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Microcomputer Preparation of Volume-Variable Budgets: Terminals on the Boston & Maine Railroad

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INTRODUCTION

Today, while students in grade schools throughout the country are learning to use microcomputers, many railroads managers still have little direct contact with computers. However, this situation is changing. There is a continuing trend to use microcomputers for a variety of applications including word processing, budgeting, filing and data base management, report preparation, analysis using commercially available software, modeling, and real time control. MIT researchers have had the opportunity to introduce microcomputer applications to railroad systems on several projects sponsored by the Freight Car Management Program of the Association of American Railroads. This article dscribes the introduction of volume-variable budgets on the Boston & Maine (B&M). Considerable attention is devoted to the structure of the volume-variable budget in order to show how the flexibility and capability of the microcomputer can be used to advantage in a complex budgeting situation.

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BACKGROUND

Car Costs in Terminal Budgets

The Freight Car Management Program has supported various studies and demonstrations of ways to improve terminal control. An MIT study in 1980 began with the premise that railroads would benefit from systems in which car costs (hourly costs of both system and "foreign" cars) are incorporated into the budgeting process and the budget is dependent on actual operating conditions and volumes.[1] More recently, the Task Force on Car Cost Allocation and Budgeting reviewed the experience of individual railroads with car cost budgets at the system and terminal levels. In 1982 the task force published descriptions of the use of car costs in the terminal control systems used by Missouri Pacific, Burlington Northern, and Conrail.[2] All of these railroads established standards for train connection and yard time; Missouri Pacific and Burlington Northern multiplied the car time standards by actual car hire rates to obtain car cost standards for terminals. This paper is based on an MIT study that showed how to incorporate car costs into a terminal budget and suggested ways to structure daily, weekly, and monthly reports to monitor car costs and train connection performance.[3]

The basic concept behind a car cost budget is quite simple if the standard yard time is given. The more difficult step is determining the standard yard time. At the simplest level, a target for the overall average yard time can be specified based on past performance for all cars going through the yard. At the opposite extreme, a standard can be derived for each car based upon the operating conditions when that car arrives in the yard. For example, this standard yard time could be defined as the time from the actual arrival of the car until the actual departure of the first train that a) departs after sufficient time for processing, b) carries the outbound block to which this car is assigned, and c) has room for this car today. Whatever the method, however, the purpose of the car time standard is to enable railroad managers to calculate a car cost budget that can be used to evaluate terminal performance in conjuction with labor budgets, service standards, and equipment utilization measures.

Volume-Variable Budgets

As the number of cars handled at a terminal varies, the number of switches and other resources needed to process these cars would also be expected to vary. However, most terminal budgets and productivity standards do not vary with volume, which makes it difficult to evaluate performance when volume is significantly above or below the projected volume that was used to establish the budget. An inflexible budget will unfortunately be unrealistically high or unrealistically low a great deal of the time, casting the budget in a poor role for terminal control. Providing a volume-variable budget process should therefore enhance the ability of management to evaluate performance under a variety of conditions, to make greater use of the budget as a control, and to understand more of the trade-offs implicit in operating decisions.

Some railroads have reporting systems that have so-called "earned budgets" for terminal switching expense. Each car handled in each area of the yard "earns" a fixed amount. As a result, the switching budget will be directly proportional to volume. However, various studies have shown that the number of switch engines required actually varies *less* than proportionately with the number of cars handled.[4] It may therefore be desirable to use somewhat more complex procedures for creating a volume-variable budget. In particular, it may be desirable to use regression analysis and other analytic techniques to relate budgetary items such as switching expense to traffic volume, the operating plan, and productivity standards. The distinction between a fixed budget, a proportional (per car standard) budget, and a budget with both fixed and variable components is illustrated in Exhibit 1.

Why Microcomputers?

As mentioned at the onset, MIT demonstrated how to design and implement a volume-variable budget in cooperation with B&M. The MIT research team decided to use microcomputers as part of this study for a variety of reasons. Since microcomputers were already available to the MIT researchers, no capital investment was necessary. Furthermore, in contrast to the use of mainframe computers, there would be minimal operational charges, an important factor since student research assistants would be spending a great deal of time using the microcomputers in statistical analysis and in developing budgeting procedures. Because the microcomputers were located in areas directly under the control of the research team, easy access would also be assured at all times.

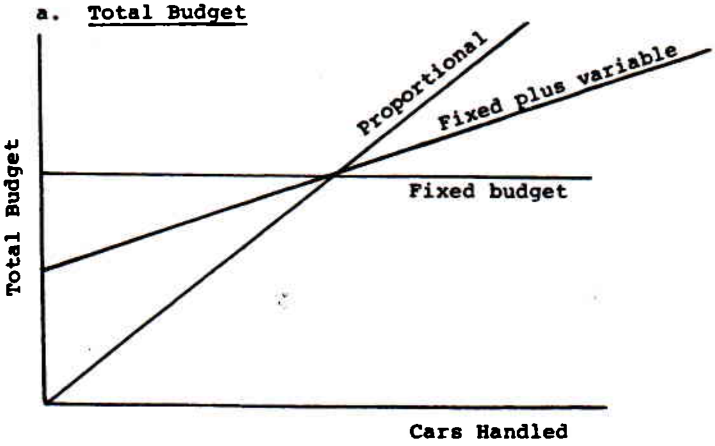
The existence of commercially available microcomputer software packages for statistical analysis, spreadsheet analysis and graphics, provided capabilities not easily accessible on the mainframe computer. The existing training manuals for the software packages would facilitate learning and transfer of knowledge among MIT researchers.

The use of microcomputers also would facilitate the transfer of knowledge

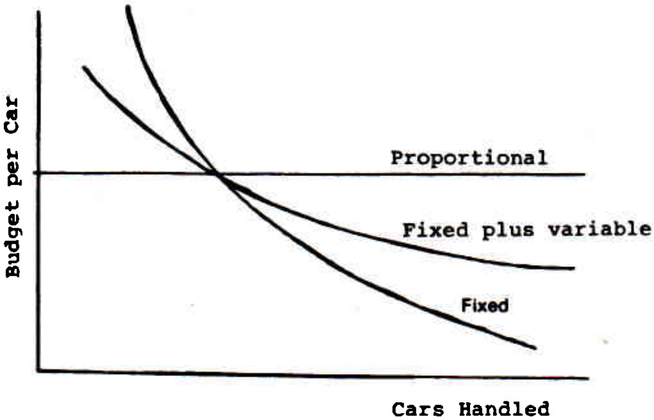
EXHIBIT 1

COMPARISON OF FIXED, PROPORTIONAL AND FIXED PLUS VARIABLE BUDGETS

a. Total Budget



b. Budget per Car



from MIT to the railroad. Once the railroad purchased the same microcomputer, computer programs and data could easily be interchanged on diskettes. From the railroad's perspective the managers could bypass the Management Information Systems (MIS) Department and all the bureaucracy and writing involved in starting up a new project on the company's mainframe computer. Since a large amount of modifications and refinements to the programs would have to be made, it would be advantageous to be operating outside of the MIS Department. The microcomputer could also be placed in the field on either a temporary or permanent basis. In addition, the use of microcomputers would aid the MIT researchers in transferring their programs to other railroads sometime in the future.

Within the railroad the microcomputers would provide a non-threatening environment where non-computer literate managers could learn to use software packages in the privacy of their offices. An additional advantage of using microcomputers on the railroad extended beyond this project. Once the managers became comfortable with the microcomputers, they would look for other applications ranging from other research programs to non-research uses, such as word processing.

DEMONSTRATIONS: VOLUME-VARIABLE BUDGET FOR EAST DEERFIELD

The East Deerfield yard of the B&M was used as a case study to demonstrate the techniques of car cost budgeting and volume-variable budgeting. Prior to 1980, the Transportation Department's budget for individual yards included only labor expense, which was closely monitored together with train crew expense in the weekly "Payroll Control Report". Car costs were not included at all in any budget below the departmental level, nor were any budgets explicitly variable with volume at any level of the company. By February 1982, as part of this FCMP project, weekly expenses at East Deerfield were measured against a volume-variable budget that included car costs. The budget calculations were done by yard personnel using a Visicalc program in a microcomputer located in the yard office.

The volume-variable budget for East Deerfield included expenses in the following five categories:

(a) Yard Train & Enginemen (T&E) Labor cost: this category included the straight-time, overtime, and constructive allowances of the four-man switch engine crews, three-man switch engine crews, and utility men working in the yard,

(b) Fuel Cost: this category included the fuel used in switch engines working at the yard,

(c) Car Cost: the hourly costs of system, foreign, and private car detention at the yard (obtained from B&M's daily train connection reports, which showed the actual car hire for each car going through the yard),

(d) Other Weekly Labor Cost: this category included the costs of supervisory personnel, yard masters, clerks and other personnel working for the Transportation Department at the yard,

(e) Other Expenses: this category included telephones, paper, and other materials and services required by transportation personnel at the yard.

Microcomputer analysis of weekly expenses in these categories for the years 1980 and 1981, demonstrated that yard T&E and car costs were the only ones to vary on a weekly basis with the volume of cars handled at the yard, while fuel costs varied with the number of switch engine shifts worked. Other weekly labor cost and other expenses did not vary on a weekly basis, although they were reduced on a more permanent basis in response to a sustained drop in traffic volumes.

The volume-variable budget was implemented in a Visicalc program whose output is summarized in Exhibit 2. The first part of the report shows how the number of crews worked is estimated for each day of the week for inbound traffic volumes ranging from 1600 to 4000 cars per week. First, the weekly traffic volume is assumed to be distributed over the seven days of the week according to the distribution in the middle of the exhibit that is entitled, "fraction of weekly volume". For example, past experience had shown that 17.6% of the average weekly traffic arrived on Friday. The number of crews scheduled each day was then calculated using a simple formula of the form:

$$\text{Daily Crews} = a + b\ (\text{cars arriving})$$

In this formula, the fixed level of crews (a) is what is shown in Exhibit 2 as the "starting reference point," while (b) is shown as the "change in number of crews to be worked (day 1) per inbound cars (day 1)."

In creating the budget, the user provides values of (a) and (b) and the "fraction of weekly volume" and the program calculates the resulting number of crews to be worked. If (a) were set equal to zero, then the number of crews worked would vary directly with volume. If (b) were set equal to zero, then the same number of crews would work every day of the week. Values of these two coefficients could be chosen to reflect the desired performance of the yard in the future or they could be estimated based on a regression analysis of past performances.

EXHIBIT 2

1982 WEEKLY VOLUME VARIABLE BUDGET
EAST DEERFIELD TERMINAL

CREW REQUIREMENTS

STARTING REFERENCE POINT (CREW PER DAY INDEP. OF VOLUME) 4.85

CHANGE IN NUMBER OF CREWS TO BE WORKED (DAY 1) PER:
INBOUND CAR (DAY 1)................................... .00291

MINIMUM CREWS PER DAY 3
MAXIMUM CREWS PER DAY 9

	FRI	SAT	SUN	MON	TUE	WED	THU	
FRACTION OF WEEKLY VOLUME	.176	.167	.098	.096	.135	.144	.182	
INBOUND VOLUME FOR WEEK	CREWS TO BE WORKED							CREWS FOR WEEK
1600	5	5	5	5	5	5	5	35
2000	6	6	5	5	5	5	5	37
2400	6	6	5	5	6	6	6	40
2800	6	6	5	5	6	6	6	40
3200	6	6	5	5	6	6	6	40
3600	6	6	6	6	6	6	6	42
4000	7	7	6	6	6	6	6	44

COST INFORMATION

YARD T&E LABOR COST

STRAIGHT-TIME COST PER FOUR-MAN CREW............................ 249.00
STRAIGHT-TIME COST PER THREE-MAN CREW........................... 165.83

FRACTION OF ABOVE BUDGETED FOR ADDED COST OF YARD T&E
OVERTIME............................ .04
CONSTRUCTIVE ALLOWANCES............ .17

COST PER UTILITY MAN PER TRICK.................................. 83.10

FUEL
GALLONS PER CREW 40
COST PER GALLON 1.13
HOURLY CAR COST .07

BUDGET FOR WEEK:

INBOUND VOLUME	STANDARD AVERAGE YARD TIME	TOTAL CREWS TO BE WORKED	SHORT CREWS TO BE WORKED	UTILITY MEN TO BE WORKED	YARD T&E LABOR COST	SWITCHER FUEL COST	CAR COST	OTHER WEEKLY LABOR	OTHER EXPENSES	GRAND TOTAL
1600	20.7	35	5	21	16024	2737	15366	19401	7183	60771
2000	20.7	37	5	21	16860	2893	19455	19401	7183	65804
2400	20.7	40	5	21	18135	3128	23330	19401	7183	71277
2800	20.7	40	5	21	18135	3128	27241	19401	7183	75166
3200	20.7	40	5	21	18135	3128	31133	19401	7183	79060
3600	20.7	42	5	21	18980	3284	35024	19401	7183	83953
4000	20.7	44	5	21	19824	3441	38916	19401	7183	88845

The bottom part of the budget adds the unit costs for four and three-man crews, utility men, fuel, and car-hours. Overtime and constructive allowances were budgeted as a fraction of the straight time crew costs. Two productivity indices were also used. The total fuel cost was calculated as the product of the hourly car cost, the standard yard time, and the inbound volume. In the example in the Exhibit, the same standard yard time was used for all levels of traffic volume, although this was not required by the program. The total volume-variable budget is shown at the bottom of the exhibit. Other weekly labor and other expenses were simply left constant for all levels of volume, while the other categories were calculated as shown above.

The car cost category is clearly the most variable budget item; for traffic volumes above 2000 cars per week, it is also the largest (Exhibit 3). At 3200 cars per week, roughly the average volume at the yard in mid-1982, car costs account for 39.4% of the budget compared to 22.9% for T&E labor, 24.6% for other labor, 4.0% for fuel and 9.1% for other expenses. Because of the high proportion of fixed budget items, the average budget per car declines from $38.12 at 1600 cars per week to $22.21 at 4000 cars per week (Exhibit 4). The marginal budget, however, is always less than $14.00 per car in this range of traffic volumes. Note that the budget could be made more or less variable for any or all of the budget items in order to reflect either corporate objectives or the operating capabilities of the yard.

The volume-variable budget was incorporated in a weekly two-page expense report for East Deerfield. The first part (Exhibit 5) is similar in concept to the first part of the budget (Exhibit 2), but uses the actual daily volume to calculate the budget. The report also shows the actual number of outbound trains for the yard and the actual and standard yard times for each day of the week. Note that standard yard times were established for each day of the week in a manner consistent with past performance at East Deerfield. The bottom part of the weekly expense report (Exhibit 5) is also modeled on the budget report (Exhibit 2). The major difference is that the weekly report shows the budget, the actual, and the variance of the actual from the budget for the actual volume handled during the week. The most important performance measures for the yard were then taken from the weekly expense report and incorporated in the summary of weekly performance that was reviewed by senior transportation department officers. These summary measures included the budgeted and actual figures for car time, the six categories of costs, and the total cost.

EXHIBIT 3
VOLUME VARIABLE BUDGET FOR EAST DEERFIELD

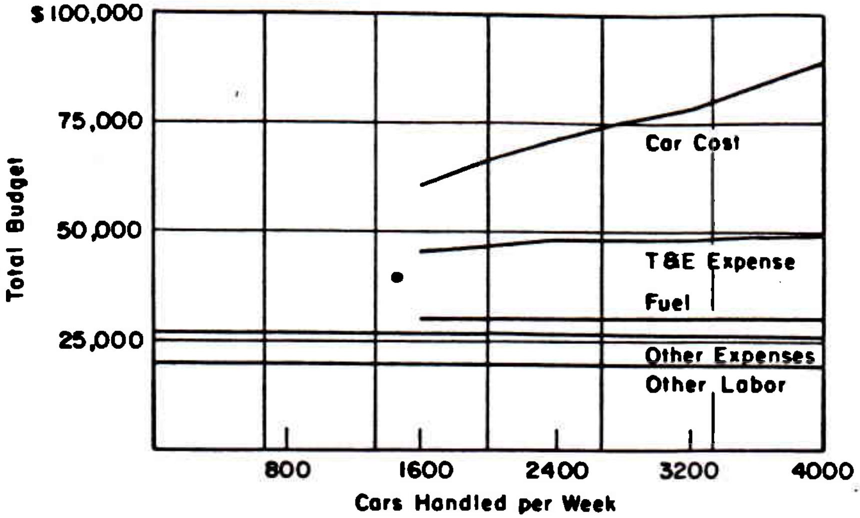


EXHIBIT 4
BUDGETED COST PER CAR FOR EAST DEERFIELD

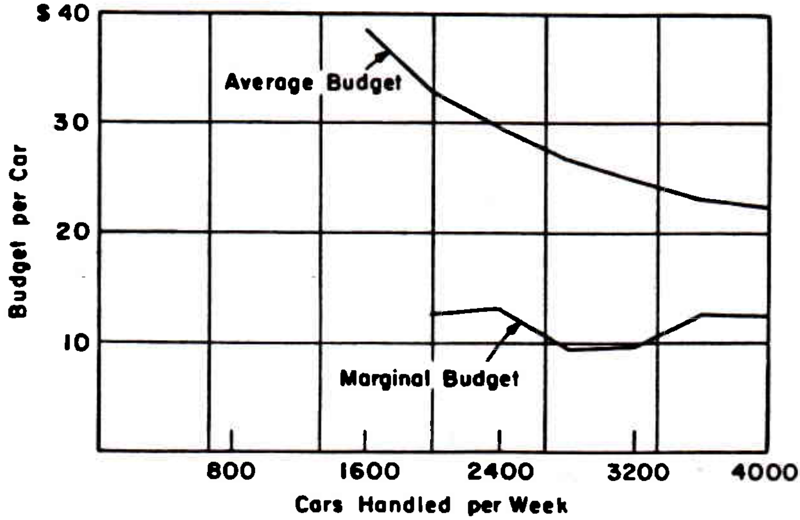


EXHIBIT 5

WEEKLY EXPENSE REPORT — TRANSPORTATION DEPT. — EAST DEERFIELD TERMINAL

STARTING REFERENCE POINT (CREW INDEP. OF VOLUME)	4.55
CHANGE IN NUMBER OF CREWS TO BE WORKED (DAY 1) PER:	
INBOUND CAR (DAY 1)	.00291
MINIMUM CREWS PER DAY	2
MAXIMUM CREWS PER DAY	9

	FRI	SAT	SUN	MON	TUE	WED	THU	WEEK
INBOUND VOLUME	500	554	306	345	424	444	502	3075
OUTBOUND TRAINS	16	19	10	14	14	14	11	89
AVERAGE YARD TIME:								
STANDARD	21.4	23.8	20.5	18.8	19.4	21	19	21
ACTUAL	20	21.9	18.6	15.6	16.3	20	17.8	19
CREWS: BUDGET	6	6	5	6	6	6	6	41
ACTUAL	6	6	5	5	6	6	6	48

BUDGETED VS. ACTUAL EXPENSES

FROM THIS WEEK'S PAYROLL CONTROL REPORT:	
TOTAL YARD T&E	16283
TOTAL PAYROLL	33604

	AVERAGE YARD TIME	CAR COST	TOTAL CREWS WORKED	4-MAN CREWS WORKED	3-MAN CREWS WORKED	UTILITY MEN WORKED	YARD T&E LABOR COST	OTHER LABOR COST	GALLONS OF FUEL	FUEL EXPENSE	OTHER EXPENSES	GRAND TOTAL
BUDGET	21	29954	41	36	5	21	18924	19481	2788	3206	7183	78748
ACTUAL	19	27328	40	38	2	20	16283	17317	3196	3675	7183	71787
DIFF	-2	-2626	-1	2	-3	-1	-2641	-2164	408	469	0	-6962
PCT DIFF	-9	-9	-2	6	-68	-5	-14	-11	15	15	0	-9

EVALUATION

A volume-variable budget was implemented at East Deerfield yard in February 1982 and used in parallel with the standard B&M budgeting system, which did not include car costs in the Terminal budget and was not volume-variable. The use of volume-variable led to better understanding of the impact of car costs and was one of the factors that resulted in improved terminal performances at East Deerfield.

The budget served three purposes: a) it focused attention of senior management at the terminal and at headquarters on something closer to total costs, b) it provided a more reasonable guideline for evaluating and predicting change in total costs in response to changes in traffic volume, and c) it promoted joint consideration of budget variance and service variance. The techniques incorporated into the new budget program and the weekly expense reports were more than adequate to achieve these objectives.

The ease of creating flexible reports and flexible budgeting techniques, made possible with the microcomputer, allowed B&M to put the reports in place, to test them, then to evaluate and modify them several times.

A problem centered around the collection, storage, processing and summarization of data on the several measures of yard performance used in the weekly performance report. The new reports were based upon data previously available only on a variety of computer-generated reports, manual reports, and clerical records. Collating this information and producing weekly reports proved somewhat complicated and burdensome for the people at East Deerfield. Since the purpose of the project was to demonstrate alternative budgeting techniques that could be transferred to other railroads, the researchers elected to minimize the implementation expense by using microcomputers, which further added to the burden of preparing these reports. In theory, future efforts could be more efficiently implemented using reports generated from the mainframe computer data base. This will be possible to the extent that management information systems become more flexible, so that managers at different levels of the organization can get information having the level of detail, the categories of data (car movement, switcher use, labor cost, fuel use, and overhead expense), and the desired periodicity (daily, weekly, and monthly). If a mainframe system is utilized, however, the budget analysis would still benefit from the flexibility afforded by microcomputers for analysis, for creating sample reports, and for quickly modifying the reports.

The major effort in implementation was the time required on the part of participants to set up the Visicalc programs, develop the relationships among measures of yard activity that served as the bases for the standards in the reports, and finally, modify both the reports and standards so that, by stages, everyone was satisfied with the reports. Approximately 20 man-months of MIT staff time went into this effort, including extensive theoretical work and even more extensive analysis of historical performance that would not necessarily have to be repeated for implementing a new system elsewhere. Approximately one man-month was required from B&M personnel during this development period. Also, B&M acquired microcomputers for headquarters and for East Deerfield at a total cost of about $12,000. Having these computers available allowed the researchers to avoid any mainframe computer expense and also allowed B&M to streamline their overall budgeting process for the transportation department.

Preparing the weekly report required approximately two hours of work each week on the part of a clerk at East Deerfield. Most of this time was spent in assembling the necessary data from a variety of sources, a task that involved some simple addition and subtraction of figures available in previously developed reports. The actual effort of entering less than 50 numbers into a Visicalc worksheet and running the program required less than 15 minutes. Taking the nine summary numbers off the weekly performance report and re-entering them in the weekly summary report to the vice president of transportation also required only a few minutes.

Updating the standards for average yard time, for overtime and constructive allowances, for fuel consumption, and for unit costs would require a day or two once or twice a year. Updating the volume-variability standards would require an additional day or two.

Unfortunately, despite the modest size of the effort required to produce the weekly reports and maintain the standards, this is an effort that fell upon the managers and the clerical staff of the transportation department, not upon the MIS department. Hence, as these people responded to other pressures and demands upon their time, they sometimes fell behind in producing the reports. One aspect to be noted is that the operating personnel, concerned with their immediate problems, do not derive any instantaneous benefits in solving "today's crisis" from taking the time to produce the weekly report. Consequently, in times of "crisis," which may be often, finding the time to prepare these weekly reports may become a low priority. This problem could eventually be solved by producing these reports routinely off the mainframe computer, which would first require the creation of computer files for a number of items that are now recorded manually or that are produced daily in hard copy, but not retained in machine-readable format.

Because of the above problems, the volume-variable budget and the related reports were not used after the termination of this demonstration project in mid-1982. However, based on periodic interviews with operating officials the project continued to have favorable impacts on East Deerfield and headquarters staffs, who continue to use volume-variable budget techniques informally. There was also more two-way communication and discussion between terminal and headquarters personnel, as Headquarters took a stronger interest in all aspects of yard performance and exerted pressure for improvements. As a result, the number of crews varied more with volume, and headquarters personnel listened more to terminal officers' perceptions of operating conditions and possibilities for improvements. At all levels in the Transportation Department there was more concern for car costs, total costs, and average yard times rather than labor costs, switch engines worked and the status of individual cars.

The introduction of microcomputers to demonstrate volume-variable budgeting techniques led to many other applications. By mid-1984, nearly a dozen microcomputers at B&M were utilized in an increasingly diverse set of uses. Since the mainframe computer did not readily perform graphics, managers stored data of immediate concern on the microcomputer where it could readily be used for graphics and statistical analysis using commercially available software. Other applications included the M.I.T. Service Planning Model (a network planning model designed to run on a microcomputer), train-delay programs, crew dispatching programs and, of course, wordprocessing.

CONCLUSION

This application produced mixed results. The volume-variable budget imparted a more comprehensive view of total costs of terminal operations, these ideas were useful to rail management apart from computerization per se. The case also reminds us of the problems which arise when data gathering and entry fall upon operating personnel who may not perceive as much benefit as more senior management. Integrating the microcomputer application with mainframe supported data bases would reduce the data compilation burden for terminal personnel.

But even in its experimental form, the case demonstrates how conceptualizing the problem for the computer brought new insight to rail management, and the presence of the microcomputer spawned interest in other applications which proved more permanent than the initial experiment.

FOOTNOTES

1. Rothberg, Sussman, and Martland, *The Design of a Management Control System for Railroad Freight Terminals*, MIT Studies in Railroad Operations and Economics, Vol. 27, p. 1, 1980.

2. Task Force on Car Cost Allocation and Budgeting, *Compendium of Railroad Car Cost Allocation and Budgeting Systems*, AAR Report No. R-531, August 1982.

3. Martland, Marcus and Raymond, *Improving Railroad Terminal Control Systems: Budgeting Techniques, Probabilistic Train Connection Analysis, and Micro-computer Applications*, MIT Studies in Railroad Operations and Economics, Vol. 37, July 1983.

4. For an example based upon B&M data, see C.D. Martland and W.J. Rennicke, "Unit Costs and Capacity Relationships at Railroad Terminals," Proceedings — Nineteenth Annual Meeting: Transportation Research Forum, Richard B. Cross Co., Oxford, Indiana, 1978, pp. 136-144.