Long-Range Transit Fleet Planning: Defining and Costing a Replacement-Only Scenario for Seattle

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Transit fleet capital planning is a major element in the long-term assessment of asset replacement. As transit systems mature, increased emphasis must be given to the sizing and costing of replacement needs. The large fleet operated by Seattle Metro is chosen as the case study to illustrate a long-range planning approach to timing and quantifying transit fleet replacement over a 15-year period. Parameters such as specific coach lives and fleet age profile, as influenced by coach mileage outputs, are analyzed in order to account for known or expected differences among transit vehicle types. Several coach-life and fleet-mix variations are tested and compared for the magnitude and direction of their impacts on capital costs. Also briefly addressed is the way in which the relative shares of systemwide capital versus operating and maintenance expenditures are affected by the definition of the replacement-only program.

Development of the Long-Range Plan for Seattle Metro is a 2-year effort. The Long-Range Plan is aimed at identifying a range of public transportation alternatives within the Seattle Metro service area for the next decade. This effort will set the direction of future operating and capital programs after the opening of the downtown electric transit tunnel in the fall of 1990. One start-up task of the plan is first to define and then to cost Metro's basic replacement needs. Those needs cover Metro's active vehicles, transit facilities, and equipment that already exist or are scheduled for delivery or completion by the end of this decade. The purpose of the task is to quantify the minimum year-to-year expenditures that would be required under a hypothetical no-expansion scenario for all capital and service elements between 1991 and 2005.

This paper focuses on the transit fleet replacement portion of the capital needs assessment. The reason for focusing on the transit fleet instead of other capital assets is that coach replacement amounts to the largest long-term capital item of the replacement needs. In addition, the findings about active coaches have greater potential for transferability to other transit operators or administrators than is expected for fixed transit facilities or other smaller assets.

First, the assumptions are presented that were developed for the replacement of active transit coaches under base-case conditions. Second, estimates of the capital costs for replacement of the transit fleet are given and the various cost components are analyzed. Third, the sensitivity of the estimated fleet capital costs to variations in the coach-life and fleet-mix assumptions is discussed, and fourth, the potential impacts of some of these variations on the capital and operating and maintenance shares of systemwide annual equivalent costs are evaluated. Fifth, the long-range transit fleet planning approach is summarized.

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ASSUMPTIONS FOR REPLACEMENT OF METRO'S ACTIVE TRANSIT COACHES

The assumptions about future coach replacements are first developed for a single long-term scenario, the base case. The year 1991 is chosen as the start-up year for the analysis of coach replacement needs. This date comes after several major coach purchases made in the late 1980s and the completion of the electric transit tunnel in downtown Seattle. These purchases consist of 147 standard diesels, 46 articulated (electric) trolley coaches, and 236 dual-power coaches. [A dual-power coach (sometimes called a dual-mode bus) is an articulated coach equipped with both a diesel engine and an electric motor; the main advantage of this type of vehicle for the Seattle Metro is its capability to run in an electric trolley mode within the downtown electric transit tunnel and in a diesel mode along the freeway network.] Figure 1 shows the near-term changes anticipated in the transit fleet composition as a result of these new purchases. Although the net growth in the number of active coaches appears relatively modest, a noticeable gain is achieved in the seating capacity of the fleet. This gain is due to the increase of the relative share of articulated coaches from 33 percent in 1986 to an estimated 55 percent in 1991.

The 1986 active fleet is composed of 606 standard (40- and 35-ft long) diesels with ages ranging from less than 1 year to 18 years, 353 articulated diesels with ages ranging from 4 to 8 years, and 109 7-year-old standard trolley coaches. These correspond to ages averaged by coach type of 7.6 years for standard diesels and 5.7 years for articulated diesels. The 1986 fleet mix results in a fleetwide mean age of 6.9 years among all active coaches.

Starting the next decade with an active fleet of given size and composition (by coach type and their respective ages), the key parameters needed to prepare a schedule for long-term replacement consist of the expected lives of the active coaches and the composition of the fleet in the future. The base-case initial working assumption was to hold the active fleet mix constant

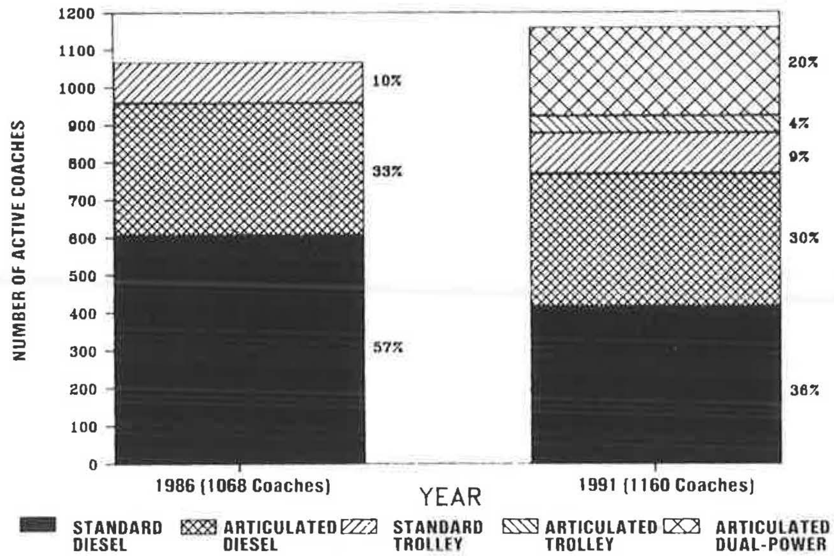

FIGURE 1 Seattle Metro active transit fleet composition as percentage of total fleet size.

over the 15-year planning period. This was done in order to develop a simple, theoretical one-on-one replacement scenario as a starting point for the capital costing. Possible variations in the fleet mix were then examined and their costs compared with the base case.

A historical analysis of a sample of Seattle standard diesels showed that, on the basis of average equivalent annual costs only, economic coach lives could be as long as 22 years (*1*). The average annual equivalent cost combined initial capital costs, estimated resale values by year, and the unit maintenance cost per mile converted to direct annual maintenance costs for each service year. The unit-cost-per-mile derivation accounted for mechanical trouble calls and down time, which were computed by coach series as linear functions of the coach age.

The ultimate economic life is then assumed to exceed the probable useful life of a standard diesel coach by an estimated 8 years. Such adjustment is made in order to account for several qualitative factors, not part of the above annual equivalent costs. The same 8-year reduction from the estimated ultimate economic life is used for all coaches in the fleet. This is based on uniform maintenance practices among the various coach types and comparable standards of safety, comfort, or design quality. As given in the next section, the standard diesel findings are generalized to other coach types in the active fleet without performing a detailed economic-life analysis. The assumptions made in deriving useful coach lives include the following:

- An average useful life for standard diesels is closer to 14 years if one takes into account higher standards of operating safety and more stringent environmental controls as well as greater rider comfort and more modern design.
- The higher initial capital cost of articulated diesels (approximately 87 percent above standard diesels) is more significant economically than the somewhat higher maintenance costs (due to a longer body, the third axle, and the turntable components) over the coach life. These elements suggest using an average useful life of 16 years for articulated diesels.
- The more durable electric motor (as compared with the diesel engine) combined with the higher initial capital cost of standard trolleys (approximately twice that of the standard diesels) points to a longer average useful life, estimated at 18 years. A factor that is somewhat peculiar to Seattle, because of the compact trolley overhead network and the lower average operating speeds on inner-city routes, is the comparatively lower annual mileage in early years of revenue service for the electric trolleys. However, the inner-city trolley service, characterized by stop-and-go operations in mixed traffic with short stop spacings, tends to intensify the annual service hours of electric trolley coaches. (The existing trolley network covers approximately 55 mi of two-way overhead wire within inner-city neighborhoods. Another 7 mi are scheduled to be added by 1990. Before the 1978 Seattle trolley network reconstruction and the complete fleet replacement, standard trolleys had been in active service since 1940. Their operating environment would have been less seriously affected by street traffic in these earlier years.)

The above types of coaches are already in Seattle Metro's active fleet. This helps to validate these assumptions with actual operating and maintenance experience. However, by the end of this decade, two new coach types will be added to the active fleet. The long-range planning assumptions prepared for those newer coaches rely on their expected similarities to some existing Metro coaches. These base-case assumptions are mainly as follows:

- The higher contract price for new articulated trolleys (approximately 26 percent above that of new standard trolleys) is more significant economically than the potentially higher maintenance costs. A maintenance cost relationship is assumed that is similar to the one observed between an articulated diesel and a standard diesel (*2*). These factors suggest using an average useful life of 20 years for articulated trolleys under the base case.

• By 1991, the new dual-power coaches are expected to run in the electric mode through the downtown electric transit tunnel for less than 5 percent of their platform miles (revenue service plus deadhead miles). Thus their resemblance to articulated diesels is much greater than it is to the articulated (electric-only) trolleys. The proposed configuration of initial dual-power tunnel routes is also similar to the current express service from residential neighborhoods to downtown Seattle. The much higher initial contract price for new dual-power coaches (estimated at more than three times that of a standard diesel or close to twice that of an articulated diesel) is more significant economically than the higher maintenance costs. These factors point to a longer economic life for dual-power coaches than for the other diesel-only coaches in the Metro fleet. The base case assumes an average useful life of 18 years for dual-power coaches. (The dual-power capability results in greater complexity, for which actual maintenance experience under the revenue service conditions of the Seattle tunnel application is still to be gained. The Renault experience in Nancy, France, is not comparable with the proposed use of the Breda coaches now being built for Seattle Metro.)

Table 1 summarizes the estimates for coach life in the base case. Figure 2 shows the transit fleet replacement schedule derived from the preceding base-case assumptions on transit coach life. The peaks in the graph represent those years with the largest number of replacement purchases (or expected coach retirements). The valleys on the same graph correspond to those years without any coach deliveries (or with no retirements). No attempt was made to even out this curve. In most cases, the replacement orders were kept at no fewer than 50 coaches a year, because smaller orders would become less economical on a per-coach basis.

TABLE 1 ACTIVE LIFE OF TRANSIT COACHES APPLIED TO THE BASE CASE

Coach Type	No. of Seats[a]/Coach	Active-Life Estimate (years)
Standard diesel	47	14
Articulated diesel	70	16
Standard trolley	45	18
Articulated trolley	64	20
Dual power	65	18

[a]The seating capacities vary by model; those values are averages of actual number of seats on the current or anticipated new coaches.

Figure 3 shows the fleet age profile from 1991 to 2005. The upper curve shows how the mean age (i.e., the arithmetic average for the 1991 fleet composition) fluctuates over time. The fluctuations in the mean age match the peaks and valleys of the fleet replacement schedule. The lower curve shows the weighted age (i.e., adjusted as a function of the estimated miles driven each year on the various coaches). The weighted age is a preferred measure of fleet aging, which occurs not only with time but also with actual use over time. Annual mileage is one measure of coach use that tends to equate different service types, such as a freeway express versus a local route. Comparing the post-1990 estimates with the recent Metro fleet age profiles (*3*) suggests the following points:

• From 1991 to 1997, the weighted age (currently 6.3 years) would drop to lower values in the 4.5- to 6.0-year range. This change is due to the coach replacements scheduled through the mid-1990s.

• Beyond 1998, the weighted age starts to climb each year up to an estimated 10.6-year age by 2005. This steady increase comes from the accelerated aging of the 236 dual-power coaches, which, under the base case, would be expected to accumulate relatively high annual mileage, even in their later years.

BASE-CASE ESTIMATES OF THE CAPITAL COSTS OF FLEET REPLACEMENT

Seattle Metro's actual experience with transit coach procurement (in the Capital Planning and Development Division) serves as the basis for deriving the capital costs of replacing transit coaches after 1990. First, the foregoing fleet replacement schedule (by year and coach type) leads to estimates of net capital costs. This is done by multiplying the annual coach

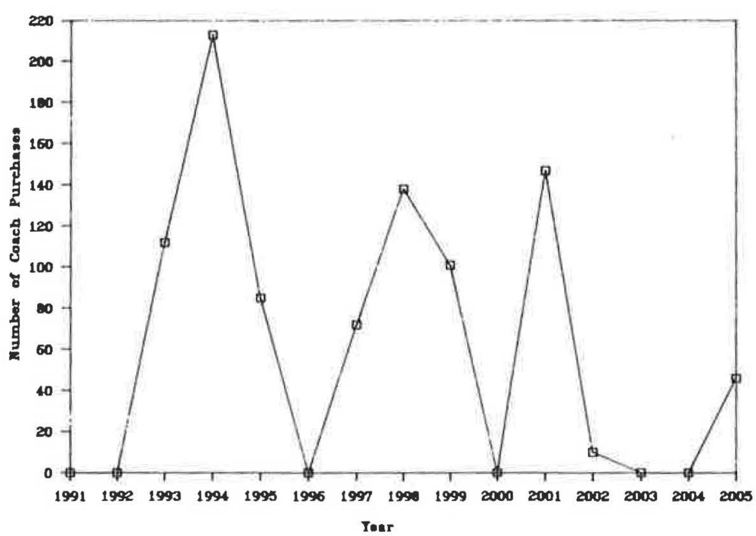

FIGURE 2 Base-case fleet replacement schedule.

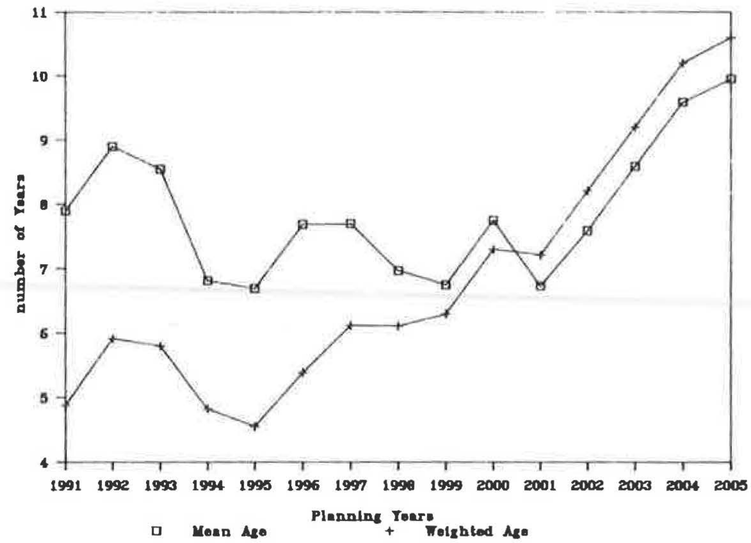

FIGURE 3 Base-case fleet age profile.

quantities by their corresponding unit contract price, taken as \$130,000 per standard diesel, \$243,000 per articulated diesel, \$270,000 per standard trolley, \$340,000 per articulated trolley, and \$425,000 per dual-power coach (in 1986 dollars). (Each price includes the wheelchair lift being installed on all new Metro coaches as part of the agency policy on accessibility. These prices are not meant to represent national averages in any of the above coach categories.) These costs appear in the first two rows of Table 2. The net capital costs after sales tax (paid by Metro as a public agency in Washington State) represent 94 percent of the total fleet capital cost estimates over the 15-year planning period (in inflated dollars).

In addition to the net contract prices and the local sales tax, transit vehicle procurement typically incurs several other expenses. Those include items such as the following:

- Initial preparation for service, which is incurred before the delivery of the coach, during the delivery, and until coach acceptance;
- Ordering special tools, which are often needed for the proper maintenance and servicing of new coaches;
- Installation, or purchase and installation, and testing of onboard coach equipment that is not usually part of the coach manufacturer's package, including radios, fareboxes, and automatic passenger counters; and
- Soft capital costs that cover inspection of the manufacturer's plant, warranty supervision, contract management, travel and staff labor expenses incurred before, throughout, and several months after the actual coach delivery.

To derive the costs of preparation and soft capital items, a scale of unit cost per month by the different coach types is developed in line with current Metro procurement budgets. A lump sum is applied to each future group of new coach deliveries in order to cover the cost of ordering special tools. Radios are itemized by using the latest equivalent unit price from the purchasing contract for this new, more sophisticated equipment.

Table 2 details all these other expenses, which amount to an estimated 6 percent of the total fleet capital costs in inflated dollars. Not included in the base-case estimate is the potential replacement of the existing conventional fareboxes by newer and not yet specified automated fareboxes. Hence the base case assumes that future coaches can be operated by transferring existing fareboxes from the retired coaches onto the new ones at replacement time.

A look at the total inflated capital costs of fleet replacement over each 5-year interval shows the following distribution: \$123 million from 1991 to 1995, \$183 million from 1996 to 2000, and \$111 million from 2001 to 2005. These compare with a current transit fleet program estimated at \$270 million (inflated) from 1985 to 1990 (according to the adopted 1988 budget); this current amount combines expansion and replacement needs over the 6-year period.

The foregoing estimates of the capital costs for fleet replacement do not attempt to account for other factors that could affect future fleet capital costs, including the following:

- Market contract prices of future transit coaches—assuming a gradual reduction in the contract price differential between standard diesels and newer coach types in potentially greater demand in the future and within the North American transit industry.
- Rate of annual inflation for capital replacement needs—this external variable will fluctuate instead of remaining constant at the 6 percent annual rate assumed.
- Technological improvements in transit coach design—these could make a true one-on-one replacement more or less "obsolete" as coach production evolves toward newer electronic components or alternative fuels. [Seattle Metro is currently operating a small number of methanol-powered standard coaches; it is too soon to determine the long-term implications of this demonstration project. Other changes that would cause partial obsolescence in existing Metro coach design are a new color scheme (now evaluated for the dual-power contract) and physical enhancements for the driver's area for extra security.]
- Risk of potential retrofits—no capital cost allowance is made for retrofits outside the manufacturer's warranty, even

TABLE 2 BREAKDOWN OF THE ESTIMATES OF CAPITAL COSTS FOR TRANSIT FLEET REPLACEMENT, 1991 TO 2005

Cost Element	1986 Constant Dollars (millions)	Cost Element	Inflated Dollars[a] (millions)	Share of 15-Year Total (%)
Net contract price[b]	185.430	Net price after sales tax	392.700	94
Local sales tax[c]	15.760	–		
Preparation	1.200	–		
Special tools	1.050	–		
Other on-board equipment	6.280	–		
Soft capital	3.640	Other expenses	24.270	6
Total fleet capital costs	213.360		416.970	

[a]Using 6 percent capital inflation per year (after 1988).
[b]Price reflect current Seattle Metro coach design specifications without contingencies.
[c]Estimated at a future 8.5 percent (or 0.6 percent above existing).

though some retrofits may be capitalized. Yet it is difficult to assess their incremental long-term cost.

RELATIONSHIP OF FLEET REPLACEMENT NEEDS TO TOTAL CAPITAL PROGRAM

As shown in Figure 4, the capital costs of the transit fleet replacement represent more than two-thirds of the total capital costs of the base-case needs (*4*). The costs of replacing vanpools in the Metro fleet (assuming a 5-year life before resale) amount to less than 5 percent of the total. The second-largest component of the capital costs is replacement of the nonfleet assets, such as bus bases, park-and-ride lots, and associated support facilities. Those assets represent about 15 percent of the total. Other base-case capital items (such as computers and miscellaneous capital outlay) add another 15 percent to the total.

Sensitivity to Variations in Coach-Life Assumptions

The base-case fleet replacement plan will most likely underestimate future coach needs if active coaches last fewer years than has been assumed. This is tested by shortening coach life and estimating the resulting costs over the same planning period. The shorter lives affect not only the estimated capital costs of transit fleet replacement, but also the potential interest earnings from outstanding capital balances for the entire capital program. Compared with other transit systems, Seattle Metro has had a fairly predictable and very stable local funding base for its operating and capital programs. In addition to the formula-grant funding, this local condition has enabled the agency to set aside and collect interest on the outstanding fund balance in favorable years. In the tests just mentioned, a constant fleet mix for the entire planning period is assumed. Separate tests of possible fleet-mix variations are given next.

TABLE 3 YEARS OF REDUCTION IN ACTIVE COACH LIFE USED FOR SENSITIVITY TESTS

Coach Type	Base Case	Test 1	Test 2	Test 3
Standard diesel	14	13	12	12
Articulated diesel	16	15	14	14
Standard trolley	18	17	16	15
Articulated trolley	20	19	18	17
Dual-power	18	17	16	15
Mean reduction from base case	0	1	2	2[a]; 3[b]

[a]For all diesels.
[b]For other coaches.

Table 3 gives the modified assumptions about active coach life that are used to quantify the capital cost impacts of a coach life shorter than that in the base case. As shown in Table 4, the resulting changes to the base-case fleet replacement schedule have the following capital cost impacts:

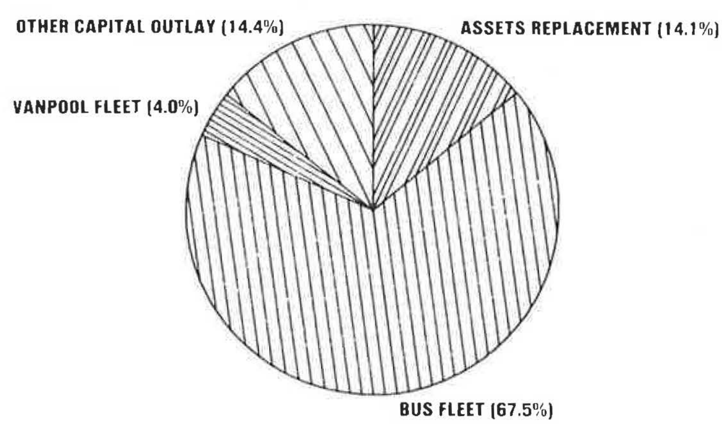

FIGURE 4 Capital replacement costs as percentage of total capital base-case costs.

TABLE 4 IMPACTS ON CAPITAL COSTS OF REDUCTIONS IN ACTIVE COACH LIFE

Test	Millions of Inflated Dollars[a] Direct Change from Base Case[b]	Estimated Interest Loss[c]	Net Cost Change[d]	Percent Increase over Base Case
1	–24	+25	+1	0.3
2	–11	+48	+37	9.4
3	+127	+56	+183	43.9

[a]Rounded to nearest million.
[b]Before reflecting the associated reductions in interest earnings.
[c]Scheduling future coach replacements in earlier years reduces the annual interest earnings derived from outstanding capital balances. The estimates assume a 6.3 percent interest rate.
[d]This net change is the sum of the first two columns.

- A small relative increase below 1 percent for the 1-year reduction of Test 1;
- A relative increase of about 10 percent for the 2-year reduction of Test 2; and
- A significant cost increase of 44 percent above the base-case estimates for Test 3.

The aforementioned capital cost increases appear fairly small for Tests 1 and 2. Their net estimates account for the direct savings (caused by earlier purchases of the same number and type of coaches with lower inflation) and the potential losses of interest earnings (relative to the earnings estimated for the base case). The much greater impact of Test 3 is partly caused by the shorter coach life assumed for the dual-power coach (i.e., 15 instead of 18 years) and by the fact that this is the most expensive coach in the fleet and, further, by the even greater losses in interest derived from lower outstanding capital balances in the later years.

In the analysis by using Tests 1–3 a 15-year planning period is assumed. Hence, in the coach-life definition in Test 3, the first replacement of the dual-power coaches would occur before the end of the planning period. If the same tests were evaluated over a longer planning period (i.e., 20 to 25 years), a somewhat less significant gap in capital costs would be found between Test 3 and the base case. However, the comparative ranking of Tests 1, 2, and 3 would remain the same relative to the base case.

Figure 5 gives the fleet-age profile under Test 3 and shows the following changes from the base case:

- With the shorter coach lives of Test 3, which call for earlier replacements of all coaches than under the base case, the gap estimated between mean age and weighted age becomes even narrower.
- The mean age of the coaches in Test 3 is consistently below the base-case mean age by a 1- to 3-year increment for only the early years (1991 to 1997). Beyond 1998 and through 2005, this reverses, because most replacements under Test 3 had already taken place in the earlier years.

Sensitivity to Variations in Fleet-Mix Assumptions

The base-case fleet replacement plan might overstate future coach needs if the share of articulated coaches dropped below the 55 percent level. This is first tested by replacing some articulated diesels with an equal number of standard diesels. The resulting smaller fleet mix leads to a capital cost saving. A variation of this test, replacing the same articulated diesels with a somewhat larger number of standard diesels, slightly increases the fleet size.

Another factor, somewhat unique to Seattle, is the long-term goal of making maximum use of the capacity of the downtown electric transit tunnel by running more dual-power coaches over time. This is simulated by substituting an equal number of new dual-power coaches for some old articulated diesels. The resulting fleet size equals the base case because no additional purchases are made. The resulting fleet mix—measured by the share of articulated coaches—also remains equal to the original 55 percent level. However, the greater share of dual-power coaches leads to an increase in capital costs. A variation of this test further increases capital costs by assuming an even larger substitution of dual-power coaches.

Table 5 summarizes the fleet-mix variations that are tested to quantify the impacts on capital costs of shares of articulated coaches lower than the base case.

The fleet-mix reduction is achieved in several ways:

- Replacing some articulated diesels with standard diesels (1:1) in Test M-0;
- Adding a partial substitution of new dual-powers for articulated diesels in Test M-1;
- For Test M-2, replacing the same articulated diesels as in Test M-0 with a larger number of standard diesels (3:2) and using the same dual-power substitution as in Test M-1; and
- For Test M-3, while using the constant base-case articulated share and fleet size, doubling the dual-power substitution used in Test M-1 by the year 2000.

The same cost approach used for the coach-life reductions is used for the fleet-mix variations. As shown in Table 6, the resulting deviations from the base-case assumptions have the following capital cost impacts:

- A significant net decrease of 28 percent for the standard diesel substitution of Test M-0;
- A small relative decrease of 1 percent for the added dual-power substitution of Test M-1;
- A negligible net change for Test M-2 (analyzed below); and
- A significant cost increase of 40 percent for the greater dual-power substitution of Test M-3.

Test M-2 consists of two simultaneous variations, the cost impacts of which tend to cancel each other out. On one hand, the relative decrease in the number of articulated diesel coaches results in a net capital cost saving (smaller than Test M-0). On the other hand, the relative increase in dual-power coaches results in a net capital cost increase (similar to Test M-1).

OPERATING AND MAINTENANCE COSTS RELATIVE TO CAPITAL COSTS

Using the base-case assumptions, the total operating and maintenance (O&M) cost estimates are nearly $4 billion (in inflated

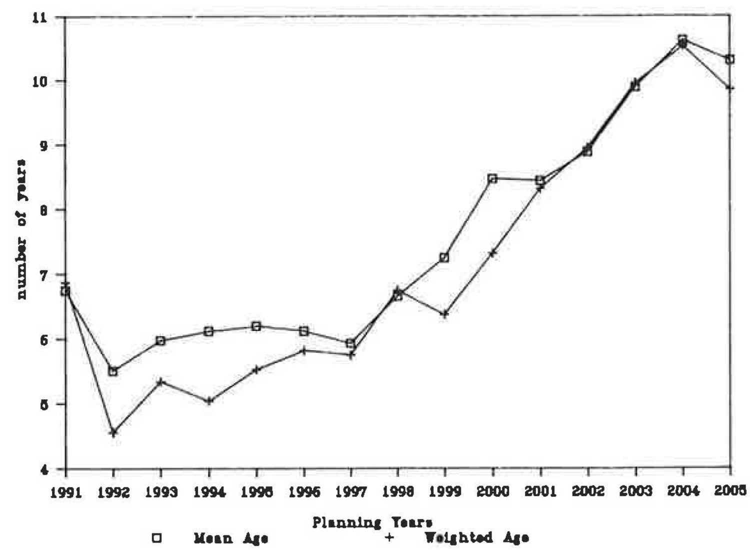

FIGURE 5 Test 3 fleet age profile.

TABLE 5 VARIATIONS IN ACTIVE FLEET MIX

Test	Articulated Fleet Share[a] (% of total active coaches)	Dual-Power Substitution	Dual-Power Fleet Share[b] (% of total active coaches)
Base case	55[c]	No	20[c]
M-0	42 in mid-1990s, 33 in late 1990s	No	20[c]
M-1	42 in mid-1990s, 33 in late 1990s	Yes (late 1990s)	29 in late 1990s
M-2	39 in mid-1990s, 31 in late 1990s	Yes (late 1990s)	Same as M-1
M-3	Same as base case	Yes (twice the M-1 substitution)	38 in late 1990s

NOTE: Except for Test M-2, which replaces some articulated diesels with standard diesels on a 3 to 2 ratio, these tests use the same base-case fleet size as in Table 4.
[a]Share of articulated coaches (diesel-only, trolley-only plus dual-power articulateds) within the active fleet.
[b]Share of dual-power coaches only within the active fleet (i.e., a portion of the articulateds share in the first column).
[c]Constant.

dollars) from 1991 to 2005. After 15-year costs are converted to annual equivalent costs in constant 1990 dollars, the base-case capital needs represent approximately 14 percent of the total costs (i.e., sum of capital and O&M estimates). This is a noticeable change from the current Metro program, under which total capital and O&M costs contribute equal shares to the annual budget expenditures. This shows the contrast between the capital-intensive program of the 1980s and a replacement-only scenario for the 1990s. The major capital activities of the current decade include the electric transit tunnel construction, several new or expanded facilities, and the fleet expansion. Similar activities are not provided for by the base-case definition of a theoretical replacement-only scenario. Hence, the very large capital expenses of the 1980s tend to amplify the magnitude of the post-1990 shift toward greater system O&M costs relative to total capital replacement costs.

The current Metro operating practice maximizes the annual coach mileage in the early years (typically the first 6 or 7 years). Following the first engine rebuild, the practice has been to reduce the annual mileage. There is a gradual year-to-year increase of annual maintenance costs in the first 6 or 7 years, and a relatively stable pattern follows in later years. Hence the coach lives used in Tests 1 to 3 have negligible cost impacts on the fleet maintenance costs, because coaches are retired after 7 years with the more stable O&M cost pattern. For instance, Test 3 with the shortest coach lives has the same total O&M cost estimates as the base case. Because of the higher fleet capital costs used in Test 3, its annual equivalent capital needs would amount to a slightly larger share, estimated at 16 percent of the total system costs (see Table 7).

The current Seattle O&M cost model is not sensitive enough to fleet-mix variations. This is because standard and articulated diesel coaches are aggregated into a single diesel-only category. Hence, Tests M-0 through M-3 give annual O&M costs very similar to the base case through the late 1990s. Beyond the year 2000, the dual-power substitutions cause a very slight increase in vehicle maintenance and fuel consumption costs over the base case. (The fuel efficiency of the dual-power coach is assumed to be 10 percent less than that of a diesel-only articulated coach in order to account for the increased weight of both a diesel engine and an electric motor.) These two components of systemwide O&M costs represent 21 and 3 percent respectively of the annual O&M costs. The resulting impacts on total systemwide post-2000 costs appear negligible at the base-case service levels. As shown by Table 7, Test M-0, with the lowest fleet capital costs, has the lowest annual equivalent

TABLE 6 IMPACTS OF CHANGES IN FLEET MIX ON CAPITAL COSTS

	Millions of Inflated Dollars[a]			
Test	Direct Change from Base Case	Estimated Interest Loss[b]	Net Cost Change[c]	Percent Change from Base Case
M-0	−56	−59	−115	−27.6
M-1	−16	+11	−5	−1.2
M-2	+1	−1	0	Negligible
M-3	+81	+86	+167	+40.0

[a]Rounded to nearest million.
[b]A negative sign corresponds to interest earnings (due to reduced capital costs) and a positive sign to interest losses (due to increased capital costs).
[c]This net change is the sum of the first two columns.

TABLE 7 RELATIVE SHARES OF SYSTEMWIDE AND O&M COSTS

	Annual Equivalent Costs ($1990 millions)	Share of Costs (%)	
		O&M	Capital
Base case	201	86	14
Test 3 (shortest lives)	210	84	16
Test M-0 (lower mix)	195	90	10

capital cost. Hence, its corresponding share of capital needs is slightly smaller at 10 percent of total system costs.

DATA NEEDS FOR TRANSFERABILITY TO OTHER AREAS

The data needs for programming long-term transit fleet replacement as given by the Seattle case study are as follows:

- A historical record of annual vehicle maintenance costs and platform miles by coach series,
- A current estimate of other expenses due to chargeable mechanical trouble calls and down time for the same coach series, and
- Original coach purchase prices and a trend curve of coach resale values over the initial 15 to 20 years of service by coach series.

These items will serve to measure optimal economic coach life within the existing active fleet. If annual platform miles is not readily available, one might use annual platform hours to quantify the service output over the coach life. The uniform recording of mechanical trouble calls and down-time expenses (5) will help in validating the cost data with different coach series. Estimates of coach resale values might have to be secured outside the transit agency.

In addition to this initial data collection and analysis, some planning and agency policy assumptions will be needed to derive average coach lives. These averages can then be used to prepare the long-term fleet replacement schedule. Other data needed for estimating future fleet capital costs include

- Recent bid prices on the coaches either already in the fleet or contemplated for future acquisition;
- Current cost estimates for on-board equipment excluded from the above bids, as well as their estimated lives (if not the same as those of the coaches); and
- Capital budget estimates for other vehicle procurement expenses (or actuals from recent procurements).

Finally, a planning estimate of future platform miles by year for each coach series will allow quantifying the annual fleet age weighted by miles. Such estimates can be compared with the current fleet-age profile to assist in evaluating fleet replacement options.

CONCLUSION

Transit fleet planning is essential in assessing the replacement needs for long-term assets of a transit system. This information can assist the operator in making shorter-term decisions on the timing of coach retirement, rehabilitation, or phased substitution by younger coaches. Expansion needs can also be compared with basic replacement needs over the intermediate planning horizon (5 to 6 years).

The case of Seattle Metro is unique in some respects. The agency already has a high percentage of articulated buses in its fleet, and this will soon be increased. The acquisition of newer coach types is tailored to very site-specific service applications. The best example is the programmed delivery of dual-power coaches for operations in the downtown electric transit tunnel. The quality of the vehicle maintenance program, in addition to the favorable operating environment characterized by a very mild climate and a fairly new freeway infrastructure (as compared with that in older cities), has helped Metro to maintain its very large fleet quite efficiently.

When transferring this approach to fleet replacement to other systems, enough time should be spent gathering local data on experience with replacing and rehabilitating active coaches, current maintenance practices over the lives of those coaches, and platform mileage accumulated each year. Dealing with a more uniform fleet mix than that found in Seattle would likely simplify the analysis. Considering a much smaller fleet size could also affect some of the economies of scale experienced by a larger fleet.

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