concern for the fiscal impact of transportation projects and a high degree of policy sensitivity to the level of employment and economic welfare in Michigan. The model accordingly provides a means of rapidly evaluating the income and fiscal effects of employment changes that are the outcomes or by-products of transportation improvement projects. The model is also quite easy to run and is therefore accessible to those whose responsibilities will not permit the luxury of becoming acquainted with complicated run instructions or computer jargon.

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Microcomputer Decision Support System

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ABSTRACT

In the past 2 years the Maryland Department of Transportation has developed a decision support system that provides financial advice to the Secretary of Transportation and to other policy-making officials within Maryland state government. The components and techniques used in developing this system are described. To place the system in perspective, there is a brief comparison of the process before implementation of the system with current practice. General guidelines are given to assist the reader in identifying issues and criteria for development of decision support systems. These criteria are general in nature and may be applied to a wide variety of situations, not just financial planning or transportation-related analysis. Comments, conclusions, and specific hardware and software evaluations based on experience to date are offered.

The purpose of this paper is to inform other professionals in the transportation field about the experiences of the Maryland Department of Transportation (MDOT) in developing and implementing a microcomputer-based decision support system. In order that the reader may better appreciate the nature of work performed by the Financial Planning and Analysis Section at MDOT, a brief description of the department and its funding sources is included. In the balance of the paper, concentration is on the components of the financial decision support system at MDOT, guidelines for developing a decision support system and financial modeling, and conclusions and comments regarding the MDOT experience to date.

BACKGROUND

MDOT is responsible for all state-owned transportation facilities and programs. This responsibility includes the planning, financing, construction, operation, and maintenance of various modes of transportation. In addition, the department carries out various related licensing and administrative functions.

The department is supported by the Transportation Trust Fund, which consists of revenues from motor fuel taxes, motor vehicle taxes, a portion of the state corporation income tax, operating revenues generated from MDOT-owned facilities, transit fares, federal aid, and bonds and notes supported by the trust fund.

The Financial Planning and Analysis Section is part of the Secretary's staff. This section is charged with the responsibility for providing the Secretary with impartial advice on the financial impact of policy-level, program-level, and project-level decisions.

MAJOR ISSUES

The Financial Planning and Analysis Section performs three distinct types of analyses. The first type of analysis is focused on providing revenue and expense forecasts covering 5-year and 20-year planning horizons. The second major area of analysis is the determination of upper and lower limits of the department's bonding capacity given projected levels of revenues, operating expenditures, and capital program spending. The final area of analysis deals with special projects and detailed analyses of a nonroutine nature.

Before the department purchased a microcomputer and financial spreadsheet software package, these analyses were performed using a time-sharing service for the revenue projections and bonding capacity. Special projects were analyzed using hand-held calculators, paper, and pencils. Each of these analyses required a substantial investment in time just to produce the initial results. Any sort of "what if?" or sensitivity analysis required a similar amount of time.

As an example of the amount of effort then required, the 5-year financial projection required about 1 month to complete with the aid of the time-sharing service and two mainframe computers. The output generated was a one-page report focused on a

dozen or so key variables and linked to one national economic forecast.

Beginning with the purchase of the first microcomputer in the fall of 1981, the Financial Planning and Analysis Section refined the procedures and methods used in their analyses. For example, the same 5-year projection now includes about 100 variables that are validated against four separate national economic forecasts. The MDOT 5-year financial projection now usually requires only 1 week from start to finish and is produced without any increase in the number of personnel in the Financial Planning and Analysis Section.

This dramatic increase in productivity has been a result of the development of a decision support system based on a microcomputer and VisiCalc spreadsheet software. A decision support system is an interactive computer-based system that allows decision makers to analyze and solve complex, unstructured problems. Interactive is used to mean the ability to directly enter any changes in the base model and to review results immediately. In the following section the components of the decision support system now being used at MDOT by the Financial Planning and Analysis Section are described.

COMPONENTS OF THE DECISION SUPPORT SYSTEM

The first component of the decision support system is a series of models used to project revenues and expenditures. By using the spreadsheet software a number of techniques may be combined into a single model. For example, MDOT operating expenditures are extrapolated from budget figures using an inflation rate adjustment derived from national economic forecasts. For each year of the projection, the previous year's expenditure is multiplied by the inflation factor to derive the expense in that year. In addition to this capability, certain variables within the forecast may be held constant from year to year.

Another technique used to make long-term projections is regression analysis. Again, the spreadsheet package makes it possible to incorporate the regression coefficients into a formula to calculate receipts for a given year.

To determine the department's bonding capability, a model incorporating information about the department's past bond issues, characteristics of proposed issues, desired capital program, and projected revenues was developed. This model was adapted from an earlier linear programming model written in FORTRAN and run on a mainframe. The current model is much quicker to revise and has the added advantage of allowing the user to immediately see the impact of changes in any of the input variables.

Models developed for special project analyses all have a number of common features. Wherever possible, constants used within the models are referenced separately from outputs. For example, calculations involving the use of a constant interest rate are modeled in such a manner that the user can perform "what if?" or sensitivity analysis by changing the desired input only once as opposed to having to change the value of the constant at each occurrence within the model. In addition, each model contains documentation about what disk the model is located on, the developer's name, and any special instructions regarding print formats or other aspects.

One important point should be stressed regarding the development of these models: All of the models were developed by the Financial Planning and Analysis Section staff without the aid of data processing personnel. This was made possible by the purchase of spreadsheet software in addition to the microcomputers.

The current decision support system allows the Financial Planning and Analysis Section to produce a greater quantity of work of higher quality than was possible previously.

GUIDELINES FOR DEVELOPING A DECISION SUPPORT SYSTEM

The following list and the associated comments should assist in the development of a decision support system. Bear in mind that not all items will apply to any specific situation and that possibly not all relevant considerations are included. The list is intended as a general guide to assist in identifying the key elements required to develop an effective decision support system.

1. Determine the types of answers desired. Are they one number, a range, or a conclusion? As an example, the system used at MDOT for revenue and expense forecasts results in a single number for each item for each year. On the other hand, special project analyses performed for the purpose of establishing rates at state-owned facilities usually result in an acceptable-range-type of answer. An example of where a conclusion-type answer is required is the analysis of past performance of specific units within the organization.
2. Establish standards for acceptable levels of error permitted for each of the various types of answers. For example, multiple-year forecasts may have an acceptable error of plus or minus millions of dollars. For analyses of past performance of specific units, the results generated should have a minimal level of error because actual data are available.
3. Determine what types and amounts of data are required to develop and use the system. One key question to be answered is whether the required data are available or can be acquired at a reasonable cost.
4. Document all assumptions caused by lack of information or unreliable information.
5. Determine how often the system will be used. In general terms, the more frequently a support system is called on to generate a specific result, the more detailed the required analysis becomes. Detailed financial models require a longer setup time.
6. Standardize formats for the output generated by each part of the system. Summarizing the results of a quarterly forecast in the same format each time makes it easier for the decision maker to find needed information.
7. In financial analyses, graphs should be included in the summary of results only as supporting information. Limit the number of graphs included in the analysis to the bare minimum required to emphasize major points. However, graphic techniques can be extremely useful in assisting in the developmental phases of model building. Many hours of analytic work can be eliminated by using graphs to clarify the relationships between variables.
8. The organizational unit that undertakes the development of a decision support system is alone. That unit and only that unit is responsible for seeing that the work gets done--no more blaming the data center because the computer is "down."
9. There is a real difference of opinion in the community about whether hardware or software is more important. The most important aspect seems to be dealer support for both hardware and software. When something does not work, fast, reliable, and affordable hardware support is required. Even more important, software support and training are needed.

The dealer should have knowledgeable people who can help you make the software you purchased func-

tion more effectively. This goes beyond selling the latest fad. It means that the dealer should have hands-on experience with daily applications. The dealer can then make realistic recommendations and will be able to answer specific questions from actual experience, rather than from reading manuals.

10. Even with the best support and training it is unreasonable to expect anyone else to truly understand your exact needs or problems. Do not accept anyone's word that a given product or combination of products will meet your needs. Insist on trying products out, either at the dealer's store or, for large purchases, in your own office. Reputable dealers will allow 15 days or more to test a product.

11. Avoid dependence on any other organizational branch of government for microcomputer purchase and support. Find a system that meets your immediate needs and that is understandable and usable by your employees. The most efficient way to send information from one computer to another is to take the disk out of one computer and place it in the next. Keep things simple: find the least expensive and most straightforward method of completing the task at hand. Later, if requirements grow or become too involved for the original approach, upgrade to a more powerful configuration.

12. It is a mistake to attempt to start off with the "optimal system." Start small and grow in manageable steps. This will allow hedging bets and keeping mistakes to a minimum.

In the next section the experiences of the Financial Planning and Analysis Section with hardware, software, and dealer support are related. In the last section capsule evaluations of each item are presented.

MDOT EXPERIENCE TO DATE

In the fall of 1981 MDOT purchased a TRS-80 Model II microcomputer with 2 disk drives, 64K memory, and a Daisy Wheel II printer through a statewide procurement contract. Scriptsit word processing software, the VisiCalc spreadsheet program, a Profile database package, and a Radio Shack Statistical Analysis Package were also included.

In hindsight, this particular configuration was and remains marginally acceptable compared with less expensive and more powerful systems that were then available. This is especially true of any comparison with systems available today. However, having even a marginally acceptable system is infinitely better than having no system at all, being dependent on a mainframe system, or paying time-sharing charges.

Increased dependence on the microcomputer-based decision support system and growing reliability problems required the purchase of another TRS-80 Model II with 128K of RAM and a Dot Matrix 400 printer. This and the simultaneous upgrading of the original Model II to 128K and the purchase of Enhanced VisiCalc took place in the spring of 1983.

Increased responsibilities assigned to the Financial Planning and Analysis Section combined with growing dissatisfaction with Radio Shack equipment's reliability and limited capabilities justified the procurement of an Apple II with 128K RAM and an Okidata 93 Dot Matrix printer in the fall of 1983. Also purchased at that time were VisiCalc, Advanced VisiCalc, Apple Writer IIe, VisiPlot/VisiTrend, and Ascii Express Professional. (Data compatibility between spreadsheets was not an issue because of the use of VisiCalc. The VisiCalc models are 100 percent transferable between the two systems. Any future purchases would also require similar compatability.) Although this system is not up to the latest state of the art (for example, an IBM system), it was about one-third the price and currently meets the real needs of the user. Naturally, an IBM XT with Lotus 123 and so forth would be a superior configuration, but it was estimated not to be three times as valuable for current or foreseeable needs.

The experience of MDOT with these various systems has been mixed to date. The TRS-80 Model II computer system was an expensive investment that did not perform up to the standards promised by the manufacturer. The TRSDOS operating system is slow and cumbersome and the Radio Shack manuals are poor. The software received from Radio Shack was always several versions behind the same software made by competitors. Profile and the Statistical Analysis packages have received little use because they are so limited and hard to use. Scripsit, although it seems to be a reasonable word-processing package, is so poorly documented and so unfriendly that secretaries took almost a year to learn to use it.

Experiences with the Apple IIe system have been entirely different. This is attributable to two factors. First and foremost is the reliable and professional dealer support provided by the Apple retailer. The employees are professionals and there is a stable core of senior management to train the junior salespeople, technicians, and software specialists. Equally important is the extensive competition among third-party vendors for Apple software and peripherals. This forces prices to be competitive, and at the same time focuses vendor efforts on developing quality products.

CONCLUDING REMARKS

For substantially less than the annual cost of a clerical position, MDOT was able to obtain a microcomputer and a single first-generation spreadsheet program. This allowed two professionals to routinely perform the various analyses described. It is believed that the Financial Planning and Analysis Section has just begun to scratch the surface of the potential of the state of the art in microcomputing. The stand-alone microcomputer freed the section from dependence on time-sharing services and mainframe computers. It is true that the processing time for certain types of problems is longer on the microcomputer, but output is received for review much faster.

The key to the present decision support system was the purchase of the spreadsheet software. This software has enabled the section to develop fairly complex financial models without the use of programmers and data processing facilities. As a result, the section has a much greater degree of control over the scheduling of workflow. In addition, the decision support system is capable of the fast turnaround times that are achieved in large part because of these very factors.

Although the current decision support system is still evolving, when compared with the methods used before its development the section is far ahead. The rewards in both improved product quality and increased quantity of output are well worth the effort required to develop the system.

PRODUCT EVALUATIONS

The following equipment, as well as items from Radio Shack, was used:

Manufacturer	Registered Trademark
Apple Computer Co.	Apple IIe, Apple Writer IIe

Manufacturer	Registered Trademark
Tandy Corporation	TRS-80 Model II
	TRSDOS
	Dot Matrix Printer 400
	Daisy Wheel Printer II
	Scriptsit, Profile
	Statistical Analysis
VisiCorps	VisiCalc
	VisiPlot/VisiTrend
	Advanced Visicalc
	Enhanced VisiCalc
Southwestern Data Systems	Ascii Express Professional
IBM	IBM XT
Lotus	Lotus 123

Hardware

Radio Shack Model II Computer

The strong points of the Model II computer are

- Large disk storage capacity,
- Detachable keyboard, and
- Separate number keys.

The weak points of the Model II computer are

- Black and white display,
- Complicated operating system,
- Inefficient use of memory (see VisiCalc description),
- Expensive service calls,
- High frequency of maintenance,
- Lack of a high-resolution display,
- Highly limited software selection, and
- Expensive peripherals.

Radio Shack Daisy Wheel Printer II

The strong points of the Daisy Wheel Printer II are

- Relatively fast (40-50 cps) and
- High reliability.

The weak points of the Daisy Wheel Printer II are

- High repair costs and
- High ribbon-replacement costs.

Radio Shack Dot Matrix Printer 400

The strong point of the Dot Matrix Printer 400 is its reliability. The weak points are

- High cost,
- Poor print quality,
- Short ribbon life, and
- High ribbon-replacement cost.

Apple IIe

The strong points of Apple IIe are

- Low initial cost,
- Modular construction (if one part goes to the shop the rest of the system can still be used),
- Efficient use of memory (see VisiCalc description),
- Ease of upgrading from a wide selection of peripherals, and
- High-resolution graphics and color capability.

The weak points of the Apple IIe are

- Limited disk storage capacity and
- Wide variety of accessories can lead to compatibility problems if proper care is not taken.

Okidata 93 Dot Matrix Printer

The strong points of the Okidata 93 are

- High print quality,
- Large variety of print styles,
- High through-put (160 cps), and
- Low ribbon-replacement cost.

The weak points of the Okidata 93 are

- Changing ribbons can be messy and
- Printer noise may require the purchase of a sound enclosure

Software

Original VisiCalc

The strong points of original VisiCalc are its ease of use and flexibility. Its weak points are

- Small model size (25K on a 64K computer);
- No logic functions (if, then, else);
- No entry editing; and
- Limited display capability (no commas in numbers).

Enhanced VisiCalc

The strong points of Enhanced VisiCalc are

- Ease of use,
- Flexibility,
- Logic functions, and
- Edit capability.

Its weak points are limited model size (18K on a 64K computer, 50K on a 128K computer) and limited display capability (no commas in numbers).

Scriptsit

The strong points of Scriptsit are its large number of features and its ability to handle very large documents.

The weak points of Scriptsit are the facts that it is very poorly documented and hard to learn.

Profile

The strong points of Profile are unknown because of lack of use.

Its weak points are

- Poor documentation,
- Highly limited display capacity, and
- Difficulty of use.

Statistical Analysis

The strong points of Statistical Analysis are unknown.

It weak points are

- Poor documentation,
- Limited capacity, and
- Poor data handling routines.

VisiCalc to Run on Apple IIe

The strong points of VisiCalc are

- Ease of use,
- Flexibility,
- Efficient use of memory (96K available for the model), and
- Logic and editing functions.

Its weak point is its poor display capabilities (no commas in numbers).

Advanced VisiCalc

The strong points of Advanced VisiCalc are

- Ease of use;
- Powerful financial routines (e.g., time, IRR); and
- Powerful display capabilities (e.g., commas, negative numbers in parentheses).

The weak points of Advanced VisiCalc are that it uses a lot of memory (only 70K available for the model) and is slower than VisiCalc.

Apple Writer IIe

The strong points of Apple Writer IIe are that it is easy to learn and relatively powerful.

Its weak points are that it does not handle very large documents without splitting them into separate chapters and requires memorizing control codes.

VisiPlot/VisiTrend

The strong points of VisiPlot/VisiTrend are

- Ease of use,
- Excellent documentation,
- Adequate statistical functions,
- Outstanding data manipulation capabilities, and
- Powerful graphics capabilities.

The weak points are that it operates relatively slowly and is not a full statistics package.

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Applications of Computer Graphics to Chicago Area Transportation Planning and Programming

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ABSTRACT

In the last few years computer graphics has become an important analytic tool. This tool exceeds the individual capabilities of both rapid computing and graphic illustrations in providing insightful perspectives and understanding of planning data. While the field of computer graphics has been rapidly developing as a general business aid, transportation professionals have been developing interactive computer graphic programs designed for specialized modeling functions. The use of existing software packages to supplement transportation planning and programming has lagged. Instances in which current planning and programming techniques can be enhanced by integrating existing software graphics packages with transportation models and functions are described. The tailoring of existing software packages for use by transportation planners who are inexperienced in system analysis is also discussed.

That graphics is an important tool for understanding and communicating information is not new. There are many instances in which a visual image of a phenomenon raises new questions or produces insight into the meaning of the data being displayed. There also is no doubt that the speed and flexibility of computers have vastly expanded and enhanced the potential scope of any analysis. Planners now have access to a vast amount of information from which to infer relationships and project future effects of various alternatives.

Computer graphics, a combination of these two important techniques, is a tool for analysis that goes beyond either graphics or rapid calculations. The speed and accuracy with which a computer can manipulate, modify, and visually represent data make computer graphics a valuable new tool for both analysis and presentation.

In the past, planners spent long hours studying numbers to determine relationships. Then those numbers were sent to graphics departments for visual representation. Anywhere from 2 days to 2 weeks later visual aids were returned to be used for pre-