Economics of Bus Rehabilitation

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The cost-effectiveness of bus rehabilitation versus new bus acquisition warrants close examination because of the rapid increase in the costs of new bus acquisition and the scarcity of financial resources for local transit systems. In 1980 and 1981 the Florida Department of Transportation conducted a study of the economic feasibility and implementation of bus rehabilitation within Florida. This paper reflects the economic research and findings of that study, modified to incorporate the Urban Mass Transportation Administration's early 1981 guidelines on bus rehabilitation. Economic analysis techniques are used to evaluate the cost-effectiveness of bus rehabilitation from national and local viewpoints. A mainline economic analysis is developed with appropriate economic input values. The paper concludes that, from the viewpoint of national and local transit interests, bus rehabilitation is a cost-effective alternative to new bus acquisition. Local transit operators should consider providing additional funds beyond the required federal matching share. However, local transit operators should obtain substantial federal funding assistance before undertaking a bus rehabilitation program. Because cost-effectiveness of bus rehabilitation is dependent on economic input values, sensitivity analyses and general equations are presented so that local transit operators have the option to use values that more appropriately represent their particular situations. Short-term updating procedures are provided.

The concept of bus rehabilitation is not new; to various extents, transit agencies have been rehabilitating buses for several years. However, due to the rapid increase in the costs of new bus acquisition, increasing vehicle requirements, and relative scarcity of financial resources for local transit systems, the cost-effectiveness of bus rehabilitation warrants close examination.

In part as a response to these factors, in February 1980, the Urban Mass Transportation Administration (UMTA), issued a notice of proposed rule making (NPRM) to financially aid comprehensive bus rehabilitation projects (1). In order to benefit from the rehabilitation program, the Florida Department of Transportation (FDOT) initiated a feasibility study for bus rehabilitation in Florida (2). Concurrent with completion of the FDOT study, UMTA issued its final rule on bus rehabilitation policy and procedures in January 1981 (3); however, with the change in federal administrations, this final rule was withdrawn and is being reassessed. The expressed purpose of withdrawing the rule was to make the bus rehabilitation program as flexible as possible by providing guidelines rather than a fixed rule. Nevertheless, the current administration believes that bus rehabilitation is a good concept, and UMTA is funding bus rehabilitation projects by using the "withdrawn final rule" as a guideline. This paper reflects the research and findings conducted for the FDOT bus rehabilitation feasibility study (2), based on UMTA's 1980 NPRM on bus rehabilitation (1) and modified as appropriate to incorporate UMTA's 1981 bus rehabilitation guidelines (3).

To determine appropriate levels of investment between the acquisition of new buses and rehabilitation of existing buses, the following economic factors should be considered:

1. Initial capital investment costs,
2. Service lives,
3. Salvage values,
4. Operation and maintenance costs, and
5. Appropriate discount rate.

Consideration of the relative worth of a rehabilitated bus versus a new bus, which reflects qualitative differences, may also be appropriate.

In the following sections, UMTA's bus rehabilitation guidelines are evaluated from an economic viewpoint and mainline values are determined for the economic parameters listed above. National and local maximum acceptable bus rehabilitation costs are presented, sensitivity analyses of the economic parameters are performed, and short-term updating procedures are provided.

ECONOMIC SUMMARY OF UMTA'S BUS REHABILITATION GUIDELINES

Of the five key economic inputs needed to evaluate cost-effectiveness of bus rehabilitation versus new bus acquisition, only two inputs were addressed in the UMTA guidelines: initial capital investment costs and bus service lives. UMTA's estimated cost of a new bus did not include the cost of a lift for the elderly and handicapped (3, p. 9862). The current new bus cost provided in the UMTA guidelines is \$120 000; this cost will increase due to inflation.

The need for structural improvements is UMTA's primary basis for evaluating the feasibility of bus rehabilitation; however, as a general guideline, buses should be at least 12 years old or should have accumulated 500 000 miles (3, pp. 9864-9865). No clear guidance is given as to the extended service life of a rehabilitated bus; however, the minimum extended service life of a rehabilitated bus is 5 years, and examples of extended service lives of 5, 8, and 10 years are cited (3, p. 9862).

In the NPRM (1, p. 9244), UMTA stated that its initial experience with bus rehabilitation indicated that the capital cost of bus rehabilitation should not exceed 50-60 percent of the cost of a new bus over a 12-year service life in order to ensure a worthwhile return on local and federal investments. UMTA used the 60-percent value as an input in the bus rehabilitation funding formula. Essentially, by introducing the 60-percent value, UMTA recognized the worth of a rehabilited bus as 60 percent of the worth of a new bus after accounting for different service lives. In the subsequent UMTA guidelines a 70-percent value was used (3, p. 9864); however, the meaning of these values appears to have changed. In the latter document, the value was used as a funding cap to approximate the median cost of bus rehabilitation (3, p. 9862). Nevertheless, by incorporating the 70-percent value in the guidelines, UMTA implicitly recognized the worth of a rehabilitated bus as 70 percent of the worth of a new bus after accounting for different service lives.

Salvage values for new and rehabilitated buses were not addressed in UMTA's guidelines. In the NPRM, UMTA requested comments regarding operating costs of new versus rehabilitated buses; however, the subsequent guidelines did not provide operating and cost differentials. Discount rates were not considered in the UMTA documents. Thus, the guidelines implicitly assumed no salvage values, no difference between the operation and maintenance costs of new and rehabilitated buses, and a zero-percent discount rate. The key economic inputs used or implied by the UMTA guidelines are summarized in Table 1.

The funding formula used by UMTA is, "The full cost of rehabilitation may not normally exceed seventy percent (70%) of the average annual amortized value of a new bus (based on a 12-year life), multiplied by the number of years the bus life is pro-

Table 1. Key economic input values of UMTA guidelines.

Economic Input	Value
Initial capital cost	
New bus	\$120 000[a]
Rehabilitated bus	\$35 000-\$70 000[a]
Bus service life	
New	12 years[b]
Rehabilitated	5-10 years
Bus salvage value	
New	\$0
Rehabilitated	\$0
Cost differential for operation and maintenance of rehabilitated versus new bus	\$0
Discount rate	0 percent
Worth of rehabilitated versus new bus	70 percent

[a]Changes over time. [b]Minimum value.

Table 2. Mainline bus rehabilitation economic input values and national analysis.

Item	Value
New bus cost	\$125 000
Bus service life	
New	12 years
Rehabilitated	8 years
Bus salvage value	
New	\$25 000
Rehabilitated	\$10 000
Cost differential for operation and maintenance of new bus versus rehabilitated bus	\$4 000/year
Discount rate	10 percent
Worth of rehabilitated versus new bus	80 percent
Maximum acceptable rehabilitation cost	\$73 065

jected to be extended" (3, p. 9864). For 5-, 8-, and 10-year extended rehabilitated bus service lives, UMTA would recognize maximum bus rehabilitation costs as \$35 000, \$56 000, and \$70 000, respectively.

UMTA regards bus rehabilitation projects as capital expenditures and, as in the acquisition of new buses, would participate on a funding-share basis of 80-percent federal, 20-percent local (3, p. 9865). For an 8-year extended service life, UMTA would recognize a maximum bus rehabilitation cost of \$56 000, of which \$44 800 would be borne by UMTA and \$11 200 by the local transit agency. UMTA would participate in additional costs of handicapped accessibility features and would consider participating in additional costs of new equipment (3, p. 9865). Analysis of these additional costs is beyond the scope of this paper.

BASIC ECONOMIC INPUTS OF BUS REHABILITATION

To evaluate the cost-effectiveness of bus rehabilitation versus new bus acquisition five key economic parameters should be considered. This section addresses these parameters, inflation, and other economic considerations and presents justification for values used in the subsequent economic analysis. The values used for the mainline economic analysis are presented in Table 2.

Initial Capital Investment Costs

Based on the analysis conducted for FDOT, the estimated average cost of new Advance Design Buses (ADBs) without lifts for the elderly and handicapped was \$125 000 in the second quarter of 1980. This cost does not include delivery charges, local inspection, or other non-manufacturing-related costs. Thus, an estimate of \$130 000, as well as UMTA's figure of \$120 000, is used in the sensitivity analysis. These new bus costs will increase over time due to inflation.

Levels of rehabilitation and associated commercial costs for Florida buses in the second quarter of 1980 are presented in the table below.

Level	Degree of Rehabilitation	Estimated Cost (\$)
1	Comprehensive rehabilitation with new engine and transmission	74 000
2	Comprehensive rehabilitation with remanufactured engine and transmission	64 000
3	Rehabilitation of parts as needed	54 000

No data are available regarding the projected cost of rehabilitating buses over time; however, the cost of rehabilitating buses will probably increase at approximately the same rate as the cost of new buses because of the similar work and materials involved.

Service Lives

The service life of a bus is its length of operation. With rehabilitation, a bus's service life can be extended. Generally, in Florida, UMTA's 12-year criterion for a new bus will be met prior to the 500 000-mile criterion; therefore, the 12-year criterion is used throughout the remainder of this study.

New Bus Service Life

In response to UMTA's NPRM, some northern transit operators stated that their buses' service lives were less than UMTA's 12-year standard because of climate. Concern was also expressed that the buses of certain manufacturers have shorter service lives than others and that the service lives of new ADBs may not equal that of the older, new-look buses.

In Florida, the 12-year standard appears reasonable. Although heat causes greater strain on air conditioning units and corrosive effects are caused by the proximity of Florida's major urban areas to the ocean, Florida's buses do not encounter the effects of northern climates. Furthermore, more than 30 percent of Florida's current bus fleet has been in use at least 12 years. A 12-year service life is used in the mainline economic analysis. For sensitivity analysis, 10- and 15-year new bus service lives are also considered.

Rehabilitated Bus Service Life

In response to UMTA's NPRM, leading bus rehabilitation companies and transit experts stated that an 8-year extended service life for rehabilitated buses was more reasonable than the 5-year value often illustrated. A 10-year extended service life was also suggested as practical. In response, UMTA stated that use of the 5-year extended service life in the NPRM was for illustrative purposes only; in the subsequent guidelines, extended service lives of up to 10 years were illustrated.

To extend the service life of a bus by at least 5 years, a comprehensive rehabilitation process is required, including mechanical rebuilding, electrical work, and body work. In the FDOT study, three levels of bus rehabilitation were evaluated. The FDOT study concluded that a 5-year extended service life value may be appropriate for a level 3 program and an 8-year value appropriate for a level 2 program. The difference in scope between levels 1 and 2 was considered too insignificant to alter the extended service life of 8 years for a level 1 program.

Given the projected extended service lives and costs, a level 2 rehabilitation program was deemed the most cost effective. Thus, the FDOT economic analysis concentrated on a level 2 program with an 8-year extended service life. Extended service lives of 5 and 10 years were analyzed in the sensitivity analysis.

Salvage Value

Salvage value is the value of an investment that remains at the end of the study period. Although the service life of a new bus may be 12 years, a bus still has value at the end of that period. It can be resold, used for spare parts, or held for use in case of emergency. In 1980 the estimated salvage value of new buses after 12-15 years was $25 000, and the salvage value for rehabilitated buses was $10 000. A $20 000 value for rehabilitated buses and $0 value for both types of buses were also employed in the sensitivity analysis.

Operation and Maintenance Costs

Operation and maintenance costs as well as initial capital expenditures should be considered in economic analyses of transportation projects. In fact, for transit-related projects, total operation and maintenance costs usually exceed initial capital costs. However, for the purpose of economic analysis, the difference in costs rather than total costs is important.

There is relatively limited experience and documentation on operation and maintenance costs of ADBs versus rehabilitated, new-look buses. Nevertheless, it is widely accepted that operation costs for lighter, new-look buses are less than for ADBs. Available data reflect that the fuel efficiency of an ADB is 0.5-1.0 mile/gal less than for an air-conditioned, new-look bus. Consider a 0.5-mile/gal decrease in fuel efficiency at 30 000 miles/year, with a fuel cost of $0.90/gal; an ADB would then cost $963 more per year to operate than would an air-conditioned, new-look bus.

Tires and brakes on new-look buses last longer. Because the seating capacity of a new-look bus is 10-12 percent greater than that of an ADB, transit agencies may need fewer buses to meet peak-hour transit demands.

It is also widely accepted that maintenance costs for new-look buses are less than for ADBs, largely because new-look buses are less sophisticated and established maintenance techniques and controls exist. Maintenance labor costs are less because it is easier to replace parts and repair the buses and less training is needed. The cost of parts is less and brakes are easier to maintain. The new-look buses are reported to be more reliable. The Detroit Department of Transportation (DDOT) operates more than 200 ADBs and has rehabilitated 79 buses. DDOT reported that the annual preventive maintenance cost for an ADB exceeds that required for a rehabilitated bus by $3370/year.

Even with limited experience and data for operating ADBs and rehabilitated buses, indications are that the ADB is more costly to operate and maintain. Based on the data presented in the preceding paragraphs and on level 2 rehabilitation specifications, an annual operating and maintenance differential of $4000 is a reasonable expectation ($3370 DDOT maintenance differential and $963 fuel differential, rounded to $4000). This value has been used for economic analysis. Savings of $0 and $2000/year are used for the sensitivity analysis.

Discount Rate

The discount rate allows economic analysts to bring back future benefits and costs to their present worth. The discount rate represents the average rate of return on private investment, before taxes and after inflation. In many benefit/cost analyses, the value of the chosen discount rate is crucial. A high rate diminishes the present value of future benefits and costs; however, a low rate overstates these benefits and costs. Suggested values for the discount rate range from 4 to 15 percent. The guidelines for highway and bus-transit improvements adopted by the American Association of State Highway and Transportation Officials (AASHTO) recommend a 4-percent discount rate (4). The discount rate most widely used by federal agencies is 10 percent, as prescribed by the Executive Office of the President, U.S. Office of Management and Budget (5). UMTA has required use of the 10-percent rate in evaluating programs and projects subject to its jurisdiction.

Although the discount rate is essential to economic analyses, it is seldom used in accounting. The opportunity cost of capital (the discount rate) is not considered in depreciating items. In many ways UMTA's funding formula, which includes use of average annual amortized costs, more accurately represents an accounting analysis than an economic analysis. Implicit in UMTA's guidelines is the use of a zero-percent discount rate, which results in an underestimation of the economic benefits of a bus rehabilitation program.

The mainline economic analysis in this study employs a 10-percent discount rate to comply with the U.S. Office of Management and Budget's directive. However, strong cases can be made for lower discount rates. In the sensitivity analysis of this paper, 0-, 4-, and 7-percent discount rates are considered.

Inflation

Although inflation may be of great concern to transportation and other interests, general inflation should not be included in benefit/cost analyses because all benefits and costs are estimated in constant dollars--the general purchasing power of the dollar at the time of decision. If, however, the cost of an item is increasing faster than the general rate of inflation, it may be appropriate to take into account the difference between the item's inflation rate and the general inflation rate.

In 1972, the average cost of a new bus was $40 500. By the end of the second quarter of 1980 the average cost was $135 000, which represents an increase of 3-1/3 in the cost of a new bus. In the same period, the consumer price index nearly doubled; therefore, the cost of new buses increased considerably faster than did the U.S. general price level.

The buses of 1972, however, are not comparable with those of today. The modern ADB is built to entirely new specifications, including special provisions for the elderly and handicapped. In view of these changes, the increase in bus costs versus the twofold increase in the general price level appears less excessive. Nevertheless, data indicate that the cost of comparable buses has been increasing faster than the general rate of inflation. Not only has the cost of new buses increased at a faster rate than general inflation but so have fuel and maintenance costs. The difference between transit's increasing cost rate over time and general inflation can be approximately accounted by subtracting the difference from the standard discount rate. Although subject to discrepancies between price trends of different transit costs, the lowering of the discount rate is easy to use and will generally not distort economic results for a few years. Although the mainline economic analysis uses a 10-percent discount rate, it is reasonable to decrease the selected standard discount rate by no more than 5 percent to account for transit's real inflation rate. Discount rates of 0, 4, and 7 percent, as well as the 10-percent standard, are presented in the sensitivity analysis.

All cost figures used in this analysis are based on 1980 second-quarter values. As stated previously, general inflation should not be included in an economic analysis; however, at the actual time of decision, the cost of a new, comparable bus will have risen. This change in cost should be considered at that future time in determining whether to rehabilitate a bus or to purchase a new one. For instance, a local transit operator may be considering rehabilitation of buses in December 1982, at which time new buses may cost 25 percent more than the estimate of $125 000 used in this analysis. To account for the change in prices, the local transit operation should increase its maximum acceptable rehabilitation cost (presented in this text) by 25 percent. Although subject to increasing error, this procedure would be reasonably accurate in the short run.

Rehabilitated Versus New Bus Worth

UMTA's funding formula implicitly assumes that, after accounting for differences in service lives, a rehabilitated bus is worth 70 percent (60 percent in the NPRM) of a new bus. Certainly, the more expensive ADBs have qualities superior to new-look buses or they should not be produced. A good assumption of an ADB's minimum qualitative advantage over a new-look bus is the difference in cost. Data from 1976 to 1980 indicate differences from 74 to 87 percent, which gives an average of approximately 80 percent. Thus, the value of a new-look bus could be roughly 80 percent of a new ADB. The mainline economic analysis assumes that a rehabilitated bus is worth 80 percent of a new bus after consideration of service lives. Because the recognized worth of a rehabilitated bus in comparison with a new bus is such an important consideration, the sensitivity analysis includes 60-, 70-, and 100-percent values.

MAXIMUM ACCEPTABLE BUS REHABILITATION COSTS BY USING BASIC ECONOMIC INPUTS

By using the national maximum acceptable rehabilitation cost general equation (Equation 1) and second-quarter 1980 cost data, on a national basis, bus rehabilitation should be funded up to $73 065/bus (see Table 2) or at a level of approximately 58 percent of the cost of a new bus. The level of $73 065 is approximately 1.3 times greater than the acceptable rehabilitation level of $56 000 (for an 8-year extended service life) used in UMTA's guidelines and approximately 2.8 times greater than the acceptable rehabilitation level illustrated in UMTA's bus rehabilitation NPRM. This indicates that, although UMTA is considerably closer to recognizing an optimum rehabilitation level, as illustrated by UMTA's examples, UMTA is not giving adequate recognition to the economic worth of bus rehabilitation. Furthermore, UMTA's maximum acceptable rehabilitation cost of $56 000 for an 8-year extended bus service life does not reflect the cost to rehabilitate a bus; the commercial cost to rehabilitate a Florida bus was about $64 000. (If a 5-year extended service life were used, UMTA's recognized rehabilitation cost would be totally inadequate; for a 10-year extended service life, UMTA's recognized level may be adequate.) Thus, this analysis lends further credence to the reasons that local transit operators have for allocating funds to bus rehabilitation with no or only partial UMTA participation.

The general equation to determine the national maximum acceptable rehabilitation cost is as follows:

$$\begin{aligned} R = {} & (N \cdot W_{R/N} - S_N) + OM_{N/R}(pwf\text{-}d\text{-}sl_N) - S_n(pwf'\text{-}d\text{-}sl_N) \\ & - (N \cdot W_{R/N} - S_R)(pwf'\text{-}d\text{-}sl_R) - OM_{N/R}(pwf\text{-}d\text{-}sl_{N-R})(pwf'\text{-}d\text{-}sl_R) \\ & + [N \cdot W_{R/N} - (N \cdot W_{R/N} - S_N)(sff\text{-}d\text{-}sl_N)(caf\text{-}d\text{-}sl_{N-R})](pwf'\text{-}d\text{-}sl_N) \end{aligned} \quad (1)$$

where

R = national maximum acceptable initial cost of rehabilitating a bus,
N = initial cost of a new bus,
$W_{R/N}$ = worth of a rehabilitated bus versus a new bus,
S_N = salvage value of a new bus,
$OM_{N/R}$ = operation and maintenance cost differential between a new bus and a rehabilitated bus,
$(pwf\text{-}d\text{-}sl_N)$ = uniform series present-worth factor for a given discount rate for the service life of a new bus,
$(pwf'\text{-}d\text{-}sl_N)$ = single payment present-worth factor for a given discount rate for the service life of a new bus,
S_R = salvage value of a rehabilitated bus,
$(pwf'\text{-}d\text{-}sl_R)$ = single payment present-worth factor for a given discount rate for the service life of a rehabilitated bus,
$(pwf\text{-}d\text{-}sl_{N-R})$ = uniform series present-worth factor for a given discount rate for the difference between new and rehabilitated buses' service lives,
$(sff\text{-}d\text{-}sl_N)$ = uniform series sinking fund factor for a given discount rate for service life of a new bus, and
$(caf\text{-}d\text{-}sl_{N-R})$ = uniform series compound amount factor for a given discount rate for the difference between new and rehabilitated buses' service lives.

The values in Tables 1, 2, and 3, and other values not shown, can be obtained through use of the equation. The equation is based on economic analysis principles that incorporate present-worth concepts. A computer program has been developed by Environmental Science and Engineering, Inc., to calculate the maximum acceptable rehabilitation costs given appropriate economic input values.

SENSITIVITY ANALYSIS OF ECONOMIC INPUT VALUES AND RESULTING EFFECTS ON NATIONAL MAXIMUM ACCEPTABLE REHABILITATION COSTS

Although the inputs for the mainline economic analysis are soundly based, other values can be justified. The following sensitivity analysis provides transit interests and others with the option to use other inputs in determining appropriate national maximum cost levels for bus rehabilitation. Table 3 uses the mainline economic input values and varies these inputs one at a time.

As can be seen from Table 3, most cases result in maximum acceptable rehabilitation cost levels above what UMTA may recognize (assumed to be $56 000) and the cost of level 2 rehabilitation ($64 000). Table 3 also indicates inputs that have greatest impact on the national maximum acceptable rehabilitation cost. These inputs are the rehabilitated bus service lives (cases 5 and 6), bus salvage values (cases 7 and 8), operation and maintenance costs (cases 9 and 10), and rehabilitated versus new bus worth (cases 14, 15, and 16). Although some of the

Table 3. Sensitivity analysis of mainline economic inputs on maximum acceptable rehabilitation costs.

Case	New Bus Cost ($000s)	Bus Service Life (years)		Bus Salvage Value ($000s)		Operational and Maintenance Cost Differential of New Versus Rehabilitated Bus ($/year)	Discount Rate (%)	Worth of Rehabilitated Versus New Bus (%)	Maximum Acceptable Rehabilitation Cost ($)	Percentage of Mainline Maximum Acceptable Rehabilitation Cost (%)
		New	Rehabilitated	New	Rehabilitated					
National mainline	125	12	8	25	10	4000	10	80	73 065	
1	120	12	8	25	10	4000	10	80	69 933	-4.3
2	130	12	8	25	10	4000	10	80	76 197	+4.3
3	125	10	8	25	10	4000	10	80	79 460	+8.8
4	125	15	8	25	10	4000	10	80	66 947	-8.4
5	125	12	5	25	10	4000	10	80	47 575	-34.9
6	125	12	10	25	10	4000	10	80	86 430	+18.3
7	125	12	8	0	0	4000	10	80	99 637	-36.4
8	125	12	8	25	20	4000	10	80	77 730	+10.6
9	125	12	8	25	10	0	10	80	51 725	-29.2
10	125	12	8	25	10	2000	10	80	62 395	-14.6
11	125	12	8	25	10	4000	0	80	67 000	-8.3
12	125	12	8	25	10	4000	4	80	69 775	-4.5
13	125	12	8	25	10	4000	7	80	71 540	-2.1
14	125	12	8	25	10	4000	10	60	53 491	-26.8
15	125	12	8	25	10	4000	10	70	63 278	-13.4
16	125	12	8	25	10	4000	10	100	92 639	+26.8
17[a]	105	12	5	0	0	0	0	60	26 250	-64.1
18[a]	120	12	5	0	0	0	0	70	35 000	-52.1
19[a]	120	12	8	0	0	0	0	70	56 000	-23.4
20[a]	120	12	10	0	0	0	0	70	70 000	-4.2

[a]UMTA examples.

influence of the discount rate is masked in other variables, it had relatively little influence (cases 11, 12, and 13). Due to the importance of these inputs, distinct sensitivity analyses are presented in the FDOT bus rehabilitation study (2, appendix E). Those sensitivity analyses indicated that the cost-effectiveness of bus rehabilitation varies substantially depending on the assumptions made.

MAXIMUM ACCEPTABLE REHABILITATION COSTS AND FUNDING LEVELS FOR LOCAL TRANSIT OPERATORS

On a national basis, level 2 bus rehabilitation is a cost-effective alternative to the acquisition of new buses; however, UMTA will probably not recognize bus rehabilitation at an economically efficient level ($73 065). Therefore, local transit interests may find it worthwhile to devote some additional funds for bus rehabilitation even without federal funding participation.

For capital expenditure programs, UMTA contributes 80 percent and local transit operators contribute 20 percent of the cost. Similarly, when receiving money from salvage of a bus purchased with UMTA assistance, 80 percent returns to UMTA. Operation and maintenance costs are not based on the 80-20 funding percentage formula. Although UMTA participates in funding up to 50 percent of bus operation and maintenance costs, actual funding is usually considerably less. In Florida the operation and maintenance percentages are approximately 33.3 percent for UMTA and 66.7 percent for the local transit operators. This difference in funding percentage is significant in determining maximum acceptable funding levels for UMTA and local transit operators.

From a national viewpoint, the maximum acceptable rehabilitation cost ($73 065 for the mainline assumptions) represents the maximum cost at which it is economically worthwhile to rehabilitate buses. If funding percentages of 80-20 were used for all initial capital costs, salvage values, and operation and maintenance costs, then the maximum amount local transit operators should pay for rehabilitation would be $0.20 for every dollar of the maximum acceptable rehabilitation cost. For national mainline analysis purposes, this would amount to $14 613 ($73 065 x 0.20). However, in the case of operation and maintenance costs, for every dollar spent, local Florida transit operators on the average pay $0.667 instead of $0.20, which effectively alters the maximum acceptable rehabilitation costs for local transit operators. UMTA would recognize operation and maintenance costs, but these costs would not be as important as capital expenditure costs because of UMTA's lower funding participation rate. Thus, the maximum acceptable rehabilitation cost from a national viewpoint is not the maximum acceptable rehabilitation cost for UMTA and the local transit operators. Given the existing funding formulas to maximize their funds, UMTA would recognize a value less than the national optimal level, and the local transit operators would recognize a higher value.

Table 4 indicates local transit operator's maximum acceptable bus rehabilitation costs and corresponding funding levels for different recognized UMTA funding levels and operations and maintenance costs. The table values are obtained from the following general equations:

$$U = 0.8A \quad \text{if } A \leq B \text{, or } U = 0.8B \quad \text{if } A > B \tag{2}$$

and

$$L = 0.2A + 0.2(B - A - M) + XM \tag{3}$$

where

U = UMTA's share,
A = UMTA's recognized maximum rehabilitation cost,
L = local transit operator's share,
B = national maximum acceptable rehabilitation cost for a given operation and maintenance cost differential,
X = percentage of operation and maintenance costs borne by local transit operators, and
M = present worth of operation and maintenance cost differential.

For example, assuming the 80-20 funding split for

Table 4. Local maximum acceptable rehabilitation costs and funding shares.

Case	UMTA Recognized Maximum Rehabilitation Cost ($)	Present Worth of Operation and Maintenance Costs Differential ($)	UMTA Rehabilitation Cost Share ($)	New Versus Local Transit Operator's Maximum Rehabilitation Cost Share ($)	Local Maximum Acceptable Rehabilitation Cost[a] ($)
Mainline	56 000	21 340[b]	44 800	24 579	69 379
1	56 000	10 670[c]	44 800	17 462	62 262
2	56 000	0[d]	41 380	10 345	51 725
3	35 000	21 340	28 000	24 579	52 579
4	35 000	10 670	28 000	17 462	45 462
5	35 000	0	28 000	10 345	38 345
6	70 000	21 340	56 000	24 579	80 579
7	70 000	10 670	56 000	17 462	73 462
8	70 000	0	41 380	10 345	51 725

[a] Value is column 4 plus column 5.
[b] Present worth of $4000/year, operation and maintenance cost differential for 10 percent discount rate for 8-year rehabilitated bus service life.
[c] Present worth of $2000/year, operation and maintenance cost differential for 10 percent discount rate for 8-year rehabilitated bus service life.
[d] Present worth of $0/year, operation and maintenance cost differential for 10 percent discount rate for 8-year rehabilitated bus service life.

capital investments, an UMTA recognized rehabilitation cost of $56 000, the national mainline maximum acceptable rehabilitation cost of $73 065, 66.7 percent of the operation and maintenance costs being borne by local transit operators, and an operation and maintenance cost differential of $4000/year between new and rehabilitated buses ($21 340 present worth), the UMTA share becomes U = 0.8 ($56 000) = $44 800, and the local operator's share becomes:

$$L = 0.2(\$56\,000) + 0.2(\$73\,065 - \$56\,000 - \$21\,340) + (0.667)(\$21\,340) = \$11\,200 - \$855 + \$14\,234 = \$24\,579 \quad (4)$$

Thus, the maximum acceptable bus rehabilitation cost a local transit operator should accept is $69 379 ($44 800 plus $24 579).

As presented in Table 4, the maximum acceptable rehabilitation cost for local transit operators would be $69 379 for the mainline assumptions, of which $44 800 would be incurred by UMTA and $24 579 by the local transit operators. Of the local operator's share of $24 579, $13 379 is in excess of federal funding assistance. In other words, it would be cost effective for local transit operators to spend up to an additional $13 379 without federal assistance. Note, however, that the maximum amount local transit operators should spend to rehabilitate a bus is $24 579. Thus, as long as federal funds are available for acquisition of new buses, local transit operators should not begin a bus rehabilitation program without significant federal funding.

The local maximum acceptable rehabilitation cost of $69 379 and the local cost share of $24 579 are 55.5 and 19.7 percent of the cost of a new bus, respectively. These percentages should remain nearly constant for the next few years. As an alternative to the procedure of updating rehabilitation costs, the percentage values of 55.5 and 19.7 can be used. For example, if the cost of a new bus without a lift is $160 000 in February 1983, then the maximum acceptable rehabilitation cost to local transit operators would be $88 800 ($160 000 x 0.555) and the maximum funding share would be $31 520 ($160 000 x 0.197).

CONCLUSIONS

Significant values presented in this paper are highlighted in the following list:

1. $24 579 (maximum rehabilitation cost incurred by local transit operators),
2. $56 000 (UMTA guidelines' maximum acceptable bus rehabilitation cost for an 8-year extended service life),
3. $64 000 (level 2 rehabilitation cost),
4. $69 379 (maximum acceptable rehabilitation cost incurred by local transit operators), and
5. $73 065 (national maximum acceptable rehabilitation cost).

Based on the above values, from the national and local transit operators' viewpoints, bus rehabilitation is a cost-effective alternative to acquisition of new buses. Furthermore, it may be desirable for local transit operators to provide additional local funds above their normal federal matching share because UMTA may not recognize an economically efficient rehabilitation funding level and because of existing funding structures. Local transit operators, however, should not undertake a bus rehabilitation program without substantial federal assistance. Although this paper presents a mainline economic analysis, the cost-effectiveness of bus rehabilitation is sensitive to economic input values. Local transit operators may wish to use values more appropriate for their particular situations. Guidelines are provided to perform these specific analyses.

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