different from that of the Houston CPI.

2. Inflated dollars. Costs are computed by using the inflation rates defined in Table 1. These costs, deflated by the Houston CPI, equal the 1982 dollar costs.

3. 1982 dollars, no incremental inflation. Costs include no inflation whatsoever and are based solely on the FY1982 base year unit costs, wages, and salaries. These costs can be considered as the costs to operate the FY2000 systems in 1982. Thus, these costs can be useful in comparing the model results with current transit industry experience (7).

Table 5 presents FY2000 employees for each alternative. These values are determined during the course of the cost model computations and are useful in explaining some of the differences in costs. In addition, they can provide guidance to management in the consideration of service expansion plans.

CONCLUSION

The transit operating cost model presented in this paper has several important features that make it a useful analytical tool for transit management. First, the model is rich in detail, capturing the cost effects of staffing levels, labor productivity standards, unit prices, and inflation for different cost components. Second, the model is user-oriented. It is formulated on the basis of data commonly developed in the budgeting process. Its responsibility center-based organization provides for both ease in comparing projections with current conditions and ease in updating various data values. Finally, the model can be applied either manually or on a computer. Simplified worksheets allow for organized computation. Both mainframe and microcomputer applications have been successfully performed.

There are fundamentally two potential applications of the cost model. For short-range planning, the model can be used in the budgeting process for quick-response sketch planning. It could be used in many of the what-if questions typically asked by management regarding the cost effects of alternative service changes or potential labor productivity changes. It can also be useful in the context of sensitivity analyses concerning rates of inflation or other unknowns.

In long-range planning, the model can apply current and anticipated cost experience to project operating costs in the financial and cost-benefit analysis of major capital investments. The cost model described in this paper provides a strong analytical foundation for multiyear analysis of transit investment in Houston, Texas. Other such applications should certainly be possible.

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Tri-Met Bus Operator Costing Methodology

JANET JONES

Traditional financial planning techniques are rapidly becoming inadequate as public mass transit confronts an environment characterized by limited and fluctuating revenues, funding shortfalls, and rising costs. The Tri-Met operator costing model is a part of a financial forecasting system approach toward the planning process in which short- and long-term consequences of alternative operating policies and performance can be determined. Tri-Met has drawn on past experience, research and review of existing methodologies, and future needs assessments to develop a costing methodology that combines the positive features of cost build-up and historical cost approaches and represents a sensitivity to the causal relationships underlying fixed and variable cost items at a marginal cost level. Bus operator costs are projected on a monthly basis over a six-year time frame as a function of service levels, service characteristics, work rules, productivity, and economic conditions. Common applications of the model range from service and scheduling changes to union labor contract provisions, assessments of part-time drivers, benefits, productivity, and absenteeism. The forecast technique has proved to be an invaluable tool of cost management and control, minimizing the risks involved in critical policy decisions.

Traditional financial planning techniques were sufficient tools of cost-revenue management when costs remained relatively stable and revenues were predictable and even sufficiently available. But growing complexities that characterize today's financial policy decisions require sophistication in planning, anticipating, and coping with financial uncertainties. Transit planning is increasingly complex due to demands to apply new and better tools for handling the dynamics of limited and fluctuating revenues, funding shortfalls, and rising costs. As a result, transit operators are directing greater attention toward cost effectiveness, efficiency and control, productivity, and performance analysis. It is fundamental to the responsibilities of transit operators to not only manage existing revenues and

Figure 1. Financial forecasting system.

REVENUE MODELS		COST MODELS	
INPUT	Revenue Line Items	Cost Line Items	INPUT
NON-CAPITAL REVENUES	Fare Revenues Tax Base Revenues Federal Operating Assistance (Section 5) Federal Technical/Demonstration Grants Miscellaneous (interest on investments, etc.) State Operating Assistance Other	Bus Operator Costs Other Transportation and Operations Costs Fuel Maintenance General and Administrative including pension cost and insurance and claims	OPERATING COSTS
CAPITAL REVENUES	Federal Capital State Capital Local Capital Other Local Assistance	Capital Costs: Vehicles, facilities and equipment Vehicle replacement Debt Service Project Scheduling Life-cycle Costing	CAPITAL COSTS
OUTPUT	SUMMARY STATISTICAL REPORTS SUMMARY FINANCIAL FORECAST REPORTS		OUTPUT

cultivate new resources but also to better anticipate, monitor, and control costs.

Although there are many types of approaches applied to address these needs, financial forecasting provides a forward-looking economic planning tool. It steps beyond the customary budgeting process--financial forecasting in its most basic form--to assess the often profound financial implications of certain courses of action. And, unlike budgeting, it captures a consideration of the real causes and consequences underlying many revenues and costs. This is especially useful when incorporated into the planning process to assist in shaping and evaluating alternative plans and policies. However, because costs and revenues are controllable only within certain limits, financial forecasting can bring about a greater awareness of marginal cost-revenue impacts of alternative policies and the extent to which they are within management control.

It is difficult to measure the usefulness of financial forecasting. Recognizing, however, that transit reaps the result of decisions and not the result of plans, financial forecasting is effective in increasing the opportunities for making better (or at least better-informed) decisions and minimizing the risk of making a poor decision. It can be an invaluable interface between the planning process and the decisionmaking process.

FINANCIAL FORECASTING SYSTEM

Tri-Met faces a continuing need for accurate, timely financial projections that are readily responsive to policy issues. Answering this need, Tri-Met has made strides toward the development, improvement, and application of forecasting for use in the financial planning process and in program planning, including an automated version of a bus operator costing technique, which is discussed in this report.

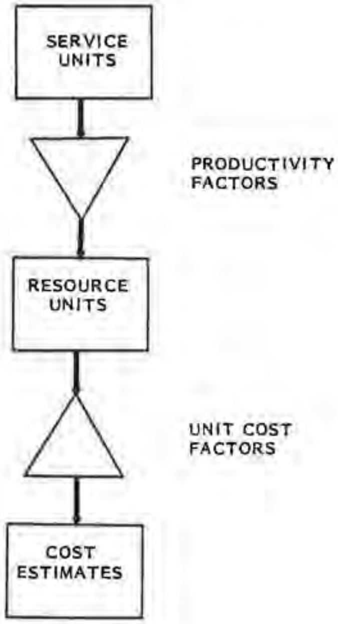
The financial forecasting system is composed of a set of models and a planning structure. The planning structure serves as an analytical framework within which the models reside. Financial forecasting is the process in which a number of techniques, or models, which share a common data base, calculate future costs and revenues in terms of cash flow. Each model, supported by one or more subprograms, forecasts a distinct segment of costs or revenues within the comprehensive system structure. (See Figure 1.)

The concept behind this modular approach is to achieve a great deal of flexibility for testing what-if kinds of questions that require varying appropriate levels of detail. For example, a six-year cash flow annual summary report may be desired, requiring application of all of the cost and revenue models, or any model can be run individually if a monthly breakdown of detailed departmental line item costs is required.

The models represent mathematical relationships between cost-revenue items and a simulation of cause and effect. The causal factors are input data (independent variables) and the effects are the cost and revenue output (dependent variables). Results of the models are calibrated to match observable data and validated against available historical data.

The planning structure provides an organized method to input, access and analyze data and control parameters, and specify output reports. The structure contains a multioption variable processor, coded in FORTRAN, which incorporates such features as parameter-driven inputs and built-in default values. It allows flexible interpolation of missing values and extrapolation of input data on growth-inflation factors. It facilitates input data file editing and labeling capabilities. Reporting is

Figure 2. Financial forecast model structure.



allowed at various levels of detail and aggregations may be made on a quarterly or annual basis from monthly projections.

These features were developed in light of several characteristics that were considered desirable attributes in a financial forecast system. Flexibility was a high priority because in setting up a system, one cannot hope to predetermine all requirements. Therefore, the system was structured to allow for model changes and enhancements as development proceeded. It was also recognized that the system should be relatively simple to work with from a user standpoint. The models were built within a framework designed to accommodate a variety of input options, built-in default values, and convenient data interpolation-extrapolation features with a modular format that will permit independent subroutines for testing or future enhancement. Another requirement was sensitivity within the models to small changes at a marginal cost level. This is especially useful where a change in assumptions might make a difference, but it is not clear how much difference it might make. Perhaps the most important attribute to be considered was the value of the system in application. The system has been successfully applied in policy alternatives analysis for major decisions at Tri-Met. It has provided quality information that has minimized the risks involved in critical policy issues.

TRI-MET APPROACH TO BUS OPERATOR COSTING

Organization of Bus Operator Model

The bus operator costing model was designed to provide detailed, accurate financial information that would reflect sensitivity to operational policy and performance changes at a marginal cost level and would also capture the primary interrelationships among fixed and variable costs and their causal factors. With expanding applications ranging from service and scheduling changes to union labor contract provisions, assessments of part-time drivers, benefits, productivity, and absenteeism, it became clear that overly simplified techniques were not only inflexible, but inadequate as well. Tri-Met has drawn on past experience, research and review of existing methodologies, and future needs assessments to develop costing techniques.

The methodology of the model combines the positive features of cost build-up and historical cost approaches. The unit cost build-up approach is used to develop labor requirements based on service characteristics (e.g., peak to base ratio, service hours, and miles). The historical cost approach is used to develop labor cost factors per productivity unit (e.g., extraboard, work rule constraints, supervision, fringe, etc.) based on historical data. The historical cost approach captures the inefficiencies of exception pay, replacement labor costs as a function of absenteeism, and some work rules under existing conditions. However, it does not achieve the sensitivity to costs incurred due to major changes in service and operating characteristics, which is better accomplished by the cost build-up approach.

The bus operator model represents a dynamic costing technique designed to project future costs as a function of service level, service characteristics, work rules, productivity, and economic conditions. The model is initially driven by daily-level service hour input and further responds to any alterations in the type of service such as changes in the peak to base ratio, adjustments in weekday versus Saturday or Sunday service, or a shift from urban radial to time transfer service. Productivity factors reflect the efficiency of service provided in terms of ratios between service hours, platform hours required to support a particular service level, and operator pay hours required to assure to certain reliability at that service level.

Underlying the operator cost component calculations are assumptions that reflect work assignment provisions such as extraboard rules, constraints on the use of part-time drivers, and specifications for wage rates, cost-of-living adjustments, and benefits. Productivity assumptions take into account absenteeism, extraboard requirements, and unscheduled overtime. Based on the number of scheduled operators, additional operators are figured in to cover absence exceptions such as sickness, vacations, holidays, and other miscellaneous absences. This is achieved by applying various productivity factors, efficiency ratios, and unit costs to derive total operator requirements and direct labor costs. Finally, economic assumptions impact variable overhead costs including benefits and pension and payroll taxes.

Structure of Model

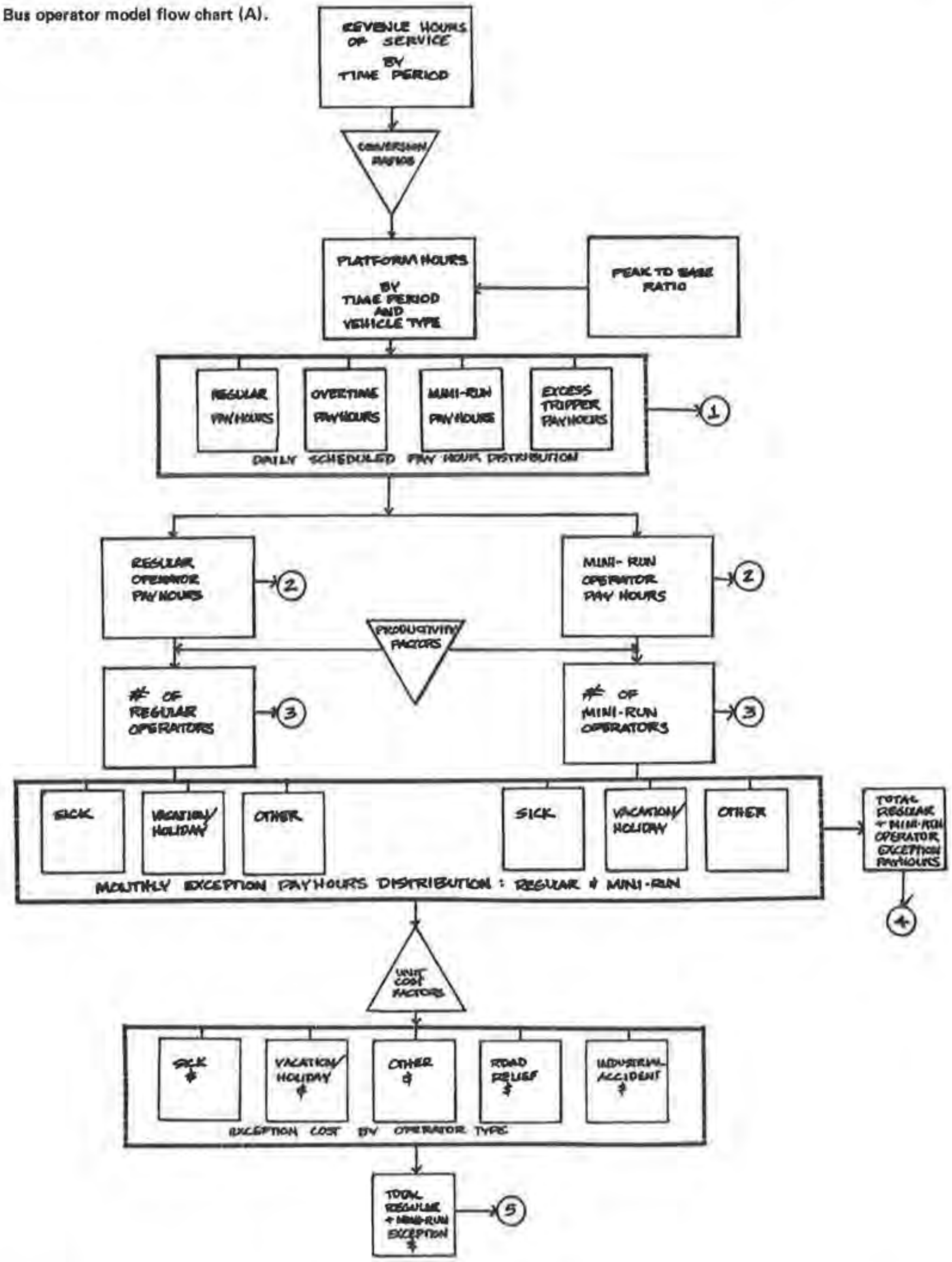
The bus operator costing process is structured in a hierarchical manner, starting from basic service units (service hours, miles, and vehicles) and working back to resource units (consumable items for which the transit operator must pay directly such as labor hours). The conversion from service units to resource units is accomplished through a series of productivity factors (such as pay hours per platform hour) that are based on primarily historical experience of Tri-Met and other transit operators. Once resource units are derived, they are converted to expenditures by applying (unit) cost factors. This general process is illustrated in Figure 2.

The bus operator costing model is divided into eight principal sections. These are discussed in sequence in this section, supported by flow chart diagrams (Figures 3-5).

Variable Declaration and Identification

Variables are processed primarily through the main program. All variable arrays are identified, in-

Figure 3. Bus operator model flow chart (A).



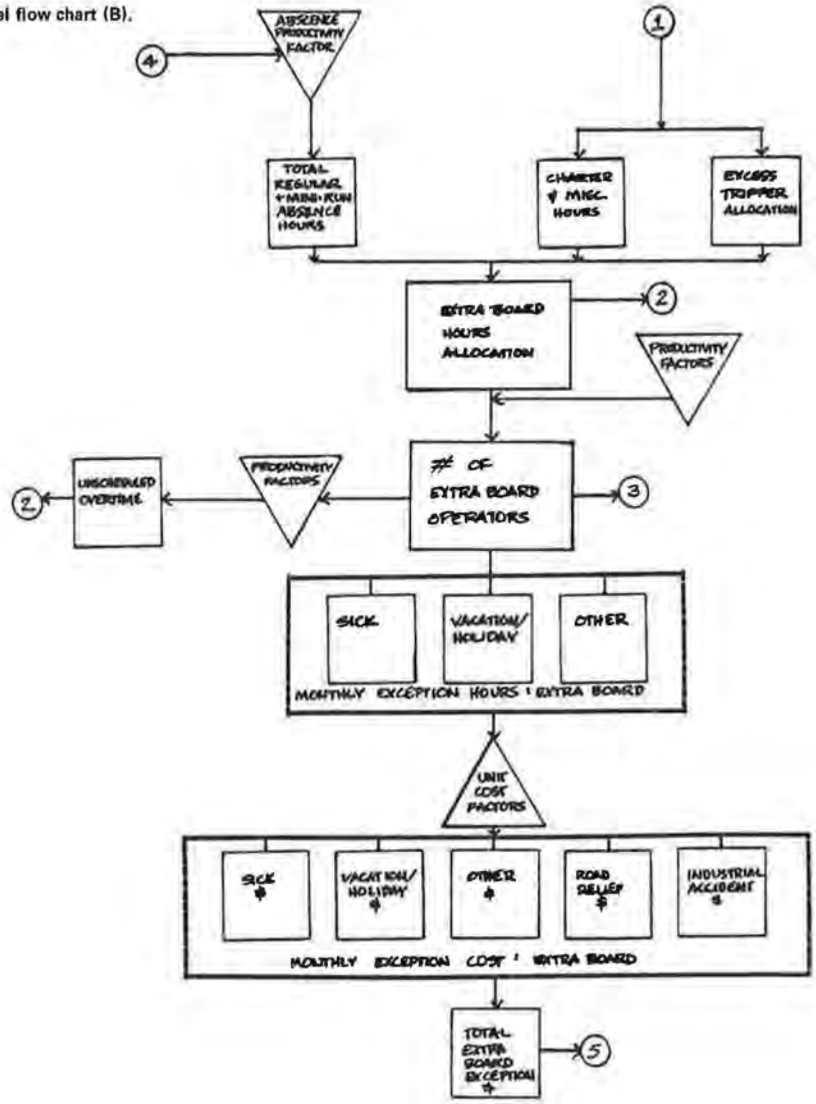
dexed, and declared as integer or real and are passed through the bus operator model using COMMON statements. The variables are input through a separate data file.

Program control parameters are input through the FORTRAN NAMELIST function. "&PARAM" is used to set the base year of the projections and "&SELECT" is used as a report parameter and contains arrays to control the output reports. The values assigned to these arrays call the appropriate subroutines, such as the bus operator model, and specify the desired output report.

Input/Computational/Output Variables are separated into two types of variables. The first type of variable includes time-based monthly data such as growth rates, unit cost factors, and operations costs. Each has a capacity for 72 time periods and is categorized by variable function. Each variable also is associated with a 20-character variable label and a 12-character units label, and it can be tied to a 12-digit accounting code. The second type of variable is characterized by changes that do not occur on a monthly basis, such as service levels and productivity factors. These values may be input with up to only nine changes, although they are calculated on a monthly basis.

Both types of variables require a label card that performs three functions. First, it simply defines the variable. Second, it designates an appropriate interpolation-extrapolation code to be performed on the variable, and third, it indexes the variable labels to correspond to the data cards.

Figure 4. Bus operator model flow chart (B).



Initial Input Data

The basis of all future cost estimates is the description of the future alternative transit service networks. These are quantified through the computerized simulation urban transportation planning system (UTPS) program, INET. This process converts the basic network description (route alignments, headways by time interval, running times, and layovers) into estimates of service units (revenue service miles, hours, and vehicles by time period by mode). The output must be refined to reflect actual conditions through several steps. Since INET is not a perfect simulation tool, evening peak and daybase statistics require adjustment by using calibrated factors: pure revenue hours (no layover)--peak, 0.80 and daybase, 0.99.

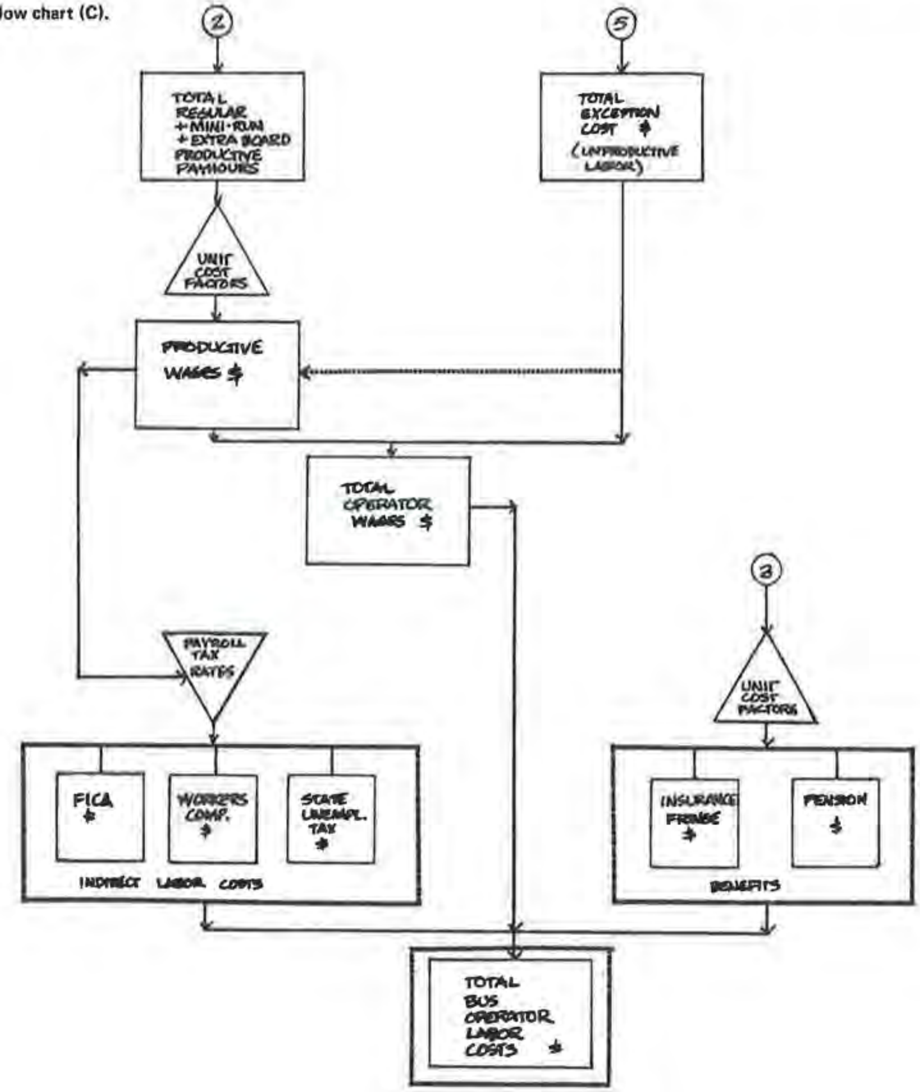
To derive "pure" revenue hours for all service periods in agreement with an actual run cut, as performed by RUCUS, INET/RUCUS conversion factors are applied. This is done in order to eliminate layover time included in the INET revenue hours summaries and to adjust systemwide statistics to realistic figures. (Assumed service period factors are shown in Figure 6). RUCUS simulations would yield more precise figures than INET, but RUCUS is data-intensive and quite difficult to use as a forecasting tool. The need for INET can be substituted by a SAS simulation, used to determine vehicle and service hour estimates of service changes.

Data availability can be a problem when estimating potential changes in service levels or service characteristics, so the program is constructed to handle several input options. Flags are used for indication of the desired input entry level. For example, if service hour data are unavailable for the evening peak and daybase, total weekday hours may be input instead. Input can be any of the following combinations: (a) weekday evening peak and daybase revenue hours; (b) weekday revenue hours; (c) weekday, Saturday and Sunday revenue hours; (d) weekday, Saturday and Sunday revenue hours plus weekday, Saturday and Sunday articulated bus revenue hours; or (e) weekday, Saturday and Sunday platform hours.

INET produces revenue hour figures in terms of the evening peak and daybase service levels. After these figures are factored to reflect actual conditions, the assumed service factors are employed to develop total weekday service levels from evening peak and daybase figures.

Non-peak weekday revenue hours are derived as a function of the daybase. Peak weekday revenue hours are derived as a function of the evening peak. The sum of weekday peak and non-peak revenue hours represents total weekday revenue (in service) hours.

Figure 5. Bus operator model flow chart (C).



Saturday and Sunday revenue hours are derived as functions of total weekday revenue hours.

Platform time, which includes hours of scheduled service operated (revenue hours) plus deadhead and layover time, is calculated in the next step of the process. No overtime, guarantee, or report-clear time is included. The conversion from revenue hours to platform hours requires ratios applied on the basis of the weekday, Saturday and Sunday relationships between total daily platform hours and daily revenue hours. The ratios, which account for deadhead and layover time combined, average about 1.32 under present service conditions:

Item	Weekday	Saturday	Sunday
Layover	0.20	0.26	0.27
Deadhead	0.12	0.04	0.07
Revenue	1.00	1.00	1.00
Total	1.32	1.30	1.34

The composition of these ratios in terms of proportion of layover and deadhead varies by time period as well as by weekday, Saturday and Sunday. This relationship for weekday service is shown in Figure 7.

Layover is a function of running time and remains fairly constant throughout the day. Deadhead is a function of peak service during the day and amount of tripper service. The proportion of deadhead time increases at the beginning and the end of each concentration of service hours as drivers begin and end their runs, and remains at a minimum during peaks of service. Whereas non-peak revenue hours include all service outside the morning and evening peaks, platform hours falling in the non-peak time periods include not only deadhead and layover time for off-peak service but also deadhead time for service that is provided during the peak. Consequently, in order to accurately evaluate the cost of peak service (and assess the portion of platform hours falling in the off-peak associated with service during the peak), it is necessary to allocate a cumulative portion of the off-peak deadhead to the peak revenue hours.

In comparing weekday, Saturday and Sunday hours, there is a higher proportion of deadhead time on weekdays than on Saturdays and Sundays because of the nature of tripper service that provides service exclusively to the peaks. Trippers, operating only on weekdays, have a high ratio of deadhead to layover time. Straight shifts, which generally involve a much greater number of repeated runs, have a larger proportion of layover time and a smaller proportion of deadhead time as compared in Figure 8. Additional comparisons of platform hour components revealed that although a low peak to base ratio is

Figure 6. Service period factors.

Period	Time Interval	# Hours		Factor	1980 Service Hours	1980 Service Hours/Hours
Wee Hours	1:00 - 5:00 A.M.	4.0	X	.05 X Midday	39.3	9.8
A.M. Shoulder #1	5:00 - 7:00 A.M.	2.0	X	.42 X P.M. Peak	301.9	151.2
A.M. Peak	7:00 - 8:00 A.M.	1.0	X	1.00 X P.M. Peak	359.4	363.8
A.M. Shoulder #2	8:00 - 10:00 A.M.	2.0	X	.71 X P.M. Peak	510.3	254.8
Midday (Base)	10:00 - 2:30 A.M./P.M.	4.5	X	1.00 X Midday	883.3	196.3
P.M. Shoulder #1	2:30 - 4:30 P.M.	2.0	X	.75 X P.M. Peak	539.1	271.1
P.M. Peak	4:30 - 5:30 P.M.	1.0	X	1.00 X P.M. Peak	359.4	359.4
P.M. Shoulder #2	5:30 - 7:30 P.M.	2.0	X	.70 X P.M. Peak	502.7	250.6
Evening	7:30 - 1:00 P.M./A.M.	5.5	X	.41 X Midday	442.6	80.1
		24.0			3,938.0	

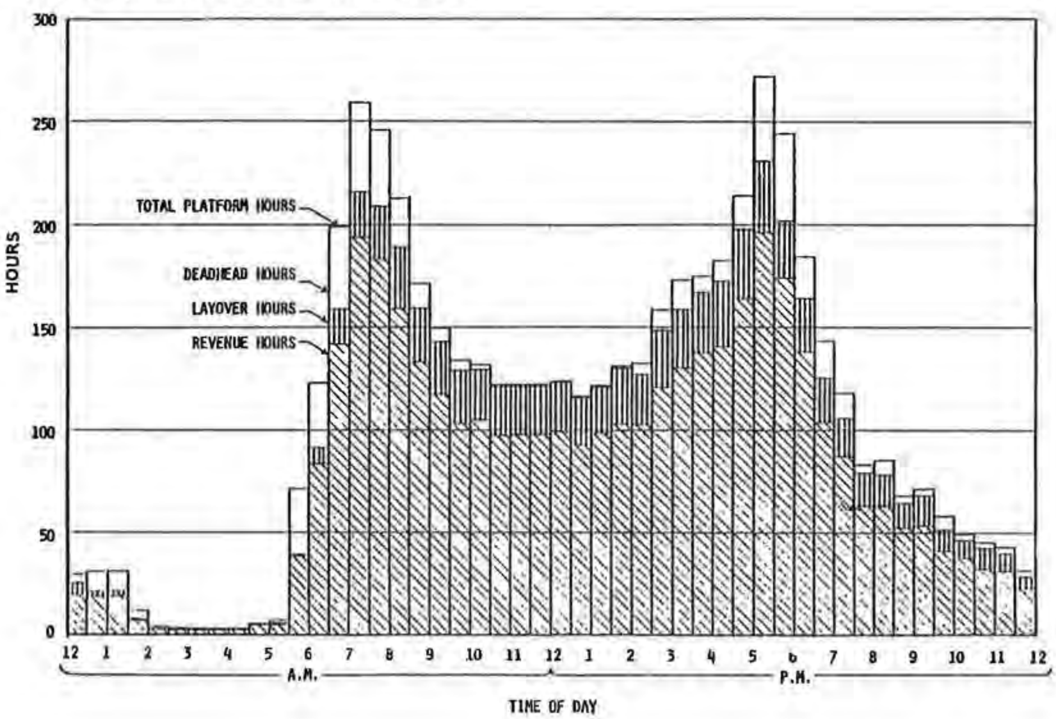
Total Daily Revenue Service Hours = 6.95 X Midday + 7.16 X Peak
= 6.95 X 196.3 + 7.16 X 359.4 = 3,937 hours

Total Saturday Revenue Service Hours = 9.62 X Midday = 9.62 X 196.3 = 1,888 hours

Total Sunday Revenue Service Hours = 5.10 X Midday = 5.10 X 196.3 = 1,001 hours

Total Annual Revenue Service Hours = 2,568 X Midday + 1,926 Peak

Figure 7. Comparison of platform hours to revenue hours.



associated with a large proportion of layover time, a higher ratio is characterized by a small proportion of layover and greater deadhead requirements as shown in Figure 9.

Scheduled Pay Hours

From daily platform hours, scheduled pay hours, which represent the hours required to operate the platform service, are derived. They range up to 110 percent of scheduled platform time, accounting for union work rules and provisions involving report-clear and overtime pay.

The reciprocal ratio of platform time to scheduled pay hours serves to identify the percentage of scheduled operators pay that applies to productive platform service. This efficiency factor generally ranges from 90 to 91 percent. The RUCUS programming system strives to optimize the various runs within the work rules for the best efficiency and thus the lowest system cost per platform hour.

In converting from platform hours to pay hours, the peak to base ratio is incorporated into the model in order to account for its relationship between regular scheduled pay hours, scheduled overtime pay hours, and minirun (tripper service) pay hours. As a function of the peak to base ratio, the allocation of these pay hours can be determined as shown in Figure 10. The peak to base ratio is found on the horizontal axis and the percentage of total pay hours along the vertical axis.

Currently at Tri-Met, 14 percent of the number of existing full-time operators are employed as minirun operators. At the current 2:1 peak to base ratio, there are 180 trippers worked by minirun operators, comprising 7 percent of total pay hours. Beyond a 2:1 ratio, minirun trippers remain constant at the maximum allowable level, and unassigned (open) trippers occur. For each 15 additional trippers, there is a corresponding 1 percent increase in overtime pay hours. As shown in Figure 10, as the peak to base ratio increases, especially beyond 2:1, the proportion of overtime and open trippers continues to increase and the proportion of regular pay hours declines. Weekday, Saturday and Sunday scheduled pay hours are interdependently assigned in the model based on the weekday peak to base ratio in order to reflect these relationships.

At this point in the model, daily platform hours are converted to total weekday, Saturday and Sunday pay hours per quarter. They are then aggregated to sum quarterly (a) regular operator pay hours, (b) scheduled overtime pay hours, and (c) scheduled minirun pay hours. These quarterly pay hours take

Figure 8. Straight shift and tripper platform time.

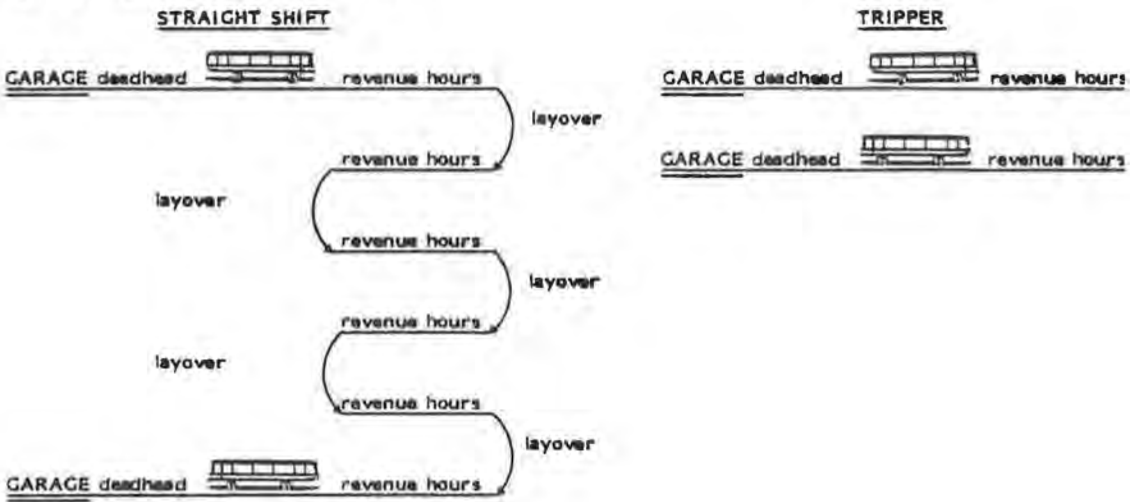


Figure 9. Effect of peak to base ratio on platform hour ratios.

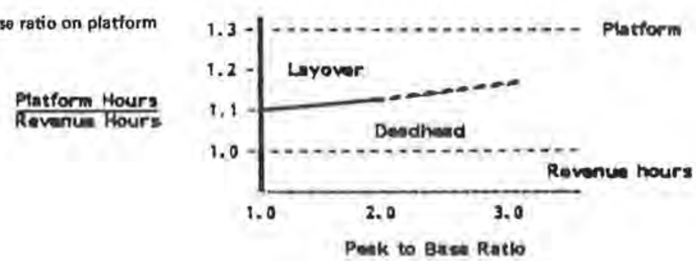
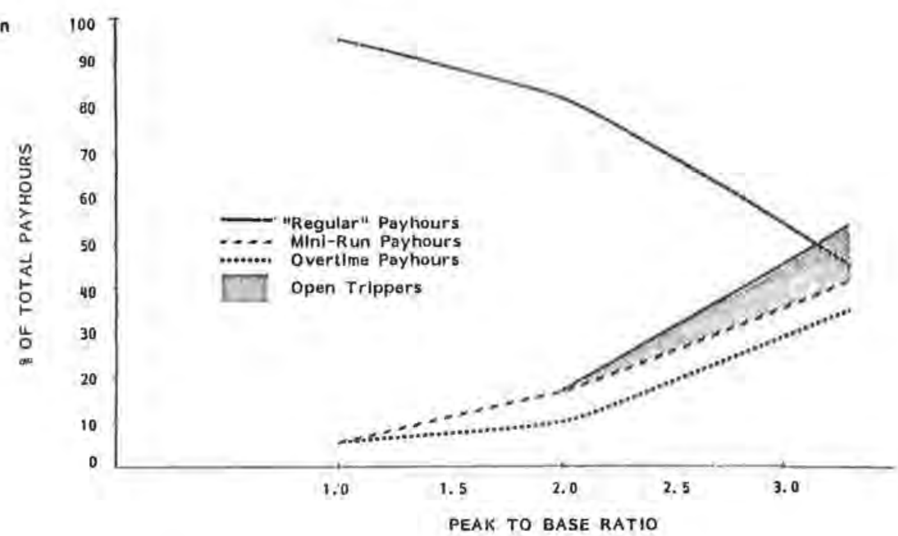


Figure 10. Proportion of payhours as a function of the peak to base ratio.



into account all of the scheduled pay hours required for scheduled service.

Operator Requirements

Regular and Minirun Operator Requirements

The number of regular operators required is based on a weekly aggregated number of scheduled regular operator pay hours plus overtime pay hours that exceed the 8-h limitation. Similarly, weekly scheduled minirun pay hours determine the number of minirun operators required. The number of minirun operators is limited to 14 percent of the number of full-time operators, however, by current union contract provisions. Should the number of minirun pay hours dictate a requirement of minirun operators in excess of this limitation, the "unassigned trippers" are allocated to regular operators.

Regular and minirun drivers perform work that is assigned to them, according to their preferences, exercised on the basis of seniority, through periodic "sign-ups". These individuals sign up for various runs as well as two days off per week and vacation or holiday time. A considerable portion of transit service cannot be assigned in this manner, however, and there is also service (although unassigned) that must be filled due to scheduled operator absence. It is the function of vacation relief and the extraboard to meet these needs on a day-to-day basis. Minirun drivers are never allowed to perform work on the extraboard.

Regular Operator Exception Pay Hours

Exception pay hours include all of the paid "nonproductive" hours of labor. Exceptions consist of three major categories: (a) sick, (b) vacation and holidays, and (c) other exceptions that include jury duty, accident reporting, funeral leave, student training, and operators in other positions. The sick exception calculation incorporates measurement of cost savings due to changes in the rate of absenteeism. Costs of road relief and industrial accidents are calculated using a unit cost-per-operator.

Minirun Operator Exception Pay Hours

Although minirun operators are now eligible for only a small portion of exception pay, the calculation procedure is the same for minirun operators as for regular operators. This enables testing of costs associated with potential proposals liberalizing these benefits and easily accommodates future changes.

Minirun operators are eligible only for student training, industrial accident, and accident reporting exception pay. They become eligible for holiday pay (on a pro rata basis based on hours worked) after one year and, with two years of service, become eligible for pro-rata vacation pay.

Extraboard Operator Requirements

The extraboard work assignment process is complex as it is responsible for meeting a variety of needs. There are runs, portions of runs, or pieces of work termed "open" work, which cannot be assigned because they do not fit within the work rule constraints. This occurs, for example, if trippers exceed the 60:40 ratio of "straight" to "split" runs, or if there are too many trippers to be worked exclusively by minirun operators. There are runs that become open between sign-ups due to promotion, retirement, termination, or long-term disability. There are reliefs to be provided for supervisors, dispatchers, operating clerks, and time for "breaking in" operators to be able to relieve these positions. There are special services that arise such as charters and overloads. There are regularly assigned runs that must be filled due to sickness and absence on the part of regular and minirun operators. The extraboard fills in for more than just their exception pay hours--in fact, there is up to 60 percent additional unpaid exception time beyond paid exception hours. There are exceptions on the part of the extraboard operators to be allowed for as well. There is the added premium of unscheduled overtime that varies according to the size of the extraboard.

In order to include these points in the calculation of extraboard sizing, the initial hours-per-operator procedure relies on the input of average quarterly charter hours, excess tripper hours (if not allocated to regular operators and cannot be met by minirun operators), and regular and minirun operator exception hours that are factored to reflect unpaid absences as well as paid exceptions.

Extraboard Operator Exception Pay Hours

In order to account for extraboard operators exception hours to be covered, the exception pay hour procedure is followed. It is assumed that extraboard operators have the same rate of exceptions (factors) as the regular operators. On deriving the total extraboard exception pay hours, this figure is factored to account for unpaid exception hours and then added to regular and minirun exception hours. The sum equals total paid and unpaid exception time for all part-time and full-time operators.

Extraboard Operator Unscheduled Overtime

Unlike regular and minirun operators, extraboard operators are assigned their work on a day-to-day basis. On the previous day, a list of the extraboard operators and their preassigned work for the next day is posted. Also, operators are assigned to report at various time intervals on the given work day as final adjustments are made to the work assignments. When the demands on the extraboard become particularly heavy, extraboard operators are first contacted to report back and stand by for additional work, then those on a regular day off are asked to come in, and, finally, regularly assigned operators who have either completed their regular work or are on a regular day off. When this occurs, costs expand to include a minimum guarantee of eight hours of pay, plus report time and any unscheduled overtime, at overtime rates for all operators called in on a regular day off. Alternatively, maintaining an abundance of extraboard operators requires a minimum guarantee of eight hours pay, five days a week, as well as fringe benefits, payroll taxes, and other variable overhead costs for each additional extraboard operator.

Enlarging the extraboard, while reducing unscheduled overtime and increasing guarantee time, assures an available supply of operators for work assignments that would otherwise be handled by unscheduled overtime or missed entirely. The benefits derived from increasing service reliability must be balanced against the high overhead costs of additional operators. To accurately simulate an ideal extraboard size that minimizes cost would require a submodel to address such issues as optimization, given the trade-offs between guarantee time and overtime; optimal size of the report crew, given probabilities of absence patterns on a daily basis; and sensitivity of extraboard costs to changes in absenteeism, work rules, and schedules. Such a submodel, currently under development, will serve to greatly enhance this costing technique and will be accommodated as more data and resources become available. The costing model bridges these considerations by using productivity factors based on historical data to derive total unscheduled overtime.

Wages

Total operator wages are separately calculated for productive labor that includes straight time, scheduled and unscheduled overtime and premium pay, and for unproductive labor that consists of the total of all exception pay. Regular straight time labor includes wages paid to regular operators, minirun operators, and extraboard operators. These "regular" extraboard hours consist of the paid and unpaid exception hours of regular and minirun operators. Note, however, that extraboard exception hours are not included as part of "regular" extraboard hours because extraboard operators do not have regularly scheduled pay hours requiring specific replacement by another operator. Because extraboard requirements are a function of exceptions and not exclusively a service level, it is clear that if the exception rate improved, fewer extraboard operators would be required. Overtime labor includes scheduled overtime worked by the extraboard. Premium pay includes an additional $0.50/h for time spent driving an articulated bus. The components of total driver pay hours follow: regular operator scheduled pay hours, regular operator exception pay hours, regular operator scheduled overtime pay hours, extraboard "regular" pay hours, extraboard exception pay hours, extraboard unscheduled overtime pay hours, minirun operator scheduled pay hours, minirun operator exception pay hours, articulated bus scheduled platform hours, exception wages--regular operators, exception wages--extraboard operators, and exception wages--minirun operators.

In order to derive total regular operator productive wages, the model first sums regular operator scheduled pay hours and scheduled overtime. This represents total regular operator scheduled pay hours. Regular operator exception pay hours must be subtracted from this to separate out the unproductive pay hours. The ratios of scheduled regular-scheduled overtime pay hours to total scheduled pay hours are then applied to split the correct proportions of regular and overtime pay hours. The scheduled overtime pay hours are then multiplied by 1.5 times the pay rate. Both regular pay hours and overtime pay hours are then multiplied by the appropriate wage rate to derive total regular operator productive wages.

Minirun total scheduled pay hours are separated according to the productive and nonproductive pay hours by subtracting the exception pay hours. Productive pay hours are then multiplied by the appropriate wage rate to derive total minirun productive wages.

Extraboard pay hours consist mostly of "regular" pay hours, comprised of the regular operators' and minirun operators' scheduled pay hours that are not worked due to a variety of exceptions. There also exist unscheduled overtime pay hours that result primarily due to variations in the sizing of the extraboard, depending on the number of extraboard operators available to perform the work at straight time. The number of unscheduled overtime pay hours is multiplied by 1.5 times the pay rate. Both the productive "regular" pay hours and overtime pay hours are then multiplied by the appropriate wage rate to derive total extraboard operator productive wages. Exception wages calculated for regular, extraboard, and minirun operators are combined to sum total exception (unproductive) wages.

All operators receive an additional $0.50/h for time spent driving an articulated bus. Total articulated bus platform hours are derived from articulated bus revenue hours, the multiplied by the premium pay rate.

Fringe Benefits

Fringe benefits include the cost to Tri-Met of providing life, medical, and dental insurance and a pension plan to its employees. Operator pension costs (which are expensed as defined by a standard actuarial study) are based on a cost-per-operator factor, multiplied by the number of regular and extraboard operators. Other bus operator fringe costs are determined by the total number of regular and extraboard operators and the small number of eligible minirun operators, multiplied by a cost-per-operator figure for life, medical, and dental insurance coverage. The sum of these costs equals total bus operator fringe cost, yielding nearly a 12 percent additive to the cost of operator wages.

Indirect Labor Costs

Indirect labor costs include employer-paid overhead costs of payroll taxes including Social Security, workers' compensation, and unemployment compensation. A tax rate (currently 0.0670 percent on a taxable base of $32 900 annual individual income) is applied to total labor costs to determine Social Security taxes. The rate of taxation is subject to escalating changes as shown in the current Social Security Administration's schedule as past, present, and proposed rates, shown below:

Year	Taxable Base ($)	Rate (%)
1980	25 900	6.13
1981	29 700	6.65
1982	32 900	6.70
1983	33 900	6.70
1985	38 100	7.05
1987	42 600	7.15

Maximum tax levels are established each year in association with the above bases and rates and are also subject to change. Workers' compensation is similarly calculated by applying a tax rate to total labor costs, excluding vacation and merit bonus pay. (Unemployment taxes are paid on an individual basis, rather than as a taxable rate paid to the State of Oregon. The cost model simplifies this calculation by applying an average cost-per-operator factor to the number of operators. Total indirect labor costs represent approximately an 11 percent additive to total wages.

Output

Report output is specified using the "&SELECT" option in the main program. Optional informational reports are available including a distribution of weekday, Saturday and Sunday pay hours, a breakdown of operator requirements by type, and exception pay hours and costs by operator type. Final reports can be printed showing monthly, quarterly, and/or yearly costs. Variable and data listings are also available. Output report options include operator statistical reports--distribution of weekday, Saturday and Sunday pay hours, operator requirements, distribution of exceptions by operator type; and bus operator cost reports--monthly, quarterly, and annual.

Figure 11. Sample financial forecast.

NON-CAPITAL
COST REDUCTION REDUCED/DEFERRED CETIP

	FY 81	FY 82	FY 83	FY 84	FY 85
NON-CAPITAL REVENUES					
Farebox Revenues	19029	19990	23338	26978	29098
Other Operating Revenue	1041	2025	1664	2031	1631
Payroll Tax	34965	37820	40701	45760	50950
State Operating Revenue	---	1000	1100	1150	1200
Federal Operating Assistance	5890	5890	3877	1994	---
Federal Tech/Demo Assistance	1566	1300	100	100	100
Miscellaneous	(12)	---	---	---	---
Interest	2319	2100	1900	1600	1200
New Revenue Source					
TOTAL NON-CAPITAL REVENUE	64798	70125	72680	79613	84179
NON-CAPITAL COSTS					
Bus Operators	25710	29569	31772	32854	35517
Fuel	4944	5415	6312	7157	8139
Maintenance	11178	12911	13904	15085	16489
Operations Adm/Support	5940	7278	9628	10694	12046
General & Administrative	11137	12903	12903	13935	15050
Banfield LRT Project	451	---	---	---	---
TOTAL OPERATING COSTS	59360	68076	74519	79725	87241
Debt Service	336	399	400	480	967
TOTAL NON-CAPITAL COSTS	59696	68475	74919	80205	88208
NET WORKING CAPITAL PROVIDED FROM OPERATIONS	5102	1650	(2239)	(592)	(4029)
CONTINGENCY			1000	1000	1000
BEGINNING WORKING CAPITAL		17181	18831	15592	14000
ENDING WORKING CAPITAL	17181	18831	15592	14000	8971

APPLICATIONS

Tri-Met Experience

Tri-Met commonly uses the bus operator costing model in assessing operating policy and performance, and short- and long-range financial impacts resulting from changes in economic conditions. Probably the most common application is the assessment of service improvements or expansion in the short range. This application also takes into account the associated marginal costs of new increments of service, with leading costs such as the hiring and training of new operators in advance of implementation. It is less effective, however, in the application of assessing reductions in service hours, necessitating layoffs on a low seniority basis, and changing the distribution of the run cuts.

The bus operator model, when applied in concert with all of the cost/revenue models, yields a cash flow status in terms of working capital after all the current period's revenues are summed, less costs, from the previous period's ending working capital figure. Through cash flow analysis, overall financial consequences can be quickly determined. This process provides a tool of cost management, and perhaps more important, an understanding of degrees of cost control. Through a process of sensitivity analysis, in which key variables are changed and the cost impacts are noted, comparisons can be made among alternatives to determine to what extent costs are controllable, and to what degree costs are impacted by policy and performance assumptions.

An example of the cash flow forecast is shown in Figure 11. An analysis was conducted to assess the impact of amounts of proposed new service and timing adjustments regarding implementation under a range of pessimistic, optimistic, and most-likely conditions. The result of these forecasts was the guidance to a series of decisions to pare the proposed amount of service by one-third and defer implementation by nine months. Six-year projections indicated that despite a financially healthy situation today, the expansion of a $7 million service improvement (roughly equivalent to 10 percent of Tri-Met's current annual operating budget) during a period of dwindling revenues threatened to produce a deficit within three years. Sometimes the role of the financial forecaster is to raise a red flag before the agency commits itself to a costly long-term improvement plan.

It is acknowledged that the forecasts are only one input among many other less-structured inputs within the institutional and political processes that simply depend on sound judgment. Adding forecasting to these processes does not make the financial uncertainties any less unpleasant, but by increasing the awareness of those who must make policy decisions, financial forecasting offers direction and depth of insight.