EQUIPMENT AND MAINTENANCE OF DEMAND-RESPONSIVE TRANSPORTATION SYSTEMS

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In 1958, when the Ottawa Transportation Commission converted from streetcars, trolley coaches, and buses to an all-bus operation, tenders were requested for 107 buses. At the same time, our system was completely reorganized. One thing we agreed on was that our procedures should provide for the purchase of the best bus available based on initial cost, availability (downtime), reliability (road calls), and operating and maintenance cost—all of which could be expressed in dollars. Bus appearance, comfort, driver and passenger appeal, service, and delivery were considered as important intangibles, but we did not attempt to express these in dollars. Specifications were prepared, and tenders were invited; two were received. After an evaluation based on the above factors, the tender of the supplier whose initial cost was more than $1,000 higher than the other was accepted.

In 1961 the commission adopted a bus-replacement policy to maintain the average age of the fleet at 7.5 years. This resulted in the purchase of about 20 buses per year until 1972, when the system became regional and larger purchases were made. Again in 1961, the lowest tender (initial cost) was not accepted and in fact this has continued to be the case many times.

DATA, CONDITIONS, AND CIRCUMSTANCES REQUIRED

To make such an evaluation of tenders acceptable to all concerned requires that certain factors be satisfied.

1. The evaluation must be completely objective and unbiased and cannot include data that are not factual or substantiated.
2. The data should be based on operations and experience on one's own property so that there can be no argument with regard to weather conditions, terrain, duty, maintenance, or servicing.
3. Maintenance records must be carefully kept, for such an evaluation generally involves comparing other products to equipment owned. The more complete the records are, the better and more valid the evaluation can be.
4. Suppliers bidding should be aware that contracts are awarded based on such an evaluation. We have been using this procedure for years, and our suppliers know that it is standard practice. Even so we remind them of it in our tender forms or in a covering letter that goes out with the forms.
5. The number of buses used in such an evaluation must be sufficient to represent a "typical sample." One or 2 buses are inadequate. We have used as few as 3 to 5, but have been able to show that the performance of such a sample was consistent with the performance of the rest of our fleet.
6. The test or evaluation should be based on operations in which the buses work on

the same route during the same hours with the same group of drivers from the same garage and the same group of mechanics and servicemen. Duration of the test should be at least 1 year to ensure that all circumstances and variations of weather and exposure have been experienced.

7. If the evaluation is based on a test group of buses, suppliers are invited to participate to ensure that their buses are properly inspected and repaired. Then service representatives can call as often as they choose. We have even kept a log book in which all incidents of significance are recorded, not only matters pertaining to maintenance or equipment performance but also drivers' comments. This log is reviewed by service representatives.

8. If the evaluation indicates a significant difference in maintenance cost, road calls, or downtime, the maintenance chief should be able to account for the difference and indicate how, where, and why it happened.

9. The maintenance chief must make certain the foreman and the mechanics are not biased unfavorably against a new or different product.

10. The evaluation has to allow for product improvement. This can be done by allowances or variations in values arrived at from test programs, identification of areas of fault and cost, and agreement with the supplier on an adjustment in that element of cost.

TYPICAL EXAMPLE

Initial Cost Adjustments

The first step in the evaluation is based on the premise that tenders for the supply of buses to a specification rarely if ever meet the specifications in every respect. This in itself is probably justification for an evaluation. All the tenders must be analyzed to consider what has been included or excluded in the buses offered, and the initial cost adjusted accordingly. An exercise of this nature is generally standard procedure under any circumstances to establish to what extent the specifications have been satisfied. Also some suppliers quote a base price for a standard base bus to which the various options may be added; others quote a price that includes everything requested in the specifications.

Sometimes prices have to be adjusted; something is requested (e.g., standee windows) that cannot be supplied because of the basic construction or design of the bus. Then, too, items may be standard for the buyer but not for the bus suppliers (special instruments or sensing devices). Consider 3 fictitious tenders from companies A, B, and C whose quotes are given in Table 1. An adjusted equivalent price must be established for the bus of each supplier.

Table 1. Quoted and adjusted prices of 3 suppliers.

Item	Company A	Company B	Company C
Quoted price	45,000	47,000	48,000
Options requested			
Silicone hose	+200	Included	Included
Teflon oil lines	+200	Included	Included
Windshield washer 5-gal tank	+80	+75	Included
Windshield washer outside filler	+50	+40	Included
Air cleaner	+250	Included	Included
Bolted brake spider	+60	Included	Included
Low water indicator	+75	Included	Included
Standee windows	+1,000	+1,000	Included
Miscellaneous	+600	+300	+200
Adjusted equivalent price	47,515	48,415	48,200

Availability

From maintenance records based on 1 year of operation under conditions mentioned above (i.e., same duty, drivers, maintenance), suppose we find that the average miles per bus per year was 45,000 for bus A, 50,000 for bus B, and 55,000 for bus C. The only reason for the difference is that bus A was in the garage more often than bus B, which was in more often than bus C, because it needed more repairs and had more road calls. If the availability of bus C is 95 percent (established in years previous), then the availability of buses B and A may be calculated as 86.4 and 77.6 percent respectively.

If this tender were called to provide, say, 20 buses for service, then we would have to buy

20/0.95 = 21 of bus C

20/0.864 = 23 of bus B

20/0.776 = 26 of bus A

Or conversely, the adjusted equivalent cost per bus, taking into account service on the street (availability), may be adjusted further to become

$47,515/0.776 = $61,250 for A

$48,415/0.864 = $56,000 for B

$48,200/0.95 = $50,800 for C

These figures better represent the cost of the test buses in terms of their being able to provide service in transit operations where the test is conducted.

Road Calls

On our property, buses in service that develop some defect that may affect safety or operation are generally changed on the road, i.e., switched at some convenient point with a bus dispatched from the garage. The estimated cost to do this is $20 per bus change. This includes cost of direct labor only; no allowance is made for service adjustments if required. Suppose the maintenance record shows the following:

Bus	Miles/Road Call/Bus	Road Call Cost/ 50,000 Miles of Operation
A	3,000	333
B	6,000	167
C	9,000	111

For about every 20 bus changes, we sustain a tow-in, which costs a bit more than a bus change. This merely involves a little arithmetic for evaluation.

Operating and Maintenance Costs

In general, motor oil costs do not vary much and are not considered unless the comparative costs in other areas of the evaluation are close. Fuel consumption must be checked closely every month, for a serious discrepancy with one bus or a poor engine tune-up or malfunction could create a serious distortion in fuel costs, particularly with a small sample of 3 to 5 buses.

Suppose maintenance records show average fuel consumption as follows, where the costs are based on 35 cents/gal for 50,000 miles (80 000 km) of operation:

Bus	Miles/ Gal	Costs
A	4.8	3,650
B	5.1	3,430
C	5.0	3,500

First the maintenance costs, in cents per mile, are plotted for each month (Fig. 1). For a relatively new product, the points are generally more scattered as for company A buses. Also, for a product that is not so well designed and manufactured, the curve will generally have a steeper slope because more maintenance is required more often. When 2 products have the same slope but one is higher than the other, they generally have the same maintenance intervals but one requires more dollars in material or labor or both than the other.

Our standard procedure for many years was to plot maintenance cost of buses in cents per mile against number of years in operation (Fig. 2). When plotted these costs fall on a straight line, which increases at the rate of 1.2 cents/mile/year. This curve represents the maintenance cost standard for our property and the bus we have standardized on.

In Figure 1, the line representing the test group (company A) falls right on top of our standard maintenance cost curve in Figure 2, which indicates that the number of buses used and other conditions experienced during the test were typical and therefore completely valid.

The next step is to consider the upgrading that these buses may enjoy in the next year, apply this to the data on hand, and then plot maintenance costs typical of the next 5 years (Fig. 3). This can be done with reasonable validity if data shown in Figure 2 are available.

The company A product, which represents relatively new equipment, is allowed 0.3 cents/mile for product improvement because this product is new and has more room to move. We consider the supplier's remarks relative to product improvement when this is done. The company B product is allowed only 0.1 cent/mile for improvement. This is typical for a product that is reasonably well established and has little room for improvement. The company C product is given no allowance, for it is a well-established product and improvements would not affect cost very much. However, this does not necessarily mean that company C is making no improvement.

The projected cost curves shown in Figure 3 are based on test data shown in Figure 1 and our background data shown in Figure 2. From these curves maintenance costs in cents per mile for the first 5 years are as follows:

Years in Service	Company A	Company B	Company C
1	2.5	1.7	1.2
2	3.85	2.9	2.4
3	5.2	4.1	3.6
4	6.6	5.3	4.8
5	7.95	6.5	6.0

Figure 1. Maintenance costs for 3 types of buses under identical operating conditions.

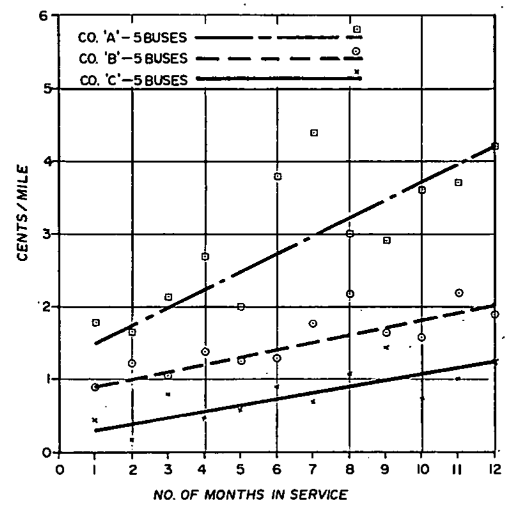


Figure 2. Average annual maintenance costs by years of service.

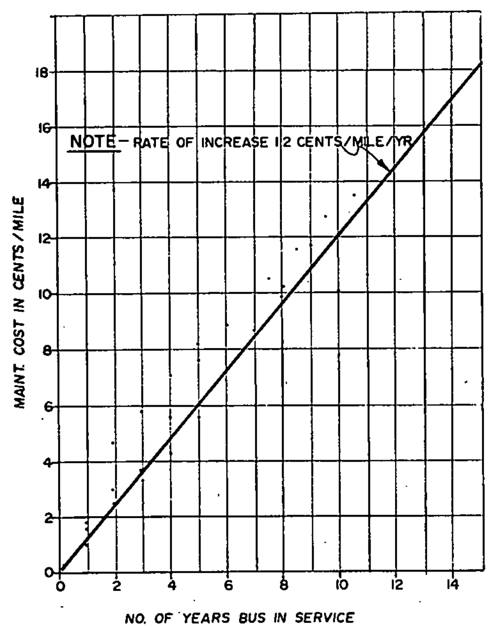
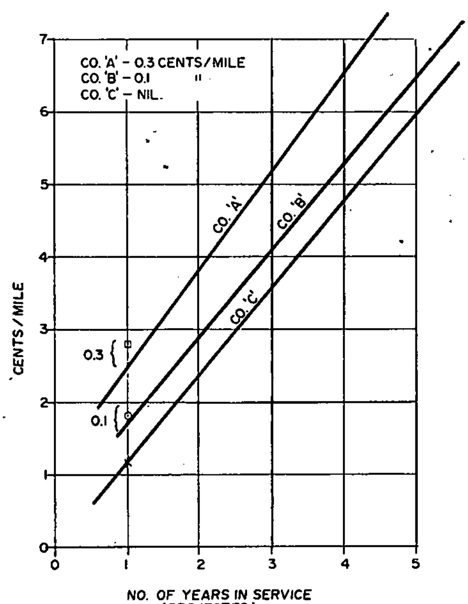


Figure 3. Five-year projected maintenance costs based on weighted test data.



Based on a demand mileage of 50,000 miles/year (80 000 km), which is normal on our property for buses in the first 5 years of service, the maintenance costs can be calculated from the data established above.

Company	Maintenance Cost
A	13,050
B	10,250
C	9,000

The projected costs developed at this point are generally sufficient to indicate with reasonable accuracy which product costs less to operate and by how much. Adjusted equivalent cost is a measure of initial cost and availability, but fuel, road calls, and maintenance costs are a function of proposed miles operated per year.

If, because of some peculiarity, the evaluation does not indicate clearly which bus costs less to buy and operate, the study can be extended over the life of the bus. This is done by extending the maintenance cost curves in a straight line. Figure 2 shows that this line does not flatten out because it represents unit cost and in later life the bus runs fewer miles per year. This drives up maintenance cost per mile inversely to miles operated (i.e., fewer miles increase cost per mile).

The maintenance costs per mile thus obtained and the fuel and road-call costs are applied to the miles operated through the life of the bus. On our property the miles operated would be as follows:

5-Year Period	Miles/Year
1	50,000
2	36,000
3	14,000

If the evaluation is carried this far, a small element of compounding should probably be applied to fuel costs and road calls (say, 0.5 and 1.0 percent respectively), for they no doubt deteriorate with age and usage. We have found that such an approach indicates quite positively which is the best product in terms of initial cost and variable cost. If this were not enough, there is no reason why resale value should not also be considered.

The above calculations are to establish relative costs. If actual costs are desired, interest and inflation percentages must be applied to the yearly costs to express them all in dollars for a given year (say, the year of purchase).

An examination of the facts and figures above establishes quite clearly which product represents the best investment in terms of initial cost (adjusted) and operating and maintenance costs. Generally, the product that has the lowest adjusted cost by virtue of more reliability and availability also has the lowest maintenance cost because components, design, and manufacture are a little better—but this is not necessarily so. We have found exceptions.

APPLICATION TO OTHER PROPERTIES

In recent years, quite a few new products have come on the market. This approach can be used for these products.

For example, suppose you have used a standard product for years. Assemble the data as suggested earlier and then "buy" in the same year a sample quantity of the types of equipment you are considering (say, 5 of each). Now you have set the stage for the test and evaluation. How good and how valid it is depends on how objective and realistic you are.

OTHER FACTORS

An evaluation of this nature is not designed to blackball any product or company. Conversely, it gives new suppliers an objective and fair appraisal of how their products compare with others. It indicates in some detail where products may be weak or superior. It permits suppliers to upgrade faster and more positively.

Under such circumstances we take the attitude that competition makes for better products as well as better prices and services. If a new product appears on the market, we say to our staff, "Let's see what we can do to make this product work and make it better." It is more than a matter of giving a new product a fair break; it is a matter of improving and helping it to develop. If it makes the grade, it will inevitably contribute in some way to improving the products we are using today.

Standardization is fine, but having only 1 or 2 products to choose from is not good. It stifles development and sometimes leaves the purchaser at a disadvantage.

George W. Heinle, Southern California Rapid Transit District, Los Angeles

The Southern California Rapid Transit District was one of the first to get involved with the small transit vehicle. When we first embarked on our small vehicle venture more than 3 years ago, few vehicles and alternatives were available on the market. The project was not strictly a DRT operation, but the vehicles used to provide the downtown circulation system in Los Angeles are in our opinion most adaptable to a variety of similar services, including DRT operations.

The project was novel in a number of respects. It marked the first time that 4 Los Angeles public agencies came together and agreed to share the cost of providing this type of service. The city of Los Angeles, the county of Los Angeles, the Community Redevelopment Agency, and the Southern California Rapid Transit District all agree to bear a part of the cost. The 3 other agencies shared the operational costs, and SCRTD purchased the vehicles. We had to develop specifications and get vehicles operating quickly because, once the public financed and supported this program, it wanted to see some action.

Therefore, we bought minibuses because we had to consider an "on-the-shelf" bus that would provide the kind of service and give the type of aesthetic appeal that we wanted. Some of the criteria that we developed included low steps for easy access by the aged and infirm, seats arranged for ready access, and natural circulation toward a rear exit door. We also wanted a sturdy, rugged small bus that had an ecologically acceptable power plant.

At the same time, we could not design a completely new vehicle and expect the operation to commence within a short period of time. So that emissions would be minimized, we decided to use natural gas as the regular fuel and gasoline as a backup fuel. The dual fuel system provides for using either gasoline or compressed natural gas. We would have used liquified natural gas, but it was not available in Los Angeles. Our estimates indicated that the compressed natural gas would be just barely sufficient with five 375-ft^3 (10.6-m^3) tanks to obtain a range necessary for our regular route operation from 9:00 a.m. to 4:00 p.m. Therefore, the gasoline backup was necessary.

We also tried to incorporate in the specifications features that would make the vehicle more durable and minimize maintenance needs. In this respect, we were only partially successful. We were able to develop, along with the Herz Erhardt Company, disk brakes that were applicable to the Dodge chassis and were a substantial improvement over the standard drum brakes.