Seats

Reclining or semireclining, high-back, cushioned seats are to be installed. All passenger seats must be forward facing. Seats are to be reupholstered, and seat assemblies including frames, reclining mechanisms, and adjustable headrests and footrests if so equipped are to be inspected and replaced with new parts or repaired. Additional seating specifications such as color arrangement, manner of attachment, and accessories will be specified by the county at a later date. Overhead package racks and individual reading lights are required. Vinyl/cloth box seats with supported expanded vinyl 4502 to the yard with Fifth Quality 4916 fabric for the cloth are required. Armrests and headrests should be vinyl.

Paint, Trim, Striping, and Undercoating

The bus interior and exterior are to be painted according to the graphics scheme specified by Prince William County.

Striping and decals are to be installed according to the graphics scheme specified by Prince William County.

Detailed painting and graphic specifications will be provided by the county at a later date. However, the bidder should submit the cost of a standard three color paint scheme. Exterior and interior paint is to be Dulux paint (Alkyd enamel) or an approved equivalent.

The bus understructure is to be undercoated with Tectyl 165G or an approved equivalent.

Life-Cycle Costing in the Transit Industry

ALLEN R. COOK, T. H. MAZE, UTPAL DUTTA, and MARK GLANDON

ABSTRACT

Life-cycle costing is an economic evaluation scheme that accounts for capital, operating, and maintenance costs during the usable life of transit vehicles. Cost containment is a major concern of transit agencies, and life-cycle costing has the potential to facilitate significant decreases in transit agency budgets as well as to enhance future budget planning and cost forecasting. However, a 1983 General Accounting Office (GAO) survey of 186 transit agencies found that most agencies lacked experience with and understanding of the procedures. The GAO concluded that most agencies lacked adequate technical information and adequately trained staff. In this paper an independent analysis of the original GAO data is reported. The analysis found that many agencies still keep largely manual operating and maintenance records. Some do not collect this information by individual bus. Seven prerequisites to good life-cycle costing procurement are presented.

Present practices in life-cycle cost procurement in the American bus transit industry are reviewed. The role of life-cycle costing is discussed first. There follows an analysis of the types of maintenance information collected by transit agencies and their experiences with life-cycle costing as reported in a 1983 General Accounting Office survey of 186 transit bus fleet operators in the United States. The paper concludes with a review of seven prerequisites for good life-cycle cost procurement.

LIFE-CYCLE COST PROCUREMENT

Background

Life-cycle costing is an economic evaluation scheme that accounts for capital, operating, and maintenance costs during the usable life of an investment. In theory, it is both a common-sense approach to equipment procurement and a well-established evaluation procedure in engineering economics. Most private equipment investment and replacement decisions instinctively incorporate at least a recognition, if not a formal accounting, of life-cycle costing.

In practice, at least in the public sector, life-cycle costing has been promoted as an innovative alternative to equipment procurement based on minimum initial capital cost, the "lowest bid" (1). In the federal government life-cycle costing has been used for military procurement by the Department of Defense since the 1960s (1). It is also used by the General Services Administration for the purchase of such standardized items as typewriters and office supplies.

UMTA, in response to congressional dictates, first required life-cycle costing for the purchase of transit vehicles in 1982 (Federal Register, Vol. 47, No. 33, Feb. 18, 1982, pp. 7361-7364), and later, in 1983, UMTA made it optional. A 1983 General Accounting Office (GAO) report (2) castigated UMTA for not documenting the cost-effectiveness of life-cycle costing, although it conceded that UMTA previously had expressed similar reservations to Congress.

Both UMTA and GAO agreed that most transit agencies lacked the technical information, resources, and staff expertise to adequately undertake a life-cycle procurement program. The GAO report noted that for many transit agencies the program was costly to implement and occasionally delayed vehicle procurement. However, because the federal government funds most of the capital investment, it is in the best interests of all concerned, including the taxpayer, that this investment be protected through adequate procurement and maintenance management systems. Life-cycle costing can facilitate both programs.

Cost Factors in Transit Bus Operations

Bus operating and maintenance expenses are significant elements in transit agency budgets. A 1983 UMTA report estimated transit bus operating and maintenance costs as follows, on the basis of 1981 Section 15 reports (3):

Cost Category	Percentage of Total
Operator labor (wages, benefits)	46
Vehicle maintenance	
Labor	15
Materials and supplies	6
Fuel and lubricants	10
Other	23
Total	100

Those costs directly associated with the operation of transit vehicles, fuel and maintenance, were 31 percent of the total, and this amounted to an annual national expenditure of more than $1.3 billion in 1981.

Individual public transit agencies report figures similar to these national statistics. In FY 1983 these costs amounted to about 34 percent of the total operating expenses for the Central Oklahoma Transportation and Parking Authority in Oklahoma City. Jones (4) cited fiscal year cost projections from 1981 to 1985 for Tri-Met in Portland, Oregon, of which about 27 percent was for maintenance and fuel costs. Peskin (5) projected that bus vehicle maintenance costs (including fuel) for Houston's Metropolitan Transit Authority would be 45.8 percent of total operating costs in 2000.

Inadequacy of Common Bus Costing Models

Conventional bus costing models, typically developed with other objectives in mind, are generally unable to extract these factors. Both Cherwony et al. (6) and Kemp et al. (7) have reviewed the state of the art in bus costing models. Most of these models appear to be based on average costs per vehicle-mile or vehicle-hour and are intended for use in making service provision decisions about things like route and headway changes.

Such models assume that a bus is a bus and they do not address different bus models or alternative maintenance policies. Kemp et al. (7,p.29) complain that present models are inadequate even for level of service decisions:

> Much of the information in the bus costing literature is not directly relevant to practical problems of this nature. Many studies have suffered from a lack of attention to the reasons for wanting cost information and to the relation between the information and the decisions being made.

The same argument could be made for their utility in life-cycle costing analysis. Ortner (8) reviewed eight urban transit operating cost models and found that all were unreliable in forecasting future operating costs.

Cherwony et al. noted in 1982 that more recent research in bus costing has emphasized labor costs because transit is a labor-intensive industry: "Not surprisingly, the latest research places a common focus on examining the major cost element of transit service: drivers' wages" (6,p.59). They conclude: "With greater emphasis on cost containment and resource allocation in the future, planners will need to understand the factors that influence bus operating costs" (6,pp.59-60). Kemp et al. (7,p.29) contend that future bus costing procedures must be more responsive to what they call "innovation":

> By comparison with service changes that use only procedures and types of resources already in use, innovation involves some new feature in the way output is produced. For instance, transit management might be asking whether new types of buses can be substituted for old, whether cheaper sources of labor might be used, whether a new way of organizing services might be beneficial, and so on. Bus operators face make or buy decisions; for example, they must decide whether to contract for maintenance work or provide it in-house.

One example of a more responsive costing framework is suggested by Peskin (5) and used to project the costs of significant transit alternatives (e.g., bus-only options, options that include light rail service) to the year 2000 for the Metropolitan Transit Authority in Houston. Costs are allocated in this model to administrative units (e.g., maintenance and operations) and labor categories, hence making it possible to extract the cost implications of different vehicle technologies and management strategies. It is interesting to contrast Peskin's application of the term "cost allocation" with Cherwony et al. (6) who "allocate" costs to aggregate measures of transit service, such as vehicle-miles and number of peak service vehicles. Another example is provided by Jones (4) who describes a costing methodology used by Tri-Met to forecast revenues and costs 5 years in advance. This methodology is also based on labor, administrative, operational, and maintenance components.

Applications of Life-Cycle Costing

Seldon (1) described six primary uses for life-cycle costing, which have been adapted to the transit industry:

Long-Range Planning and Budgeting

As Seldon notes, gathering the data needed to do life-cycle analysis forces an agency to clarify and identify the operational and maintenance cost elements of a transit organization. This should facilitate the projection of agency budgets over a long period of time, as demonstrated by Jones (4) and Peskin (5).

Comparison of Competing Programs

Life-cycle costing can provide some of the information needed for broader policy making, such as proposals to implement light rail services as an alternative to expanded bus service. Other examples include decisions to purchase different types of buses (e.g., vans, articulated buses, minibuses) or proposals to purchase used or remanufactured buses.

Comparison of Maintenance Strategies

There are alternatives in maintenance management that are best analyzed in the long range, in keeping with the life-cycle costing approach. These include analysis of the levels of maintenance to be performed as a function of equipment life and policies with regard to the use of in-house maintenance expertise instead of contracting for some maintenance work from outsiders.

Decisions About Replacement of Aging Equipment

There is a variety of strategies for determining when to replace aging vehicles [Rueda and Miller (9) compare six of the more popular models] and most would benefit from the information needed for life-cycle costing. Life-cycle costing would enable transit agencies to more effectively implement and monitor a particular procurement strategy.

Control over an Ongoing Program

The effective management of any program requires adequate information on what aspects of the organization contribute to costs. Life-cycle costing implies the development of a data base that should facilitate the ongoing monitoring of organizational performance. In the 1980s this is of particular significance to transit agencies that are experiencing soaring operating deficits at a time of diminished financial resources. Cost containment is a primary objective of contemporary transit service provision.

Selection Among Competing Contractors

Finally, life-cycle costing, in principle, is the rational economic approach to evaluating alternative bids for equipment, including transit buses. Seldon in 1979 anticipated the questions that UMTA and GAO were grappling with 5 years later: Can explicit performance requirements be written? Are enough historical data available? Is the additional time required for life-cycle costing acceptable? Do both the buyer and the seller have the management resources to carry out the analysis?

Example Application

Figure 1 shows one potential product of a life-cycle costing information base. The average capital, operating, and maintenance costs per mile over the lifetimes of 120 automobiles owned by the Oklahoma Department of Transportation were modeled and graphed in the figure for a range of hypothetical original purchase prices. The operating and maintenance costs per mile were modeled as a function of mileage. Differences in the operating characteristics of automobile models were factored out using dummy variables. The hypothetical purchase prices ($6,000 to $16,000) were divided by the mileages and added to the average operating and maintenance costs.

Note that the average cost minimums of all six curves are at approximately the same mileage, about 71,000 to 78,000 miles, which is a range of 9 percent of the mean mileage. Total average costs per mile at the minimums vary from $0.21 to $0.33 per mile, a range of 44 percent of the mean value, and the assumed purchase prices vary from $6,000 to $16,000, a range of 91 percent of the mean value. Note that the large variations in purchase price have a relatively small impact on the total average cost and an insignificant impact on the optimal replacement mileages. This example demonstrates that the original capital cost of a vehicle is not as important as the operating and maintenance costs incurred over time.

Such information is useful for long-range planning and budgeting and for decisions about vehicle replacement, two of Seldon's applications for life-cycle costing. Because unexpected problems can occur with vehicles, this information is equally useful for the annual planning of vehicle replacement. The costs associated with retaining vehicles that have incurred unexpectedly large operating and maintenance expenses can be compared with those of new replacements each budget year, regardless of the remaining useful lives of the older vehicles. Furthermore, this information can be used to support transit agency contentions that some information supplied by manufacturers is inaccurate or that certain components or bus models should be avoided. The only real assurance that transit agencies have that data supplied by manufacturers are accurate is confirmation from actual operating experience.

Summary

Cost containment is a major concern of the transit industry in the 1980s. Present bus costing models tend to be unresponsive to some of the larger issues confronting transit agencies, notably significant and rising operating and maintenance costs. The federal government is halfheartedly encouraging the transit industry to engage in life-cycle costing procurement in hopes that it can help transit agencies save money and get a better grasp of the cost drivers in transit operations. In the past, life-cycle costing has been promoted as a strategy that can respond to these issues and concerns.

TRANSIT INDUSTRY EXPERIENCE WITH LIFE-CYCLE COSTING

Background

In 1983 the GAO undertook a survey of 186 transit operators with motor bus fleets to support their report, "Cost Effectiveness of Life-Cycle Process in Buying Transit Vehicles Questionable" (2). The GAO used this information to support their contentions that transit operators lacked sufficient guidelines and information to adequately do the job. The questionnaire responses presented in this paper were obtained from independent statistical analysis of the GAO questionnaire results and represent information not reported in the GAO report.

The GAO data were used to determine the extent of computerization of maintenance records by transit agencies, the types of maintenance data collected, and the difficulties agency personnel have encountered in doing life-cycle costing. This information helped in the formulation of the seven prerequisites to life-cycle costing that conclude the paper.

The respondents represented approximately 53.8 percent of the estimated 346 transit systems eli-

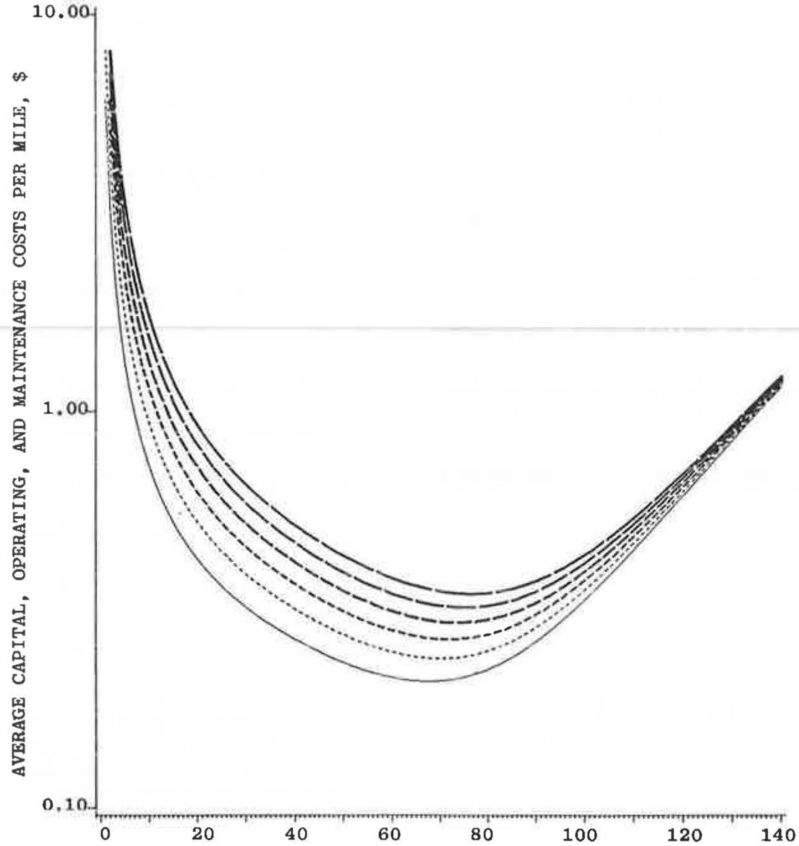

FIGURE 1 Example life-cycle costing analysis.

gible to receive federal financial assistance to purchase buses and included most of the largest bus fleet operators. For purposes of statistical analysis the transit systems were grouped into four fleet size ranges: less than 25, 25 to 99, 100 to 999, and 1,000 or more vehicles. The majority of these bus fleet operators, regardless of fleet size, have buses made by more than one manufacturer. In most fleets the average fleet age tends to be 7 to 9 years.

Use of Computer-Based Operating and Maintenance Records

The 186 transit agency respondents were asked if their operating and maintenance cost and frequency of occurrence records were kept manually or on a computer. Surprisingly, four systems (2.2 percent of the total) indicated that they kept no cost records at all, and 19 systems (10.2 percent) kept no frequency of occurrence records. There was no particular correlation of lack of record keeping and size of the motor bus fleet, although all operators with more than 1,000 buses kept records.

Tables 1 and 2 give the type of record-keeping system, by size of bus fleet, for cost and frequency of occurrence records, respectively. In both tables a statistically significant interaction between the variables is present; the larger the bus fleet is the more likely it is that records are computerized. However, in this age of rapidly advancing computer technology, it is somewhat startling to note that 77 operators (42.3 percent) kept manual cost records only in 1983 and 91 (54.5 percent) kept only manual frequency of occurrence records.

Only about one-fourth of the sampled transit agencies have gone largely to computerized record-keeping systems. Only four operators (2.2 percent of the total 186) reported fully computerized cost records, and only six (3.2 percent) had fully computerized frequency of occurrence records.

Vehicle Classifications in Record Keeping

The GAO asked if the respondents kept their operating and maintenance records by individual bus, bus model, total fleet, or some combination thereof. Agencies that at least aggregate their records by bus model can use their own past experience in the life-cycle costing procurement process; those that keep individual bus records are in an even better position do so. Furthermore, the latter operators can relate operating and maintenance histories and costs to the operating environment and service characteristics experienced by each bus.

The majority of bus operators who kept records did so by individual bus. GAO requested the record type for the following factors: fuel, tires, engine oil, brakes, transmission, engine, air conditioning, preventive maintenance, and chassis. Responses were virtually identical for all factors except tires, which typically are leased from manufacturers or

TABLE 1 How Bus Operating and Maintenance Cost Records Are Kept

	Size of Motor Bus Fleet				
Record Type	Less than 25	25 to 99	100 to 999	More than 1,000	Total
Only manual records	35 (59.3%)	23 (38.3%)	16 (32.0%)	3 (23.1%)	77 (42.3%)
Mostly manual but some computerized	15 (25.4%)	22 (36.7%)	15 (30.0%)	6 (46.1%)	58 (31.9%)
Mostly or all computerized	9 (15.3%)	15 (25.0%)	19 (38.0%)	4 (30.8%)	47 (25.8%)
Total	59 (100.0%)	60 (100.0%)	50 (100.0%)	13 (100.0%)	182 (100.0%)

Chi-square = 14.305. d. f. = 6. prob. = 0.0264, significant

TABLE 2 How Bus Operating and Maintenance Frequency of Occurrence Records Are Kept

	Size of Motor Bus Fleet				
Record Type	Less than 25	25 to 99	100 to 999	More than 1,000	Total
Only manual records	38 (71.7%)	28 (53.9%)	22 (44.9%)	3 (23.1%)	91 (54.5%)
Mostly manual but some computerized	9 (17.0%)	14 (26.9%)	11 (22.5%)	7 (53.8%)	41 (24.5%)
Mostly or all computerized	6 (11.3%)	10 (19.2%)	16 (32.6%)	3 (23.1%)	35 (21.0%)
Total	53 (100.0%)	52 (100.0%)	49 (100.0%)	13 (100.0%)	167 (100.0%)

Chi-square = 17.703, d. f. = 6, prob. 0.0070, highly significant

distributors. The transmission records reported hereafter are representative of the remaining operating and maintenance factors.

The data given in Table 3 indicate a highly significant interaction between vehicle classification and size of the bus fleet; the larger the fleet the less likely agencies were to keep transmission cost records by individual bus. Overall, 68.9 percent of those operators that kept transmission records (115 operators) did so by individual bus. Fifty-two operators (31.1 percent) kept transmission cost records by total fleet or bus model only; 47 of the 52 kept their records by total fleet only. Smaller operators were more likely to keep individual bus records; only half of the nation's largest transit fleet operators bother to collect the information for each bus.

The same patterns did not prevail with frequency of occurrence records; transit agencies were much more likely to keep these records by individual bus. Furthermore, there were no significant interactions by size of the bus fleet, as indicated by the data given in Table 4 for transmission records. These responses should not be a surprise because frequency of occurrence records are most relevant for the analysis of vehicle and parts histories, whereas cost records are developed primarily for accounting purposes.

Eighty-nine percent of the operators (145) kept transmission frequency of occurrence records by individual bus. Relatively few operators aggregated this information for the whole fleet, and 15 (8.1 percent) kept fleet transmission records only.

Difficulties with Life-Cycle Costing Procurement

On the basis of their questionnaire survey and additional discussions with transit agencies, the GAO identified 43 agencies with past or present experience in life-cycle cost procurement (2). The GAO concluded that many of these operators had experienced higher costs and delays in bus procurement because of life-cycle costing. The lack of standard-

TABLE 3 Vehicle Classification for Cost Records Kept of Transmissions

Vehicle Classification	Size of Motor Bus Fleet: Less than 25	25 to 99	100 to 999	More than 1,000	Total
By total fleet or by bus model only	15 (28.8%)	10 (17.5%)	21 (45.7%)	6 (50.0%)	52 (31.1%)
Individual bus	37 (71.2%)	47 (82.5%)	25 (54.3%)	6 (50.0%)	115 (68.9%)
Total	52 (100.0%)	57 (100.0%)	46 (100.0%)	12 (100.0%)	167 (100.0%)

Chi-square = 11.55, d. f. = 3, prob. = 0.0091, highly significant

TABLE 4 Vehicle Classification for Frequency of Occurrence Records Kept of Transmissions

Vehicle Classification	Size of Motor Bus Fleet: Less than 25	25 to 99	100 to 999	More than 1,000	Total
By total fleet or by bus model only	6 (11.5%)	4 (8.0%)	8 (16.7%)	0 (0.0%)	18 (11.0%)
Individual bus	46 (88.5%)	46 (92.0%)	40 (83.3%)	13 (100.0%)	145 (89.0%)
Total	52 (100.0%)	50 (100.0%)	48 (100.0%)	13 (100.0%)	163 (100.0%)

Chi-square = 3.643, d. f. = 3, prob. = 0.3026, no significance

ized vehicle performance data hampered the agencies in preparing and evaluating their procurement requests and made it difficult for the GAO to assess the economic benefits of life-cycle costing procurement. The GAO noted that UMTA had not prescribed specific procurement guidelines and that there was inadequate information on bus operating and maintenance costs.

Finally, transit agencies typically reported that they lacked sufficient staff expertise to adequately evaluate life-cycle cost information. The GAO reported that 36 of the 43 transit systems had obtained outside technical and legal assistance, typically from UMTA, other transit systems, private consultants, and the American Public Transit Association.

Among 173 questionnaire respondents to the question, "How difficult will it be for your transit system to prepare a LCC procurement bid for motor buses given the cost data your transit system currently maintains?" more than 40 percent indicated that they would experience great or very great difficulty, or that it would be impossible. A tabulation of the responses is given in Table 5.

The size of the bus fleet made no difference in the reported degree of difficulty, but past experience in life-cycle costing did make a difference. The data in Table 6 indicate the statistically significant relationship between degree of difficulty and past experience. Interestingly, 22.4 percent of the experienced agencies still found the task to be of very great difficulty or impossible. Finally, there was no significant relationship at all between the availability of computerized records and the degree of difficulty.

With respect to frequency of occurrence records, the degree of difficulty responses were similar, although there was a significant interaction with bus fleet size, as the data given in Table 7 indicate. The smallest fleet operators tended to report greater difficulty than the larger operators. As with the cost records, it made no difference in difficulty whether records were kept manually or by computer.

Understanding of Life-Cycle Cost Procurement

The GAO asked operators how well their staff understood the current life-cycle costing requirement. Their responses are given in Tables 8 and 9. Only 35 of the respondents (18.8 percent) stated that they had a "great amount" of or a "thorough" understanding, and the interaction in Table 8 indicates that understanding increased with the size of the transit operation. Less than 10 percent of the operators of fleets of less than 25 buses had a great amount of or a thorough understanding. It is likely that larger agencies have more knowledgeable staff mem-

TABLE 5 Difficulty of Preparing a LCC Procurement Bid for Motor Buses on the Basis of Currently Maintained Cost Data

Degree of Difficulty	Number of Respondents	
Little or no	10	(5.8%)
Some	25	(14.4%)
Moderate	65	(37.6%)
Great	38	(22.0%)
Very great	28	(16.2%)
Impossible	7	(4.0%)
Total	173	(100.0%)

TABLE 6 Difficulty in Preparing a Life-Cycle Costing Procurement with Cost Data Based on Agency Experience

Degree of Difficulty	Transit System Has or is Making an LCC Procurement	Transit System Has Never Made an LCC Procurement	Total
Some, little, or none	18 (31.0%)	18 (15.1%)	36 (20.3%)
Moderate	15 (25.9%)	51 (42.9%)	66 (37.3%)
Great	12 (20.7%)	28 (23.5%)	40 (22.6%)
Very great or impossible	13 (22.4%)	22 (18.5%)	35 (19.8%)
Total	58 (100.0%)	119 (100.0%)	177 (100.0%)

Chi-square = 8.316, d. f. = 3, prob. = 0.0399, significant

TABLE 7 Difficulty in Preparing a Life-Cycle Costing Procurement Using Frequency of Occurrence Maintenance Records

	Size of Bus Fleet			
Degree of Difficulty	Less than 25	25 to 99	100 or more	Total
Some, little, or none	11 (19.0%)	12 (21.4%)	21 (33.9%)	44 (25.0%)
Moderate	14 (24.1%)	26 (46.3%)	17 (27.4%)	57 (32.4%)
Great	18 (31.0%)	9 (16.1%)	14 (22.6%)	41 (23.3%)
Very great or impossible	15 (25.9%)	9 (16.1%)	10 (16.1%)	34 (19.3%)
Total	58 (100.0%)	56 (100.0%)	62 (100.0%)	176 (100.0%)

Chi-square = 12.859, d. f. = 6, prob. 0.0453, significant

TABLE 8 How Well Transit System Staff Understand Life-Cycle Costing

Degree of Understanding	Size of Motor Bus Fleet: Less than 25	25 to 99	100 or more	Total
Limited	29 (47.5%)	19 (31.2%)	9 (14.1%)	57 (30.7%)
Some	11 (18.0%)	16 (26.2%)	10 (15.6%)	37 (19.9%)
Moderate amount	15 (24.6%)	17 (27.9%)	25 (39.1%)	57 (30.7%)
Great amount or thorough	6 (9.8%)	9 (14.8%)	20 (31.2%)	35 (18.8%)
Total	61 (100.0%)	61 (100.0%)	64 (100.0%)	186 (100.0%)

Chi-square = 42.124, d. f. = 6, prob. 0.0005, highly significant

TABLE 9 How Well Do Transit System Staff Understand Life-Cycle Costing Based on Agency Experience?

Degree of Understanding	Transit System Has or is Making an LCC Procurement	Transit System Has Never Made an LCC Procurement	Total
Limited	5 (8.5%)	49 (40.2%)	54 (29.8%)
Some	8 (13.6%)	28 (23.0%)	36 (19.9%)
Moderate	23 (39.0%)	33 (27.0%)	56 (30.9%)
Great	10 (17.0%)	9 (7.4%)	19 (10.5%)
Thorough	13 (22.0%)	3 (2.5%)	16 (8.8%)
Total	59 (100.0%)	122 (100.0%)	181 (100.0%)

Chi-square = 37.689, d. f. = 4, prob. = 0.0000001, highly significant

bers or have a greater ability to make use of outside consultants.

Not surprisingly, experience with life-cycle costing made a difference in the degree of understanding, as indicated by the extremely highly significant interaction shown in Table 9. However, it is evident in both Tables 8 and 9 that all too many transit agencies were experiencing problems with life-cycle costing. Even among the experienced agencies, more than 20 percent of the respondents had only "limited" or "some" understanding of the process (Table 9).

Transit Agency Support for Life-Cycle Costing

Respondents were asked if they favored or opposed life-cycle cost procurement requirements for motor buses. Fifty-seven percent of those who answered the question were neutral or favored them to some degree. Responses were about the same regardless of the size of the bus fleet and past experience with the procedures, although proportionately fewer experienced respondents were neutral on the subject. In terms of degree of difficulty, those who favored life-cycle costing tended to have, or expected to have, less difficulty with the requirements, although the interaction was not statistically significant.

Summary

Significant numbers of transit operators still kept manual or mostly manual operating and maintenance records in 1983, making it less convenient for them to do life-cycle costing analyses. Large fleet operators, were even less likely to have computerized records. Furthermore, many agencies did not keep such records by individual bus. Finally, many operators, even some of those with experience, have difficulty with the life-cycle costing procedures. The existence of computerized maintenance records did not appear to help transit agencies in easing their difficulties with the procedures. The GAO found that transit agencies lacked guidelines and many of them lacked adequate staff expertise to do the job satisfactorily. It was concluded that this has led to added expense and delays in bus procurement with no guarantees that the buses so obtained will cost less over their operating lives.

PREREQUISITES TO LIFE-CYCLE COSTING

Kain et al. (10,p.2) noted:

> The success of life cycle costing in the procurement of buses depends upon several factors. First, the property must have the ability to identify, measure, and evaluate the factors affecting its current operating and maintenance costs. Second, the bus manufacturers must demonstrate the ability to identify, quantify, and support their estimates of the cost impact which bus design changes will have on a property's operating and maintenance costs. Third, harmonious working relationships between the manufacturers and the properties must exist.

The GAO study (2) concluded that none of these factors were particularly present in the American transit industry today.

The following prerequisites to successful life-cycle cost procurement therefore appear to be in order on the basis of the comments of the GAO and the questionnaire responses summarized previously.

1. Standard and uniform guidelines for life-cycle costing procurement are necessary both to facilitate the task for the operator and to encourage manufacturers to provide appropriate information. This would promote transit agency understanding and either enable their own staff to do the work or facilitate the use of outside expertise.

2. Transit operators need adequate records to support the procedures and monitor the results when buses have been procured. In addition, comprehensive cost and frequency of occurrence records would enable the efficient management of transit operations, a worthy objective in its own right. Such records should be computerized to facilitate statistical and economic analysis with mathematical models appropriate to the available data. For example, meaningful cost and frequency of repair predictions can be accomplished with a relatively small number of cases (e.g., 10 to 20 buses), but the analysis is best done on a computer.

3. Transit agencies should integrate their operating and maintenance records with both long-range and annual budget and operations planning. As noted earlier, Seldon described a variety of applications for life-cycle costing information in planning.

4. Cost and frequency of occurrence records should be collected for individual buses. A southwestern transit agency maintenance manager, responsible for a fleet of 100 buses, told the authors that 100 buses was about the limit of his ability to be personally familiar with each vehicle's maintenance history without the help of a good record-keeping system. With computer-based records, summaries can easily be provided for bus fleet and model totals.

Transit agencies typically expect bus manufacturers to provide frequency of occurrence information for the major maintenance tasks and components in a bus. For example, Table 10 gives the cost drivers used in the bus procurement process by the Central Oklahoma Transportation and Parking Authority (COTPA). The major cost drivers, as interpreted by COTPA, are fuel and oil consumption, tires, preventive maintenance, brake relining, engine repair, transmission repair, and air conditioning repair. The associated costs are itemized for each bid received. Other aspects of comparative evaluation included performance criteria (service support, compliance with specifications, and delivery dates) and component standardization, and these aspects are included in the bid evaluations by means of a rating scheme.

Although the information on these major cost drivers is obtained from the manufacturer, it can be helpful to the transit agency to have its own tabulations. Conscientious transit operators, including COTPA, are alert to and commonly specify specific types and brands of components (e.g., air conditioning units or engines) in their bid specifications because of past maintenance experiences, either within the agency or reported by other agencies. Maintaining a data base of frequency of occurrence statistics for the transit agency's own fleet can only facilitate the procurement process. It gives the agency a basis for assessing the validity of manufacturer claims or justifying the specification of specific components. It also enables the agency to account for local climatic and bus duty cycle conditions.

Cost and frequency of occurrence maintenance records are useful for planning and annual budget analysis as well as life-cycle procurement. It is probably not feasible to account for every component of a bus in life-cycle costing because too much information could defeat the objectives of life-cycle cost procurement. The analysis of these other components (e.g., body parts, door components, passenger seats), however, can aid in monitoring the performance of the maintenance shop. Particularly troublesome components (e.g., body components that corrode) could be identified and thus included in future bus procurement specifications.

5. The time value of money should be considered in life-cycle cost procurement, mainly because of the long time period involved (12 years typical bus life) and the magnitude of fuel and maintenance costs that are incurred over time. This was demonstrated earlier in the example shown in Figure 1. The GAO noted that few transit operators included the present worth of future expenditures. Uncertainties about such things as future fuel prices and maintenance expenses are best accounted for by the thoughtful and conservative use of economic principles.

6. None of this is easy to implement without adequate staff expertise and the availability of training courses and guidelines. Tables 6 and 7 indicate that good records alone are not enough. Management information systems and a capable supporting staff should be recognized as fundamental components of transit agency administration.

7. Top-level management support is needed because life-cycle costing departs from traditional procurement practices and requires more staff time to prepare and evaluate. Management must be willing to provide the staff and training resources needed to satisfy prerequisite six.

TABLE 10 Life-Cycle Cost Procurement Information Required from Manufacturers by Central Oklahoma Transportation and Parking Authority

COST FACTOR	INFORMATION REQUIRED [a]
FUEL CONSUMPTION	Fuel economy in miles per gallon based on specified fuel economy test operations.
OIL CONSUMPTION	Consumption (excluding oil changes) in miles per quart
TIRES	Number of tires (brand specified by COTPA) required for 500,000 miles of anticipated bus use
BRAKE RELINING (front and rear)	Parts and labor for life of bus, including expected interval in miles between replacements and overhauls
PREVENTIVE MAINTENANCE	
Oil change & filter	Parts and labor, expected intervals
Engine air filter	Parts and labor, expected intervals
Engine Tune-up	Parts and labor, expected intervals
Transmission	Parts and labor, expected intervals
Air conditioning	Parts and labor, expected intervals
Chassis lubrication	Parts and labor, expected intervals
Differential	Parts and labor, expected intervals
Brake adjustment	Parts and labor, expected intervals
ENGINE REPLACEMENT AND OVERHAUL	Parts and labor, expected intervals
TRANSMISSION REPLACEMENT AND OVERHAUL	Parts and labor, expected intervals
AIR CONDITIONING COMPRESSOR REPLACEMENT AND OVERHAUL	Parts and labor, expected intervals

[a] The manufacturer is required to tabulate all of the above costs and maintenance performance intervals and provide total maintenance costs for the life of the bus using labor, fuel, and oil costs supplied by COTPA as well as miscellaneous maintenance practices information.

CONCLUSIONS

Life-cycle cost procurement is a rational economic approach to the selection of transit vehicles. The data base needed to support the process has a variety of other uses in maintenance planning and operational management.

At present most transit agencies lack the information needed to facilitate life-cycle costing, and even experienced agencies have difficulty with it. The development of computer-based operating and maintenance records, coupled with adequately trained support staff, is among the prerequisites to successful implementation of life-cycle costing. Because vehicle operating and maintenance costs are significant elements of transit budgets, both annually and over the long term, life-cycle costing has the potential to generate significant savings to agencies and to lead the way to improved transit cost forecasting methodologies. It will do so only if transit agencies collect the proper data and then make good use of it.

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Use of Cooperatives for Alternative Rural Passenger Transportation: Report on a New York Study

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ABSTRACT

The New York State Department of Agriculture and Markets conducted a study to examine the feasibility of using the cooperative concept to provide rural passenger transportation. On the basis of interviews with transportation providers in two study counties and an analysis of transportation in each county, three transportation alternatives using the cooperative approach were developed. The first alternative provides for a cooperative composed of public and private human service agency transportation providers and the users of that transportation service. The study details the activities such a cooperative may progressively undertake, beginning with a simple clearinghouse function and moving toward a cooperative that would assume all transportation responsibilities for its members. The second cooperative concept relies on a service club or civic organization to provide rural passenger transportation. Composed of service club members, human service agencies, and community residents needing transportation, the cooperative would depend on volunteers to maintain a transportation network for rural residents. A third alternative incorporates rural postal carriers in either the human service agency cooperative or the service club cooperative. Rural postal delivery routes extend into virtually all isolated rural areas and are a ready-made transportation system that can augment existing passenger transportation services at a low cost. By providing an array of flexible organizational options to supplement existing transportation resources at a low cost the cooperative approach can offer transportation alternatives, which are subject to local control and responsive to local conditions, to rural areas.

The need for effective rural passenger transportation gained national attention only recently. Beginning with rural Poverty Program transportation projects in the late 1960s, interest in rural passenger transportation had developed by 1973 into the Section 147 Rural Highway Public Transportation Demonstration Program. As the first national program to explicitly recognize rural transportation needs, it was designed to test a variety of transportation methods to fit highly variable rural transportation needs. By 1978 the Section 18 Program, the Formula Grant Program for Areas other than Urbanized, became the first full-scale federal program providing assistance for transportation in rural areas (1,2).

As part of its continuing interest in developing alternative approaches to providing rural passenger