I. INTRODUCTION

PURPOSE OF THIS REPORT

3074

This report provides guidance regarding the development and application of operating and maintenance (O & M) cost models and supplements the Federal Transit Administration's Procedures and Technical Methods for Transit Project Planning. An operating and maintenance cost database containing representative information for motor bus, rail rapid, light rail, and commuter rail modes is presented. The data base provides 1) labor productivity and unit cost information that can be directly applied in structuring O & M cost models and 2) aggregate costs per unit of service for major functional areas at peer transit properties that can be used to test the reasonableness of model results.

This report draws on the operating experience of many transit systems contained in Section 15 data reported to FTA, in detailed budgets of several representative transit systems that operate light rail, and previously developed cost models. While this appendix is not intended as a standard or specification, it does outline the expectations of the FTA Office of Grants Management when it reviews operating costing methodology reports, Alternatives Analysis/Draft Environmental Impact Statement Reports, and Detailed Financial Analysis Reports for the Locally Preferred Alternative, including:

- **Level of detail:** Transit systems are complex businesses composed of a broad range of operational, maintenance, and administrative functions. Each function is composed of many components; each component is driven by the quantity of service provided and factors related to management and governance board policy and legislative and regulatory mandates. Because of inherent differences between transit systems, the level of detail in the O & M cost model should be sufficient to assure that costs specific to the transit property are accurately being addressed.

- **Extent of documentation:** Because of the level of detail noted above, a large amount of data and assumptions are included in the O & M cost models. This information should be referenced so that when the model is reviewed the appropriateness of the data can be assessed.

- **Tests of reasonableness:** The results of the O & M cost models, both in terms of total and component costs, should be carefully assessed for reasonableness. This includes comparisons to peer transit properties and comparisons to historical operations.

- **Sensitivity tests:** The O & M cost models should be structured so that uncertainty in various model components can be examined. Analysis of risk is an important part of the financial analyses conducted as a part of alternatives analyses and the analysis of the locally preferred alternative.

ORGANIZATION OF THIS REPORT

The report begins with a discussion of ten principles of operating cost models used in alternatives analysis and preliminary engineering. Next, the sources of information that may be utilized in structuring O & M cost models are reviewed, including a discussion of the advantages and disadvantages of each source. The O & M cost data base is then described, including the sources of data, organization, and potential application. Finally, guidelines for the documentation of O & M cost models are discussed.

II. PRINCIPLES OF OPERATING AND MAINTENANCE COST MODELING

INTRODUCTION

This section addresses ten principles of O & M cost modeling for use in alternatives analysis (AA) and preliminary engineering (PE). These objectives address both the process by which O & M cost models are structured and the manner in which they are applied:

- Principle 1: Reflect historic operations
- Principle 2: Anticipate future operations
- Principle 3: Address all functional responsibilities of the transit property
- Principle 4: Focus on major cost components
- Principle 5: Apply consistent level of service data
- Principle 6: Apply peer transit property experience
- Principle 7: Apply readily available information
- Principle 8: Provide fully-allocated costs for use in cost-effectiveness analysis
- Principle 9: Structure for sensitivity analyses
- Principle 10: Document model theory and application

PRINCIPLE 1: REFLECT HISTORIC OPERATIONS

O & M cost models should reflect recent operations, including the cost experience and associated operational trends of the transit property that will operate the transit system addressed in AA and PE. Examination of detailed operating budgets, Section 15 data, staffing plans, and operational data are typical points of departure for such analyses. Among the trends that should be examined are the following:

- **Labor productivity:** Labor productivity is affected by the union contract and work rules and by the service profile by time of day. If no changes are anticipated, labor productivity ratios (e.g., scheduled operator pay hours per platform hour, actual pay hours per scheduled pay hour) should remain unchanged.

- **General and administrative costs:** Many transit properties find that general and administrative costs do not grow at the rate of service growth. Some of these costs are relatively fixed, responding to governance board policies and state and federal legislative and regulatory mandates.

The process of establishing values for the various coefficients in resource build-up cost equations (the "calibration" of the model) should be based on a careful examination of recent cost trends. Projected improvements in labor productivity and unit cost should be justified, the current and/or prior years' budgets. To the extent that the model is based on the same as the budget, the results should be similar to budget values.

It is recommended that if cost models are calibrated based on a single year of budget or actual data, then they should be validated by applying the model to a different prior year.

Another approach would be to calibrate the model based on a multi-year trend of costs. Exhibits 1 and 2 summarize an analysis in which five years of Section 15 data were reviewed. Exhibit 1 summarizes a trend analysis of aggregate costs of motor bus service per vehicle-mile and per vehicle-hour. The erratic cost per mile experience suggests that the recent decline might not continue and that the average value may be a better predictor of cost. Indeed, in terms of overage cost per hour, costs have been increasing. Exhibit 2 summarizes the validation of the O & M cost model. The relatively minor variances between modeled and historic actual costs indicate that the model was properly validated.

PRINCIPLE 2: ANTICIPATE FUTURE OPERATIONS

The most appropriate perspective in structuring O & M cost models is that they should embody the full range of management concerns addressed in the transit property's budgetary process. To a large extent, annual budgets (particularly "zero-based" budgets) are a "model" of the coming year's operations. Such budgets can be the point of departure for structuring O & M cost models.

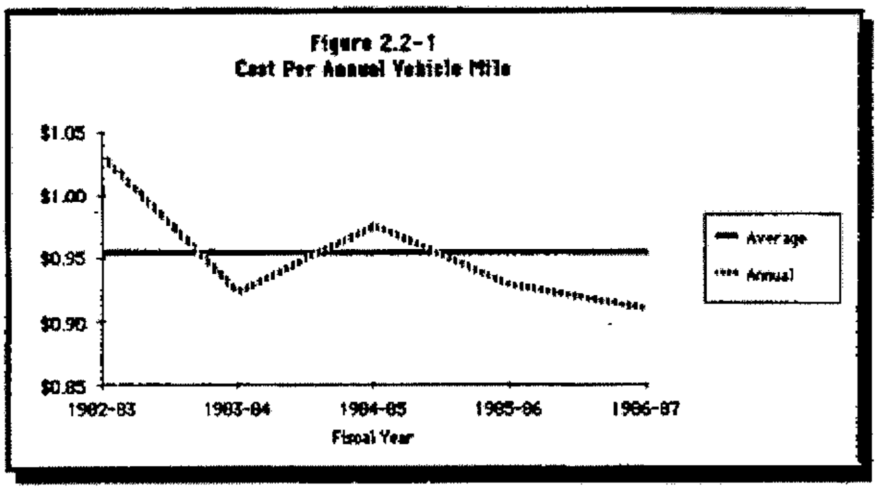
The models should address the following types of cost factors that will change in the future:

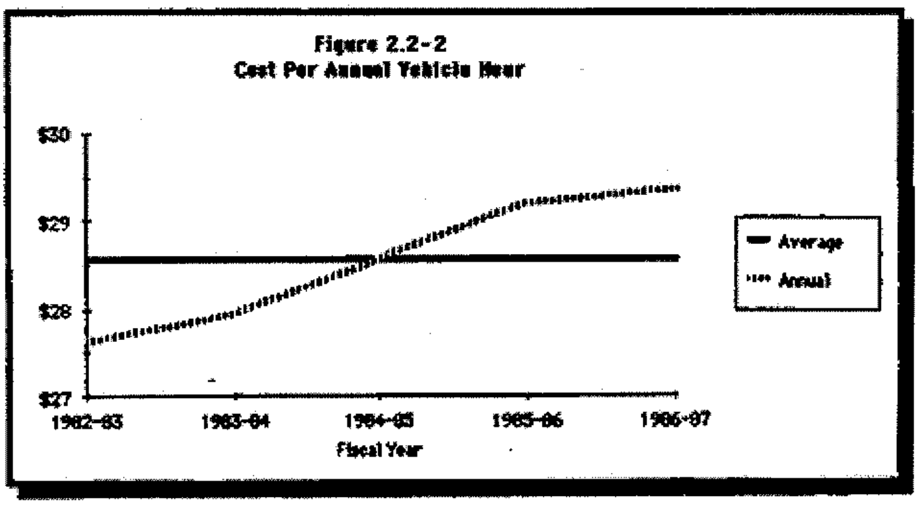
- **Inflation:** The O & M cost model should be able to model the impact of inflation on costs. In particular, the models should be able to distinguish the projected inflation rates for major cost components (including wages, salaries, fringe benefits, fuel, and electricity) for which detailed inflation projections may be available.
- **Union contract:** The O & M cost model should reflect known and anticipated changes in the union contract that will affect costs. Examples of such changes include:
- Wage changes (both lump sum payments and periodic raises)
- Work rules changes which affecting computation of pay time)

In most cases, the productivity of rail operators for a new rail system will be governed by the same collective bargaining agreement as for current bus operators. The work rules in such agreements will, in large measure, determine the constraints on scheduling and dispatching and on premium pay for rail operators.

EXHIBIT 1

ANALYSIS OF TRENDS IN O & M COST BASED ON SECTION 15 DATA





Source: City and County of Honolulu, Rapid Transit Development Project, Working Paper

EXHIBIT 2

EXAMPLE OF VALIDATION OF O & M COST MODEL

	1982-83	1983-84	1984-85	1985-86	1986-87
Predicted Cost (Millions)	$53.110	$53.234	$54.445	$54.641	$54.587
Actual Cost (Millions)	$53.090	$51.897	$54.527	$55.049	$55.511
Variance Predicted to Actual	0.0%	2.6%	-0.2%	-0.7%	-1.7%

Source: City and County of Honolulu, Rapid Transit Development Project, Working Paper For similar service profiles (e.g., peak-to-base ratio; relative number of straight, split, and tripper runs) future operator productivity should be similar. This would include such measures as:

- Revenue plus deadhead hours per platform hour
- Scheduled pay hours per platform hour
- Actual pay hours per scheduled pay hour

- **Fringe benefit costs:** Rising health care and insurance costs are likely to continue, most likely increasing faster than wages. For this reason, it is likely that historical fringe benefit rates may understate future costs.
- **Aging fleet:** Maintenance costs should reflect possible changes in the average age of the fleet. One bus maintenance standard is that the ideal fleet mix is an average age of six years (one-half the 12-year useful life), with one-twelfth of the fleet replaced each year. Few transit properties achieve this ideal, however. As a result, the age distribution varies from property to property. Further, the average fleet age for a given property changes over time, as older subfleets are retired and new subfleets are added.

In general, maintenance costs (measured in labor hours per 1,000 vehicle miles, parts cost per mile, and fuel consumption per mile) increase as vehicles age. These trends can be verified through the analysis of subfleet-level data typically available in a maintenance work order management information system, if available. Older buses will generally require more labor, parts, and fuel costs per vehicle-mile. If new or rehabilitated buses will be introduced, appropriate efficiencies should be included.

- **Aging infrastructure:** Similarly, the cost for maintenance facilities, structures, and non-vehicle equipment will increase as they age. O & M cost models should recognize that infrastructure components require additional maintenance as they age.
- **New technology:** New technology can be a "double-edged sword" with respect to O & M costs. It can improve productivity and reduce costs in some areas yet increase costs in others. For example, in the case of a new bus garage, it may be appropriate to include some operating efficiencies resulting from improved physical layout, lighting, inspection pits, and the like. At the same time, a new building may have lighting, ventilation, and pollution control systems that will be more expensive to operate than an older "less efficient" building.
- **General administration costs:** The addition of rail transit service or a significant increase in bus service (e.g., busways) suggests that there may be significant increases in various administrative activities. A fully-allocated cost analysis would suggest that such

increases in indirect costs would be proportionate to the overall increase in direct operating costs (for the service delivery or transportation and maintenance functions). Comparisons of alternatives require that fully-allocated costs be used in the evaluation measures.

On the other hand, in the case of incremental changes in service (e.g., extension of a rail transit line) an incremental cost analysis may be more appropriate. This is especially true where O & M cost models are sufficiently detailed that specific administrative functions (and the associated staff) can be clearly identified.

- **Changing work force:** The transit industry is facing a significant change in its work force which can have significant impacts on operating cost. Demographers project that the number of high school graduates entering the work force will decline each year in the 1990's. Further, reflecting overall demographic trends, the typical new hire is more likely to be married and a parent, with less education and technical skills. The impacts of these changes include:
  - **Higher wages:** Competition for skilled entry-level employees is likely to put upward pressure on wages. While there will be tremendous pressures to contain costs, transit managers will likely want to avoid becoming "the employer of last resort".
  - **Higher training costs:** A diminishing number of high school graduates and an increasing percentage of the population for whom English is a second language are some of the most important reasons why training costs are likely to increase.
  - **Suboptimal utilization of manpower:** Scheduling and dispatching of operators involves managing the use of overtime as a resource. Optimal sizing of the operator extraboard involves trade-offs between undersizing, which results in excessive overtime premium pay, and over-sizing, which results in excessive fixed fringe benefits and guarantee time. Some level of overtime is, therefore, needed to minimize costs.

    Many transportation managers are finding it increasingly difficult to schedule optimal levels of overtime from their operators. As noted above, operators who are married and/or parents generally have less flexibility in their personal schedules and are less willing to work extended hours. The long-term impact of this phenomenon may be higher operating cost per unit of service delivered.

  - **Benefits costs:** With more employees from households with two wage earners, employees may desire less benefit coverage if similar coverage can be obtained through a spouse's employer. Transit properties with "cafeteria" benefit plans may be able to provide less fringe benefits coverage, resulting in lower costs.
  - **Training:** Expansion of transit service resulting from the opening of a new fixed guideway line or the extension of an existing line results in significant training requirements. These costs usually precede revenue service by between one to six months, depending on the requirements of each position. Exhibit 3 summarizes the advance training requirements assumed by WMATA for bus and heavy rail positions.
  - **Termination lapses:** Turnover in personnel is an inevitable occurrence in transit operations. Terminations result from retirement, dismissal with cause, promotion, and other factors. Typically, budgeted positions will assume a predetermined lapse rate. Exhibit 4 summarizes the termination lapse rates assumed by WMATA for bus and heavy rail positions.

PRINCIPLE 3: ADDRESS ALL FUNCTIONAL RESPONSIBILITIES OF THE TRANSIT PROPERTY

Many transit properties are not responsible for funding and staffing all of the functions required for transit operations and capital development. The reasons for such arrangements is often the result of institutional and organizational peculiarities of each property. Some examples of this situation include:

- **City transit departments:** Transit systems that are departments of city government frequently rely on the city for various administrative services such as bookkeeping, accounts payable and receivable, payroll, personnel, legal counsel, risk management, police and security, and facility maintenance.
- **Functions provided by other agencies:** Independent transit properties may be provided functions through agreement with other agencies. Examples include police services, snow removal.

The construction and operation of a fixed guideway system will typically result in significant increases in the demand for such outside services. Unless there is clear and documented reason to believe that the responsible outside agencies will increase funding and staffing, the financial analysis (and, thus, the O & M cost model) should include the costs for expanding such functions. In the evaluation of alternatives, the various functions performed by outside agencies should be identified.

PRINCIPLE 4: FOCUS ON MAJOR COST COMPONENTS

The level of precision (i.e., detail) in O & M cost models should be consistent with the relative importance of each functional area being modeled. In this regard, bus O & M cost models should address the following types of driving variables:

EXHIBIT 3

EXAMPLE OF TRAINING REQUIREMENTS ASSUMED OPERATING BUDGET

Department/Office	Branch/Position	Training Requirement
Bus Service	Operators	1.0 month
	Mechanics	0.5 month
Rail Transportation	Station Manager	1.5 months
	Train Operator	3.0 months
	Train Supervisor	3.0 months
	Station Supervisor	2.5 months
	Operations Control Center Supervisor	4.0 months
Rail Car Maintenance	Mechanics	3.0 months
Rail Systems Maintenance	Automatic Train Control Technician	3.5 months
	Automatic Fare Collection Technician	1.5 months
	Communications Technician	1.5 months
	Power Electrical Mechanic	1.5 months
	Computer Technician	1.5 months
Transit Police and Security	Transit Police Officers	6.0 months
	Special (Security) Police Officers	1.5 months
Facilities Maintenance	Mechanics, Equipment Operators	1.5 months

Source: Washington Metropolitan Area Transit Authority, FY 1992 General Manager's Budget, Vol. 1, Financial Program and Summaries

EXHIBIT 4

EXAMPLE OF ASSUMED PERCENTAGE OF WAGES AND SALARIES NOT TO BE INCURRED IN OPERATING BUDGET DUE TO VACANCIES

Department/Office	Salaried	Union
Independent (reporting to Genl Mgr) except Procurement	3.32%	n/a
Procurement	6.63%	2.79%
Finance	3.43%	2.79%
Administration	6.63%	2.79%
Design & Construction except Construction & Facil Maint	3.43%	n/a
Construction	7.50%	n/a
Facilities Maintenance	3.37%	5.37%
Bus Service except Bus Operators	2.08%	0.61%
Rail Service except Rail Operators & Station Managers	5.20%	4.92%

Source: Washington Metropolitan Area Transit Authority, FY 1992 General Manager's Budget, Vol. 1, Financial Program and Summaries

- **Peak vehicles, by type of vehicle:** drives facilities maintenance and some vehicle maintenance costs, can be applied as a surrogate for system size in projecting general administrative costs
- **Revenue hours, peak and off-peak:** drives operator costs
- **Vehicle-miles, by type of vehicle:** drives vehicle maintenance and claims costs
- **Number of maintenance facilities:** drives facilities maintenance and some front-line supervision costs
- **Park-and-ride lots/spaces:** drives some facilities maintenance costs
- **Route-miles of busway:** drives some facilities maintenance costs if the transit property is responsible for maintaining busways

For bus systems the emphasis should be placed on the following functions (numbers in parentheses refer to Section 15 function codes):

- **(031) Revenue vehicle operators:** This function accounts for approximately half of total bus costs. Given significant service changes could result when fixed guideway systems are implemented (e.g., conversion from line-haul to feeder service, changes in peak-to-base ratio, changes in interlining) it is likely that changes in labor productivity will occur as well. The sophistication of the model use to address these changes will depend on the extent of change.

  Resource build-up equations should apply revenue hour projections from the travel demand analysis to project pay hours and operator wages. One structure for such equations is as follows:

$$\text{Operator Pay Hrs} = \text{Revenue Hrs} \times \frac{\text{Platform Hrs}}{\text{Revenue Hr}} \times \frac{\text{Sched Pay Hrs}}{\text{Platform Hr}} \times \frac{\text{Act Pay Hrs}}{\text{Sched Pay Hr}}$$

  or (if less detailed payroll data is available)

$$= \text{Revenue Hrs} \times \frac{\text{Platform Hrs}}{\text{Revenue Hr}} \times \frac{\text{Actual Pay Hrs}}{\text{Platform Hr}}$$

  where

- Platform hours/revenue hour addresses impacts of deadheading, report time, turn-in time, meal time
- Scheduled pay hours/revenue hour addresses premiums for overtime, intervening time, and spread time
- Actual pay hours/scheduled pay hours addresses extraboard management and staffing of open runs (runs for which the scheduled operator is not available due to being sick or injured, in training, on vacation, or on other assignment)

$$\text{Operator Wages} = \text{Operator Pay Hrs} \times \frac{\text{Average Wage}}{\text{Pay Hr}}$$

$$\text{Number of Operator} = \text{Actual Pay Hrs} \times \frac{\text{Operators}}{\text{Actual Pay Hrs}}$$

$$\text{Wage-Related Fringes} = \text{Operator Wages} \times \frac{\text{Fringe \$}}{\text{Hourly Wages \$}}$$

[Includes FICA and pension costs]

$$\text{Headcount-Related Fringes} = \text{Number of operators} \times \frac{\text{Fringe \$}}{\text{Operator}}$$

[Includes medical and life insurance premiums and workers compensation costs]

Transit properties with a high peak-to-base ratio should model peak and off-peak platform hours separately. The ratio of platform hour/revenue hour will be higher for peak periods than for off-peak period and will vary by garage. The ratios of scheduled pay hour/platform hour and actual pay hour/scheduled pay hour will also vary by garage. The garage-to-garage variance typically results from different relative amounts of open work which is, in turn, affected by scheduling and runcutting practices and absenteeism (related to average seniority of operators at each garage).

Transit properties expecting a significant change in the bus service profile by time of day or significant changes in union work rules should consider applying an operator/extraboard model to project the wage and fringe benefit costs for bus operators. This type of model addresses the following key factors:

- **Mix of run types, by time of day:** This includes the number of straight, split (or "swing"), and tripper runs during the early AM, AM peak, midday, PM peak, and evening periods
- **Labor productivity for each type of run:** This includes the following measures, ideally for each operating garage:
  - Platform hours/revenue hour
  - Scheduled pay hours/platform hour
  - Actual pay hour/scheduled pay hour
- **Analysis of open runs:** This includes analysis of frequency distributions of open work on any given day.
- **Work rule-related costs:** This includes premiums for intervening time and spread time for split shifts, guarantee time
- **Mix of full-time and part-time operators:** This includes constraints on the application of part-time employees, e.g.,

maximum run length, maximum hours worked per week.
- **Absenteeism:** including controllable (sick, injury) and uncontrollable (holiday, vacation) absenteeism
- **Attrition:** including terminations with cause and promotion to other positions

Operator/extraboard cost analysis involves determining the optimal operating staffing level by considering the trade-offs between:

- **Employing too few operators:** which results in excessive overtime and variable fringe benefit costs
- **Employing too many operators:** which results in excessive guarantee time and fixed fringe benefit costs

- **Revenue vehicle maintenance wages and fringes:** The model should address the different maintenance requirements of each subfleet of buses (e.g., intensity of required maintenance labor effort measured in terms of mechanic labor hours per 1,000 vehicle-miles, the impacts of an aging fleet and the introduction of new vehicles, and the implications of new maintenance facilities.
- **Other labor costs:** The model should project front-line supervisory staff based on actual span of control and deployment of these personnel. For example, the following approaches may be appropriate:

- **Bus street supervisors:** based on total platform hours, peak vehicles, number of garages
- **Garage foremen:** based on the number of mechanics

Administrative personnel are best projected based on a detailed review of the entire organization. Exhibit 5 is an analysis of bus-related staff (including salaried and hourly employees) in a recent cost model.

- **Fuel:** The model should address differences in fuel consumption of each subfleet of buses, the implications of new vehicles (particularly pollution control mandates, and changes in operating speed resulting from new service plans (e.g., a shift from line-haul to feeder service may lower average speed).
- **Parts:** If maintenance work order data is available, the model should address differences in parts consumption of each subfleet of buses and the implications of new vehicles. Particular care should be taken in accounting form costs for major component overhaul costs (e.g., engines, transmission, and differentials).

Exhibit 6 presents a summary of labor productivity and unit cost coefficients used in a recent bus O & M cost model that was applied at the route level. The model included coefficients that were sensitive to time of day, type of vehicle, and operating garage.

Rail O & M cost models should address the following types of driving variables:

- **Peak vehicles, by type of vehicle:** drives some vehicle maintenance costs and can be applied as a surrogate for system size

- **Revenue train hours, peak and off-peak:** drives operator costs

- **Revenue vehicle miles, by type of vehicle:** drives vehicle maintenance and propulsion power costs

- **Route-miles:** subway, surface, aerial: drives track and structures costs

- **Stations:** subway, surface/aerial: drives station, fare collection system, automatic train control, and communications maintenance costs, station manager costs

- **Maintenance facilities/yards:** drives facilities maintenance and electricity costs
- **Park-and-ride lots/spaces:** drives facilities maintenance costs
- **Annual passengers:** drives fare collection costs

For rail systems the emphasis should be placed on the following functions:

- **Revenue vehicle operators:** The number of operators should be consistent with the level of service provided as well as additional requirements for yard operations and other ancillary functions. To the extent that bus and rail operators will be subject to the same labor agreement, the labor productivity for both modes should be consistent. If there are projected to be variances, the reasoning for such variances should be documented.

- **Station operations:** If stations are manned, then costs should be included for station agents. Specific attention should be given to staffing levels consistent with the level of responsibility of the agents (e.g., if agents manually collect fares, then sufficient numbers of agents should be assumed during peak periods).

EXHIBIT 5

EXAMPLE OF BUS TRANSIT STAFFING ASSUMPTIONS IN O & M COST MODEL

Position		Job Code	Salary Without Benefits	Salary (1) With Benefits	FY89 FTE's
Overhead Labor Costs Allocated to Transit Operations (Fund 1628):	Administration	600	NA	$858,840	NA
	Marketing	601	NA	$1,983,621	NA

	Fiscal Resources	602	NA	$1,398,238	NA
	Human Resources	609	NA	$1,398,238	NA
Bus Operations Budget Unit 0604: Engineering Services	Transit Foreperson	4100.01	$39,824	$53,857	2
	Advance Clerk Typist	4100.02	$19,543	$25,241	2
	Clerk Typist	4100.03	$21,422	$27,669	2
	Engineering Technician II	4100.04	$34,493	$44,551	2
	Senior Mechanical Engineer	4100.05	$57,631	$74,436	2
	Assistant Mechanical Engineer	4100.06	$38,683	$49,963	2
	Division Maint. Supt.	4100.07	$50,943	$65,798	2
					14
Bus Operations Budget Unit 0604: Material Control	Parts Foreperson	4102.01	$39,711	$53,705	1
	Parts clerk – Bus	4102.02	$33,043	$44,688	36
	Buyer Assistant	4102.03	$47,830	$61,777	2
	Supervising Clerk	4102.04	$28,342	$36,606	1
	Clerk Typist	4102.05	$20,025	$25,864	3
	Inventory Control Assistant	4102.06	$22,355	$28874	3
	Vehicle Parts Manager	4102.07	$55,070	$71,129	1
	Vehicle Parts Supervisor	4102.08	$49,755	$64,264	5
					52
AGNEWS Overhaul & Repair	Overhaul Foreperson	4103.01	$39,842	$53,858	3
	Mechanic G	4103.02	$34,342	$46,445	20
	Mechanic	4103.03	$34,552	$46,728	22
	Paint & Body Foreperson	4103.04	$39,842	$53,857	1
	Paint & Body Repairperson	4103.05	$36,838	$49,820	13
	Support Mechanic	4103.06	$33,991	$45,969	3
	Service Mechanic	4103.07	$31,679	$42,842	1
	Service Worker	4103.08	$30,531	$41,291	3
	Facilities Worker	4103.09	$25,852	$34,962	2
	Upholsterer	4103.10	$37,155	$50,249	4
	Maintenance Superintendent	4103.11	$55,070	$71,129	1
	Clerk Typist	4103.12	$21,422	$27,669	1
	Account Clerk I	4103.13	$21,422	$27,669	1
	Transit Maint. Supervisor	4103.14	$47,362	$61,162	3
	Vehicle Maint. Scheduler	4103.15	$32,886	$42,475	2
					80

Source: Manuel Padron & Associates, Tasman Corridor Alternatives Analysis, Operating & Maintenance Methodology Report, prepared for Metropolitan Transportation Commission and Santa Clara County Transportation Agency, April 1990

EXHIBIT A-6

EXAMPLE OF O&M COST MODEL COST DRIVERS AND KEY LABOR PRODUCTIVITY AND UNIT COST VALUES

		Garage/Type of Service								
			Platte				Boulder		Longmont	
DRIVING VARIABLES	Systemwide	Alameda	Peak Mall	Off-peak Mall	Other	East Metro	City	Intercity	City	Intercity
Peak Trips X Mall	598	155	0	0	285	114	0	36	0	8
Peak Vehicles	601	143	5	13	176	162	30	50	11	11

		Garage/Type of Service								
			Platte				Boulder		Longmont	
DRIVING VARIABLES Platform Hours	Systemwide	Alameda	Peak Mall	Off-peak Mall	Other	East Metro	City	Intercity	City	Intercity
Peak	673,978	151,223	20,344	0	201,014	190,041	37,761	50,364	12,165	11,066
Off-Peak	1,164,318	215,952	0	56,979	385,343	347,200	76,478	51,291	18,588	12,487
Total	1,838,296	367,175	20,344	56,979	586,357	537,241	114,239	101,655	30,753	23,553

		Garage/Type of Service								
			Platte				Boulder		Longmont	
DRIVING VARIABLES Vehicle Miles	Systemwide	Alameda	Peak Mall	Off-peak Mall	Other	East Metro	City	Intercity	City	Intercity
Articulated	2,290,000	0	0	0	818,100	1,471,900	0	0	0	0
Double Deck	23,200	0	0	0	0	0	23,200	0	0	0
Handyride Van	133,700	110,500	0	0	0	0	0	0	23,200	0
Intercity	3,964,400	0	0	0	813,300	0	0	3,151,100	0	0
Mall Electric	21,700	0	5,709	15,991	0	0	0	0	0	0
Mall Diesel	287,300	0	75,590	211,710	0	0	0	0	0	0
Medium Transit	1,143,200	35,900	0	0	0	0	897,200	0	118,978	91,122
Medium Transit w lift	405,600	194,200	0	0	0	0	76,400	0	76,449	58,551
Suburban	775,100	434,500	0	0	340,600	0	0	0	0	0
Transit w lift	18,227,600	4,707,400	0	0	6,903,800	5,866,900	637,500	0	63,425	48,575
Total	27,271,800	5,482,500	309,000	81,300	8,875,800	7,338,800	1,634,300	3,151,100	282,052	198,248

		Garage/Type of Service								
			Platte				Boulder		Longmont	
PRODUCTIVITY FACTORS Operator Productivity	Systemwide	Alameda	Peak Mall	Off-peak Mall	Other	East Metro	City	Intercity	City	Intercity
Pk pay/platform hr	1.2053	1.1732	1.2071	na	1.2071	1.1737	1.1261	1.4635	1.1325	1.13235
Offpk pay/platform hr	1.1085	1.1103	na	1.1013	1.1013	1.1043	1.0877	1.1883	1.1287	1.2114
Act/sched pay hr	1.0239	1.0196	1.0196	1.0196	1.0196	1.0196	1.038	1.0571	1.038	1.0571
Avg operator wage/hr	$12.3025	$12.4236	$12.3762	$12.3762	$12.3762	$12.2066	$12.1336	$12.0924	$12.4508	$12.2696
Annual hrs/operator	1825.52	1791.1	1897.31	1897.31	18.97.31	1898.38	1773.89	1303.27	1830.53	2355.31
Op fringe/comp abs	45.74%	46.86%	47.26%	47.26%	47.26%	44.12%	43.78%	43.78%	43.78%	43.78%

Source: KPMG Pet Marwick, Working Paper No. 2 (Revision 3), Development of Fully-Allocated Cost Model in Compliance with UMTA Guidelines, prepared for Denver Regional Transportation District, August 1989.

- **Vehicle maintenance labor:** The cost model should separately address routine maintenance requirements and occasional corrective maintenance campaigns. The financial analysis should include provision for routine rehabilitation and replacement costs, either within the O & M cost model and/or in separate capital reinvestment analysis.
- **Police and Security:** This includes the costs for the following functions:
  - Patrol of trains, stations, park-and-ride lots, and other passenger facilities
  - Investigative and administrative functions
  - Security of transit property facilities, including shops and administrative buildings
- **Other labor:** Exhibit 7 is an analysis of projected light rail staff for the same transit property described in Exhibit 5. Note that many new light rail positions are based on current bus positions.
- **Non-vehicle maintenance wages and fringes:** The cost model should address labor productivity for the following maintenance functions:
  - Signals/revenue vehicle movement control
  - Communications
  - Traction power
  - Track and structures
  - Fare collection equipment
  - Buildings and other facilities
- **Non-vehicle maintenance parts and supplies:** The models should separately account for parts and supplies for each of the non-vehicle maintenance functions noted above. Particular care should be made to assure that routine capital rehabilitation and replacement costs are included in the financial analysis, either within the cost model (in the form of preventative maintenance) and/or in a separate capital reinvestment analysis.
- **Electricity:** O & M cost models should separately address traction power and other uses because of different demand and usage characteristics and associated different tariff structures applied by the electric utilities. Depending on the structure of the local electric power tariff, the model should separately address the following power requirements:
  - Propulsion power
  - Station power
  - Chiller plants (subway stations)
  - Yards and ancillary facilities

In the case of extensions to existing rail systems, the models should address energy conservation and management schemes currently underway or proposed to minimize electric utility costs.

PRINCIPLE 5: APPLY CONSISTENT LEVEL OF SERVICE INFORMATION

The operating statistics applied in O & M cost models should meet the following internal consistency requirements:

- **Consistency with travel demand analysis assumptions:** The routes, service frequency, average operating speed, peak vehicle, and train length assumptions implicit to the travel demand analysis should be used as the driving variables in the O & M cost models. This information should be used to develop projections of annual revenue hours and vehicle miles.
- **Consistency with construction schedules:** The annual service statistics in O & M cost projections should reflect service adjustments consistent with projected schedules for the opening of new fixed guideway segments, transfer centers, park-and-ride lots, maintenance garages, and other facilities. This includes both the operation of fixed guideway segments and feeder bus routes.

PRINCIPLE 6: APPLY PEER TRANSIT PROPERTY EXPERIENCE

Unless the O & M cost models will be applied in the context of expanding an existing mode, the models will need to reflect the combined experience of engineering and planning analysis and judgement and the experience of similar transit operations at other transit properties. While there is much to be learned from the experience of peer transit properties, operational and cost data from such sources should be applied with care. No two transit systems are identical, regardless of type of service and equipment operated. The following discussion highlights some of the important considerations in applying peer transit property data and addresses common pitfalls observed by FTA and others:

- **Rail transit general and administrative (G & A) ratio:** In some O & M cost models and operating budgets the ratio of G & A cost allocated to the new rail mode to rail operating and maintenance cost is frequently much lower than the similar ratio for the existing bus system. The argument typically made is that the additional positions hired for the new rail system will be limited to management and supervisory positions directly related to rail operations.

EXHIBIT 7

EXAMPLE OF LIGHT RAIL TRANSIT STAFFING ASSUMPTIONS IN O & M COST MODEL

POSITION	JOB CODE	SALARY WITHOUT BENEFITS	SALARY (1) WITH BENEFITS	FY89 FTE'S

OVERHEAD LABOR COSTS ALLOCATED TO TRANSIT OPERATIONS (FUND 1628):	Administration	600	NA	$73,811	NA
	Marketing	601	NA	$170,477	NA
	Fiscal Resources	602	NA	$288,767	NA
	Human Resources	609	NA	$120,168	NA
LIGHT RAIL OPERATIONS (B.U. 0607): LRT ADMINISTRATION:	Assistant General Manager	644101	$70,067	$88,474	1
	Secretary I	644102	$25,406	$32,080	1
	Clerk Typist	644103	$21,070	$26,605	3
	Account Clerk I	644104	$20,407	$25,768	2
	Light Rail Ops. Spec. (Safety)	644105	$57,976	$73,206	1
	Management Analyst	644106	$44,280	$55,912	0
	Admin. Support Officer	644107	$37,326	$47,132	1
	Systems Engineer	644108	$55,400	$69,954	1
	Light Rail Warranty Corridor	644109	$36,796	$46,462	1
OPERATIONS:	Supt. of LRT Operations	644101	$51,782	$66,027	1
	Supervisor of Rail Control	644102	$46,779	$59,846	11
	Rail Operator	644103	$32,521	$44,303	35
	Dispatcher	644104	$34,678	$47,242	4
	Transportation Instructor	644105	$42,752	$54,513	0
VEHICLE MAINTENANCE:	Superintendent	644201	$54,146	$68,733	1
	Vehicle Maintenance Supervisors	644202	$49,272	$62,546	6
	Maintenance Scheduler	644203	$33,928	$43,068	0
	Maintenance Instructor	644204	$44,708	$56,752	1
	Maintenance Specialist (Trolleys)	644205	$57,976	$73,595	1
	Parts Supervisor	644206	$46,949	$59,597	1
	Facilities Maintenance Representative	644207	$33,043	$41,945	1
	Electronics Technician	644208	$38,052	$51,264	2
	Paint, Body & Uphol. Worker	644209	$38,884	$52,385	1
	Electro Mechanic	644210	$38,615	$52,023	12
	LRV Service Worker	644211	$30,407	$40,965	11
	Facility Worker	644212	$28,571	$38,491	2
	Foreperson	644213	$41,403	$55,779	5
	Parts Clerk	644214	$32,407	$43,659	4
WAY, POWER & SIGNALS:	Supt. of Way, Power & Signals	644301	$58,975	$73,913	1
	Supervisor of Power	644302	$46,382	$58,131	1
	Supervisor of Signals	644303	$52,837	$66,221	1
	Supervisor of Track Maintenance	644304	$46,542	$58,331	1

	Supervisor of Station & Way	644305	$40,187	$50,366	1
	Overhead Line Worker	644306	$41,471	$55,542	3

Source: Manuel Padron & Associates, Tasman Corridor Alternatives Analysis, Operating & Maintenance Methodology Report, prepared for Metropolitan Transportation Commission and Santa Clara County Transportation Agency, April 1990.

It is possible, however, that G & A expenses will increase proportionately to the increase in direct operating costs (vehicle operations, vehicle maintenance, and non-vehicle maintenance) for the combined bus and new rail transit system.

- **Adjustments for local conditions:** O & M cost models should account for local conditions which make the planned transit system different from peer systems. These conditions include the following:
  - **Labor cost factors:** Most of these factors are embodied in the labor contract for hourly employees. This includes the following cost components:
    - **Wages:** including wage per hour, scheduled raises and lump sum payments, and progression from entry level to top wage rate (which, along with average seniority, determines average wage rate)
    - **Fringe benefits:** including both wage-related benefits (e.g., pension) and headcount-related benefits (e.g., medical, life insurance)
    - **Work rules:** especially for operators, this includes premium pay for report time, layover time, meal time, intervening time, spread time, turn-in time, travel time, guarantee time, training and other premiums.
  - **Unit price factors:**
    - **Diesel fuel:** costs per gallon for diesel fuel
    - **Electricity:** costs per kilowatt hour. Local tariffs will determine the formula for determining electricity costs. The formula may address such components as the number of connection points, peak kilowatt loads, and types of use (e.g., traction power versus lighting or other uses).
  - **Operational factors:**
    - **Staffing practices:** Because of heavy passenger loads and union contract requirements, some properties staff trains with more than one operator:
      - **Conductors:** Some heavy rail properties utilize conductors to open and close doors, make train announcements, and collect fares.
      - **Additional operators:** Some light rail properties utilize an operator in each car when they are trainlined.
      - **Climate:** Adverse weather conditions, particularly winter weather, can result in higher costs. For example, track tamping on ballasted track is likely to be a higher cost for northern rail systems experiencing freeze-thaw cycles than for southern and southwestern systems.
      - **Deadheading:** The location of bus garages, and the distance of garages from the beginning of revenue service on routes will vary from property to property.
  - **Technology factors:** The sophistication of overall systems and important components and subsystems can have important impacts on costs. For example:
    - **Traction motor controllers:** On rail transit cars, cam controllers are typically less efficient than "chopper" controllers. As a result, otherwise identical cars in identical operating conditions may consume less net electrical power, and have less operating cost, if equipped with chopper controllers.
    - **Automatic train control:** Less complicated rail systems can operate effectively without expensive ATC systems. However, as train frequencies increase and the rail network becomes more complicated (e.g., branching and merging routes), ATC becomes more important. ATC systems can centralize and reduce the number of train control personnel who might otherwise be deployed in the field (at interlocking towers, for example). At the same time, ATC systems require considerable maintenance effort which may offset such savings.
- **Accounting for contracted services when using peer labor productivity data:** Properties that contract out certain functions may have a lower ratio of in-house employees per unit of service than properties that do not contract out. Care should be taken that such lower labor productivity ratios are not inappropriately used in making comparisons or in calibrating O & M cost models. The following functions may be performed in-house, but are frequently contracted out:
  - **Vehicle maintenance:**
    - Component rebuild:

    - Bus: engines, transmissions, differentials, alternators
    - Rail: traction motors, fan and pump motors, other components
    - Heavy maintenance (accident repairs)
    - Tire maintenance
    - Fluid analysis (engine oil, transmission fluid)
  - **Non-vehicle maintenance:**
    - Snow removal
    - Roof repairs
    - Landscaping
    - Equipment repair
    - Garage and shop equipment repair
    - General building repair (plumbing, electrical, painting, concrete repair)
    - Elevator and escalator maintenance
    - Communications equipment repair
    - Service vehicle repair
    - Refuse collection
    - Station cleaning
  - **General administration:**
    - Fare revenue collection and counting
    - Proof-of-payment (self-service) fare inspection
    - Ticket sales
    - Security police at facilities
    - Police patrol on vehicles & at passenger stations/ terminals
    - Outside legal counsel
    - Claims adjusting
    - Transfer printing and other reproduction
    - Custodial services

- **Overly optimistic scenarios:** In planning for lower cost light rail systems, there may be a temptation to structure O & M cost models based on the best (lowest cost) aspects of similar systems, reflecting an assumption that "we'll be better". While there may be considerable justification for such an approach, planners need to understand why various peer properties have certain cost characteristics. Examples of these peculiarities include:
  - **Light rail operator staffing:** Light rail transit in Boston and San Francisco have relatively higher vehicle operation costs per vehicle mile because all vehicles should be manned, regardless of train length, per union work rules.
  - **Track maintenance:** New California light rail systems track maintenance staffing is low compared to northern and eastern rail systems because of relatively infrequent service, mild climate and lack of freeze-thaw cycle, and contracting out of some track maintenance functions.
  - **Transit police:** The SCRTD Blue line has an intensive level of contract police protection because of relatively high crime rates in the communities through which the line runs.

- **Vehicle maintenance data from peers during warranty period:** Care should be taken to consider maintenance activities that might be undertaken by the vendor during the initial operation of new vehicles. Such initial experience (in terms of labor productivity and unit cost per vehicle-mile) may not be representative of longer-term cost experience.

PRINCIPLE 7: APPLY READILY AVAILABLE INFORMATION

O & M cost models should be based, to the greatest extent possible, on readily available information. There are two reason for this:

- O & M cost models should be part of the overall budgeting process applied by management
- FTA and other reviewers should be able to easily confirm the sources of information used in structuring the model

The most important sources of information that will be available, discussed further in the sections below, include the following:

- **Budgets and budgeting data:** Ideally, the O & M cost models should be structured based on the most detailed budgeting data (i.e., line item budgets which identify individual positions and major components of non-personnel cost)
- **Peer transit system data:** The cost experience of similar transit properties may be very useful (subject to the limitations noted above). Among the sources of peer data are the following:
  - Section 15 data
  - APTA operating data
  - Peer property budgets
  - Peer property cost models

It is also important that driving variables in the O & M cost model (e.g., peak vehicles, vehicle-hours, and vehicle-miles) be readily available. This information should be derived from routine operations planning or long-range planning procedures. For example:

- Revenue hours, revenue vehicle-miles, and peak vehicles are typically derived from network analyses as part of a long-range urban transportation planning process.
- Platform hours (which include revenue hours plus deadheading and contract-mandated pay hours for report time, turn-in

time, intervening time and similar time) may be derived either through a more detailed runcutting-type analysis conducted by operations planning staff or may be derived by factoring the revenue hour projection, based on systemwide average ratios of platform-hours per revenue hour.

PRINCIPLE 8: PROVIDE FULLY-ALLOCATED COSTS FOR COST-EFFECTIVENESS ANALYSIS

FTA planning guidelines require that alternatives be evaluated on the basis of equivalent annual costs per incremental passenger. Such costs should be based on fully-allocated operating cost. For the purposes of a cash flow analysis, however, it may be more appropriate to consider incremental costing approaches, particularly for near-term operations.

Fully-allocated operating cost analysis is based on the assumption that in the long-term various administrative and overhead costs are directly related to the quantity of service provided. This assumption is strongly supported by the cost experience of transit properties that have implemented new fixed guideway systems. There have, however, been instances where incremental extensions to existing fixed guideway systems have not resulted in proportionate increases to overhead. This has been demonstrated by recent expansions at WMATA and San Diego Trolley. To some extent, many overhead costs are more the result of responding to local Board of Director policy and local, state, and federal legislative and regulatory mandates and are not directly a function of the quantity of service provided.

Thus, it may be correct to project costs on an incremental basis in some applications. However, from the standpoint of comparing alternatives (and, in the case of FTA review, determining whether an alternative meets national cost-effectiveness standards), fully-allocated costs should be considered.

PRINCIPLE 9: STRUCTURE FOR SENSITIVITY ANALYSES

Financial analyses in Draft Environmental Impact Statements and in detailed financial analyses of the Locally Preferred Alternative should address the uncertainty of various inputs and the extent such risks may affect the financial capacity of the financing entity to undertake the transit investment. The O & M cost model should be applied in a sensitivity analysis to consider the uncertainty in the operating cost component of the overall financial plan.

Sensitivity analyses should establish a lower and upper bound for the operating cost projections by applying lower and upper values for the following cost components:

- **Inflation:** including baseline inflation rates and inflation of major cost components that may significantly differ from the baseline rate, e.g., hourly labor, fringe benefits, fuel, and electricity
- **Labor productivity:** particularly for operators (e.g., pay hour per platform hour) and mechanics (e.g., mechanic hours per 1,000 vehicle miles)
- **Fuel consumption:** in terms of mile per gallon (e.g., in response to an older or younger fleet or the introduction of alternative fuel buses)

PRINCIPLE 10: DOCUMENT MODEL THEORY AND APPLICATIONS

The O & M cost model should be sufficiently documented to permit simple verification of the assumptions and sources of information used. All calculations should be clear and no calculations should be hidden. Intermediate calculations, not required in final published reports, should be documented in subsidiary technical memoranda. Every equation and every coefficient in each resource build-up equation should be clearly referenced, including the source of the information used.

Specific recommendations regarding documentation of key assumptions are included in the last section of this appendix.

III. SOURCES OF INFORMATION

INTRODUCTION

This section addresses the potential sources of information that might be used to structure an O & M cost model. These sources include:

- Transit property budget
- Peer property Section 15 data
- Peer property APTA data
- Peer property O & M cost models, budgets, and other sources of data

Each of these sources is addressed in the discussion below.

TRANSIT PROPERTY BUDGETS

One point of departure in structuring an O & M cost model is the current (or projected) detailed operating budget of the transit property. This source can provide important information for both the existing transit system and for proposed new technologies (e.g., labor unit costs). Budgets have the following advantages as a data source:

- **Detailed staffing data:** Budgets can provide important information regarding the staffing throughout the organization. In the case of multi-modal organizations, the budgets may provide some information regarding the allocation of staff by mode. This information, along with the assumed level of service provided (e.g., vehicle-miles, revenue hours) can yield labor productivity values.
- **Identification of contracting:** Budgets can clearly identify the level of contracting. This is important because low staffing levels may actually result from high levels of contracting.
- **Clear documentation of assumptions:** Well prepared budget documents may provide a concise source of information

regarding assumptions of future financial conditions. These assumptions can include:

- Inflation: including hourly labor, salaried labor, hourly fringes, salaried fringes, claims, fuel, parts, electricity
- Work rule changes (e.g., changes in use of part-time operators)
- Levels of service (e.g., peak vehicles, vehicle-miles, platform-hours, hours of operation)
- Absenteeism and other labor productivity factors
- Major maintenance campaigns

- **Accepted internally:** Quite often the budget document is accepted as the authoritative source of financial information in a transit agency. For a variety of reasons, other references, such as Section 15 reports and planning documents, may not be accepted by management, governance boards, and outside agencies as complete or accurate.

Despite these advantages, there are some limitations in the applicability of budgets as the source of information for structuring O & M cost models:

- **Difficult to compare to peers:** Most transit properties structure their operating budgets according their internal organizational structure. Every transit property is organizationally different, as a result of governance board policy, local laws and regulations, types of service offered, relationships with local governments, and the skills and experience of senior managers. Such differences imply that comparisons between peers should be done with care.
- **May reflect only historical trends:** It is possible (indeed, likely) that future conditions will be different than the past, resulting in changes in labor productivity and unit costs. Examples of such future changes include:
    - New union contract with associated increases in wages and changes in work rules
    - Aging vehicles, resulting in increased maintenance and fuel costs
    - New vehicles, resulting in reduced maintenance and fuel costs

SECTION 15 DATA

The Section 15 Reporting System evolved from the transit industry-initiated Project FARE (Uniform Financial Accounting and Reporting Elements). The system involves the reporting of financial and operating data according to a standard chart of accounts on a standardized set of reporting forms. FTA has undertaken several actions to assure that the data submitted are accurate, uniform in definition, and timely:

- The data to be provided is defined by FTA in a users guide
- Transit property employees responsible for preparing the reports are trained by FTA
- Independent certified public accountants review the submissions
- Contractors to FTA review the data for reasonableness, based on an analysis of trends over time and comparisons to industry standards

The Section 15 data base provides a powerful basis for the analysis of transit operating costs. The most important advantages include:

- **Industry standard:** The common format in reporting aids in making comparisons and computing industry averages
- **Fine level of detail:** Some of the largest transit properties in the country, and those that have received FTA grants for management information systems, report at Level A, which included detailed cost reports for 44 cost functions. This allocation of costs is frequently more detailed than the information found in operating budgets.

Despite these significant advantages, Section 15 data does have the following disadvantages when applied for the purpose of structuring and calibrating operating cost models:

- **Inadequate labor detail:** Section 15 does not provide for much detail in the classification of employees. Only ten categories are available:
    - **Vehicle operations:**
        - Transportation administration
        - Revenue vehicle operator
        - Transportation support
    - **Vehicle maintenance**
        - Vehicle maintenance administration
        - Revenue vehicle inspection and maintenance
        - Vehicle maintenance support
    - **Non-vehicle maintenance**
        - Non-vehicle maintenance administration
        - Non-vehicle maintenance support
    - **General & administrative**
        - Marketing and planning
        - General administration support

This coarse level of detail limits the usefulness of Section 15 data, particularly for rail transit modes, in the following functions:

- **Vehicle operations:**
  - Provides full-time equivalents only and does not separate full- and part-time operators
  - Does not distinguish between other hourly employees (e.g., depot clerks, dispatchers) and salaried employees
  - Does not provide the same level of detail by function as the Level A chart of accounts for expenses
- **Vehicle maintenance:** Does not separate the following vehicle maintenance activities:
  - Service and inspection (the preventative maintenance function)
  - Servicing and cleaning
  - Heavy maintenance: which includes both major in-house vehicle overall and rehabilitation functions as well as some corrective maintenance functions
  - Component rebuild (part of the preventative maintenance function, sometimes extensively contracted-out)
  - Paint and body shop (partly preventative and partly corrective maintenance)
- **Non-vehicle maintenance:**
  - Does not separate the following functions (even though the costs for these functions are reported by Level A reporters):
    - Vehicle movement control systems
    - Fare collection and counting equipment
    - Roadway and track
    - Structure, tunnels, and subway
    - Passenger stations
    - Operating station buildings, grounds, and equipment
    - Garage and shop buildings, grounds, and equipment
    - Communication systems
    - General administration buildings, grounds, and equipment
    - Operation and maintenance of electrical power facilities
  - Does not distinguish between mechanics and salaried staff (as in the case of vehicle maintenance)
- **General administration:**
  - Does not distinguish among the 16 functions reported by Level A reporters.
  - Does not distinguish between non-supervisory and front-line supervisory positions, particularly for the following functions, which typically involve significant levels of manpower:
    - Ticketing and fare collection
    - System security
    - Purchasing and stores

- **Inadequate breakdown of labor costs:** Section 15 expense forms separate labor costs for each function into only two object classes:
  - Operators' wages
  - Other salaries and wages

  Hence, except for operators, there is no distinction between costs for management, supervisory, administrative, support, and labor personnel.
- **No information regarding local cost factors:** Section 15 data does not report local cost factors that are likely to differ between transit properties, such as:
  - Wage rates (e.g., top hourly wage, average hourly wage, mix of full-time and part-time operators)
  - Runcutting measures (e.g., mix of straight, split, and tripper runs)
  - Fringe benefits (e.g., employer contributions as percentage of wage or per employee for medical/insurance, pension)
  - Work rules (e.g., specific provisions that result in premium hours)
- **No information regarding physical differences:** Section 15 data does not describe the physical differences between otherwise similar transit properties, e.g., age of fixed plant, technology, climate, passenger loading, fare collection technology
- **Errors in data definitions and reporting:** Recent data is more reliable than earlier data.

PEER PROPERTY APTA DATA

The American Public Transit Association (APTA) annually publishes Transit Operating and Financial Statistics. The data presented are based on FTA Section 15 reports provided directly by the transit properties, not by FTA. These data have the following advantages:

- **Prompt reporting:** APTA usually publishes annual statistics much sooner than FTA because the data are not subject to the intensive review that FTA and its contractors undertake to assure completeness, accuracy, and consistency of the data.

- **Concise reports:** Data are presented by transit property, rather than by type of expense or revenue category. Most transit properties are summarized within two to four pages. Data include:
    - Operating revenues, by category
    - Operating expenses, by Level C function, by object class
    - Operating expenses, by mode:
        - by Level C function
        - Total salaries and wages, fringe benefits, services, purchased transportation
    - Service data, including:
        - Directional route miles and miles of track
        - Stations
        - Active, total, and emergency contingency vehicles
        - Vehicles operated in AM peak, midday, PM peak
        - Vehicle operator and total employee equivalents
        - Unlinked passenger trips and passenger-miles
        - Revenue and total vehicle miles
        - Revenue and total vehicle hours
        - Gallons of fuel/kilowatt-hours of electricity
    - Vehicle operator wages, by type of payhour
    - Fringe benefits, by type of benefit.

The primary disadvantage of these data is that since it is not subject to the same level of review as the published FTA Section 15 data, it may include some errors and, as a result, may not be consistent with such published Section 15 data.

PEER PROPERTY O & M COST MODELS

A third important source of operating data is operating and maintenance cost models developed for peer transit properties (and other operating data) which underlie such models. There are many examples of operating cost models that are based on a carefully researched and reasoned set of assumptions.

The key advantages of these previously developed models include:

- **Provides additional data:** Carefully applied, these models provide a large amount of data that may be valid for similar transit systems.
- **Provides an upper and lower bound of key labor productivity and unit cost values:** These models typically span a range of values for important model cost components that could be useful in conducting sensitivity analyses.
- **Reasonableness tests:** The models can serve as a test for reasonable aggregate values of costs per unit of service (e.g., cost per vehicle hour for vehicle operations, cost per vehicle mile for vehicle maintenance)
- **Validation:** O & M cost models which address expansion of existing fixed guideway systems are typically structured based on actual data (prior, current, or future year budgets). The extent to which such information is a valid basis for projections should be addressed, however. For example, the following changes might result in costs that would not be suggested by prior cost experience:
    - Massive expansion in service, involving a significant change in the service plan (i.e., conversion of line haul bus routes to feeder routes), due to changes deadheading and utilization of operator labor)
    - Opening of new maintenance facilities (i.e., investment in new maintenance equipment and provision of improved working conditions may result in increase labor productivity)

There are, however, some important limitations to the application of cost models prepared for other transit properties:

- **Prospective nature:** In the case of proposed new rail transit systems, the models will be untested against actual operations.

- **Contracted maintenance services:** The models may not reveal the implicit assumptions regarding the quantity of work not performed in-house. This may result in inappropriate assumptions of labor productivity.

IV. DESCRIPTION OF O & M COST DATA BASE

This section, which contains data from 1985-1990, is not available on-line. To view this section order a copy of this publication, Estimation of Operating and Maintenance Costs for Transit Systems.

V. GUIDELINES FOR DOCUMENTATION OF ASSUMPTIONS IN O & M COST MODELS

INTRODUCTION

Documentation of an O & M cost model is necessary to permit FTA and other reviewers to:

- Determine the reasonableness of the cost projections

- Establish lower and upper bounds in the context of sensitivity analyses
- Serve as a point of departure for future studies
- Educate other professionals.

Ideally, every line item and every component in every line should be documented. The minimum requirements for documentation should include the following:

- Logic behind structure, e.g., if prior models distinguished between old and new vehicles, but future operations assume that the older vehicles will be retired, this should be noted)
- Source document(s) name(s) and transit property (or other source)
- Date of data
- Discussion of anticipated changes from current conditions (e.g., labor contract, aging fleet) and, if appropriate, other reasons why historical trend data is not used
- Correlation between ranges in data base and assumptions actually used, i.e., explanations if outside range
- Reasons for applicability of peer property data

One approach to accomplish this, in a microcomputer spreadsheet application, would be to add comment columns for each row in the spreadsheet.

This section suggests the appropriate level of documentation of information, assumptions, and sources of information and assumptions in the structuring and application of O & M cost models. Specifically, documentation is important for the following:

- Characterizing similar transit systems whose labor productivity and unit cost experience is applied in the model.
- Developing a checklist of changes to the model to consider in future applications.

DOCUMENTATION OF VEHICLE OPERATIONS

The following issues should be addressed in the documentation of the vehicle operations portion of O & M cost models:

- **(011) Transportation administration:** value as a percentage of total operations costs
- **(012) Revenue vehicle movement control:**
  - Bus systems:
    - Rationale for deployment of street supervisors (e.g., by sector or garage or per platform hour)
    - Potential use of automatic vehicle location technology
  - Rail systems:
    - Sophistication of train control (automatic block signals, cab signals, automatic train control)
    - Level of effort required as network becomes more complex (e.g., increased branching) and as train frequencies increase
    - General: Salaries for supervisors and controllers
- **(021) Scheduling of transportation operations:**
  - Deployment of traffic checkers; potential changes with implementation of rail service and feeder bus service
  - Sophistication of scheduling and runcutting; increased use of automation
- **(031) Revenue vehicle operations:**
  - Service profile, by time of day: mix of straight, split, and tripper runs
  - Labor productivity (peak/off peak, by division to address differences in deadheading):
    - Platform hours per revenue hour
    - Scheduled pay hours per revenue hour
    - Actual pay hours per scheduled pay hour
    - Wage rates: including average rate for full and part-time operators
    - Fringe benefits:
      - Wage related: pension, FICA
      - Head count-related: medical, insurance

DOCUMENTATION OF VEHICLE MAINTENANCE

The following issues should be addressed in the documentation of the vehicle maintenance portion of O & M cost models:

- **(041) Maintenance administration:** value as a percentage of total vehicle maintenance costs
- **Each Level A function:** The following should be documented for revenue vehicle servicing (051), inspection and maintenance (061), accident repairs (062), vandalism repairs (071); service vehicle servicing (071), fuel (081), and inspection and maintenance (091):

- Labor productivity, by type of vehicle
- Average wage rates
- Fringe benefits
- Parts, by type of vehicle
- Fuel, by type of vehicle
- Contracted services

DOCUMENTATION OF NON-VEHICLE MAINTENANCE

The following issues should be addressed in the documentation of the non-vehicle maintenance portion of O & M cost models:

- **(042) Maintenance administration - non-vehicles:** value as percentage of total non-vehicle maintenance cost
- **(101) Maintenance of vehicle movement control system**
  - Sophistication of technology (e.g., automatic block signal, cab signal, automatic train control
  - Split between way-side and control center equipment
- **(122) Maintenance of Roadway and Track**
  - Extent of tangent and curve sections
  - Track wear (vehicle-miles per mile of track) compared to peer properties
  - Type of rail fixation (e.g., wood tie on ballast, concrete tie on ballast, direct fixation on floating slab)
  - Hours of operation: 24-hour operation limits availability of track for extensive maintenance and increases costs
  - Busways: Assignment of responsibility to transit property or highway department for roadway surface repair and lighting
- **(123) Maintenance of passenger stations:**
  - Age of peer property stations
  - Mix of surface/aerial and subway stations
  - Climate (particularly for maintenance of surface/aerial stations)
  - Passenger traffic
- **Maintenance of Operating station buildings, grounds, and equipment (includes 121, 124, 128, 131):**
  - Passenger amenities (e.g., rest rooms, enclosed waiting areas)
  - Landscaping responsibility of transit property or other public entity
  - Size and number of park and ride lots
- **(125) Maintenance of garage and shop buildings, grounds, and equipment:**
  - Number and age of buildings
  - Size of garages (number of service positions, number of vehicle hoists and inspection pits)
  - Type of activities performed (e.g., component rebuild, paint and body shops)
- **(126) Maintenance of communication system:**
  - Number of vehicles
  - Age of equipment
  - Sophistication of equipment (e.g., simple voice, AVL)
  - Percent of work contracted out
- **(127) Maintenance of general administration buildings, grounds, and equipment:**
  - Age and size of buildings
  - Portion of general administration space leased and owned by transit property
  - Percent of work included in capital budget
  - Percent of work contracted out
- **(141) Operation and maintenance of electric power facilities:**
  - Number of substations (longer trains and more frequent service may result in more traction power substations)
  - Sophistication of traction power substations and tie-breaker stations)
  - Percent of work contracted out

DOCUMENTATION OF GENERAL ADMINISTRATION

In the cases of transit systems that are departments of municipal government, many general administrative functions may not be addressed in the Section 15 data. The mix of work performed in each function between in-house forces and contractors may vary from property to property. While this may not affect comparisons of total cost, it probably will affect comparisons of number of employees. Among the more important issues to be addressed are the following:

- **(145) Preliminary transit system development:** Service planning costs associated with day-to-day service decisions should be included. Much of this function is capital-related, however, and is not pertinent to projecting operating costs.
- **(151) Ticketing and fare collection:**
  - Fare collection technology
  - Hours of operation and hours that stations are manned
  - Extent of contracting out
- **(161) System security:**
  - Extent of law enforcement responsibilities of transit property and of local governments
  - Intensity of police patrol function (e.g., number of stations patrolled by each police officer)
  - Number of facilities with 24-hour security protection
  - Extent of contracting out
  - Extent of investigation and other administration functions
  - Extent of training requirements
- **(165) Injuries and damages**
  - The claims experience for third party liability claims and for workers compensation claims should be addressed separately.
  - Third party liability claims experience is typically very different for bus and rail modes for a given transit property.
  - Workers' compensation claims experience typically varies for bus operators, rail operators, bus mechanics, rail mechanics, non-vehicle mechanics, station agents, and other employees (both in terms of claims rate and cost per claim)
  - Third party liability claims rates and costs per claim vary from property to property, depending on trends in jury awards, "deep pocket syndrome", and other factors
  - Workers' compensation claims rates and costs per claim vary from property to property, depending on state workers' compensation laws and regulations.
- **(168) General legal services**
  - Should address requirements related to contracts and tort litigation as well as general legal issues, including drafting of legal documents.
  - Many properties contract-out significant portions of this function.
- **(169) General insurance**
  - Should include premiums for the following types of insurance:
    - Operating liability (injuries to passengers and third party property)
    - Operating property (damages to transit property-owned assets, e.g., buses, trains, equipment, facilities)
    - Boiler and machinery (damages to and caused by dangerous equipment)
    - Disappearance, Dishonesty, Destruction ("3-D") Crime (damage resulting from criminal activity)
    - Data processing (damages to computer equipment and data bases)
    - Owners, Landlord, and Tenant (damages related to leased real property)
  - Premiums will depend on loss history, market conditions, and magnitude of (self-insured) deductible.
- **(172) Purchasing and stores:**
  - Number of storerooms
  - Hours of operation of storerooms
  - Number of subfleets of revenue vehicles (as the number of subfleets and vehicle manufacturers increases, so does the size of the inventory and the number of storeroom bins to be managed.
- **(162) Customer service:**
  - Division of responsibilities between transit property and other regional transportation agencies

DOCUMENTATION OF OPERATING STATISTICS

The documentation of O & M cost model driving variables should focus on level of service and facility descriptors:

- **Level of service statistics**
  - **Bus:** At a minimum this should include peak vehicle, revenue hours, and vehicle miles by type of vehicle, by operating garage. If significant changes in service profile by time of day is anticipated, then additional data regarding the breakdown of straight split, and tripper runs should be addressed.
  - **Rail:** Number of peak trains, peak vehicles, and vehicle miles

- **Physical description of facilities**
  - **Bus:** garages, park-and-ride lots, bus shelters, transfer centers, busway route-miles
  - **Rail:** route-miles or track miles, by vertical profile (e.g., subway, street operation, surface in private R.O.W., aerial); stations, by vertical profile; maintenance facilities and yards, chiller plants (if subway); traction power substations

DOCUMENTATION OF INFLATION

O & M cost model documentation should address the assumed annual rates of inflation and sources of information for the following:

- **Baseline rate of inflation:** This is the projected rate of inflation that underlies all projections of expenses and revenues. It is used for the basic conversion from base year (or uninflated) to year-of-expenditure (or inflated dollars). Typically, the local or national Consumer Price Index is used as the baseline rate of inflation.
- **Incremental rates of inflation:** Various components of expense and revenue may have rates of inflation above or below the baseline rate:
  - Hourly wages
  - Fringe benefits (especially health insurance costs)
  - Fuel
  - Electricity

Appendix

1. O & M COST DATA BASE

2. Cost, Labor Productivity, and Physical Characteristics of Light Rail and Rail Rapid Transit Properties

3. Cost, Labor Productivity, and Physical Characteristics of Commuter Rail Properties

This section, which contains data from 1985-1990, is not available on-line. To view this section order a copy of this publication, Estimation of Operating and Maintenance Costs for Transit Systems.