THE MINNESOTA LAND MANAGEMENT INFORMATION SYSTEM TEN YEARS LATER

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This is the text of Craig's keynote address at the thirteenth annual conference of the Australasian Urban and Regional Information Systems Association in Adelaide, Australia, November 27-29, 1985. The text is reproduced here from a publication of the proceedings: URPIS 13: Land Information Systems, Planning and People (Adelaide: Australian Urban and Regional Information Systems Association, 1985), pp. 281-290.

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A publication of the Center for Urban and Regional Affairs, 330 Hubert H. Humphrey Center, 301 19th Avenue S., Minneapolis, Minnesota, 55455.

1986

Publication No. CURA 86-3

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ABSTRACT

The Minnesota Land Management Information System (MLMIS) is one of the world's premier systems for supporting natural resource planning and decision making. The system is used in 150 projects per year, supporting efforts at all levels of government: federal, state, and local. Changes in elements of the system have followed available technology, but have been directed by the needs of user applications. An original data base was established and has remained useful, but has been augmented by the operational files of many agencies, which have been mandated compatible with MLMIS. A second generation of map data is being entered at-scale using the vector/polygon approach. Following a world trend toward "market orientation," development money for the system has been eliminated, so future enhancements must come through user fees which now account for two-thirds of the budget. Future developments, especially in cheaper data entry and interactive analysis, should make the system even more useful. The ultimate key to success is whether the user community is willing and able to make full use of this power.

INTRODUCTION

Though Minnesota is an average-sized U.S. state, whether measured by land area or by population, it has excelled in a number of areas including the education and welfare of its citizens, new and existing innovative businesses (including 3M, Honeywell, and Control Data), an open political system, and excruciatingly long and cold winters. One area of excellence is its computer-based system for supporting natural resource planning and decision making, the Minnesota Land Management Information System (MLMIS). What is unique about the system is not its wonderful technical capabilities, but the depth and breadth of the use of the system by all levels of government.

The system has gone through a tremendous evolution over the past decade, when it first attained operational capabilities. The purpose of this paper is to detail that evolution. The paper begins with a detailed look at the system in 1985 including the hardware, software, data bases, and applications. A second section looks at the origins and changes in these elements over time, and explains the forces operating to make these changes. A final section looks to the future, where MLMIS hopes to be in the next five years, and what is hoped for in the uses of the system.

MLMIS IN 1985

During the past year MLMIS was used in about 150 different projects, employed a professional staff of twenty-five, and had an operating budget of $1.2 million (U.S.) A representative sample of projects is shown in Table 1. The resources available to support these projects are listed in Table 2 (hardware), Table 3 (software), Table 4 (in-house graphic data bases), and Table 5 (compatible geographic data bases). Graphic data bases are of two types: original data is in 40 acre (16 ha) grid form, more recent data is largely vector/polygon collected at map scale.

TABLE 1

SAMPLE PROJECTS, 1984-85

Mapping & Descriptive Studies

- Land use inventory of the seven county metropolitan area.
- Aeromagnetic mapping to assist mineral exploration.
- Initial entry of detailed soil maps.
- Summarize water usage by watershed.
- Public lands inventory.
- Summarize and print voting patterns for publication.
- Demographic profile of legislative districts.
- Profile of low income pop-ulations by county.
- 7000 information requests.

Modeling & Analytical Projects

- Preliminary screening for new solid and hazardous waste sites.
- Vulnerability of state lakes to acid rain.
- Suitability of state-owned lands for various uses.
- Assessment of impact of peatland development.
- Potential soil and wind erosion.
- Projections of labor force supply.
- Assess forest management work loads.

Operational Information Systems Development

- System to track generation, transport, recovery, and disposal of solid and hazardous waste.
- Statewide archeological resources.
- Wastewater treatment financing information.
- Track official environmental reviews.
- Revenue data for Minnesota cities.
- Tourism information request support system.

TABLE 2

CURRENT HARDWARE CONFIGURATION

Central Computer: Prime 850 super mini-computer with 8MB (8000 KB) of memory.

Data storage/access:
- 4 x 300 MB disk drives
- 2 x tape drives (1500 tapes in library)

Output devices:
- Versatec 8122 A electrostatic plotter
- Houston pen plotter
- Zeta pen plotter
- Trilog line matrix printer, (color)
- NEC letter quality printer with daisywheel
- Matrix/PCR film recorder
- 35mm camera

Data entry devices:
- Two digitizing stations with interactive graphic display
- NVG scanner (2000 x 1500 pixel resolution)

Work stations:
- DeAnza IP5524 image array processor (with 512 x 512 color display)
- Fifty-five user ports available--twenty-eight onsite, twenty-seven for remote use (onsite terminals include six graphic stations)

TABLE 3

CURRENT MAJOR SOFTWARE SYSTEMS
(with notes on special features)

EPPL (Environmental Planning and Programing Language):
- Gridoriented system
- Heavily used for data analysis and output
- Homegrown, in public domain

ARC/INFO:
- Vector/polygon system (ARC) and relational DBMS (INFO)
- Heavily used for data entry and display
- Purchased from ESRI (Redlands, California), proprietary

MINITAB:
- General purpose statistical package
- Proprietary

TABLE 4

IN-HOUSE GRAPHIC DATA BASES

- Local government boundaries
- Public ownership (including recommended use and disposition
- Zoning (not complete state-wide)
- Land use (1969)
- Geomorphic region
- General soil type (including a dozen interpretations e.g. cropland productivity)
- Tree cover type
- Adjacency to water (by type)
- Adjacency to road network (by type)
- Census boundaries*
- Watershed (major & minor)*
- Elevation*
- River network*
- Lake boundaries*
- More detailed data for many study sites*
- Various Landsat scenes*
- Postal area boundary file*
- School district boundaries*

*Added since 1977

TABLE 5

COMPATIBLE GEOGRAPHIC DATA FILES
(representative)

- Historic and archeologic sites (Minnesota Historical Society)*
- Unique natural areas (Minnesota Heritage Program)
- State Ownership (Department of Natural Resources--DNR)
- State land leases (DNR)*
- State mineral leases (DNR)*
- Water use and appropriations permits (DNR)*
- Well logs (DNR and Minnesota Geological Survey--MGS)
- Geographic place names (U.S. Geological Survey)
- Lakeshore study (DNR)*
- State forest land inventory (DNR)
- Voting records (Secretary of State)*
- Census of Population and Housing (U.S. Department of Commerce)
- Outdoor recreation facilities, public and private (DNR)*
- Lakes data base--with nine related files of physical and development characteristics (DNR)*
- Groundwater contamination site files (Pollution Control Agency--PCA)*
- Hazardous waste tracking system file (PCA)*
- Water use and appropriations permits (DNR)*
- Aeromagnetic, anomolies (MGS)

*Primary support on LMIC computer

TABLE 6

EVOLUTION OF THE SYSTEM

	c. 1975	1985
Location	University of MN	State Planning Agency
Primary focus	research & development	Service Bureau
Annual budget (U.S.$)	$300,000	$1,200,000
Funding sources	100% state-supported	35% state-supported, 65% Service Bureau income
Computer	CDC6600 mainframe	Prime 850 SuperMini
Machine interaction	batch via card	batch via CRT
Data entry	card/CRT	digitizer, scanner, file merge
Output	electrostatic plotter, line printer	matrix printers, vector plotters, film recorders
Software generation	home-grown	same plus purchased
GIS functions	many	some increase
Data base	core/internal	access to many compatible files
Data structure	grid-based, raster code	increasing vector/ polygon; grid-based, now run-length encoded
Data sources	air photo interpreta- tion plus whatever available	many depts. through mandated compatibility
Scale	40 acre/400m grid	large scale maps original source scale
Data base size	100 tapes	1,500 tapes
Topical focus	natural resources	same plus many mapping, planning, & administration functions
Number of applica- tions/users	4	150
System users	internal	60% state government, 25% federal government, 15% local government,
Application complexity	single issue	same plus some compehen- sive plans
Professional staff size	3.5 people	25 people
Staff background	University grad/ generalist	same
Staff assignments	long term	weekly

EVOLUTION OF THE SYSTEM, 1975-1985

In 1975, MLMIS was a research project at the University of Minnesota with this author as project director. The professional staff numbered roughly 3.5 people, the budget was about $300,000 (U.S.), and the few applications of the system were performed entirely by project staff and students. The changes that took place in the decade that was to follow are outlined in the three sections that follow (hardware/ software, data base, and user environment). Table 6 provides an overview of these changes highlighting two dozen specific areas.

An important note should be added to this description of the evolution; it has been directed entirely by the application needs of end users. New equipment and software, new data, and new modes of user access have been added or created to meet the needs of specific projects or the general needs of the user community. To be sure, the staff of MLMIS had final say and did not add everything that was asked for, but the direction of all enhancements and the justification for any single enhancement came from user applications. The enhancements and changes have been incremental; always one more was required to complete this or that project. Over time, they have changed MLMIS into what it is today.

The System--Hardware and Software

The original MLMIS was built using available technology, and that continues to be true today. The system was built around the most accessible and high power computers of the day and that continues to be the case. In 1975, no proven geographic information system (GIS) software was available, so all software was written by the staff or on contract. By the early 1980s efficient software was available and was acquired to complement the home-grown programs.

Available hardware of 1975 was mainframe computers with batch processing, card entry, and line printer output. The University had just acquired a dot matrix electrostatic plotter, and a hopeful MLMIS was one of the first users as the square grid cells of its data base did not map well on the line printer. Data entry was performed by teams of undergraduate students handcoding maps under acetate overlays.

Hardware of the 1980s has greatly simplified the operation of MLMIS (see Table 2). The cost of computers has decreased enough to justify purchasing a dedicated mini-computer. Having a dedicated computer means that intensive data processing projects can be undertaken, where they would have been prohibitively expensive when paying for time on a remote computer. The next breakthrough, the use of microcomputers for GIS processing, is under investigation and promises significant increases in the number, distribution, and empowerment of end users.

The other major change in hardware has been the recent introduction of scanners for data entry. Instruments costing as little as $20,000 (U.S.) can scan a soil map with several thousand polygons in as little as thirty minutes. Using software and editing techniques developed by the MLMIS staff, one to two such sheets with labeled polygons can be entered into the data base per day involving the time of but two persons. Just around the corner is character recognition and automatic labeling of polygons. Experimental work looks promising for scanning original maps rather than having first to scribe polygon boundaries. All of this works to greatly reduce the largest single cost of GIS operations, data capture.

The major software change over the past ten years has been the acquisition of proprietary software to handle polygonal data (see Table 3). The original software was developed to handle a gridoriented data base. It has been upgraded over the years in both power and useability and remains the most used of all available software. The polygonal software is most useful for data entry, especially when tied to the scanner and display of map products. Data can be captured at the original map scale and grid-to-polygon conversion made as needed and to the required grid size. Analysis can be done in either grid or vector mode, but more often grid is used. If a subsequent study requires the same data at a different scale, the original map need not be digitized a second time. Other software has been created or purchased to support wider information needs and is addressed in the next section.

Data Base

The core data base of MLMIS has grown very little over the past decade. Major advances have been made by ensuring that existing and new data bases are compatible with MLMIS. This shift has come through a growing awareness of the power of MLMIS by both operational agencies and by the principal funding body, the state legislature. This growth in compatible data bases is critical. The kind of questions which can be answered, and the depth with which they can be answered, is tied to the number and types of data available to address the issue. It has been argued that a synergy operates and richness of the data base is exponentially related to the number of items in the overall data base.

The core MLMIS data base is presented in Table 4. Of the statewide data, only one-half is new in the past decade. This somewhat shocking figure is an indication of how well the initial base was chosen. Innumerable site studies have been completed using this data or used it with one or more additional variables. Some of that data has been updated. In 1977, the tree cover item was updated using new aerial photography; this was a joint project with the federal Forest Experiment Station. Still wanting is an update of the 1969 land use data item. More recent aerial photos have been of lower quality and interpretation costs have grown so that attempts to update this item with traditional techniques have been both unreliable and exorbitantly expensive. Landsat data has been less expensive, but more unreliable. Negotiations (at the time of this writing) have been taking place with the federal Soil Conservation Service and the Forestry Division of the State Department of Natural Resources (DNR) to develop cooperative land use mapping programs. The DNR would augment its developing geographic information system to include land use on non-state lands.

The answer to this critical data shortfall may be in the creative use of the growing number of operational data files which are compatible with MLMIS. The key to this compatibility is a geographic code (geocode) on each record. That geocode may be a geodetic co-ordinate or may be tied to the original Public Land Survey which divided the United States into townships composed of thirty-six one-mile square sections. Table 5 shows data files currently compatible with MLMIS. Unfortunately, the most useful data source, the records of the land valuator, is decentralized and resides in eighty-seven separate county courthouses. A state-funded pilot project has developed a computer-assisted valuation system, running on a microcomputer. It now runs on the computer system used by seven counties in one computer consortium and is being transferred to the other major consortium, used by another fifty-one counties. Another six large counties run their own systems, but most are also compatible; this could potentially cover 74 percent of Minnesota's counties.

Another dimension has been added to the available data base. MLMIS has become the core of a new Planning Information Center within the State Planning Agency. This center is responsible for retaining and disseminating a wide variety of information useful to researchers and planners across the state. This information includes all Census data, so that demographic and socioeconomic data can be computer mapped quickly and cheaply. At the same time, this information is available in a spatial mode to be used in combination with environmental data for modeling and planning.

User Environment

The number of projects undertaken in a given year has grown from a handful to more than 150. But the number of projects is not the only change witnessed in uses of the system: changes have also come in the source of project initiation, costs paid by the user, and technical ease of use. Surprisingly, many areas of use have seen little or no change: the basic mode of batch-access has yet to be replaced, the percentage of users who are self sufficient has remained unchanged, and the mix of users is unchanged.

In the beginning, every project undertaken by MLMIS was done so at its own staff initiative. Successful projects on important issues needed to be completed and the results circulated in order to prove the value of the system. In an intermediate stage, enthusiastic young turks from staid, mainline departments, saw they could make use of this innovative technology; they became the most important users of the system. Eventually, the departments and the state legislature came to see the general usefulness of the system and mandated its use on all new initiatives and many older projects. Many of the users of MLMIS now have been told they must use the system.

At the same time, the costs of using the system have been increased dramatically. In the perilous first days, projects were totally subsidized as the project searched for interested users. In the middle period, basic support funds were used to subsidize the many projects, again with a view to building a broad base of support and history of success. At the current time, users are asked to pay full costs plus an approximate 15 percent overhead fee which is retained and used for future upgrades of machinery, software and data.

Two points should be made about this switch in subsidy. First, like most government operations, the ability to rollover or retain funds was a special privilege granted by the legislative body. Second, the reasons for increasing charges were not as perverse as they might seem--tied to mandated studies. Like all governments in the 1980s, Minnesota has been less generous with its base funding and told its many departments and centers that they "must prove their worth in the marketplace." Acquisition monies were eliminated and charging overhead was the only alternative. Money that had been used to subsidize projects has been switched to enhance the system, primarily updating and expanding the data base and upgrading software.

Technically, the system is much easier to access and use than it was ten years ago. In 1975, workers on a crash production schedule would drive to the computer center and stay up all night submitting decks of cards and getting one turnaround per hour. In 1985, many users can interact with the system from over twenty terminals in the MLMIS offices or dial up from anywhere into twenty ports available to remote users. The software has become more user friendly switching from binary codes representing, for example, the direction of search, to the English language. The system has switched from being a collection of discrete programs to an integrated package which supports the user throughout a project.

Although the system is easier to use in most respects, it has yet to become as interactive as might be desired. The user sitting at a terminal does get immediate feedback on the syntax of his control statements, but eventually submits a batch job to produce the final maps for a project; if they are wrong, the answer may not be known for several hours and the work must start again. Some terminals allow the user to preview a portion of the map on a screen before submitting for final map output. The DeAnza image processor allows a user to transform and overlay a map interactively, but more complex geoprocessing must be done elsewhere. Thus, the dream of moving a terminal into a committee room to become part of a working session has yet to be realized, awaiting cheaper, more powerful hardware and a new generation of software.

Perhaps for this reason, the percentage of users who have gained self-sufficiency has remained stagnant at about 25 percent. This figure is not different from the earliest years when 100 percent self-sufficiency was forecast. Three-quarters of all projects still make major use of MLMIS personnel to formalize the approach to the users problem and then make all computer runs necessary to produce final maps and tables. The two basic reasons for this stagnation are the need for a systematic approach to the use of a GIS (or any computer system), and the technical difficulty of using the system. Concerning the systematic approach, little needs to be said to this audience. The task of transforming and overlaying specified levels of a dozen odd data elements in a way that eventually addresses a real world problem, is not something which comes easily to anyone, and training for such tasks is rare. Regarding the technical difficulty of using the system, the problem is not in the system (which is systematic and friendly), but the lack of regularity of use by most people. Those users who are required to use the system every day have no difficulty. Those who use it once a year or so would rather pay to have the work done by "experts."

Surprisingly, the mix of users of the MLMIS system has remained relatively constant over the years. The mix is roughly 25 percent federal, 60 percent state, and 10 percent local government. Within the state segment, under 10 percent is within the Planning Agency itself. One-quarter of the state work is for the Department of Natural Resources (which includes state parks and forests) and one-eighth for the Pollution Control Agency. The issues have changed over time, but not the agencies or levels of government responsible for dealing with the issues of natural resource management.

THE FUTURE

As with everything in life, the future of MLMIS must be built upon its past. The core of the system will continue to be natural resource and mapping capabilities. Agencies with applications in these areas will continue to build and utilize compatible data bases, because of both expediency and requirements by the legislature. Some larger users will create their own compatible geographic information systems; adding to the richness of data bases and analyses. Improvements in scanning technology will greatly reduce the costs of entering map data. Partly because of these lowered costs, and partly because of need, a second generation of core data will be added. Chief among these new items will be detailed soil maps and an up-to-date land use map. A critical issue will become data storage and retrieval of mammoth files resulting from digitizing thousands of dense polygon maps. Cheaper and more powerful hardware may make truly interactive analysis a possibility with microcomputer-based systems available in committee rooms around the state. More urban geographic information systems techniques and data will be incorporated into MLMIS in the future. Software is even now being tested for additional applications of "network analysis" useful for emergency vehicle and bus service routing. An unknown part of the future is whether users can be enticed to fully utilize these increased capabilities and expand the level of their work beyond single-issue studies and work towards total areal plans or multi-faceted approaches to complex issues. Herein, ultimately, lies the key criterion for evaluating the success of MLMIS.

BIBLIOGRAPHY

Jimmy E. Hicks and Tom Hauger, Managing Natural Resource Data: Minnesota Land Management Information System, Council of State Governments, Lexington, KY, 1977.

LMIC, Introduction to the Land Management Information Center, Land Management Information Center, State Planning Agency, St. Paul, MN, 1984.

LMIC, Minn. In The Eighties... Its People and Its Land, Land Management Information Center, State Planning Agency, St. Paul, MN, 1983.

LMIC, Overview, Land Management Information Center, State Planning Agency, St. Paul, MN, 1982.

PIC, "Activity Review: 1984-85," Planning Information Center, State Planning Agency, St. Paul, MN, 1985.

Alan Robinette, "Evolution of the Minnesota System," paper presented at the 1982 URISA Conference.

Alan Robinette, "Institutional Innovations: Moving from Academia to Serving Government Needs," Seminar on the Multipurpose Cadastre: Modernizing Land Information Systems in North America, Bernard J. Niemann, Jr., ed., Wisconsin Land Information Reports, No. 1, University of Wisconsin, Madison, December, 1984, pp. 155-166.

Alan Robinette, "Managing Natural Resource Data: Minnesota Land Management Information System," presented at an International Symposium on Landscape Information Systems in Bonn, 1982 (published, in German, in Natur und Landschaft, 57, December 1982, pp. 454-57).

Alan Robinette and Earl Nordstrand, "A Resource Information System Developed by User Applications," URISA Proceedings, 1978, pp. 255-267.