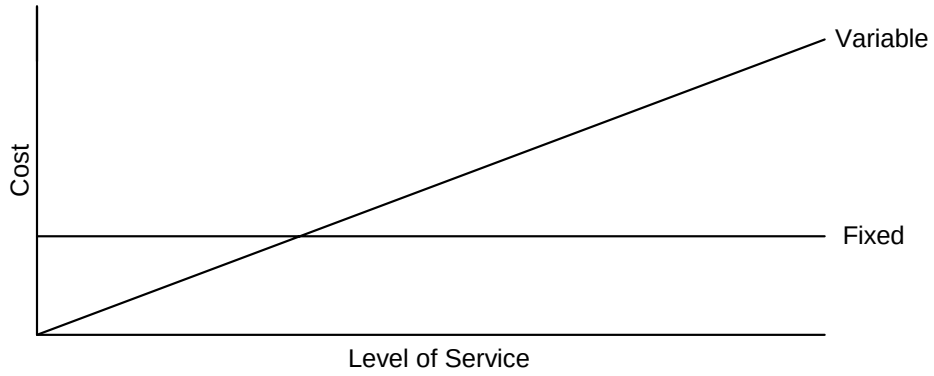
Transit Cost Analysis

Types of Costs

Fixed Cost: does not vary with the amount of service provided in the short run.

Variable Costs: change with the amount of service provided.



Average Cost: total cost (fixed and variable) divided by output i.e., cost per platform hour.

Marginal cost: the change in total cost for each unit of output.

Principles of Cost Analysis

The purpose of the analysis dictates the way you analyze costs.

Analysis of the costs of a service change: use the incremental, marginal cost -- which costs are affected by the change? Need to decide term of analysis next year? 5 years?

Analysis of a new system: look at total costs, set up of administration, vehicle purchase, facilities, hiring, training and operations.

Allocation of deficit, revenue: take costs and allocate them to individual routes. What is their share of revenue, deficit?

Service changes are incremental -- you save money by cutting pieces of work -- value of one to seven hours of saving is zero. The extra cost of using vehicles in off peaks is likely only a portion of the per mile cost, i.e. extra fuel and maintenance costs.

Key is what you use it for -- compare the world with it versus the world without it. Look at <u>incremental</u> cost change -- with addition or deletion of services use a total allocation system.

Cost Model for Transit Planning

Use a variety of approaches depending on the situation. From sketch planning, to detailed budget analysis.

Simple extreme

Average system cost per unit of service, i.e. total cost/hour or total cost per mile, used for quick calculation, analysis of a new system. This method will tend to overestimate potential savings of a service cut or costs of a service expansion since it includes fixed as well as variable costs.

Complex extreme

Reschedule the whole system to look at the effect of a change, run cutting, used to implement services and for budgeting for next system change.

Intermediate

Cost models with a limited number of variables – per hour, per mile, and per vehicle.

Cost Allocation Methods

To calculate the costs of transit service, all costs of the system need to be allocated to given categories for example.

Cost = .44 * VM = 12 * VH + 15,000 * Veh.

VM = vehicle miles
VH = vehicle hours
Veh. = number of vehicles

Need to go through your expenses and allocate each to miles, hours, and vehicles.

- per hour costs – driver wages and fringe.
- per mile costs – maintenance wages and fringe, parts, fuel, tires, accidents (insurance?)
- per vehicle – management, advertising, legal fees, office supplies, training, overhead items, utilities, etc.

(Some expenses could fall into multiple categories.)

Note that a few items (driver wages and benefits, fuel, maintenance wages and benefits) are the bulk of the costs.

Fully allocated model takes fixed costs and attempts to make them variable, especially the per vehicle portion, i.e., if you added 10% to your vehicle fleet administrative costs wouldn't rise by 10%. Think about how the change will take place.

Transit Cost Allocation Procedures[1]

Many performance indicators – operating expense per vehicle hour, operating expense per one-way passenger trip, administrative expense as a percentage of total expense, and revenue per one-way passenger mile – require accurate financial information. **A complete performance evaluation requires revenue and expense estimates not only for the transit system as a whole, but also for the individual service components that are being analyzed.** For example, to perform a comprehensive diagnosis of a system's operating problems, the manager needs a separate analysis of each service sector or type of service within the operation to determine if one part of the operation is dragging down the performance of the whole system. The costing issues that must be considered before applying the performance evaluation methodology described in this guide involve two primary topics: cost determination and cost allocation.

Cost Determination:

Cost determination is the process of identifying the total cost of providing the service. The goal of this process is to produce a statement of the revenue and expenses for the paratransit service for a particular period. The basic source of information for this cost determination is the accrual accounting system that will result in a listing of expenses such as that shown in the following table. Though the example expense listing in the table is for a twelve month period, performance evaluations also use monthly, quarterly, or semiannual information.

The accrual accounting system, as contrasted to a cash accounting system, records revenue and expenses when they are due or incurred, rather than received or paid. An accurate performance evaluation requires that the accrual system be used so that revenue and expenses can be properly associated with the services provided and consumed. For example, if the accrual system is not used, an annual vehicle insurance bill paid in one month will overstate expenses and the related financial performance measures for the month when the bill is paid. Likewise, counting revenue in the period when it is received, rather than when it is earned, will improperly represent the true revenue per passenger, or overall cost recovery of the system.

In addition to the operating revenue and expense data provided by the accrual accounting system, the system manager may, depending upon the purpose of the evaluation, need to make adjustments to the expense data. The need for such adjustments often arises when the evaluation involves comparing the performance of a privately operated system with that of a nonprofit or public agency-operated system. For this type of comparison, in addition to basic operating expenses, special treatment of costs may be required for costs incurred by the private operator but not by the public on nonprofit agency such as depreciation, profit, and certain taxes.

[1] This material is adapted from a NTI course “Improving Transit System Performance: Using Information Based Strategies” developed at the University of Wisconsin-Milwaukee 1996-98. This material was written by Jack Reilly of the Capital District Transportation Authority (Albany, N.Y.), Edward Beimborn or UWM and Robert Schmitt of RTR Associates in Pittsburg.

Sample Chart of Accounts Used for Cost Allocation

Expense Object Class	Annual Expense	
TRANSPORTATION EXPENSE		
Driver Wages and Salaries	$195,000	
Driver Fringe Benefits	42,900	
Fuel and Oil	42,500	
Tires and tubes	6,500	
Vehicle Insurance	39,500	
Vehicle Lease	6,500	
Purchased Transportation	46,900	
Other	3,460	
TOTAL TRANSPORTATION EXPENSE		$379,760
MAINTENANCE EXPENSE		
Mechanic Wages and Salaries	$23,000	
Mechanic Fringe Benefits	4,830	
Materials and Supplies	14,600	
Contracted Maintenance	26,800	
Facility Rental	6,000	
Utilities	4,000	
Contracted Services	8,900	
Other	3,350	
TOTAL MAINTENANCE EXPENSE		$91,480
CALL TAKING AND DISPATCHING EXPENSE		
Dispatcher Wages and Salaries	$31,500	
Dispatcher Fringe Benefits	6,500	
Telephone Expenses	6,600	
Computer Expenses	4,200	
Rent	3,600	
Other	5,400	
TOTAL CALL TAKING AND DISPATCHING EXPENSE		$57,800
ADMINISTRATIVE EXPENSE		
Administrative Salaries	$69,500	
Administrative Fringe Benefits	15,500	
Materials and Supplies	4,500	
Nonvehicle Insurance	2,200	
Professional Services	6,500	
Travel	3,000	
Office Rental	6,000	
Utilities	3,600	
Equipment Rental/Service	5,400	
Other	3,300	
TOTAL ADMINISTRATIVE EXPENSE		$119,500
TOTAL OPERATING EXPENSE		$648,540
TOTAL VEHICLES		14
TOTAL VEHICLE MILES		399,000
TOTAL VEHICLE HOURS		28,500

Because proper treatment of these cost differences is essential to a fair comparison of public versus private transit operations, the Federal Transit Administration (FTA) has sponsored several studies of the issues and published a number of reports and guides that explain how to properly determine these expenses. *Fully Allocated Cost Analysis: Guidelines for Public Transit Providers*,[3] a report prepared by Price Waterhouse, provides detailed information on how to construct fair and accurate cost comparisons of private and public transit services. The Price Waterhouse report describes how the three-variable unit cost model can be used to estimate total expenses and it also explains the adjustments that must be made to compensate for differences between the public and private sectors. For those persons interested in using a microcomputer model to estimate total as well as subservice costs, the UMTA-sponsored Public Private Transportation Network (PPTN) has prepared and distributed a cost allocation model[4] that can be used for either fixed-route or paratransit operations. The private-sector comparison principles proposed in the Price Waterhouse study are incorporated into the PPTN model. Because the cost determination and cost allocation methods described in the next section of this guide are consistent with those presented in these manuals, they are only summarized here and presented in the context of the needs of the paratransit performance evaluation process. The reader is referred to the other resources for more detailed information on cost allocation and determination of private versus public sector costs.

[3] *Fully Allocated Cost Analysis: Guidelines for Public Transit Providers*, Prepared by Price Waterhouse for the Urban Mass Transportation Administration, April 1987.

[4] "Cost Allocation Model: A Microcomputer Software for Transit Service Costing," The Comsis Corporation, February 1988.

Cost Allocation Models

Nearly all performance evaluation studies require that total operating expenses such as those listed in the cost allocation table be allocated so that the cost of providing a particular type of service can be determined. The cost allocation process involves distributing each cost element among the service components. For example, to determine the cost of operating a particular vehicle or group of vehicles in a particular service sector, total operating costs must be apportioned among all vehicles and/or services. Individual vehicle or service cost estimates are useful not only to evaluate the operating and financial performance of the service component, but also, such disaggregation of expenses is necessary to evaluate the desirability of private versus public provision of service.

The most common method of allocating operating expenses incurred by transit systems, and the one recommended here, is called the three-variable unit cost model. The unit cost model assigns actual operating costs experienced by a system to each sub-service (vehicle, route, service area, etc.) based on three service variables: vehicle hours, vehicle miles, and vehicles. The underlying assumption behind the allocation model is that the cost of operating a transit system is directly related to the number of vehicle hours of service provided, the number of miles traveled, and the number of vehicles required to provide the service. Therefore, the expense of providing service in a specific service sector can be determined by apportioning total expenses of the organization in proportion to the number of vehicle hours, miles, and vehicles required to provide the particular service.

The model can be described as follows:

Annual Total Expense = (Vehicle Hour-Related Expenses * Vehicle Hours) + (Vehicle Mile-Related Expenses * Vehicle Miles) + (Fixed Expenses/Vehicle * Vehicles) (1)

This cost expression can be used to represent the entire paratransit operation for the entire year, or it can be used to calculate the operating expenses for a sub-service and/or for a shorter time period.

The remainder of this section presents a simplified example that applies the unit cost model to the data presented in the Cost Allocation chart. A more detailed explanation of the unit cost model and various refinements can be found in the sources listed earlier in this chapter. Also, a recent report prepared for the Maryland Department of Transportation[5] provides a thorough explanation of how to apply the unit cost model to demand-responsive transportation services. The reader should consult this report for step-by-step instructions on applying the unit cost model to a variety of situations faced by demand- responsive operators.

[5] Cost Analysis Methodology for Demand-Responsive Service, prepared for the Maryland Department of Transportation Mass Transit Administration by Comsis Corporation, October 1988.

The unit cost model is applied by completing three steps.

1. **Assembly of the data** required to produce the line-item expense data shown in the chart of accounts given earlier for a transit system. The table lists the operating data required in addition to the financial data. To apply the model, total vehicle miles, vehicle hours, and vehicles must be known. Also, the quantity of these variables associated with sub-service components must also be known. For example, for the sample data shown in the table, the system operated 14 vehicles a total of 28,500 vehicle hours and 399,000 vehicle miles. This operating data can be obtained using the procedures described in chapter 3. The most important factors to remember concerning this first step are that the expense data and the operating data must represent the same service and for the same time period. That is, the operating expense listing should include all of the costs associated with operating the 14 vehicles for the number of miles and hours listed for the period included with these statistics.

2. **Assignment of each expense line item to one of the unit cost variables** (vehicle hours, vehicle miles, or number of vehicles). The line items are assigned to the unit cost variables based upon the service variable that most closely controls or determines the expenses for the line item. For example, driver salaries, wages, and fringe benefit expenses are most closely related to the number of vehicle hours of service provided. Likewise, fuel, maintenance, and tire expenses are most closely linked to the number of miles operated. Finally, many costs, including most administrative expenses, are fixed, and therefore are arbitrarily allocated based on the number of vehicles associated with a service. (An alternative approach to assigning fixed costs is discussed later in this section.) The table on the next page presents a suggested assignment of the line items to the unit cost variables.

3. **Calculation of the average unit costs and application of the model to sub-service cost estimations.** Unit costs are calculated by summing the expense items assigned to each of the three cost variables and then dividing the total expenses for each category by the service variable. For example, the total cost due to driver hours is $288,260, and the number of vehicle hours is 28,500 so that the vehicle hour-related expense is $10.11 ($288,260/28,500). The unit cost table lists the expense data by category and shows the calculation of each unit cost.

Applying these unit costs to the annual cost model results in the following equation, which can be used to estimate the cost associated with each portion of the sample system's operation.

Annual Total Expense = ($10.11 * Vehicle Hours) + ($.30 * Vehicle Miles) + ($17,075 * Vehicles) (2)

Table 5:. Recommended expense assignment for three-variable cost model.

Expense Object Class	Assignment Variable		
	Vehicle Hours	Vehicle Miles	Vehicle
TRANSPORTATION EXPENSE			
Driver Wages and Salaries	X		
Driver Fringe Benefits	X		
Fuel and Oil		X	
Tires and Tubes		X	
Vehicle Insurance			X
Vehicle Lease			X
Purchased Transportation	X		
Other	X		
MAINTENANCE EXPENSE			
Mechanic Wages and Salaries		X	
Mechanic Fringe Benefits		X	
Materials and Supplies		X	
Contracted Maintenance		X	
Facility Rental			X
Utilities			X
Contracted Services			X
Other			X
CALL TAKING AND DISPATCHING EXPENSE			
Dispatcher Wages and Salaries			X
Dispatcher Fringe Benefits			X
Telephone Expenses			X
Computer Expenses			X
Rent			X
Other			X
ADMINISTRATIVE EXPENSE			
Administrative Salaries			X
Administrative Fringe Benefits			X
Materials and Supplies			X
Nonvehicle Insurance			X
Professional Services			X
Travel			X
Office Rental			X
Utilities			X
Equipment Rental/Service			X
Other			X

Table 6: Unit Cost Calculation for Sample Data

Expense Object Class	Vehicle Hour	Vehicle Mile	Vehicle
TRANSPORTATION EXPENSE			
Driver Wages and Salaries	$195,000		
Driver Fringe Benefits	42,900		
Fuel and Oil		$42,500	
Tires and tubes		6,500	
Vehicle Insurance			$39,500
Vehicle Lease			
Purchased Transportation	46,900		
Other	3,460		
MAINTENANCE EXPENSE			
Mechanic Wages and Salaries		23,000	
Mechanic Fringe Benefits		4,830	
Materials and Supplies		14,600	
Contracted Maintenance		26,800	
Facility Rental			6,000
Utilities			4,000
Contracted Services			8,900
Other			3,350
CALL TAKING AND DISPATCHING EXPENSE			
Dispatcher Wages and Salaries			31,500
Dispatcher Fringe Benefits			6,500
Telephone Expenses			6,600
Computer Expenses			4,200
Rent			3,600
Other			5,400
ADMINISTRATIVE EXPENSE			
Administrative Salaries			69,500
Administrative Fringe Benefits			15,500
Materials and Supplies			4,500
Nonvehicle Insurance			2,200
Professional Services			6,500
Travel			3,000
Office Rental			6,000
Utilities			3,600
Equipment Rental/Service			5,400
Other			3,300
TOTAL OPERATING EXPENSE	**$288,260**	**$121,230**	**$239,050**
Total Vehicles			14
Total Vehicle Miles		399,000	
Total Vehicle Hours	28,500		
Vehicle Cost Factor			$17,075
Vehicle Mile Cost Factor		$0.30	
Vehicle Hour Cost Factor	$10.11		

The cost of providing a particular service is estimated by substituting the number of miles, hours, and vehicles associated with the service and then calculating the resulting cost. For example, if the paratransit service in a particular community within the overall

system's service area requires 3 vehicles to provide it, and these 3 vehicles travel 90,000 miles in 6,000 hours, then the cost of this community's service would be:

Cost for Community Service = $10.11 * 6,000 + $.30 * 90,000 + $17,075 * 3

= $60,660 + $27,000 + $51,225 (3)

= $138,885

This expense estimate would then be used to calculate the financial performance indicators requiring the operating expense information.

Transit Route Revenue Allocation

An important task associated with transit service performance monitoring is the allocation of costs and revenues among services. Information on this provides insights into the relative performance of service and can provide the basis for making decisions regarding transit resource allocation.

Revenue Allocation

The increased utilization of non-cash instruments such as passes and permits complicates the allocation of revenue. Early on, the analyst must make a judgment of the desired accuracy required since an exact allocation of revenue requires considerable statistical sampling and analytical work. The procedure for determining route revenue depends on whether or not the transit system has electronic registering fareboxes.

Nonregistering Fareboxes

Without registering fareboxes, the task of determining route revenue is more complicated particularly if the fare structure contains zones fares, and considerable use of non cash instruments such as tokens and passes. Again, the level of investment in collecting the information must be consistent the level needed to make decisions. If the fare structure is not very complicated (i.e. no zone or express fares), one can make an assumption that the average revenue per customer is the same throughout the route network and the task of revenue allocation is merely one of determining passenger counts by route and multiplying this value by the average fare.

More elaborate means are required under the following conditions:

- There is a variety of fare elements (zone, express fares, etc.) **and** there is likely to be some variation between routes in the average revenue per customer.

- There is a requirement for more accuracy, possible due to the existence of targeted subsidies for certain types of customers or for different routes.

Registering Fareboxes

The introduction of electronic registering fareboxes has greatly simplified the revenue allocation process, since the fareboxes provide an enumeration of cash revenue and tally counts of non-cash payments such as tokens and passes. The primary task of

revenue allocation is to provide an imputed value of each of the non-cash instruments. For example, farebox systems provide a count of tokens but not the imputed value they represent. For each non-cash instrument the average value of each should be determined either through accounting records or other farebox data. Tokens generally have a fixed face value but there may be discounts for volume purchase. The appropriate procedure for determining the imputed value of tokens is to determine the *average* price of tokens, this being the total revenue from tokens divided by the total number of tokens sold.

Allocating pass revenue is a little more difficult. For each denomination of pass sold, one can obtain the average revenue per pass use as the imputed value. This is the total sales value (from accounting data) divided by the number of uses of all passes of that denomination.

A Special Note on Transfers

Like in any analysis, some judgment must be made about the data in order to form a reasoned analysis for decision-making. Revenue allocation is no different. In transit systems somewhere between 10% and 20% of boardings are from transfers. With free transfer policies in place, there is generally no attributable revenue to those boarding with transfers. However, one can make poor service allocation errors if we literally perform a revenue allocation analysis. Consider the case of a neighborhood or feeder route to a primary network of major arterial routes. If a person boards the neighborhood bus in the morning and transfers (without charge) to an arterial route and reverses the procedure in the afternoon, generally an equal amount of revenue is apportioned to each route. However, if we use strictly revenue analysis as the basis of determining service levels on the neighborhood route, we might underestimate the value of the service it provides. If the neighborhood route performs poorly and is a candidate for termination, the actual revenue loss from termination would be not only the revenue physically attributable to this route but also some of the revenue from the corresponding trunk route since without the neighborhood route, the revenue of the trunk route would be reduced. This is an analytical problem not limited to transit operators. Airlines with hub and spoke systems have a similar difficulty in ascribing revenue to trips, routes or cities served.