CLOSING REPORT

NCGIA RESEARCH INITIATIVE 9

Institutions Sharing Geographic Information

Harlan J. Onsrud and Gerard Rushton

March 1996

ABSTRACT

This report describes the results of NCGIA Research Initiative 9 on Institutions Sharing Geographic Information. It begins with a discussion of objectives and the process of developing a research agenda. The initiative was active during the period June 1992 through the summer of 1994, although the final wrap-up meeting was not held until July 1995. Since that time, off-shoot research activities have continued and include activities within the research agenda of Initiative 16 on Law, Information Policy and Spatial Databases. Some of the technical aspects of sharing geographic information are also being addressed in a newly proposed research initiative on Interoperating GIS. This report describes each of the major areas of the Initiative 9 research agenda and the research activities of the Center during and subsequent to the time period of the initiative. The report ends with an assessment of the initiative against five criteria.

BACKGROUND

One of the challenges in organizing a specialist meeting is identifying a group of specialists who, as a group, can represent a broad perspective on the research area and yet can narrow in on priority knowledge needs. Initiative 9 began with selection of a core planning group with representation from six universities (Onsrud and Rushton, eds., 1992, pp. 29-30). This group prepared a background paper laying out the issues to be addressed at the specialist meeting and developed a process for selecting meeting participants that was based on visible evidence of scholarly input and commitment to contribute. A public call for papers was issued accompanied by the jointly prepared foundation paper and participants were selected through the refereeing of submitted paper proposals by the core planning group. Thirty papers were accepted for presentation at the meeting and all papers were refereed by other participants prior to the specialist meeting. At the meeting speakers were limited to ten-minute presentations of paper "highlights." Two or three presentations were made in each session followed by a short discussion period. Upon completion of these presentations and discussions, specialists were assigned to small focus groups, asked to review the material from the discussions, and requested to prepare a list of major incentives and impediments to the sharing of geographic information. The lists were reported back in a plenary session. Through consideration of these lists and reflection, participants were then each asked to suggest a subset of important researchable issues which could be addressed in greater depth through a working group. From this larger body of

topics, a small number of research topics were selected for detailed consideration by focus groups at the meeting. This specialist meeting process resulted in well prepared participants, substantive discussions at the meeting, and research products flowing from the meeting. The essential elements of the process were subsequently adopted generally for NCGIA research initiatives.

In its pre-specialist meeting background paper, the core planning group highlighted three components of a research framework that it advised participants to consider. The three components of that framework were: the *theories* of individual and organizational behavior (particularly their relevance in understanding impediments and incentives to the sharing of information); the *arenas* among which sharing of spatial data occurs, could occur, or could be enhanced; and *observations* of the process of spatial data sharing in existing settings. It was felt by the core planning group that ultimately these three components must be brought together to produce models of behavior in regard to spatial data sharing. These results, in turn, should be useful in developing normative proposals for successful spatial data sharing in specific situations.

As Figure 1 shows, the three framework components discussed by the core planning group subsume a vast coverage of theory, sharing arenas, and observation settings. Although all elements of the framework were discussed in papers prior to and after the specialist meeting and research recommendations were made across the full range of topics, the actual research work under the initiative was purposely focused on a much more limited set of topics. For instance, in the upper left corner of Figure 1, it was decided that Initiative 9 would focus primarily on behavioral and social theory in regard to understanding impediments and incentives to sharing rather than focusing on the other two elements indicated. Initiative 16 was eventually approved to address the issue of understanding the law within geographic information use environments and Initiative 19 is taking on many of the societal impact issues. Similarly, as detailed later, we focused on only specific selected sharing arenas and observation settings in the research arising under the initiative.

As mentioned above, after extensive discussions and consideration of a lengthy list of issues that participants felt were fundamental to the understanding and enhancement of geographic data sharing, a smaller number of topics were selected in an open plenary session for detailed priority consideration by focus groups. The five topics selected for focus group consideration were:

1. Metadata
2. Infrastructure
3. Legal, Economic and Cultural
4. Organizational Aspects of Sharing Geographic Data
5. Methodology and Substantive Case Studies

Participants formed themselves into focus groups and each group was charged to:

a. Identify the research issues and define researchable questions
b. Construct a research agenda, and
c. Suggest for the broad research community a list of potential actions.

The extensive key questions and recommendations for research as organized under each of the five topics are contained in the Specialist Meeting Report (Onsrud and Rushton, eds., 1992, pp. 12-27).

After the specialist meeting, NCGIA researchers developed a work plan that included activities addressing fundamental questions within the general areas of metadata, infrastructure, and organizational aspects of sharing geographic data. Selection of topics within these areas for detailed consideration was based on the high priority given these topics and the availability of resources and requisite personnel with the motivation, background, and ability to contribute to the topics. In addition, recommendations by some of the focus groups were not so much research as they were actions that would promote research or promote geographic data sharing. We also tried to avoid duplication of effort and designed our research program to support and complement the activities of government such as the activities of the Federal Geographic Data Committee (FGDC).

The range of research issues raised during the Initiative 9 specialist meeting was large and the methodologies enabling substantive knowledge advancements is complex and difficult for many of

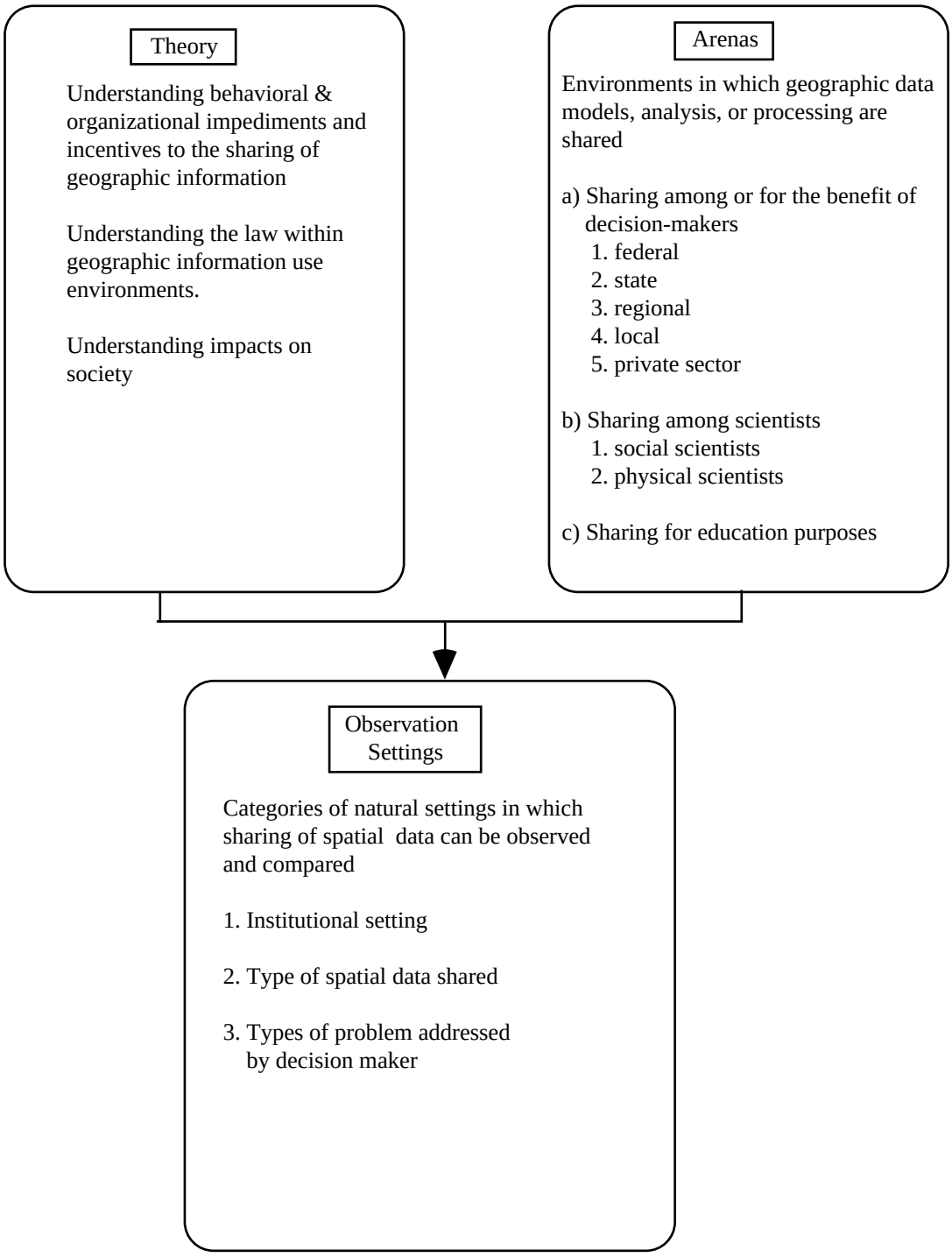

Figure 1. Pre-specialist Meeting Research Framework

the areas. Although many important issues are in need of study, it has not been possible to cover all of them within the constraints of time and resources available. As a result, the closure of any initiative is not intended as a terminus of research but as a point to evaluate knowledge advancements and to provide impetus for further or alternative expansions by the rest of the research community.

It is also interesting to note that the title and broad subject matter of NCGIA's initiative 9 were set in late 1987, when the consortium members met to finalize the list of research topics to be included in the proposal submitted to the National Science Foundation in early 1988. Although several years elapsed, the research agenda developed at the initiative's Specialist Meeting in early 1992 was still broadly consistent with the original concept. Since then, however, we have seen enormous progress in the technologies needed to make effective sharing possible, and increased attention to sharing of data not only between institutions but within the scientific community and in society generally. The ability to share data and information easily and cheaply is now seen as one of the major goals of the information age. Much spatial data is now available using technologies that were almost inconceivable in 1987 (and even in 1992), resulting in dramatic changes in the context of spatial data sharing. Moreover, we can now begin to see additional special problems that spatial data raises, and that make the effective sharing of spatial data more than usually difficult to achieve (Goodchild 1995, 652). Thus, the environment in which I9 research has been accomplished has been highly dynamic. For some of the research questions, the urgency in addressing them was radically altered during the time frame of the initiative due to a major shift in the ability of parties to disseminate and publish spatial data without going through intermediary parties or custodians and due to advances in the ability to transfer spatial data over networks.

The following sections discuss each of the priority research issues identified at the specialist meeting (with adaptation over time) and the research progress achieved during the active period of the initiative. Topics discussed and explored at the specialist meeting and in subsequent research are of course colored according to the interests and specialized knowledge of the participating researchers. Although few NCGIA resources were devoted to this initiative after May of 1994, derivative work has continued and been incorporated into Initiative 16 on Law, Information Policy, and Spatial Databases and further technical issues will be addressed during the initiative on Interoperating GIS. Indeed, the number of fundamental questions and important research issues relative to the sharing of geographic information are growing at a far faster rate than the current research community can hope to address with current resources.

PROGRESS ON THE RESEARCH AGENDA

At the Specialist Meeting, discussions progressed from identifying impediments and incentives for sharing geographic information, to identifying fundamental questions, and finally to identifying high priority researchable topics. It is important to understand that the areas addressed below are not the only areas relative to the sharing of geographic information where fruitful research topics may be discovered. Additional areas deemed important by the specialist meeting participants, some of which will require much longer time frames to accomplish, are reported in the I9 Specialist Meeting Report (Onsrud and Rushton, eds., 1992). Rather, the broad topics addressed below were felt by the participating researchers to be of high priority and more realistically pursued given present knowledge and research tools.

Metadata

Although not initially included as a key sharing issue by the core planning group, metadata and the issues surrounding metadata arose as a critical priority through participant discussions at the specialist meeting. The following fundamental questions were raised by the Initiative 9 metadata working group.

> In order to provide maximum opportunity for sharing geographic information, what mix of standards, infrastructure, and organizational frameworks will best support a metadata regime of maximum utility?
>
> In developing a metadata regime, is there a need to strike a balance between exhaustive completeness (spatial metadata for the user who knows nothing about soils) and cryptic efficiency (spatial metadata for the soil scientist)?
>
> Where should metadata reside - with the date set or in some repository - and who should maintain it?
>
> What kinds of standards can be formulated to guide the compilation, reporting, and use of spatial metadata?
>
> Is it possible to determine geographic metadata requirements such as contents, methods of distribution, and usefulness from users and potential users directly?
>
> What is the role of current and proposed spatial metadata standards, such as SDTS (the Spatial Data Transfer Standard evaluated by the National Institute of Standards and Technology) and efforts under ASTM (the American Society of Testing and Materials)?

The primary NCGIA effort in responding to these questions was accomplished through the Ph.D. dissertation work by Steven Frank at the University of Maine. In this work, the literature was reviewed for past solutions to the problems of finding information resources. This included a comprehensive review of cataloging techniques including bibliographic cataloging, bibliographic retrieval systems, information resource dictionaries, geographic data cataloging, and trends in cataloging and information retrieval automation. Technologies affecting cataloging such as ftp, remote login, archie, gopher, WAIS, World Wide Web(WWW), directory service protocols, and trends in networking technologies were also reviewed in the context of supporting cataloging of metadata. Next, existing current spatial resource systems were examined to determine how spatial resources cataloging was being accomplished in libraries and electronic environments using previous technologies. The elements of spatial data and the role they played in existent systems was also examined. A taxonomy for classifying spatial cataloging and indexing systems was developed and within that framework detailed descriptions of various bibliographic based cataloging systems, customized non-bibliographic systems, MetaGIS systems, and non-cataloging systems were provided.

With this background, it was then possible to postulate a range of infrastructure navigation strategies. Spatial data infrastructure scenarios postulated for consideration included: national digital spatial data base systems, integrated spatial data infrastructures, distributed spatial

database infrastructures, spatial metacomputing infrastructures, and embodied spatial infrastructures. Postulated paradigms for navigating these infrastructures included: super catalogs, virtual catalog cards, hyperlinked spatial resources, metadata collectors, and service protocols.

The next step was to develop the basis for building tools that could support or be useful to several different infrastructure scenarios and cataloging schemes. Through this work several conclusions and recommendations were reached for cataloging for spatial metadata. Recommendations for further research and development work were also suggested. (Frank 1994)

In addition to this work, Gerard Rushton and Marc Armstrong accomplished work on "Development of a Spatial Data Infrastructure for Transportation Planning and Public Policy Analysis." In this project they addressed methods of transferring data from traditional information systems in a State Department of Transportation into the TIGER topological record system. The work involved making the output of the new system compatible with the TIGER profile of the Spatial Data Transfer Standard (SDTS). They also explored metadata aspects of the data descriptions for fitness-for-use purposes.

Spatial metadata issues are also being addressed by NCGIA researchers in implementing spatial digital libraries (Frew et. al., 1995)

Infrastructure

Spatial data infrastructure has been defined as the basic geographic data used for reference and for linkage, the coordinating and control structures that develop and maintain the data, and the distribution system that enables access to the geographic data. (NCGIA Tech Report 92-5, p.16) A nationwide spatial data infrastructure might be viewed as a single integrated robust system. However, a national spatial data infrastructure might also be viewed as consisting of separate major database components suitable for different purposes with not all systems necessarily integrated with the others. For instance, there are great incompatibilities in data among local governments and with federal agencies that make it difficult to aggregate local data upward to the federal level.

Regardless of these concerns, there is general agreement among the users of geographic and land information systems that common sets of geographic data on which users could build to their own particular data needs would promote greater sharing among the various players in the geographic information system (GIS) community (NRC 1994). Such common data sets -- often referred to as "core" or "framework" data sets -- could be collected by designated government agencies or by participating members of the private sector and added to the public domain, via the National Spatial Data Infrastructure (NSDI) for the use of any and all interested parties. (Frank et. al. 1995b, 637).

However, it became highly evident prior to and through the specialist meeting discussions that consensus failed to exist as to what data should be included in a national general-usage spatial data infrastructure. This led to the articulation of a series of key questions by the infrastructure working group. The questions raised included the following:

What is the status of the current spatial data infrastructure?

> Would the establishment of a more coordinated or cooperative spatial data infrastructure be conducive to improved sharing?
>
> What are the most pervasive elements of the current spatial data infrastructure and what should be the taxonomy of an infrastructure that would be useful across many applications ? (cadastral, street centerline data system, land use/cover, remotely sensed?)
>
> How can a networked spatial data infrastructure that is not centrally controlled be sustained?
>
> What are the key fundamental elements of a generally useful spatial data infrastructure at the local, state, national, and global levels?
>
> Can a staged implementation strategy be designed with key milestones and strategies for moving from any one stage to the next?
>
> What will be the profile of uses and users of the spatial data infrastructure of ten years hence?
>
> What articulated long term goal would be appropriate with regard to developing the nation's spatial data infrastructure? (Onsrud and Rushton, 1992, p. 17)

Although numerous recommendations for research were eventually suggested for the academic community as a whole, it became apparent that one of the most pressing needs for both the research community and the GIS community-at-large was for detailed information on the geographic data needs and preferences of current users and potential users. Without this initial information, advancement in addressing related spatial data infrastructure questions would be hampered.

While much anecdotal information is available, studies and surveys on geospatial data needs have been primarily limited to hardware/software issues, implementation and marketing issues, or confined to a particular state or region. In this work, the NCGIA conducted a nation-wide mail questionnaire survey to gather information concerning the technical requirements for geospatial data. The questionnaire targeted existing users of GIS or GIS products (i.e., maps, reports, etc. generated from GIS). These users were asked for responses regarding their data needs for that class, including content, tasks for which the data are used, format, geocoding scheme, positional accuracy, vertical accuracy (if needed), updating interval, needs for historical data, and the sources for data currently being used. The returned information was analyzed across sectors of government, private industry, and academia by region and by professional area of application, showing the technical preferences for framework data sets across each sector profile.

It should be noted that this research was not concerned with establishing the relative value of various types of data to the user community. Rather, our objective was to help clarify competing criteria for prioritization of spatial data by identifying the specific aspects of data sets that are perceived to be of most value to specific communities of users. The results of the work are also intended to provide a guideline for the selection and/or prioritization of possible framework data sets into the National Spatial Data Infrastructure (NSDI). As such, the mail questionnaire survey

conducted by the NCGIA with oversight from a peer focus group was funded by the Federal Geographic Data Committee (FGDC).

We expected that no single set of criteria would be appropriate for all GIS users. Thus, our goal going into the research work was to identify criteria that could form the basis of selecting current digital geographic data sets that best meet framework data set criteria and for improving framework data sets to meet the full needs specified by different subsets of users.

Those interested in the details of the work are encouraged to obtain NCGIA Technical Report 95-1 Framework Data Sets for the NSDI (Frank et. al., 1995a). That report as well as the survey response data files are available through the NCGIA ftp site (ncgia.ucsb.edu) under the same report number.

Organizational Aspects of Sharing Geographic Data

The major questions raised through the specialist meeting process relative to the organizational aspects of geographic information sharing included:

- identification of the sharing relationship variables in a distributed system structure that promote or inhibit data sharing

- identification of the processes and functions of the coordinating bodies in a data sharing environment

- development of process and content model(s) of inter organizational cooperation as related to data sharing as well as political factors

- identification of bureaucratic factors that affect GIS and data sharing

- examination of the application of organizational theory to GIS data sharing

- examination of the aspects of creating vs. sharing data

Diverse views on what constitutes organizational/behavioral aspects of geographic information sharing were expressed prior to, during, and after the specialist meeting. There were several views expressed on what constitutes an "organizational view" and what is important or critical to geographic information sharing. One view expressed was that organizational survival is often very important in explaining organizational behavior and therefore research which tries to address geographic information sharing should do so by evaluating sharing behavior from an organizational survival perspective. Another view was that organizational survival is but one of many potentially important factors, and should be included with those other important factors as "content factors" in a model of facilitators/inhibitors of the geographic information sharing. Another complementary view was expressed that a process time-dependent stage model of geographic information sharing should be developed because any useful model should reflect the reality of major stages that "typical" geographic information sharing goes through. Still another view was expressed that any model of sharing derived from process and content factors should include acknowledgment of the "chaotic" and ad hoc nature of decision-making that typically is experienced in geographic information sharing.

Some members expressed the view that GIS as a product versus GIS as tool should figure prominently in the design/formulation of research because of the drastic impact of each on geographic information sharing.

A strong view was expressed by some that the dominant research question should be "What is (are) the most effective organizational form(s) for coordinating geographic information sharing?" Still another strongly stated research interest was "What practical advice can be developed or investigated by the research community and provided to GIS practitioners on how to proceed on various aspects of geographic information sharing?"

Several studies were begun after the specialist meeting. Nancy Obermeyer and Jeffrey Pinto felt strongly that the treatment of organizational issues within the GIS community had yet to be embedded in the lessons learned from the organizational and behavioral theory fields. Thus, they embarked on a program of researching the literature from those fields and reflecting upon how that knowledge might be utilized in GIS management environments. Although only a single chapter of their 1994 book directly addresses sharing of geographic information, other chapters and the book as a whole tie in many of the additional issues addressed at the specialist meeting. For instance, issues affecting sharing such as bureaucratic factors and standard operating procedures, internal organizational expectations about cooperation, organizational structure, corporate culture, strategic planning, professional qualifications, and political environment are all highlighted in the book (Obermeyer and Pinto, 1994).

To Zorica Nedovic-Budic, one of the more promising domains for enhancing the ability for widespread sharing of geographic data was pursuit of better understanding of the sharing mechanisms and factors that affect coordination of spatial database development and use. Review of mechanisms currently in use and evaluation of their effectiveness under a variety of organizational circumstances was the first step proposed in the process. In assessing which organizational and environmental factors might affect inter and intra-organizational sharing, she began by drawing from the recent findings from GIS implementation and diffusion research. She reviewed sharing models and policies applied in public and private organizations generally and hypothesized from anecdotal evidence in the field and lessons suggested from related technology innovation literature, organizational factors that may exert influence on the success of database and data set sharing (Nedovic-Budic, 1995). In a cooperative effort with Jeffrey Pinto, she began developing a specific research plan for better understanding coordination mechanisms in developing and using GIS data sets and evaluating the effectiveness of the mechanisms. A proposal to fund their joint work is still under consideration by NSF and USGS at the time of writing of this report. (Pinto and Nedovic-Budic, 1995).

Hugh Calkins and Richard Weatherbe took a direct case study approach and in their pursuit of advancing knowledge of spatial data sharing. While Obermeyer and Pinto's concern was that foundation work had not yet been done in embedding the study of GIS sharing within the context of lessons drawn from other organizational and behaviorial theory fields, the concern of Calkins and Weatherbee was that foundation research work was yet insufficient on the current effect of spatial data sharing in local and regional governments and observations enabling identification or hypotheses of impediments to and successful strategies for implementing data sharing were yet lacking. Five local government sites were selected for study and observations were made as to the characteristics and problems of spatial data sharing at the sites. Each of the study sites

involved a multi-participant local government GIS and the study focused on organizational, management and cultural characteristics of the organizations and their data sharing activities. Patterns of data sharing and expressed and observed impediments to data sharing were documented for each of the multi-participant GIS environments. Several observations, conclusions, and recommendations for further work were made by the researchers (Calkins and Weatherbe, 1995). Due to the unfortunate sudden death of Richard Weatherbee, further work on the specific case studies was cut short but may be returned to by others working with Hugh Calkins in the future.

Jeffrey Pinto and Harlan Onsrud, extending some of the research on the diffusion of innovations pursued under Research Initiative 4, continued pursuit of the study of facilitators of information among organizations. They explored the significance of a selected group of organizational and behavioral antecedents that may be necessary or beneficial in allowing the sharing or increased sharing of geographic information among various producer and user organizations. In order to posit a model of inter organizational information sharing, they drew on the literature from a number of sources, including organizational theory, intergroup dynamics, exchange theory, and political economy research. In their model, information sharing represents the mediating link between several antecedent variables and organizational outcomes. The organizational outcomes include greater internal efficiency, increased organizational effectiveness, and improved decision making (Pinto and Onsrud, 1995). The model and research propositions were purposely developed in testable form in order to facilitate a second stage stream of research into facilitators of organizational sharing (Pinto and Nedovic-Budic, 1995).

ASSESSMENT

The previous section reviewed activities under Initiative 9 in three of the priority areas defined through the specialist meeting process. This section provides a scientific assessment of the initiative, organized according to the five criteria for initiative assessments established by the NCGIA Board of Directors.

As mentioned earlier, for the agenda that arose from the specialist meeting, some parts received more attention than others, either because they were perceived to have higher priority or because there was more interest in them by center-affiliated personnel. The center's involvement in focusing on a subset of organizational and institutional issues has helped encourage research on sharing geographic generally within the GIS community. We note that the book produced from the specialist meeting process is one of the academic publisher's best selling books and is being considered in discussions over the sharing of government data generally. Other articles and research results have been passed along to government policy makers as well.

We have extracted liberally from the documents referenced at the end of this report in answering the following questions.

How is the research agenda different from when the Research Initiative started?

The development of spatial metadata cataloging paradigms has allowed the exploration and examination of some of the assumptions and characteristics inherent in each of the individual

paradigms. Comparison of these paradigms based on their characteristics has led to a logical starting point for allowing widespread spatial resource interoperability.

The cataloging and metadata work has examined current spatial resource systems to examine how they fulfill needs of spatial resource users in the National Information Infrastructure. Many of the existing systems are based on traditional library paradigms, but have been adapted specifically for the needs of spatial resource searchers in electronic environments. These systems provide many of the spatial metadata elements necessary for the needs of spatial resource searchers, but do so in a variety of approaches. Many of the spatial metadata elements are recorded and retrieved in manners unique to individual systems.

This work envisioned several possible scenarios in which spatial resources might be used in the National Information Infrastructure and concluded that spatial resources will exist at many levels in the NII. Low level resource access will include spatial data sets and spatial databases that will offer users a wide variety of spatial data with few ways of assessing compatibility and usefulness of data. Higher level spatial resource access will require the development and adoption of standards that will allow systems to interoperate with little or no human guidance.

The NCGIA work developed several paradigms for locating spatial resources in the NII. Among them, service protocols were judged to best allow system interoperability, and to be the most flexible solution for spatial resource development in the NII. Service protocols will allow users to interoperate between a wide variety of resource types using one or more searching strategies of their choice. Sample protocols were developed suitable for allowing compatibility for spatial metadata among many different locational systems. These protocols do not offer full compatibility among all spatial resources, but appear to allow similar spatial resources to become interoperable in limited ways. Expanding these protocols may lead to the development of many high level spatial resource applications in the National information Infrastructure. Thus, through this work, the research agenda has moved from general exploration of alternatives for handling cataloging and indexing systems to a focus on a specific promising paradigm for navigating among a variety of spatial data infrastructures.

As mentioned in the previous section of this report, one of the research needs for both the research community and the GIS community-at-large was identified at the specialist meeting as the systematic collection and analysis of detailed information from users and potential users on their geographic data needs. In response, NCGIA conducted a nation-wide questionnaire survey to gather information on the technical requirements for geospatial data and analyzed the data across several sectors. This study represents to our knowledge the first large-scale effort to sample the U.S. population of GIS users in a systematic fashion regarding their current and future uses of geospatial data and related technologies. The survey database allows identification of those current geospatial data sets that may be useful for the greatest numbers of users as reflected in the broad sample and the technical needs of users for those data sets. We anticipate that others may have specific questions they wish to ask of the database and we are making the database available to any bona fide group or agency wishing to conduct further analysis.

With a much better grasp of the technical needs of users for specific geographic data sets, the further key questions regarding infrastructure research issues raised at the specialist meeting (see the section on infrastructure above) have become clearer and more bounded. For instance, the issues of coordination and cooperation become easier to address once the technical needs and

commonalties in them across disciplines have been identified, new taxonomies might be constructed based on predominant uses and needs, and at least some evidence has been gained as to what might constitute fundamental elements of a generally useful spatial data infrastructure.

What do we know now that is new?

The previous sections have already addressed this question to some extent. However, we recap several of the contributions here. Please note that specific results of individual studies are documented in the accompanying literature and typically need to be left embedded in the explanatory text to avoid their misinterpretation. However, at the risk of over simplification or misinterpretation, some examples of specific findings are as follows:

After reviewing a range of spatial data infrastructure scenarios and the variety of spatial cataloging and indexing systems likely to be incorporated in them over time, paradigms for navigating the spatial data infrastructures were postulated. Among these navigation strategies research focused on service protocols as a promising means for accommodating interoperability. Example protocols for queries were developed, not to form a basis for a spatial query language, but instead to illustrate a means of interoperability by specifying how information is passed between clients and servers.

The service protocol approach counters the traditional cataloging approach that advocates the development of forms wherein a diverse set of information are entered using a complex set of rules. Since different cataloging forms fit different information needs, it seems that the development of a universal form will be extremely difficult, if not impossible. Developing protocols to deal with individual pieces or sets of information will allow us to bypass the arguments that focus on which cataloging form to use, since we would be able to communicate the critical information of each form to the user in a single, easily understood format.

The request for geographic or temporal search services must be established during the initialization between the client and the server. Since the server might serve many non spatial searching services, such as WAIS indexing services or UNIX grep services, for client access, the agreement on how such services should be specified and the procedures for registering new services are left to the Internet community. We believe that a single server may provide more than one method of searching, such as geometric searching for spatial data and grep searching for text files and that this multiple ability should be reflected in protocols.

Virtual Catalog Card records and Hyperlinked Spatial Resources could use geographic or temporal protocols for specifying how the requested information is presented to the user. For example, a VCC record could list the actual information, such as geocoding type and geocodes, needed to pass from client to server and vice versa. In Hyperlinked Spatial Resources, the protocols could specify a manner of hyperlinking a graphic representation, such as an index map, to hyperlinked spatial metadata or spatial data. Super Catalogs could use the protocols to forward requests to individual resources. Protocol format translators for different geocoding schemes could reside within Super Catalogs (or within Metadata Collectors) that would let them make the necessary translations needed to access information within individual resources.

Our survey of users regarding their use of digital geographic data confirmed that the FGDC's primary nominations for core or framework datasets were important data sets from the users'

perspectives. Our work does not test whether these were the only possible framework data sets, or that these were necessarily the top priority framework datasets of users. Rather, the data sets selected by the various working groups of FGDC were confirmed as heavily used data sets across a broad range of sectors. In addition, the work provides evidence of the range of technical needs of users in regard to these data sets including content, tasks for which the data are used, format, geocoding scheme, positional accuracy, vertical accuracy (if needed), updating interval, needs for historical data, and the sources of the data.

For instance, boundary data was the most frequently cited framework data category with more than 94% of the respondents using or needing such data. The respondents primarily wanted boundary data for towns, cities, counties, and states in vector format, geocoded using state plane coordinates at a positional accuracy of 1 to 10 meters. This data is used primarily for address matching, demographic analysis, and site analysis.

Transportation feature data was the second most frequently cited data category with almost 92% of respondents using or needing such data. These respondents primarily wanted transportation data about freeways, highways, local trunk roads, rural roads, and city or town streets. They wanted this data in vector format, in state pane coordinates, and with street address information, primarily at a positional accuracy of 1 to 20 meters. Only about half of the respondents needed elevation information about transportation data, primarily at a vertical accuracy of 1 to 10 meters. This data is used primarily for address matching and site analysis.

Water feature data was the next most popular data category with about 85% of respondents using or needing water data primarily about rivers, streams, lakes, ponds, constructed waterways, wetlands, and watersheds. This data is used primarily for site analysis, inventorying, and environmental monitoring. The users primarily want the data in vector format, geocoded using state plane coordinates at a positional accuracy of 10 meters.

Land parcel data was cited as being needed or used by over 80% of the respondents. They wanted land parcel data about single and consolidated land ownership, easements, and right-of-ways. They wanted this data in vector format, primarily geocoded in state plane coordinates, parcel IDs, and street addresses at a positional accuracy of 1 meter. Land parcel data is used primarily for site analysis, address matching, and inventorying.

Elevation data was used or needed by over 70% of the respondents who wanted primarily digital contour data geocoded using state plane coordinates at 1 to 10 meter positional and 1 meter vertical accuracy for site analysis.

Respondents wanted dated updated primarily as changes occurred and were split in most cases on their need for historical data. The primary source for digital geospatial data was from the federal government except for land parcel data where the primary source was local government.

Many findings of a similar nature are contained in the various articles reporting the results of the research work and should be directly consulted.

What recommendations does NCGIA have in this area?

Adequate research does not exist to determine if certain methods of locating spatial resources are, in fact, more appropriate than others. However, it appears that it may be a long time, if ever, before a single solution can be found. We have and will continue to have an information infrastructure with several methods of locating spatial resources. This multiplicity should not be considered as detrimental to the development of spatial resources in the NII, but as a healthy mechanism to stimulate competition and research into increasing better methods to locate spatial resources and to make them compatible with one another.

Much more work in developing protocols for information searching will be needed if we are to integrate various searching capabilities to allow the greater sharing of spatial information. Additional protocols not related to spatial queries , such as a protocol for the graphic display of images, would also greatly enhance the needs of spatial resource users. So would a protocol for specifying a data set translation to a user specified data format. Concepts used in spatial query languages could form a basis for many useful protocols that would help spatial data users treat spatial data and spatial metadata in a similar manner.

Although many infrastructure tools of great potential for spatial resource application are being developed outside the spatial resource community, certain tools useful primarily for spatial applications have yet to appear. The spatial and temporal retrieval protocols proposed by Steven Frank (1994a) have the ability to allow a level of much needed compatibility to spatial infrastructure applications. More work is needed to provide further compatibility.

Further protocols must also be contemplated. The need to develop semantic context for text based searches is a prime example. The spatial data community needs to examine which metadata elements are critical to the efficient transfer of spatial information and develop well understood concepts that can be easily implemented for transferring such elements.

Survey responses showed that many current GIS user respondents had difficulty in either addressing or understanding positional and vertical accuracy. Several possibilities arise that might explain this phenomenon. First, users might not have documentation (metadata) that can readily give them answers to such technical questions. Second, users may depend on secondary positional and vertical accuracy measures, such as map scale and contour interval, to provide accuracy measures. Third, users might depend on the judgment of others to provide them with data of sufficient accuracy for their needs. Fourth, users might be using whatever data sets they find available without worrying about the possible technical qualities of that data. Although much has been done to promote concerns about these issues -- such as the FGDC Metadata Content Standard and the International Symposium on the Spatial Accuracy of Natural Resource Data Bases -- more education and emphasis on understanding the implications of the accuracy of framework data sets may be in order.

It appears also from the survey responses that certain GIS applications have similar technical needs for data with other applications. The question arises whether a taxonomic assessment might reveal whether GIS users could be naturally grouped into a limited number of user categories.

Additional research needs are those identified through the specialist meeting process as priority topics but were not addressed by the work plans of this initiative. These research topics falls primarily under the general headings of "Legal, Economic and Cultural Aspects of Sharing Geographic Data" and "Methodology and Substantive Case Studies." Numerous of the legal issues and cultural topics are slated to be addressed under Initiative 16 (Law and Information Policy for Spatial Databases) and Initiative 19 (GIS and Society: The Social Implications of How People, Space, and Environment are Represented in GIS). Methodological issues were a strong focus of research Initiative 4 on the "Use and Value of Geographic Information", work continued with this initiative, and methodological issues have become important under several of the projects being accomplished or being proposed for research Initiatives 16 and 19. Both inside and outside the center, researchers are following, testing, or critiquing the center's methods or results. The research agenda in this area has moved from initial explorations of the applicability of organizational and behavioral theory in the geographic data sharing domain to a cumulating scientific tradition. This work is necessarily ongoing, embedded within, and a major consideration of each new research program.

What has NCGIA learned about the Initiative process and how might the operation of future Initiatives be improved?

The Initiative 9 specialist meeting process worked extremely well. Initiative 9 began with selection of a core planning group with representation from six universities. This group prepared a background paper laying out the issues to be addressed at the specialist meeting and developed a process for selecting meeting participants that was based on visible evidence of scholarly input and commitment to contribute. A public call for papers was issued accompanied by the jointly prepared foundation paper and participants were selected through the refereeing of submitted paper proposals by the core planning group. Thirty papers were accepted for presentation at the meeting and all papers were refereed by other participants prior to the specialist meeting. Only a very small proportion of the participants were selected on other than the refereeing process.

At the meeting speakers were limited to ten-minute presentations of paper "highlights." Two or three presentations were made in each session followed by a short discussion period. Upon completion of these presentations and discussions, specialists were assigned to small focus groups, asked to review the material from the discussions, and requested to prepare a list of major incentives and impediments to the sharing of geographic information. The lists were reported back in a plenary session. Through consideration of these lists and reflection, participants were then each asked to suggest a subset of important researchable issues which could be addressed in greater depth through a working group. From this larger body of topics, a small number of research topics were selected for detailed consideration by focus groups. This specialist meeting process resulted in better prepared participants, more substantive discussions at the meeting, and immediate substantive products flowing from the meeting. The essential elements of the process were adopted generally for NCGIA research initiatives (See the NSF renewal proposal supplement).

As mentioned earlier, the goals of this research initiative were altered as the initiative progressed. The goals as set forth in the 1988 proposal to NSF were revised by the core planning group through the preparation of the extensive research background paper. Then, through the process of the specialist meeting itself, the goals were honed and additional topics not viewed earlier as critical to understanding the sharing of spatial information were added. As networking capabilities and hardware and software improved over the life of the initiative, new opportunities and altered visions for functional sharing of

geographic data arose. Many of the institutional, organizational and cultural impediments and opportunities continued to exist but the operational context in which sharing could occur became a moving target. This didn't affect so much the underlying personal, organizational, and institutional problems to sharing as it did the priorities that one might assign to one set of problems over another. The priorities we arrived at through the specialist meeting process would not likely be the same as that arrived at by a similar group of specialists today. Regardless, we believe the work carried out under the initiative has led to understanding in several areas critical to sharing of geographic information among individuals and institutions.

In regard to research carried out under the initiative, we learned that research into the social, economic and institutional impacts of the use of geographic information in decision-making (through actually examining operational GISs) is generally a longer term activity than experienced under other research initiatives and must be planned accordingly. If a substantial number of individuals within the GIS community are not already carrying out research on the range of topics covered by the initiative, the time spent in exploring foundation principles also must be greater.

What contribution has the initiative made to GIS education?

The initiative is at least in part responsible for spurring interest in formalized case study and survey approaches in evaluating geographic information sharing issues, which has resulted in sessions at conferences and chapters in books. As a result of their involvement in Initiative 9, Obermeyer and Pinto produced a book addressing issues arising from or directly related to the initiative topics (Obermeyer and Pinto 1994). Many GIS researchers were exposed to organizational theory and technology transfer theories through the products of this initiative. The primary book arising from the initiative, *Sharing Geographic Information* (Onsrud and Rushton, eds.) is one of the academic publisher's best selling books and the issues detailed in it are being discussed in a range of academic and government policy settings.

As with other research initiatives, one area of educational impact has been the pursuit of graduate theses. One Ph. D. theses completed was "Cataloging Paradigms for Spatial Metadata" (Steven Frank, 1994). Due to his death, the Ph. D. dissertation work by Richard Weatherbe was never completed but, as mentioned earlier, some of that work may be taken up again by Hugh Calkins and future graduate students. Case study and survey methodology materials generated from the research initiative have now been incorporated into the graduate course in research methodology at the University of Maine.

ANNOTATED LIST OF NCGIA PUBLICATIONS FROM INITIATIVE 9

The following section includes the references and abstracts to the papers arising under Research Initiative 9. Although legal issues affecting the sharing of geographic information were identified as priority research topics through the specialist meeting process, they were not included within the bounds of Initiative 9 because of ongoing Initiative 16 on Law, Information Policy and Spatial Databases. Authors affiliated with the Center (i.e. receiving some form of compensation for research expenses) are listed in bold.

Aitken, S.C. and **G. Rushton** (1993) Perceptual and Behavioural Theory in Practice. *Progress in Human Geography*, 17(3):378-388.

This report explores the notion of perceptual and behavioral theory in practice. It raises questions about some of the ways in which perceptual and behavioral theory has found its way into contemporary planning and design contexts. The use of the word application to describe the relations between theory and practice is problematic to us because it carries meanings which are grounded in our collective cultural and intellectual history. The concept of an 'application' is based on the understanding that knowledge generated in one sphere (academia) is then used in the 'real' world by potential consumers of research results. Within this mode, research and practice are institutionally separated in space and time. Schon (1983:26) points out that with this model the '...researcher's role is distinct from, and actually considered superior to, the role of the practitioner.' This may lead to the belief that research is objective and value free, and results can be used in practice to validate action without attending to the values inherent in the knowledge. In short, power is given to the knowledge without reference to the human condition through which it is produced and consumed (Schneekloth, 1987:311). We find the term *praxis* to be a suitable definition of what we are trying to uncover with this report because it engenders a set of beliefs and approaches that, rather than applying the results of prior research to subsequent action, merges academic and professional spheres and blurs the boundary between theory and practice, research and application.

Budic, Z.D. (1993) GIS Use Among Southeastern Local Governments - 1990/91 Mail Survey Results, *URISA Journal*, Volume 5, Number 1, 1993, pp. 4-17. (Initiative 4 and 9 topic)

This paper presents the results of a mail survey of local governments in four southeastern states - Florida, Georgia, North Carolina, and South Carolina - regarding development and use of geographic information systems (GIS). Adoption of GIS technology among those governments was intensive. However, the use of the technology still could not be considered widespread. Cities and counties with smaller populations were slower to implement GIS technology than local governments with larger jurisdictions. GIS technology met the expectations of all respondent governments that had substantial experience in using it. While local governments employed a diversity of commercially developed software, graphic workstations emerged as the most prominent hardware platform. Agencies used GIS for a variety of applications. Most agencies were in the initial phase of GIS utilization, employing the technology sub-optimally, i.e., primarily for mapping purposes. Data base development was isolated as the most time-consuming task in the GIS implementation process. Intensity and level of GIS usage depended significantly on how comprehensive the GIS databases were.

Budic, Z.D. (1994) Effectiveness of Geographic Information Systems in Local Planning, *Journal of the American Planning Association*, Volume 60, Number 2, Spring 1994, pp. 244-263. (Initiative 4 and 9 topic)

Geographic information systems have the potential to aid planning functions in both data processing and decision making. Because the incorporation of GIS technology into local government is at an early stage, knowledge about GIS implementation and its impact on

planning activities is scarce. Using a survey of local governments in four southeastern states, this paper explores how the new technology affects planning and whether it meets the expectations of the planning agencies using it. Most of the agencies surveyed report improvements in communication of information, data accessibility, and data accuracy. They report that more current data are available, and they have confidence in analyses performed with GIS technology. Political support, staffing, length of experience with GIS technology, system sharing, data-base contents, and number and type of GIS applications all exert some influence on either planning operations or decision making. While experience with GIS emerged as the most significant factor in achieving operational benefits, using GIS technology for analytical tasks positively affected improvements in decision making.

Budic, Z.N. (1995) Mechanisms for Coordinating Development and Use of GIS Databases: A Research Framework. *Proceedings, URISA* "95 (San Antonio) 662-674.

Recent evidence on the functionality and benefits of distributed geographic information systems (GIS) is mixed, yet promising. Implementation of shared systems introduces additional difficulties into an already complex process of technological adoption. This paper suggests that better understanding of the sharing mechanisms and factors that affect coordination of spatial database development and use will advance the efforts in building the national spatial data infrastructure. Review of mechanisms currently in use and evaluation of their effectiveness under a variety of organizational circumstances is the first step in the process.

Budic, Z.D., and D.R. Godschalk (1994) Implementation and Management Effectiveness in Adoption of GIS Technology in Local Governments, *Computers, Environment and Urban Systems*, Volume 18, Number 5, Sep/Oct 1994, pp. 285-304.

Acquisition of geographic information system (GIS) technology is only the first step toward its effective use by an organization. The research reported in this article compares the relative success of GIS implementation within four agencies of a North Carolina county government. Using innovation diffusion theory as a basis, the research study identified implementation phases, targets, paths, and outcomes in each agency. Outcomes ranged from complete adoption in a school transportation department to failure to adopt in a comprehensive planning section. Implementation effectiveness in these cases depended both on choice of proper strategy, as related to the agency's organizational environment, and on commitment of adequate management resources to overcome institutional and individual obstacles.

Calkins, H.W. and **R. Weatherbe** (1995) A Case Study Approach to the Study of Institutions Sharing Spatial Data. *Proceedings, URISA* '95 (San Antonio) 675-687.

An NCGIA-sponsored research project is using case studies to determine the current extent of spatial data sharing in local and regional governments and to study the impediments to and successful strategies for implementing such data sharing. The

methodology is defined and described, as is spatial data sharing. Five study sites are described and preliminary observations are made as to the characteristics and problems of spatial data sharing at these sites.

Carver, L., C. Fischer, J. Frew, **M.F. Goodchild**, M. Larsgaard, T. Smith, and Q. Zheng (1995) The Alexandria Rapid Prototype: building a digital library for spatial information. *Proceedings, 1995 ESRI User Conference*, Palm Springs, CA, May 22-26 (CD-ROM and WWW).

A first step toward the Alexandria Project's goal of a distributed digital library for spatially-indexed information is a "rapid prototype" system. The system was built in a period of six months, with a small team, almost entirely from commercial "off-the-shelf" software and hardware, at a single site, and populated with a limited set of heterogeneous spatial data. We are currently using the system to evaluate such issues as: implementing spatial metadata standards in a relational schema; using high-level scripting languages to customize large software packages and "glue" them together; and the relative merits of map-based versus forms-based user interfaces. These evaluations are helping drive the ongoing design of Alexandria's final deliverable, a distributed "testbed" system. The rapid prototype system is also serving as a staging area for data and metadata that will eventually be migrated to the testbed.

Ferrari, R. and **H.J. Onsrud** (1995) Understanding Guidance on GIS Implementation. A Comprehensive Literature Review. *Technical Report 95-13.*

Numerous articles and books have been written to provide guidance on GIS implementation. This Technical Report organizes that literature. One primary goal is to organize the proposals exposed in the literature by heterogeneous patterns, enabling comparisons and answering the question: "What does the literature say about GIS implementation?". The analyzed literature includes "step-by-step" directions, lists of "success factors", alternative strategies for implementation, and similar lessons and recommendations. The conclusions of the Report highlight the proposals identified on several specific issues concerning GIS implementation (overall strategy), the alternative strategies proposed for persuasion of managers, for dealing with user resistance, and for project and system management.

Frank, S. (1994a) Cataloging Paradigms for Spatial Metadata. *Ph.D. thesis*, University of Maine, Ann Arbor UMI Dissertation Services.

The transfer of information from paper based to electronic forms raises questions about how this information might be most easily and reliably found and accessed in a vast network of interconnected computers. This thesis examines specifically how spatial (geographic) information might be handled in such a network. It first examines the current state of spatial data cataloging. It then looks at how spatial resources (in the forms of archived data sets, active databases, analytical software, and automated services) might be arranged in the National Information Infrastructure by developing limited scenarios of spatial resource interactions.

Five possible paradigms (based on trends in current electronic access mechanisms) to catalog these scenarios are compared. Service protocols, conceptual models for developing intelligent computer to computer exchanges, were found to be the most pragmatic choice of possible cataloging paradigms. Two examples of spatial resource service protocols are developed and presented.

Frank, S. (1994b) The National Spatial Data Infrastructure: Designing Navigational Strategies. *Journal of Urban and Regional Information Systems Association*, Vol. 6, No. 1, pp. 37-55.

The place of digital geographic data and land information in the evolving electronic information infrastructure is of great concern to many in the GIS/LIS field. The way we structure spatial data and information (spatial resources) within the architecture of the information infrastructure may determine both the manners in which those resources may be used and the design of parts of the infrastructure architecture itself. A part of this architecture should include navigational tools that may be easily used to efficiently and effectively locate and access the information contained in the infrastructure.

Frank, S. (1994c) Cataloging Digital Geographic Data in the Information Infrastructure: A Literature and Technology Review. *Information Processing & Management*, Vol. 30, No. 5, pp. 587-606.

Cataloging has long been recognized as an efficient method for condensing knowledge of large collections of items. Special approaches to cataloging have proven successful for many collections, including collections of spatial resources. The advent of interconnecting computers and new network information retrieval tools calls for an examination of catalog-like services that these tools might provide. In this paper we examine several likely scenarios for implementation of the information infrastructure as it pertains to spatial resources. We then develop cataloging paradigms to examine how the needs of spatial resource searchers may be met in possible infrastructure scenarios using the concepts provided by these new networking retrieval tools.

Frank, S. (1995) A National Spatial Data Infrastructure as a Marketplace for Geographic Data. *GIS in Business*, Gothenburg, Sweden (keynote address March 29, 1995).

The potential for using the National Spatial Data Infrastructure as a marketplace for data is discussed along with potential user/buyer concerns. The use of metadata to quickly find, access and evaluate data sets may prove crucial to the success of marketing geographic data.

Frank, S. (in publication) Cataloging Digital Geographic Data in the Information Infrastructure. In: *Encyclopedia of Library and Information Science*.

Frank, S.M., M.F. Goodchild, H.J. Onsrud, and **J.K. Pinto** (1995a) *Framework Data Sets for the NSDI* (Santa Barbara: NCGIA Technical Report 95-1)

This report provides details and background on a nation-wide mail questionnaire survey conducted to gather information on the technical requirements for geospatial data. See the next two references for articles arising from this work.

Frank, S.M., M.F. Goodchild, H.J. Onsrud, and **J.K. Pinto** (1995b) A Survey on User Requirements for Framework GIS Data. *Proceedings, URISA '95* (San Antonio) 637-651.

Common sets of framework geospatial data--data usable across many applications--have been proposed as a method to promote GIS data sharing. While there is much anecdotal information about what the characteristics of such data should be, studies and surveys on GIS data needs have been limited primarily to hardware/software issues or confined to a particular state or region. The National Center for Geographic Information and Analysis (NCGIA) conducted a nation-wide mail questionnaire survey to gather information concerning the technical requirements for geospatial data. The questionnaire targeted existing users of GIS or GIS products (i.e., maps, reports, etc. generated from GIS). These users were asked for responses regarding their data needs for six possible framework data sets. 1360 questionnaires were mailed out. 595 usable questionnaires were completed and returned. The returned information was analyzed across sectors of government, private industry, and academia by geographic region and by professional area of application, showing the technical preferences for framework data sets across each sector profile. A summary of those responses is given in this paper.

Frank, S.M., M.F. Goodchild, H.J. Onsrud, and **J.K. Pinto** (in press) User Requirements for Framework Geospatial Data. *URISA Journal.*

Common sets of geospatial data, usable across many applications, have been proposed as a method to promote GIS data sharing. Questions arise as to the appropriate characteristics of framework data. Which features need to be included in framework data sets? What accuracies are required for features? Which geocoding schemes are needed? How often do framework data sets need to be updated to remain useful? While much anecdotal information is available, studies and surveys on geospatial data needs have been primarily limited to hardware/software issues or confined to a particular state or region. The National Center for Geographic Information and Analysis (NCGIA) conducted a nation-wide mail questionnaire survey to gather information concerning the technical requirements for geospatial data. The questionnaire targeted existing users of GIS or GIS products (i.e., maps, reports, etc. generated from GIS). These users were asked for responses regarding their data needs for that class, including content, tasks for which the data are used, format, geocoding scheme, positional accuracy, vertical accuracy (if needed), updating interval, needs for historical data, and the sources for data currently being used. 1360 questionnaires were mailed out. 595 usable questionnaires were completed and returned. The returned information was analyzed across sectors of government , private industry, and academia by geographic region and by professional area of application, showing the technical preferences for framework data sets across each sector profile.

Goodchild, M.F. (1994) Information highways. In D.R. Green and D. Rix, editors, *The AGI Source Book for Geographic Information Systems.* London: Association for Geographic Information, pp. 107-111.

The paper discusses the role of communication technology, particularly wide area networks such as the Internet, in the sharing of geographic information. Simple applications such as electronic mail and list servers are now giving way to more sophisticated tools such as WAIS that allow primitive forms of search. The development of metadata, and associated standards and techniques for storage and processing will be the key to increased utility.

Goodchild, M.F. (1994) Sharing Imperfect data. In A. Singh, editor, *Proceedings, UNEP and IUFRO International Workshop in Cooperation with FAO on Developing Large Environmental Databases for Sustainable Development.* UN Environment Programme, Grid Information Series, No. 22, pp. 102-110.

Quality is almost always an issue in working with spatial data, since almost all spatial data are of limited accuracy. Access to appropriate information on quality is essential if agencies or scientists are to share spatial data, since no user should be willing to trust data of unknown accuracy. The concept of metadata provides an effective means of ensuring such access, by integrating information on quality with the data themselves, and by updating metadata as the data are processed and modified by GIS operations. Standards for the description of quality and for metadata are emerging, and procedures for quality assurance and quality control of GIS data are under development. But much more work is needed in basic research and software development if metadata is to be used effectively. The impact of effective metadata on the use and value of spatial data has yet to be evaluated.

Goodchild, M.F. (1995) Technical Advances in Spatial Data Sharing. *Proceedings, URISA* "95 (San Antonio) 652-661.

NCGIA's Initiative 9 was conceived largely before today's methods of electronic communication became widely available and popular. New Internet-based tools and new institutional frameworks have vastly altered the environment of digital spatial data sharing over the past eight years by providing electronic implementations of traditional data sharing concepts. The digital library brings all of these together in an electronic analog of the traditional functions of the library. The paper ends with a discussion of the Alexandria Digital Library project and its focus on spatially indexed information.

Goodchild, M.F. (1995) Spatial databases for global environmental issues. In Toward Global Planning of Sustainable Use of the Earth, edited by S. Murai. *Proceedings of the Eighth TOYOTA Conference*, Mikkabi, November 8-11, 1994. Amsterdam: Elsevier, pp. 43-58.

The presentation begins with a review of the roles played by spatial data in global environmental research. While remote sensing provides much of the data input for studies of the physical environment, other more problematic sources must be used for data on the human dimensions of global change, and for formulation of environmental

policy. In addition to remote sensing, contemporary handling, storage, distribution, and analysis of spatial data is facilitated by a range of technologies that includes geographic information systems (GIS) and the global positioning system (GPS). The presentation reviews the current status of these technologies, and the roles they are playing in global environmental research.

Current spatial data technology has inherited many of the limitations of its predecessors, particularly mapping. These include the difficulty of linking views at different levels of spatial resolution, or map scale; the essentially static or snapshot nature of much geographic data; the difficulty of dealing with continuous transition and fuzzy or uncertain position; and the varying quality of much data obtained by ground observation. Current research in geographic information science is attempting to remove or reduce many of these impediments, and the presentation includes a brief status report in each of these areas. The capabilities of novel hierarchical data structures, automated generalization algorithms, object oriented techniques, and spatial statistics will be reviewed, and the presentation will conclude with a general assessment of the prospects for significant progress in these areas in the near future.

Lopez, X.R. (1995) From Gravel to Diamonds: The National Spatial Data Infrastructure at a Crossroads. *Proceedings, URISA '95* (San Antonio) 611-625.

This paper compares how state and local government dissemination policies affect access and commercialization of spatial databases, commonly used in geographic information systems. Three public information dissemination models (cost recovery, public-private partnerships and open access) are evaluated, as are their predicted long-term impacts on the development of a national spatial data infrastructure. The author suggests that policies promoting greater openness and diversity in channels of dissemination are central to the success of the NSDI. This paper is exploratory by design and intended to stimulate discussion rather than offer concrete solutions to a complex issue.

Nedovic-Budic, Z., and D.R. Godschalk (forthcoming) Human Factor in Adoption of Geographic Information Systems (GIS): A Local Government Case Study, *Public Administration Review.*

How do perceptions, experience, attitudes, and communication behavior of local government employees affect the adoption of GIS technology as an organizational innovation? The authors examine the largely unexplored process of GIS diffusion inside local governments in terms of the impact of human factors, internal organizational context, external organizational environment, and GIS management activities. Using a multiple-case study of four agencies within a North Carolina county government, the authors find that GIS diffusion is a very complex process. They conclude that perceived relative advantage, previous computer experience, exposure to the technology, and networking are the most significant determinants of employee willingness to use new GIS technology, while organizational and GIS management factors strongly influence GIS diffusion. The research findings have important implications for devising strategies for effective incorporation of GIS and other information system technologies in public organizations.

Obermeyer, N.J. (1995) The Hidden GIS Technocracy. *Cartography and Geographic Information Systems.* 22(1):78-83.

The trend toward geographic information systems that are more powerful, less expensive, and easier to use seems to be unequivocally a democratizing, counter-technocracy trend, but goes hand in hand with a centralization of the geographic modeling programming that underpins the GIS. These paradoxical trends give the illusion of growing democratization of GIS technology, while in reality, there is a growing danger of a hidden GIS technocracy, owing primarily to the lack of recognition that such a technocracy exists. While the decentralization of the technology is likely to prevent any major widespread cataclysms, individual organizations implementing a GIS may experience problems caused by the implementation of geographic modeling programs that may be inappropriate to their needs. The remedy for such problems is awareness of the hidden technocracy and of the potential for trouble. One way to increase this awareness is to promote the use of lineage information for the geographical models embedded in geographic information systems in the same way that the GIS community has pressed for lineage information on databases.

Obermeyer, N.J. (1994) Spatial Conflicts in the Information Age. *Urban & Regional Information Systems Association 1994 Annual Meeting Proceedings.*

One of the claims made by advocates of GIS is that geographic information systems can help to minimize conflicts over land use by providing more and better (more accurate, more current) information about the subject of the conflict. This naive claim overlooks an important source of conflict: the underlying value differences represented by conflicting parties. This paper hypothesizes that geographic information systems will tend initially to increase rather than decrease conflict, since geographic information and analyses made possible by GIS can be used selectively by conflicting parties to support their positions, which are often based on conflicting values.

Obermeyer, N.J., and **J.K. Pinto** (1994) *Managing geographic information systems.* New York: Guilford Press.

Managers in charge of creating an effective geographic information system (GIS) for their organization often find that they are faced with two problems: mastering the GIS technology and managing its effective introduction and use. Existing literature in the field has focused on explaining and teaching GIS technology, often ignoring issues of implementation. This book provides a guide to organizational and behavioral dynamics that can determine where a GIS should be used and how it may be successfully employed. It covers a range of institutional issues relating to the implementation and management of these systems in both public and private sectors. Using a background of management and social science theory, the book can function as a reference for agency managers, analysts, and project managers in public and private organizations who work with GISs. The book concludes by suggesting that the use of GISs in political reapportionment and redistricting provides evidence of its value in a democratic society. GIS professionals

need to recognize that their work has implications for democracy and must accept the societal responsibility that their work entails.

Onsrud, H.J., et. al. (1995) Experiences in Acquisition, Implementation, and Use of GIS in U.S. Local Governments: A Sampler of Academic Studies and Findings. *Proceedings, URISA* '95 (San Antonio) 626-636

Numerous maxims have been suggested regarding what allows individuals and organizations to acquire, implement, and successfully employ GIS. Identifying determinants of successful acquisition, implementation and use of geographic information innovations is a significant research stream drawing the attention of numerous U.S. researchers over the past several years. In addition, researchers have been documenting the extent and nature of GIS use in U.S. local governments in order to track the diffusion of the technology over time. This paper begins by setting forth a framework for classifying GIS organizational research. Within the context of the framework, the paper summarizes the objectives of several recent case study and survey efforts by GIS researchers in the U.S, the methods used by the researchers, and their findings.

Onsrud, H.J. and **G. Rushton,** eds. (1992) Report of the Specialist Meeting, Research Initiative 9: Institutions Sharing Geographic information (Santa Barbara: NCGIA Technical Report 92-5)

This report provides a summary of the purpose and scope of the research initiative on institutions sharing geographic information, describes the specialist meeting process, and documents the recommendations for research in sharing geographic information made by the specialist meeting participants.

Onsrud, H.J. and **G. Rushton,** eds. (1995) *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers)

This book consists of compiled articles and is broken into five major sections. In the first, organizational theory issues are considered in the context of geographic data-sharing. The second section provides a sampler of experiences in the sharing of geographic data. In the third section the chapters focus primarily on broader institutional issues. The fourth section addresses pragmatic considerations in the further development and improvement of a spatial data infrastructure. Finally, in the fifth section, research and development activities that might facilitate increased use and sharing of geographic information are set forth and discussed.

Pinto, J.K. (1994) Successful Information System Implementation: The Human Side. Upper Darby, PA: PMI Publications.

One of the practical lessons that most information systems mangers learn at some point in their is the importance of balancing a technical perspective with a managerial, or behavioral mind-set. In other words, there is a strong tendency for "technologists" to approach any project, such as implementing information systems, from a purely technical perspective, expecting that once technical bugs in a system are ironed out, acceptance of

the IS is routine. The reality is that gaining successful implementation (including acceptance and usage) of any new IS is a difficult, "human" problem far more than simply a technical challenge. This book explores the nature of the human challenge in IS implementation, looking at how to define successful implementation, develop appropriate project tracking and control systems, and address the wide variety of behavioral issues that can impact on implementation success.

Pinto, J.K. (1994) Update on Research Progress into the Institutional Sharing of GIS Information. at the Annual Urban and Regional Information Systems Association (URISA) Meetings, Milwaukee, WI., July.

The success of organizations in both the public and private sectors can be greatly enhanced by the open exchange of information across organizational boundaries. One of the problems hampering the integration and wide-spread use of Geographic Information Systems (GIS) has been the continued inability of various public agencies at the federal, state, and local levels to develop purposeful and productive collaborative relationships. Specifically, there is a general inability to effectively share GIS information among these organizations, resulting in the duplication of systems and services at different levels. This paper proposes a research framework that addresses the influence of a set of antecedent constructs (superordinate goals, accessibility, communicative proximity, bureaucratization - formalized rules and procedures, the quality of exchange relationships among organizations, and resource munificence/scarcity) on the attainment of both interorganizational cooperation and optimal use of GIS information.

Pinto, J.K. (in press) Power, Politics, and Project Management. Upper Darby, PA: PMI Publications.

The ability to successfully manage projects, including the introduction of a new information system, in organizations is a difficult process. The problems facing project managers are exacerbated by the position they occupy in most companies in that they often possess little authority or status relative to other functional departments. Consequently, learning an appreciation of and ability to apply political tactics in furthering project goals is of vital importance. Politics refers to the process of enacting power in organizational situations. In practical terms, it means learning how to negotiate, bargain, make deals, and influence others when the project manager cannot rely on direct authority to achieve implementation goals. This book explores, in detail, the nature of power and politics, offering a number of pragmatic lessons on how to achieve project success through effective politics.

Pinto, J.K. and B. Azad (1994) The Role of Organizational Politics in GIS Implementation. *Journal of the Urban and Regional Information Systems Association (URISA)*, 6(2(:35-61.

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 slow-downs 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. Towards 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.

Pinto, J.K. and O.P. Kharbanda (1995) *Successful Project Managers*. New York: Van Norstrand Reinhold.

The skills that define successful project managers (behavioral, managerial, and technical) have rarely been explicitly codified. In fact, in most organizations, new project managers are expected to learn their duties the hard way, often through trial and error. Obviously, such an ad hoc approach to developing project managers leads to tremendous waste and inefficiencies in companies that are intent on improving their project management techniques. This book explores the wide range of duties expected of project managers, seeking to lay out, as systematically as possible, the comprehensive nature of their duties, the skills they will require to perform successfully, and actual case examples of both successful project managers and their projects.

Pinto, J.K. and O.P. Kharbanda (1995) Project Management and Conflict Resolution. *Project Management Journal,* XXVI (4).

Conflict is a natural by-product of project management. It arises for a number of reasons that are directly related to the project management process and hence, ensure its inevitability. Because of this inevitability, we argue that successful project managers are not those who can eliminate conflict from their teams and their project's development process; rather, the mark of effective project management is to understand the nature of

conflict, recognize its patterns, and proactively search for optimal methods to resolve it with minimal impact on the project. In this paper, we examine the nature of conflict, identify the pattern that conflicts often follow, and offer some advice on alternative methods for dealing with conflicts once they have evolved.

Pinto, J.K. and **H.J. Onsrud** (1995) Sharing Geographic Information Across Organizational Boundaries: A Research Framework. *Proceedings, URISA '95* (San Antonio) 688-694.

Although the success of organizations can be greatly enhanced by the open exchange of information across organizational boundaries, one of the problems hampering the wide-spread use of GIS is the continued inability of various public agencies at the federal, state, and local levels to develop purposeful and productive collaborative relationships. This paper proposes a research framework that addresses the influence of a set of antecedent constructs on the attainment of both inter organizational cooperation and optimal use of GIS information.

Pinto, J.K. and **H.J. Onsrud** (1996) In Search of the Dependent Variable: Toward Synthesis in GIS Implementation Research, in I. Masser and M. Craglia (Eds.), *Geographic Information Research: Bridging the Atlantic.* London: Taylor & Fanncis, (forthcoming).

One of the enduring problems with implementing geographic information systems is gaining a clear idea how best to judge the degree of success with which they have been introduced. Researchers have devoted considerable time and effort attempting to explore the causes of system implementation success, at the same time positing almost as many different models of success as there are articles written on the topic. This lack of consensus has led to significant problems in attempting to synthesize and generalize GIS implementation research. For example, in dealing with the practitioner audience, it is difficult to clearly demonstrate how the GIS will benefit their organizations; that is, what the expected payoff of using the system will be. Consequently, academic and practitioner efforts at evaluating these systems are often tentative due to the lack of any sort of systematic and useful metric. This paper addresses many of the problems currently found in the area of implementation success, offering some historical viewpoints on what has been written in the past. Finally, we will propose a parsimonious model of system implementation success that takes into account a wide variety of factors and synthesizes them into a framework that can be used by researchers and managers in accurately assessing their system's efficacy for organizational operations.

Rushton, G. (1993) Perceptual and behavioural theory in practice. *Progress in Human Geography,* 17,(3), 378-388.

Rushton, G. (1993) Human behavior in spatial analysis. *Urban Geography,* 14, (5), 447-456.

In the early years of the quantitative revolution in geography, the questions asked were dominantly about spatial regularities in patterns of events. In the 1960s, a subgroup turned their focus on the decisions of individuals and organizations in their spatial context. Much was learned about spatial behavior as well as about behavior in

space. Determining the synergistic relationships between behaviors that change in their spatial context and spatial contexts that become changed by the pattern of behaviors within them proved to be a challenge that was abandoned too early. These relationships can now be studied more effectively as a result of the recent development of methods for encoding, storing and manipulating spatial data in geographic information systems. Spatial analysis has entered a new age where human-map interactions in a data-rich environment are becoming a part of traditional scholarship, entering many practical domains, and, for those who want to be a part of the next revolution, a world of knowledge-based, spatial decision support systems.

Additional References

In order to include abstracts to all articles prepared in conjunction with this initiative in a single document, following are the abstracts contained in the primary book arising from this initiative, Onsrud, H.J. and G. Rushton, eds. (1995), *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers)

Meredith, P.H. (1995) Distributed GIS: If Its Time Is Now, Why Is It Resisted? In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 7-21.

Tremendous value may be realized by storing, sharing, merging, and manipulating large scale databases in a distributed processing environment (Toperczer 1991 and Keen, 1988). Yet there is deep-rooted and widespread resistance to distributed processing of data, even when it is limited to intra-organizational sharing of processing responsibility. When distributed strategies are advanced which transcend organizational boundaries resistance magnifies. Why is administrative and user resistance so high, and what alternatives exist for managing or overcoming the sources of resistance? This paper responds to that question in the following manner. First, organization theories on three types of organizational interdependence and how organizations respond to them are explored. Second, a theoretical framework for understanding various levels of interorganizational cooperation, and factors influencing their adoption are provided. These theories are linked to a conceptual framework from the field of Management Information Systems (MIS). The MIS material referenced identifies a set of criteria for the organizational evaluation of distributed processing proposals. Special emphasis is placed on understanding the principal sources of resistance to adopting distributed solutions. Finally, a testable framework for managing and/or overcoming those sources of resistance is proposed. Concepts found in literature on the management of technology and innovation are employed.

Azad, B. and L.L. Wiggins (1995) Dynamics of Inter-Organizational Geographic Data Sharing: A Conceptual Framework for Research. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 22-33.

This paper addresses geographic data sharing from an organizational perspective, considering it an inter-organizational relation (IOR). The underlying principle of this perspective is that autonomy considerations dominate the decisions to engage in and maintain IOR. With organizational autonomy as its centerpiece a research framework is proposed that covers reasons for, levels of, and stages of IOR: the basic and fundamental reasons that push public and/or private organizations to engage in IOR how to concretely characterize different levels of IOR and the key dimension(s) along which the levels of IOR can be measured and finally stages that usually accompany these levels of IOR. First, the problem of geographic data sharing is defined as an IOR and a simple illustrative inter-organizational typology of possible configurations for geographic data sharing is suggested. Second, relevant work from organization behavior/organization theory (OB/OT) literature is briefly reviewed and the basic and fundamental reasons for geographic data sharing is re-cited from this review of inter-organizational relations. Third, the key factor in IOR is identified as autonomy. We will argue that intensity of IOR increases as organizations move from initial inter-organizational collaboration to cooperation and finally to coordination. We will also identify a dimension which will indicate these increasing levels of IOR and therefore of geographic data sharing. Fourth, we propose -- based on a review of OB/OT literature -- the typical process of growth of IOR and its stages. We will then identify some key elements of these stages. Then, we illustrate our synthesis of the reasons, levels, and stages of IOR for geographic data sharing with three mini-case examples. Finally, the reasons, levels and stages of IOR for geographic data sharing are proposed as a research framework that can be used both for theory building and theory testing activities under the NCGIA Initiative 9.

Pinto, J.K. and **H.J. Onsrud** (1995) Sharing Geographic Information Across Organizational Boundaries: A Research Framework. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 44-64.

As development of geographic information systems progresses, and technical problems are overcome, new problems arise. One of the frequently mentioned problems is that of the need for information and data bases that may be housed in several organizations. This chapter explores the organizational and managerial roots of difficulties in sharing data bases. Historically, a combination of organizational structure and operations has resulted in the fragmentation of work projects into individual tasks and growing powerlessness among manual and clerical. Such fragmentation of tasks tends to increase the power of knowledge workers and their organizations, since such workers and organizations often control information that is valuable because it is often both unique and indispensable. This chapter identifies a three-stage path model which delineates: 1) a set of facilitators of organizational information sharing, 2) the process of information sharing, and 3) consequences of enhanced information sharing.

Calkins, H.W. and **R. Weatherbe** (1995) Taxonomy of Spatial Data Sharing. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 65-75.

Modern implementations of Geographic Information Systems function as distributed systems and can support multiple participants, each contributing data to the database. Additionally, the high cost of building and maintaining comprehensive databases comprising a variety of themes will force GIS users to share or exchange data with others. With the growth and maturation of GIS technologies and implementations it is now possible to perform surveys and case studies on spatial data sharing. These will develop technical and organizational descriptions of data sharing activities and will assist in developing prescriptive or normative methods and structures for spatial data sharing. A taxonomy of spatial data sharing must be developed to provide a descriptive and analytical framework for such studies and to provide a common vocabulary for discussion.

Calkins, H.W., F.F. Xia, and W. Guan (1993) GIS Based 3-D Segmentation for Water Quality Modeling. *GIS/LIS '93*, Vol. 1.

A three dimensional segmentation editing tool is designed for water quality modeling needs. It extended the 2-D editing capability of GIS and provided a 3-D segmentation utility for water quality modeling. The technical approach adopted in this study is to first decompose the 3-D modeling segments into interacting 2-D components, perform the editing in the 2-D environment, manage the relationships among the 3-D segments, and finally re-assemble the edited 2-D objects into the
3-D segmentation scheme.

Kevany, M.J. (1995) A Proposed Structure for Observing Data Sharing. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 76-102.

That the sharing of information or data is a desirable process appears in the GIS industry to be a universally accepted "truism". Why is sharing so important? Perhaps because it offers the opportunity for great financial gain or saving, perhaps the opportunity for compatibility in information, perhaps many other benefits. Nevertheless sharing is treated as very significant when justifying or planning a GIS. The purpose of this paper, however, is not to justify sharing but to explore methods for analyzing the environments of sharing.
Since we generally accept the practice of information sharing as a desirable condition, it is important in a GIS project to create conditions that are conducive to sharing. Little is known, however, of what conditions create a conducive environment. The purpose of this paper is to explore factors impacting sharing and to make a contribution toward an analytical structure for improving the level of knowledge. The paper identifies potential factors and proposes and evaluates a structure for measuring the reality of, or potential for, information sharing in a GIS environment. The structure may be used initially to improve the knowledge of factors that affect data sharing and later to apply that knowledge to GIS situations to increase the potential for sharing.

Craig, W.J. (1995) Why We Can't Share Data: Institutional Inertia. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 107-118.

Public agencies are focused on their own mission and mandates and they have little time or incentive to worry about sharing their data with others. Individual organizations pursue their narrow goals even when a small amount of additional effort would add critically useful data and information to the corporation *e.g.*, state government. This is my conclusion based on a career of public policy research using data about neighborhoods, cities, counties, and state governments. This "Institutional Inertia" manifests itself in three general ways. First is refusing to cooperate, either outright refusal or setting outrageous conditions such as excessive prices. Second is the selection of technology adequate to meet limited internal needs, but inadequate for others. Third is the use of narrowly defined data items and data definitions. The article expands upon these general barriers and illustrates them with personal "war stories." I conclude that change can come only by expanding the mandates of the organization to include the sharing of data, providing incentives to do so. The imposition of mandates is within the authority of elected officials and bodies, so we must learn how best to enlighten these people. Case studies should be undertaken where sharing has been successful to measure the correctness of my hypotheses. We need to learn how critical actors were converted, whom they influenced, and how they plied that influence.

Bamberger, W.J. (1995) Sharing Geographic Information Among Local Government Agencies in the San Diego Region. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 119-137.

The high cost of developing geographic information systems and the benefits of sharing geographic information are encouraging local governments and utility companies to cooperate in unprecedented ways. But there are many obstacles that make cooperation difficult. These obstacles result in redundant mapping systems and expensive duplication of geographic information. The San Diego Regional Urban Information System (RUIS), created in 1984, is one of the early attempts to create a multi-participant GIS. RUIS is now an integrated GIS, providing services to ten departments in the City and County of San Diego. RUIS has developed relationships with San Diego Gas and Electric Company and other cities to share a common base map. This paper describes the evolution of RUIS, the barriers to data sharing which it has encountered and how it has attempted to overcome those barriers.

Obermeyer, N.J. (1995) Reducing Inter-Organizational Conflict to Facilitate Sharing Geographic Information. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 138-148.

The implementation of large-scale geographic information systems requires an openness to both a new technology and new procedures, especially procedures that facilitate the sharing of geographic information across organizational boundaries. In an earlier paper, I suggested that negotiation is an important strategy in establishing inter-organizational information-sharing strategies. The experience of the Cincinnati Area GIS project (CAGIS) supports this concept, and takes it further, suggesting that ongoing readjustments are often required to enable the project to continue to function smoothly. These readjustments are made possible by flexibility within the overall structure of the inter-agency agreement. This paper examines the experience of the Cincinnati Area GIS

project, paying special attention to the role of flexibility in the ability of the member organizations to share geographic information across organizational boundaries in a long-term, open-ended project. The case study also reinforces the importance of a project champion.

Dueker, K.J. and R. Vrana (1995) Systems Integration: A Reason and a Means for Data Sharing. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 149-171.

Data sharing takes place within and between organizations when they operate in common geographic areas and when the costs of original compilation and data capture are significant. When geographic data can be shared, efficiency, effectiveness, and enterprise benefits are made possible. Implementing systems integration to facilitate this data sharing may require some organizational restructuring to take full advantage of new technologies. Some resistance to organizational restructuring, however, can be anticipated and in fact, may be directly proportional to the level of expected benefits. This study examines integration issues and impediments to change in three case studies offering different approaches to data and systems integration. It is found that organizational structure, type of analytical system(s) to be integrated, and the degree to which users access a common database are important considerations for anticipating resistance as well as evaluating the benefits to be derived from better integration.

Ventura, S.J. (1995) Overarching Bodies for Coordinating Geographic Data Sharing at Three Levels of Government. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 172-192.

This paper compares the development and potential effectiveness of over-arching bodies charged with facilitating geographic data sharing at three levels of government -- local (Dane County, Wisconsin: DaneLINC, the Dane County Land Information Consortium), state (State of Wisconsin: WLIB, the Wisconsin Land Information Board), and national (Trinidad and Tobago: Interministerial Committee on Land Information Systems). Observations are primarily focused on three groups of factors that appear to influence the process of creating the over-arching bodies -- technology introduction, practices and structures within organizations, and interagency relations. The process of formation and the form and authority of the over-arching bodies will probably affect the success of data sharing between agencies, though it is too early in their implementation to document such effects. Observation of their formation process raises a series of questions, to study through long-term observation of these and similar situations, which will provide evidence of factors influencing the success of coordinating bodies for geographic data sharing.

Tosta, N. (1995) The Evolution of Geographic Information Systems and Spatial Data-Sharing Activities in California State Government. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 193-206.

Continued expansion in the use of technology for mapping and other geographic data activities has generated a growing demand for digital spatial data. California state agency use of GIS technologies in the late 1970's was limited to approximately six individuals in as many agencies, but by 1992 had spread to more than 100 users in at least 25 agencies. Interest in digital spatial data saw an even more dramatic rise as agencies came to understand the potential usefulness of the technology in addressing numerous management concerns. Most agencies realized the value of sharing digital geographic data because of the costs of data capture and maintenance, but actual instances of sharing, particularly in data creation were relatively rare. The evolution of geographic information system technologies in California state government between 1977 and 1992, and the accompanying interest in, practice of, and constraints to data sharing are examined in this paper. Comments are offered on factors that influenced the ability to share digital, geographic data including politics, individual behavior, organizational structures, and changes in technology. Various approaches to facilitate data sharing activities are identified.

Rocheleau, B. (1995) Computers and Horizontal Information Sharing in the Public Sector. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 207-229.

Implementation of geographic information systems requires a great deal of sharing between municipal departments but there is little information available on the nature and frequency of shared information. This study reports on the rate of sharing of information between police and other city departments in Illinois. It reveals that the overall rate of sharing is infrequent, less than monthly. The highest rate of sharing is with the administrative and budget departments. Qualitative data suggest that much of sharing is due to factors such as hierarchical authority and accountability requirements rather than task-oriented reasons. Statistical analysis shows that the use of electronic sharing does encourage a higher overall rate of sharing between departments. Other variables including hardware configurations, departmental size and autonomy, and crime-related variables were not found to be significant. The implications for the implementation of geographic information systems are discussed.

Masser, I. and H. Campbell (1995) Information Sharing: The Effects of GIS on British Local Government. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 230-249.

The arguments for information sharing are discussed in the context of British local government. The case for more corporate approaches which maximize the benefits to be obtained from information sharing is evaluated and an alternative case which highlights the operational advantages of departmental approaches is considered. The advantages and disadvantages of these two approaches are examined both in overall terms and in relation to the preliminary findings of a comprehensive survey of GIS implementation. The findings of this survey show that there is a 50:50 split between corporate and departmental approaches in current British practice.

King, J.L. (1995) Problems in Public Access Policy for GIS Databases: An Economic Perspective. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 255-276.

The leadership of the city of Buena Vista faces a dilemma following the successful implementation of their new geographic information system. The system, which cost the city over $5 million, is desired by various organizations, including for-profit firms, who argue that the city is compelled by state "open access" laws to release the entire, intact GIS data base at cost for reproduction. Elected city officials believe this constitutes a "gift of public funds," and argue that compliance with these requests is equivalent to giving away city assets. Not surprisingly, the debate quickly turns away from arguments on principle to the practicalities of establishing a reasonable price for access. But establishing an appropriate price turns out to be an extraordinarily complicated challenge. The dilemma faced by the city of Buena Vista confronts many local agencies who are struggling with the economics of their GIS systems in light of fiscal constraints.

Taupier, R.P. (1995) Comments on the Economics of Geographic Information and Data Access in the Commonwealth of Massachusetts. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 277-291.

The Commonwealth of Massachusetts, like many other states in the U.S., over the past several years has developed a significant base of digital geographic information (GI). Each year additional Massachusetts agencies develop GIS capabilities and improve upon their ability to make efficient use of GI. As a result of the demand for more and better geographic information, data access and exchange policies are of substantial interest. Massachusetts has evolved through various stages similar to those encountered in other states and expects further evolution to occur. An understanding of this behavior and the incentives for exchange of GI requires some basic understanding of the economics of public goods, the value of geographic information and the nature of efficient public organizations. This paper explores some of the details of those issues and demonstrates that efficient public agencies that are capable of generating substantial value from GI will be inclined to enter into data exchange agreements.

Onsrud, H.J. (1995) The Role of Law in Impeding and Facilitating the Sharing of Geographic Information. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 292-306.

The widespread use and accessibility of geographic data sets in combination with the capabilities provided by other communication technologies are raising numerous public concerns. Among these include the effects of such technologies on personal privacy, access to the information used by government, work product protection laws, legal liability for errors and inadequacies in GIS products and services, and concerns that information infrastructure arrangements will contribute to the widening of socio-economic gaps among members of the social system. As developers and purveyors of a powerful social resource, the GIS discipline needs to identify the consequences of use of the technology and consider those consequences in the light of their general social effects.

The policy implications of different geographic information sharing arrangements need to be explored and the legal conditions and constraints that will affect the ability to share geographic data widely among divergent groups of potential users of GIS need to be fully discussed.

Epstein, E.F. (1995) Control of Public Information. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 307-318.

Public information data sharing depends upon incentives and barriers that are legal and economic as well as technological. The complex set of relations between people in regard to use of information is expressed legally and economically. These relations, constituting an information institution, determine who has what rights in the information, who controls the information, and conditions for sharing among producers and users. The legal regime includes intellectual property, freedom of information, tort, and government law. Geographic and land information relationships add environmental, land use, property, boundary, and resource law to this list. Fundamental and traditional democratic principles, especially open government concepts, and difficulties in capturing information as an economic commodity mean that distribution of public information by public agencies at dissemination costs remains good public and economic policy in the age of computers.

McGlamery, P. (1995) Libraries as Institutions for Sharing. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 319-330.

This paper presents libraries as both a model and a vehicle for the effective distribution of spatial data. It begins with a discussion of the Federal Depository Library Program, a federally mandated program which "Shall be to make government publications available for the free use of the general public..." The paper goes on to describe spatial data currently being distributed by the Program, the potential of networking, and the library as watchdog of public domain information. The paper then focuses on how libraries share large and complex databases among themselves. Finally, it provides a brief discussion of what is happening in libraries now vis-a-vis digital spatial data.

Dangermond, J. (1995) Public Data Access: Another Side of GIS Data Sharing. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 331-339.

There have been many discussions of and experiences with the sharing of digital geographic data between and among various public and private organizations. Most of these discussions have been associated with the topics of joint sponsorship, cost sharing, technical interchange, agency conflicts, and legal as well as administrative conflicts. A completely separate set of issues arises when considering the sharing of data with the public and the distribution of data to the public. The issues deal not only with the needed technology but also with the more fundamental question of how governments should relate to citizens. A number of the behavioral, organizational, and institutional issues are covered here these include: a review of the models and methods that public agencies at

the federal, state, and local levels of government have used for distribution of their data (including spatial data) to the public a description of some of the public issues associated with both the distribution of data and the connection of the public to the databases which governments use in making policy and conducting their operations an outline of some of the key geographic data-related issues that should be addressed or are of interest to citizens organizations a review of some of the technical means which could be employed to support government data sharing with citizens a consideration of some of the institutional mechanisms and barriers which must be taken into account in creating a successful information link between government and the public and, finally, some indications of the benefits which such citizen participation in government might be expected to produce.

Bossler, J.D. (1995) Facilitating the Sharing of Spatial Data: Perspectives from the Mapping Science Committee. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 347-354.

Within the National Academy of Sciences/National Research Council (NAS/NRC), under the general guidance of the Board on Earth Sciences, the Mapping Science Committee (MSC) attempts to serve as a focus for external advice to the federal agencies on scientific and technical matters related to spatial data handling and analysis. The purpose of the committee is to provide advice on the development of a robust national spatial data infrastructure (NSDI) for making informed decisions at all levels of government and throughout society in general. This chapter presents some personal perspectives on issues discussed and knowledge gained by the MSC over the past several years.

Frederick, D. (1995) Coordination of Surveying, Mapping, and Related Spatial Data Activities. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 355-362.

On October 19, 1990, the Office of Management and Budget issued the revised Circular A-16, titled "Coordination of Surveying, Mapping, and Related Spatial Data Activities." The revised Circular A-16 expands the breadth of coordination of spatial data and assigns leadership roles to Federal departments for coordinating activities related to these data. The revised Circular A-16 also establishes a new interagency coordinating committee named the Federal Geographic Data Committee. The committee has established subcommittees and working groups and is coordinating different categories of data and working on issues of standards, technology, and liaison with the non-Federal community.

Cooke, D.F. (1995) Sharing Street Centerline Spatial Databases. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 363-376.

Street Centerline Spatial Databases (SCSD) are good examples for the study of data sharing, as there is a long SCSD history to examine involving private, quasi-private and all levels of government organizations. The history provides examples of sharing both of data and the labor of data preparation and maintenance. SCSD have such widespread applicability and potential value in public and commercial applications that it is

suggested that the national SCSD and a few other datasets be afforded a special category of "sharing": that of "Spatial Data Infrastructure". Establishment of an effective Spatial Data Infrastructure will require many changes from the present government operations. Suggestions are offered to this end.

Sperling, J. (1995) Development and Maintenance of the TIGER Database: Experiences in Spatial Data Sharing at the U.S. Bureau of the Census. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 377-396.

The U.S. Census Bureau has played, and will continue to play, a vital role in the development, maintenance, and sharing of spatial and attribute data for geographic information systems (GIS) on the local, regional, national, and international level. The Census Bureau's development of sharable geographic data files, the GBF/DIME (Geographic Base File/Dual Independent Map Encoding) Files for the 1970 and 1980 censuses and the TIGER (Topologically Integrated Geographic Encoding and Referencing) data base for the 1990 census, have provided a major impetus to the rapid growth and diffusion of GIS technology. This paper discusses the Census Bureau's experiences in spatial data sharing during these two file-building projects as well as from ongoing experiences in developing Memoranda of Understanding with federal and state agencies to update and improve the spatial and attribute data in TIGER. On the basis of these experiences, preliminary generalizations are made concerning the incentives and impediments to future digital spatial data exchanges.

Alfelor, R.M. (1995) GIS and Integrated Highway Information System. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 397-412.

The application of GIS in Transportation (also called GIS-T) has evolved from simple graphic and map-based representation of roads and geographic features to serve specific functions in a highway agency to a more complex and powerful tool for integrating information and decision-support systems within and among agencies. This change is partly driven by the limited budgets and resources faced by highway departments which required them to find means to minimize the cost of managing and operating their transportation infrastructure including the network of highways, bridges and other facilities. An Integrated Highway Information System (IHIS) on a GIS platform avoids duplication of highway data collection effort and supports integrated decision-making at various administrative and functional levels of the organization. This paper describes both the incentives and requirements for spatial data sharing in IHIS. Some of the technical and non-technical issues involved in implementing GIS for data sharing in IHIS are discussed, with emphasis on those arising from institutional, organizational and behavioral characteristics of highway agencies.

Goodchild, M.F. (1995) Sharing Imperfect Data. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information.* New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 413-425.

Quality is almost always an issue in working with spatial data, since almost all spatial data are of limited accuracy. Access to appropriate information on quality is essential if agencies or scientists are to share spatial data, since no user should be willing to trust data of unknown accuracy. The concept of metadata provides an effective means of ensuring such access, by integrating information on quality with the data themselves, and by updating metadata as the data are processed and modified by GIS operations. Standards for the description of quality and for metadata are emerging, and procedures for quality assurance and quality control of GIS data are under development. But much more work is needed in basic research and software development if metadata is to be used effectively. The impact of effective metadata on the use and value of spatial data has yet to be evaluated.

Stage, D. (1995) A Multi-Agency Management Structure to Facilitate the Sharing of Geographic Data in Florida. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 426-447.

The Florida Growth Management Data Network Coordinating Council (GMDNCC) was created by the Florida Legislature in 1985 to facilitate the sharing of information needed for growth management planning. In 1988 the GMDNCC recognized that access to geographic information is essential to making informed decisions on this topic. With this in mind the GMDNCC stated that one of its major objectives was to promote information sharing through the creation of a "federation of independently held databases that are linked together by standards and a management structure". After three years of facilitating cooperative activities, it is the conclusion of this author that the primary impediments to information sharing are the difficulties of operating in a multi-agency environment without the appropriate support mechanism to facilitate cooperative activities. This paper describes the author's observation of the major problems that must be addressed, and the organizational structure and decision support tools that were developed to overcome these problems.

Evans, J. and J. Ferreira (1995) Sharing Spatial Information in an Imperfect World: Interactions Between Technical and Organizational Issues. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 448-460.

In today's unsettled, rapidly changing technological and organizational context, spatial data sharing is neither a purely technical problem nor a purely behavioral one. Despite innovations on both the technical and organizational fronts, both of these areas will remain "messy" (imperfect and dynamic) for some time, and we must learn to address such a context. In addition, too sharp a dichotomy between "technical" and "organizational" problems risks missing many aspects of the problem that are unique to spatial data. Rather than isolate technical from organizational issues, research efforts should focus on their overlap. We encourage (i) technical innovations intended for multiple actors with imperfect coordination (ii) organizational research tightly linked to current and upcoming technology and (iii) an emphasis on the pieces of the problem which are unique to spatial data. We offer three examples of such research, and propose a

cooperative research agenda based on experiments in spatial data sharing across sectors and levels of government.

Rushton, G. and **S. Frank** (1995) Sharing Spatial Data Among Social Scientists. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 461-474.

Social scientists are now able to access social and economic data at finer levels of spatial resolution than before and to flexibly aggregate such fine resolution, or small area, data. Using TIGER Line files--the geographic base file developed by the U.S. Census--many applied social scientists are address-matching data from administrative record systems and providing spatial decision support for many human services management problems. Spatial data sharing is further facilitated with the development of State Data Centers by the U.S. Census Bureau and with the activities of The Inter-university Consortium for Political and Social Research.

Goodchild, M.F. (1995) Sharing Spatial Data Among Physical Scientists. In H.J. Onsrud and G. Rushton, editors, *Sharing Geographic Information*. New Brunswick, New Jersey: Center for Urban Policy Research (Rutgers), pp. 475-489.

This essay begins by asking why physical scientists need spatial data at all, and finds a recent explosion of need largely attributable to renewed interest in modeling the global physical environment. It asks what kinds of spatial data are most valuable to physical science, and identifies some of the characteristics that make data valuable and suitable for sharing. It then moves to a discussion of the context provided by the culture of physical science, with its customs and myths, and makes comparisons with other cultures in which spatial data plays an important role. Finally, it looks at changes under way in the culture of science that are affecting data sharing, particularly those attributable to the introduction of new technologies of communication.