chines are more efficient in memory allocation and would have worked very well for this city with 256K (or perhaps even less); but because the actual uses were only vaguely defined at the time of acquiring the microcomputer, the configuration for initial installation was determined more by price than user definition. Mr. Nimz documents later in the paper that the original printer order was deleted and replaced with a hard disk "with no deviation from the contract price." It would be helpful to know the time sequence of events that produced this change of hardware. Some agencies and suppliers might not have the flexibility to make such a drastic change without an increase in contract price. If an additional cost were incurred, some agencies might not be able to absorb it within a budget year.

Mr. Nimz states in his paper that "the long-term goal of the program is to reduce the number of accidents caused by faulty or substandard highway features and traffic control devices as well as reduce the possibility of liability law suits." This is a typical type of general goal that requires upper level review to make a "leap of faith" in accepting the premise that computerization of some process will be a step toward this goal. Was any measurable objective set that could be used to evaluate the effectiveness of the computerized inventory such as "reduce the ratio of citizen notices to county forces notices of defective traffic control devices by 20 percent"? Was there an attempt to set any operational improvement measures that could be evaluated in the short-term (1 or 2 years) that might justify computerization even if no reduction in accidents or law suits was noticed?

I especially appreciated Mr. Nimz including information on the resources required to develop the initial data base. He indicated that he hired two summer employees and assigned two permanent persons on an occasional basis to inventory 270 miles of county roads with 290 bridges, 1,100 culverts and 2,300 signs. His records indicated that 1,000 manhours and 5,572 road miles of travel were required to complete the data collection and processing. It is necessary to share that type of information for other agencies to make an intelligent management decision about whether they should or should not computerize with microcomputers. This paper is informative and contains a prime example of the inventiveness of local highway agency managers to try out technological advances to improve their operation.

Publication of this paper sponsored by Task Force for the 1984 Maintenance Management Workshop.

Playing Games with the Maintenance Program on A Microcomputer

DENNIS FILE

ABSTRACT

The Illinois Department of Transportation's maintenance management information system (MMIS) is being extensively enhanced and modernized. The new system will be composed of three synergistic subsystems--performance budgeting, maintenance management, and equipment management. Micro- and minicomputers dedicated to the MMIS will play a prominent role in the new system. The project to rebuild the system began in 1980 and the new MMIS is scheduled for installation over a 3-year period, which began in March 1984. Therefore, several of the features described are planned and designed but not implemented at this time. The report examples shown are mock-ups.

In the past decade there have been major changes in the maintenance of state highways in Illinois. Reduced revenues and escalating labor, material, and equipment costs have required that the transportation department take a number of unprecedented steps. Field crews have been pared down to meet reductions in staff allocations; and equipment life has been extended, where possible, by postponing replacements. Levels of service have been reduced to address only the most urgent needs while the backlog of unmet needs continues to accumulate.

Faced with the challenge to do more with less, the transportation department is also in the process of upgrading its system of management controls in the area of highway maintenance. In January 1980, the Illinois Department of Transportation requested proposals for developing the "requirements definition" and "logical design" for a system to better plan and control maintenance efforts and resources.

The selected consultant, Byrd, Tallamy, MacDonald, and Lewis, completed the study in early 1981. The new system is entitled the maintenance management information system (MMIS) and is comprised of three, interrelated, synergistic subsystems:

- Performance budgeting subsystem,
- Maintenance management subsystem, and
- Equipment management subsystem.

The following describes the primary objectives and features of each of the subsystems.

Performance budgeting subsystem (PBS). The PBS will enable a manager to show maintenance needs in three different forms on the maintenance budget (in both its request and final forms). These three budget formats are (a) conventional budget line items (e.g., commodities, contractual services, and personal services); (b) resources (e.g., labor hours and equipment hours); and (c) work activity quantities (e.g., square yards of partial depth patching). The translation from work activity quantities to resources and budget-line-item dollars will be accomplished by models and standards based on cost and production history and management judgment. Microcomputer spreadsheets will enable maintenance engineers to create and model the maintenance program and budget.

This subsystem will also produce an annual work plan by assigning the work activity quantities delineated in the budget to work locations and time periods within the fiscal year. Priorities, resource availability, and seasonality must be considered in this process. Microcomputer spreadsheets will also assist field engineers in performing this function.

Maintenance management subsystem (MMS). The MMS will use microcomputers to collect and edit cost and production data to

1. Measure adherence to the work plan and to highlight situations needing management attention.
2. Measure labor efficiency and to highlight situations needing management attention.
3. Monitor indirect costs, that is, those costs associated with supporting (not performing) the direct, on-road activities.
4. Accumulate historical data as a basis for developing relationships between work activity quantities, required resources, and budget-line-item disbursements. These relationships will be used to establish and refine models and standards for budgeting and work planning.

Equipment management subsystem (EMS). The EMS will establish and maintain an inventory of maintenance equipment, and collect and present information on operating costs, repair costs, and use of individual units of maintenance equipment. This information will enable the department to

1. Improve the preventive maintenance program.
2. Make better decisions regarding selection and replacement of maintenance equipment.
3. Highlight high-cost equipment that has a low utilization rate.
4. Develop more exact equipment use rates.

CONCEPTS

The new MMIS emphasizes the planning and control functions of management. It provides a useful tool for achieving greater effectiveness and efficiency in performing the important and public-sensitive function of maintenance. The system recognizes that maintenance management is a cyclical process that corresponds to the classical cycle of management--plan, execute, control, and evaluate; replan, execute and so on as illustrated in Figure 1.

Planning

Planning includes developing and expressing the budget request, not only in the conventional terms of budget-line-time dollar amounts, but also in terms of the quantities of production enabled by those budget-line-item dollars. This function will be performed using a chart format referred to as a spreadsheet.

FIGURE 1 Cycle of management.

The budget request will be based on the following:

1. Needs, which are stated in terms of work quantities;
2. Models, which are the factors that permit work quantities to be translated into budget-line-item dollars; and
3. Head count constraints, which limit the budget request. Given the magnitude of the needs, an unreasonably large budget request would result if no constraints were observed. It therefore becomes necessary to consider the head count likely to be allowed so that a practical budget request will be developed.

After proceeding through the various budget reviews, an approved budget will result. Changes made to line-item dollar amounts during these reviews will be made correspondingly to the work quantities.

In the last phase of planning, the annual quantities will be assigned to time periods within the year. Certain constraints will be considered in developing the work plan. These include the seasons, the availability of resources (manpower and equipment), and policies (e.g., mowing policy).

Execution

Following the priorities indicated by the work plan, the various work activities will be performed. The number of units completed and the resources used will be reported along with the costs of operating and repairing the equipment.

Microcomputer terminals will be installed in the field team sections to facilitate the prompt collection of field reported data. This will permit a more timely assessment of staff efficiency and plan adherence.

Control and Evaluation

Using committee-established statewide labor standards (e.g., 4.3 labor hours per square yard of partial depth patching), the efficiency of a measurable activity will be computed as follows:

Efficiency = (labor standard x units completed) - actual hours worked.

Efficiency reports will be produced for the various levels of the organization so an unusually high or low efficiency can be highlighted. Plan adherence reports will monitor adherence to the work plan and will highlight unusual variances for management attention.

The cost of operating and repairing each piece of maintenance equipment will also be reported from the field. These reports will keep track of operating costs such as gas, oil, and antifreeze, and repair costs, which include repair parts and labor. Odometer and hour meter readings will also be reported. These data will enable a manager to identify equipment most in need of replacement and give notice when equipment is due for preventive maintenance.

The actual cost of resources used will be determined by using cost accounting techniques to relate resource costs to budget expenditures. These techniques will also address the measurement of indirect costs (i.e., the costs of supporting rather than performing production activities). This feature will enable maintenance managers to determine what was done and how much was spent at a given location during a certain time period. Over a period of time these files will accumulate into a history. The history combined with management judgment will provide averages and models to be used for the next planning cycle.

THE MAINTENANCE ORGANIZATION IN ILLINOIS

Maintenance responsibility within the Illinois DOT is shared by the central bureau, districts, and team sections. The state is divided into nine districts that encompass 6 to 15 counties each (see Figure 2). Each district, in turn, is divided into 7 to 23 team sections. Field engineers assisted by engineering technicians supervise the activities and manage from one to six team sections.

The team sections are the field operating units. Each team section manager has an assigned equipment fleet and head count. MMIS and its hardware have been designed to correspond to the maintenance organization.

HARDWARE

A request for proposal for hardware was distributed in late spring 1983. A total of five responses were received. Three of the vendors were disqualified; two immediately, because they could not meet mandatory requirements, and the third for failing to demonstrate the company's product.

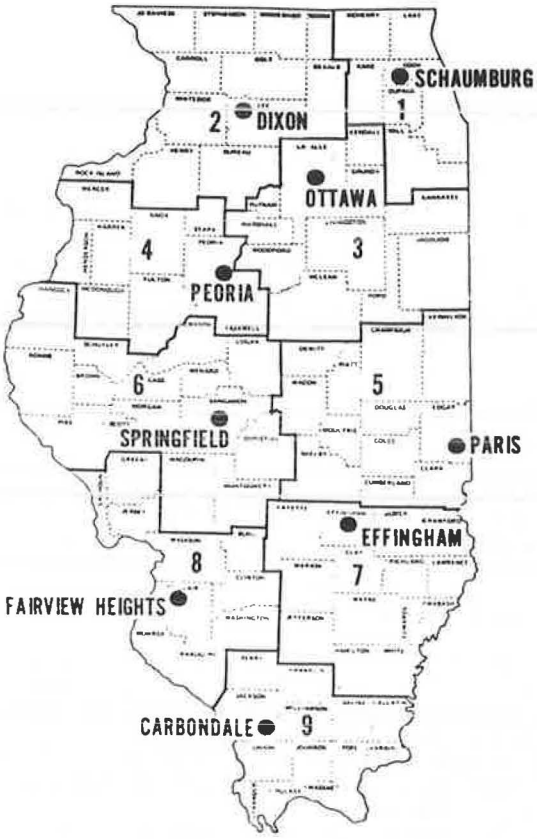

FIGURE 2 Illinois Department of Transportation highway districts.

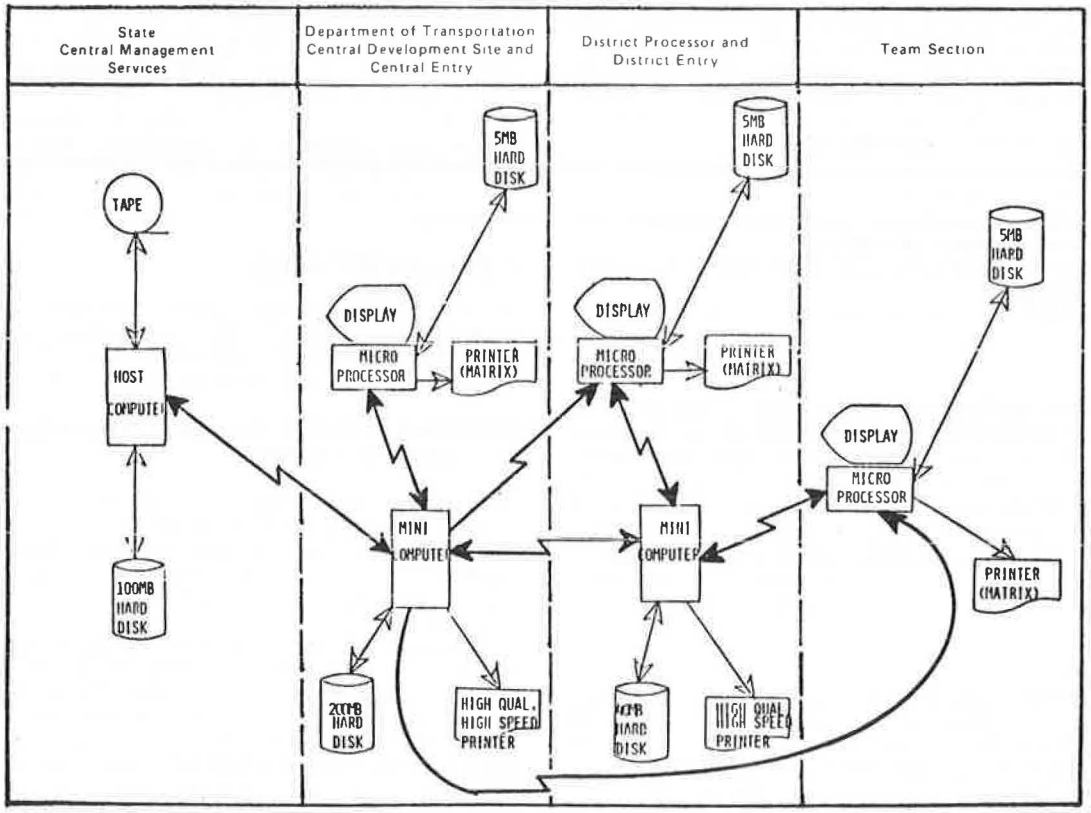

FIGURE 3 MMIS network.

The final selection was made between DEC and IBM. IBM bid Series 1 with PC/XTs. DEC bid VAX 11/730 minicomputers for the nine districts with a VAX 11/750 at the central bureau in Springfield and PRO350 microcomputers for the team section locations. DEC was selected. The first equipment was delivered in October 1983. It consisted of the VAX 11/750 and ten PRO350 microcomputers that are now being used to develop the MMIS.

The first application of the microcomputers will be a pilot program to develop the performance budgeting subsystem in three districts. This will entail delivery of three more microcomputers plus another minicomputer (this one in a district office). The next scheduled application will include testing the field reporting techniques on a controlled basis in the same three districts. This will include the installation of another minicomputer along with up to 10 more microcomputers.

A system phase-in period will follow over the next 6-month period as the final hardware installation is completed in the three test districts. Following that, installation will begin for the other six districts on an individual baisis. The final statewide configuration will total 10 mini- and 53 microcomputers.

The entire sytem will operate as a network with two-way information flow between the team sections and the district offices and then between the districts and the central bureau at Springfield. The team sections will be able to combine batch-type reports provided by the printer with the data entry capabilities of their microcomputer. The system network is illustrated in Figure 3.

The task of training and installation will be complex and will require considerable coordination. It will involve a team effort of central bureau and district personnel. At least two persons per district will serve on the training task force along with central bureau representatives. However, final plans for training have not been formulated.

MMIS SPREADSHEET APPLICATIONS

Two of the MMIS requirements in the planning cycle will be accomplished by using the spreadsheet capabilities of the microcomputers. These are the online ability to

- Develop the annual program budget by inserting various work activity quantities and review the

(a)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUB SEC	DESCRIPTION	LANE MI.	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
000	NOT ASSIGNED		_____	_____	0	0	0	2	0	4	0	3	0	7
100	1 MI SW OF SCHULYR ADAM COUNTY LINE	10.1	_____	_____	25	10	18	9	25	6	20	9	15	7
101	CONGRESS ST.RUSHVILLE CAP. AVE. MT.STERLING	5.3	_____	_____	15	9	21	10	30	10	5	5	5	0
330	ROUTE 61, AUGUSTA COUNTY LINE	22.4	_____	_____	40	20	25	22	35	15	25	10	25	6
600	US 24 ROUTE 104 PIKE CNTY	4.2	_____	_____	40	11	13	13	20	11	10	24	20	7
601	IL 101 US 24 MT.STERLING	8.9	_____	_____	20	9	20	10	22	9	30	10	34	22
660	FREDRICK FLTN/SCHULYR CO LINE	15.6	_____	_____	20	15	20	17	15	12	10	16	8	22
990	UNMARKED RT AT RIPLEY	2.0	_____	_____	0	0	0	0	0	0	0	0	0	0
992	UNMARKED RT AT RSHVLE	4.6	_____	_____	20	16	20	14	14	0	12	0	8	0
994	US 24 - RUSHVILLE	22.6	_____	_____	20	17	20	20	30	12	30	12	20	12
995	RUSHVILLE	12.6	_____	_____	30	13	24	6	30	8	22	8	0	6
WORK ACTIVITY TOTALS:		108.3	_____	_____	230	120	181	123	221	87	164	97	135	69

END OF REPORT

(b)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUB SEC	DESCRIPTION	LANE MI.	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
000	NOT ASSIGNED		0	0	0	0	0	2	0	4	0	3	0	7
100	1 MI SW OF SCHULYR ADAM COUNTY LINE	10.1	15	10	25	10	18	9	25	6	20	9	15	7
101	CONGRESS ST.RUSHVILLE CAP. AVE. MT.STERLING	5.3	10	10	15	9	21	10	30	10	5	5	5	0
330	ROUTE 61, AUGUSTA COUNTY LINE	22.4	25	20	40	20	25	22	35	15	25	10	25	6
600	US 24 ROUTE 104 PIKE CNTY	4.2	25	10	40	11	13	13	20	11	10	24	20	7
601	IL 101 US 24 MT.STERLING	8.9	10	10	20	9	20	10	22	9	30	10	34	22
660	FREDRICK FLTN/SCHULYR CO LINE	15.6	30	10	20	15	20	17	15	12	10	16	8	22
990	UNMARKED RT AT RIPLEY	2.0	5	0	0	0	0	0	0	0	0	0	0	0
992	UNMARKED RT AT RSHVLE	4.6	25	15	20	16	20	14	14	0	12	0	8	0
994	US 24 - RUSHVILLE	22.6	20	10	20	17	20	20	30	12	30	12	20	12
995	RUSHVILLE	12.6	30	10	30	13	24	6	30	8	22	8	0	6
WORK ACTIVITY TOTALS:		108.3	195	105	230	120	181	123	221	87	164	97	135	69

END OF REPORT

FIGURE 4 (a) Input: Forecast worksheet for the direct operations of a team section. (b) Output: Needs forecast for direct operations of a team section.

results in terms of budget-line-item dollars, and
- Develop and alter the annual work plan.

Spreadsheets will be used for these functions for several reasons. They are user friendly, thus training is minimized; they are relatively easy to program and modifications are not difficult to implement; and user entries can be made for anything seen on the screen. Results of changes to entries will be reflected instantly on all other information displayed on the screen. Finally, spreadsheets can interchange information with other files and reports.

Programming the Maintenance Work Budget

One of the new aspects of the MMIS will be the involvement of field personnel in developing the annual program budget. Under the new procedures, the maintenance budget will be developed by the district maintenance staff and the costs will be calculated by the system. Field engineers will play an active role in developing programs submitted by team sections. Program requests for each team section will be made to the district maintenance engineer in the form of work activity units.

As the first step in the budget cycle, each field engineer will assess and submit both a total needs and budget request quantity for each work activity for each roadway within the team section as shown by Figure 4. These needs and request quantities will be based on past history of needs and work accomplished. The submitted needs and request quantities will be summarized for each field engineer (see Figure 5). This information will be summarized as shown in Figure 6 and used by the district mainte-

FIELD ENGINEER: 10
WORK ACTIVITY: 410 POTHOLE PATCH
TONS

TEAM SEC.	DESCRIPTION	LANE MI.	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
611	PITTSFIELD	232	385	130	335	146	328	109	235	110	210	91	160	73
612	QUINCY	334	475	70	425	98	400	60	320	50	260	55	260	42
613	MT. STERLING	128	205	115	240	130	191	133	231	97	174	107	145	99
614	JACKSONVILLE	422	470	90	410	107	385	63	360	59	340	64	330	74
615	CARTHAGE	264	120	40	130	54	130	20	130	43	140	47	110	32
WORK ACTIVITY TOTALS:		1380	1655	455	1540	535	1134	385	1276	309	1124	364	1005	320

WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

TEAM SEC.	DESCRIPTION	LANE MI.	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
611	PITTSFIELD	222	375	120	325	136	318	99	225	100	200	81	150	63
612	QUINCY	324	465	60	415	88	390	50	310	40	250	45	250	32
613	MT. STERLING	108	195	105	230	120	181	123	221	87	164	97	135	89
614	JACKSONVILLE	412	460	80	400	97	375	53	350	49	330	54	320	64
615	CARTHAGE	254	110	30	120	44	120	10	120	33	130	37	100	22
WORK ACTIVITY TOTALS:		1320	1615	395	1490	485	1084	502	1226	259	1074	314	955	270

WORK ACTIVITY: 422 ADD AGGREGATE-MACH
TONS

TEAM SEC.	DESCRIPTION	AGGR/MI	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
611	PITTSFIELD	75	112	15	115	28	100	12	70	10	60	15	70	10
612	QUINCY	75	112	15	115	28	100	12	70	10	60	15	70	10
613	MT. STERLING	90	55	25	55	30	41	43	61	27	44	27	45	24
614	JACKSONVILLE	112	162	20	100	27	85	13	90	19	80	14	80	16
615	CARTHAGE	60	30	10	30	14	30	3	30	13	40	12	25	10
WORK ACTIVITY TOTALS:		412	471	85	415	127	279	83	321	79	284	83	290	70

WORK ACTIVITY: 443 MOWING
ACRES

TEAM SEC.	DESCRIPTION	TURF/AC	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
611	PITTSFIELD	822	1475	480	1225	536	1218	395	965	400	800	81	150	63
612	QUINCY	1224	1665	240	1665	388	1390	200	1210	160	1050	45	250	32
613	MT. STERLING	1268	795	405	930	480	781	483	821	287	664	97	135	89
614	JACKSONVILLE	1195	1660	320	1600	397	1475	203	1450	209	1230	54	320	64
615	CARTHAGE	1000	440	120	480	134	480	40	480	123	630	37	100	22
WORK ACTIVITY TOTALS:		4433	6035	1565	5900	1935	5344	1321	4926	1179	3774	314	955	270

FIGURE 5 Forecast summary for direct operations of a field engineer.

WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

TEAM SEC.	DESCRIPTION	LANE MI.	FY85 NEEDS	FY85 REQUEST	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP	FY81 NEEDS	FY81 ACCOMP	FY80 NEEDS	FY80 ACCOMP
611	PITTSFIELD	222	375	220	325	136	318	99	225	100	200	81	150	63
612	QUINCY	324	465	360	415	88	390	50	310	40	250	45	250	32
613	MT. STERLING	108	195	105	230	120	181	123	221	87	164	97	135	89
614	JACKSONVILLE	412	460	380	400	97	375	53	350	49	330	54	320	64
615	CARTHAGE	254	110	30	120	44	120	10	120	33	130	37	100	22
FIELD ENGINEER 10 SUBTOT:		1123	1354	898	1328	438	1277	332	1279	370	1004	366	956	418
621	MASON CITY	295	160	35	150	52	150	17	145	12	135	16	130	22
622	LINCOLN	321	100	30	90	22	80	20	80	25	70	10	70	12
623	SPRINGFIELD WEST	186	180	32	200	24	200	24	185	0	160	30	170	40
624	RIVERTON	345	140	22	120	20	120	0	130	22	110	17	95	5
625	TAYLORVILLE	276	200	50	210	48	220	45	230	57	210	33	190	28
626	CARLINVILLE	178	100	30	90	28	95	15	80	12	70	7	60	29
627	LITCHFIELD	356	295	100	330	90	290	84	270	88	245	68	270	96
FIELD ENGINEER 20 SUBTOT:		1654	1433	467	1349	333	1145	234	1096	156	966	158	884	177
690	DISTRICT WIDE	0	0	0	0	0	0	12	0	10	0	9	0	7
999	NOT ASSIGNED	0	0	0	0	0	0	12	0	10	0	9	0	7
WORK ACTIVITY TOTALS:		3277	2780	1394	2680	769	2439	552	2346	535	2076	504	1940	589

FIGURE 6 Forecast summary for the direct operations needs of a district.

nance engineer as the basis for developing the annual program budget.

At this point the sum of the work activity units for all team sections will be entered into the spreadsheet on the microcomputer. As they are entered the labor requirements and associated costs, developed using the district's models, will be displayed (see Figure 7).

The district maintenance engineer may then enter changes in the quantity for any work activity and immediately see the effect on the line-item dollars for that activity and compare the total program dollar amount with the budget dollars available. The microcomputer spreadsheet will also display a comparison of the labor hours available with the labor hours required.

If entries boxed in on Figure 7 in the rows entitled DISTRICT FACTORS and CONSTRAINTS, under the column heading QUANTITY, and entries under INDIRECT COSTS are altered by the engineer, all other numbers on the entire spreadsheet will be recalculated and changed appropriately. In addition, a supplementary spreadsheet (see Figure 8) will display estimated equipment requirements.

The models used to develop these costs will be compared with actual expenditures and annual adjustments will be made. Therefore, the micromputer's spreadsheet capability will enable district maintenance office personnel to develop quickly alternative maintenance work programs, review the results of policy decisions, and answer "what if" questions.

From this new system the Illinois DOT expects:

1. An increased emphasis on work to be accomplished rather than dollars being appropriated; that is, a commitment by field engineers to accomplish the work will begin early in the budget process.

2. Those who review budget requests to be better informed and thus make better decisions because they will be able to review the effect of line-item-budget constraints on the work to be accomplished.

3. An improved ability to balance resources by optimizing the distribution of dollars among the budget line items within the district bureau of maintenance as a whole and also within the team sections.

The planned use of the microcomputer spreadsheet facility will be one of the most unique features in the MMIS. Backed by the involvement of the field personnel in developing the budget request, the district maintenance office staff can prepare any number of viable, alternative work programs with various mixes of activities and levels of service. They can adapt work plans to support policy decisions established by the district or central office. In effect, they can play games with the maintenance program.

Work Planning by Team Sections

The second application of the spreadsheet feature on the microcomputers for the new MMIS is to aid in the development of the work plan. After the district has established the work activity quantities that will be budgeted, the same microcomputer spreadsheet feature will be used to assist field engineers in preparing a work plan that will lead to the accomplishment of the work activity quantities of the program budget. The final work plan will specify how much, where, and when the work will be done. Three steps will be involved.

Step 1. The district maintenance office staff will use the microcomputer to assist in allocating,

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	NR REG. RATE	NR OT RATE	NR RETIRE%	NR S.S.%	EH REG. RATE	EH OT RATE	EH S.S. %	NO.OF NR	HRS. PER PERSON	% OF LEAVE	LEAVE HOURS	NET NR HOURS			
DISTRICT FACTORS:	$10.00	$15.00	5.00	6.00	$ 8.00	$12.00	6.00%	170	1,808	15.00	46,104	261,256			
LINE ITEMS:									1300 COMMOD$	1600 EQP OPR$	1200 CNTRCT$	1700 TELECOM$			1290 TRAVEL
CONSTRAINTS:									300,000	100,000	200,000	90,000			25,000
DIRECT OPERATIONS:															
WORK ACTIVITY NO. DESC UNIT	QUANTITY	TOT HRS REQUIRED	NR REG HOURS	NR OT HOURS	EH REG HOURS	EH OT HOURS	1120 NR $	1130 EH $	1300 COMMOD$	LAB HRS PER UNIT	MAT$ PER UNIT	% NR REG	% NR OT	% EH REG	% EH OT
410 POTHOLE PATCH TONS	4,400	22,924	18,339	2,292	1,375	917	217,778	22,004	92,400	5.21	21.00	80.00	10.00	6.00	4.00
412 PARTIAL DEPTH PATCH SQ.YDS.	4,400	8,580	5,148	1,716	1,287	429	77,220	15,444	9,372	1.95	2.13	60.00	20.00	15.00	5.00
422 ADD SPREAD AGG TONS	1,500	1,560	1,482	78	0	0	15,990	0	13,500	1.04	9.00	95.00	5.00	0.00	0.00
443 MOWING ACRES	22,000	41,800	39,710	2,090	0	0	428,450	0	0	1.90	0.00	95.00	5.00	0.00	0.00
471 SNOW FENCE LIN.FT.	9,000	450	405	23	23	0	4,395	184	90	0.05	0.01	90.00	5.00	5.00	0.00
SUBTOTAL OF DIRECT OPERATIONS		75,314	65,084	6,199	2,685	1,346	743,833	37,632	115,362						
INDIRECT COSTS															
							1120 NR $	1130 EH $	1300 COMMOD$	1800 EQP OPR$	1200 CNTRCT$	1700 TELECOM$			1290 TRAVEL
TEAM SECTIONS HOURS	40,000	40,000	36,000	0	4,000	0	360,000	32,000	160,000	115,000	155,000	45,000			
DISTRICT OFFICE HOURS	4,000	4,000	3,600	0	0	400	36,000	4,800	25,000	12,000	47,000	5,000			25,000
LEAVE HOURS		24,297					242,970								
TOTAL REQUEST:															
		TOT HRS REQUIRED	NR EXCL LVE HRS	NR OT HOURS	EH REG HOURS	EH OT HOURS	1120 NR $	1130 EH $	1300 COMMOD$	1800 EQP OPR$	1200 CNTRCT$	1700 TELECOM$	1161 RETIRE$	1170 S.S.$	1290 TRAVEL
		143,611	104,684	6,199	6,685	1,746	1,382,803	74,432	300,362	127,000	202,000	50,000	91,791	129,446	25,000
LINE ITEM CONSTRAINT AMOUNT MINUS REQUEST:			156,572						-362	-27,000	-2,000	40,000	0	0	0
													TOTAL BUDGET -		$2,382,834

FIGURE 7 District budget spreadsheet.

TEAM SECTION: 613 MT. STERLING

WORK ACTIVITY ACT.	QUANTITY	LABOR B PER QUARTER 1	2	3	4	QUANTITY PER QUARTER 1	2	3	4	EQUIPMENT CATEGORY	QTY	MRS/ UNIT	HOURS REQUIRED 1	2	3	4
410	460	20	30	45	5	80	120	180	20	100 ASPHALT DISTRIBUTOR	2	1.75	140	210	315	35
										911 PICKUP/CARRYALL TRK	3	2.75	220	330	495	55
411	1000	15	25	30	30	150	250	300	300	100 ASPHALT DISTRIBUTOR	1	1.75	263	438	525	525
										911 PICKUP/CARRYALL TRK	1	2.75	413	688	450	425
										231 MIXER - CONCRETE	1	1.75	263	438	525	525
412	800	25	25	25	25	200	200	200	200	231 MIXER - CONCRETE	3	1.75	350	350	350	350
414	400	15	30	35	20	60	120	140	80	100 ASPHALT DISTRIBUTOR	1	1.75	105	210	245	140
417	500	20	25	35	25	100	125	175	100	100 ASPHALT DISTRUBUTOR	3	1.75	175	219	306	175
										911 PICKUP/CARRYALL TRUCK	1	2.75	275	343	481	275
440	800	15	35	35	15	120	280	280	120	543 CHAIN SAW	4	2.00	240	560	560	240
										911 PICKUP/CARRYALL TRUCK	1	1.75	210	490	490	210
443	500	0	45	45	10	0	225	225	50	500 TRACTOR WITH MOWER	1	2.00	0	450	450	100

TEAM SECTION: 613 MT. STERLING

TEAM SECTION TOTALS:

	EQUIPMENT CATEGORY	QUARTER 1	2	3	4
HOURS REQUIRED:	100 ASPHALT DISTRIBUTOR	683	1077	1391	875
HOURS AVAILABLE:		700	1000	1400	900
HOURS OVER/SHORT:		17	-77	9	25
HOURS REQUIRED:	231 MIXER - CONCRETE	613	788	875	875
HOURS AVAILABLE:		600	800	900	900
HOURS OVER/SHORT:		-13	12	25	25
HOURS REQUIRED:	500 TRACTOR WITH MOWER	0	450	450	100
HOURS AVAILABLE:		0	435	475	110
HOURS OVER/SHORT:		0	-15	25	10
HOURS REQUIRED:	543 CHAIN SAW	240	560	560	240
HOURS AVAILABLE:		240	560	560	240
HOURS OVER/SHORT:		0	0	0	0
HOURS REQUIRED:	911 PICKUP/CARRYALL TRK	1118	1851	1916	965
HOURS AVAILABLE:		1120	1860	1900	1000
HOURS OVER/SHORT:		2	9	-16	35

END OF REPORT

FIGURE 8 Team section equipment requirements by quarter.

balancing, and assigning the budgeted districtwide work quantities to each team section (see Figure 9). This allocation will be based on

1. The total needs and budget request quantities as submitted earlier by the team section; and
2. The quantities of priority 1, 2, and 3 work as indicated by the field needs survey submitted by the team section immediately before the allocation process.

Step 2. Given the allocated annual work quantity, field engineers will use their microcomputers to allocate and assign the budgeted quantity of work for each activity to each subsection (i.e., to an actual roadway location) under their maintenance responsibility (see Figure 10). These two steps will provide information required for the basic work plan in terms of how much and where work will be done.

Step 3. The microcomputer spreadsheet will be used to make a preliminary assignment of when the work will be performed. Four years of history containing the amount of work performed for each work activity by month will be maintained for each team section. A model of work performance based on the history will be kept for each team section. The spreadsheet will use the percentages based on that history as a model to spread the budgeted work amount for each work activity across the year (see Figure 11). For example, if the history for a particular team section showed that 11 percent of their full depth patching was done in July, 67 percent in October, and 22 percent in November, and the annual budgeted amount were 90 square yards; the preliminary work plan for full depth patching would be

Team Section: 613 Mt. Sterling

Work Activity	Total	July	October	November
Full depth patching	90	10	60	20

This procedure would be used for all work activities. The final result will be an overall monthly plan by work activity. Each work activity can be reviewed and changed accordingly if and when required.

The work activity quantities allocated to each subsection will be combined with the total assigned for the month to prepare a work plan by location, month, and work activity amount (see Figure 12). The field engineer will be able to alter any part of the work plan to meet further policy requirements or apparent situational needs. Any need to alter the work plan can be assessed and approved or disapproved by the district maintenance engineer.

(a)

WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

TEAM SEC	DESCRIPTION	LANE MI.	ADJUSTED BUDGET REQUEST	SEPT. BUDGET REQUEST	NEEDS SURVEY (APRIL 1984) PRTY1	PRTY2	PRTY3	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP
611	PITTSFIELD	222	_____	220	31	126	220	325	136	318	99	225	100
612	QUINCY	324	_____	360	110	50	310	415	88	390	50	310	40
613	MT. STERLING	108	_____	105	116	54	73	230	120	181	123	221	87
614	JACKSONVILLE	412	_____	380	210	79	302	400	97	375	53	350	49
615	CARTHAGE	254	_____	30	73	12	14	120	44	120	10	120	33
621	MASON CITY	295	_____	35	56	11	45	150	52	150	17	145	12
622	LINCOLN	321	_____	30	32	23	44	90	22	80	20	80	25
623	SPRINGFIELD WEST	186	_____	32	64	32	54	200	24	200	24	185	0
624	RIVERTON	345	_____	22	56	12	68	120	20	120	0	130	22
625	TAYLORVILLE	276	_____	50	88	110	210	210	48	220	45	230	57
626	CARLINVILLE	178	_____	30	22	24	63	90	28	95	15	80	12
627	LITCHFIELD	356	_____	100	76	42	104	330	90	290	84	270	88
690	DISTRICT CREW	0	_____	0	0	0	0	0	0	0	12	0	10
999	NOT ASSIGNED	_____	_____	0	_____	_____	_____	0	0	0	12	0	10
WORK ACTIVITY TOTALS:		3277	_____	1394	934	575	1507	2680	769	2439	552	2346	535

ADJUSTED BUDGET TOTAL: 1390

END OF REPORT

(b)

WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

TEAM SEC	DESCRIPTION	LANE MI.	ADJUSTED BUDGET REQUEST	SEPT. BUDGET REQUEST	NEEDS SURVEY (APRIL 1984) PRTY1	PRTY2	PRTY3	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP
611	PITTSFIELD	222	220	220	31	126	220	325	136	318	99	225	100
612	QUINCY	324	360	360	110	50	310	415	88	390	50	310	40
613	MT. STERLING	108	105	105	116	54	73	230	120	181	123	221	87
614	JACKSONVILLE	412	380	380	210	79	302	400	97	375	53	350	49
615	CARTHAGE	254	30	30	73	12	14	120	44	120	10	120	33
621	MASON CITY	295	35	35	56	11	45	150	52	150	17	145	12
622	LINCOLN	321	30	30	32	23	44	90	22	80	20	80	25
623	SPRINGFIELD WEST	186	30	32	64	32	54	200	24	200	24	185	0
624	RIVERTON	345	20	22	56	12	68	120	20	120	0	130	22
625	TAYLORVILLE	276	50	50	88	110	210	210	48	220	45	230	57
626	CARLINVILLE	178	30	30	22	24	63	90	28	95	15	80	12
627	LITCHFIELD	356	100	100	76	42	104	330	90	290	84	270	88
690	DISTRICT WIDE	0	0	0	0	0	0	0	0	0	12	0	10
999	NOT ASSIGNED	0	0	0	0	0	0	0	0	0	12	0	10
WORK ACTIVITY TOTALS:		3277	1390	1394	934	575	1507	2680	769	2439	552	2346	535

ADJUSTED BUDGET TOTAL: 1390

END OF REPORT

FIGURE 9 (a) Input: Adjusted budget worksheet for district direct operations. (b) Output: Adjusted budget for district direction operations.

The reports described in these steps will enable all field engineers to compare actual work accomplished with the work plan; this is one of the important management tools produced by the new MMIS.

SUMMARY

The success of Illinois' new MMIS is largely due to the use of microcomputers. The department expects MMIS to be successful because

1. Field personnel will be given a highly visible and important role in preparing the program budget and annual work plan.
2. Budget decisions will be weighed in terms of their impact on the work program and vice versa.
3. It will produce a realistic work plan that then can be customized and tailored by field personnel.
4. The source of information used to develop follow-up reports to measure work plan adherence and performance standards will be apparent to all system users. These standards will be constantly evaluated and fine tuned.
5. Many of the system's reports will be available for review on request. In addition, because of daily field entry, response or turnaround times for reports will be very short.
6. The system closely corresponds to the cycle of management.

Producing the budget and work plan using the spreadsheet allows maintenance managers to

- Answer "what if" questions,
- Develop and review various options and results,
- Build a practical work plan to accomplish the budgeted work, and
- Be more active in planning maintenance work.

Management is performed by people, not systems--but a system can provide (and it is believed that MMIS will provide) the capability for substantially improving maintenance productivity.

(a)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUBSEC SP.DSG	SUBSEC-SP. DESIGNATION DESCRIPTION	LANE MI.	QNTY. TO BE SCHLD.	SEPT. BUDGET REQUEST	NEEDS SURVEY (APRIL 1984) PRTY1	PRTY2	PRTY3	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP
000	NOT ASSIGNED			0	0	0	0	0	0	0	2	0	4
100	1 MI SW OF SCHLYR ADAM COUNTY LINE	10.1		10				25	10	18	9	25	6
100-01	1 MI SW OF SCHLYR 2 MI SO ADAM C.L.				10	8	6						
100-02	CONGRESS ST. RUSHVILLE ADAM C.L.				0	0	4						
101	CONGRESS ST. RUSHVILLE CAP. AVE. MT. STERLING	5.3		10	5	4	1	15	9	21	10	30	10
330	ROUTE 61, AUGUSTA COUNTY LINE	22.4		20	20	13	8	40	20	25	22	35	15
600	US 24 US 24 MT. STERLING	4.2		10	10	8	6	40	11	13	13	20	11
600-01	US 24 ROUTE 104 PIKE CNTY				0	5	6						
600-02	IL 101 US 24 MT. STERLING				0	6	6						
601	IL 101 US 24 MT. STERLING	8.9		10	5	4	1	20	9	20	10	22	9
660	FREDRICK FLTN/SCHULAR CO LINE	13.6		10	10	3	0	20	15	20	17	15	12
990	UNMARKED RT AT RIPLEY	2.0		0	0	5	0	0	0	0	0	0	0
992	UNMARKED RT AT RSHVLE	4.6		15	17	0	0	20	16	20	14	14	0
994	US 24 - RUSHVILLE	22.6		10	16	0	18	20	17	20	20	30	12
995	RUSHVILLE	12.6		10	17	8	17	30	13	24	6	30	8
WORK ACTIVITY TOTALS:		108.3		105	116	54	73	230	120	181	123	221	87
ADJUSTED BUDGET TOTAL:			105										

END OF REPORT

(b)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUBSEC SP.DSG	SUBSEC-SP. DESIGNATION DESCRIPTION	LANE MI.	QNTY. TO BE SCHLD.	SEPT. BUDGET REQUEST	NEEDS SURVEY (APRIL 1984) PRTY1	PRTY2	PRTY3	FY84 NEEDS	FY84 SUBMIT	HISTORY FY83 NEEDS	FY83 ACCOMP	FY82 NEEDS	FY82 ACCOMP
000	NOT ASSIGNED		0	0	0	0	0	0	0	0	2	0	4
100	1 MI SW OF SCHLYR ADAM COUNTY LINE	65.5	10	10				25	10	18	9	25	6
100-01	1 MI SW OF SCHLYR 2 MI SO ADAM C.L.		0		10	8	6						
100-02	CONGRESS ST. RUSHVILLE ADAM C.L.		0		0	0	4						
101	CONGRESS ST. RUSHVILLE CAP. AVE. MT. STERLING	5.3	10	10	5	4	1	15	9	21			
330	ROUTE 61, AUGUSTA COUNTY LINE	38.3	20	20	20	13	8	40	20	25	22	35	15
600	US 24 US 24 MT. STERLING	30.8	10	10	10	8	16	40	11	13	13	20	11
600-01	US 24 ROUTE 104 PIKE CNTY		0		0	5	6						
600-02	IL 101 US 24 MT. STERLING		0		0	6	6						
601	IL 101 US 24 MT. STERLING	8.9	10	10	5	4	1	20	9	20	10	22	9
660	FREDRICK FLTN/SCHULAR CO LINE	26.0	10	10	16	3	0	20	15	20	17	15	12
990	UNMARKED RT AT RIPLEY	11.2	0	0	0	5	0	0	0	0	0	0	0
992	UNMARKED RT AT RSHVLE	2.8	15	15	17	0	0	20	16	20	14	14	0
994	US 24 - RUSHVILLE	15.3	10	10	16	0	18	20	17	20	20	30	12
995	RUSHVILLE	4.2	10	10	17	8	17	30	13	24	6	30	8
WORK ACTIVITY TOTALS:		108.3	105	105	116	54	73	230	120	181	123	221	87
ADJUSTED BUDGET TOTAL:			105										

END OF REPORT

FIGURE 10 (a) Input: Adjusted budget worksheet for direct operations of a team section. (b) Output: Adjusted budget for direct operations of a team section.

TEAM SECTION: 613 MT. STERLING

WORK ACT.	DESCRIPTION	UNIT OF MEASURE	BUDGETED WORKPLAN	QUANTITIES TO BE ACCOMPLISHED TOTAL	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE
410	POTHOLE PATCHING	TONS	40	40		5				10		10	10		5	
411	PARTIAL DEP PATCH	SQ. YD.	120	120	120											
412	FULL DEPTH PATCH	SQ. YD.	105	105	10	10	5	60	20							
413	BITUMINOUS OVERLAY	TONS	50	50				5	20	5					20	
414	C.&.C. PAVT PATCH	SQ. YD.	120	120						10	60	10	40			
415	DUMP BURNING	LIN. FT.	100	100			20	5	10	5				20	20	20
416	CRACK & JOINT SEAL	GALS.	40	40		40										
400	TRUCK MAINTENANCE	HOURS	500	500	75	25	30	30	25	25	50	125	30	50	25	10
401	OTHER EQUIP MAINT	HOURS	700	700	30	40	30	30	25	35	30	30	30	120	200	100
402	HOOTRS, YARD MAINT	HOURS	400	400	20	20	25	15	75	75	20	15	20	20	75	20
—	TIME OFF	HOURS	2000	2000	300	150	50	400	200	350	100	100	50	50	200	50

END OF REPORT

FIGURE 11 Work plan summary for a team section.

(a)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUBSEC SP.DSG	SUBSEC-SP. DESIGNATION DESCRIPTION	QNTY. TO BE SCHLD.	QUANTITIES TO BE ACCOMPLISHED TOTAL	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE
000	NOT ASSIGNED	0													
100	1 MI SW OF SCHLYR ADAM COUNTY LINE	10													
100-01	1 MI SW OF SCHLYR 2 MI SO ADAM C.L.	0													
100-02	CONGRESS ST. RUSHVILLE ADAM C.L.	0													
101	CONGRESS ST. RUSHVILLE CAP. AVE. MT. STERLING	10													
330	ROUTE 61, AUGUSTA COUNTY LINE	20													
600	US 24 US 24 MT. STERLING	10													
600-01	US 24 ROUTE 104 PIKE CNTY	0													
600-02	IL 101 US 24 MT. STERLING	0													
601	IL 101 US 24 MT. STERLING	10													
660	FREDRICK FLTN/SCHULAR CO LINE	10													
990	UNMARKED RT AT RIPLEY	0													
992	UNMARKED RT AT RSHVLE	15													
994	US 24 - RUSHVILLE	10													
995	RUSHVILLE	10													
WORK ACTIVITY TOTALS:		105													
WORKPLAN GOAL:			105	10	10	5	60	20	0	0	0	0	0	0	0

END OF REPORT

(b)

TEAM SECTION: 613 MT. STERLING
WORK ACTIVITY: 412 FULL DEPTH PATCH
SQ. YD.

SUBSEC SP.DSG	SUBSEC-SP. DESIGNATION DESCRIPTION	QNTY. TO BE SCHLD.	QUANTITIES TO BE ACCOMPLISHED TOTAL	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MARCH	APRIL	MAY	JUNE
000	NOT ASSIGNED	0	0												
100	1 MI SW OF SCHLYR ADAM COUNTY LINE	10	10					10							
100-01	1 MI SW OF SCHLYR 2 MI SO ADAM C.L.	0	0												
100-02	CONGRESS ST. RUSHVILLE ADAM C.L.	0	0												
101	CONGRESS ST. RUSHVILLE CAP. AVE. MT. STERLING	10	10				10								
330	ROUTE 61, AUGUSTA COUNTY LINE	20	5					5							
600	US 24 US 24 MT. STERLING	10	10	10											
600-01	US 24 ROUTE 104 PIKE CNTY	0	0		10										
600-02	IL 101 US 24 MT. STERLING	0	0			5									
601	IL 101 US 24 MT. STERLING	10	10				10								
660	FREDRICK FLTN/SCHULAR CO LINE	10	10				10								
990	UNMARKED RT AT RIPLEY	0	0												
992	UNMARKED RT AT RSHVLE	15	15				15								
994	US 24 - RUSHVILLE	10	10				5	5							
995	RUSHVILLE	10	10				10								
WORK ACTIVITY TOTALS:		105	105	10	10	5	60	20	0	0	0	0	0	0	0
WORKPLAN GOAL:			105	10	10	5	60	20	0	0	0	0	0	0	0

END OF REPORT

FIGURE 12 (a) Input: Work plan worksheet for direct operations of a team section. (b) Output: Work plan for direct operations of a team section.

Discussion

Kenneth A. Brewer*

Mr. File's paper is fundamentally an example of the same kind of microcomputer application as Mr. Nimz's from the microcomputer perspective. It is a different application from the engineering management perspective. Mr. Nimz indicated that electronic spreadsheet software was used to manipulate the highway inventory in a filing sense. Mr. File's paper describes the use of an electronic spreadsheet to do "what if" scenarios on the maintenance budget and resource allocation program within a department of transportation at the district level.

Mr. File's paper contains a complicated figure depicting the flow of information and decision making in the Illinois Department of Transportation's maintenance management information system (MMIS). It would be most helpful to me, and probably to the reader, if Mr. File could take that figure and explain what parts of it reside only in the central mini- or mainframe computers and what parts of the process reside in the district microcomputers. It appears that Illinois DOT is using the district microcomputer as a "smart terminal" to a larger computer system data base for overall departmental budget and management processes. This is a very good application of microcomputers. I am aware of a federal agency installation that does a great deal of local processing of research data and information handling on a Hewlett-Packard (H-P) mainframe. They recently found that new H-P 150 microcomputers with a terminal interface connection to the H-P mainframe are as cheap (in the quantities they needed) as simple mainframe terminals. This is enabling the agency to do analytic processing at the individual work station and use the mainframe computer as basically a large library of information.

Mr. File's paper suggests that the Illinois DOT maintenance and budget program is now created from the bottom up with the microcomputer at the district level. The wording of the paper suggests that prior to the installation of microcomputers this was not the case. There are two ways that a management process can be computerized.

The first is to take a process that was previously not computerized and essentially make the computer do what the people used to do in their standard operating procedures. This is known as a people dominated computer installation. If the budget and program development prior to the acquisition of microcomputers was bottom up in the form of budget and program requests submitted from the district up to higher levels, then the installation of microcomputers was really incidental to creating the interactive management process. It could have been done with any type of computer system and, with enough lead time, it could have been done in a paper-and-pencil report cycle format.

The second way of computerization is to define the computer structure needed to carry out the intended management function (in this case I assume it is to institute a bottom up budget and program development process) and to superimpose the computer structure on the people. For this path to be successful a significant amount of time and effort has to be devoted to training and teaching personnel responsible for using the computer system how to do the old job the new way. Difficulties with human errors associated with the inability to quickly break old habits must be expected. I am interested in, and think it would be useful for others to know, which of these two paths to computerization (or a combination) more closely describes how this MMIS was constructed.

Electronic spreadsheet programs are powerful tools. If you purchase a personal microcomputer and acquire a spreadsheet program you will find that it will require an investment of 40 to 100 hours to learn the full capabilities of an electronic spreadsheet (unless it is the new graphics/icon driven spreadsheet). A great deal of thought and time goes into defining and creating the blank spreadsheet into which values are inserted and selected parameters are changed to test the "what if" scenarios. I would like to know who developed the basic spreadsheet format for Illinois DOT. I assume that the same format is transmitted to each district. Is that a correct assumption? What is the origin of the cost models mentioned in passing? Do these models control the changes in values of cells in the spreadsheet? What kind of training, how much training, and training done by whom was associated with familiarizing the various district personnel with the use of the spreadsheet?

Because it is difficult for anyone who has not used a microcomputer electronic spreadsheet before to appreciate what is involved in such an analysis, is it possible to take us through a simple example "screen by screen" as a district maintenance engineer would do?

I like what is outlined in skeleton form in this paper. Mr. File's paper is an example of the use of accounting software in an engineering management application not unlike what stockbrokers and money managers do with microcomputers. We must be willing to make technology transfer from any area of the management world to enhance our ability to manage the highway system.

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