EPA, needed a means to satisfy NEPA’s project impact-prediction requirements. Consequently, they funded new applied research for topics as diverse as noise, erosion, scenic quality, and landfill leachate. Within a decade, funding dried up and analysts were left with toolboxes primarily consisting of pragmatic, empirical estimates. (Felleman 1990) Although there have been few audits of federal impact analyses, and probably none of state “little NEPA’s,” the quality of prediction appears alarmingly low.

In contrast to the initial project impact focus of the seventies, federal agencies in the eighties were asked to make systems-related management decisions. These included acid rain, groundwater pollution and critical habitat preservation. Understandably, the response was a call for research and data gathering. All of these study arenas began to reveal a degree of complexity, which essentially concluded that precise predictions are probably not possible. For example, the National Research Council studying subsurface pollution has concluded:

There is a range of capability in modeling fluid flow in geologic media. Modeling saturated flow in porous media

is straightforward . . . (however) conceptual issues and/or problems in obtaining data on parameter values limit the reliability and therefore applicability of flow models involving unsaturated media, fractured media, or two or more liquids . . . Agencies can (should) not specify a list of government-approved models . . . (because such a list appears to be an implicit warranty). (Water Science and Technology Board 1990)

Equally disturbing has been the realization that, despite the existence of regulatory permit systems, it was virtually impossible to aggregate a valid estimate of environmental systems health from the individual actions. The dead-end permit recording systems were never designed to provide strategic information.

The modern program of environmental management fails to meet the challenges of the emergent sustainability issue because of its narrow construction of stakeholders, and its internalized environmental ignorance. A management structure that successfully accommodates change and uncertainty must first and foremost be a system that promotes learning. (Simon 1992) Knowledge-building is necessarily founded on complementary information generation, dissemination and feedback structures. Clearly the ad hoc, artificially deterministic, one-stop regulator-regulatee dialog is inadequate to the task.

A more robust construct would embrace market mechanisms, political pressure, torts (including class vs. class actions), and evolving personal value systems. For our emergent environmental issues, the legitimized stakeholders include not only governments and developers, but present and future landowners, land managers, occupants, lending institutions, insurers, neighbors, industry, and environmental interest groups. These parties need both continuous, direct access to parcel-specific environmental information, and the ability to report monitoring data to the appropriate governmental body.

At the systems scale, public agencies need to develop working understandings of environmental processes. Although clearly a public good, as in all natural and social science, development of such knowledge can only occur through the critical give and take of multiple parties each with differing agendas. Methods include stochastic math models incorporating the parcel-based data mentioned above, in combination with independent monitoring of system dynamics. The systems models and information need to be readily accessible to all stakeholders.

Synergistically, these two complementary continuous information approaches, integrative multiattribute parcel scale and aggregate functional systems scale, constitute a structure of “deep information.” Deep information facilitates iterative knowledge-building and
supports the multi-stakeholder negotiations that are increasingly critical in developing wise stewardship.

Deep information in conjunction with the modern program holds considerable promise as a means for achieving sustainability. Although intrinsically complementary, the two decades plus of the current top-down regulatory approach has resulted in a set of significant institutionalized barriers to change. These barriers are particularly high for parcel information. The following section will focus on the parcel issues, drawing examples primarily from the state of New York.

Parcel Information in New York State

Real property ownership is traditionally defined as the "bundle of rights" encompassing the possession, use, and disposition of the land, its underlying soil and geology, overlying air, and physically affixed structures and trees. Although primarily conceived from the perspective of private ownership, several "branches out of the bundle" are in the domain of federal and state government, including power to tax, police, and condemn. (Pedowitz 1984) In the United States, the sets of public records dealing with real property ownership are traditionally known as the "cadastre," and today are being reformulated as Land Information Systems (LIS).

By the end of the nineteenth century, a mature cadastral process had evolved to meet the multiuser commercial needs of the private sector, and the administrative and tax needs of the public sector. The process was a truly integrated distributed information system, with sets of deeds, plats, liens and mortgages, and assessments linked by chronological transaction indices of names and addresses of buyers/sellers, lenders/borrowers, etc. These records and indices have historical pointers to preceding records, are transactionally updated, and are typically available in geographically distributed county offices. In most areas, this century-old system remains virtually intact today.

The actual descriptions of the real property's physical attributes in these records are spatial, typically limited to a description of its spatial location (sometimes ambiguously), and computed or estimated area. Property tax files would normally also include a dominant land use category and some quantitative and qualitative description of building improvements. Completely missing from this system are state records of police power interests. This dearth of environmental and regulatory information strongly reflects the dominant eighteenth and nineteenth century ethics of land as a private commodity, and caveat emptor.

The post-World War II metropolitan-development boom severely strained the capabilities of the traditional cadastral system from the perspectives of private development, public infrastructure planning, natural resource management, and property tax assessment. In his seminal work, Land Use Information, Clawson (1965) defined the growing information gap by identifying the integrated bundle of descriptors necessary for comprehensive land management:

- geomorphic base (geology, soil, hydrology)
- surface cover (vegetation systems)
- structures
- utilities
- activity patterns
- management practices
- user populations
- ownership
- regulation
- taxation

In addition to the inadequacy of the traditional cadastre's attribute descriptors, its locator and indexing system became severely stressed. Quality control involving inconsistent names and addresses, access time involved in manual record searching, problems in spatial location, and the imminent need to reconceptualize prior to electronic conversion of data generating a crisis of national scope. Following a decade of study, four primary conclusions were reached:

1) The land ownership parcel must be the basic spatial information unit;
2) Name/address identifiers are inherently inadequate; therefore
3) Each land parcel should be assigned a unique hierarchical Parcel Identification Number (PIN) such as municipality-section-block-lot, and includes a State Plane Coordinate System-based visual centroid coordinate pair; and
4) The additional cost of developing this system could be met by expanding beyond traditional land title applications to the development of a multi-use cadastral resulting in a broadened user base.

At the time of the national studies, New York state had recently emerged as a leader in the development of a modernized state real property assessment system, which incorporated advanced mapping standards: PINs. The rationales behind the program were: 1) the legal need to impose equity through data standardization (and "equalization" multipliers), and 2) the pragmatic need to increase effective yields through a comprehensive top-down reform of the prior highly politicized local-assessment practices. This progressive change can be understood as a fundamental restructuring of a public information system. This was necessary to support the concurrent regionalization of service districts such as schools and utilities, and the emergence of strong metropolitan counties.

Despite its leadership, the New York system was hardly visionary. It was authorized and implemented as a single-purpose (taxation), single-user (government) construct. It added no additional real-property descrip-
tors identified by Clawson, except utility districts (which is not equivalent to on-site utilities) and physical-based exemptions (such as wildlife preserves) permitted, but not required, by tax law. While meeting a few of the internal structural reforms called for by Moyer and Fisher (1973), it essentially ignored the promise of a multi-use cadastre.

The Environmental Movement

The rapid growth of the fifties and sixties included massive sprawl, interstate highways, urban renewal, and extensive energy-generation and transmission projects. These in turn spawned the modern environmental movement. In 1969, NEPA opened the floodgates to federal, state and local regulation of parcel-specific aspects of the environment.

For much of the twentieth century, the primary police-power regulation of real property has been municipal zoning. This highly politicized, temporally volatile, and (in New York) locally optional practice was not designed for environmental stewardship. As an information "system," zoning maps and ordinances are locally available, and thus present only modest additional effort to the private sector use of the traditional deed/mortgage/tax cadastre available at county clerks' offices.

The explosive post-NEPA growth of federal and state environmental regulations has occurred in complete conceptual and physical isolation from the cadastral system (Table 1, Columns 1 and 2). Many regulations are state implementations of federally mandated programs. Most have been promulgated in the past two decades. All involve long-term physical attributes of real property. Collectively, they constitute a broad new state declaration of real property "interest" representing a fuzzy mixture of public ownership (with all the inherent complexities of police powers and takings), and private stewardship responsibility.

Have these regulations, designed to solve environmental problems, fostered the generation of deep information? A series of prototypical questions based on the two cornerstones of deep information—environmental systems level knowledge, and informed private sector transactions—is illustrative:

- Can a prospective developer rapidly assemble a comprehensive set of state environmental records regarding a parcel (and its neighboring properties)?
- Can an environmental interest group ascertain the health of a regional ecosystem?
- Can a state legislative committee determine the cost-effectiveness of a regulatory program?
- Can an insurance company establish actuarial-based environmental property and life insurance rate zones, similar to fire or automobile insurance?

Virtually none of the underlying deep information needs embedded in these scenarios can be met by the state's bureaucracies. Despite the millions of public and private sector dollars spent over the past two decades on environmental regulation, mapping, studies and impact statements, the "traditional" real estate information crisis of the 1960s has now blossomed into the environmental information crisis of the 1990s. Many local governments have initiated database and geographic information systems (GIS) projects partially to meet this need. In most cases, these systems either omit critical state regulatory data, or are forced to approximate it at either high cost or dubious data quality.

Information Barriers

The modern program has generated three intertwined sets of barriers to the development of deep information:

1) Jurisdictional Balkanization
2) Inappropriate Mapping Scale
3) Internally Focused Management Information Systems (MIS) Databases

A fourth barrier is the inertial resistance to change jointly presented by the real estate and development sectors and the responsible public agencies.

Jurisdictional Balkinization

A state environmental regulation cannot be arbitrary or capricious; it must apply uniformly across the state wherever a set of specified conditions exists. However, the use of specifying threshold conditions (such as a 100-year flood plain) in environmental regulations is actually a highly simplified view of complex exchange processes which typically have sources, pathways, and receivers. No single descriptive information system covers the broad spectrum of environmental processes. They can be simplified into a two-by-three matrix of the basic combinations of sources and receivers (Table 2).

Column 3 of Table 1 extends this classification to the state's privately owned real property interests. In addition to the basic couplet forms, the dynamics of physical processes can create linked chains of these issues such as flood plain encroachment which increases flood peaks which harm built structures (H-N-B), and lead paint and petroleum discharges which enter a drinking water aquifer and affect children (H-N-H). In each classification category the environmental information involved is unique. A robust information system needs to link each component of the operational chains and the affected parcels for modeling, education and responsibility.

Once there is a public and political consensus about an environmental problem, and a real property-related action is called for, policy decisions must be made in
<table>
<thead>
<tr>
<th>Topic</th>
<th>Agency (1)</th>
<th>Causal Chain (2)</th>
<th>Delineation (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adirondacks</td>
<td>APA, DEC</td>
<td>L-N/H</td>
<td>OM,FZN</td>
</tr>
<tr>
<td>Air Emissions</td>
<td>DEC</td>
<td>L/N</td>
<td>FZH</td>
</tr>
<tr>
<td>Airport Noise</td>
<td>DEC, DOT</td>
<td>L-H</td>
<td>OM</td>
</tr>
<tr>
<td>Archeol Hist.</td>
<td>Parks</td>
<td>L-B</td>
<td>FZH</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Labor</td>
<td>L-H</td>
<td>FZH</td>
</tr>
<tr>
<td>Bulk Fuel</td>
<td>DEC</td>
<td>L-H/N</td>
<td>FZH</td>
</tr>
<tr>
<td>Chemical Stor.</td>
<td>DEC</td>
<td>L-H/N</td>
<td>FZH</td>
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<tr>
<td>Endang Species</td>
<td>DEC</td>
<td>L-N</td>
<td>FZN</td>
</tr>
<tr>
<td>Essen. Habitat</td>
<td>DEC</td>
<td>L-N</td>
<td>OM,FZH</td>
</tr>
<tr>
<td>Floodplain</td>
<td>DEC, Municipal</td>
<td>L/N-H/B</td>
<td>OM</td>
</tr>
<tr>
<td>Haz. Waste</td>
<td>DEC</td>
<td>L-H</td>
<td>FZH</td>
</tr>
<tr>
<td>Landfill</td>
<td>DEC</td>
<td>L-H/N</td>
<td>OM</td>
</tr>
<tr>
<td>Pesticide App.</td>
<td>DEC, Agricul.</td>
<td>L-N/H</td>
<td>FZH</td>
</tr>
<tr>
<td>Prime Agricul.</td>
<td>Agriculture</td>
<td>L/N-N/H</td>
<td>OM</td>
</tr>
<tr>
<td>Radon</td>
<td>Energy, Health</td>
<td>N/L-H</td>
<td>(FZN/H ADHOC)</td>
</tr>
<tr>
<td>Scenic River</td>
<td>DEC</td>
<td>L/N-N/B</td>
<td>OM</td>
</tr>
<tr>
<td>Septic Sys.</td>
<td>Health, County</td>
<td>L-H/N</td>
<td>FZH</td>
</tr>
<tr>
<td>Sole S. Aquifer</td>
<td>DEC, Health</td>
<td>L/N-H</td>
<td>OM</td>
</tr>
<tr>
<td>Surface Mine</td>
<td>DEC</td>
<td>L/N-N</td>
<td>FZH</td>
</tr>
<tr>
<td>Surface Water</td>
<td>DEC</td>
<td>L/N-N/H</td>
<td>OM</td>
</tr>
<tr>
<td>Well-Gas</td>
<td>Energy, DEC</td>
<td>L-H/N</td>
<td>FZH</td>
</tr>
<tr>
<td>Well-Water</td>
<td>Health, County</td>
<td>H/N-H</td>
<td>FZH</td>
</tr>
<tr>
<td>Wetland</td>
<td>DEC, County</td>
<td>L/N-N</td>
<td>OM</td>
</tr>
</tbody>
</table>

Abbreviations:

- APA-Adirondack Park Agency
- DEC-Dept. Environmental Conservation
- DOT-Dept. Transportation
- B-Buildings
- H-Human Health
- L-Land Use
- N-Natural System
- OM-Official Map
- FZN-Floating
- Zone: Natural
- FZH-Human Activity

Legislative drafting as to what form of action is to be taken, and which agency should have implementation authority. Action forms include: acquisitions, regulations (mandatory or locally permissive), tax incentives, assistance in obtaining federal aid, and informational.

New York, like many states, had developed in the first half of the century a clear division of responsibility between the Departments of Health (H receivers), and Conservation (N receivers). The former focused on public health with origins in controlling communicable diseases, while the latter emerged from fish and game management combined with reforestation and recreation. Other departments which had environmental-related administrative responsibility are Transportation, Labor, Agriculture and Markets, and regulatory bodies such as the Public Service Commission.

The creation of a Department of Environmental Conservation (DEC) in 1970 was a first step toward comprehensively engaging the rapidly growing list of environmental problems. But as shown in Table 1, fundamental divisions of responsibility between agencies persist. The information balkanization problem is further exacerbated by the programmatic division of responsibilities within agencies. All state agencies incorporate a combination of centralized and decentralized functions. Regarding the latter, the state health department has a long
TABLE 2. Environmental Causal Chains

<table>
<thead>
<tr>
<th>Source</th>
<th>Human Health (H)</th>
<th>Receiver Built/Cultural (B)</th>
<th>Natural Sys.(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use (L)</td>
<td>L-H</td>
<td>L-B</td>
<td>L-N</td>
</tr>
<tr>
<td>Natural (N)</td>
<td>N-H</td>
<td>N-B</td>
<td>N-N</td>
</tr>
</tbody>
</table>

history of weak regional management with extensive delegation of responsibility to strong county health departments. In contrast, the newer Department of Environmental Conservation has had to rely on strong regional bureaus in the absence of complementary county governmental structures. Thus for each state environmental regulatory activity, the resource or regulatory record system may be in Albany, in the department’s regional office, in a county government department, or some combination of these.

Inappropriate Mapping Scale

State environmental regulations specify the conditions which trigger jurisdiction, the physical classification descriptors under which a specific privately held parcel falls under the regulation. Three distinct approaches toward establishing state environmental interest in private real property have been developed (Column 4, Table 1). In some instances, a publicly significant, spatially articulated natural resource or phenomenon is pre-identified by the government. Examples include floodplains, wetlands, and prime agriculture. In each case an “official” map (OM) of the affected area is created and legitimized by administrative procedure.12

In the second situation, the characteristics of a regulated natural resource or phenomenon is known, but its spatial location has not been apriori articulated. This is a “floating natural zone” (FN). Examples include endangered species, and radon in buildings. Once identified by public or private sources, there is a need to integrate this information into the permanent public record. In the third jurisdictional situation, it is the human land-based activity itself, historical or proposed, which may trigger regulatory action. These are “floating human activity zones” (FH). Public records of these activities may or may not exist, depending on the date of action, knowledge of a regulation, and degree of conformance with the regulatory process. Examples include use of pesticides, removal of asbestos, and disposal of hazardous wastes.

Official map state delineation approaches have chronically suffered from inadequacy of mapping scale. Professional standards, shown in Table 3, exist for mapping based on intended use (Committee on Cartographic Surveying 1983). The presence or absence of resource or phenomenon within an ownership parcel is a “Micro-Planning” scale mapping problem, requiring maps between 1” = 100’ and 1” = 1000’ depending on the size of the parcels. The specific location of a problem such as a storage tank or a flood limit is equivalent to “General Design,” calling for mappings of 1” = 40’ to 1” = 200’ in scale.

Obviously, if effective public management and private sector stewardship of these resources and phenomena is to occur, they must be delineated at the parcel level and continuously communicated to all interested parties. New York state has high-quality professional parcel maps at the desired scale range (1” = 50, 100, 200, 400, and 800’ based on density of development pattern). These are mandated for taxation purposes, and are maintained locally by each county (N.Y.S. Local Government Law Part 189). But what about environmental mapping?

Resource thematic data such as soils and floodplain boundaries are normally compiled at scale between 1:10,000 (1” = 830’) and 1:100,000 (1” = 8300’). Transferring the already imprecise boundaries, whether by hand or by computer, to a cadastral (parcel) mapping scale implies a higher accuracy than warranted, which may create erroneous information relating to specific parcels of land.

(National Research Council 1983, p. 104)

Sadly, New York remains in the majority of states criticized a decade ago by the National Research Council:

TABLE 3. Appropriate Mapping Scales

<table>
<thead>
<tr>
<th>Use</th>
<th>Scale Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Design</td>
<td>1” = 2’ to 1” = 50’</td>
</tr>
<tr>
<td>General Design</td>
<td>1” = 40’ to 1” = 200’</td>
</tr>
<tr>
<td>Micro Planning</td>
<td>1” = 100’ to 1” = 1,000’</td>
</tr>
<tr>
<td>Local Planning</td>
<td>1” = 400’ to 1” = 2,000’</td>
</tr>
<tr>
<td>Regional Planning</td>
<td>1” = 1,000’ to 1” = 10,000’</td>
</tr>
</tbody>
</table>

Source: ASCE (1983)
Exchange of land data between systems describing natural phenomena, on the one hand, and cultural phenomena, such as attributes of land parcels, on the other are greatly facilitated when both are built upon the foundation of a multipurpose cadastre... However, more existing natural area data have been compiled without the benefit of this accurate spatial referencing. Until their boundaries are referenced to the same coordinate system, such data exchange will require arbitrary apportionments...

(Ibid., p.3)

Three examples will serve to illustrate the widespread occurrence of spatial misinformation. The state freshwater wetlands maps prepared by D.E.C. (and by some counties) are mapped on 1" = 2000' U.S. Geological Survey maps for permit decisions. These local/regional scale (see Table II) delineations are a continuing source of controversy, negotiation, and litigation involving property owners. Neighboring states in New England and New Jersey are moving to larger scale mapping of wetlands as overlays on the property ownership maps to resolve this situation. The persistence in New York is both an economic drain and a probable contributor to the continuing degradation of the resource base. The inappropriate mapping scale causes particular problems in areas with small parcel sizes, and led to a major confrontation in Staten Island.13

A second example involves the continuing debate over the appropriateness and effectiveness of the state’s Adirondack Park Agency in protecting the state’s environmental interests in thousands of private inholdings of the park. Here an even bigger map-scale compatibility problem exists. While the large scale tax mappings described above exist for the park, the jurisdictional map for the regulated use zones is published at a gross Regional Planning scale (Table II). In addition to frustrating local owners and developers, this disparity is so fundamental that it helps undermine the ability of the state to even determine whether the regulatory process is meeting the stewardship objectives.

A final example involves flood insurance. This is a classic example of a federal “pass through” program. New York, unlike many states such as Michigan, has never been serious about environmentally regulating floodplains. It was, and is politically expedient to write off land use as a local “home rule” responsibility, conveniently overlooking the physiographic reality that hydrology ignores political boundaries. The enabling statute blatantly reflects this non-environmental objective in its title: “Participation in Flood Insurance Programs.” (N.Y. State Environmental Conservation Law sec. 36)

In order to qualify for federally subsidized flood insurance, the state D.E.C. has a token unit which facilitates federally mandated mapping and planning requirements. Predictably, the minimal federal mapping (General Design / Micro Planning, Table 3) is frequently insufficient to ascertain whether an inhabitable structure is in or out of the designated flood area (a Critical Design to General Design scale, Table 3, decision). This complex technical determination is left to the lending institutions, a group with little or no cartographic or engineering capability and a vested interest in selling insurance (Federal Emergency Management Agency 1987). The state could have required adequate mappings, such as overlays on the tax parcel base, and the development of a public record of affected parcels.14 Rather, it has chosen to be satisfied with the federal lowest common denominator. By default, the state has no capacity to build knowledge regarding flood areas; the private sector reinvents the wheel each time a parcel is sold or structure erected.

These diverse examples point out a strategically fundamental problem related to environmental mapping in New York state: there is no central coordination and no state mapping standards. Many states, such as Georgia, Oregon, Wisconsin and Minnesota, and the federal agencies, have in recent years set up (by executive order or legislative mandate) interagency mapping groups to develop standards, coordinate major mapping expenditures and promote information sharing. New York, however, is still at the informal discussion stage.15

Internally Focused Management Information Systems

The legislative assignment of a new regulatory activity to an administrative department is just an initial step in the evolution of an information system. The department must internally decide whether to delegate to an existing unit (division, bureau...) or to create a new one. Permit forms must be generated, logs of permitting activities developed, and tracking strategies developed for conformance compliance.

Permits are a classic type of transaction, and lend themselves to being organized by principles of Management Information Systems (MIS). The modern environmental movement has coincided with the information revolution. Typically the responsible unit has set up an internal database, either comprehensive or summary, for permits. A comprehensive database would include all the data elements in the permit form; while a summary database uses selected data fields (e.g., name, address, date, number, action) to provide information for resource management, such as staff assignments, budgeting and locating the original paper permit records.

The regulatory permit record approach to environmental administration has demonstrated a strong tendency to become an end in itself rather than a means to
stewardship. (Mattingly 1993) Although this is understandable from the perspectives of both bureaucratic organization theory, and the chronic underfunding which characterizes many environmental agencies, it poses a major constraint to the development of deep information.

The permit databases are typically designed to rely solely on internal (applicant/agency) data sources, and to be used solely by internal employees. In combination with the administrative balkanization of environmental responsibilities, the existence of numerous disconnected data sets undermines effective usage by the private sector and interested publics. For example, a centralized subunit of DEC manages the Bulk Oil Storage program, regional DEC offices handle wetlands, while septic system records are held by a county health department, and asbestos removal information is the responsibility of the licensed contractor.

New York's Department of Environmental Conservation has developed a Regulatory Compliance Information System (RCIS) which has greatly enhanced its efficiency in processing applications, tracking renewals and violations, and gaining a “multimedia” composite of a facility. However, the system does not make use of PINs with their tie to parcel information and high-quality visual centroid. Rather it relies on name, address, and a crude EPA quality estimate of latitude and longitude. (N.Y. D.E.C. 1987)

If managed for knowledge creation, the MIS record system could be used to improve the inherent fuzziness of originally inappropriate mapping scales. As each structure is surveyed for flood insurance, and each wetland is field-checked for a disturbance permit, the original maps could be updated and refined. At a systems scale for example, as development progresses in a watershed, the predictive basis for delineating the flood zones evolves. Therefore, the affected parcel designations require periodic revision. In no instance has such information feedback-based stewardship been done.

A major independent study of the Adirondack Park Agency sought to ascertain whether its regulatory system was actually leading to the achievement of the legislated environmental goals. Not unexpectedly:

As a practical matter, nobody really knows with great certainty how much noncompliance is occurring and how effective is the Agency's enforcement program ... our inability to determine compliance rates in a reasonable time suggests the law is seriously flawed.

The Commission further recommended:

The construction and maintenance of a system of information... Essential to the above information system must be a layer of ownership and unique tax identification numbers for all lands within the park... this is the only and economically and logistically feasible method to manage a political and geographic area as large and complex as the Adirondack Park. (Commission on the Adirondacks 1990)

The agency has been using PINs in its application forms for a number of years; however there was not an integrated information system which could readily aggregate scattered regulatory data. A pilot project currently underway is examining a fully electronic document-image management system encompassing both new and historical records.

Private and Public Sector Inertia

Many environmental health problems such as asbestos, lead paint, and radon are causally tied to the physical character of the site and buildings. These are clearly a component of real property. Since awareness of these problems has typically arisen after the decisions to build and occupy were made, an effective stewardship approach must address a composite of education, regulation, and positive and negative economic incentives. The time frame and geographical distribution of these problems create unique sets of owner stakeholders.

Generalizing, asbestos involves many post-World War II (1950s and 60s) structures including public buildings, commercial, and subdivisions. Lead paint problems are centered on early and mid-twentieth century urban areas, often low income districts. Radon occurs throughout the nation, has no time frame, and often has high occurrence rates in suburban and rural owner-occupied single family residences.

An information-based model for the rational management of this class of problems was developed at the turn of the century in the control of tuberculosis and other diseases endemic in overcrowded urban tenements. The components include: 100 percent inspection conducted by professionals; the development of parcel and building specific public records; periodic monitoring and notification/education of owners and residents; and the cooperation of other agencies, public interest groups, elected boards and the media. (city of New York 1903)

It is interesting to contrast what a century of “progress” has brought. By some estimates, radon may pose a risk to New York state residents of a magnitude similar to that of the tenements. In response, there are no regulations and no knowledge-building open-information system to manage this entirely controllable problem. The Environmental Health unit of the Department of Health sponsored some billboards; their 800 number told you to go to a hardware store and buy a test kit (which are notoriously easy to fake safe results by simply covering the holes). The real-estate sector informally encourages sale contract conditions creating a patchwork grey/black market of testing and ameliora-
tion. Cae\textit{vat} emptor reigns! Unlike the earlier reform model which had the slumlords as a clear target, the homeowner population of New York and its elected officials are ignorant and afraid. The professional health department is dysfunctional, waiting (as per lead, radon, asbestos... ) to see if there will be a federal mandate for action.

Probably the major high-visibility example of the potential for parcel-based environmental information systems to revolutionize stewardship is the field of hazardous waste. Evolving federal legislation\textsuperscript{15} has established strict liability, in essence transcending a strict regulatory framework and embracing a broad approach of nuisance-focused “statutory common law.”\textsuperscript{17} The private sector had two questions: where are the problems, and who pays?

In general, to argue that someone is a non-liable innocent landowner they must demonstrate they’ve reviewed “any commonly known or reasonably ascertainable information about the site,” including its immediate neighboring parcels, and conducted an on-site audit.\textsuperscript{(Turner 1988)} The full impact of the liability responsibilities came center stage in U.S. v. Maryland National Bank and Trust Co., where a bank that gained title through a mortgage foreclosure was held liable for costly cleanup (632 F.Supp. 573 (D.Md. 1986)).

All public records may be legally considered commonly known and reasonably ascertainable. Inferences that some potentially hazardous waste activity may have occurred on a particular site in the past may be found in literally hundreds of different federal, state, and local public data sources ranging from tax assessments to fire inspections; from operating licenses to zoning variances. There is no way our currently chaotic set of records can support the timely needs of the private sector. Hazardous waste represents a floating-zone human-activity jurisdictional information problem (Tables 1, 2). In stark contrast to the lead and radon issues, CERCLA generated a major demand in the real estate and business communities, (and affiliated demand by the neighboring publics and non-governmental environmental interest groups), for an adequate information system. Because of Love Canal, New York became a leader in addressing the abandoned hazardous-waste site problem. While RECRA was focusing initially on active sites, New York took a more comprehensive view. The legislatively mandated information trajectory which has evolved around the 1979 New York State Hazardous Waste Disposal Sites Act is quite revealing:

\begin{itemize}
  \item In 1980, and every year thereafter, the DEC is to report to the legislature and governor the identity of every inactive hazardous waste site known to the department, including site address, location latitude and longitude (EPA) and current owners (N.Y.S. Environmental Conservation Law sec. 27-1305).
  \item 1982. DEC shall maintain and make available for public inspection at its regional and subregional offices and at the office of the county clerk or register for each county the facility address and “site boundaries” (replacing latitude and longitude); time used for hazardous waste; name of current owners and operator, and names of past owners and operators during time period used for disposal (ibid.).
  \item 1990. By July 1993 each county recording officer must provide an index of present and past owners and operators of inactive hazardous waste disposal sites contained in DEC’s annual report. The index shall contain: an alphabetical list of present owner; reference to page and year of DEC report (N.Y.S. Real Property Law sec 316(b)).
  \item 1991. Drop requirement of recording past owners and operators and present operators. Add: “The index shall also contain the tax map parcel number or the section, block, and lot number of the site” (ibid.).
\end{itemize}

This information evolution is not unique to New York. Formal parcel linking had previously been adopted in Minnesota (Minn. Environmental Protection 115B.16); West Virginia (W.Va. Code sec 20-5E-20); and Pennsylvania (35 Pa. Sec.6018.405). The conclusions in this high-stakes arena are quite obvious. First, the environment is the joint responsibility of the public and private sectors. Second, stewardship responsibilities exist in perpetuity. Therefore, narrowly construed agency management information systems need to be comprehensively redesigned to encompass the needs of pluralistic sets of end-users.

In the high-visibility case of hazardous waste, some fundamental information stewardship questions remain:

\begin{itemize}
  \item When a site has been certified as being “cleaned,” will it disappear from the indices (even though future standards may be more stringent)?
  \item As a floating human-activity zone delineation problem, sites are continuously being discovered. Most of the current discovery takes place during privately contracted site audits. Should this information enter the public record?\textsuperscript{18}
\end{itemize}

Finally we must again address the lower-profile but more significant problems such as asbestos, lead and radon. How do these follow hazardous waste into a land information system?

**Can We Get There From Here?**

Every state-level examination of environmentally related stewardship in recent years has identified the gap between real property information and environmental information. The RCIS initiative from DEC, its wetland\textsuperscript{19} program review, Governor’s Adirondack Park Review Commission, the hazardous waste legislative maturation, and the Vision 2000 study (1993), all strongly reinforce the recommendations reached ten years ago by the National Research Council (1983):
In a multipurpose cadastre, these (data) components must be maintained in a manner that provides the foundation for other registers of land data, each keyed to the standard parcel identifiers for the retrieval of specific records and for linking with data in other files . . .

The decisions of state governments, or their lack of decisions, will set the pattern. The adoption of standards will depend on the authority of state legislation. Each state (should) create an Office of Land Information Systems to provide the needed leadership and administer (the necessary) grants in aid to local governments.

The databases used in agencies are relational. By using a common data field, data tables can be linked, and logical operations performed to facilitate searches, create new records, and customize tables and reports. Since none of New York's state environmental record databases incorporate PINs, the promise of deep information, via a distributed multi-purpose environmental LIS, remains merely conceptual.

The challenge of developing a deep environmental information system in a state like New York is quite complex. The cumulative information response since the 1970s, including administrative balkanization, imprecise resource mapping scales, and disjointed databases are the antithesis of public sector knowledge building and private sector communication. These obstacles are compounded by the magnitude of the problem (New York has approximately 5 million parcels with roughly 10 percent changing ownership annually), and the state's lack of a centralized approach to information stewardship.

Despite these problems, recent advances in both the technical and policy arenas hold considerable promise in the short run. What would such a system look like? Initial highlights would be:

- Rather than a single centralized database, a distributed network of connected data indices would link central state offices, regional state offices, and county offices (and potentially dial-up remote private parties).
- All new real property transactions, including the traditional deed, tax, mortgage, lien records would incorporate the appropriate PIN, and electronic indices including the PIN would be maintained on line by the county clerks.
- All new environmental records would include the appropriate PINs. Electronic indices of these PINs would be maintained by the appropriate county, state-regional, and state-central offices.
- A "locator" front end would handle queries providing a comprehensive listing of all available environmental records and the appropriate source for further detail.

Models for all of these components now exist. The province of Alberta has been the North American leader in a "state" level, remotely accessible, comprehensive, land information system. In Australia, the development of a central "Registry of Restrictions" is designed to serve the multi-agency, multi-end user information needs. The "locator" concept is being implemented in federal agencies. Idaho is putting its water resources on line, and Texas is rapidly moving toward statewide interconnections. Meanwhile, distributed real-time transactional data linking is fueling the productivity revolution in the retail and manufacturing private sectors.

New York has developed distributed, linked transactional systems in response to major high-publicity information-driven crises: criminal records and welfare fraud. It remains to be seen whether the "quiet crisis" in environment and real estate will lead the governor and legislature to similar action. Meanwhile the problems continue to grow. The federal government has recently given New York City two options: treat its water at a cost of billions of dollars, or manage its sprawling mid-Hudson and Catskill watersheds encompassing hundreds of thousands of urban and rural residents, farmers and businesses. The city, with few fiscal resources, has pragmatically chosen the latter. Will it work? "... nobody can promise the city that protecting the watershed will be enough ..." (N.Y. Times Dec. 20, 1992).

There is a clear sign of progress however. The city has recently entered into a contract with the state Division of Equalization and Assessment to obtain parcel files for five counties. This may enable the development of a linked LIS-runoff modeling-regulatory compliance framework.

The Federal Dimension

The above discussion has focused on the state level. States constitute the critical environmental stewardship Lynch-pin in our system of federalism. In reviewing New York's situation, we must also examine briefly the influence of the national government. The need for deep information has been recognized within the federal natural resource agencies. It has not, however, emerged as an objective of environmental regulators.

For federally owned and managed lands, the multiple-use legislation of the 1960s followed by the environmental mandates of the 1970s has led to the continuing development of planning-monitoring-modeling approaches. Although there is still considerable controversy regarding the openness of these processes in regards to meaningful public participation, considerable progress has been made toward gaining a better understanding of basic natural systems. Since virtually all these systems are disturbed, the continuing effects of human activity and the associated complex of managerial and permit-regulated actions constitute a critical dimension of stewardship.
In a final report required by the Federal Land Exchange Facilitation Act of 1988, the Department of Interior’s first recommendation was:

1A) The concept of a nationwide land information management system should be adopted.
1B) Components that all land information systems should contain are:
   - geodetic control...
   - basic map information...
   - property boundaries including uniquedentifier for land parcels; and land attributes, including legal rights and land use information as needed by particular jurisdiction.

(U.S. Department of the Interior 1990)

The federal land management agencies, such as the Forest Service and Bureau of Land Management, are making considerable LIS progress. The federal private sector regulatory agencies such as FEMA and EPA aren’t. It appears that because it would be unfeasible for them to develop uniform parcel linkages for the whole country they therefore ignore it out of hand. A more proactive information policy approach to federalism would be for such agencies to encourage and require parcel linking for programs such as flood insurance, and toxic release inventories in those states that have parcel numbering data systems.

Beyond the obvious pragmatic benefits in both public and private sectors to such an approach, is the deep information potential for continued knowledge-building. Illustrative is the EPA’s continually controversial Environmental Monitoring and Assessment Program (EMAP). The agency states its objectives are to: estimate ecological status, change, distribution and extent; seek associations between selected indicators of natural and anthropogenic stresses and ecological conditions; and to generate periodic reports. (EPA 1993)

The National Research Council’s continuing critiques have in part focused on the “stressor indicators...natural processes, environmental hazards or management actions...which will often be measured and monitored by programs other than EMAP.” (National Research Council 1992, p.5) The apparent reliance on remote sensing land cover (as opposed to comprehensive land-use information) and second- and third-party stressor indicators raise serious questions about the ability to develop informed causality-based policy. Parcel level land information is as essential to this objective as field monitoring of some indicator species. To date, the voluminous EMAP study design and literature appears to ignore the proposed federal approach toward an integrated LIS.

There is currently a wide range of discussion and committee work underway on data-exchange standards, data-quality analysis, and the “information highway.” Such efforts are necessary building blocks, but together do not constitute a coherent framework for deep information. What is needed at the state level is comprehensive information policy that expands the obsolete nineteenth-century view of the cadastre to include legislatively mandated state environmental interests in real property. Similarly, at the federal level, we need broad policy to legitimize state LIS within federally mandated environmental regulation. In combination with the continuing evolution of electronic public access and open systems, these fundamental policy shifts would help build the deep informational bridge to environmental stewardship.

Notes

1. The successes of the regulatory approach have been far greater for initial compliance than for continuous performance. See Russel (1986).
2. Environmental sustainability involves maintaining the functional and restorative capabilities of natural systems. The term is commonly expanded to “sustainable development,” which embraces continued growth in human population and economic activities. That these two goals are compatible remains to be seen. For some insights to this ongoing debate, see Colby (1990).
3. Revisionist historical perspectives of this “reform” have downplayed the importance of environmental concerns such as public health (air and light), and safety (congestion and fire), and focused on zoning’s blatant economic segregation means to the primary general welfare end of stabilized real estate values. See Boyer (1983).
4. The debate over taking is only a dilemma (public good vs. private property) when one fails to examine the potentials of the information revolution and the market. What if the state of South Carolina had publicly pre-identified that housing construction in one coastal reach would directly increase storm damage in another specified reach as a basis for subsequent class vs class actions (see Lucas 1992)? What if all children’s camps were required to have insurance to operate, and Los Angeles Co. notified carriers that specific properties in the creek zone were subject to flash flooding (see First English 1987)?
5. For the perspective that essentially all regulation is a taking, see Epstein (1985). For the view that sustainable development requires a fundamentally new ownership stewardship ethic, see Bromley (1991).
6. For a review of this problem, see Culhane (1985). Since there is virtually no monitoring data, the researchers relied on interview “guesstimates.” Another issue was precision vs. accuracy. The study tabulates many high-accuracy rates because the analyses were so vague that almost any future would be consistent with the prediction.
7. For a rare look into both the total absence of an aggregate perspective in permit-based regulations and the difficulty in assembling such a view, see Mattingly (1993).
8. The modern program is inherently monolithic, while the new environmental reality ranging from global warming to local “Not In My Backyard” (NIMBY) is pluralistic. For an insightful treatment of this shift, see Schwarz (1990).
9. The breadth of active participation in this undertaking reflects both the extent and depth of the perceived information crisis, and the promise of newly emerging computer approaches such as the Sensus DIME work, and the Federal Information Processing Standards (FIPS).

10. It is important to recognize that NEPA is both a facilitator of regulation creation, and an anti-information systems policy. For the former it is of the "candy over the fence" category. Controversial projects generate impact statements which identify potential impacts to the public and various administrators. This creates highly focused pressure to pass regulations. As an information systems policy, NEPA is an abject failure. A complete lack of standardization in classification, mapping and modeling; the absence of even rudimentary quality control; the failure to develop storage-retrieval-archival mechanisms; and the great consumption of scarce resources are the antithesis of cumulative knowledge-building.

11. An examination of regulatory management regarding "pathways" is illustrative of the inability of permit systems to build process knowledge. A good example is the static 20-year use in New York state of a generic 100-foot buffer around all regulated wetlands regardless of geomorphic, hydrologic or ecologic contexts. What started out as a legal convenience has become institutionalized ignorance.

12. In the case of wetlands, state administrative procedures require notice be given affected property owners during a review period prior to formal map approval. DEC staff hand-generated a mailing list by visually matching mapped wetland units with tax parcel maps. Once mailing labels were generated, the PIN indexed owner lists were discarded! From a regulatory monitoring standpoint, the department has no ability to update current owners; from a stewardship perspective it has no proactive targeted continuing information/educational program. Wetland informational materials are passively available upon request.

13. See Riexinger (1983). New York regulates wetlands greater in size than 12.4 acres. The Corps of Engineers regulates wetlands greater than 1 acre based on gross U.S. Fish and Wildlife Service maps at 1:24,000 scale. Recently DEC's Commissioner has stated that New York should take over complete responsibility for this resource. See DEC (1992). Although New York's management of small wetlands would be a clear improvement over the chaos of the current federal approach, the state's currently inappropriate mapping scale would be even more inequitable; while its misuse of PINs would continue to undermine the potential of private stewardship.

14. A similar land information systems dead end appears to be developing in the state of California. In response to its continuing earthquake presence, the state has undertaken an ambitious hazard-mapping program. Building regulation is the responsibility of local government, the market is supposedly informed by "... sellers disclosure to buyers of properties in hazardous zones" (Turner 1992).

15. The high cost of developing large geographic information systems has been a major stimulant for state coordination efforts. See Warneke (1991). Legislation to establish a state GIS "study" committee is pending in New York.


18. This issue involves the debate between privacy and public safety. See Nolan (1992).

19. In a internal legislative memorandum dated 1987, the DEC acknowledged the wetland information disparity, and supported passage of a legislative requirement wherein "... necessary (landowner) information would be available in the miscellaneous indices in the county clerk's office which are routinely checked as part of the title search for property land transfers."

20. A two-year study of modernizing land record information systems has made this recommendation to the Governor (Governor's Task Force on Filing and Recording 1993). To date there has been no executive action or legislative initiative response.

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Sec. 271305 (1982).


Visualization of Spatial Data Quality for the Decision-Maker: A Data-Quality Filter

Jeffrey Paradis and Kate Beard

Abstract: The lack of effective communication of data quality (fitness for use) is a key issue hampering the successful utilization of geographic information systems (GIS). Current GISs do not explicitly address quality information and provide few or primitive means by which to communicate it. This work proposes a “data-quality filter” to efficiently organize and communicate data quality to a decision-maker. The filter relates data quality information directly to the visualization of data, providing an implicit yet precise portrayal of the data’s fitness for use. To apply the filter, the user defines a set of quality requirements with respect to accuracy, resolution, consistency and lineage. As the user retrieves and processes one or more data sets, only data meeting the specified criteria pass through the “filter.” The visualization technique simply displays the data meeting the user’s specifications. The application of the filter to a cadastral data set of heterogeneous quality illustrates the effectiveness and utility of this approach. The filter directly relates quality and its communication and encourages users to become intimately involved with their actual data requirements, contemplate trade-offs, define a realistic error budget and participate in comprehending the effects of a GIS function on a data set.

Effective communication of data quality is a key issue hampering the utilization of geographic information systems (GIS). Current GISs do not address quality information (Burrough 1992; Chrisman 1989) and provide few or primitive means by which to communicate it. Goodchild (1993, p. 94) highlights the lack of quality communication saying, “... spatial databases ... rarely inform the user of their accuracies in any useful manner.” Quality (fitness for use) is a major concern because it determines the limits of use for any data set. GIS must therefore support and communicate quality information to fulfill its role as a technique for rapidly combining information from multiple sources to aid decision-making.

Openshaw (1989, p. 263) succinctly describes the communication problem stating:

... with manual cartographic methods many problems are visible and the highly skilled operator makes the necessary adjustments and knows how far the information can be relied upon. With GIS the equivalent operations are transparent, the operators are no longer so knowledgeable in or aware of the limitations of the data and problems are more or less completely invisible.

The key to the success of the manual process was the interaction between the data collector, the map-maker and the user as described by Raisz (1938, p. 1), “... The surveyor measures the land, the cartographer collects the measurements and renders them as a map, and the geographer interprets the facts thus displayed.”

The functions were separate, yet there was a logical flow and order by which information was passed between phases. This process generated specific information products along with implicit measures of quality understood by experts. In some cases, maps included explicit quality information in the form of reliability diagrams (Chrisman 1983). Many of these beneficial characteristics of maps should exist at the visual interface of a successful GIS.

Within current GIS the user can be completely isolated from and often ignorant of the data collection and compilation processes and their potential to affect and influence the results of GIS processing. The transparency of GIS operations and their effects compound the isolation of the user from the potential problems of the information processing and the outputs. Computer-generated maps may, in fact, imply much higher quality than is warranted. According to Goodchild (1991, p. 118), “... The average user will approach a GIS or spatial data-handling system with the assumption that all internal operations are carried out with infinite precision.”

Jeffrey Paradis is a graduate student in surveying engineering at the University of Maine. He has been working on the NCGIA Initiative 7, “Visualizing the Quality of Spatial Information.”

Kate Beard is associate professor of surveying engineering at the University of Maine. She is co-leader of NCGIA Initiative 7.
Current approaches to GIS have bypassed much of the quality information of traditional mapping by focusing on issues and components of data that can be rapidly captured and implemented on a computer. Substantial numeric processing capability alone does not solve the problem faced by a GIS user (with what confidence can the data be used?). For example, the digitization process used today (digitizing paper maps) discards much of the useful information normally incorporated in a paper map, such as ancillary textual information (compiled by whom, when, etc.). Ancillary textual information combined with map style, scale, series and publication or production organization (e.g., 1:20,000 SCS Soils Map) provides an implicit concept of the overall fitness for use of paper maps. Digital products do not carry such quality information, although some researchers (Chrisman 1983; Goodchild and Gopal 1989; Lanter 1991) are addressing the inclusion of quality information in GIS. To formulate a successful GIS strategy it is necessary to provide such information and allow the user to interact with the data and its quality directly.

Quality information is the key to putting GIS products into an understandable form. Such information provides the necessary context to place information in a model that verifies potential uses and failings of data with respect to an application. In the traditional process, a USGS 1:24,000 scale topographic map may have been chosen over a surveyor’s 1:1200 scale topographic survey, depending on potential application and the effect of quality (fitness for use) on that application. The limiting factor is that quality is implicit and the users’ assessment depends wholly upon their knowledge of mapping. Because the nature of digital data requires an explicit approach, GIS has the potential to be much more effective and robust in managing and communicating quality. The capability to explicitly access and interact with data based on overall quality needs will allow future systems to pass the expertise/knowledge of the surveyor, cartographer or other experts to the GIS user.

The data-quality communication problem can be addressed by the efficient and effective use of visualization tools in combination with modeling and measurement of quality variables. From the viewpoint that the strength of the mapping process lies in its ability to deal with data quality, albeit implicitly, and the strength of maps lies in visualization, GIS technology should focus on quality in two ways: 1) support quality reporting as an integral part of data, data collection and information processing (Goodchild 1991), and 2) allow the user to directly interact with the data with respect to quality issues. This paper focuses on a technique that addresses the latter issue, providing true user involvement in the data-quality issue. The proposed approach, a ‘data-quality filter’, controls the display of data based on its quality. The filter concept is a tool that requires users to specify data-quality needs according to their prospective application. The data-quality filter provides a structure in which to specify data-quality needs and view the data based on these quality specifications. These characteristics provide effective communication of data quality and education on the limits of the available data.

Context for the Filter: Quality and the Decision-Maker

Beard and Mackaness (1993) describe three contexts for quality assessment: a production context, an exploration context and a decision-making context. This paper focuses on the decision-making context. The decision-making context is the strength of GIS, allowing the combination of many resources to formulate a ‘best’ solution: “...the ability to manipulate spatial data into different forms and to extract additional meaning from them is at the root of current interest in GIS technology.” (Goodchild 1987, p. 327) GIS is currently being used to more efficiently model natural phenomena and analyze the effect of different management practices (e.g., erosion and pollution monitoring, Ventura 1990; Niemann et al. 1988; Young et al. 1989; and Vieux and Needham 1993). When GIS is used to determine the utilization of limited resources, the quality of the data has critical consequences.

In a decision-making environment, the digital representation of any spatially referenced feature is ambiguous at best without aspects of quality such as described in Goodchild and Gopal (1989), or Veregin (1989). To base even the most rudimentary choice on information generated by a GIS, a decision-maker must know how the data were collected, how they were processed, and the values of specific measures of quality. Even simple measures such as overall root mean square error (rmse) or percent correctly classified (PCC) can help inform the user/decision-maker. Quality and its measures can be classified many ways, in order to fit various schema, but it is essentially task defined: Does the quality of the information meet the decision-maker’s needs? Beard and Mackaness (1993) describe the quality information requirements of decision-makers as:

- immediately accessible
- interpreted in the context of the task
- available in a format pertinent to the decision-making environment

Because user data-quality needs are dynamic and vary with application, there is no efficient or practical manner to design a system to anticipate all possible users’ data-quality needs and prevent possible misuse (Coulcelis 1992). The variation of user needs combined with a lack of communication tools for data quality hin-
der comprehensive and efficient analysis by the
decision-maker. Because of this variation, any system
design should avoid a propensity to rigorously define
and dictate potential fitness for use to the user.

To provide flexibility in a decision-making context, a
communication technique must encompass the prag-
matic production context requirements as well as some
Exploratory Data Analysis (EDA) (Beard and Mack-
anness 1993). Exploration of data quality can shift focus
away from a results-oriented approach to an open-
ended search for ‘new’ relationships between variables,
which may not be the most efficient method of attack
for a decision-maker. The complexity and focus on ‘ex-
ploration’ limits the use of EDA as the primary source of
data-quality information for the average decision-
maker. EDA should be employed as a secondary arm to
investigate data quality when commonly used ap-
proaches, such as analysis of variance, cannot provide
understandable answers. Examples of innovative sys-
tems that could be utilized in such a role are: Polygon
Explorer (MacDougall 1992), SPIDER (Haslett, Wills and
Urwin 1990) or OMEGA (Weihs and Schmidli 1990).

To accommodate the decision-maker it is necessary to
provide a context in which quality information is ex-
plicit, robust, and yet subtle. Subtle communication cre-
ates a context in which the effectiveness of data is en-
hanced, not overwhelmed, by quality information. Both
implicit and explicit measures of data quality can be
combined to provide for the variable needs of decision-
makers, through communication of and education in
the limits of data. Geographic information systems must
provide storage, computation and communication capa-
bilities that complement and aid the human interpretive
and creative processes used by decision-makers.

A Data-Quality Filter

This paper describes a ‘data-quality filter’ in which
measures of data quality are used to filter data as they
are retrieved and/or processed by a user of a GIS. The
user defines a set of quality requirements with respect to
positional and attribute accuracy, resolution and lineage.
Only data meeting the specified criteria are passed
through the filter to be viewed by the user. Other re-
searchers (MacEachren et al. 1993) have touched upon
the filtering idea, but the core of this concept is to create
a logical framework for mapping quality to a visualization
technique that provides a simple yet effective tool
for the decision-maker.

The Filter Concept

The filter is based on the data-quality matrix (Figure 1)
described by Beard and Buttenfield (1992), which is
composed of the combination of Sinton’s (1978) obser-

![FIGURE 1. Data-Quality Filter Matrix composed of Sinton’s (1978) observation requirements and the FIPS data quality standard (Feagas et al. 1992)](image)

![FIGURE 2. The shaded areas (a) illustrate how any combination of quality components important to a user’s application can be chosen. Measures that could be chosen to define locational accuracy are highlighted (b).](image)
quality measures could be computed from primitive quality values stored as data attributes or if a GIS operation has been performed, from a GIS error propagation function. For example, positional accuracy measures such as RMSE (Figure 2b) could be computed from coordinate (x and y) residuals stored as point attributes. Values for frequently used measures could be precomputed or compiled and stored routinely as part of standard GIS operations.

The decision-maker uses the matrix structure to describe quality criteria appropriate for the prospective application. These criteria are defined by specifying a quality component, quality measure and a threshold value for that measure. The filter consists of one or more user-specified data-quality tuples (component, measure, threshold). When data are retrieved and/or processed by a GIS, the filter (all data quality tuples—component, measure, threshold) is applied to the data and only data meeting the criteria are displayed. To assist the user, two techniques clarify the status of the displayed data. First, the filter reports the percentage of the total data set(s) passed. Secondly, the filter provides the capability to toggle on and display data which did not pass. These features communicate the availability of additional lower-quality information.

To enhance assessment of quality, the filter allows separate examination of the data’s behavior with respect to each user-specified quality threshold. For example, a classified image could be subjected to a positional attribute and temporal filter simultaneously or to each filter independently. The user can thus experiment to determine the limiting quality component of the data set. These features back up, enhance and explain the potentially unexpected results generated by the filtering process.

The filter would sit on top of current GIS and be invoked at the user’s discretion. When invoked, the filter alerts the decision-maker to potential problems and limits of data by not displaying data of inferior quality, as defined by the user’s criteria. This informs the user that quality limits do exist. The data-quality filter provides multiple quality measures and several techniques (separate filtering, toggle and percent passed) to help the user determine a meaningful definition of quality and a measure of its magnitude. For example, the filtering process could produce a view with little or no data passing the filter, resulting in a blank screen or areas with no data visible. Such a blank, or nearly blank, screen explicitly and directly notifies users that a data set or results of an operation do not meet their quality requirements. The shock value achieved through this approach sharply contrasts the characteristics of the available data and the user’s expectations. The filter requires users to become intimately involved with their actual data requirements, contemplate trade-offs, define a realistic error budget and participate in comprehending the effects of a GIS function on a set of data.

The filter fulfills the three decision-making quality requirements described by Beard and Mackaness (1993). First, it is not only immediately accessible, but an integral component of the analysis process. Second, because it is part of the analysis process it is automatically interpreted in the context of the task. Finally, it is available in a format pertinent to the decision-making because the quality components of interest are determined by the user. The filter presents the opportunity for effective feedback, interaction between the user and the system, and visualization of quality components. The importance of visualization in the effective communication of data quality cannot be overemphasized. By operating directly on the data, the filter provides an efficient framework to visualize and assess data quality at any time. This capability better informs decision-makers by furnishing applicable quality information while simultaneously presenting the data.

Filter Requirements

The focus of all GIS processes from data collection to final production should be on the creation of data in which quality is incorporated in order to fulfill the information needs of a decision-maker. The filter is based on the existence of quality measures not currently incorporated in GIS data sets. Presently, if the filter is used in conjunction with a GIS and no data quality measures are available, no data will pass the filter. This communication technique effectively accomplishes a goal of the filter by simply alerting the user that the quality component of the data is missing from the data and that the data are of unknown quality. As more complete data sets (containing quality information) become available and the filter is incorporated into GIS, this capability will help blend new and old data sets while consistently informing the user of the availability of quality information. The incorporation of some quality information in data is being formalized by the FGDC Content Standards for Digital Geospatial Metadata (1994) and ASTM Content Specifications for Digital Geospatial Metadata (1994). These standards define measures for positional and attribute accuracy that could be readily incorporated into the filter.

Implementation of a complete data-quality filter (Figure 1) necessitates not only the formulation of new error models or measures but further study in error propagation. The filter could rely on error propagation functions similar to those described by Lanter and Veregin (1992) for each possible measure. These error-propagation functions for every error measure or index would exist for a wide range of GIS operations, forming part of the “ideal” GIS (Goodchild 1991). Furthermore, quality in-
formation or functions to generate quality information need to be added to the database and integrated with the GIS software in order to respond to user queries.

The need to provide and store additional information requires a reassessment of current data collection and storage techniques. The data-collection techniques used in traditional mapping focused on collecting data for creation of specific products. The data were collected in a manner only adequate for their intended use. Data-collection techniques which were formulated for the generation of paper maps must be modified to support quality assessment for multiple uses. Effective data collection for GIS must use adequate measurement and documentation of data quality to provide spatially referenced data-quality attributes necessary for filter operations. Better measurements and documentation of quality, not higher precision, are elements of the solution to effective communication of data quality. New data structures should be investigated to facilitate the application of the data-quality filter. For example, hierarchical storage of data with respect to locational uncertainty (Dutton 1989) would facilitate filter operation by creating a data structure built on fundamental levels representing data accuracy. A user’s prescribed threshold then becomes the index to directly retrieve the applicable data.

The quality matrix and multiple measures for each category add versatility allowing decision-makers to choose the most appropriate measure(s) for their specific purpose. Coupling a range of potential quality measures with data sets containing attributes from which measures are computed provides a flexible capability from which various views can be generated or new quality measures determined. This versatility is further enhanced by the potential to extend the filter with new or more advanced error measures.

Filter Operation

The filter provides two useful functions: 1) it immediately notifies users of the limits of the data with respect to their specific requirements (these requirements are reflected in quality specifications used as a filter), and 2) it provides a framework of standard quality measures and visualization techniques through which to interact with data.

The filter operates in the following manner:

1) The user chooses the applicable quality categories needed for the prospective GIS application (Figure 2a).
2) The user chooses one of several standard quality measures from each highlighted quality category (Figure 2b).
3) The user specifies minimum quality requirements (a threshold) for all chosen quality measures.
4) a) Actual values for the user-specified quality measures are computed or retrieved for selected data sets.

b) Any GIS operation generates spatially referenced primitive quality attribute values based on error propagation techniques. These are used as above to compute actual values for the user-specified measures.

5) Data sets and GIS products are filtered by comparing the computed values against the user-specified criteria (threshold). The filtering process passes to the user’s view only results meeting the specified criteria (Figure 3a).

The filter’s focus on user choice of quality measures and thresholds provides for direct user interaction with the data in relation to data quality. The capability to allow only appropriate information to be seen clearly informs and simultaneously educates the user in the limits of the data regarding quality for a specific application. By directly involving the user in a context specific assessment of the quality of data, the filter performs a similar function as “go get me the USGS Topographic Map sheet versus a surveyor’s plan.” If the user’s criteria define a “surveyor’s plan” and the data are a “USGS Topographic Map” then no data pass through the filter.

Examples

Example 1

Assume thematic accuracy is chosen as an important quality component for operations on a set of pixels classified for land use. The probability that land use is classified correctly is chosen as the measure and a threshold of 90 is set as the acceptable minimum. When data are accessed, only grid cells/pixels with a probability of correct classification greater than 90 are displayed by the filter. When operations such as resampling are performed, the appropriate error propagation function is applied to the entire data set but only grid cells/pixels meeting the criteria are displayed. This visualization technique applies to operations on all data and prevents the communication of sub-standard (by the user’s own definition) data. The filter provides a safety net that protects users from exceeding the limits of the data with respect to the specific requirements of their application.

Example 2

A rudimentary, yet widely applicable GIS operation is the transformation of data from one coordinate system to another. A set of point data is transformed into a new coordinate system and the filter is applied (Figure 3). In this example, the selected quality category is positional accuracy. The standard quality measure is distance and the user-specified threshold is 30 meters. The data set undergoes an affine coordinate transformation. This operation involves a transformation function being applied to a set of data and an associated set of x,y residuals being generated from the transformed coordinates.
FIGURE 3. Point features that have undergone an affine transformation and have been filtered using a distance threshold of 30m (74 percent passed) are overlaid on the applicable road network (a). Point features not meeting the 30m threshold are 'toggled on' as open circles (b).

using the inverse of the transformation function. Distance values are computed for all points using the x,y residuals. When the filter criterion (30 meters) is applied to the data set, 74 percent of the points satisfy the criteria. The filtered data, all point positions moved less than a distance of 30 meters, are shown in Figure 3a. The points are overlaid on the applicable road network to provide context. The points not satisfying the specified (30-meter) criteria are 'toggled on' in Figure 3b, as described in the Filter Concept section.

Example 3

GIS are often utilized to help formulate land-management decisions. These decisions are often based on reconnaissance level databases (Robinette 1991). Such databases are often limited to determining areas that need further investigation. Current GIS do not show quality and can therefore give a false impression of critical areas warranting further investigation. Such misleading information has the potential to waste finite and expensive assets such as field checking. The following scenario illustrates the effect of quality on a land management decision. This example highlights the power of the filter in communicating these effects. The problem is to determine if there are any clear-cut areas within section boundaries and if applicable regulations apply.

The utility of the filter is highlighted when it is applied to data sets of heterogeneous quality. Data sets with heterogeneous quality are becoming more widely used and available, furthering the need for communication of data quality. This is following a natural evolution in digital data sets as they can now be immediately updated in a piece-wise fashion providing the user with the most current information available. The variable reliability of these data sets requires more robust communication of data quality because the user cannot expect a singular quality level throughout the system. A classified remotely sensed image, by its very nature, has heterogeneous quality described by measures like the PCC for every class. TIGER files are another example of information of heterogeneous quality and which only become more heterogeneous as updates are made. Most of the commercially available data sets have no systematic means for tracking the variation in quality.

The next example highlights the use of an existing heterogeneous data set produced by the U.S. Department of Interior's Bureau of Land Management (BLM). The coordinates in the Geographic Coordinate Data Base (GCDB) are generated by the Geographic Measurement Management (GMM) system. GMM is a computational system that generates geodetic positions of corners in the U.S. Public Land Survey System (USPLSS) based on detailed record information. GMM subdivides to the quarter quarter section level and provides parcel attribute information (Hintz et al. 1993). The strength of GMM lies in its mathematically rigorous approach to the problem of generating geodetic coordinates from record information. GMM uses a least-squares analysis technique which provides the capability to assign error estimates to all input data. Survey Identifications (SID) contain information on who performed the survey, when it was performed and the error estimates for the record data. The SIDs provide unique assets to the GCDB as a direct compilation of the lineage information associated with a survey and a specific tie between how the data were gathered and the reliability of a corner position. The least-squares analysis, using a weighting process, allows the combination of data with large precision differences to formulate a unique solution. The acquisition of new data with a higher precision can be in-
FIGURE 4A. Important quality attributes selected in Example 3 are highlighted.

<table>
<thead>
<tr>
<th>Location</th>
<th>Theme</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lineage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 4B. The quality thresholds chosen in Example 3.

<table>
<thead>
<tr>
<th>Location</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELIABILITY</td>
<td>PCC 0.85</td>
</tr>
<tr>
<td>RESIDUALS</td>
<td>KAPPA COEFFICIENT</td>
</tr>
<tr>
<td>DISTANCE</td>
<td></td>
</tr>
</tbody>
</table>

corporated piecemeal over time, continuously strengthening the results. This measurement-based, re-adjustmentally approach incorporates all available information to generate the 'most likely' location of a corner. The reliability of all corner positions generated by GMM are defined by the final coordinate standard deviations at the 95 percent level. The reliability of boundary lines is simply larger of the two endpoint reliabilities.

The quality concerns in this example are positional accuracy of the boundary lines and the attribute accuracy of the classification (Figure 4a). The user selects the quality measures as reliability generated by GMM (positional accuracy) and Percent Correctly Classified (attribute accuracy). The user determines thresholds of 200 feet and 85 percent are appropriate based on experience and an administrative rule that no clear-cuts are allowed within 200 feet of a property boundary (Figure 4b). The user chooses the four sections of a PLSS township (Figure 5a) in question and a classified image covering the same area (Figure 5b). The image contains three classes: 1) mature Spruce/Fir forest, 2) clear-cut areas and 3) newly replanted areas. At this or any subsequent time the filter can be applied to determine the effect of the filter thresholds on the data. When the filter is applied, the boundary location between sections 10 and 11 is less reliable than the 200-foot threshold and is not displayed (Figure 5c). The filter is applied to the image and the newly replanted class has a PCC less than 85 percent; therefore it is not displayed and the area it encompasses becomes the same as the screen background (Figure 5d). The filter presents the continuous opportunity to re-evaluate the quality criteria in the form of new thresholds or measures. For example, a user could re-evaluate at a new threshold of 75 percent classification accuracy or, if supported by the error model, by an alternative error measure. If the error model described by Goodchild et al. (1992) were applied, the user could view quality on a pixel as opposed to a class basis.

The results of an overlay operation on the data (Figures 5e and 5f) show the filter’s communication technique. Error propagation through the overlay operation is ignored in this example. The overlay in which quality thresholds are not considered (Figure 5e) shows that regulations apply to section 10. When quality is considered, areas in which the data are uncertain with respect to the decision criteria are clearly shown (Figure 5f). It cannot be determined if section 15 contains a clear-cut area because the classification of land use in that section is uncertain based on the user defined criteria. The uncertain boundary between sections 10 and 11 is another area warranting further investigation to determine if section 11 is affected by the clear-cut regulations. An exploratory capability is inherent in the filter concept because the thresholds can be changed at any time. This feature allows the decision-maker to effectively determine the limits of the available data.

Conclusion

The filter concept addresses two of the major stumbling blocks to the data quality issue: 1) robustness with respect to user data-quality requirements and 2) proactive involvement of the user with data-quality issues. The filter encourages the user to have an intimate involvement with the data quality because all data are passed through the filter and the effect of the filter on the resulting display cannot be ignored. The technique provides explicit measures and views of quality through user-defined filter thresholds. The user knows all visible information, irrespective of source or subsequent operations meets a certain minimum quality criteria. Such knowledge parallels the implicit measures routinely incorporated in traditional mapping.

The capability to provide an avenue of education should be a fundamental characteristic of a GIS. Data quality is a necessary component in GIS but the wide
FIGURE 5.
(A) Boundary data for Sections 10, 11, 14, and 15 of T25N17E.
(B) Land use showing clear cut and replanted areas in Spruce/Fir forest.
(C) Boundary data filtered using a 200-foot threshold.
(D) Land use showing clear cut and replanted areas in Spruce/Fir forest filtered using PCC of .85 for all classes.
range of data types and large variation in user requirements require a structured approach to documenting quality. It is unrealistic to expect operators to begin at ground zero for each data set and try to understand, let alone generate, quality information. The data-quality filter enhances the advantages of GIS (combination of large dissimilar data sets) for the purpose of analysis by helping the user understand the quality issues of the specific problem being addressed.

The data-quality filter concept allows users to interact with a GIS using data quality to ‘see’ the limits of available data. It cannot prevent users from making “bad” decisions or improperly using the data, but it can provide a forum where data quality is at the forefront and in which the system itself cannot contribute to a poor interpretation of data. Education is the most powerful force against misuse of GIS products. The data-quality filter provides an educational structure that helps users to better understand data’s limits of use and the ramifications of exceeding these limits in a decision-making environment (Beard 1989).

Acknowledgments

This research presents a portion of NCGIA Research Initiative 7, "Visualizing the Quality of Spatial Information," funded by the National Center for Geographic Information and Analysis. Support by the U.S. National Science Foundation (NSF Grant SES 88-10917) is gratefully acknowledged.

References


The Role of Organizational Politics in GIS Implementation

Jeffrey K. Pinto and Bijan Azad

Abstract: There is still far more to accomplish within the technical realms of geographic information systems (GIS)—algorithms, user interfaces, temporal databases, efficient storage schemes, better raster-vector integration, etc. Nevertheless, GIS technology continues to be acquired and put into use by a wide variety of organizations. Unfortunately, the technology implementation process in the organizational context remains riven with problems leading to project slowdowns or outright discontinuance in many instances. This trend is usually attributed to a wide range of behavioral and organizational difficulties, which tend to impede the more effective use of GIS in organizations.

This paper will focus on one of the more profound and, in many ways, fascinating (and under-studied) themes in successfully implementing new technologies such as GIS: the role of organizational politics. Although anecdotal evidence and case histories abound which link politics to both GIS implementation success and failure, we are lacking a thorough understanding of the impact of corporate politics in the GIS implementation process. In effect, there is still no organizing framework that has been advanced to suggest the ways in which politics can help or hinder the implementation of GIS.

As a first step toward building such a framework, our mission in this paper is to advance the “positive” management of organizational political behavior (OPB) as an integral part of GIS technology implementation process. Toward that end, this paper attempts to address the following five goals: (1) review the evidence on OPB and information and GIS technology implementation; (2) provide logical propositions as to why OPB takes place; (3) establish the contents of OPB in analytical terms, i.e., when can an organizational behavior be considered political; (4) put forward a normative view of “positive” OPB in the form of a number of managerial actions to promote the likelihood of successful GIS implementation; and (5) present two GIS implementation mini-cases from state agencies that illustrate and refine the analytical and normative aspects of the OPB framework provided.

Politics is the conduct of public affairs for private advantage.
Ambrose Bierce,
The Devil’s Dictionary

There is a widespread belief that technical issues and decisions are at odds with political behavior. However, this appears to be too simplistic an argument to characterize reality. Furthermore, the real issue appears to be not that the “technical” and the “political” do not mix—often, they do by reactive default rather than through proactive management—but that in organizations the “political” process has to be “positively” managed much like any other organizational concern. Let us look briefly at two well-known cases that help us better understand the core problem.

The Challenger Disaster

On the morning of January 28, 1986, schoolchildren around the country watched as, after repeated delays, the space shuttle Challenger finally lifted off. Seventy-three seconds later, Challenger disappeared in a raging fireball. The Rogers Commission, appointed to investigate the disaster, determined the immediate cause of the explosion was physical: two O-rings designed to seal joints on Challenger’s right booster rocket failed.

The more fundamental cause of the accident, however, was organizational and political (Hult and Walcott 1990). The Rogers Commission called the decision-making system for the shuttle program “clearly flawed.” The decisions by the NASA management and the contractor were influenced by myriad (political) factors that combined to produce the fateful Challenger incident: “turf” consciousness among the three space centers, inadequate communication of the technical uncertainty associated with O-ring risk, and congressional/public pressure to produce results, to name a few.

Jeffrey K. Pinto is an assistant professor of management in the School of Business at Penn State-Erie.
Bijan Azad is a doctoral candidate at M.I.T. completing his dissertation on managerial and organizational aspects of GIS implementation. He is also an associate consultant with GIS/Trans, Ltd. in Cambridge, MA.
Indeed, the Challenger episode is a dramatic illustration of the issues that concern us in this paper and of importance to an accurate understanding of the political behavior in organizations during the implementation of complex technical projects.

Xerox Alto

If we ask consumers and users what names they associate with the multi-billion dollar personal-computer market, they will answer IBM, Apple, Tandy or Lotus. The more knowledgeable among them will add the likes of Microsoft, Compaq and Borland. But no one will say Xerox. Twenty years after it invented personal computing, Xerox still means “copy” (and printers).

But in 1973, many years before Apple, IBM or Tandy released their first personal computers, scientists at Xerox’s Palo Alto Research Center (PARC) produced the Alto, the first computer designed for personal use. By 1976, still well in advance of any other enterprise, PARC’s brilliant team had completed a system of personal computing hardware and software. It was not matched in the marketplace until eight years later with the appearance of Apple’s Macintosh computer—a product whose intellectual roots, ironically, belonged to PARC and, therefore, Xerox.

Yet those at PARC who expected Xerox to capitalize on their extraordinary inventions remained frustrated throughout the 1970s and 1980s by the other workgroups at Xerox who backed a far more elaborate office computer system and then failed to introduce it until Apple and IBM had already set the standards of the marketplace. In Fumbling the Future: How Xerox Invented, then Ignored, the First Personal Computer, Smith and Alexander (1988) tell a compelling tale of how innovation within large corporate structures can be miscalculated and mishandled when organizational politics and culture are not positively dealt with by management and professionals.

Why Organizational Politics Matter

What do these “technical” failures have in common? Lack of attention to political issues in organizations and their “positive” management. Where does this lack of attention originate from? According to Norton Long (in Pfeffer 1992, p. 29), “People will readily admit that governments are organizations. The converse—that organizations are governments—is equally true but rarely considered.” While it rings true of everyday reality, it is not a given for many Americans, who generally are ambivalent about power and politics or with its dynamics. At one level, there is often a distrust of the motives of workplace people who actively seek power and thrive on politics. At another level, there is a recognition that political behavior is normal. In plain terms, the attitude and feeling toward power (perhaps this can be traced back to the nation’s birth) is negative but tolerated.

A study of organizational politics (Gandz and Murray 1980), surveyed 428 managers and their answers illustrate the ambivalence: 90 percent of the respondents said the experience of workplace politics is common, 89 percent said that successful executives must be good politicians, and 76 percent said that the higher that one progresses in the organization, the more political operations become. However, 55 percent of the same respondents said that politics were detrimental to efficiency. These figures leave an impression that we know politics exist, and we grudgingly admit that they are necessary. Nevertheless, we do not like them.

There are other reasons for this perspective towards politics. Pfeffer has eloquently offered the following reasoning:

To socialize students in a view of business that emphasizes power and politics would not only make the compliance to organizational authority and the acceptance of decision outcomes and procedures problematic, but also it might cause recruitment problems into the profession. It is certainly much more noble to think of oneself as developing skills toward the more effective allocation and use of resources—implicitly for the greater good of society—than to think of oneself engaged with other organizational participants in a political struggle over values, preferences, and definitions of technology.


Regardless of the reasons for this disposition towards politics and power in organizations, one of its impacts is that as a topic for study and dialogue, beyond the field of political science, it has not received much attention, even in the managerial circles of organization behavior and organization theory (notable exceptions are Pfeffer 1981, 1992; Mintzberg 1983; Pettigrew 1973; Bacharach and Lawler 1980; Yates 1985). This lack of attention to the topic is not limited to management. Beneveniste (1989), Forester (1989), and Fischer and Forester (1993) have offered critiques of this trend and attempted to reverse it in the urban planning arena. The fact that the subject of power and politics in organizations has received less attention than it deserves merely adds to the confusion and misunderstanding surrounding the topic. In particular, we view this misunderstanding as a liability for GIS managers, planners and professionals engaged in technology implementation, given the “technical/rational” nature of discourse on the GIS-related matters.

The development and use of GIS is often conflict-laden. Those who push the theme that GIS fosters cross-functional cooperation and integration by default, gloss
over deep social and value conflicts that social change due to GIS implementation may precipitate. In practice, organizational participants can have major "battles" about what kind of hardware platform to acquire, how to organize GIS data layers, spatial database accuracy, means distribution of processing power (workstation vs. centralized), and the standards to govern data exchange (Huxhold 1993).

Two case studies at the end of this paper will illustrate the typical conflicts among functional workgroups within state departments of transportation—choice of GIS software is one example. In one instance, the planning group structuring their work around one particular software product were at odds with the engineers and construction group which had a history of using a separate product. However, the data-sharing requirements and the assumed cost-savings had forced the issue of standard software platform across the agency on every workgroup’s agenda. One of the biggest issues of concern was the conversion of the so-called "macros" in different languages that staff in both workgroups depended on. Each viewed the costs of conversion as an unnecessary burden.

What is important to understand is that these situations of conflict cannot be written off as flukes or exceptions. In fact, a phenomenal amount of anecdotal and case history information exists which strongly reinforces the importance of understanding and effectively utilizing organizational politics as a tool in successful implementation. For example, Croswell (1991) documented some of these in his survey of GIS and related publications. Despite this "stylized fact," the GIS research community has been slow to disentangle the web of organizational politics and translate it into usable positive managerial actions that increase the probability of implementation success. However, GIS is not alone in this regard, and the study of organizational politics is only marginally better understood in similar situations, such as introduction of innovative information technology in organizations (Frantz and Robey 1984; Danziger, Dutton, Kling and Kraemer 1982; Kraemer, Dutton and Northrop 1981; Markus 1983; Mumford and Pettigrew 1975; Pettigrew 1973; Robey and Markus 1984; Robey 1984).

The rest of the paper is devoted to some major questions as an attempt to uncover the dynamics of organizational political behavior (OPB) and GIS implementation:

- Is there any evidence to show the impact of OPB on information and GIS technology implementation?
- Why does OPB take place?
- What are the analytical contents of OPB?

- What are some concrete OPB steps that can enhance the success probability of the information and GIS technology implementation process?
- Can we illustrate the impact of OPB on the GIS implementation process through concrete evidence?
- What are the major conclusions and directions for further research?

We will address these questions in sequence in following sections.

Politics and Public Sector Information Technology

We are interested to find out how "positive" OPB can contribute to the success of GIS implementation. From a research point of view, this can be translated as follows:

1. Project success is the dependent variable;
2. OPB is one of the independent variables during GIS implementation; and
3. The dynamics of OPB and implementation process interaction is also a determinant of success.

Although the issues in the latter category are interesting, they fall beyond the scope of this paper. We are more concerned with the second group of issues, or more concisely, what are the contents of OPB?

Perhaps due to the present early stages of research on GIS implementation, researchers in studying GIS implementation have not addressed the second question, or at least not in enough depth to illuminate the complexities of the topic. For example, Budic (1993) confirmed earlier assertions about the importance of political backing in GIS acquisition (Godschalk et al. 1985; Somers 1987; Croswell 1991), asserting that political support was rated very highly for incorporating GIS technology within government agencies among four states in the southeastern United States. Similarly, Campbell (1991) found that political factors were important in GIS project implementations in two United Kingdom local authorities.

However, as mentioned earlier, GIS is not alone in this respect. The research on information technology (IT) implementation has paid little more attention to OPB. No matter how scant this research is, it is useful to review its major themes in the hope of gaining insight into OPB during GIS implementation. In general, the majority of research in this area has been concerned mostly with uncovering some form of political (intangible upper management) support in successful IT implementation (see the inventory of survey research by Kraemer and Dutton, 1991). A very small portion of the research has concentrated on political organizational behavior and IT implementation (Frantz and Robey 1984;
Kling 1980; Markus and Bjorn-Andersen 1987; Robey 1984; Robey and Markus 1984).

First, we will consider the latter body of research. We offer an interpretation of the evidence based on two streams of research: 1) the “political impact” school of IT in organizations; and 2) the “conflict resolution” model of IT in organizations. Although our approach of applying “positive” OPB in the IT/GIS implementation process for higher success rate is quite distinct from these streams of research, we are closer to the latter than the former.

**Political Impacts of IT and GIS**

**Political Impact School**

A small but thriving research track on politics and IT implementation in the United States has been the so-called “impact school.” In other words, there are important considerations of how the implementation of IT changes social and power relations in the organization. Researchers at the University of California at Irvine (URBIS group, now CRITO) are the main adherents to this view and have produced evidence to support their assertions (Danziger, Dutton, Kling and Kraemer 1982; Kraemer, Dutton and Northrop 1981). In a nutshell, Kraemer and his associates have opposed the characterization of IT as an instrument by which different organizational goals might be accomplished. Because, in their view, this image can lead to the incorrect conclusion that IT is simply a neutral tool in organizational life to be used as best fits the organization. In fact, they postulate that the potency of IT in decision-making, if not in other areas, makes it politically important. According to Kraemer and associates, the political significance of IT arises from three features of IT use.

First, they argue that there is the political significance of the outputs produced by IT. Information per se is not power, but those with the “best” information are often successful at accomplishing their objectives. Depending on how IT and information delivery is organized and provided, different individuals and factions in organizations can gain or lose power relative to others. This is especially true in the context of the contributions of IT to decision-making mentioned above.

Second, there is the “resource politics” of IT, arising from the fact that those who control IT govern a large share of organizational resources. Control over these resources brings power, both through building a base for further increases in demands on resources and through control over capabilities that others in the organization or its clients need.

Finally, IT brings “affective power” with its inherent attractiveness as an activity. Those who are engaged in IT are perceived by many as advanced, sophisticated and professional. Also, since many people are intimidated by technical jargon and IT outputs, these can be used effectively to obfuscate the underlying issues in disputes and to weaken opposition.

Overall, Kraemer and associates have focused on the aggregate organizational impacts of IT. This is because, in their view, the fundamental question about IT and organizational politics is who gains and who loses from IT. To simplify, the “dependent variable” in their framework is “redistribution of power.” The input (independent) variable appears to be the implementation of IT itself. Then these inputs to the process are moderated to re-distribute power by: 1) organization of production/delivery for information in the organization; 2) control over IT-related resources; and 3) symbolic value of being associated with high profile IT-related activities.

Figure 1 is a “distillation” of their framework and major conclusions. It is clear from our characterization, that their concern is that IT implementation leads to political shifts and distribution of power; therefore, our label “political impact.” They are not concerned (as directly as us) with the use of positive OPB to enhance the chances of successful IT implementation. An important aspect of their research—to most GIS professionals—is that it is conducted solely based on public sector data and evidence since its inception in the early 1970s.

A subsidiary point to our concerns, but an interesting one in their conclusions, is the so-called “reinforcement politics.” That is, they provide counter-evidence to the two prevailing views on IT impact: some have predicted that IT will alter the political profile of organizations by shifting power to technocrats—largely emulating from the literature on the role of experts in organizations (Downs 1967; Crozier 1964; Elul 1964); and others have suggested that IT can strengthen pluralistic features of organizations by providing interest groups with the ability to respond to their opposition with the tools of technology—this view is largely influenced by the political science models of organizational behavior (Allison 1971), interest group competition, and public choice models of public administration. However, the UC-Irvine group maintains that IT has reinforced the status quo by providing the existing power elite with the tools to perpetuate and strengthen their power. The evidence presented by them suggests that this has been the most common outcome of IT.

**User Participation (or Conflict Resolution) School**

Another stream of research also explicitly incorporates politics into its framework and results. The major focus is on user participation in IT implementation, casting it as a political process. The core element of this approach
is its focus on differences among the expectations and interests of stakeholders, attributing the general dissatisfaction with IT implementation to unmet stakeholder expectations (Markus 1983). This literature has provided a starting point for understanding the politics of IT implementation (Frantz and Robey 1984; Kling 1980; Markus and Bjorn-Andersen 1987; Robey 1984; Robey and Markus 1984) focusing on the strategies and tactics used by stakeholders to influence the IT implementation process in their favor. Because the stakes in IT implementation are usually high and have long-term consequences—the “moderator” variables by Kraemer and associates—a high level of political activity during IT implementation can be expected (also identical to Kraemer’s conclusions).

However, this stream of research itself can be divided at least into two groups: “zero sum” and “non-zero sum” categories. There are those who treat IT implementation as a purely political process with clear disregard for legitimate organizational goals. This position tends to mistrust all appeals to organizational goals and to suspect that individuals are motivated only by their own interests. The complicating factor in IT implementation is that, because advance demonstration of universal benefits is always problematic, the legitimacy of organizational goals is hard to establish objectively (Kling 1980; Mowshowitz 1981). Thus, according to this group of researchers, conflicts during IT implementation may be viewed as “zero-sum” games in which the gains won by one party must be losses suffered by another.

The other group of researchers are less skeptical of the political model and espouse a “constructive” conflict resolution mode of IT implementation. They conceive of IT implementation as a “non-zero-sum” game, wherein multiple parties can come away satisfied. This line of inquiry grounds itself in the management literature on resolution of conflict as an essential skill and process characteristics (Filley 1975; Minzberg 1983; Robbins 1992; Slevin 1989), thereby making management of conflict during IT implementation a central piece of the puzzle for more successful systems. Thus, researchers put forth the positions that, despite the presence of conflicting interests among the stakeholders in IT implementation, it is conceivable that managers could facilitate the resolution of conflicts and produce a “win-win” outcome, deemed successful by all parties.

Robey and associates have tested several versions of this conflict resolution model (Robey 1984; Robey and Farrow 1982, 1989; Robey, Smith and Vijayasarathy 1993). The model consists of four variables: participation, influence, conflict, and conflict resolution. Participation is treated as a determinant of influence, and influence is treated as a determinant of both conflict and conflict resolution. Overall, the results of the model sup-
port the key role of participant influence and conflict during IT implementation. Figure 2 illustrates the structure of this model.

According to Robey et al., given the "realistic" assumption that stakeholders will disagree on fundamental issues during an IT implementation project, it is important to understand the manner in which conflicts are managed. One approach smooths over conflicts by minimizing disagreements among participants. This can reduce conflict in the short term, but in the long run it may result in important issues going unaddressed. If conflicts are encouraged to surface and then be resolved constructively, project success is likely to be greater.

Robey and his associates' results provide convincing evidence of the presence of conflict during implementation of IT, and the general means to its resolution through influence by users participating in the process. However, the model has limitations in two important respects. First, as we will see later, presence of conflict and influence are only two manifestations of OPB. Second, the resolution of conflict in the organizational context may be an excellent explanatory variable, but without concrete advice on the approaches to conflict resolution, most managers and professionals will be at a loss. A related but no less important point is that this research has been carried out based exclusively on private sector data. This last point will be addressed at length next.

Do Public Sector Differences Affect IT Implementation?

There is a very legitimate and important issue for any manager or professional faced with reviewing and making use of the OPB research evidence: Are the frameworks and evidence relevant and applicable to particular circumstances they are faced with? This is particularly important for the GIS community for the following reason: the majority of the community is in the public sector, while most of the research (not all) on OPB is based on the observations in the private sector. So, there are two crucial questions: First, to what extent are the results of general organizational behavior and theory (OB/OT) transferable to the public sector? Second, in particular, what can be usefully applied during the implementation of information and GIS technology in the public sector? We will address these two questions, to establish a means of judging the relevance of OPB as framework grounded in largely private sector research and its limitations.

Public Organization Theory and Behavior

The issue of public-private distinction is quite hot in some circles and has only begun to receive attention from organization theory and behavior experts as well as those in the field of public administration. At one end of the spectrum, there are those managers and professionals in the public sector that dismiss any relevance of the OB/OT; because it is mainly developed in business schools to fit business managers' environment (Stevens, Wartick and Bagby 1988; Weiss 1983). Golombiewski (1984) characterizes this as the "Dr. No" syndrome of the public agencies.

At the other end of the spectrum there are those who say "an organization is an organization"—private or public. Therefore, they see no reason for changes to the theory or prescriptions. Much of the early theory and research was based on this view (Perrow 1967; Blau 1970). The privatization debate is a good example of how simplistic this view has become (Donahue 1990; Wise 1990) despite the intentions of its protagonists. It is important to acknowledge that clear demarcations between the public and private sectors are impossible, and oversimplified distinctions between public and private organizations are misleading.

This is all well and good, but we still face a paradox, because researchers, managers and professionals continue to use the public-private distinction repeatedly in relation to important issues (e.g., IT and GIS implementation) and public and private organizations differ in some obvious ways. The recent developments in the "public organization theory" can shed some light on
this debate. The work of Bozeman (1987), Bozeman and Loveless (1987), Perry and Rainey (1988) are among the first to point out the bases for the public-private distinctions and their implications.

According to their view, all organizations are public to some degree because all have some political influence and are subject to external government control which varies based on the continuum of political and economic authority. Economic authority increases as owners and managers have more authority over the use of income and financial assets of the organization. It, however, decreases as external government authorities exercise more control over these matters.

**Sectoral Differences and IT Implementation Process**

The majority of research on information systems (in general) in the last three decades has been based on the experience of the private sector; the work of Kraemer et al. is the notable exception. However, as suggested earlier, the latter group has mostly concerned itself with the "political impact" issues. Furthermore, there has been very little in that research that considers the validity of prescriptions based on private sector IS research since it is largely based on public sector evidence. More recently, this trend is starting to reverse itself (Bozeman and Bretschneider 1986).

Using the dominance of economic/political authority framework as proposed by Bozeman, a helpful organizing scheme has been proposed by Bretschneider (1990). This scheme consists of some propositions and allows us to think through the public-private differences as far as the general IT activities (and by extension from our standpoint GIS) are concerned during implementation. These relate to two major areas: 1) organizational environment (consisting of inter-organizational interdependence, and procedural delay (red tape)); and 2) managerial actions (consisting of criteria for evaluating hardware and software, and planning process). The four propositions below describe the essence of the model advanced by Bretschneider (A fifth is significant but not to our concern—the level of IT manager in the organization).

**Public IT managers must contend with greater levels of interdependence across organizational boundaries than do private IT managers.**

The legal and constitutional arrangements in large part determine the authority of public organizations. This very political authority has a level of embeddedness in its concerns for checks and balances, which are manifested as oversight groups or external organizational control of personnel activity and financial resources as well as expectations of cooperation (non-competition) to reduce waste. Therefore, public organizations tend to exhibit higher levels of interdependence across organizational boundaries than do private organizations.

**Public IT managers must contend with higher levels of red tape than private IT managers.**

It is expected that greater interdependency, largely due to checks and balances (or accountability), will lead to more procedural steps for a specific management action (red tape).

**Criteria for the evaluation of hardware and software, which ultimately lead to purchasing decisions, are different for public IT and private IT.**

There are numerous textbook and practical approaches for purchasing decisions of either hardware or software. Some reflect economic criteria such as cost-benefit analysis, while others reflect feasibility issues such as compatibility, connectivity, etc. It is expected that differences here will reflect general differences in organizational environment and be manifest as different weights for a more or less fixed set of criteria.

**Public IT planning is more concerned with inter-organizational linkages, while private IT is more concerned with internal coordination.**

The organization behavior and theory tell us that planning is a major component of management. However, public IT management faces planning issues in a different manner. High levels of interdependency among public agencies (say, city departments) lead to higher levels of uncertainty and less control over the environment by any individual group. This condition leads to planning activities serving more as a vehicle for managing inter-organizational linkages than coordination of effort within the organization.

Bretschneider (1990) tested these propositions on more than 1300 public and private managers and found significant differences for all four, between the public and private managers. At the more detailed level for each item the significance varied, but at the aggregate the propositions held. These results are significant for our purposes. If we can establish plausible hypotheses about the interaction of OPB and these dimensions, then our OPB framework, propositions and prescriptions can be said to be on a far more solid basis than if they were supported solely on the private sector data.

**Bases for Organizational Politics: Six Propositions**

At the outset it is important not to overstate the case for OPB, but to accurately characterize it. It is fair to assume
that most organizational behavior is governed by a model that falls somewhere between the two poles of procedural rationality\(^1\) and political behavior (Zey 1991). In other words, both models can to varying degrees explain a particular behavior. In fact, Hardy (1987, citing Burns 1961) has pointed out that individuals in organizations are both "rivals and cooperators," and that in a large number of cases (not all) the individual success is bound up with organizational success. Therefore, a realistic model of organizational behavior must account for both situations. The question then becomes as far as we are concerned: When are political factors likely to be the most important? We will answer this question in the form of six propositions.

These underscore the "logical" or "natural" view of OPB in situational contexts, where it is most likely to occur. These propositions follow a logical sequencing as they develop the argument for understanding the "true" nature of organizational politics. The objective is to show that OPB in these situations is not only not irrational or illogical, but in fact the reverse. That is, OPB grows out of certain rational and/or logical considerations of individuals and workgroups within organizations.

**Proposition 1a: Large scale innovations (like GIS) involve changes in resource allocation patterns, or re-allocation of scarce resources.**

According to Hardy (1987), political influences are likely to be particularly intense when the existing pattern of resource allocation is changing (it is important to note that this is not always the case)—for it presents opportunities to enhance power positions. Large-scale innovation decisions (like GIS) typify this pattern. Furthermore, in these situations there is a significant amount of complexity, unpredictability and uncertainty, which renders formal economic criteria for project evaluation less feasible (Wiletsky 1967, as cited in Hardy 1987). Also, Hardy cites Gore and Dyson (1964) in support of her view, "... The relations between participants in routine decisions are typically characterized by cooperation, while conflict of some sort is the norm in innovative decisions." (p. 103)

**Proposition 1b: The organizational decision process, in the context of innovation, often involves bargaining, negotiation, and jockeying for position.**

It is likely to come as no surprise to the majority of readers, particularly those who are currently employed in organizations, that the manner by which many decisions are made is often based less on purely logical decisions processes than on a variety of intervening criteria. Certainly, as James March and Herbert Simon noted nearly 35 years ago, individuals strive for logic in their decision processes. However, for a variety of reasons, we are often more likely to be influenced by and make use of a variety of extra or additional criteria in arriving at decision choices (March and Simon 1958). One process that is common within organizations where scarce resources are the rule is to make use of bargaining or negotiation behavior. Bargaining follows one of the most common approaches to dealing with conditions of scarce resources and especially so in the context of innovations (Wilson 1982): individuals and department heads make "deals," or compromises between the variety of competing desires and organizational reality.

**Proposition 2a: Groups differ in terms of interest, values, attitudes, time frames, etc. making intergroup disagreements or cleavages a permanent feature of organizational life.**

In 1967, a landmark study was conducted by Paul Lawrence and Jay Lorsch which sought to investigate the manner in which roles and attitudes differ among various sub-groups in organizations (Lawrence and Lorsch 1967; 1969). Through their research, Lawrence and Lorsch uncovered and introduced a phenomenon that they referred to as organizational differentiation. The concept of differentiation was later used by Astely and Associates (1982) to describe the fact that in certain decision situations, especially involving strategic, structural and technological changes this same differentiation translates into an intensification of differences among workgroups. This contextual phenomenon is such that the workgroup behavior around these special decision topics become cleavages—that is, "semi-permanent" non-convergence of interests. However, this non-convergence of interests according to Bacharach and Lawler (1980) does not equate with contention of objectives.

**Proposition 2b: In the presence of high uncertainty and complexity associated with technology implementation projects, e.g., GIS innovations, cleavages in organizations leads to workgroups exhibiting interest group or coalitional behavior.**

According to Walsh et al. (1981, p. 131):

The starting point of the political model is the existence of differentiation. An organization is conceived as be-
ing made up of separately identifiable groups differentiated both horizontally and vertically according to division of labor and authority... These differentiated groups may just as easily have conflicting as coinciding interests and values.

This points out an important issue to understand, that when we refer to an "organization," it may be a convenient short-hand to use the term in a monolithic sense; that is, that an organization can and will act as a single, purposeful entity. In reality, the term "organization" gives meaning to the reality behind this misperception. In both the public and private arenas, organizations are composed of a variety of groups: labor vs. management, finance vs. marketing, and so forth. These groups, which must be viewed as essentially self-interested, are the sum total of what comprises an organization (March 1962; Mintzberg 1985; Pfeffer and Salancik 1977; Tushman 1977). Under certain conditions there will be pressure to act in a purely self-interested manner. While in other cases, there will be impetus to act in a coalesional manner (Yates 1985).

Note also that, in effect, these first four propositions have a lot in common with the conclusions by Kraemer and his associates cited earlier. However, they are not corollaries, and in fact the scope of these propositions is thought to be far greater and more general.

**Proposition 3a:** In the presence of complexity/uncertainty (GIS innovations) resource re-allocation decision process of bargaining/negotiation and coalition dynamics give rise to more intense conflict than otherwise will be the case.

This proposition forms one of the fundamental aspects of political behavior; it is the underlying rationale behind the political model of organizational life. Because of the essential cleavages (Astley et al. 1982) in certain decision situations—innovations—as well as a higher level of engagement in negotiation and bargaining (Wilson 1982), conflict among workgroups becomes more pronounced in organizational decision-making (Bacharach and Lawler 1980). Therefore, the essence of the above proposition is not that GIS implementation produces inter-group organizational conflict but that it intensifies the process. This intensification has implications for the decision-making processes of the organizations, which when more conflict-ridden than usual will resort to non-standard (mostly non-cooperative/political) modes of resolution. This is the topic of the next proposition.

**Proposition 3b:** During innovation processes due to bargaining/negotiation, coalition behavior, and presence of conflict there is a tendency for more intense political behavior than otherwise will the case.

On the one hand, organizational conflict—the exertion of influence, through informal means in an inter-group organizational decision-making process—has its origins in cleavage (Astley et al. 1982). On the other hand, organizational conflict has its roots in the resource re-allocation process engendered by the innovation decisions which generate disagreements (Wilson 1982). Given the increase in the conflict level that is the result of these two trends, the pre-disposition for organizational members is to resort to political behavior in resolving these conflicts. These are the basic propositions that constitute the basis for the framework of our view of organizational political behavior, portraying them as "rational" response to a situation of increased conflict. Figure 3 illustrates these propositions and the underlying constructs.

**FIGURE 3.** Constructs and Propositions Leading to Organizational Behavior
Organizational Political Behavior: A Framework

After providing the propositions that constitute the logical bases for OPB, we now wish to establish the analytical contents of OPB. The major goal is to distinguish between OPB and non-OPB based on the contents of a particular behavior. After all, if every intent, action or outcome in an organizational situation is classified as OPB, it loses its explanatory power. Furthermore, this is needed to set bounds on the concept of OPB for two reasons. First, researchers must clearly delimit the OPB construct before it can be used. Second, managers and professionals must be able to understand OPB in order to manage it and/or effectively deal with it.

Characteristics and Components of OPB

We follow the work of Drory and Romm (1990)—in which they provide a synthesis of the OPB—to present a classification of OPB contents based on certain categories. Figure 4 is an adaptation of their classification scheme through which we can identify OPB based on three subject categories: 1) the ends (or intent or goals or outcomes) of OPB; 2) the means employed in (or process of) OPB; and 3) the context (or situational characteristics) of OPB.

The typical goals (intent/outcomes) category of OPB according to Drory and Romm can be grouped into four sub-categories:

- self-serving, 
- against the organization, 
- resources distribution/redistribution, and 
- power attainment.

The overall orientation of the outcomes/goals characterized by these various categories clearly indicates that they all deviate from formal organizational goals or even contradict them to varying degrees. The first category of goals suggests that individuals engaging in OPB are generally intent on only self-serving actions rather than organization-serving actions. The next outcome/goal category in Figure 4 encompasses those actions that are against the organization, implying a direct opposition of OPB to organizational goals. The remaining two self-serving OPB outcomes/goals, namely, protecting one’s share in formal organizational resources and the attainment of power are generally placed outside the formal organizational goals as well.

Drory and Romm put forward in the means category of OPB certain actions that are in almost all cases not endorsed by the formal organization: 1) influence, 2) power tactics, 3) informal behavior, and 4) concealing motives. For example, influence and informal behavior are often (if not always) applied in the absence of formal authority. In the case of power tactics, they are usually employed when formal rules are not sufficient. The last sub-category, concealing motives, clearly does not coincide with the formal organizational model.
It is interesting to note that the various means and outcomes sub-categories seem to have yet another common characteristic. They all imply or assume to some degree the notion of potential conflict. In the majority of cases, informal influence, power tactics, and concealing motives are all employed under the assumption that the other side is not likely to cooperate under their own volition. In the case of OPB outcomes, they are also in direct or potential conflict with the formal organization and/or with other parties. Potential conflict with other organizational actors is usually a direct result of the self-serving nature of OPB intent/goals. It is axiomatic that desired outcomes that are contrary to the organization mission are by definition in conflict with the formal organizational goals. In addition, the attainment of outcomes relating to resource allocation and power in most cases (if not all) contradicts the interest of others. If one engages in increasing one's share in the resource allocation process or the goal of power attainment, these acts very likely will lead to conflict with other organizational members. Therefore, the element of conflict is not just a contextual (situational) characteristic which may or may not be associated with OPB; it is at the core of any OPB situation.

Uncertainty is another contextual (situational) characteristic that is logically derived from and structurally associated with the overall construct of OPB. That is, informal influence tactics, we suggested above, may be used more effectively where there is a lack of objective information to guide the decision-making process. Given the typical uncertainty associated with the outcomes of information technology projects and GIS, one would expect more intense OPB in these situations (Mumford and Pettigrew 1975; Pettigrew 1973, 1975). The expected observation, therefore, is that the political actor will prefer to exploit situations of uncertainty to try and further his or her goals by using political behavior than others. However, we should qualify that observation—this does not necessarily exist in every OPB situation and as such is only optional.

In summary, when all the elements of ends, means and context of OPB are considered together, two major common behavioral conditions (characteristics) emerge: 1) a divergence from the formal organization; and 2) the underlying assumption of potential conflict. Thus, to formally state what is usually implicit in the discussions of the topic: OPB is associated with organizational behavior, which deviates from the formal, techno-economic goal-oriented approach assumed by the rational models of organizations (Drory and Romm 1990, p. 114).

As we discussed in the early part of the paper, the term bears very negative connotations for most managers because of the core element of conflict. Stated more directly: There is no reason to believe that OPB keeps everybody happy. Although most academic definitions of the term adopt a neutral stance toward the morality or ethics of OPB, given our interest in successful GIS implementation through sensitivity and management of OPB, we put forward a normative approach of "positive OPB." (That is not to say that the consequences of OPB may be undesirable to some individuals, groups, or to the organization at large.)

Classification of OPB

It may be noted that not all OPB situations are characterized by all the sub-categories of each ends, means and context elements. These represent an organizing framework for research and practice around the analytical contents of OPB. In fact, many situations may consist of only one or two of these categories/sub-categories. The meaning of OPB in a given situation depends to a large degree on which categories/subcategories are included in the schema for analysis. A distinction can be made between three types of definitions in this respect.

A. Identifying OPB by Ends/Outcome.

In such cases, the political behavior is defined by its goals regardless of the means employed to attain them. Defining OPB as self-serving, or as the struggle to attain power, fall within this category. This approach allows for relative flexibility in exploring behavioral tactics which might serve the purpose of attaining informal goals. It is relatively narrow in its scope, however, as it excludes all cases of manipulation and informal influence geared toward the attainment of formal outcomes. Typical collective-bargaining processes are examples of using informal means for rational and formal outcomes. Such behavior, would not be considered political according to the above definitions.

B. Identifying OPB by Means Used.

This grouping is based exclusively on the type of the means used to engage in and achieve OPB goals. The prime example of this is the exercise of power tactics. Usually, the definitions in this category refer to informal means of influence and consider the use of such means as political no matter what the nature of the anticipated outcome. Consequently, it should be clear that OPB may be applied toward the attainment of both informal and formal outcomes. Therefore, this grouping presents a relatively comprehensive view of OPB although the range of means employed may be quite specific.

C. Identifying OPB by Combination of Ends and Means.

Work in this category is usually characterized by both means, ends, and sometimes context variables. However, such cases are normally limited as they tend to restrict the meaning of OPB to a particular combination of means, outcomes and conditions.
Essential Contents of OPB

Now we can draw together the above categories into a more comprehensive conceptual framework. We do not want to suggest that a single working definition of OPB is possible or workable. In fact, we agree with Drory and Romm that a multitude of working perspectives as an organizing framework may be more desirable. However, the essential analytical contents of OPB, beyond the specific definitions, can be captured through the minimal combination of the following three categories.

Influence.

The presence of an element of influence in OPB is almost axiomatic. There is wide consensus in the OPB literature that political behavior is essentially influencing behavior in the sense of trying to change or affect someone’s behavior or attitude. This is equivalent to propositions 1a and 1b presented earlier. That is, under certain conditions—innovations—the use of influence (e.g., negotiation and bargaining), becomes the dominant form of decision-making.

Informal Means.

The use of informal means is another element implied by most definitions. It represents the divergence from the formal organizational model. Under the OPB concept, informal means may be employed in the pursuit of either informal or formal outcomes. Formal means, however, are by definition only employed for the pursuit of formal legitimate organizational outcomes. This characteristic is also equivalent to propositions 2a and 2b. In other words, under conditions of uncertainty/complexity, the use of informal means by functionally differentiated groups, e.g., coalitional behavior outside the formal organizational avenues of action, becomes the primary apparatus for getting things done.

Conflict.

The third essential element to the construct of OPB is conflict. The way in which conflict is derived from both the nature of the OPB means and outcomes was discussed earlier. It is therefore suggested that the presence of direct or implied conflict is immediately derived from the nature of both the means and the outcomes associated with OPB definitions. The notion of conflict was explicitly incorporated in proposition 3a, and its presence was a key contributing factor to the OPB.

To summarize, the basic OPB situation occurs when goal attainment is sought by informal, rather than formal means of influence in the face of potential conflict.

Positive Political Behavior for Successful GIS

We started by discussing how prevalent the “negative” view of OPB is. By now, we hope to have articulated a more realistic view of OPB from analytical and research angles. We want to complement these by more concrete and practical guidelines on engagement in OPB to enhance the probability of successful GIS implementation. Readers need to come to their own conclusions about their own individual views and roles in OPB. We would suggest that there are usually three distinct individual views and roles regarding OPB—two of these roles are equally inappropriate, but for entirely different reasons, and probably the major cause of the “negative” view. The first approach can be best termed the “naive” attitude regarding organizational politics. The naive view is characterized by a willingness to ignore organizational politics or simply view them as “dirty tricks” in which one resolves never to engage. Benveniste (1989) an advocate of the pragmatic approach to urban planning has termed this view “apolitical politics” and dysfunctional (p. 72). His criticisms of the naive view of (technical) planning—and by extension GIS implementation as one such activity—is that it has the following consequences:

1) widespread perception of mystification;
2) lack of preparation and resources to play political roles;
3) distrust by high level executives and politicians;
4) disregard for implementation details;
5) blame of failures on politics and management; and
6) distortion of (GIS) professional’s role (tendency to elevate technical elegance rather than effective implementation).

The second, and opposite, approach is undertaken by individuals who enter organizations with the express purpose of using politics and aggressive manipulation to reach the top. Christie and Geis (1970) in Studies in Machiavellianism put forward four characteristics of such a person:

- a relative lack of affect in interpersonal relationships;
- a lack of concern with conventional morality;
- a lack of gross psychopathology; and
- low ideological commitment.

We refer to such people as “sharks.” While actually few in number, this type readily embraces political behavior in its most virulent form. Their loyalty is entirely to themselves and their own objectives. Work with them and one is likely to be used and manipulated; get between them and their goal and their behavior becomes utterly amoral. The only cause these individuals espouse is their own. As we stated initially, we regard both the “naive” and “shark” as wrong-minded about politics, but for completely different reasons. Their attitudes underscore the awareness of the third type of organizational actor: the “politically sensible.” Table 1 provides distinctions among characteristics of these views and roles.

Politically sensible individuals view OPB “positively” with few illusions about how major resource-allocation decisions are made. Their position is charac-
TABLE 1. Characteristics of Political Behaviors

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Naive</th>
<th>Sensible</th>
<th>Sharks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying Attitude—</td>
<td>Unpleasant</td>
<td>Necessary</td>
<td>An opportunity</td>
</tr>
<tr>
<td>&quot;Politics is...&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intent</td>
<td>Avoid at all costs</td>
<td>Used to further department’s goals</td>
<td>Self-serving and predatory</td>
</tr>
<tr>
<td>Techniques</td>
<td>Tell it like it is</td>
<td>Network, expand connections, use system to give and received favors</td>
<td>Manipulation, use of fraud and deceit when necessary</td>
</tr>
<tr>
<td>Favorite Tactics</td>
<td>None, the truth will win out</td>
<td>Negotiation, bargaining</td>
<td>Bullying, misuse of information, cultivate and use “friends” and other contacts</td>
</tr>
</tbody>
</table>

Characterized by factors opposite those of the naive approach but at the same time they are the anti-thesis of the “shark” approach. They understand, either intuitively or through their own past experiences and mistakes, that politics is simply another side, albeit an unattractive one, of the behavior in which one must engage in order to succeed in modern organizations. The politically sensible person is apt to state that this behavior is at times necessary because “that is the way the game is played.” It is also important to point out that politically sensible individuals generally do not play predatory politics, as in the case of the sharks who are seeking to advance their own careers in any manner that is expedient. Politically sensible individuals use politics as a way of making contacts, cutting deals, and gaining power and resources for their departments in order to further cooperate, rather than for personal gains.

Figure 5 illustrates conceptually the fact that the sensible political approach is the most beneficial from the whole organization’s standpoint. That is, assuming that in the case of some decision outcomes (say, GIS implementation), certain outcomes are to the benefit of the organization as a whole while others are either detrimental to it or less than optimal. We may represent this case by an inverted U curve which exhibits lower organizational performance at either low (naive) or very high (“shark”) levels of political behavior. However, the moderate (sensible) level of political behavior is associated with highest level of organizational performance.

Acknowledgment of OPB

What can we summarize here? In dealing with individuals suffering from a variety of dysfunctional illnesses, therapists and counselors of all types have long taken as their starting point the importance of a patient’s acknowledgment of their problem. Positive results cannot be achieved in a state of continued denial. While it is not our purpose to suggest that this analogy holds completely true with organizational politics, the underlying point is still important: denial of the political nature of organizations does not make that phenomenon any less potent. Organizations in both the public and private sectors are inherently politicized for the reasons that have been previously discussed. We realize that, in offering this view, we run the risk of offending some readers who are uncomfortable with the idea of politics and believe that, somehow, through the combined efforts of all organizational actors, it is possible to eradicate the political nature of companies or governmental agencies. We must disagree, as will, we believe, the majority of managers in organizations today. Politics are too deeply rooted within organizational operations to be treated as some aberrant form of bacteria or diseased tissue that can be excised from the organization’s body.

The first implication argues that before managers are able to learn to utilize politics in a manner that is supportive of GIS implementation, they must first acknowledge: 1) their existence, and 2) their impact on adoption success. Once we have created a collective basis of understanding regarding the political nature of organiza-


FIGURE 5. Conceptual Representation of the Relationship Between Level of Political Behavior and Organizational Performance

![Diagram showing the relationship between political behavior and organizational performance.]

FIGURE 6. Stakeholder Analysis

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Schedule</th>
<th>Performance Specs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Management</td>
<td>↓</td>
<td>↓</td>
<td>-</td>
</tr>
<tr>
<td>Accountant</td>
<td>↓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Client</td>
<td>↓</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Implementation Team</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

With these reactions, it is possible to begin to develop some action steps that will aid in GIS implementation.

Doing your OPB Homework: Stakeholder Analysis

Another way to illustrate the essential conflict in GIS implementation is through the use of stakeholder analysis. Stakeholder analysis is a useful tool for demonstrating some of the seemingly irresolvable conflicts that occur through the planned introduction of any new information system such as GIS. The concept of an organizational “stakeholder” refers to any individual or group that has an active stake in the success or failure of the planned GIS. For example, top management, as a group, once committed to acquiring a GIS, has an active stake in that GIS being accepted and used by client departments. For the purposes of simplicity, we are categorizing together all members of upper management as one stakeholder group. A valid argument could be made that there are obviously differing degrees of enthusiasm for and commitment to the adoption of GIS technology. In other words, a good deal of conflict and differences of opinion will be discovered within any generalized group. Nevertheless, this approach is useful because it
demonstrates the inherent nature of conflict arising from GIS adoption as it exists between stakeholder groups, rather than within them.

For the sake of our discussion, let us assume that in the case of an effort to implement a new GIS, there are four identifiable stakeholder groups: top management, the accountant, the clients, and the manager's own implementation team. As we suggested previously, top management has given the initial go-ahead to acquire and install the GIS. Likewise, the accountant provides the control and support for the implementation effort, ensuring that budgets are maintained and the project is coming in near projected levels. The clients are the most obvious stakeholder as they are the intended recipients of the new system. Finally, assuming an implementation team is working together to implement the GIS, this team itself has a stakeholder interest in the implementation, particularly if they are receiving some type of evaluation for their efforts.

To demonstrate the nature of conflict among stakeholder groups, we have developed three criteria under which the implementation will be evaluated: schedule, budget, and performance specifications. Schedule refers to the projected time frame to complete the installation and get the system on-line. Budget refers to the implementation team's adherence to initial budget figures for the GIS adoption. Finally, performance specifications involve the assessment that the GIS is up and running, while performing the range of tasks for which it was acquired. Certainly, additional evaluative criteria can and should be employed; however, for simplicity's sake, these three success measures serve to illustrate the nature of the underlying conflict in any GIS implementation.

Figure 6 shows the four identified stakeholders and the three success criteria that have been selected. The arrows are used to illustrate the emphasis placed on each of these criteria by the stakeholders. For example, consider the case of stakeholder preferences in terms of the differences between clients and the implementation team. It is obvious that in terms of evaluation criteria such as schedule and budget, there are significant differences in attitude: The clients want the system delivered as soon as possible for as cheap a final price as possible. On the other hand, the implementation team would like large budgets and longer installation schedules because that takes the pressure off the team in terms of bringing the system on-line. Further, the criterion of performance specifications will vary by stakeholder group. Clients want the opportunity to alter the system, customize it, or add as many technical capabilities as possible. The implementation team is much more comfortable with a simple system that has few technical surprises (and therefore less likelihood of long debugging procedures) and is not changed or modified once it has been acquired.

Figure 6 presents a compelling case for the underlying conflict of most GIS implementation efforts. It also serves to illustrate one inescapable conclusion: in order to rationalize and resolve the varied goals and priorities of the various stakeholders, a considerable amount of bargaining and negotiation is called for. As the reader will recall, bargaining and negotiation are two of the primary defining elements of organizational politics. Clearly, political behavior is required in successful implementation efforts. If we take as our starting point the conclusion that a successful GIS manager is not one who will satisfy all stakeholder parties, it becomes clear that implementation success is instead predicated on the GIS manager's ability to successfully bargain and negotiate with the various stakeholders in order to maintain a balance between their needs and the realities of the GIS implementation process. Implementation becomes a process that depends on the GIS manager's clever and effective exercise of political skills.

The one important implication of this discussion of project managers tasked with implementing a GIS is the necessity of cultivating the ability to use organizational politics effectively. By "effectively," we do not mean to imply that politics should be practiced in predatory ways. In fact, that approach is likely to seriously backfire on the viability of GIS managers who need to develop trust and goodwill to implement their systems. Rather, they must learn to appreciate and use politics as a negotiating and bargaining tool in pursuit of their ultimate goal of installing the GIS. This is another example of the reason we had earlier suggested that both the politically "naive" and the "shark" are equally inappropriate personae for managers to adopt. Successful implementation will not occur without the use of political behavior. Conversely, however, the degree of rancor and bitterness that is usually a by-product of predatory political behavior is one of the surest ways to torpedo the introduction of a new system.

**Active Engagement in OPB**

An understanding of the political side of organizations and the often intensely political nature of system implementation gives rise to the concomitant need to develop appropriate attitudes and strategies that help GIS managers operate effectively within the system. What are some steps that GIS managers can take to become politically astute, if this approach is so necessary to effective GIS implementation?

*Learn and cultivate "positive" OPB*

This principle reinforces the earlier argument that, although politics exists, the manner in which organiza-
tional actors use politics determines whether or not the political arena is a healthy or unhealthy one. We have tried to assert (see Table 1) that there are appropriate and inappropriate methods for using politics. Since the purpose of all political behavior is to develop and keep power, we believe that both the politically naive and shark personalities are equally misguided and, perhaps surprisingly, equally damaging to the likelihood of GIS implementation success. A GIS manager who, either through naiveté or stubbornness, refuses to exploit the political arena is destined to not be nearly as effective in introducing the GIS as is an implementation manager who knows how to use politics effectively; that is, to promote the organization’s overall goals which include the development and use of geographic information technologies. On the other hand, GIS managers who are so politicized as to appear predatory and aggressive to their colleagues are doomed to create an atmosphere of such distrust and personal animosity that there is also little chance for successful GIS adoption.

Pursuing the middle ground of political sensibility is the key to new system implementation success. The process of developing and applying appropriate political tactics means using politics as it can most effectively be used: as a basis for negotiation and bargaining. As Table 1 pointed out, politically sensible managers understand that initiating any sort of organizational change, such as installing a GIS, is bound to reshape the distribution of power within the organization. That is likely to make many departments and managers very nervous as they begin to wonder how the future power relationships will be rearranged. “Politically sensible” implies being politically sensitive to the concerns of powerful stakeholder groups. Legitimate or not, their concerns about the new GIS are real and must be addressed. Appropriate political tactics and behavior include making alliances with powerful members of other stakeholder departments, negotiating mutually acceptable solutions to seemingly unsolvable problems, and recognizing that most organizational activities are predicated on the give-and-take of negotiation and compromise. It is through these uses of political behavior that managers of GIS implementation efforts put themselves in the position to most effectively influence the successful introduction of their systems.

Understand, accept, and practice “WIIFM”

One of the hardest lessons for newcomers to organizations to internalize is the consistently expressed and displayed primacy of departmental loyalties and self-interest over organization-wide concerns. There are many times when novice managers will feel frustrated at the “foot-dragging” of other departments and individuals to accept new ideas or systems that are “good for them.” It is vital that these managers understand that the beauty of a new GIS is truly in the eyes of the beholder. One may be absolutely convinced that GIS technology will be beneficial to the organization. However, convincing members of other departments of this truth is a different matter altogether.

We must understand that other departments, including system stakeholders, are not likely to offer their help and support of the GIS unless they perceive that it is in their interests to do so. Simply assuming that these departments understand the value of a GIS is simplistic and usually wrong. Our colleague, Bob Graham, likes to refer to the principle of “WIIFM” when describing the reactions of stakeholder groups to new innovations. “WIIFM” is an acronym which means “What’s In It For Me?” This is the question most often asked by individuals and departments when presented with requests for their aid. They are asking why they should help ease the transition period to introducing and using a new system. The worst response GIS managers can make is to assume that the stakeholders will automatically appreciate and value the GIS as much as they themselves do. Graham’s point is that time and care must be taken to use politics effectively, to cultivate a relationship with power holders, and make the deals that need to be made to bring the system on-line. This is the essence of political sensibility: being level-headed enough to have few illusions about the difficulties one is likely to encounter in attempting to install a new system such as GIS.

GIS Implementation and OPB: Two Illustrative Cases

The use of GIS in the transportation business, and particularly for the state departments of transportation is gaining momentum. In part, this growth is fueled by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 (the federal government has mandated information requirements on these agencies that would be difficult if not impossible to meet without the use of GIS technology). Most of these agencies have embarked on some form of stand-alone (bottom-up) GIS implementation. However, subsequent technological difficulties and especially, organizational problems have generated enough dissatisfaction that most, if not all, of these agencies have engaged in organization-wide GIS strategic plan development and implementation.

Using two such cases—pseudo-named XDOT and YDOT because of non-disclosure agreements—we will highlight some of the major GIS implementation steps and their possible political nature; especially, how the political managerial actions are applicable (or not). We will advance our interpretation of how the agencies have dealt with (or are dealing with) these situations in politically productive or nonproductive manner.
General Implementation Steps

Implementation of technologies in organizations has been the subject of investigation by researchers and practitioners for more than a quarter of a century. There are many ways of characterizing the process: by phases, by activities, by episodes, by actions, by steps, etc. Each author seems to have a favorite. Obviously, the choice of a particular scheme has to do with what one is trying to use the elements of the implementation process for. For example, Antenucci et al. (1991) adopt the GIS steps all in sequence. Huxhold (1991) also proposes a similar GIS-stages scheme, while Montgomery and Schuck (1993), focusing on spatial data conversion, suggest a phase approach.

For studying OPB in the implementation process, we propose a variant of these approaches which we call tracks of the implementation process. The object is to give some (artificial) structure to the implementation process for identifying events of interest that involve major decision points in the life of a GIS project. The advantage of tracks is in letting us classify implementation events in sequence and parallel for the purposes of the study without imposing any rigid framework on the actual events taking place (i.e., it is purely a cognitive device). A typical GIS implementation process can have six tracks (or more depending on one’s scheme): organization, application, database, systems, training/education and funding. The typical contents of each track will, naturally, vary. For example, some of the key steps in the organization track would include obtaining a mandate, establishing an executive committee, appointing a statewide coordinator, and so forth. Likewise, the education track may include such activities as producing an executive summary, developing a newsletter, and conducting annual workshops. Potentially, all tracks with decision points can be contentious, although in reality that is not the case for all situations.

Case 1: XDOT

XDOT is a large state department of transportation (SDOT). It has over 13,000 employees, and it is responsible for the upkeep of 44,000 miles of roads as well as a variety of other transportation mode facilities. However, the majority of its work is related to roads: 11,000 of the 13,000 employees work in road-related activities. The general organizational climate or culture can be characterized as very formalized (Burns and Stalker 1961).

XDOT has been using CAD technology since the early 1980s and is considered one of the leading SDOTs in this regard, with over 300 CAD workstations. Beginning in the late 1980s, several divisions had shown interest in GIS, the main one being the paper-map production division. It was natural that staff saw GIS as an extension of what they were already doing. (This division is housed in the planning directorate of the XDOT which also houses all information reporting for transportation system performance mandated by the federal government.)

In 1988, experimentation with GIS began through several pilot projects. In late 1989, a consultant group was hired to develop a GIS strategic plan. This plan called for a 5-phase implementation strategy (and provided projected costs for each phase): strategic plan development; detailed implementation plan; core spatial database construction/application development; database construction/application development expansion; and agency-wide distribution. XDOT proceeded with the plan and hired another consultant for the development of the detailed implementation plan (hereafter just the Plan—one of the authors was a senior member of the consultant team directly taking part in the Plan development process). The activities of the Plan development contained the major elements of the tracks presented earlier in approximately the same sequence.

The project was overseen out of the planning directorate of the agency which was associated with GIS activities since their inception. However, as one of the recommendations of the strategic plan, the GIS steering committee was the final (formal) arbiter of Plan contents during major disagreements. The major track events of interest, due to expected conflict in decision-making, were the following:

- organizational location of GIS unit and hiring new staff;
- the mechanism for moving (attribute) data from and to MIS division databases;
- standards for GIS application development;
- scale of the base map;
- geographic features priorities for databases and application development priorities;
- standard software and hardware platform selection and procurement; and
- job re-classifications to GIS-based occupations.

Organizational location of the GIS Unit.

The staff of the planning directorate were quite keen on having the GIS unit located in their workgroup. This, however, was rarely mentioned explicitly, and assumed to be the consultant recommendation based on historical reasons and pilot application development. On several occasions when the point was brought up by the consultant team, it was subtly evaded and regarded as unnecessary for inclusion in the consultant report (the consultant team was aware that at other sites this is a point that can stifle GIS implementation and must be explicitly dealt with).

The staff of the planning directorate expressed worry about the topic in the following manner: if options other than those of the planning directorate are considered, then either the MIS division or the CAD division will

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try to “steal” the GIS unit. The rationale being that either had more experience with information technology through standard MIS operations or the CAD use. The consultant team considered other location options and recommended that the GIS unit stay with the planning directorate for a period of up to three years, at which time a re-evaluation of the location decision can be made. The planning directorate staff at first were not happy with the explicit location-options assessments. However, they accepted it based on its short-term recommendations and other factors that are explained below. This appears to be a very contentious point in most GIS implementations, and it was so at XDOT. However, a mechanism for its resolution can be highlighted through the next decision point.

Hiring New GIS Staff.

For historical reasons XDOT has been resistant to hiring new staff and, in fact, turnover rates for technical staff are somewhat low—under 10 percent. Perhaps the state being the major employer is an explanation for the low rate. In any event, as a part of the strategic plan recommendations and the Plan recommendations, three new hires were proposed. The agency had gone ahead with one new hire for GIS—a recent graduate with excellent UNIX and workstation/networking skills and some GIS training.

However, two other staff were “loaned” out of the MIS division to the GIS unit. This produced some friction for three reasons: the staff were “mainframers” with little or no workstation/UNIX know-how; their education dated back some years; and most important they were not under the direct control of the GIS unit (MIS still signed their time sheets). Initially, one of the senior managers in the planning directorate expressed much concern over management of “loaned” staff and its implications for the real GIS priorities. However, in a later meeting that same manager appeared to have accepted the situation as a fact of life and more to the point as a quid pro quo for the head of administration directorate allowing the GIS unit to remain in the planning directorate (this is an inference made by the authors, because such comments were never explicitly made, but always indirectly, however, it also serves to highlight typical problems of doing research on OPB given its informal nature in the majority of cases).

Mechanisms for moving attribute data from MIS to GIS. XDOT has one of the most highly developed road information systems in the country. However, like the majority of these systems, it was developed in the mid-1980s and it is highly mainframe-dependent (it also cost millions of dollars to develop). As such, it poses enormous and expensive technological integration problems for GIS, not to speak of organizational and cultural integration issues.

These technological and cultural clashes manifested themselves in the form of the MIS division being very resistant to providing any kind of “live” access to their attribute road data (a GIS life blood) for the GIS unit. They expressed their opposition in the form of concern over three issues:

- being burdened with writing custom code for extraction of data to specific GIS requirements;
- concern over data integrity and quality issues, if live access is provided to someone “who does not understand the mainframe”;
- and risk to data not just on the road information system but other parts of the system with more sensitive information such as driver’s license data.

Some of their concerns over security and integrity were very legitimate and understandable. However, their disagreement over live access was not totally warranted. After several meetings with the consultant team and explanations of the need for eventuality of live access, they evolved toward a softer position. They agreed to a three-phase strategy of one-way access (no live or “dead” updating of data or no two-way links, only read access). This, in the minds of the GIS staff, was a major disappointment given that the major touted benefit of GIS by vendors is its ability to provide attribute feature update through geographic feature manipulation.

The MIS division finally agreed to the consultant team’s recommended phased solution. The solution would entail three phases. In phase one, they would be creating a shadow database that would provide access to the data, but it would be updated every 2 to 3 months, and the communication would be only one-way to GIS as a user of data. In phase two, some “live” one-way access will be provided through the so-called “pipeline” technology, while the rest will still be duplicated in the shadow database. In the third phase, the link will be fully “live” but still with one-way access. The issue of two-way access was never resolved and was left to a later stage in the process of implementation.

Standards for application development.

Since the beginning, the MIS division had a very intimate involvement in the GIS procurement process. Initially, the MIS had approached the GIS implementation as just another application and therefore wanted to subject it to the rules governing the MIS application development process. However, this implied: either MIS or their consultants would design and develop the applications; or an intense period of learning all the rules and methods by the GIS unit. Almost all data processing know-how was concentrated in the MIS division. In addition, it turned out that most other divisions that had

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tried to grow their own mini-MIS, had either “failed” or were “presumed as failures” by the MIS division.

This created a significant bone of contention between the GIS unit/consultant team on one side and MIS on the other. After several presentations to the GIS steering committee as well as individual meetings with MIS management, the MIS appeared to accept GIS as new technology whose development process may be governed by different rules at least at the beginning. This position, however, seemed to have been somewhat related to the MIS’s insistence on no two-way links to GIS for some time into the future (again a quid pro quo).

Base-Map Scale.
One of the key tasks in the Plan development was determining the most suitable base-map scale and providing recommendations for it. This process is often rife with disagreements over what each function within an agency is apt to call their appropriate GIS base-map scale. However, two issues usually are overriding: the first series of GIS applications and their scale requirements; and the costs associated with developing the base map at a particular scale. It goes without saying that, as scale becomes larger and accuracy increases, costs go up geometrically. Therefore, one would expect major conflict and disagreements before a choice is made.

However, at XDOT this turned out to be something of a non-issue. Within the GIS steering committee, there was consensus that application development should proceed based on the updated version of XDOT’s state centerline file at the 1:24,000 scale and at the accuracy of ± 50 feet. The authors can only conjecture, based on interviews with CAD engineers, that CAD work with its project and small-area focus requires the large scales and high levels of accuracy. And that is quite different from the GIS uses foreseen by the plan.

Geographic features database design and construction (and application development) priorities.
A large number of interviews were conducted to uncover the user needs for particular geographic information features as well as the related attribute information. In fact, the interview list was expanded mid-way in the project based on issues raised by various division heads and section chiefs in one of the GIS steering committee meetings. However, the expansion of the interview list did not appear to change the database construction list, which appeared largely governed by two external factors: a general concern in XDOT and state government about highway safety, making such application first priority; and ISTEA-mandated management systems requiring particular information about priorities already identified. It appears as though the interview list was expanded to input and change the priority list of database construction. However, there was no observed change in the priority list (perhaps a means of co-opting opposition, etc.).

Standard software/hardware platform.
It is customary for agencies acquiring GIS technology to spend significant effort and money to “benchmark” vendors of hardware and software before a procurement decision is made. Of course, the legal aspects of procurement as well as government regulation regarding competitive bidding, etc. has a lot to do with this. XDOT was no different, and such work was stipulated in the detailed implementation plan. As the consultant team started working on the plan development, however, the client appeared very keen on staying with their current hardware and software vendor (for both CAD and GIS). In fact, several indirect allusions were made to the effect that, although there is a formal review on the bench-marking part, the GIS unit had a strong preference for one vendor.

In several other discussions, a consultant team suggested that if the client is not seriously interested in the bench-marking, the effort can be re-allocated to another task. The client agreed. In the next GIS steering committee meeting the suggestion for dropping the bench-marking task and adding other tasks was formally presented by the consultant team. All XDOT participants agreed, except for the representative from the Governor’s Office on Information Technology. The representative insisted that she had not heard any “good” reason for dropping bench-marking. It appears as though XDOT is favoring vendors, which is a practice not advisable in state government. The XDOT staff gave the go-ahead for the bench-marking and the task was conducted. The results, however, were largely superfluous because the consultant team already was aware of a large procurement package for the existing vendor’s products.

There appeared to be an implicit element of appeasement in the informal exchange between the governor’s office (and their concern for the appearance of impropriety) and XDOT (and their concern for expediency).

Job Re-Classification Issues.
Two separate but related matters of job re-classification appeared to surface during the Plan development. First, the human resource division of XDOT was resistant to and not convinced of developing GIS-related job categories. Their rationale was that CAD was introduced into the agency, and the engineers who were using them were still classified as engineers even though occupationally they used CAD in their work; in their view, what is the difference in GIS? The consultant team provided several examples of GIS job re-classifications from other agencies (largely non-SDOTs). The team also ex-
plained the need for a career path of GIS specialists, otherwise the agency may be faced with severe turnover problems if these specialists realize there are no career paths for them in a transportation agency. The human resource staff usually countered with the belief that the informal culture of a SDOT, such as XDOT, where engineering careers are the route to upward mobility will not value such a career path. At the close of the Plan development, this issue was still not resolved.

Second, there was the issue of existing jobs being reclassified. In particular, an interesting incident currently under grievance arbitration at XDOT highlights this. The professional cartographers in the paper-map production division had filed a request for being reclassified as computer analysts with greater pay and better career prospects—with intent to sue if denied, since they were unionized. Their rationale was that their work has become similar to a computer analyst in content due to work with CAD and GIS equipment, therefore they should be reclassified and upgraded in terms of occupational category. This incident happened just before the Plan was developed. It is now in arbitration. It shows a potential conflict that must be addressed in the long run if the GIS profession is to flourish. That is, successful implementation of GIS requires people with complete career paths moving in and filling the GIS positions in organizations.

**Case 2: YDOT**

YDOT is a small state department of transportation, with over 700 employees and close to 6,000 miles of roads to maintain. YDOT is also involved with other transportation modes, but much like other SDOTs, its major function is to construct and maintain highways. The agency has been using CAD in its design and construction work. It has also been developing major highway information systems since the mid 1980s. The major information system platform in the MIS division is mini-computer-based. The general organizational climate or culture can be characterized as “loosely coupled” (Weick 1973).

YDOT engaged in a major information engineering effort in the late 1980s to early 1990s and developed an agency-wide transportation information plan. The plan produced more than 3,000 fields and 143 tables of information. Shortly following that project, there was a GIS implementation effort for which a consultant team was hired to give advice on the GIS effort within YDOT. However, the team was not hired by the workgroup that was building the GIS, but by the MIS division. At the outset, it should be made clear that the consultant advice was not heeded by the GIS workgroup, perhaps understandably, as it was considered hostile advice.

In fact, the project was terminated a year after the consultant was hired because YDOT did not meet the federal reporting deadlines. Subsequently, the consultant team was re-hired and is in the process of developing an agency-wide GIS implementation plan. What follows is the case history of the implementation, including: hardware architecture; base-map features and scale; application development linkages; and standard hardware/software vendor selection.

**Hardware architecture.**

A major issue within the GIS community revolves around the appropriate hardware architecture for GIS. Specifically, what are the limits of using PC technology for GIS? When is the workstation technology too much for a given task? The answers are usually based on preference rather than objective tests. However, the conventional wisdom is that, for large databases of 1 gigabyte or more in a networked environment, the platform of choice is the UNIX workstation, because its performance is much more robust than the PC-based networks.

This issue also was a point of contention within the YDOT GIS effort. The GIS people went ahead and attempted to implement a PC-networked GIS. Others, especially those maintaining the paper-map production capabilities, were more interested in workstation technology. But, funding from the federal agencies allowed the workgroup to bypass the formal organizational procedures normally required for such projects. Later, as we discuss the issue of map scale, the hardware platform choice may have been flawed from that perspective, if not from others.

**Base map features and scale.**

As mentioned in the XDOT case, the decision process associated with deciding on a GIS base-map scale is rife with conflict. The YDOT case, in fact, did exhibit this behavior (as opposed to XDOT, which did not). The GIS workgroup decided to adopt a very large scale—1:100 for a parcel-level map, and TIGER (1:100,000) for their centerline file. This appeared contradictory to a number of the YDOT players, since the prevalent base-map scale for a SDOT is the centerline file with a 1:24,000 scale. Also, maintaining parcel-level base maps at 1:100 scales requires terabytes of storage per county. One can only imagine the storage and software/hardware architecture requirements. The choice for scales appears not well thought out, again driven perhaps by the funding availability through external sources.

**Application Development Linkages and Priorities.**

The information engineering effort had identified a pavement management system (PMS) as an application
priority, while GIS technology was regarded as just another application. In addition, given the behavior of the GIS unit, the impetus was there for the PMS to be developed independent of the GIS, since the GIS workgroup appeared not to be in accord with the rest of the agency’s needs and priorities. In any event, a separate pavement management system was developed by a workgroup. However, it did not use state-of-the-art GIS technology methods such as dynamic segmentation, which is a real boon to PMS development (the state of Wisconsin Department of Transportation has been the leading SDOT in demonstrating this application). Although one cannot put the blame for that on the GIS workgroup, the fact that agency-wide considerations were not given top priority, meant that efforts such as PMS and GIS were “islands of information and know-how” with little integration. In addition, the GIS workgroup application priorities were not the result of any agency-wide user-needs assessment, and it did not even correspond to the IE effort. Consequently, the rest of the agency did not take much interest in ensuring the successful completion of the project.

Standard Hardware/Software Platform Selection.
The GIS workgroup did not go through an evaluation procedure, and decided to adopt a PC-platform as well as a desktop GIS package. This was at odds with the purchasing decisions of the rest of the agency, especially the paper-map production unit, which was using workstations and their own software vendor. The same platform was used by the CAD people across the agency. Because the PMS’ application architecture being closed and proprietary, the agency relies on a different vendor to maintain it, and conversion to a multi-user system has been even more costly and lengthy (this application does not use an off-the-shelf GIS package).

The GIS workgroup’s decision appears not to be motivated by the agency-wide considerations of know-how and compatibility, but rather dictated by the workgroup’s interests. Again, the outside funding of the project, allowed the GIS workgroup to bypass normal channels of decision-making and adherence to organization-wide goals and mission.

The GIS project did not meet the deadline for the EPA regulatory filings. This resulted in a major delay in the award of the state’s federal transit grants which stipulate that EPA requirements have to be satisfied. Subsequently, the project funding was cut to zero, staff were re-assigned, and in particular, the division manager was demoted to a position in another division. This failure can be attributed to a number of factors, but most important was that this effort was regarded as a “rogue elephant” in the mind of YDOT’s other players. Perhaps it is a classic conflict situation—a workgroup attempting to implement new technology by “going it alone,” sometimes against the organizational goals (almost the replica of what was discussed in terms of content of OPB), and then not succeeding.

It is interesting to note that, for this SDOT, the new GIS Plan development now under development has coincided with the change of administration in state government.

Reflections on OPB in GIS Planning and Implementation

In each SDOT case we have elements of behavior in the organization that can be characterized as political. However, GIS technology acquisition and implementation in each case is not just one decision. It is a process of many decisions and events. It involves a number of subcomponents, namely, “track events.” Therefore, given the details of these cases and the framework presented earlier for OPB, we can speculate on the “validity” of: 1) the logical propositions and constructs; 2) the analytical contents of OPB; and 3) the types of political actions taken by the actors in each case.

Constructs and Propositions

A summary of our analysis of the cases based on propositions and constructs appears in Table 2. Regarding Proposition 1a, namely, that innovation decisions lead to resource re-allocations, we have strong support as far as the YDOT case is concerned. The organizational location decision for the GIS unit was a clear example of resource re-allocation which was supported by the planning directorate. This was thought to have brought with it extra resources and prestige along the lines of Kraemer et al.

In the YDOT case, there was consensus among key actors in the organization from other divisions that the GIS unit was interested in developing GIS unit’s goal primarily to “command” a first place in the organization regarding GIS expertise and respect.

Negotiation and bargaining as hallmarks of innovation-induced resource re-reallocation was expressed through Proposition 1b. The “loaning” of, versus hiring, new staff in the XDOT case pointed to this kind of behavior. Especially, the quid pro quo between the heads of planning directorate and management and budget directorate regarding the “exchange” of a GIS unit location for only one new hire, and the use of existing MIS staff indicates this kind of negotiation and bargaining.

In the YDOT case, such behavior was not readily observable. However, this was partially due to lack of researcher involvement at the early stages of the project (and the external funding of the project). Therefore, given that the claim on internal resources was largely untouched, it would be expected that we will not see as much bargaining and negotiation as would be the case if the project was funded by internal monies.
<table>
<thead>
<tr>
<th>OPB Proposition</th>
<th>XDOT</th>
<th>YDOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1a) Innovation decisions lead to resource re-allocation</td>
<td>(+) Organizational location decision was a clear example of this</td>
<td>(?) Not directly observed because of the use of outside funds</td>
</tr>
<tr>
<td>(1b) Resource re-allocation decisions are characterized by negotiation, bargaining and jockeying for position</td>
<td>(+) Hiring new staff versus &quot;loaning&quot; staff indicated &quot;behind&quot; the scenes negotiations</td>
<td>(?) Not directly observed because of the use of outside funds</td>
</tr>
<tr>
<td>(2a) Under uncertainty/ innovation conditions, functional differentiation leads to major inter-group cleavages</td>
<td>(+) MIS vs. GIS disagreement over attribute data transfer to GIS</td>
<td>(+) GIS Unit made decisions regarding base map scale, hardware, standard software, etc. in self-interested manner</td>
</tr>
<tr>
<td>(2b) Inter-group cleavages lead to workgroup coalitional behavior</td>
<td>(+) MIS with the help of Management/ Budget Directorate formed a coalition to block the short-term &quot;live&quot; attribute data transfer</td>
<td>(+) as above</td>
</tr>
<tr>
<td>(3a) Bargaining/negotiating and coalitional behavior lead to inter-personal and inter-group conflict</td>
<td>(+) New staff, choice of platform, attribute data transfer, etc. led to GIS and other groups being at odds or in conflict</td>
<td>(+) Inter-group conflict was more apparent after the GIS project was terminated based on opinions of other players</td>
</tr>
<tr>
<td>(3b) Bargaining/negotiation, coalitional behavior, and conflict lead to OPB</td>
<td>(+) All of the above as well as job reclass. etc. lead to relatively &quot;positive&quot; level of OPB</td>
<td>(+) GIS group's OPB was viewed by most other players as &quot;dysfunctional&quot; (or shark like)</td>
</tr>
</tbody>
</table>

Legend: (+) = Behavior Present; (-) = Not Present; (?) = Inconclusive Evidence

Proposition 2a related the functional differentiation to cleavages among organizational workgroups in the context of an innovation decision like GIS. In the XDOT case, the MIS division clearly engaged in self-interested behavior protecting their turf as having full control over attribute-data resources. Although the long-run ability for "two-way" update of attribute data is in the XDOT organization-wide interest in productivity, it was resisted by the MIS division. It succeeded in postponing a decision on this issue until a later date (if at all!).

In the case of YDOT, the decision on scale of base map, hardware platform and standard software for GIS by the GIS unit were made unilaterally, without regard for other divisions' needs. The self-interested behavior
TABLE 3. Assessing the Content of Organizational Political Behavior During GIS Implementation at XDOT and YDOT

<table>
<thead>
<tr>
<th>OPB Category</th>
<th>OPB Sub-Category</th>
<th>XDOT</th>
<th>YDOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outcomes</td>
<td>Self Serving</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Against the Organization</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Resources (Re-) Distribution</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Power Attainment</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Means</td>
<td>Influence</td>
<td>+++</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Power Tactics</td>
<td>++</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Informal Behavior</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Concealing Motives</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Situational Characteristics</td>
<td>Conflict</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Uncertainty</td>
<td>++</td>
<td>+++</td>
</tr>
</tbody>
</table>

Key: Activity of that type was estimated to be occurring at the following levels
? = Difficult to assess  +++ = Moderate  ++++ = High

of this workgroup was manifest based on opinions expressed by other workgroup members that did not share the priorities of the GIS unit, and who were already using another hardware/software platform.

The coalitional behavior—contained in Proposition 2b—was clearly demonstrated in the XDOT case. The MIS division was able to control the outcomes of the GIS Steering Committee meetings on this topic, and managed to effectively block the “two-way” update of attribute data. They accomplished this by clearly allying themselves with the management and budget directorate which saw itself as the “custodian” of all electronic attribute data, and did not allow encroachment, viewing it as either generating more work for them and/or loss of control of data.

In the YDOT case, the GIS unit again acted unilaterally as an interest group with little attention to other workgroup needs in almost all track events regarding hardware, software, base map scale, etc. The opposition of the rest of the organization became more apparent after the project was terminated. This workgroup is not getting cooperation from other workgroups in designing some critical information systems for the federal reporting requirements. In addition, their GIS is looked at as incompatible with any new organization-wide GIS effort.

The existence of conflict—expressed in Proposition 3a—is almost axiomatic in all political situations in organizations. Nevertheless, it is important to explicitly reference them. For the XDOT organization, the new staff hire, GIS unit location and attribute-data transfer all led to the GIS unit and other groups—particularly the MIS division—being in conflict. The conflicts were manifest as mild to intense disagreements. They never reached dysfunctional levels, except in the case of attribute-data transfer. Even in that case, the GIS unit, with the help of the consultants, managed to develop an interim solution that could demonstrate the advantages of two-way attribute-data transfer.

The existence of conflict in YDOT during the GIS implementation manifested itself through several decisions regarding base-map scale as well as hardware/software choice. The disagreements were particularly intense when consultants were brought in to mediate or to present contrary opinions to the GIS unit’s unilateral decisions.

For each case, different levels of OPB were operating. In the case of XDOT, the OPB was based on the content factors of influence, informal means and situations of conflict. In the YDOT case, these factors were not as readily observable during the implementation process, although they became more intense as the outside consultants (the authors) were brought in. However, the behavior in the post-termination phase of the project has clearly demonstrated classic OPB factors: informal means, influence and conflict.

**OPB Content in XDOT and YDOT**

In analyzing events of a case in hindsight, there is always the danger of seeing the events in the way the framework favors. However, case studies highlight the favorable and not-so-favorable aspects of this framework.
**TABLE 4. Assessment of OPB Positive Culture at XDOT and YDOT Based on GIS Implementation Track Decisions**

<table>
<thead>
<tr>
<th>GIS Implementation Track Event</th>
<th>Presence of Positive OPB Culture</th>
<th>Acceptance &amp; Practice of &quot;WIIFM&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>XDOT</td>
<td>YDOT</td>
</tr>
<tr>
<td>Organizational Location of GIS Unit</td>
<td>++ +</td>
<td>-</td>
</tr>
<tr>
<td>Hiring New GIS Staff</td>
<td>++ +</td>
<td>N/A</td>
</tr>
<tr>
<td>Attribute Data Transfer to GIS</td>
<td>-</td>
<td>N/A</td>
</tr>
<tr>
<td>Application Development Standards</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Database Construction Priorities</td>
<td>++ +</td>
<td>-</td>
</tr>
<tr>
<td>Standard Hardware/Software Platform</td>
<td>++ +</td>
<td>-</td>
</tr>
<tr>
<td>Target Delivery Architecture</td>
<td>+ + +</td>
<td>-</td>
</tr>
<tr>
<td>Base Map Scale and Accuracy</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Job Re-classification</td>
<td>-(?)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Key:**
The particular "positive" OPB culture/actions was present to the following degrees:
- ? = Cannot be determined based on case evidence
- - = None
- + = Low
- ++ = Moderate
- +++ = High
N/A = Not Applicable (track event did not take place or was insignificant)

In the XDOT case, we can say with relative certainty that almost all decisions involved high levels of self-interest, resource redistribution, power attainment, and informal behavior. On the other hand, with the exception of the attribute-data transfer, working against the organization and concealing motives was rare.

Because of less author involvement with the YDOT case, the same generalization is more risky. However, it is possible to say that activities counter to organization-wide interests were more pervasive in the YDOT case in almost all decisions. See Table 3, for our speculations on the presence of these factors in both cases, and their intensity.

The objective of this analytical speculation is not to test our OPB contents—that would be beyond the scope of the current paper—but to show it is possible to readily observe OPB. The various factors in GIS implementation need to be more fully explored to assess their reliability and validity.

**Assessment of OPB based on Managerial Actions**

We have demonstrated the presence of organizational political behavior during GIS implementation in XDOT and YDOT. However, one of the key motivations of this paper was to present certain "guidelines" for GIS managers and professionals that will help them in their projects. These guidelines included doing a stakeholder analysis, but more important, to cultivate a positive OPB culture, as well as practice of "WIIFM" (or engagement through exchange). It is imperative after having presented these ideas, to assess the extent these practices were observed in the XDOT and YDOT cases.

Table 4 is a distillation of this assessment for both cases. We have listed the major GIS implementation track events, and provided our assessment of OPB culture and/or practice of "WIIFM". In our assessment, the XDOT and YDOT GIS implementation cases demonstrate stark differences in the presence of positive OPB and practice of WIIFM: XDOT exhibited a high positive OPB culture and the practice of WIIFM; for YDOT, the opposite was true.

It is risky to offer conclusions based on only two cases. We would, however, assert that the success of GIS planning and implementation in XDOT is, in part, due to the positive OPB culture and WIIFM practice. That is, the organizational actors appear to adhere to quid pro quo's regarding informal means and influences amidst workgroup conflict, which tend to promote solutions...
that are in the interests of the whole organization. The two clear track events were: the GIS unit organizational location/new staff hires, and the application development standards. The attribute-data transfer mechanism did not adhere to such principles and involved dysfunctional political behavior at least as far as the whole organization was concerned.

In the YDOT case, we are tempted to interpret an almost total disregard for organization-wide concern with efficiency and effectiveness, which manifested itself through workgroup self-interest in almost all track events of GIS implementation. There was little positive OPB culture promotion and no WIIFM practice. We again attribute the “failure” and termination of the GIS project at YDOT at least partially to this lack of OPB and WIIFM practice.

The contrast between the two cases is sufficient, in our opinion, to point out the implications of the theoretical constructs and propositions as well as the practical implications of positive versus dysfunctional OPB.

Conclusions

Implementation politics is a process that few managers and professionals enjoy. We do not enjoy having to cut deals, to negotiate the introduction of new systems, and to constantly mollify departmental heads who are suspicious of the motives behind installing GIS, or any other system that threatens their power base. Nevertheless, the realities of modern organizations dictate that successful managers and professionals must learn to use the political process for accomplishing goals and implementing plans/projects.

Our goal has been two-fold, to offer a research framework as well as practical views on the nature and importance of political behavior in modern organizations. We have laid out some of the major issues in organizational political behavior, and illustrated them by means of two case studies of GIS implementation. Although, two cases do not constitute adequate validation, the aim was not that. It was rather, to provide exploratory evidence to deepen and refine the OPB concepts presented. This can be the point of departure for a confirmatory study of the framework presented in this paper.

Specifically, future research can test the framework presented in this paper by: (1) assessing the presence or lack of OPB; (2) whether it was characteristic of the organizational climate/context, or was it brought about through actions of the individuals; and (3) whether the eventual GIS outcomes for the organization correlate with the OPB climate and / or actions. The second point is important to establish, because we can find out to what extent OPB culture/climate is a given versus whether it can be controlled through management action. In addition, detailed case studies to demonstrate how OPB is constructively managed during GIS implementation will assist both in theoretical clarification and refinement as well as further development of managerial guidelines for OPB.

That is, the behavioral differences between effective and ineffective projects can be studied more directly to see how the application of OPB contributed to their success or rendered them a failure. With results identifying these behaviors, managers and project leaders will be more appropriately equipped to use OPB as a “positive” and constructive tool in their work in GIS project teams. We hope that the propositions advanced in this paper indicate good reasons to be concerned with both recognition of OPB and its “positive” application over the course of GIS development activities.

Future research can also extend the model by studying the relationships between organizational success and system success. While it makes intuitive sense that successful systems are more likely to be produced by successful project teams, empirical tests are necessary to verify this expectation. It is plausible that teams devoting excessive time to OPB could neglect important efficiencies in their primary GIS-related tasks. The project management literature suggests that the gains from team activities are potentially offset by “process losses,” and that effective team leaders must balance such gains and losses. As our understanding of GIS implementation project teams expands, such considerations should be evaluated empirically.

Three specific tasks are of immediate priority for further research involving survey instrument development. First, a scale needs to be developed to assess the degree to which political behavior is present in particular organizational situations. Second, a scale is required to distinguish between situations that are political regardless of the nature of technical matter involved, namely, GIS or no GIS, certain organizational environments are more political. Third, scales can be developed to assess the effectiveness of positive political tactics in various organizational environments.

Notes

This paper is based on material presented at the URISA ‘93 conference in Atlanta, Georgia, July 1993, and was partially supported by the National Center for Geographic Information and Analysis (NCGIA) under NSF grant No. SBR 88-10917. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

1 The use of the term procedural rationality is deliberate in reference to the modified rational choice models and in recognizing that to be politically self-interested is to be rational.

2 We are tempted to use the example of the DigiCom, the high tech firm in the midst of developing the “killer” virtual reality
application, in Michael Crichton's latest novel, Disclosure. The characters of Tom Sanders (up-and-coming executive), Meredith Johnson (the scheming executive), and Stephanie Kaplan (shrewd but careful executive) fit surprisingly well in our categories of naive, shark, and sensible respectively. For those of you interested in the real-life drama of organizational political behavior and in high technology settings, it is a fascinating book.

3 We are grateful to our colleague Bob Graham for this insight.


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Measuring The Benefits of GIS Use: Two Transportation Case Studies

Stephen R. Gillespie

Abstract: The U.S. Geological Survey (USGS) is researching methods to improve the measurement of the benefits of using geographic information system (GIS) technology. As part of this research, case studies of GIS transportation applications were conducted at the Oak Ridge National Laboratory and the Wisconsin Department of Transportation. Benefits can be expressed as reduced costs or as improved quality of applications. The key to measuring benefits is to identify what has changed because of the GIS. By narrowing the focus to a single effect or a single user, it is possible to ask pertinent questions about value, and to reasonably measure benefits that previously had appeared to be nonquantifiable.

Government transportation managers are under increasing pressure to do more and more with less and less. Ways must be found to make scarce budget dollars travel further. GIS technology is one possible answer to this dilemma, and transportation departments are turning to GIS with growing frequency. However, to get the most out of GIS technology, it is vital to be able to measure the potential benefits from its use. It takes a sizable initial investment to establish a GIS installation; such an investment is unlikely to be approved without solid documentation of significant potential benefits. Then, once a GIS capability has been established, there are many possible projects competing for scarce GIS resources. Without a reliable way to estimate benefits, lower-valued projects may be allowed to consume resources that could better be used on more valuable projects.

The technique used to develop estimates of benefits is a cost-benefit study. Theoretically, benefit estimates should be based on the societal marginal willingness to pay for GIS-provided improvements over the present system (Peterson and Sorg 1987). In the absence of externalities and monopoly, societal willingness to pay is measured by market prices. However, it is in the nature of government involvement in GIS operation that markets cannot set meaningful prices for many of the changes. E.J. Mishan (1982) comments that, although such intangible benefits can be measured in principle, there are likely to be difficulties in practice of putting reliable figures on them. Researchers at the U.S. Forest Service report that, although much progress has been made in recent years in the valuation of non-priced and non-priceable goods, emphasis has been on those things most readily measurable (Peterson and Sorg 1987).

Evidence of the difficulty of measuring intangible benefits can be found in cost-benefit studies in support of GIS acquisitions. The Bureau of Indian Affairs (BIA) analyzed the results of the installation of GIS at three test sites. They found that the GIS offers benefits above and beyond the outputs produced by manual alternatives, but treated most in an expository manner and made no attempt to place dollar values on the benefits (BIA 1988). A study by the Michigan Department of Transportation (MDOT) identified 156 potential benefits from the adoption of GIS technology, but could quantify only 19 (MDOT 1988). According to the Federal Geographic Data Committee (FGDC), although intangible benefits are difficult to quantify, many such benefits are the strongest arguments for having a GIS (Guptill 1988). Research conducted by the USGS provides a practical technique for improving the measurement of the benefits of using GIS technology.

Two Types of Benefits

Many different taxonomies of benefits are available for use in cost-benefit studies. The analyst might distinguish between primary benefits (from direct effects, intended effects) and secondary benefits (from ripple effects) (Tietenberg 1992). A common distinction is between tangible benefits (those which reasonably can

Stephen R. Gillespie is an economist in the National Mapping Division of the U.S. Geological Survey. He received his Ph.D. in economics from George Mason University. He came to the Geological Survey in 1989 following 17 years work at the Bureau of Labor Statistics. Dr. Gillespie's primary research interest is the economic value of geographically referenced data.
be assigned a monetary value) and intangible benefits (those which can't) (Haveman and Weisbrod 1973). Another choice is between use-value and non-use (intrinsic) value (Smith 1984).

A particularly useful distinction for measuring benefits from the use of GIS technology is between efficiency benefits and effectiveness benefits. **Efficiency benefits** result when a GIS is used to do a task previously done without a GIS; the same quality of output is produced, but at lower cost. For example, cut and fill calculations can be made by applying planimetric techniques to contour lines on a graphic map, or by manipulating digital elevation data in a GIS. Both methods yield the same results, but a GIS is much faster and easier.

**Effectiveness benefits** result when a GIS is used to improve the quality of a current output, or to produce an output not previously available; the GIS is used to do something that could not or would not be done without it. For example, a GIS can quickly and easily produce maps showing how the proposed route for a new road would impact a series of environmentally sensitive resources. Such maps could be manually drafted, but the process would be so expensive that they probably would not be prepared. A GIS can also overlay a large number of separate environmental themes and calculate an overall impact. When there are more than just a few overlays, this is a task that is simply not feasible using non-GIS techniques.

The USGS research uses the efficiency/effectiveness taxonomy, not because it is conceptually superior to other taxonomies, but because it has practical advantages in measuring benefits. The distinction between efficiency benefits and effectiveness benefits is important because their sources are different, and techniques that will measure one will not measure the other. The source of efficiency benefits is a reduction in the cost of running an application. Estimating costs is easier, in general, than estimating benefits (Tietenberg 1992), and most cost-benefit studies do a good job of measuring efficiency benefits. The source of effectiveness benefits is a change in the output of the application. Because the value of new or improved GIS outputs can be difficult to estimate, all too often cost-benefit studies call these benefits intangible or nonquantifiable, and do not measure them at all.

**Measuring GIS Benefits**

During late 1990 and 1991, the USGS conducted more than 60 case studies of GIS applications. These applications were run by more than 40 different government agencies, and cover a wide range of topics. The case studies established practical techniques for distinguishing between efficiency and effectiveness benefits, and for reliably estimating the general level of both (Gillespie 1991a).

The key to measuring benefits is to identify what has changed because of the GIS. For efficiency benefits, the GIS output is the same as the previous manual output; what has changed is the resources needed to produce that output. This benefit is measured as the reduction in variable costs for running the application. In the 30 USGS case studies where efficiency benefits were important, the bulk of this cost was usually personnel costs. There was seldom any difficulty in measuring efficiency benefits.

For effectiveness benefits, it is the output of the application that has changed. The value of this benefit depends on the extent the changed output has on each user. Note that this is a very pragmatic definition. It says that a GIS output has value only to the extent that it causes changes in behavior. This ignores the entire class of benefits called existence value. Existence value is the willingness to pay for the knowledge that a resource exists, even if the individual has no intention of using the resource (Brookshire, Eubanks and Sorg 1987). Ignoring existence value means that, all other things being equal, the USGS measurements are conservative estimates of the level of effectiveness benefits.

In the 47 USGS case studies where effectiveness benefits were important, once the specific effect on a user of a change in the GIS output was identified, it was possible to estimate the value of the effect. Effectiveness benefits for an application are the sum of the value of the effects of each change in output for each of the users of the output.

Two of the USGS case studies are transportation applications; a hazardous waste-routing project by the Oak Ridge National Laboratory (ORNL) (Gillespie 1991b), and the pavement-management program of the Wisconsin Department of Transportation (WDOT) (Gillespie 1991c). These studies do more than just show the value of applying GIS technology to two specific transportation projects. They also demonstrate general techniques that can be used on traditionally hard-to-measure effectiveness benefits to significantly improve cost-benefit analyses.

**Case Study—Moving Nuclear Wastes**

One and a half billion tons of hazardous materials are transported each year in the United States (OTA 1986). GIS technology is increasingly being applied to analyze hazardous-materials transport decisions (Abkowitz 1990). One such application is performed by the GIS unit at ORNL.

There are 80 nuclear reactor sites operating in the United States. Radioactive waste products (principally,
spent fuel rods) are being produced and stored at each site. Storage capacity is nearly exhausted at some sites. The radioactive wastes at each reactor site will need to be transported to a Department of Energy (DOE) nuclear waste disposal site. There is risk involved in the movement of radioactive wastes. The GIS unit at ORNL examines the feasible routes from each reactor to the disposal site, and determines the population-at-risk along each route (Durfee et al. 1988).

The ORNL GIS unit obtained 1980 census population counts and centroids at the level of census block groups and enumeration districts. The researchers then divided the entire country into 45 million grid cells, and calculated the population density within each cell. Using the GIS system, they then drew contour lines that connected cells of equal density. The proposed route and population density contours were overlaid on a general base map. The GIS then calculated a variety of different measures of population-at-risk:

- Total population within the route corridor.
- Average population density within corridor.
- Number of miles of route at each level of density.

The ORNL GIS unit does not believe it is possible to duplicate this GIS output via any manual method. If there were a population density contour map, it would be possible to manually plot a proposed route, and then to calculate population-at-risk with planimetric techniques. However, no such contour map exists, and it is not practical to manually create one from the 45 million density grid cells. There is no way for them to generate accurate population-at-risk information without the GIS; this means that these GIS benefits are effectiveness benefits.

The GIS output is different in that it provides information that would not be available without the GIS. DOE managers are the only users of the information. The effect of the new information the GIS provides is that DOE managers are able to select routes for transporting nuclear wastes that result in less risk to the general populace. What is the value of the selection of lower risk routes? The general level of effectiveness benefits was estimated by measuring three factors:

1) The likelihood that the GIS information will cause a lower risk route to be chosen.
2) The magnitude of the reduction in population-at-risk.
3) The value of the risk avoided.

As to the first factor, managers at the ORNL estimate that, even without the GIS information, the lowest risk route would still be selected in about half of the cases, but that a lack of GIS information would result in a higher risk route being selected in the other half of the cases.

For the second factor, the ORNL study found that the variation in population density among the various feasible routes was about 15 percent. This means that a route chosen without density information would probably involve, on average, 7.5 percent greater population density than the optimal route. The reduction in population-at-risk due to the GIS output is equal to the reduced chance of choosing a higher risk route, times the difference in density between the chosen route and the optimal route (50 percent x 7.5 percent = 3.75 percent). Most GIS routing studies find a variation in population along potential routes much higher than 15 percent (Lepofsky 1993). The relatively small variation found in the ORNL study is due to strict DOE rules that significantly reduce the number of feasible routes from each reactor.

As to the third factor, one possible approach is to identify the likelihood of an incident (significant accidental release of radiation) during transport, and multiply this by the expected cost of an incident. However, ORNL managers believe that, due to the nature of the shipping casks, the probability of an incident is extremely low. More important is the collective dose from the routine external radiation level from the casks. The public at risk are those near enough to a loaded transportation cask that they can receive a measurable dose. If fewer people are exposed to the risk of radiation exposure, then the expected collective radiation dose received by the public will be smaller. This in turn reduces the expected cost from radiation exposure during the transport of radioactive wastes. The expected cost can be determined by multiplying the expected collective radiation dose times the cost of a standard unit of dose.

Radiation doses are measured in rem's (roentgen equivalent, man). The DOE estimates that collective radiation doses from transporting spent fuel rods from the 80 reactor sites would be about 1,500 rem (DOE 1987). This collective dose is not spread evenly across the population. The various feasible routes tend to converge near the disposal site, leading to higher exposures for the population along the latter segments of a route.

The International Atomic Energy Agency (IAEA) estimates that the cost of a standard unit of dose (100 rem) is about $5,000 (IAEA 1986).

The estimated cost of radiation exposure to the public during the transport of radioactive waste from 80 reactor sites is therefore about $75,000 ($5,000 per standard unit of dose x 15 doses). The GIS output would reduce this expected cost by 3.75 percent, for an expected effectiveness benefit of about $2,800. Note that the $2,800 estimate is of the gross benefits of the application. To determine if GIS is a cost-effective approach for reducing risk, it would be necessary to compare the cost of running the application against the expected benefits.
Case Study—Pavement Management Program

A pavement-management program involves keeping an inventory of the existing condition of the roads included in the program, identifying the improvements needed, assigning priorities to these, and scheduling and carrying out improvements subject to a budget constraint. The Wisconsin pavement-management decision support system (PMDSS) was designed to provide computer support to the pavement managers (WDOT 1990).

A traditional pavement management system uses county, route, and log mile data for location information, but not geographic coordinates. The Wisconsin PMDSS has developed a conversion table to relate county, route, and log mile to geographic coordinates, to take advantage of GIS capabilities. The principal use of the GIS is to integrate data from various databases with different location reference systems, and to produce graphic product displays.

The pavement-management database includes information from a variety of other data files. The GIS provides a geographic coordinates location key that permits the easy integration of this information into the PMDSS structure. Without the GIS location key, the GIS staff would have had to manually collate the information into the PMDSS. Prior to the use of GIS, this is exactly what the WDOT did for a study comparing highway improvements with safety. In the absence of a GIS, they would have done the same type of manually collating for the PMDSS as well.

The WDOT estimates that manual collating would take about half a year of work and cost about $12,000. The GIS accomplishes the same task automatically and at trivial expense. The value of the GIS efficiency benefit is the avoidance of the $12,000 annual cost.

The graphic outputs of the application could not be produced without the GIS. The value of the graphic outputs represents effectiveness benefits. The only users of the graphic outputs are pavement managers in the WDOT. The graphic outputs have three effects on the users:

1) To improve quality control.
2) To provide better information about pavement sections needing detailed analysis.
3) To improve communications with local highway departments.

Benefits from Improved Quality Control

The graphic GIS outputs greatly improve quality control. Data errors that would remain hidden in long tables and columns of figures stand out plainly on the GIS graphic outputs. The GIS outputs have permitted the WDOT to make significant improvements in the quality of the data in the PMDSS. WDOT has identified and corrected an error rate that was as high as 5 to 10 percent.

The increased accuracy has resulted in changes in the annual pavement-management plan. The WDOT renovates about 900 miles of roadway each year. The purpose of the pavement-management plan is to make sure that WDOT renovates the 900 one-mile segments most in need of renovation. The GIS outputs enable pavement managers to identify highway segments badly in need of renovation that had been overlooked in the previous manual process. The increased accuracy due to the GIS results in the replacement of about 10 such miles of highway in the plan each year.

The GIS benefits are equal to the increase in the total value of the 900 miles of renovation. The total value increases because 10 miles of lesser valued renovation are replaced by 10 miles of more highly valued renovation. To directly measure the GIS benefits, it is necessary to know three things:

1) The value of a typical mile of highway renovation.
2) The typical variation in the value of renovation.
3) The value of renovation for the typical mile segment discovered by the GIS that had been overlooked by the manual process.

None of this information is known, but it is possible to make reasonable estimates. The value of a typical mile of highway renovation can be estimated based on total WDOT expenditures for renovation. This yields a conservative estimate of $350,000 per mile of renovation. WDOT officials believe that a 50 percent variation in the value of renovation is a reasonable estimate. This means that the value of the various road segments ranges from a low of about $230,000 to a high of about $470,000.

It is reasonable to expect that the 10 miles that are replaced from the original plan fall at the low end of the value range. It is also reasonable to expect that the overlooked segments that replace them are not the most highly valued segments; that is, it is more likely that average to lower valued segments would have been overlooked. WDOT officials believe that the overlooked segments on average are about 20 percent below the average value; that is, the overlooked segments have an average value of about $280,000.

The GIS benefits are measured as the increase in the total value of the 900 renovated miles. This increase is estimated to be $500,000 ($280,000 - $230,000) x 10).

Benefits from Better Analysis

The GIS graphic outputs help pavement managers to identify segments of roadway that deserve additional study. Prior to the use of GIS, it took about 40 hours to
do the research necessary to answer a question about one segment. With the GIS, the needed information is available at the touch of a button. The GIS, therefore, enables the additional research to be done at much lower cost. In fact, prior to the use of GIS, pavement managers seldom did the additional research, and so made their decisions without the benefit of this information. The GIS effectiveness benefits are equal to the value of the new information.

The fact that pavement managers generally chose not to do additional research suggests that the value of the additional information was generally less than the cost of gathering it. The cost of 40 hours of research is about $475. Since pavement managers sometimes did do the manual research, this suggests that the value of the additional information is sometimes greater than $475, but not often. WDOT officials believe that $200 is a reasonable estimate of the average value of the additional information.

Only a small number (about 10 percent, or 90 miles) of the segments can benefit from additional study. The value of the GIS effectiveness benefit, therefore, is estimated as $18,000 ($200 per one-mile segment × 90 segments).

**Benefits from Better Communication**

Personnel from local highway departments meet with state DOT officials, at which time GIS-produced maps are used to help explain how the state pavement-management plan relates to local areas. These meetings involve considerable discussion, debate and negotiations, as this is the principal forum in which local concerns are incorporated into the plan.

The use of GIS outputs has not changed the amount of time and effort invested in these meetings. However, it has led to a positive change in the focus of the arguments. Prior to the use of GIS, much time was spent arguing about the accuracy of the data underlying the plan. Since the use of GIS, there has been general acceptance that the data are accurate, and the discussions have been much more directed toward questions of policy.

This change in the focus of the discussions almost certainly makes the meetings more enjoyable for most participants. However, it is less clear if the change yields any objectively measurable benefits. It is tempting to measure the GIS benefits as the value of the time saved on discussions of data accuracy. The fact that the meeting participants voluntarily chose to invest the time saved in discussion of data accuracy to discussion of other topics suggests that they believed those discussions to be worth at least as much as the value of their time.

The true measure of the value of the additional discussion, however, depends on what effect it has on decisions reached in the meetings and modifications to the pavement-management plan. This effect is not known, and it did not prove possible to make a reasonable estimate of it. The benefits of improved communication are probably positive, but have not been measured.

**Summary and Conclusions**

All too often, cost-benefit studies of GIS technology have done a good job of measuring efficiency benefits, but a poor job of measuring effectiveness benefits. This has the effect of concentrating attention on how a GIS can help to reduce the cost of an organization's existing applications. It suggests that expenditures on GIS technology are justified only when they will result in large efficiency benefits. This is a serious mistake. For many organizations, the real value of a GIS is not that it helps them do their work cheaper, but that it helps them do their work better. GIS technology has the potential to fundamentally change the functioning of many organizations. Measuring benefits only with an efficiency yardstick tends to slow down the adoption of GIS and to delay the realization of effectiveness benefits.

The solution to this shortsightedness is to do a better job of recognizing and measuring effectiveness benefits. When effectiveness benefits are not objectively measured, it is easy to dismiss them as intangible. When they are measured, it is clear that they are just as real as efficiency benefits.

The USGS case studies demonstrate a practical technique for measuring effectiveness benefits. The key is to identify how the GIS outputs are different from the previous manual outputs, and how those differences affect the users of the GIS outputs. Measuring the value of a single effect on a single user is a difficult task, but it is usually a feasible task. The case studies demonstrate that, by narrowing the focus to the point where pertinent questions can be asked about the value, it is usually possible to reasonably measure benefits that previously had appeared to be nonquantifiable.

The Oak Ridge National Laboratory case study shows that existing documents can be adapted to yield inferences about benefits, even when those documents do not explicitly address benefits themselves. The Wisconsin Department Of Transportation case study shows that the lack of hard data is not an insurmountable obstacle. Common sense assumptions and informed estimates can be used to reasonably measure the general level of benefits. The Wisconsin DOT case study also shows that it will not always be possible to measure every effectiveness benefit. The point is not that the USGS technique provides an infallible method for mea-
suring effectiveness benefits—because it doesn’t. What the USGS technique does do is provide a practical alternative to simply writing off effectiveness benefits as intangible. Better measurement of effectiveness benefits provides a better understanding of where and how GIS technology is useful, so that organizations can invest their GIS dollars wisely and well.

References


In This Issue...  
Both the practical and the philosophical are fodder for this issue's feature section. Dan Parr takes a broad look at the business of designing and organizing information. The long-term focus, he suggests, should be on the information and how an organization structures and uses it, rather than on the technology that drives it.

On the practical side, the remaining three articles focus on local governments—how they've done things right, and how they might proceed to do things right. Paul Vastag, Peter Thum and Ben Niemann examine the practical aspects of implementing LIS/GIS in local government. Wisconsin's Project LOCALIS presents a step-by-step analysis of what it takes to implement statewide LIS/GIS.

This year's ESIG awards, outlined by Bob Lima, are a showcase for how local governments have done things right. The awards recognize excellence in three categories: Small Municipal Systems, Operations Automation Systems, and Corporate Systems.

Local governments are among the organizations that are least surveyed about information technology issues and trends. To remedy this, the International City/County Management Association (ICMA) conducted an extensive survey last year on how cities and counties used information technology. Milford Sprecher presents the results.

Editorial Intent

The URISA Journal was originally conceived as having several sections. The refereed portion would be the most intellectually rigorous, suitable for academic submittals. The Feature section would be more journalistic and visual (that is, giving special emphasis to maps, photographs, other graphics). The remaining sections—Feature Map, Reviews, In My Opinion—are, hopefully, unambiguous. Now, with the Journal beginning its fifth year, this conceptual framework appears to be working. We will, accordingly, carry on.

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

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

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

Warren Ferguson  
Lynne Wiggins
Cover Feature

GIS and Nonpoint Pollution Modeling: Lessons Learned from Three Projects

Kristine Kuhlman, David Hart, Stephen Ventura and Jeffrey Prey

Editor's note: This feature is adapted from the Project Showcase “Best Map” winner at the 1994 URISA conference in Milwaukee, Wisconsin.

Nonpoint source pollution poses a serious threat to the nation’s waterways. In Wisconsin, approximately 90 percent of lakes and 40 percent of streams are degraded by nonpoint source pollution. In urban areas, stormwater runoff and combined sewer overflows have been identified as the most significant nonpoint pollution source. To reduce pollutants, the Environmental Protection Agency in 1990 mandated permits for certain categories of municipal and industrial stormwater discharge.

Urban nonpoint source pollution is generally predicted as a function of land use and storm events, modified by soil and other environmental conditions. An empirical model, Source Loading and Management Model (SLAMM), developed by the Wisconsin Department of Natural Resources (WDNR) and the University of Wisconsin-Madison, was used to estimate nonpoint loadings in urban stormwater. The following three mapping projects are the result of a joint effort between WDNR and University of Wisconsin-Madison researchers to improve data acquisition, analysis and display for SLAMM by incorporating a GIS (ARC/INFO).

Project 1: Beaver Dam

The first and smallest study area in Beaver Dam, Wisconsin identified the cost and time associated with assembly of land use and land cover data as a major bottleneck in using SLAMM over large areas. The project analyzed several sources of land cover data including LandSat Thematic Mapper (TM) and SPOT satellite images, high- and low-altitude photographs, and zoning maps.

Among the lessons learned:

- The most accurate land-cover classification came through manual interpretation of large-scale aerial photography.
- Satellite imagery, because of the high initial cost, would be more cost-effective with study areas greater than 50 square miles.
- Greater specificity was obtained with aerial photography: more than 15 land-use categories were identified by aerial photos; only six with satellite imagery.
- Additional geographic data such as zoning and population density (TIGER) could be used to improve the accuracy and specificity of satellite-based classification.

Project 2: Kinnickinnic River Watershed

The Kinnickinnic River project focused on analysis of methods for collecting data, the Kinnickinnic River project (30 square miles) focused more on assimilating data from six municipal jurisdictions in Milwaukee, Wisconsin. The project relied on USGS 1:100,000 digital line graphs (DLGs) for a base map. Large scale photographs were used to update a 1985 land use map.

Important lessons learned from this project include:

- Techniques used proved to be an effective means for selecting critical information (those with the highest pollutant loadings per area) for more detailed planning.
- Analysis of control practices identified the most effective alternative for achieving up to 90 percent pollutant reduction in this critical watershed: a regional wet-detention pond.

Project 3: Lake Superior

The third project involved acquiring, automating and analyzing geographic data for urban nonpoint source stormwater management in the Lake Superior Basin. Because of

Kristine Kuhlman is a GIS specialist and environmental planner with H2GEO Consulting in Madison, WI.

David Hart is a graduate student in land resources and a research assistant at the Land Information and Computer Graphics Facility at the University of Wisconsin-Madison.

Stephen Ventura is an assistant professor in the Department of Soil Science and the Institute for Environmental Studies at UW-Madison.

Jeffrey Prey is a water resources specialist at the Wisconsin Department of Natural Resources.
FIGURE 1. Full-sized map of Kinnickinnic River Priority Watershed. (Lower left portion appears on the cover)

Kinnickinnic River Priority Watershed Project

Milwaukee County, Wisconsin

FIGURE 2. Map showing the three project areas.

the relatively pristine condition of Lake Superior, there is great interest in protecting its water quality.

Two primary research issues arose from the overall objective to create GIS databases for the 14 diverse communities: 1) the integration and standardization of data from many sources, and 2) the development of information processing routines to ensure consistent and reliable model results within and between communities.

Some lessons learned from the Lake Superior Project include:

- As familiarity with methods improved, projects of increasing size and complexity could be undertaken without a corresponding increase in funding. The area mapped and modeled as part of the Lake Superior project was 42 times larger than the Beaver Dam project, yet it was completed with a budget only 50 percent larger.

- Technology transfer is an important side benefit. The digital files developed as part of the project are useful for other purposes such as trans
FIGURE 3. The methodology for using GIS in urban nonpoint source modeling.
TABLE 1. A Comparison of the Three Projects

<table>
<thead>
<tr>
<th>Area Mapped</th>
<th>1990 Population</th>
<th>Project Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver Dam</td>
<td>4.8 sq. mi.</td>
<td>14,000</td>
</tr>
<tr>
<td>Kinnickinnic</td>
<td>26.8 sq. mi.</td>
<td>300,000</td>
</tr>
<tr>
<td>Lake Superior</td>
<td>201.3 sq. mi.</td>
<td>229,000</td>
</tr>
</tbody>
</table>

portation planning and environmental management, and benefiting local and state government, county and regional agencies, and the private sector.

- A recognition of the need for more detailed and integrated digital information to assist in sewershed and land use delineation. Photography from the National Aerial Photography Mapping Project (NAPP), while current and commonly available, is not well suited for urban land use inventory, even when enlarged from the original scale of 1:40,000. Large-scale digital orthophotos as a base map feature can improve the efficiency of urban nonpoint source projects by reducing the time needed for creating datasets, and by providing greater accuracy in identifying land use categories.

In the future, communities will increasingly rely on automated methods for assessing and controlling nonpoint source pollution. Already, the city of Marquette, Michigan, in cooperation with university researchers, is developing a "stormwater utility" in an effort to keep our waters "swimmable and fishable."
As committees meet and pundits preach, thousands of organizations are building information systems with minimal design and engineering. Information system standards are adopted by default for individual applications, public and private agencies, local governments, states and nations.

Knowledge is the means of production in our world economy and will be the basic economic resource in the "knowledge society" of the near future, according to Peter Drucker in The Post-Capitalist Society (1992). Productivity in the knowledge society is dependent on the effective and efficient application of information to create knowledge. Improvements in the productivity of this application is the fundamental goal of information technology—management information, land information, geographic information. Each type is one denomination of the currency of the knowledge economy. The value of the currency rests on the standards that back it up.

Drucker says that we are living in an era of transition from a knowledge economy to a knowledge society. The adoption of information technology in our organizations—government, business, schools—must coincide with changes in the way we think and organize. Survival in the brave new information world depends on an organization's ability to allocate knowledge resources, and improve the productivity of knowledge workers. Information systems should be designed to better apply what we know to what we do, and iteratively, to the knowledge base itself.

Organizations are being "re-engineered" to meet this challenge. Information engineering—the systematic and methodological design and building of information systems—is not about technologically adept computer systems; it is about reorganizing the way every component of an organization interacts with information. Information engineering uses structured methodologies to provide the discipline necessary for developing an information system as opposed to a data system.

How effectively we use information will determine the success or failure of our organizations. Success is not related to the size of our computer network, the accuracy of our base map, or the speed of our central processing unit. Effective re-engineering is the key, instead of repeated reorganizations that amount to trial-and-error management.

Failure to recognize and respond to the demands of the knowledge economy is why the GIS boom has gone, and will go, bust for organizations whose focus is on technology and not information—on the short-term instead of the mid- or long-term. The means-to-an-end has become the end purpose of too many GIS projects. Organizations have embraced the hardware, software and data collection, but not the raison d'être of information systems. They have rushed to change tools and materials, but not the way they think and work. It has hurt businesses like General Motors and IBM; it is hurting local, regional and national government; it is hurting education. Information engineering helps an organization make certain that technological dazzle does not blind an organization to information technology's substance.

However significant non-technological issues may be, they often are obscure to people who are trying to improve the way they work, who are struggling against organizational inertia to learn about and build an information system. The GIS industry, in particular, does little to clear the murky waters of technology marketing. In fact, stirring the waters with a well-turned phrase about the latest features and newest data "conversion" methods is not uncommon. The rush to sell and buy has obscured the long-term goals. It is survival of the fittest consumer—the most knowledgeable. Hardware and software will come and go, the question is who goes with them? How does one know whether progress is being made, or if one is caught in one of the many soon-to-be-extinct branches of evolving information technology?

Daniel Parr is a consultant and owner of Daniel Parr Associates, Inc. in Takoma Park, Maryland. He is a member of the URISA board, and editor of the URISA News.
Standards for Change

Organizations need underlying values—standards for change. There are no commonly recognized measures, or standards by which one can gauge progress toward the knowledge society, or successful competition in the knowledge economy. One cannot easily show the accumulated knowledge “capital” to the people who pay the bills, or the return on capital investments in the information infrastructure.

How can we gauge our progress? Do we only assess success or failure, a final application of Darwin’s law? It need not be. Knowing and using standards for change should help gauge the fitness of our systems as we engineer them. Information engineering has been professing such standards for decades. The failure of organizations to adopt these standards, while they continue to spend billions on automation, threatens to undermine many businesses’ and governments’ survival in the knowledge economy.

As experts meet to debate technical standards for GIS or even the “information infrastructure,” de facto standards are adopted as a matter of expedience. The cheapest system is purchased; the most quickly implemented selected; market prevalence determines system architecture; databases are designed by implementation. Like the builders of Jurassic Park in Michael Crichton’s novel, many organizations are taking the simplistic approach to complex systems because they are cheaper, faster and more easily understood in the short term. Just as a GIS appears to be “a map on a screen,” complex systems may appear to be work orders or permit forms in a computer. These simplistic views will miss the larger benefit of re-engineering an organization.

Why? Because the planning focuses on the immediate products, not the purposes and consequences. Crichton’s mathematician, Malcolm, describes this narrow focus on technological and scientific accomplishment:

They’re technicians. They don’t have intelligence. They have what I call thin intelligence. They think narrowly and call it ‘being focused.’ They don’t see the surround. They don’t see the consequences.

(Jurassic Park, p. 284)

His point, that technological results and accomplishments cannot be judged in isolation, is very applicable to GIs development. Projects should not be focused on technological accomplishments, but on achieving improvements in our organization. Geographic information systems that are driven only by technology will, like the novel’s theme park, succumb to non-technological variables. The question is: will the organizations that build narrowly focused GIS get the opportunity to evolve into members of the knowledge society, or will they become artifacts for technological and sociological archeologists?

If one knows the brief history of computer technology, it is easy to see that the hardware and software components of most systems built today won’t be around in several years. They will evolve at an ever-increasing pace as information and knowledge are reapplied to make machines faster, user interfaces smoother, information access greater. Other essential components of information systems also change—data, processes and people—but they are more fundamentally constant, i.e., their superficial characteristics or values may change, but their essential nature and relationships to information, technology and each other will remain constant. These are the big picture, the surround of information systems. Understanding the nature of their stability will help us set standards for change. Such standards enable us to gauge an organization’s progress toward survivability in the knowledge society.

Data and Information

There is no more basic component of information than the data entity. If data standards cannot withstand changes in technology, people and process, then an organization’s fitness to compete will steadily diminish. Data entities and their logical relationships are constant because they are the raw material of information; therefore, the technology must evolve around them.

... something about which we store data: for example, customers, parts, employees, or machine tools. The entity types do not change in the lifetime of a business except for the occasional (rare) addition of new entity types. The types of attributes that we store about these entities also rarely change. The values of data change constantly, like the data in a flight information board at an airport, but the structure of the data does not change much if they were well designed to begin with.

(Strategic Data-Planning Methodologies, James Martin, 1982)

Information engineering requires data models that define the organization’s entities and the relationships among them. This is why geography has become so important to urban and regional organizations that are trying to build information systems. Geography is a key component of data and knowledge bases in urban and regional organizations. The entities in the system have geographic attributes linking them to location. These logical relationships never change because they are based in physical reality. Every location has a relationship with every other location. Each relationship can be modeled and described mathem-
matically, thus lending itself well to automation. The consistency provides a common index to almost all data in organizations whose entities are defined at least in part by location.

Geography, however, is not the only attribute type that drives the urban and regional models. As Wiggins, Craig, and Langendorf pointed out in the 1992 URISA Proceedings (Vol. 5):

We have not come very far since the origins of URISA [1963] in our views about data or its availability...In many ways, our pursuit of good data has led us from our original intentions. We have become enmeshed in improving geographic detail, when often street center-line (block) data would have been adequate for many of our original purposes. We have become experts in cadastral data, knew data was so basically geographic, but have neglected the geographically related data about people. We have also neglected our role in improving the modeling and analytics for urban and regional planning, management and decision-making. It is important to remember that we got into the GIS/LIS technology because we wanted better data for decision-making.

Large geographic databases are not sufficient to build urban and regional information systems. Geographic information is only one denomination in the urban and regional knowledge economy, like having only pennies to conduct business. Data must be modeled so that they relate to the organization’s goals, processes, and people. Information engineering is intended to design data models, and build databases that produce better data for decision-making. These are essential to make an organization fit to meet the future.

Data models are standards for change; they set the fundamental structure for information systems. Establishing organizational data models is one gauge of advancement toward being competitive in the knowledge economy, and of an organization’s fitness for the knowledge society.

Process and Function
Information engineering recognizes process and function as essential parts of an information system. It is the analysis of processes—in essence, the determination of functional areas—that determines the standards for change for this component of an information system. Functional areas refer to major areas of activity in a corporation, such as engineering, marketing and research.

Policies and activities of a business or government will change, but the basic functions will remain. An organization’s survivability in the knowledge society can be gauged by the level to which its fundamental functions have been standardized. Not solely by automating, but by incorporating why and therefore—the surround—into the structure of our information systems.

One reason urban and regional organizations have failed to understand and adopt the principals and methodologies of information engineering, especially in regard to geographic information, is that none of the key literature deals with government and the public sector. The necessary cross-functionality of the information engineering approach is more complex in service organizations than in profit-oriented ones. Profit is a straightforward, quantifiable measure, while health, safety and welfare are quite subjective and determined by policy choices.

The vagaries of political economies are daunting when trying to analyze the data, processes, and people of government and public programs, and organize them into an information system. Analogies to information systems are attempts to simplify in order to understand and/or manage. Information systems are analogies developed for a purpose, and not duplications of reality.

An understanding of the limitations of computer-aided systems is the first step toward successful application of the technology. And GIS is no exception. Good information engineering requires a clear delimitation of purpose and function, before automation begins. Until this is done for the public sector, which controls almost all basic geographic data either by law or default, GIS will continue as a marginally effective, and minimally productive, technology in urban and regional organizations.

Failure to adapt to the knowledge economy, and to evolve as part of the knowledge society, will mean extinction for business organizations—no profit, no business. What does it mean for government—for the governed? Government’s survival in the knowledge society is required for freedom, social order, availability of goods and services, the public infrastructure, clean air and water, and a sustainable ecology. Can one, or much, of our society’s problems be tied to government’s increasing inability to deal effectively with information? Are governments becoming more ineffectual because they are becoming less knowledgeable, in spite of information technology?

People and Organizations
People, and how they are organized, are the third constant component of an information system. As Peter Drucker writes in Post-Capitalist Society, “the function of organizations is to make knowledge productive.” And because individuals obviously change, “every organization of today has to build into its very structure the management of change.”

Information engineering has been trying to build structures for change since at least the 1970s. IBM’s classic, Business Systems Planning (1975),
was the outgrowth of years trying to apply technology to organizations. They had learned that investment in computers was only productive when there was an organization-wide approach to information. Their business systems planning (BSP) is certainly dated when specific technologies are discussed, but the methodology and basic concepts are exceptionally robust. They can, in fact, serve as standards by which an organization’s progress toward viability in the knowledge economy can be gauged. Roughly stated, an information system must:

- Support the goals and objectives of the business.
- Address the needs of all levels of management within the business.
- Provide consistency of information throughout the organization.
- Be able to survive through organizational and management change.
- Implement strategy project-by-project to support the total information architecture.

(IBM, 1975, p. 5)

These information system standards coincide with standards for people espoused by Drucker about the same time:

But yesterday’s middle management is being transformed into tomorrow’s knowledge organization.

This requires restructuring individual jobs, but also restructuring the organization and its design. In the knowledge organization, the job, all the way down to the lowest professional or managerial level, has to focus on the company’s objectives. It has to focus on contribution, which means that it has to have its own objectives. It has to be organized according to assignment. It has to be thought through and structured according to the flow of information both to and from the individual position, and it has to be placed into the decision structure. It can no longer be designed, as was the traditional middle management job, in terms of downward authority alone. It has to be recognized instead as multidimensional.

Traditionally, middle-management jobs have been designed narrowly. The first concern has been with the limits on middle manager’s authority. In the knowledge organization we will instead have to ask, “What is the greatest possible contribution this job can make?” The focus will have to shift from concern with authority to stress on responsibility.

(Mangement: Tasks, Responsibilities, Practices, pp. 450–451)

He wrote about middle managers in 1973. In 1992 he wrote: “The knowledge-based organization therefore requires that everyone take responsibility for that organization’s objectives, contribution, and indeed, for its behavior as well.”

He says that people will do this by:

- Thinking through, and taking responsibility for their objectives and contributions.
- Controlling their own work by feedback from results to objectives.
- Acting as responsible decision-makers.
- Communicating their objectives, priorities, and contributions to everyone in the organization.
- Making certain that their objectives fit in with the objectives of the entire group.

The bottom line for an information system is this: How does it allow people to use their knowledge and abilities? How does it help organize people? Information engineering is not just a design-and-build process; it is a powerful educational tool for the organization. Developing an information system should produce a staff that is knowledgeable of the organization’s objectives, the responsibilities of individuals and the objectives of their contributions, and the standards for data and processes that must be met. An information system must extend beyond the technology to be productive, because systems do not make decisions—people do.

Information Investments

Skilled information engineering is a long-range investment strategy that will insure that the next generation will inherit the knowledge capital necessary to sustain them. It is a strategy that balances risks inherent in automating information. It is a strategy that accepts a lower return to insure a consistent return over the longer term. Urban and regional organizations, especially government, are inherently low-risk, and information systems especially should be the one area that is subject to a measured, long-range approach.

Information system development is not a one-shot activity, but a permanent development process requiring patient progress. Progress that rests on the ability to design and engineer an information-based organization—a knowledge organization. This requires long-range investment in education and training, in processes and organizational structures that facilitate the effective use of information, and in the basic materials of information—the data and data relationships.

For data, investments must be not just in collection, but in concept, design and structure. For processes and functions, investments must not be just in automating activities, but in making those activities most productive by tying them to the purposes and goals of the organization—the surround. For people and their organization, investments must be in education, training and organizational structures that manage change. Information engineering is an investment strategy for the basic economic resource of the knowledge economy. An organization’s investment skill will be a major determinant of its survivability.
The Costs of the Information Age

As one struggles for survival in the information revolution, there is a cost for every benefit. In our evolution toward the knowledge society, survival rests on insuring that the costs for information systems do not outstrip the benefits in individual organizations, or in society at large. The law of "survival of the fittest" will not change; there will always be losers: industries, corporations, governments, and perhaps even nations. Those who work in and with urban and regional information systems must monitor these costs. We must ask whether or not urban governments that cannot evolve fast enough are destined to become the science fiction images of George Orwell's 1984 in which people and the infrastructure have been abandoned to anarchy and chaos. Have the symptoms already begun in the failures of urban centers, public schools, and public transportation? Is information technology a problem, or part of the solution?

One assumption that pervades GIS or IS circles is that everyone will be included. But will there not be an information underclass—urban and rural schools, small governments, the traditionally poor? Who will invest for them? Will they have knowledge capital and information currency? Will government become so "business-like" that we will accept the failure of governments in the same manner we accept the failure of businesses? Are we privatizing, or commercializing, individual freedom and opportunity when we privatize public education, public infrastructure, public data? Individual freedom, safety, health and happiness are not solely dependent on successful technology, but they are dependent on successful use of information.

Gauging Information Systems

The surround of information systems cannot be ignored, because the systems' success depends on its inclusion. We must learn to gauge our progress and success if we are to avoid failure in the short and long-terms. This can only be done by measuring progress, and evaluating success using criteria that are not solely technological or fiscal. Information engineering in urban and regional organizations provides methodologies that help do just that.

Information engineering accepts the complexity of information systems, and systematically addresses each component: data, process and people. It is not a panacea or guarantee of success, but it can establish the standards we need to gauge our progress. Progress will be judged by our adaptability at allocating knowledge resources, and by improved productivity. Success depends on how well information and knowledge are used. Success will be gauged by the quality of our decisions, and judged by survival of the fittest.

Acknowledgements

The comments of Nancy von Meyer of Fairview Industries were valuable and greatly appreciated.

Note

This article is derived from the author's presentation at URISA '93 in Atlanta, Georgia.

Selected References


Project LOCALIS: Implementing LIS/GIS in Local Government

Paul H. Vastag, Peter G. Thum and Bernard J. Niemann, Jr.

Land and geographic information systems (LIS/GIS) are now widely accepted by local governments as tools for modernizing land records for land assessment, management and many other applications. But it wasn’t always so. In the 1970s, the University of Wisconsin-Madison began exploring how local government agencies might use spatial information technologies such as LIS/GIS to modernize land records. This effort grew from Wisconsin’s long-standing commitment to a land ethic and its efforts over the decades to protect the land and land rights. Education and information have played a vital role in these efforts.

One of Wisconsin’s first steps in assessing land information was to look at public expenditures. In 1976, the UW-Madison and the state Department of Administration found that Wisconsin local governments spent about $40 million annually on land information collection and management — more than half of all spending by all government agencies and utilities at the time. And today, by some estimates, America’s 3,100 counties spend more than $23 billion per year on information-related resources.

Following the 1976 study, UW faculty began to seriously evaluate information technologies such as LIS/GIS and global positioning systems (GPS) for local governments. The conclusion? Multipurpose LIS/GIS systems could address both the in-house modernization of local government land records and the various land planning and management mandates. The researchers showed that benefits would accrue not only as increased efficiency, but also in equitable treatment of those affected by the mandates.

However, they noted, to reap the greatest benefits, a “statewide orchestrated plan” for modernization and implementation of LIS/GIS would be essential to ensure system and data compatibility.

In the wake of these conclusions, a governor-appointed committee of local, state, private-sector and university professionals, and elected officials recommended an integrated local/state modernization effort, which evolved in 1989 into the Wisconsin Land Information Program (WLIP). To fund the program, the state Legislature increased the land recordation fee, thereby generating some $6 million annually to support local land records modernization.

Since then, the WLIP has provided intellectual and technical guidance to local governments as they update their system of managing land records. To help Wisconsin counties begin to implement automated systems, Project LOCALIS (meaning “place” in Latin) was born.

The goals of Project LOCALIS were to:

- Develop and demonstrate applications of LIS/GIS for land information management in local government.
- Develop spatial database-design procedures for county LIS/GIS implementation.
- Demonstrate remote database connectivity to support client/server workstation GIS operations.

Three vendors agreed to provide LIS/GIS hardware, software and financial support for the project. Six Wisconsin counties were enlisted to define county needs and to help direct research priorities in answering those needs. Four UW-Madison research groups worked with them to evaluate the technology and address issues of database design and applications design. Other UW researchers developed computer interfaces, using LIS/GIS capabilities, to access U.S. Bureau of Census files and to provide customized databases for Wisconsin state agencies and other units of government.

In the process of fostering counties’ progression toward computerization, Project LOCALIS identified and described five stages of LIS/GIS implementation.

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Paul H. Vastag is a programmer analyst for Intelligraphics, Inc. in Waukesha, WI. As a master’s degree candidate in land resources at UW-Madison’s Land Information and Computer Graphics Facility (LICGF), he was a research associate on Project LOCALIS.

Peter G. Thum is the owner of H2GeO Consultants in Madison, WI. He managed Project LOCALIS while he was facility manager at LICGF.

Bernard J. Niemann, Jr. is director of LICGF. He is a UW-Madison professor in the Department of Landscape Architecture, Cooperative Extension, and the Institute for Environmental Studies.
The Five Stages

Developing LIS/GIS within local governments involves:

- Awareness
- Feasibility
- Conceptual Design
- Development
- Operation

These stages (see Figure 1) and the process described are not significantly different from other technology-transfer efforts that take place in local governments. The emphasis happens to be on land-related records, the spatial and graphic nature of these records and, importantly, the need for cooperation among professions and units of government. First and foremost, implementing LIS/GIS must be accepted by elected officials and professionals as an integral part of local government's strategic plan in information management.

Awareness: Identifying Your White Knight

Mountains cannot be climbed and LIS/GIS cannot be implemented unless someone takes the first step. And in this game, conceptual and technical awareness of LIS/GIS is the first step. The idea of using LIS/GIS comes perhaps from someone who recognizes not only the power of computers but the inevitability of public demand for automation and access to data. Who is this person who generates such an awareness, who is willing to champion this complex and costly cause? We call him or her the "White Knight"—a person with the vision to see what areas can most benefit from LIS/GIS technology. He or she will be the one to appreciate the conceptual and technical underpinnings needed to fully exploit LIS/GIS and to ensure that its use is prudent and ethical.

For example, a variety of local government functions can benefit from LIS/GIS technology:

- Better public access and scrutiny of public ownership, taxation and regulatory records.
- Improved protection from natural hazards such as flooding.
- More citizen access and involvement in the land planning and development process.
- Improved understanding and responsibility for the impacts of agriculture and urbanization upon water quality.

All these examples use records—ownership parcels, tax assessment, permits, zoning, roads, soils, floodways, wetlands, topography—maintained by local government.

The White Knight faces another challenge in knowing that applications must be understood in the context of both the present condition and future potential of LIS/GIS technology. An LIS/GIS must be sufficiently pragmatic to address today's problems, yet flexible enough to solve tomorrow's undiscovered dilemmas.

The key is to have a thorough understanding of such conceptual and technical requirements as:

- Spatial reference frameworks and the means to develop frameworks such as GIS technology,
- Mapping procedures and accuracy requirements for each map layer or cartographic object,
- Forms of image and base-mapping technology such as orthophotography,
- Fusion of textual or attribute data with map data, and the elements of automation such as digitizing versus automated scanning.

In addition to technical requirements, an agency needs to recognize that education and training at every level in an office is essential for suc-
cess. This is a simple reality; in this era of information technology in local government, education is a continuous process. Once an agency has developed an awareness and is caught up in the White Knight’s challenge, the engine of implementation is in motion. Guiding the implementation process into reality begins with the next step.

**Feasibility: Needs and Requirements**

With the conceptual and technical awareness in place, the LIS/GIS team is ready to tackle feasibility. At this time, the decision to implement LIS/GIS will be based upon the team’s perceptions of the specific needs and requirements of the organization, as they perform an organizational needs assessment, requirements analysis and feasibility evaluation.

The organizational needs assessment is designed to produce information that will help determine the overall scope of the system—the people, institutions, and applications.

The organizational requirements analysis sorts out which individuals are interested in employing LIS/GIS technology, and what expertise they may have to offer. It also helps all participants attain their expectations of the LIS/GIS technology.

Finally, using the above information, there is a feasibility evaluation. Typically, a benefit/cost analysis is required by others to provide financial data. It is at this point that the team makes the decision whether or not to invest in LIS/GIS technology. This is a crucial stage. Because much time, money and effort will be allocated toward system implementation, any decision must be objective and thoroughly thought out.

**Conceptual Design: Thinking It Through**

Now the team has made the decision to begin implementing. The next step is to conceptually define the organization’s application and database needs. This will lead to a system development plan that outlines the overall LIS/GIS system and the steps needed to facilitate its implementation.

First, the group must develop a user-needs assessment. This assessment differs from the organizational needs assessment done during the Feasibility stage because it is a detailed assessment, designed to gather specific information for producing the system’s technical specifications. The user-needs assessment can be divided into three categories: data, procedures and products.

For the assessment to be successful, the team needs to gather information from all three areas. Information can be obtained through mandate/statute reviews, construction of data-flow diagrams, questionnaires and interviews.

Based on the defined user needs, the next step is the requirements analysis. This determines the hardware, software, communications, personnel and training requirements of the organization. Required software is determined by defining the organizational tasks to be automated with LIS/GIS. Software needs and data capabilities then determine hardware specifications. Personnel and training requirements, while different in nature, are just as important and are often the major cost associated with LIS/GIS implementation. These should be clearly defined.

When the user-requirements analysis is complete, the next step is conceptualization of the system’s applications and database. The team must identify priority applications and, in a parallel process, determine the data needed to support the applications. Application conceptualization is a complex process; it involves system visualization, user-needs assessment, functional requirements analysis and conceptual design. This process ultimately results in a “mock-up” of the applications.

Database conceptualization is also a thorough process. It demands that the team identify and classify land record features inventoried during the user needs assessment. Geographic and attribute representations of features along with the relationships between features also need to be defined to support the variety of local government database applications. This process should produce an initial dictionary of database elements and schema diagrams that help designers visualize important feature relationships.

"...this level of change—from an industrial society to an informational society—is so fundamental yet so subtle that we tend not to see it."

John Naisbitt, Megatrends

When the applications and database have been conceptualized, the team must construct a system development plan. The plan lays out the process by which the complete LIS/GIS system will be implemented: procedures and timelines for acquiring hardware/software, hiring and training staff, making necessary institutional arrangements, creating the physical database design, developing application prototypes, and conducting a pilot
project. The logistics and tasks of these components must be defined in the system development plan, and ultimately implemented during the next stage.

**Development: Making It Happen**

This stage puts everything into place and then tests it. It starts by acquiring system hardware and software based on the system development plan. When the system has been installed, development of applications and database can begin, leading to a pilot project. The pilot project includes some data conversion and application prototyping and is used to evaluate the database and applications. When the team has made the necessary design modifications, it can then develop a system operation plan that lays out the tasks necessary for full implementation of the LIS/GIS system.

The team begins by acquiring the software, hardware and peripherals as determined in the conceptual design stage. This typically involves developing a Request For Proposals (RFP), evaluating the vendor responses to narrow the field to two or three systems, and finally selecting a software package based on demonstrations, benchmarks, and how each system meets the organization’s functional requirements. Hardware selection can then be based on the software acquired.

Specific details of the database physical design can be addressed when the hardware and software have been selected; this applies especially to any specific GIS software data model. The physical design outlines the specifications and procedures for implementing the conceptual database design. The designers define the graphic specifications for geographic features, attributes, formats, and placement and validation rules. They develop procedures for data automation/conversion, along with quality assurance standards and procedures, and plans for database maintenance.

At this point, the team should address the issue of interagency data integration, for it can substantially affect the database design. Acquisition of hardware and software allows application prototyping to begin. During this step, the designers create the user interfaces to the applications and then evaluate and refine them. Application functionality undergoes the same process, ensuring that users are satisfied with the capabilities of the systems.

Software quality-assurance procedures, such as test and acceptance plans, need to be devised, as should short- and long-term maintenance plans.

Note that database physical design and application prototyping are parallel processes, happening simultaneously with a great deal of overlap, interaction, and feedback.

Now the team is ready to conduct a pilot project to evaluate the database design and the application prototypes. Typically, data are converted for a small study area, with the database design fully applied to that test data. The prototype application(s) is (are) then run with the test data set, while the users evaluate both the data and the application systems. Any problems, bugs, or major design flaws are documented and corrected.

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**Learn More About LOCALIS**

The following materials generated by Project LOCALIS are available for purchase:

- **LIS/GIS Implementation for Local Government.** Video: 4:00 hours. Set of two VHS cassettes. Cost: $100 to educators or public agencies; $400 to commercial entities.
- **Land Information Systems Data Base Design for Local Government.** 71 pp. Cost: $10 (includes shipping, handling, and applicable tax).
- **Land Information Systems Application Design for Local Government.** 73 pp. Cost: $10 (includes shipping, handling, and applicable tax).

A Catalogue of ARC/INFO Covenants from 1990 Census Bureau TIGER/Line Files. 53 pp. Cost: $10 (includes shipping, handling, and applicable tax).

For more information or to order, contact Land Information and Computer Graphics Facility (LICGF) Publications, B102 Steenbock Library, 550 Babcock Drive, Madison, WI 53706. Phone: (608) 263-5534; FAX: (608) 262-2500.

The following are available from the Wisconsin Geological & Natural History Survey:

- **Introduction to Local Land Information Systems for Wisconsin’s Future.** 84 pp. Cost: $7 (Wisconsin residents must add 5% sales tax).

To order, contact the Wisconsin Geological & Natural History Survey, 3817 Mineral Point Road, Madison, WI 53705-5100. Attn: Map Sales. Orders must be prepaid. For information on quantity prices, call (608) 263-7389 or FAX (608) 262-8086.
When the pilot project has been completed and the necessary revisions made, the team can construct a system operation plan. The plan will clearly define the tasks necessary to achieve full system implementation. This includes final data conversion procedures, application implementation and further development, final data and application-maintenance procedures, training plans and other staffing issues, and provisions for system evaluation.

Operational Fine Tuning

The Operational stage focuses on data conversion and application development/implementation. By this time, data and application-maintenance procedures are in place, and system evaluation can begin.

Full-scale data conversion also can begin. The organization might choose to automate the data themselves, or they might choose to hire a consultant or vendor to do the conversion. Data conversion is currently a "bottleneck" in LIS/GIS implementation; it is time-consuming, and other system components such as applications cannot function without automated data.

Concurrent with data conversion, it's time to implement the highest priority applications. This involves evaluating the final prototypes, fine-tuning the last modifications, and beginning hands-on training and documentation for end-users. Development work can then begin on the applications that are next on the priority list.

Maintenance of spatial and attribute data is a necessary component of an LIS/GIS program. In the local government context, updating tax parcels is typically the biggest concern. Updating usually requires changing the geometry of the parcels as well as the attributes associated with them. If a quality database is to be sustained over time, thorough updating procedures are critical.

Application modules and user interfaces also require routine evaluation and modification. Users will most likely suggest modifications and enhancements to the applications. Structured procedures for fixing system bugs are critical.

Early in the operational stage, the team should critically evaluate the LIS/GIS system to ensure it has produced the anticipated results. The overall system can be evaluated more easily part by part (database conversion, application development, training, etc.), but it is also important to maintain a broad perspective and to critique the system as a whole.

Thereafter, the team must evaluate the system periodically to ensure
that it is progressing in the right direction.

Into the Future

What local governments must go through to implement LIS/GIS remains essentially the same around the world, regardless of the differences among governments. In every case there must be the White Knight, who not only perceives the value of automation, but who also has the stamina to see it through when the interest of colleagues flags. It will be that White Knight who will make the time to identify the needs and benefits, persuade the decision-makers, put together the team that can make it happen, and bridge the gaps.

What the White Knight does is unique only in the sense that LIS/GIS must by its very nature be an integrated program—from top to bottom, from one organization to another. Project LOCALIS is based on experiences in Dane County, Wisconsin, where the role of the White Knight has been critical.

What we learned from our experiences circumscribed the model of Project LOCALIS. To some, this model of LIS/GIS implementation might seem overly complex; to others it might lack sufficient detail. This is typical when introducing a new technology. We offer our experience as a general guide; each government must adapt and use this information as appropriate to its unique circumstances.

Regardless of those circumstances, what took our predecessors 200 or 300 years to map, record, and organize will not be changed overnight. This imminent change in the way governments and citizens go about the business of land records modernization will take time. New institutional arrangements will be needed, and business will not be as usual.

We as concerned professionals must collectively and individually work to ensure that local governments contribute constructively to this process. It is our responsibility to contribute where we can at each stage of implementation to ensure that the power of this technology is used effectively, efficiently, equitably and ethically, today and into the future.

Acknowledgments

Project LOCALIS could not have been undertaken without the generous support of three organizations. IBM contributed seven RISC 6000 workstations, ten PCs, and an AS/400 to the project; several IBM managers advised participants throughout the Project. ESRI of Redlands, California, contributed its ARC/INFO software package to several sites on the UW-Madison campus; their regional manager worked continually with all project participants to meet research goals. ERDAS of Atlanta, Georgia, gave a copy of its ERDAS software to the project.

Other major supporters were representatives of Chippewa, Dane, Marathon, Oneida, Portage, and Racine counties who dedicated hundreds of hours to prioritizing implementation issues, identifying research aims addressing those needs, and participating in development projects to provide proof of concept.

References/Additional Reading


URISA's Exemplary Systems in Government (ESIG) awards are presented each year to internationally recognize exceptional achievement in the application of information technology that improves the delivery and quality of government services. With an understanding of the growing challenges facing public agencies in providing essential services, URISA believes that present and future needs can be met by sharing achievements of excellence. The ESIG awards are designed to provide a vital link between identifying, recognizing and sharing that excellence in government.

The winners of URISA’s 14th Annual ESIG awards competition include: in the Small Municipal Systems award category, the city of Wilson, North Carolina (USA), for its Wilson Automated Government Enhancement System (WAGES); in the Operations Automation Systems award category, The National Park Service in San Francisco, California (USA), for its development of the Presidio Graphic Management Information System (PGMIS); and in the Corporate Systems award category, the city of Mississauga, Ontario (Canada), for its Executive Information System (EIS).

In addition to the winners in each category, two other information systems received honorable mentions this year for their noteworthy achievements. Receiving honorable mentions for their systems were the Carnegie Library of Pittsburgh, Pennsylvania (USA), for its NeighborLINE application in the Operations Automation Category; and in the Corporate Systems category, The Providence Plan GIS developed by the Providence Plan, a nonprofit organization created jointly by the city of Providence and the state of Rhode Island (USA), was noted.

Since its inception, more than 70 public sector agencies of national, state, provincial, regional, local and special purpose governments have won ESIG awards. These organizations have been recognized for their system innovations in a variety of functional areas including land records management, natural resource analysis, facilities management, government administration, city and regional planning, transportation services, public safety, utility operations, and education.

The ESIG Competition

Every year URISA conducts the ESIG competition. Although eligible systems and applications must be administered and submitted by a public sector agency to compete in ESIG, URISA broadly solicits recommendations from both the public and private sectors.

During URISA's annual conference, a preliminary ESIG nomination form is provided to conference attendees soliciting their suggestions of potential candidates for ESIG. In the Fall, ESIG application forms are mailed to the organizations recommended by participants at the annual conference and more widely to the URISA membership. Organizations interested in competing in ESIG have until January to complete their application form and return it to URISA's ESIG Committee for review and consideration.

The ESIG Committee—which includes representatives who are involved with information systems from a variety of international public, private and academic organizations (see sidebar)—reviews all ESIG applications and makes recommendations for awards to URISA's board of directors in the Spring. Representatives from the winning organizations are invited to the annual conference to be recognized for their achievements and excellence in information technology by URISA and its membership, and to present their ESIG award-winning system at Project Showcase.

Robert J. Lima, AICP, is the executive director of the Boshe Institute in Hyannis, Mass. The institute is an independent, nonprofit research and education organization. Mr. Lima is a member of the URISA Board of Directors, and has served as reviewer and chair of URISA's ESIG awards since 1984.
In addition to being administered by a public sector agency at the national, state, provincial, regional, local or special-purpose government level, eligible system nominations must also have been: recently implemented, or be a new and significant modification of a previously operating system; and be able to demonstrate improved service as a result of the system's operation. Each nominated system is evaluated based on its exemplary characteristics, system design, implementation activities, organizational impacts, and the economy and efficacy of the system's resources. This year's winners and honorable mentions exemplify these criteria.

**Exemplary Systems in 1994**

As a part of the ESIG awards, URISA recognizes achievement and excellence in three categories.

- **Small Municipal Systems**: targets organizations in jurisdictions with less than 100,000 population who are providing extraordinary system applications through the implementation of information technology.
- **Operations Automation Systems**: focuses on public sector organizations that have implemented a system application that automates a specific set of operations or departmental functions that have led to improved efficiencies, productivity or cost-effective service.
- **Corporate Systems**: targets organizations that have implemented comprehensive systems that provide broad access to a number of diverse functions and, as a result, have improved the manner in which their organization as a whole pursues its work.

This year's ESIG competition included applications from multiple levels of government and from three continents. The winners and honorable mentions in each award category have demonstrated exceptional achievement and excellence in the application of information technology.
Small Municipal Systems—WAGES

The city of Wilson's Automated Government Enhancement System (WAGES) won for its well-executed and managed system; its comprehensive design and scope of operations has had a positive impact on government and the public. WAGES is built around a GIS that consists of approximately 100 layers, multiple menu-driven applications, a public-access system, and a wide variety of hardware and software resources.

Municipal departments—including data processing, planning, police, utilities and public works—are networked together to provide integrated access to the GIS resources of WAGES. In addition, county and state government, as well as the public use WAGES. WAGES also provides access to databases that reside on the city's central processor.

ESIG reviewers noted that although there continues to be debate regarding true enterprise GISs, WAGES seems to be one that provides a model for other comparably sized municipalities to follow. It was also noted that the benefits from WAGES are shared by government and taxpayers alike. The latter benefit from increased efficiencies in government resulting from system implementation, reduced city service costs directly attributable to the operation of WAGES, and a greater awareness of issues and public policy through direct public access to GIS resources. The former benefit from economies of organizational operation and decision-making.

WAGES grew out of a needs analysis conducted in 1988 with initial GIS resource procurements beginning in 1990. Approximately 95 percent of the GIS layers in WAGES were created in-house. It has cost approximately $720,000 to implement WAGES.

For more information: Curtis Hinton, GIS Coordinator, P.O. Box 10, Wilson, N.C., 27894; Telephone: (919) 399-2158.

Operations Automation Systems—PGMIS

In this category, the National Park Service's (in San Francisco) Presidio Graphic Management Information System (PGMIS) was recognized for its efficient and flexible system design that supports and satisfies the information needs of a wide variety of applications through easy-to-use user/system interfaces. Although its initial focus was to develop basic information to facilitate the transfer of the Presidio of San Francisco Army facility to the National Park Service, the PGMIS has grown to support a broad range of needs crossing many disciplines using graphical and tabular information.

Building on inexpensive and readily available software, the PGMIS was designed to be used by people with a variety of technical and non-technical backgrounds. It was specifically developed to automate the graphic data components of the comprehensive planning process for the Presidio, and to support redevelopment, infrastructure management, and other pertinent decision-making operations during
the implementation phase of the project.

The PGMIS primarily benefits the Presidio project and its participants. However, it will ultimately benefit the general public as a result of sound and well-managed development facilitated by the system, its data resources, its ease of analysis, and its simple user interfaces.

The PGMIS has been built around two 486/66 PCs, a scanner, plotter and printer together with other networked 486/33 PCs. CAD and facility management software are the primary resources in PGMIS. The total cost to implement was $44,100, excluding data and personnel.

For more information: Charles Swanson, The Presidio at San Francisco, Bldg. 102, P.O. Box 29022, San Francisco, CA 94129; Telephone: (415) 556-0347, ext. 152.

Corporate Systems—EIS

The city of Mississauga won in this category for its development of a "model" Executive Information System (EIS) that provides municipal executives with critical information needed for planning, budgeting and management in a timely and cost-effective manner. Implementation of the EIS has contributed to the city's ability to keep abreast of its monthly financial performance and deliver a zero-percent tax increase even after receiving two mid-year budget cuts.

The EIS integrates information from a variety of hardware platforms including the city's central processor, but provides direct access for city administrators through 386 and 486 desktop PCs with "docking-stations" for notebook computers. These notebook computers allow managers the capability to take the
EIS home or to remote sites where they can continue to review performance-based information. Initially, 37 senior-level managers were provided with access to the EIS. By the end of 1994, approximately 130 users will be on-line with the EIS.

ESIG reviewers noted that the city developed the EIS in a two-phased approach that delivered a good, accessible solution quickly, followed by refinements based on consultation with users that led to an exemplary design and implementation.

Five staff members developed the EIS, but now only one full-time staff member is required to maintain the EIS. The approximate cost of the EIS to date is $300,000—including staff, training, consulting fees, hardware and software for 131 user licenses. In December 1993, the city of Mississauga entered into a contract with its consultants to market and sell the EIS to other interested communities. Over the next two years, the city expects to generate $100,000 from the sale of the EIS.

For more information: Sven Tretop, EIS Project Coordinator, City of Mississauga, Information Technology Div., 300 Centre Dr., Mississauga, ON, L5B 3C1, Canada; Telephone: (905) 896-5212.

Honorable Mentions in 1994
In addition to the exemplary achievements of the winning organizations, two systems received
FIGURE 5. Mississauga Executive Information System (EIS).

FIGURE 6. Example of EIS municipal budget graphic output.

An honorable mention in the Operations Automation Systems category was awarded to the Carnegie Library of Pittsburgh for its NeighborLINE system. NeighborLINE provides library patrons with access to local government and other data to improve action in community and economic development, as well as to facilitate community action and services. The system represents a major step towards responding to community information needs: it optimizes limited existing resources, and networks shared data and human resources.

NeighborLINE grew from an in-depth understanding of its targeted user community obtained through a thorough needs analysis, conceptual design and vision. In the three years of its operation, it continues to positively affect community actions, improvements and services. It also serves to create working partnerships between the library and other public, private, academic and civic organizations. Many of these partnerships have resulted in funded projects that have benefited individual neighborhoods as well as the community.

NeighborLINE is comprised of an integrated and flexible system of hardware, software, communication, database, and personnel components that are focused on the management and delivery of a wide array of information resources to the public.

For more information: Patricia A. Callahan, Allegheny Regional Library, Allegheny Square, Pittsburgh, PA, 15212; Telephone: (412) 572-3715.
Corporate Systems—Providence Plan

The Providence Plan—a non-profit organization created by the city of Providence and state of Rhode Island—has been recognized with an honorable mention in the Corporate Systems category for its implementation of a pro-active GIS that uses low-cost equipment and software combined with land and demographic data to develop strategies for community-based planning and action.

The GIS is the defining element of The Providence Plan. It provides a foundation for formulating new initiatives in housing, community development, education, employment, family services, public safety and open space. It represents a commitment to the value of data-driven community-based strategic planning to facilitate public, private and civic partnerships for urban revitalization and social services.

The system is driven by off-the-shelf GIS products with little customization and runs on 486 PCs. TIGER and U.S. Census block group-attribute data initially formed the data resources to drive The Providence Plan. Additional data from a variety of municipal, state and special authorities have been appended to these records.

The system was started in 1993 and the total implementation cost for hardware, software, personnel and supplies now stands at $98,800.

For more information: Michael Rich, Executive Director, Providence Plan, 15 Westminster Street, Suite 740, Providence, RI, 02903; Telephone: (401) 455-8880.

Models for Others

URISA’s ESIG awards have not only brought recognition to recent win-
ners, but they have also had practical impacts for winning organizations. Recent winners have noted that they have had an easier time getting system budgets and equipment procurements approved by their governing bodies after receiving URISA’s ESIG award. Some have also noted increases in the number of opportunities presented to expand the system’s services for other organizational functions, as well as the increased support for system development from high-level administrators and elected officials. One recent international winner has become a de facto hub for multi-national inquiries and technical information about GIS within its region.

In establishing the ESIG awards, it was URISA’s intent to recognize information systems technology that could serve as models for others, and through this process transfer information and expertise that would serve to advance the state-of-the-art. In 1995, URISA will again be conducting its search for the next generation of exemplary systems. Maybe it’s your turn to be an ESIG winner!
Conclusions about the local government information technology market are difficult to draw, to say nothing of the geographic information systems (GIS) market, because local governments are among the organizations least surveyed about information technology issues and trends. To remedy this, the International City/County Management Association (ICMA) conducted, in 1993, an extensive survey of information technology use in cities and counties. ICMA, based in Washington, DC, is the professional association of appointed city and county managers and chief administrative officers. As such, it conducts surveys and other data collection in its efforts to serve its membership and identify issues of interest to local government managers.

The survey, which was mailed to over 7,000 jurisdictions, provides the most complete picture of the use and perception of information technology in local government in many years. The survey, which had a 35 percent response rate, asked a wide range of questions about the types of technology in use, technology spending and general attitudes about computers. Because local governments are among the largest users of geographic information systems and related applications, the data from the survey should interest URISA members.

Survey respondents have a wide variety of technology platforms. Of those responding to the survey, 18.5 percent have mainframes, 47.9 percent have minicomputers, 24.1 percent have UNIX workstations, 86.9 percent have IBM-compatible personal computers and 14.1 percent have Apple Macintosh. Local area networks (LANs) are widespread among the survey population, particularly among jurisdictions with 50,000 residents or more, with 85.7 percent reporting that they have LANs. An average of 48.1 percent of all jurisdictions have LANs, with the highest concentration in the Pacific Coast states and the lowest number in the East South Central Region.

GISs are found at 28.7 percent of respondent sites, while 38.4 percent are considering adopting GIS technology within the next two years. Interestingly, the region of the country with the highest percentage of GIS users is West South Central, with 38.7 percent reporting the use of the technology. The South Atlantic region has the second greatest usage with 38.3 percent of respondents using the application. The lowest rate of adoption of GIS is in the Mid-Atlantic region, where only 11.9 percent of respondents have adopted the technology. This is one of the most interesting findings as the Mid-Atlantic region has much population growth, a number of large cities and many environmentally sensitive areas around waterways, which should lead to major use of the technology. As one would expect, the highest usage of GIS technology is by the larger cities. All of the respondent cities with over 1 million population use the technology, while 75 percent of jurisdictions with populations between 500,000 and 1 million use the technology. Sixty-four percent of those with populations between 250,000 and 500,000 have GIS in place.

The survey also polled for the types of applications resident on centralized and distributed systems. Centralized systems are used for GIS by 10.8 percent of respondents, while 20.2 percent use microcomputers for that purpose. Thirty percent of responding jurisdictions with population greater than 50,000 use a centralized GIS system, while 10 percent of those jurisdictions with a population of over 10,000 use a personal computer-based GIS. Centralized systems are used by 72.7 percent of respondents for utilities processing, for land record management by 27.2 percent of respondents, for public works by 33.3 percent, by 19.3 percent for planning and community development and by 8.3 percent of respondents for transportation. Looking to the future, 30.9 percent plan to use a centralized system for GIS within the next two years.

Milford H. Sprecher is a vice president at Federal Sources, Inc. of McLean VA where he directs state and local government information technology market research efforts.
Microcomputers are used by a large number of respondents for a variety of planning, engineering and utility functions. Microcomputers are used for planning and community development work by 39.1 percent of respondents, by 22.2 percent of respondents for land records, by 7.8 percent for utilities systems, by 11.8 percent for engineering and by 8.1 percent for transportation functions.

When it comes to decision-making, local governments have a wide range of participants in technology-purchase decisions. The person with the most influence on technology purchases is the Manager/Chief Administrative Office. Department heads are the next most influential group, with 43.1 percent considered as having significant input to technology purchases. Elected city and county council members also figure strongly in technology procurement, with 41.3 percent acknowledging their influence on technology decision-making. Data processing and information systems directors have a fairly small role, with 24.3 percent of those surveyed mentioning that group as being a significant decision-maker. The fact that the survey was directed to the chief administrative or appointed official may explain the lack of influence of data processing personnel on the decision-making process, as well as the fact that elected and appointed officials have the final say on any project that requires expenditure approval.

The public-procurement process causes considerable frustration among public sector IT professionals. The ICMA survey asked how much time was involved in RFP preparation and RFP review. The average amount of time spent in developing an RFP is 37 days, while the average amount of time between submission of an RFP to award is 40
of award were posed, but it's reasonable to assume that the process could range from one to two years given normal budget cycles.

The perception of the value of information technology to local government managers is very high. Mainframe and minicomputers met or exceeded managers' expectations 81.9 percent of the time. Microcomputers have even higher levels of acceptance, with respondents stating that they met or exceeded expectations 90.5 percent of the time. These statistics indicate that technology is perceived as having a very positive overall benefit. The survey did not ask which technologies were perceived as providing the most value.

GIS penetration, while growing, is installed in less than half of the jurisdictions participating in the survey and is still found primarily in the larger jurisdictions. As would be expected, desktop GIS applications are more popular in the smaller jurisdictions. One of the primary trends in local government IT is the growth of integrated, enterprise-wide applications. GIS and related technology fits well into these kinds of systems and should help promote the growth of the technology. ICMA plans to update its technology survey in 1995. Additional questions on GIS and more targeted questions about GIS could provide valuable data to URISA and its members on the growth and use of the technology in local government.

For more information on the data in the current survey or the upcoming survey, please contact Haywood Talcove at ICMA at 202-962-3589.
In This Issue... 

The Monterey Bay image poster presents a striking visual example of a successful blend of art and science. With innovation, artistic creativity, and exacting attention to detail, author Michael McKaie has created an exceptionally impressive and unique poster of the Monterey Bay, California area.

Monterey Bay is part of the nation's largest marine sanctuary. The purpose of the poster is to present to the public environmental detail of the bay region, and to promote the environmental protection of the area by showing the close relationship of the bay, Monterey Canyon and the human impact and development on the land. To produce the poster's image, author McKaie selected and combined high-resolution digital bathymetric data, and high-resolution satellite data of the land area reproduced as a natural-color image.

Reproducing a large, highly detailed color image in a journal of this format is not always a successful venture. Color-separated negatives, at 30 percent of the original size, were generated directly from the poster's digital files. This process has retained much of the detail and beauty of the original published image.

Editorial Intent

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

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

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

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

Ted W. Koch
Monterey Bay: A National Marine Sanctuary from San Francisco to Big Sur

Michael McKaie

Technical innovation, artistic creativity, and emphasis on environmental detail are defining characteristics of this 1993 image of Monterey Bay, California published by Friends of Monterey Bay, a privately owned company located in the Santa Cruz, California area. Generated in its entirety from an 83 megabyte file, this natural-color image published as a large (25-inch × 40-inch) "suitable-for-framing" promotional poster, incorporates five different image data sources. It depicts the relationship between landscape and life, both above and below the ocean, along California's central coastal region. This area was designated by the National Oceanic and Atmospheric Administration (NOAA) in 1991, as the Monterey Bay National Marine Sanctuary.

Monterey Bay, a place where the deep ocean comes closest to North America, is the centerpiece of the nation's largest marine sanctuary. The sanctuary was created to protect and conserve the region's unique and irreplaceable ecological, educational, and recreational resources. The waters of the bay conceal the beginning of Monterey Canyon, an undersea canyon wider and deeper than the Grand Canyon. The depiction of this canyon is one of the most striking features of this poster.

Extending more than 50 miles from shore, to depths of nearly two miles, Monterey Canyon is the largest submarine canyon cutting across the continental shelf. The deep ocean environment of the canyon is a place where oceanographers are discovering and studying marine life never before seen.

The Monterey Bay National Marine Sanctuary covers one-fourth of the California coastline. It is the ocean's version of a national forest. Many environmental organizations and agencies feel that the bay and canyon are endangered by human activities. The recently granted sanctuary status prohibits exploration and production of oil, gas and minerals; supports commercial and recreational fishing regulations, and prevents deterioration of Sanctuary resources.

Because of its unique combination of natural and human resources, the Monterey Bay area has become a focus for extensive marine research and education. Gazing at the image, you can notice the dry lowland areas resulting from the last California drought, the irrigated farming centers and the green forests in the Santa Cruz and Santa Maria mountains. Offshore, the submerged kelp forests show spring coloration. The nearshore reef breaks and wave swells are those actually seen from 514 miles in space.

Creating the Image

Almost three years in production, the Monterey Bay image is the first publicly available remote-sensing image to combine high-resolution digital bathymetric elevation data with high-resolution satellite data of the land surface. It is our hope that this poster is a visual metaphor for global environmental awareness. It shows our activities on the land and how close they come to the deep-ocean environment.

Initially, we believed that making a poster illustrating these relationships would be a quick and easy process. In the first attempts we tried using older, high-altitude USGS color-infrared photos, but we couldn't find anyone who could eliminate variations in density between the photos, or who had experience turning "false-color" images into real-color images. We thought of shooting our own aerial photos, but the cost was prohibitive ($25,000), and they would have produced a digital file size over 800 megabytes! So we turned to the next idea—that of using satellite images and underwater (bathymetric) data.

One of the biggest challenges of the project was to integrate the bathymetric data and topographic/land-cover data into a format that was visually complementary. This meant acquiring bathymetric data for Monterey Canyon of the highest resolution possible. Until this project, high-resolution map data of the

Michael McKaie is a computer artist and founder of Friends of Monterey Bay. He has lived in the Monterey Bay, California area for the past 14 years, devoting the last several years to graphic projects showing the uniqueness of the area from new perspectives.
This reduced image (approximately 30% of the original size), still conveys the impressive detail of the Monterey Bay digital image poster. The image covers the Monterey Bay region from Santa Cruz on the north to the community of Monterey and the Monterey Peninsula to the south. The Monterey Canyon's shape, depth and proximity to the California shore is clearly apparent in the left-center area of the image.
The Monterey Peninsula, shown here at the publication scale of 1" equals 1.10 miles, depicts the rich detail captured in this digitally-produced image. Along the north side of the peninsula, the extent of the communities of Seaside, Monterey and Pacific Grove is clearly evident, while to the southwest, near the shore, the peninsula's famous golf courses are well defined in bright green. The dark areas in the water near the shore are kelp beds.
ocean floor were unavailable to the public, for national security concerns. NOAA, with the help of the United States Geological Survey, (USGS) eventually provided digital depth data obtained during sonar mapping of the bay and canyon, which provided a spatial resolution of 20 meters. The information came in spools of half-inch magnetic tape.

This data was transferred to a Macintosh workstation for editing and enhancement. An initial grayscale assignment for depth contours was given color values and balanced for appropriate tonal range. The ocean surface was depicted using SPOT satellite data. The 10-meter panchromatic band provided a spatial resolution that distinguished prominent wave trains across the bay. Analysts created a set of six grayscale masks that were individually loaded and edited to enhance the wave patterns. The result: an image that shows wind and wave patterns, kelp beds and ocean floor.

The land component of the image was processed separately from the ocean floor and surface data. The need for greatest possible spatial resolution required that SPOT panchromatic satellite data (10-meter resolution) be merged with SPOT multispectral data (30-meter resolution). This allowed color information, originally acquired at a resolution too coarse for the intended product, to be preserved on an image that displayed surface features at a 10-meter resolution. Two SPOT multispectral and two SPOT panchromatic scenes were used in the image, and precise rectification was necessary for the color-resolution merge to work. Because SPOT imagery is collected in the green, red, and near-infrared wavelengths, analysts also had to create a blue channel for the final image to appear in natural color. To do this, they simulated a blue channel using algorithms that sampled and transformed the existing data. The result was a land-color balance as if there was no atmosphere to distort color and sharpness.

This image was finally composited with the bathymetric and terrestrial data into a single image file. After several attempts to manipulate colors to approximate nature, a transformation program was used to create the desired hues. The poster was created using a color separation process directly from the digital file, and was printed using the relatively new waterless printing technology at 300 lines per inch.

**Bridging Art and Science**

After three years and thousands of dollars, this image of Monterey Bay represents a leap forward in image-enhancement technology. It has effectively combined data from different spectral or remote-sensing sources into an integrated visual image that depicts the totality of a specific environment in a more logical and aesthetic manner than has ever been possible; advances in data processing technologies during the past decade have really made this possible. The massive amount of data that was required to complete this project simply could not be feasibly processed 10 to 15 years ago.

Equally as important, this project bridges the gap between ideas and applications, between art and science. In short, it is an effective use of technology and visualization that helps us better understand our environment.
In This Issue . . .

We offer two reviews. The first is a book review, and the second is a new type of review for the URISA Journal—an information resource, in this case, an agency.

The book, Human Factors in Geographical Information Systems, reviewed by Rebecca Somers, addresses the human and organizational factors involved in GIS design, implementation and use. The authors bring concepts and expertise from a variety of disciplines, and apply them to GIS development issues.

Robert Martin's review of the Wisconsin State Cartographer's Office provides an overview and perspective of a land information resource and facilitator. Wisconsin's activities in land information systems have long served as a model for many other states and organizations.

Editorial Intent

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

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

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

For complete submission guidelines, see pp. 112-113.

Rebecca Somers
Jay Lee
This book should be read by everyone involved in implementing GIS. It helps us understand that the key to successful GIS implementation lies in human and organizational factors—a statement that is widely repeated but rarely addressed in a complete, organized or very useful manner.

This book begins with the premise that information systems are more likely to fail on human and organizational grounds than for any other reason. It addresses this issue in an organized, well-structured, researched and referenced approach.

The book, consisting of 19 chapters written by different authors, examines a wide range of issues related to the human aspects of GIS—the individual and organizational issues in the design, use and implementation of GIS. The authors bring expertise from the fields of human computer interaction, work process analysis and design, human resources management, organizational dynamics, information systems design and implementation, psychology, physical and cognitive ergonomics, cartography, geography, GIS and, yes, even Australian wine. The book is organized into six sections that progress from examining the nature of GIS from the user interface viewpoint through the organizational perspective.

The introductory section sets the tone, discussing the basics of GIS in the context of the users’ world views, and introduces the concepts of human factors and how they relate to GIS. Human factors are identified as those concerning how people accomplish their work in a human-machine environment, variables that affect the process, and the application of behavioral principles to the development of the system. The development of the human factors perspective is outlined, including concepts of human-computer interaction (HCI) and cognitive and physical ergonomics.

The second section elaborates on the GIS users' perspectives. GIS usage is analyzed with respect to cognitive sciences concepts, and a framework is developed for examining users' needs and expectations. Human spatial cognition is discussed and related to how users interact with a GIS. Concepts of navigation and wayfinding are introduced and applied to GIS. The section concludes with a discussion of the necessary training and education for GIS users.

The third section addresses human-computer interaction in GIS, or the individual’s viewpoint. The chapters in this section discuss how an individual interacts with a GIS, and the implications this has on GIS design and implementation. The chapter on designing GIS for use introduces the concepts of user-centered design, adaptive interfaces, and prototyping, among others. These concepts are drawn from HCI and general information systems design work, and provide some valuable background for use in the design of GIS. Different views of the user interface are discussed with relation to how we interact with maps and how we manipulate geographic data. Approaches and concepts related to querying GIS, visualization and decision support are also discussed.

The fourth section is fairly brief. It deals concisely with issues of physical ergonomics, focusing on matters regarding GIS hardware design and workplace design.

The fifth section addresses organizational and social issues. This material examines the issues involved in successfully implementing GIS within organizations. The first chapter discusses the role of planned change in the introduction of a GIS. Planned change is a concept that is applied to many types of organizational change, and is particularly relevant for the introduction of technology. The next chapter continues the theme of technological change by examining the role of organizational politics. The third chapter looks at change with respect to characteristics of organizational structure and process, focusing on

Rebecca Somers is president of Somers-St. Claire, GIS Management Consultants in Fairfax, VA. She has been active in GIS for over 18 years, and is co-editor of URISA Journal’s Reviews section.
organizational culture and change. The authors of these chapters introduce concepts from the fields of organizational management, human resources, organizational theory and information systems and technology, and apply it to the case of GIS.

The final section of the book consists of summary remarks outlining the research agenda for human factors in GIS. This section also contains an excellent compilation of related information resources. These resources are particularly useful for pointing the GIS-based reader to expanded horizons in related fields, such as human computer interaction and workplace ergonomics.

Several key points run through the book. Some are stated explicitly in section introductory and summary material, others are implicit in the authors’ discussions. Since the book is written by several authors, from different viewpoints, it is significant that these themes merge as baseline issues.

The first chapter in the book is taken from a statement attributed to University of Hawaii professor Matthew McGranaghan that “for GIS users, the user interface is the system” (p. 103), and this statement is discussed later. This adage serves as a major theme to the topics covered in the book. Whatever the capabilities of a GIS, the system is only as good or as relevant as its user interface—that is what the user sees as the GIS itself. While this may seem like a trivial statement to those caught up in the world of selling, implementing and talking about GIS, it is an important point to consider in order to re-ground ourselves in reality. When “powerful” GIS software systems fail to be implemented successfully we search for complex reasons and excuses for the shortcomings. Much of the answer may lie in this precept.

The concept of user-centered design is addressed in several places, and implicit in many other discussions. While the concept is not new, and is employed in various forms in many GIS development environments, the treatment it is given in this book is valuable for the perspective it provides. It is derived from information systems development and some of the key elements for making it work are outlined. Likewise, the concepts of planned change, transitions, combined organizational/technical approaches and organizational politics are key concepts to be transferred to GIS from other disciplines.

Another underlying theme is the situation we have arrived at in terms of understanding the dynamics of the GISs we are implementing. The rapid development of GIS and the emphasis on technical aspects has become apparent. This has led us to recognize that organizational aspects are of equal, if not greater, importance. The focus of organizational issues, however, has most often been on the business aspects. There has still been a lack of attention to human/social aspects. To further complicate matters, the rapid growth in GIS (and IT in general) has outpaced HCI to some extent.

The book is written from the research and academic perspective, with much of the authors’ work supported by research funds. It presents substantiated findings and is very well referenced. While the book may come from an academic perspective, it has great relevance for GIS practitioners. It is an excellent reference book and is also very readable and relevant. It provides useful background information for practitioners to understand how to use GIS effectively—particularly how to set up GIS for their users and why we keep seeing the same obstacles appear. As practitioners, we should read this type of material when it first appears, not wait until it filters through the field, is watered down, re-interpreted, commercialized, and may be too late.

This book provides an important reminder to GIS practitioners that there are significant knowledge bases in other disciplines that we can use in order to effectively implement GIS technology. When we are faced with challenges, we do not have to reinvent the wheel. Significant work exists in disciplines related to organizational dynamics, information system development, human computer interfaces, ergonomics, and the sociological and psychologic aspects of technology. This book provides the necessary linkages.
The Wisconsin State Cartographer’s Office: Review and Perspective

Reviewed by Robert Martin

The Wisconsin State Cartographer’s Office observed its twentieth year in 1993. The cartographer’s office, however, is not a map production agency. In fact, by today’s big-government standards it is not even “an agency.” Yet people who have been aware of its quiet guidance and facilitation services know that the Wisconsin State Cartographer’s Office has been a major force in bringing land-records and spatial-information access and management into the 21st century. It is dedicated to promoting state-wide mapping and information distribution activities, and to providing spatial and map-related information for various agencies, cartographers, and surveyors for better decision-making.

This is not to say that larger, more well-funded agencies like Wisconsin’s Department of Natural Resources, Department of Transportation, Land Information Board, Geologic and Natural History Survey and the University of Wisconsin’s College of Agriculture and Life Science have not played major roles. In addition I do not want to underestimate the efforts of a whole coalition of land information custodian agencies such as the Soil Conservation Service, utility companies and emerging county and regional land-records management authorities. However, the state cartographer’s office is unique in that it has maintained a non-proprietary or program-neutral stance. This has been its strength in a very program-driven world. It has become “the Office” where people can go for direction, information, facilitation, and coordination of cartographic-related information and related technology.

One of the keys to its unqualified success is its small size and highly qualified staff. They manage to show up at the right place, at the right time, and fulfill the need of the moment. Wisconsin’s land information professionals have come to rely on this constant professionalism and competence.

Another key to success is the selfless way in which the office operates. It encourages coordination and promotes the activities of others without trying to place itself in a governing or authoritative position. In this way, it has built a steady and durable trust with the Wisconsin land information community.

Following are some examples of how the Wisconsin State Cartographer’s Office has contributed to the availability of sound land information:

**Introduction to Local Land Information Systems for Wisconsin’s Future**

This document provides excellent information for the land information novice or the lay-person just starting in land information. The language is easy to understand and it carefully avoids the jargon that is often present in other publications. It is well-organized, making it easy for non-technical readers to grasp the scope of the issues. The publication takes the reader quickly through basic elements of cartography, map use and GIS. It shows how map-related information plays a real role in our daily lives, and it effectively explains how maps can be used to organize textual data for comparison, analysis and retrieval.

This document could be used as the text for a short course for public and private officials involved in managing land-related information. At a minimum, it should be required reading for any person contemplating an investment in GIS/LIS.

**Implementation of Land Information in Local Government**

This document provides a step-by-step process for government officials charged with setting up a modern land information system. First, it provides a user-needs determination (primarily for governments) and functional requirements. It recommends staff education, and provides methods for promoting and presenting the advantages of change. Then, it illustrates how systems design should be approached and how these designs produce hardware and software requirements.

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Robert Martin is a retired assistant state conservationist for the U.S. Soil Conservation Service in Madison, Wisconsin.
While this publication addresses most of the technical issues that must be understood and dealt with during LIS implementation, it does not deal with the institutional framework or the specific user needs for analysis and the ease of access. This is one need that stands between LIS technology and the ultimate implementation of these systems.

A coalition for funding of NAPP photography.

In 1992, Wisconsin was scheduled for its first National Aerial Photography Program (NAPP) flight. Although there were many concurrent program needs for these photos and orthophoto derivatives, no single entity or program would fund the local share. Using the telephone and some old-fashioned fund-raising techniques, the state cartographer raised the local money. I am convinced that without this effective use of the state cartographer’s office, there would have been no Wisconsin NAPP in 1992.

Wisconsin land cover mapping initiative

In 1993, it was apparent that 1992 Landsat imagery, combined with the Soil Conservation Service National Research Inventory, the 1992 NAPP photography, the U.S. Fish and Wildlife Service National Wetland Inventory, the Wisconsin DNR Forestry Inventory and many regional land-use and program-specific mapping efforts presented an opportunity to develop statewide land-cover maps. Once again the state cartographer’s office provided the needed leadership to form an organization that could finance and deliver the desired products for its public and private membership.

These are but a few of the ways the Wisconsin State Cartographer’s Office is making a difference in GIS/LIS in Wisconsin. Without the state cartographer’s office, countless multi-agency and multi-disciplinary efforts would have failed. Instead, Wisconsin is on a firm track toward ready access to needed land information for every citizen.
IN MY OPINION/EDITORIALS

Archer, Hugh. "Expanding Affordable Public Access To Information: Where Do We Go From Here?" Vol. 5, 2: p. 5.


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Features


Bertocci, Roberta; Francesco Brunori, Paolo Canutti, Carlo Garzonio and Sandro Moretti. "Public Safety in Italy: A Study Methodology on Settled Areas." Vol. 4,1: p. 86.


Koeppel, H.W. "CORINE: Toward a European GIS." Vol. 4,1: p. 82.


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**FEATURE MAP**

**Analysis and planning**

Site selection/analysis 4.1: 93 Crowell

**Applications**

Environmental assessment/analysis 3.1: 85 Riggle

Water resources/systems 3.1: 85 Riggle

Site design 3.2: 103 Crowell

**Databases**

Database design/development/management 2.2: 68 Flynn

Digital Mapping 4.2: 91 Walker

TIGER 2.1: 74 Cooke

**Hardware/Software**

Multimedia 5.1: 95 Yap

**Level of government**

Rural/small municipalities 2.2: 68 Flynn

**Regional Concerns**

Australia 5.1: 95 Yap

**System concepts**

Multi-purpose systems 2.2: 68 Flynn

User interface 5.1: 95 Yap

Visualization 4.2: 91 Walker
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