Spatial Data Infrastructure in Minnesota: Institutional Mission and Individual Motivation

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ABSTRACT: Minnesota had a strong early start in GIS and that history has led to both a large range of data and a sense of collegiality that supports substantial sharing of that data. Case studies of six groups provide insight into the factors critical for the creation and dissemination of a spatial data infrastructure for the state – one component of the national and international spatial data infrastructures. Two aspects prove to be key to the creation of a successful spatial data infrastructure: institutions with proper missions and individuals with high levels of motivation. Institutions that create data and institutions that coordinate and disseminate data are key. Especially in the data creation institutions, it is critical to have individuals who are called beyond narrow institutional mandates and are motivated to share their data with others; factors behind this motivation appear to be idealism, enlightened self-interest, and involvement in a professional culture that expects participation and cooperation. Holes remain in the state's spatial data infrastructure that can only be met with support from the community as a whole, rather than relying on the individual responsible institutions.

INTRODUCTION

Eight years ago the US National Research Council (1993) created the vision of a coordinated spatial data infrastructure for the nation, which provide useful data for addressing critical social and environmental issues. It was more than a vision for federal data coordination and sharing, though that was one of the goals and was supported by a 1994 Executive Order creating the National Spatial Data Infrastructure (NSDI, see http://www.fgdc.gov/nsdi/nsdi.html). The NRC report called for participation from state and local government to fulfill the vision. There are at least two important reasons for involving these lower levels of government: 1) the federal agencies do not have sufficient resources to fulfill their existing data gathering goals, 2) state and local governments have the finer resolution data necessary to make local decisions.

The state of Minnesota was already well advanced in creating its own spatial data infrastructure, though we might not have called it that. The state Planning agency had been using GIS since the late 1970s and was quickly followed by the state Department of Transportation. Minneapolis and Hennepin County developed their own GIS in the early 1980s. These early adopters quickly learned that sharing knowledge and data among themselves was valuable to all parties. By 1990, a grassroots organization was founded and was holding an annual conference and publishing a newsletter; the Minnesota GIS/LIS Consortium (http://www.mngislis.org/) has 3000 people on its mailing list and its conference draws over 600 attendees. The Consortium allowed professionals to meet one another, to exchange technical know-how, and to create a common ethic about sharing experiences and data. The Governor's Council on Geographic Information (http://www.gis.state.mn.us/) works on policy issues such as developing standards and setting investment priorities; the Council dates from 1991. Senior managers are reassured about agency direction when they know it is following Council guidelines.

The state has done an excellent job of convincing federal agencies to focus data development activities in Minnesota. The state has offered matching dollars that moved

Minnesota to the head of line in various national programs: 1:24,000 paper topographic maps, the National Aerial Photography program, the National Wetland Inventory, digital orthophoto quads (DOQ), digital elevation models (DEM), and digital raster graphics (DRG). In almost every case, Minnesota was the first state (except for the smallest states) to have complete coverage. The source for the state match most often has been the Legislative Commission on Minnesota Resources, a pool of money mainly filled from cigarette tax revenues and proceeds on the state lottery; LCMR has invested nearly $17 million in land use and natural resource information since 1991.[1] For more information on LCMR, see http://www.commissions.leg.state.mn.us/lcmr/lcmr.htm .

LCMR dollars also covered substantial state and local government GIS data activities. Some examples include a statewide land-use map, county surveys of remnant pre-settlement biological communities, forest bird diversity, environmental indicators, and watershed data. Recently LCMR invested in research and development at the University of Minnesota that allows adjustment of soil surveys mapped without adequate spatial control to the new orthophoto base.

Not only does Minnesota have a significant resource of geographic data, but considerable effort has gone toward sharing that data across all users for no cost. Data is available in cooperative agreements and across the Internet in great numbers. Data providers have been willing to create metadata and share their data widely. Data needs remain, but they are decreasing because of this sharing environment.

CASE STUDIES OF DATA PROVIDERS

The above history and list of accomplishments might inspire awe or envy, but provides little insight into the causes behind Minnesota's accomplishments. If Minnesota is a model of success, one must know more details in order to emulate that model. Why did government organizations move toward GIS? How did GIS help those organizations. What problems did the organization have in developing GIS and how were they overcome? To answer these questions, I looked at six different efforts to support Minnesota's spatial data infrastructure.[2] What follows is a brief description of each group, the nature of their GIS environment, and the extent of data sharing. I have made an attempt to cover state and regional organizations with a mission to coordinate and share data, other state agencies that have made a strong commitment to share their internal data, and local governments. I have selected the best cases, many of which have won Commendations from our Governor, with the intent of learning from the most successful organizations.

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[1] In 1994, LCMR was given a GIS/LIS Honor Roll award by the MN GIS/LIS Consortium for over 30 years support for geographic and land information systems.

[2] There is a significant number of other groups in the state who collect, manipulate, or distribute data to their members or outside groups. Most serve members in particular sectors: e.g., LOGIS; I-35W North Coalition, Ramsey County User Group (cities), MCCC (counties), TIES (schools), St. Paul Community GIS Consortium (neighborhoods). Others supply data for a fee or less broadly than the examples chosen for case studies.

In many cases I found that the impetus came from a one or two committed individuals in the organization and asked them about their motivation. For example, Don Yaeger at Minnesota Planning headed many of the efforts to get state funding to match federal programs; his motivation stemmed from an early career experience of seeing the intense interest state and local agencies had in a set of centrally distributed air photos – some 300,000 copies distributed. I asked people in my case studies about their personal motivation. What drove them to press for a GIS that was useful to the home organization and compatible with the data of other organizations? What motivated them to actively press to share their home data with other organizations? What obstacles did they need to overcome to attain these goals? From those answers can come the beginnings of answers to questions about whether a local or national or global spatial data infrastructure is possible, who to engage in the individual organization to achieve this goal, and what arguments to use in convincing the key individuals.

Land Management Information Center (http://www.lmic.state.mn.us/)

The Land Management Information Center is a division of the state Office of Strategic and Long Range Planning (Minnesota Planning), an executive department whose mission includes coordinating the activities of the many state agencies. In the late 1960s, the State Planning Agency (SPA), Minnesota Planning's predecessor, saw the potential of GIS and invested in research and development at the University of Minnesota that led to one of the world's first GIS (Craig 1985). In 1977 that system was transferred to Minnesota Planning within the Land Management Information Center (LMIC), which was created to provide GIS data and analysis to state government on a cost-recovery basis. Many other state agencies now use GIS, LMIC's role has grown to include coordination of the activities of those agencies, and many of LMIC's activities are now funded by the legislature.

Making data available to GIS users across the state is now a central goal of LMIC. It has led efforts to create and implement standards, especially the Metadata standards that are so critical to effective sharing. LMIC has been a repository and clearinghouse for most of the state's geographic data since it was created, but generally has charged some fee for providing data. During the 1990s, it began exploring ways to strengthen the identity of the Clearinghouse and ways to minimize its costs of providing users with easy access to the data they need. Supported by a Governor's Council on Geographic Information recommendation, it has worked with partner organizations to develop an integrated approach to linking distributed clearinghouse "partners." LMIC has recently developed the Minnesota GeoGateway (http://geogateway.state.mn.us) as a one stop web-based search and retrieval tool. The tool offers access LMIC's and other clearinghouse nodes across the state, connecting to some 300 datasets developed and maintained by state and local governments in the state, as well as several thousand Minnesota-related datasets maintained elsewhere. While fully compliant with national Clearinghouse standards, the GeoGateway provides significantly easier-to-use access to users, including interactive map-extent searches. Nearly 1000 data downloads with about 8 gigabytes of free data are made from the LMIC site alone, with thousands of other downloads brokered each month from almost 50 other organizations.

LMIC's home in Minnesota Planning makes data coordination and access a central part of its mission. The main barriers to achieving this mission were 1) lack of knowledge about the types of data held by other agencies, 2) lack of details (Metadata) about that data – even LMIC lacked good documentation of its own data, 3) lack of standards across data, and 4) inability to acquire funding to acquire, store, and catalog that data. GeoGateway uses a distributed standards-based approach to overcome those barriers.

I spoke with David Arbeit and Chris Cialek about their personal motivation for undertaking this work. Arbeit, LMIC's director, had been GIS coordinator in a major city which sold data to recover costs and seen that approach fail both in recovering those costs and in making data available to the user community; he observed, "There's little point to developing data with public funds and then making it hard for the public to get it." Cialek, LMIC's data services supervisor, came from the federal organization working on a National Spatial Data Infrastructure, the Federal Geographic Data Committee. He was a young professional looking for a place to implement this vision and found a home in LMIC where he could work on his dream. He has been especially passionate about the need for better metadata and standards for geospatial data.

MetroGIS (http://www.metrogis.org/)

MetroGIS is a grassroots organization established to share data across political boundaries in the Twin Cities Metropolitan Area. A regional government, the Metropolitan Council, has some regional datasets, but most data is held by local government. The region is composed of seven separate counties, each maintaining parcel data for their own territory. In addition, each of 191 cities and townships decide zoning and land use plans for their separate pieces of territory. The picture is further complicated with 59 independent school districts and 39 watershed-based bodies. A policy board, representing all these stakeholders, governs MetroGIS.

Using a highly inclusive process, MetroGIS established priorities for fulfilling the business information needs of the stakeholders (Arbeit, Craig, Johnson, and Stevenson 2000). Hundreds of candidate needs were identified, then prioritized based on two factors: importance for doing your job and reliance on other agencies for acquiring the data. To date seven regional datasets have been acquired or created to meet those needs: street centerline,[3] jurisdictional boundaries, census geography, digital orthophotos,

[3] The street centerline file was purchased from The Lawrence Group with funds from the Metropolitan Council and the state Department of Transportation along with a five-year maintenance agreement; under the agreement the data is made available to all state and local government at no cost. I asked Larry Charboneau why he chose to sell his company's data at a relatively low price. Charboneau had worked at the Metropolitan Council and knew the trouble government had in cooperating to get access to a single high quality street map; his company had created that product, but too many of the cities that needed the data couldn't afford it.. By getting his data to local government they became much more cooperative in getting new subdivision and street data to him – data which he also uses in publishing a street atlas of the Twin Cities.

parcels (with 14 attributes for each of 900,000 parcels), land cover, and land use plans.[4] These and other regional datasets are available for download from MetroGIS' DataFinder (http://www.datafinder.org/). Awards to MetroGIS have come from ESRI and National Geographic (premier winner of the 2001 Geography Network Challenge) and from the state Governor for the ease of access to key data.

The Metropolitan Council deserves major credit for starting and supporting MetroGIS. They have invested $3.2 million since 1995 in staff time and payments to support county data infrastructure. The Council's motivation was the need for parcel data to support its efforts to monitor and control sprawl in the region. Aerial photography had provided some information about that sprawl, but lacked critical information about lot subdivision, ownership, and value. Counties owned parcel data and were charging significant amounts to buyers. The Council desired a more cooperative atmosphere. They hired Randy Johnson, a local government planner who had experienced problems getting the data he needed, to help organize the stakeholders of MetroGIS. Johnson says he is driven every day for six years by a passion "to move the Metro community from disparate islands of GIS activity to a geospatial community of institutionalized interdependence and sustained cooperation."

Hundreds of individual stakeholders were similarly driven by a desire to get data from other units of government, especially overlapping and adjacent governments. I attended the initial meeting of MetroGIS in 1995 where this sentiment was clear, but equally clear was the desire to provide better government to taxpayers and the view that better data was an important ingredient to providing that service. Many of the participants in that meeting knew and trusted each other, but collegiality has been expanded to include many other people as county user groups, data workgroups, and other MetroGIS supported activities have brought people together to work on common problems. I surveyed stakeholders in 1999 and more people mentioned improved attitudes about sharing in the region than actual acquisition of data as the major benefit of MetoGIS.

Department of Natural Resources (http://www.dnr.state.mn.us/)

The DNR manages state lands for a variety of purposes (parks, forests, trails, minerals, wildlife refuges, surface water) and impacts many aspects of natural resource on private lands; e.g., hunting and fishing, ground-water extraction, mineral extraction, wild and scenic rivers, building and septic setbacks from lakes and rivers. GIS plays a major role in all of these activities and most of the departmental data is available to the public through Data Deli (http://deli.dnr.state.mn.us/).

Over 50 data layers are available on DataDeli. These range from geology to forest cover. Data are tiled by various schemes including 1:24,000 7½ minute quadrangles, entire counties and statewide files and are downloadable in Arc Export or other formats compatible with ARC/INFO. Users find their area of interest by clicking on a map and identifying a "quad" or other area of interest. Results under 20mb in size are delivered to

[4] Land-use plans are created by local government in the US. Available data for the region include both the composite quilt map of all plans and a normalized map based on standard classes.

desktop immediately. On a typical month nearly 2,500 data downloads occur. In the 7.5 months between February 2001 and the middle of September, roughly 164 gigabytes of data were downloaded by hundreds of users, including: federal agencies, other state agencies, local government, private firms of all types, academic researchers, non-profit organizations, and individual citizens.

I spoke with Les Maki at the DNR about why DNR has wanted to share data with organizations and individuals outside the department. He listed the following reasons:

- DNR needs data from others and feels this sets a positive tone.
- Better data leads to better decisions and DNR data is of good quality.
- Maturity; DNR has been into GIS so long that it is less proprietary.
- Once the data is on the web, DNR staff is freed from filling outside requests.

Two barriers had to be overcome before DataDeli could become reality – one technical and one institutional. The technical barrier was lack of coherence among the core datasets across the divisions of DNR. An internal audit identified these problems, noted an increasing need to share data across the department, and called on department to find solutions, which it did. This effort preceded the concept of sharing data with the public but was a necessary precursor. The institutional barrier was fear that data would be misused and the department held liable. The addition of metadata about the files and a disclaimer recognized in state law overcame these fears and enabled managers to feel comfortable about sharing their data with other stakeholders in the state.

Department of Transportation (http://www.dot.state.mn.us/)

The Minnesota Department of Transportation (MnDOT) is the principal agency to develop, implement, administer, consolidate and coordinate state transportation policies, plans and programs. This means MnDOT is responsible for transportation planning, construction, and maintenance of an enormous infrastructure related to highway, rail, air, and water transportation. The department first adopted GIS in the 1980s to meet its cartographic needs, but the tool has proved useful for planning and visualizing databases and the results of various models. A statewide effort to model the location of archeological sites (MnModel) brought tremendous focus on registering and integrating state-wide datasets. Support for GIS has waxed and waned over the years, depending on top management's appreciation and enthusiasm; efforts are now underway to transform road segments into transportation routes.

The BaseMaps (http://rocky.dot.state.mn.us/basemap/) that MnDOT developed for its own work are available free to others from the department's website. The BaseMaps include data on roads, railroads, and navigable waters. Bundled with this data are various political and administrative boundaries as well as data on lakes, streams, and drainage ditches. County-level road files, collected at 1:24,000, are the centerpiece of this resource, cover some 150,000 miles of streets and highways, and comprise 43 megabytes of compressed data. Full metadata is available for each layer. Data was originally distributed on CD and has recently become available on the web. When on CD, over 500

copies were distributed per year; it is too early to see the impact of the web on distribution rates.

A number of needs and circumstances led to the development of the BaseMap concept.

- Need to distribute departmental data to employees in the field and MnDOT consultants.
- MnDOT began selling its data, but sales were rare and income was negligible.
- A great deal of staff time was required to meet custom data extractions.
- Desire to have local government and other transportation data users working off a common base.
- Development of technology that facilitated packaging of BaseMap data: first CD-ROM, then of high capacity web access.

I spoke to Denny Brott and Tom Glancy about their personal reasons for pushing the BaseMap. They were drawn to the idea of sharing data with others because of their experiences in working with other agencies: e.g., LMIC provided significant technical support; hydrographic data comes from the Department of Natural Resources. They saw value in trading data and participated in an internal committee that ultimately recommended the policy of distributing departmental data in a standard package at no fee.

Dakota County (http://www.co.dakota.mn.us/)

Dakota County is one of the fastest growing counties in Minnesota. It is in the southeastern corner of the Twin City Metropolitan Region with a 2000 population of 356,000, nearly 81,000 more than in 1990. Less than 30 percent of the county is inside the area designated for urban development and this is where most growth is occurring. The remaining land is rolling farmland, much of it quite rich and but other parts more marginal and susceptible to exurban development.

The county has one of the most developed GIS in the state, having started in 1988 and received significant support since. I authored a 1997 article about the benefits to the county of having its GIS. At that point, 86 percent of county departments were using the system on a regular basis. The county attorney reckoned the county had saved "millions of dollars" in land acquisition fees related to road building because he was able to document the value of comparable land sales using maps produced with GIS. Other offices had made less substantial but more substantiated statements about their benefits. My major criticism of the county was focused on lack of equity in not providing data to citizens. It has since put maps and data about parcels on its website for open access – see http://www.co.dakota.mn.us/assessor/real_estate_inquiry.htm . Most recently the county has added control points, elevations, and plats to its website.

The original GIS was developed as a cooperative effort of the county, eleven cities within the county, and a local electric utility. Departments in each had a need for GIS functionality, but none was able convince their elected officials to make the investment alone. The cooperative effort convinced those policy makers, by showing them the

financial savings of working together and the political embarrassment of not cooperating. Within the county, departments have gotten engaged through the extensive outreach and service efforts of the County Survey and Land Information Office.

I asked Gary Stevenson about his motivation in starting and pushing GIS in the county. His sole motivation was his conviction that government could be better if it used GIS. This led to his initial efforts to develop a GIS for his department and subsequent efforts to expand this functionality to other departments and units of government in the county. Data on the web saves his staff time responding to citizens and professionals looking for information; conversely, people looking for information can access it 24 hours/day. Stevenson has been active in MetroGIS,[5] providing the organizational and technical expertise that created the 7-county parcel map. He never encountered a major barrier to his efforts, nor did he find a champion to carry the cause for him. He has been driven by the vision of better government and has been successful in his quest.

Other Local Government

Minnesota local governments have adopted GIS as rapidly as any place in the nation. This is relatively amazing where the median size county has only 22,000 people and the median city has well under 700 people. Some of the adoption is because of the early start in the state, something that exposed locals to the benefits of the technology through their various professional activities. Since 1990, the grassroots Minnesota GIS/LIS Consortium has conducted an annual conference, now attracting nearly 600 people and providing 30 educational workshops in addition to a 2-day meeting with national speakers and concurrent paper sessions. In the early 1980s, only one jurisdiction, with a population of nearly 400,000 had GIS; now cites as small as 10,000 people are using the tool.

In 1999, a national survey was conducted to measure local effort in collecting data that would contribute to the NSDI. With 294 responses and a 72 percent response rate, Minnesota's response was one of the strongest in the nation (see http://www.fgdc.gov/framework/survey_results/readme.html). One reason for the high response rate in Minnesota was the involvement of Sally Wakefield in collecting data. As LMIC's support staff for the state coordinating council, people know and respect her – few would do anything to disappoint her. Nearly 70 of those responding are active users of geographic data, with three-quarters of the counties with populations over 10,000 being active. The vast majority of the Minnesota local GIS community is willing to share their data with other government bodies for no charge, but has yet to put significant effort into metadata.[6]

I have only anecdotes and conjecture to use in describing the ability and willingness of local governments to share their data. The enthusiastic response of local government to

[5] While he supports the concept of MetroGIS, he is less enthusiastic about the many meetings and large organizational structure of the organization.

[6] This conclusion is based on earlier local surveys and matches with analysis of county data at the national scale (Tulloch and Fuld forthcoming)

the Framework survey was partly due to individual pride in local accomplishment. It is not clear how willing these local governments will be to share their data. Longitudinal surveys of counties in an adjoining state show a natural transition from local use to wider sharing (WLIB 2001). Certainly the data would be shared with trusted nearby jurisdictions. At least where data, like tax data, is collected in accordance with state law, the data would be comparable from one jurisdiction to the next. Practically none of this data is accompanied by Metadata and none is identified or available through a clearinghouse. State or regional centers will need to assume that responsibility if local government data is to be part of our broadly defined spatial data infrastructure.

Significant effort is required if GIS functionality is to become available in smaller jurisdictions across the state. The need is especially strong for counties across the state to have digital cadastral maps. Less than one-quarter of the 87 counties now have such maps. Some would point to the neighboring state of Wisconsin where a supplemental fee on all recorded land documents is returned to counties to help them modernize their land records (http://www.doa.state.wi.us/olis/wlip/). Other cadastre solutions seen in other states include: federal support, state assuming responsibility, regional service centers, and regional cooperatives.

Summary

Minnesota is a leader in generating a spatial data infrastructure. In studying particular cases within the state, we can learn much about what works, what conditions are critical to achieving success, and what barriers need to be overcome. Success appears to hang on two factors: institutional mission and individual motivation.

Institutions fall into three major categories: data coordinators, data generators, and non-participants. I have focused on the first two categories because they provide the available spatial data infrastructure. Data coordinators are important because work on standards and the data delivery mechanisms; they also help set priorities for data to be collected and disseminated. Data generators provide the substance of what is available to distribute and it is good for society if they believe in standardizing, documenting, and sharing their data. Non-participants are a problem because they are responsible for missing segments in the information highway. To the extent that those segments are critical, external resources and pressure will need to be applied to gain participation.

Individual motivation proved to be critical, especially within data producing institutions. Data coordinating institutions have mandates to collect and distribute spatial data infrastructure. In data producing institutions, the initiative comes from inspired people who press for wider distribution of the institution's data. In every one of my cases, those individuals were middle managers who worked to convince upper management to their point of view: a bottom-up initiative. Those middle managers were driven by idealism, by enlightened self-interest, and by involvement in a professional culture that expects participation and cooperation. The first two factors are personal and job related, while the last is a factor that can be affected by the professional community – local, national, and global.

CONCLUSIONS

Minnesota has been successful in developing a spatial data infrastructure for itself. In doing so, it has made a contribution to the International Spatial Data Infrastructure by providing data about its portion of the globe. Clearly, a strong foundation was built by three statewide bodies: the Legislative Commission on Minnesota Resources, the Governor's Council on Geographic Information, and the Minnesota GIS.LIS Consortium. By looking at case studies of data providers, we see that critical factors are institutional mission and individual motivation; the right mix of each is required. I have also shown that success breeds success, that an open sharing environment leads to a community norm of trust and sharing.

There are still major gaps in Minnesota's spatial data infrastructure. Surveys of the GIS community in 1994 and 2000 show a strong and continuing need for digital soil and cadastral data. The federal Natural Resource Conservation Service is accelerating digital soil mapping, but is still more than a decade from completion. The cadastre is a county responsibility and most counties lack the resources for the job of creating and maintaining a digital map. Unlike soil mapping, the federal government has yet to take on the cadastral map as a national program; the Bureau of Land Management has a program idea, but will need Congressional support to more forward. The state has several options and it is not clear which will win out:

- ignore the problem and hope for the best
- encourage regional cooperatives
- provide technical and/organizational resources like the state of Wisconsin
- assume responsibility for cadastral mapping like the state of Montana

The events of September 11, 2001 cast a shadow on the future of Spatial Data Infrastructure. Just as the hijacked planes destroyed the supporting infrastructure of the World Trade buildings in New York, so they severely damaged the trust required to sustain widespread dissemination of data. Discussions are underway in Minnesota about security issues related to open access. They are no-doubt underway elsewhere as well. I cannot predict where those discussions will take us.

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