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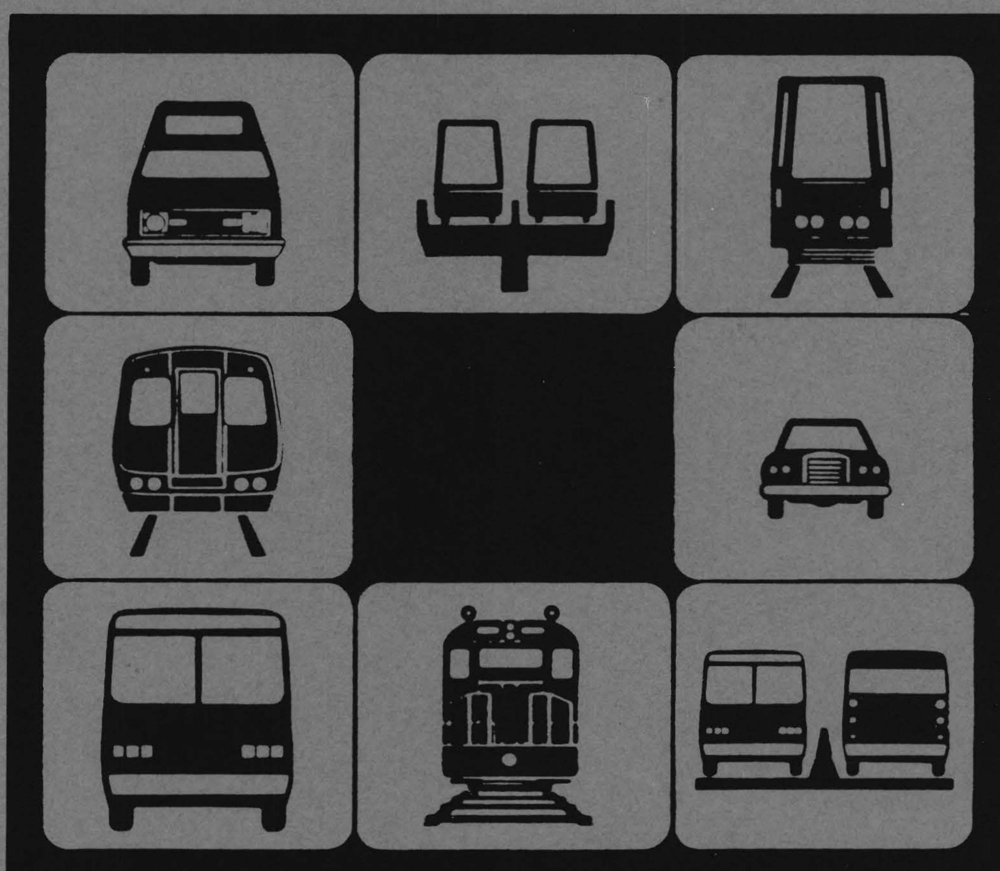
URBAN RAIL TRANSIT PROJECTS: FORECAST VERSUS ACTUAL RIDERSHIP AND COSTS

October 1989



URBAN RAIL TRANSIT PROJECTS: FORECAST VERSUS ACTUAL RIDERSHIP AND COSTS

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SUMMARY

Under a variety of grant programs administered by the Urban Mass Transportation Administration (UMTA), the federal government has contributed nearly $12 billion to support U.S. cities' investments in new rail transit facilities. This study evaluates the ridership and cost forecasts that led local officials to select ten rail transit projects that have been constructed with federal financial assistance during the past two decades, by comparing those forecasts to each project's actual costs and ridership. The forecast data employed in making these comparisons were originally reported in published planning documents prepared for each project, while actual data were drawn from a combination of published sources, internal documents provided by local agencies involved in constructing and operating these projects, and direct contacts with employees of those agencies.

Although different forecasts were prepared at varying stages during the planning process for many of the projects examined, this study focuses upon the accuracy of projections that were available to local decision-makers at the time the choice among alternative transit improvement projects was actually made. Because forecasts of ridership and costs prepared for a specific project after it was designated as the locally preferred alternative cannot have influenced its choice from among competing alternatives, the accuracy of these post-decision forecasts is not a focus of this study.

The study also attempts to identify causes of the divergence between forecast and actual performance of these projects, and makes specific recommendations intended to improve the accuracy of forecasts prepared for future projects. Its purpose is thus to improve the process currently used to plan and evaluate major transit capital investments, by recommending measures to increase the reliability of information available to local decision-makers when they compare and choose among alternative projects.

The differences between forecast and actual values of transit ridership and costs have important implications for the reliability of the process currently used to develop and choose among alternative transit projects:

(1) Actual ridership that differs significantly from its forecast level indicates that a project's benefits are also likely to vary from the expected level that led to its selection from among the alternatives under study.

(2) Capital costs that differ markedly from their anticipated level can substantially increase the financial burden on the government program and agency funding the project, resulting in postponement or cancellation of other projects competing for its support.

(3) Similarly, operating expenses that exceed their projected level can increase operating deficits or require reductions in the level of other transit services that an agency can operate within its budget.

(4) If the divergence between a project's forecast and actual cost-effectiveness in attracting new transit passengers exceeds the margin by which the chosen alternative was preferred to others that were rejected, the planning process may not have led to selection of the most desirable project.

Thus, an important objective is to ensure reasonable accuracy of forecasts prepared to support future choices among alternative transit improvement projects. To help attain this objective, it is useful to examine why the actual costs and ridership experienced by past projects diverge so markedly from their forecast values.

RIDERSHIP FORECASTS

Table S-1 compares forecast and actual passenger boardings on each of the ten new rail transit projects reviewed as part of this study.[1] As it indicates, only the extensive rail rapid transit system under construction in Washington, D.C. experiences actual patronage that is more than half of that forecast, and even there ridership remains 28% below that originally anticipated. The number of passengers carried by new rail lines in Baltimore and Portland is somewhat below half of that forecast, while actual ridership on Miami's Metrorail line, as well as on the light rail lines recently completed in Buffalo, Pittsburgh, and Sacramento ranges from 66% to 85% below its forecast levels. Similarly, the two downtown people movers constructed in Miami and Detroit carry 74% and 83% fewer daily passengers than were originally anticipated to use them.[2] The consistent over-estimation of future ridership on recent rail transit projects suggests that, with few exceptions, the levels of travel and related benefits they currently provide are far below those originally anticipated by the local decision-makers who selected these projects.

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[1] *The only forecast of rail ridership available for the Atlanta rail system applies to a much more extensive system than is presently in operation, and was not expected to be reached until it had been in operation for nearly 15 years. Therefore Table S-1 presents no forecast of rail transit ridership for Atlanta.*

[2] *The dates to which ridership forecasts prepared for light rail lines in Portland, Buffalo, and Sacramento apply have not yet been reached. Forecasts of ridership and other variables prepared for these projects applied to the years 1990, 1995, and 2000, respectively.*

Table S-1.
FORECAST AND ACTUAL COST PER PASSENGER FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Weekday Rail Passengers (thousands)										
Forecast	569.6	NF	103.0	239.9	92.0	90.5	42.5	50.0	41.0	67.7
Actual	411.6	184.5	42.6	35.4	29.2	30.6	19.7	14.4	10.8	11.3
% difference	-28%	--	-59%	-85%	-68%	-66%	-54%	-71%	-74%	-83%
Rail Project Capital Cost (millions of 1988 dollars)										
Forecast	4,352	1,723	804	1,008	478	699	172	165	84	144
Actual	7,968	2,720	1,289	1,341	722	622	266	188	175	215
% difference	83%	58%	60%	33%	51%	-11%	55%	13%	106%	50%
Annual Rail Operating Expense (millions of 1988 dollars)										
Forecast	66.3	13.2	NF	26.5	10.4	NF	3.8	7.7	2.5	7.4
Actual	199.9	40.3	21.7	37.5	11.6	8.1	5.8	6.9	4.6	10.9
% difference	202%	205%	--	42%	12%	--	45%	-10%	84%	47%
Total Cost per Rail Passenger[1] (1988 dollars)										
Forecast	3.04	NF	NF	1.73	2.15	NF	1.68	1.53	0.90	1.14
Actual	8.75	5.93	12.92	16.77	10.57	7.94	5.19	6.53	7.11	10.21
% difference	188%	--	--	872%	392%	--	209%	328%	693%	795%

[1] *Annual total cost of rail service divided by annual equivalent of "Weekday Rail Passengers," computed using numbers of average weekday equivalents per year derived from annual total and average weekday rail ridership reported by project operators. Annual total cost of rail service is the sum of (1) the annualized value of "Rail Project Capital Cost," computed assuming a 40-year project lifetime and a discount rate of 10% per year, and (2) "Annual Rail Operating Expense."*

NF indicates no forecast of a data item was obtainable from published sources.

Calculations using measures of the sensitivity of transit ridership to demographic variables, transit service levels, and automobile costs -- the major inputs into ridership forecasts prepared for these rail projects -- suggest that errors in projecting their future values typically explain less than half of the observed gap between predicted and actual rail ridership. Overly optimistic assumptions about the frequency and speed of service that new rail lines would provide, as well as about the quality of bus feeder service on which these lines rely to generate much of their ridership, made the largest contributions to the over-estimation of their future ridership levels.

Even where a significant fraction of the difference between projected and actual rail ridership can be explained by errors in forecasting these inputs, these differences were usually so large that a substantial absolute difference remained unexplained. This suggests that important errors must have arisen from other, less obvious sources, including the structure of the ridership forecasting models, the way in which they were applied, or the misinterpretation of their numerical outputs during the planning process.

CAPITAL COST FORECASTS

Table S-1 also compares these projects' forecast and actual capital outlays, which include costs for acquiring rights-of-way, constructing fixed facilities, and purchasing vehicles. (Both forecast and actual outlays reported in the table are expressed in 1988 dollars). As these comparisons indicate, capital outlays for Pittsburgh's South Hills light rail reconstruction project were actually 11 percent below their forecast value, while cost overruns on other projects ranged from 13% for Sacramento's recently completed light rail line to 106 percent for Miami's downtown "Metromover" project.

Because changes in the physical characteristics of these projects between their planning and construction stages were generally quite minor, and because many of the changes that were made should have reduced rather than increased capital outlays, it appears that very little of the substantial cost overruns experienced in building most of these projects can be ascribed to major design changes. Instead, cost escalation must have been the product of many smaller changes in the physical design of facilities or the standards for their performance, no one of which was extremely costly but the cumulative effect of which was often a substantial increase in construction outlays.

Federal assistance under a variety of funding mechanisms ranged from 53 percent to 83 percent of capital outlays for the ten projects reviewed. Actual federal outlays for these ten projects totaled about $7.1 billion, although the equivalent of this figure in 1988 dollars would be considerably higher because much of it was denominated in the higher-valued dollars of previous years. Financing of the remaining share of capital outlays varied widely among these projects, although in nearly every case, either state or local government financed most of the non-federal share of project costs. (Only one project received substantial support from both state and local government.) Local financial contributions amounted to 5% or less of both planned and actual capital outlays for five of the ten projects studied (those in Baltimore, Buffalo, Pittsburgh, Portland, and Detroit), a surprisingly modest level of local government support considering the highly localized nature of the benefits from transit projects.

Until recently, the federal treasury assumed most of the burden of financing the large cost overruns that have characterized many of these projects. The federal government financed three-quarters or more of the cost overruns experienced by six of the ten projects, including four of the five on which these overruns exceeded the hundred-million dollar mark. In fact, the financing mechanisms originally incorporated in federal capital assistance programs placed on the federal treasury a share of the burden from cost overruns that often substantially exceeded its originally planned share of the project's total cost.

More recently, the declining federal share of cost overruns on rail projects appears to indicate that the use of "full-funding" agreements -- which limit the federal government's dollar contribution to a project -- has transferred much of the financial risk of cost overruns from the federal government to state and local agencies responsible for selecting these projects. The effectiveness of such arrangements in controlling cost escalation is limited, however, by the fact that they are not entered into until well after the local choice among projects has been made, by which time the estimated cost of constructing the preferred project has often escalated considerably from the forecast on which its selection was based.

OPERATING COST FORECASTS

Table S-1 also compares the forecast and actual values of annual operating expenses for rail service provided by each of the ten projects (again, these are expressed in 1988 dollars to remove the effect of errors in forecasting inflation). As the table shows, actual rail operating expenses are above those forecast in all but one case for which this comparison can be made: actual operating expenses for Sacramento's light rail line are 10% below those forecast, but elsewhere, actual expenses range from 12% to more than 200% above their projected levels.[3] Further, except for the two downtown people mover systems, the actual expenses reported in Table S-1 understate the full costs of operating rail service, because they omit the costs of operating the networks of feeder bus routes on which these projects rely to generate much of their ridership.

While actual operating expenses would be expected to exceed those forecast if the level of rail service actually provided is higher than that

[3] *Operating expenses for Sacramento's light rail line during 1988 were 10 percent below the level project to be reached by the year 2000; however, the number of vehicle-miles of service operated during 1988 was 45 percent below the number expected to be operated during the year 2000.*

originally anticipated, this is the case only in Atlanta and Portland. Elsewhere, actual vehicle-miles of service are more typically only one-third to one-half of those originally planned. Instead, the substantial differences between most of these projects' forecast and actual operating expenses appear to stem from a combination of lower labor productivity in rail operations and higher compensation rates than were originally anticipated, together with vehicle operating speeds that are considerably slower than those projected during these projects' planning stages.

COST PER RAIL PASSENGER

Finally, Table S-1 shows that forecasts of total cost per rail rider for seven of the ten rail projects that were studied ranged from slightly under $1.00 to more than $3.00 (when measured in 1988 dollars). However, actual costs per rail passenger carried by these ten projects ranged from somewhat more than $5.00 to nearly $17.00, or from 188% to nearly 900% higher than their corresponding forecast values. The weighted average forecast cost per rail passenger for the seven projects where this forecast could be computed was $2.35, while the weighted average of actual costs per rail rider for all ten projects was $8.56, or 264% percent higher than this forecast average.

Errors in projecting this cost-effectiveness index are a composite of previously documented errors in forecasting each of the three variables that enter into its calculation: rail ridership, project capital outlays, and rail operating expenses. Because no project achieved actual values of ridership, capital outlays, and operating expenses that were each close to those forecast, every project's actual cost per rail passenger was considerably higher than the value implied by forecasts of these variables.

SYSTEM-WIDE IMPACTS OF RAIL TRANSIT INVESTMENTS

Another important aspect of these projects' performance is their effectiveness in increasing overall transit ridership and controlling operating costs in the urban areas where they were built -- objectives that were commonly cited by local decision-makers when selecting rail projects over competing alternatives. To assess these projects' performance in doing so, Table S-2 compares forecast and actual changes in total transit ridership and operating expenses accompanying each of the eight heavy and light rail projects that were studied.[4]

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[4] *Because the two downtown people-mover projects are so small that their effects on area-wide transit ridership are difficult to isolate, Detroit is excluded from Table S-2, while the combined effects of Miami's Metrorail and Metromover projects on transit ridership and costs are included in the table. The procedures used to estimate these projects' forecast and actual impacts on system-wide transit ridership and operating expenses are discussed in detail in Chapters 2 and 4 of this report.*

Table S-2.
FORECAST AND ACTUAL COST PER NEW TRANSIT TRIP FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
New Transit Trips per Average Weekday (thousands)								
Forecast	NF	99.1	NF	262.9	81.0	NF	51.3	13.0
Actual	281.3	36.9	37.3	-25.8	-0.4	6.3	11.5	-4.2
% difference	--	-63%	--	--	--	--	-78%	--
Rail Project Capital Cost (millions of 1988 dollars)								
Forecast	4,352	1,723	804	1,092	478	699	172	165
Actual	7,968	2,720	1,289	1,516	722	622	266	188
% difference	83%	58%	60%	39%	51%	-11%	55%	13%
Annual Operating Expense Impact of Rail Project (millions of 1988 dollars)								
Forecast	NF	NF	NF	33.9	4.7	NF	0.6	-2.1
Actual	228.5	53.8	14.7	46.0	13.7	1.4	4.6	5.6
% difference	--	--	--	36%	191%	--	667%	--
Total Cost per New Transit Trip[1] (1988 dollars)								
Forecast	NF	NF	NF	1.67	2.20	NF	1.14	3.53
Actual	11.97	29.47	13.56	--	--	34.64	9.49	--
% difference	--	--	--	--	--	--	731%	--

[1] *Annual total cost impact of rail project divided by annual equivalent of "New Transit Trips per Average Weekday," computed using numbers of average weekday equivalents per year derived from annual total and average weekday total transit ridership reported by project operators. Annual total cost impact of rail project is the sum of (1) the annualized value of "Rail Project Capital Costs," computed assuming a 40-year project lifetime and a discount rate of 10% per year, and (2) "Annual Operating Expense Impact of Rail Project."*

[2] *No actual value can be calculated because ridership declined with the introduction of rail service.*

NF indicates no forecast of a data item was obtainable from published sources.

As the table indicates, substantial growth in transit ridership accompanied the introduction of rail service in Washington, Atlanta, and Baltimore, although in no case did the increase in ridership approach that forecast. Increases in transit ridership accompanying the introduction of light rail service in Pittsburgh and Portland were more modest, particularly by comparison to the substantial growth in transit use that was forecast to occur in the latter. In contrast, overall transit ridership in Miami, Buffalo, and Sacramento -- including travel by both bus and rail -- actually declined rather than increased as rail transit service was introduced.

Table S-2 also attempts to identify the impact of introducing rail service on these cities' costs for providing transit service. This impact consists of the costs associated with investments in new rail facilities, together with any change in the total cost of operating the resulting network of bus and rail transit service. As it shows, the actual capital outlays necessary to construct new rail transit facilities were sharply higher than those initially projected in six of the eight cities that chose to make these major investments. The table also reports that while some of these projects' actual impacts on systemwide operating expenses compare fairly closely to those originally forecast, the actual effect of inaugurating rail service on systemwide operating expenses has often been a substantial increase from their "pre-rail" level, even where a reduction or only a slight increase in operating expenses was anticipated.[5] Thus, it appears that savings in total transit operating expenses, which were often anticipated to result from substituting rail for bus service, may have not have been widely realized.[6]

Finally, Table S-2 shows that the projected costs per new transit trip implied by these projects' anticipated additions to areawide transit ridership and costs were quite modest, ranging from somewhat more than $1.00 to slightly over $3.50 in the four cases where a forecast could be computed. In contrast, of the five projects for which actual costs per new transit passenger could be computed, only that in Portland was accompanied by ridership gains at a cost of less than $10.00 per new trip. While the substantial transit ridership increases in Washington and Baltimore were achieved at costs in the $12.00-13.50 per trip range, Atlanta's similarly impressive ridership gain as well as the more modest gain in Pittsburgh were attained at costs in the neighborhood of $30.00 per new trip.

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5 *The clear exception is Sacramento, where only a small fraction of the major increase in areawide transit service -- and thus in operating expenses -- that was originally projected to occur by the year 2000 has been implemented to date.*

6 *This could occur either because replacing bus service with rail service does not actually reduce operating expenses, or because reductions in bus service originally anticipated to accompany the introduction of rail service were not actually implemented. It is not possible to distinguish between these two explanations for increased operating expenses on the basis of the information reported in this study.*

CONCLUSIONS AND RECOMMENDATIONS

Implications of Forecasting Errors

It is difficult to judge whether the substantial errors in forecasting ridership and costs for the rail projects reviewed here led decision-makers to select them when more accurate forecasts might have led them to prefer other alternatives, because the accuracy of forecasts prepared for alternatives that were discarded in favor of the chosen rail projects cannot be evaluated. Nevertheless, it appears that the divergence between forecast and actual cost per rail rider and per new transit trip for these projects was often larger than the entire range of values of these measures over all of the alternatives from which these projects were selected. Thus, it is certainly possible that decision-makers acting on more accurate forecasts of costs and future ridership for the projects reviewed here would have selected projects other than those reviewed here, at least in some cases.

Even if cost and ridership forecasts for each alternative considered were subject to the same sources and degree of inaccuracy as those examined here, the systematic tendency to over-estimate ridership and to under-estimate capital and operating costs introduces a distinct bias toward the selection of capital-intensive transit improvements such as rail lines. This bias arises because, as a variety of studies has shown, rail becomes the economically preferred transit mode only when its substantial capital costs and fixed operating expenses can be spread over large passenger volumes.[7] Thus, even if cost and ridership forecasts prepared for transit improvement projects entailing investments in different modes or technologies prove to be equally optimistic (that is, to represent equal proportional over-estimates of future ridership and under-estimates of costs), the planning process will still be biased toward selection of the most capital-intensive alternatives under consideration.

Recognizing the sensitivity of local transportation officials' choices among alternative transit improvement projects to the reliability of their projected future ridership and anticipated costs, it is important that steps be undertaken to improve the accuracy of forecasts prepared to support future transit investment decisions. These steps should include specific technical improvements in the procedures used to develop and check cost and ridership forecasts, some of which have already been at least partially incorporated into UMTA project planning guidelines. They should also include subjecting forecasts to review by outside experts, as well as acknowledging to local officials and the public that the resulting forecasts are still accompanied by considerable uncertainty.

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[7] *The earliest such study is reported in John R. Meyer, John F. Kain, and Martin Wohl, The Urban Transportation Problem, Cambridge, Massachusetts, Harvard University Press, 1965, Chapters 8-11. Several subsequent studies arrive at the same conclusion, although for a variety of reasons they differ regarding the exact ridership threshold at which rail becomes the most cost-effective transit mode.*

Technical Improvements in the Accuracy of Forecasts

The errors in ridership and cost forecasts documented in this report are so large that it seems unlikely they would have been eliminated by simple technical changes in the way forecasts are generated. Nonetheless, it should be possible to reduce substantially the magnitude of future errors by combining technical improvements in the preparation of forecasts with stronger incentives for local agencies planning these projects to develop more realistic projections of their costs and future ridership. Among the potentially valuable procedural improvements, most of which have already been incorporated into the current UMTA process for planning major transit projects, are the following:

(1) Using a nearer "horizon" year for ridership and operating expense forecasts, as is now strongly encouraged under the UMTA planning process. Although this study found that errors in forecasting variables that serve as inputs to travel demand forecasting models (demographic and economic variables, transit performance levels, and automobile travel conditions and costs) were not solely responsible for overestimation of future ridership, they did contribute significantly in a few cases. Input assumptions could be made more accurate by shortening the period between their preparation and the future year to which they apply. This should reduce the number of major developments during the intervening period (often as long as twenty years in current practice) that can cause projections of these input variables to be inaccurate, such as changes in the performance of the local economy, or reorientation of travel patterns in response to changing geographic distributions of jobs and population.

(2) Developing procedures that allow the effects of individual factors on costs and transit ridership to be isolated and examined separately. One approach would be to prepare "forecasts" using existing or "base year" population, employment, and transportation system characteristics, as if each proposed transit project could be implemented instantaneously. This could provide a more realistic estimate of the costs and increased ridership that would result from the service characteristics associated with each of the proposed transit improvements, since it would allow the effects on ridership of these changes to be distinguished from those of growth in overall travel demand due simply to demographic growth or changes in other exogenous factors (such as gasoline prices) that affect each transit alternative under consideration.

(3) Conducting sensitivity analyses to examine the effects of alternative assumptions affecting cost and ridership projections. This type of analysis can be very helpful both for refining forecasting procedures themselves, as well as for examining the likely effects on costs and ridership of uncertainty regarding such factors as demographic growth, transit service levels, energy prices, future escalation of construction costs, or design and performance characteristics of transit facilities.

(4) Checking the reasonableness of construction and operating cost forecasts, of ridership forecasts, and of inputs to these forecasts, by comparing them to the record established by previous projects. Significant discrepancies with empirical data for similar projects and urban areas should require either that these discrepancies be convincingly justified, or that revised forecasts be prepared using adjusted procedures or input assumptions.

Subjecting Forecasts to Expert Review

Another potentially effective strategy for establishing the reliability of cost and ridership forecasts, as well as of the assumptions and models used to generate them, is to subject them to review and verification by independent experts. Although such a review of each urban area's forecasting efforts is presently conducted by UMTA staff members, the growing number of projects for which planning is actively underway, together with a reduction in resources available for this effort, has reduced the scope and depth of review activities that can be performed.

For example, local agencies responsible for conducting the UMTA planning process could be required to designate a peer review panel with responsibility for assessing the credibility of input assumptions, technical procedures, and forecast results when they are still subject to review and revision. The responsibilities and powers of individual members comprising such a panel would need to be clarified prior to their selection, but wider use of such groups offers the potential for bringing valuable judgement and experience to bear in generating reliable information to support local decision-makers choices among alternative transit improvement projects.

Once projects have been selected and arrangements for financing their implementation have been completed, independent expertise in activities such as construction management, testing of completed systems, and actual initiation of service could also be employed by local agencies serving as project sponsors. Such expertise has recently been provided to sponsors of some recent federally-financed rail transit construction projects by Project Management Oversight (PMO) contractors designated by UMTA, who have been retained to provide specific assistance and oversight activities agreed to by UMTA and the local project sponsor. More widespread use of such contractors, including their participation before problems have arisen with project construction timetables or financing, is thus a potentially useful strategy for bringing independent expertise to bear on project implementation activities.

Acknowledging Uncertainty in Ridership Forecasts

The errors in forecasting ridership and costs identified in this study are so large that they appear unlikely to be eliminated completely by technical changes in the procedures for developing and reviewing forecasts. It thus seems prudent that both ridership and cost forecasts prepared to support future choices among alternative projects be prepared and presented in a manner that explicitly recognizes the existence of uncertainty about whether their exact values will be achieved. Perhaps most important, this recognition also needs to be conveyed to the local political officials that will ultimately rely on these forecasts to choose among alternative projects, as well as to the more general public.

One obvious way to acknowledge that such uncertainty surrounds even the most carefully prepared and assiduously reviewed projections of ridership would be to report a range of patronage levels that could reasonably be expected to result from implementing each project under consideration. While this procedure may slightly complicate the calculation and interpretation of the cost-effectiveness measures local project sponsors are required to prepare, it will simply represent a formal acknowledgement that the performance of each alternative under consideration cannot be predicted with certainty, and that local officials' selection of a preferred alternative must recognize a variety of other criteria in addition to cost-effectiveness measures.

Increasing Contingency Allowances to Cover Cost Escalation

Recognizing that capital cost estimation and financial planning for major public works projects such as the construction of rail transit lines is an inherently difficult and risky activity, it seems prudent in project budgeting to provide contingency allowances that are adequate to cover capital cost escalation of the magnitude typically experienced by such projects. On the basis of the results reported in this study, it appears that such contingency allowances have been consistently inadequate to allow local project sponsors to absorb unforeseen developments without incurring major increases in their projects' budgets, and should be increased substantially for future projects.

Although it is difficult to specify the exact size of allowance that should be provided in capital budgeting for future transit projects, it does appear that some increase in those historically provided is warranted. The most prudent course would probably be for UMTA to draw upon the experience of other major public works projects, in combination with the record established by past major transit capital projects (including those reviewed here), to establish guidelines for the size of contingency allowances in relation to foreseeable project expenditures. Even within the scope of major capital grant programs administered by the various other branches of the U.S. Department of Transportation, there probably exists considerable project budgeting and oversight experience that could be called upon to develop guidelines for more realistic estimation of adequate contingency provisions in budgeting for future federally-supported transit investments.

1. INTRODUCTION

1.1 FEDERAL SUPPORT FOR RAIL TRANSIT INVESTMENTS

Over the past two decades, the federal government has contributed nearly $12 billion in support of U.S. cities' investments in new rail transit facilities and vehicles, through a variety of grant programs administered by the Urban Mass Transportation Administration (UMTA). Grants for new rail transit construction thus have represented nearly a third of the federal government's $37 billion in total capital assistance to the nation's urban transit industry.[1] As this substantial financial commitment illustrates, support for major new investments in rail transit service has served as one of the cornerstones of federal urban transportation policy.

During this period, UMTA has developed an increasingly formalized and rigorous planning process to be used by localities in designing, evaluating, and selecting among alternative transit capital projects. The intent of this process is to ensure cost-effective decisions at each stage of project development, and its use -- illustrated schematically in Figure 1-1 -- is required as a condition of locally chosen projects' subsequent eligibility for federal financial assistance. Federal financial support is also available for conducting the detailed studies required at each stage; detailed review of these studies and formal consent by UMTA is required for a local agency to progress to each subsequent stage.

1.2 ASSESSING THE PLANNING PROCESS

Although not all rail transit projects constructed with federal financial assistance are products of a planning process as formalized as that currently in place, most have emerged from a selection procedure with important similarities to the present UMTA process. This procedure entails the design of a variety of alternative possible transit improvement projects, and evaluation of these alternatives on the basis of their forecast costs and performance in meeting state and local transportation objectives. The preferred project is

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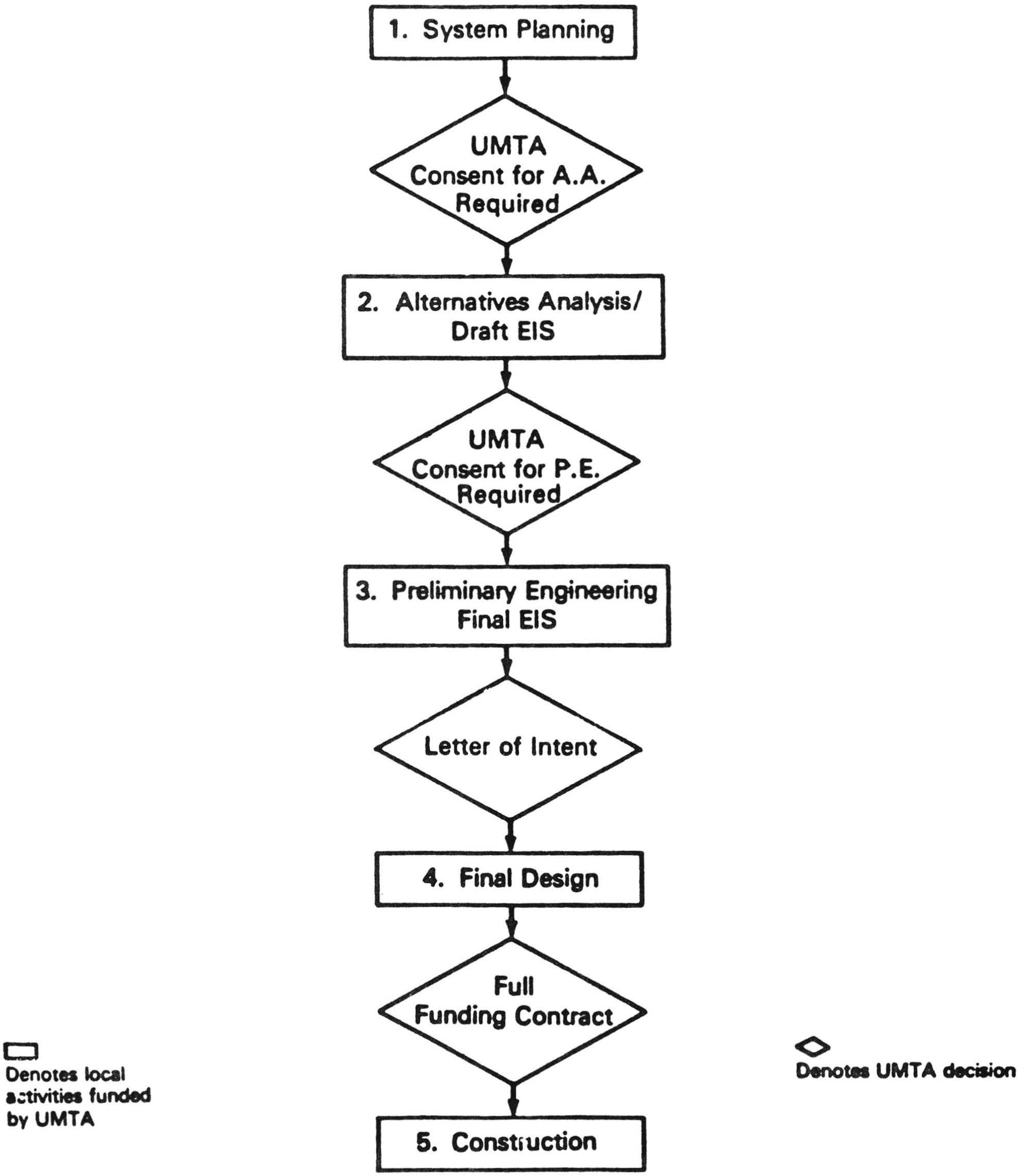
[1] *This estimate is compiled from information reported in Urban Mass Transportation Administration, "Grants Assistance Programs: Statistical Summaries," 1988, Tables B, 15, 17, and 20.*

Figure 1-1.
THE UMTA PROJECT DEVELOPMENT PROCESS



then selected by local decision-makers in a process that weighs each alternative's projected benefits against its projected costs. While the formality of the evaluation procedures leading to the selection of recent rail construction projects has varied considerably, the underlying logic of different local project selection processes was remarkably consistent even before UMTA developed specific, formal project selection procedures and required their use as a condition for receiving federal financial assistance.

This study examines one critical element of the process by which recent federally funded transit capital projects have been evaluated and selected. It assesses the accuracy of certain forecasts that contributed to the designation of a specific alternative as the locally preferred project. Specifically, for each selected alternative, it compares projected and subsequent actual values of three critical variables: ridership, capital costs, and operating and maintenance costs. Unfortunately, it is impossible to perform similar comparisons for the rejected alternatives -- a step that would be necessary to fully evaluate the overall accuracy of the entire forecasting process -- for the obvious reason that no actual information is available for projects that were never built.

1.3 THE DEFINITION OF "FORECAST" DATA

Although different forecasts were prepared at varying stages during the planning process for many of the projects examined, this study focuses upon the accuracy of projections that were available to local decision-makers at the time the choice among alternative transit improvement projects was actually made.[2] In the context of the present planning process, this refers to forecasts prepared as part of the Alternatives Analysis stage. The major published product of this stage typically is a Draft Environmental Impact Statement (DEIS) that compares forecast cost and ridership, as well as environmental, community, and other projected impacts, for a variety of alternative transit improvement projects.[3]

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[2] *Some local transit planners have expressed the view that the absolute accuracy of forecasts prepared for any single alternative (even the subsequently chosen one) at this stage of the planning process is irrelevant, since they are intended only to facilitate local decision-makers' comparison and choice among alternatives. Hence, they contend that these forecasts are only required to be of roughly equal accuracy for each alternative considered in order for an unbiased choice among alternatives to be made. However, the systematic tendency of the planning process to overestimate ridership and underestimate costs for proposed rail transit projects, documented in detail in subsequent sections of this report, biases the decision process toward high-capital alternatives such as rail transit. Thus, even if forecasts of cost and ridership incorporate roughly equal errors for each alternative under study, an unbiased choice among alternative projects of different capital intensity and with varying ridership levels cannot result.*

[3] *One exception is the forecasts of nominal-dollar capital outlays analyzed in Chapter 3, which are typically prepared as part of the Preliminary Engineering stage of the planning process (see Figure 1-1). These forecasts are generally not reported until publication of the Final En-*

Forecasts of ridership and costs for a specific project that were prepared after it was designated as the locally preferred alternative are frequently cited in public discussions and press accounts. Not surprisingly, these post-decision forecasts often have proven to be more accurate than those available to decision-makers when multiple alternatives were still under consideration. This is due both to the shorter time span between preparation of the forecasts and the future date to which they applied (sometimes as short as a few months), and to the greater scrutiny afforded a single alternative after it was designated as the locally preferred one. However, because such forecasts cannot have influenced the choice of a preferred project from among competing alternatives, their accuracy is not a focus of this study.

As an illustration, the Draft Environmental Impact Statement prepared for Portland's Banfield corridor was released in March, 1978, providing a detailed comparison of ridership, capital and operating costs, and other projected impacts for eleven alternative transit improvements in the corridor. By November of that year, each of the four responsible local jurisdictions had voted unanimously to select light rail transit in the Banfield/Burnside Street alignment as its preferred alternative.[4] As indicated in the subsequent Final Environmental Impact Statement (FEIS) prepared for the project, "Data contained in the DEIS...**provided the basis for selection of the preferred alternative by the jurisdictions.**"[emphasis added][5]

By the August, 1980 release of the FEIS, however, the estimated construction cost for the transit elements of the joint transit-highway project had increased from the original $172 million to $210 million (both estimates are expressed in 1988 dollars to eliminate the effect of inflation between their publication dates), or by 22% from the forecast on which the responsible local jurisdictions had based their selections. At the same time, the forecast of annual operating expenses for the project had been raised from $3.8 million to $7.0 million (both figures are again expressed in 1988 dollars), or by 84%, while projected ridership had been revised downward from 42,500 to 30,800 daily passengers, a reduction of 28% from the level on which decision-makers representing each of the four local jurisdictions had previously acted. Fur-

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vironmental Impact Statement (FEIS) or submission of an application for federal funding.

4 *These were Tri-Met, the agency responsible for building and subsequently for operating the project, Multnomah County, and the cities of Portland and Gresham; see Federal Highway Administration and Urban Mass Transportation Administration, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, pp. 2-51 and 2-52.*

5 *Banfield Transitway Project: Final Environmental Impact Statement, p. 2-53.*

ther, the forecast of ridership was subsequently revised downward to 18,100 daily passengers.[6]

Although each of these revised forecasts ultimately proved to be more accurate than that on the basis of which the light rail project was selected, their publication occurred too late in time to cause local decision-makers to seriously reconsider their choices. The only recourse available to local officials would have been to require the preparation of similarly revised forecasts for the ten other alternatives that had previously been discarded, in effect returning the planning process to the Alternatives Analysis phase (see Figure 1-1). This is obviously an unattractive option for local planners and political officials, particularly in view of the substantial time and other resources expended in moving the process forward from that stage. Recognizing its undesirability, this study emphasizes the accuracy of forecasts that were available to local decision-makers at the time they chose among alternative projects, and recommends measures to improve the reliability of cost and ridership forecasts developed to support future choices among projects.

1.4 WHY REVIEW PAST FORECASTS?

Examining the divergence between forecast and actual values of transit ridership and costs provides an important assessment of the project development process. First, actual ridership that differs significantly from its forecast level indicates that the project's benefits vary from the expected level that led to its selection from among the alternatives under study. Second, project costs that differ markedly from their anticipated level can substantially increase the financial burden on the government program or agency funding the project, resulting in the postponement or exclusion of other projects competing for that program or agency's support. If as a result of such errors the divergence between a project's forecast and actual cost-effectiveness in attracting new transit passengers exceeds the margin by which the chosen alternative was preferred to others that were rejected, the planning process may not have led to selection of the most desirable project.

A detailed examination of cost and ridership forecasts for past transit

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6 *These figures are reported in Parsons Brinckerhoff Quade & Douglas Inc. and Louis T. Klauder & Associates, Capital Cost Estimates/Operations & Maintenance Costs, Technical Memorandum No. 10, July 1980, Figure 2, p. 30, Figure 3, p. 31 (original and revised construction cost forecasts), and p. 44 (revised operating cost and ridership forecasts); Tri-Met, East Side Transit Operations, December 1977, Table 5, p. 37 (original ridership forecast), and Table 6, p. 40 (original operating cost forecast); and "Banfield LRT Patronage projections," Tri-Met Internal Memorandum, undated, pp. 1 and 4. . All dollar figures were converted to their 1988 dollar equivalents using the change in the Implicit Price Deflator for Gross National Product between the year of their original publication and 1988, reported in U.S. Department of Commerce, Survey of Current Business, various issues.*

projects should also help to improve the accuracy of forecasts prepared to support future choices among alternative projects, thus fostering better urban transportation investment decisions. Recurring errors in projecting specific variables may signal the need to develop improved procedures for forecasting their future levels, to improve the accuracy of inputs that are relied upon to generate those forecasts (such as assumptions about future demographic trends), or to examine the sensitivity of planning decisions to a range of possible future values of variables that remain chronically difficult to forecast accurately. Because each of these potential means for improving the accuracy of cost and ridership forecasts is both complex and costly, the division of effort among them should be guided by an awareness of where those efforts are likely to prove most productive. A review of past forecasting errors should provide an important contribution to developing such an awareness.

1.5 TYPES OF FORECASTS EXAMINED

This study reports comparisons between forecast and actual values for four types of measures.

(1) Ridership -- Recognizing the critical role of utilization in determining the transportation and other benefits resulting from the substantial capital investments represented by these projects, the study focuses first on how their forecast and actual ridership levels compare, and investigates why they differ.

(2) Capital costs and financing -- Next, the study compares actual capital outlays for each project to forecasts of their magnitude developed during the planning process, examines why actual outlays diverged from their forecast values, and documents the planned and actual burdens of financing these capital outlays.

(3) Operating and maintenance costs -- Third, the study compares actual costs of operating the improved transit service resulting from each major capital project to the costs anticipated during the planning process, and briefly explores the likely causes of the differences.

(4) Cost-effectiveness -- Finally, the study combines these data to compare each project's anticipated and actual cost-effectiveness.

The levels and patterns of ridership produced by a transit improvement project are the primary determinants of how successfully that project meets local objectives -- for example, providing improved accessibility, alleviating traffic congestion, and reducing air pollution levels. Thus, extensive efforts are made during the planning process to develop detailed patronage estimates for each alternative under consideration, including forecasts of ridership on the specific transit facilities comprising each project and of each project's contribution to areawide total transit ridership. Chapter 2 of this study examines in detail the accuracy of forecasts of these ridership measures that were prepared for recent rail transit investments, and explores why their actual ridership levels differ from those originally forecast.

The total cost of implementing many of the transit improvements under study is so large that even with the availability of federal financing for a substantial share of those costs, the local financial commitment to the preferred project can place a significant burden on total budgeted outlays for infrastructure investments and operations over a multi-year period. Thus, the anticipated cost of each alternative under study is a critical consideration in evaluating and choosing among them, and much attention is also devoted to preparing detailed cost estimates for each project.

These cost estimates consist of two components: (1) the initial outlays required to construct the planned facilities and acquire the transit vehicles that together comprise the project's capital investment; and (2) the ongoing expenses of operating and maintaining these facilities and vehicles. Generally, detailed estimates of both capital and operating cost measures are prepared for each project under consideration. Current federal project planning guidelines also require that both construction and operating cost forecasts be accompanied by specific financing plans, including an anticipated construction schedule, assumed inflation rate, planned level of service, and mix of funding sources to be relied upon.

Chapter 3 of this report reviews the accuracy with which each project's capital expenditures -- measured in both actual cash outlays and their constant-dollar (or "real") equivalents -- were forecast, and examines why capital outlays diverged from their projected levels. It also compares the projected contributions of federal, state, and local government agencies to the financing of these outlays to the actual distribution of each project's funding. Chapter 4 examines the accuracy with which expenses for operating and maintaining the transit facilities and vehicles comprising each project were forecast. Finally, Chapter 5 combines the forecast and actual values of each project's ridership, capital costs, and operating expenses into measures of its anticipated and actual cost-effectiveness in increasing transit ridership.

1.6 DATA SOURCES

The data employed in this study were gathered and verified using a multi-stage process designed to ensure their accuracy. Consultants retained by UMTA identified and collected planning documents that were the primary sources of forecast ridership, cost, and related data for the ten projects included in this review. In addition, the consultants obtained documentation of actual cost and ridership data from a combination of published sources (such as UMTA's Section 15 Annual Reports), internal documents provided by transit authorities and other local government agencies involved in constructing and operating these projects, and direct contacts with employees of those agencies. Specific references to the source of each data item reported here are contained in an Appendix to this report.

Each forecast data item appearing in a planning document was subsequently verified in its original source by project staff at the Transportation Systems Center (TSC), who also checked the accuracy of each actual data item appearing in published sources or internal transit agency documents obtained by UMTA's consultants. Finally, the assembled forecast and actual data for each project were circulated to the transit authority or other local agency responsible for planning and management of the project, who reviewed the data for accuracy and provided updated or corrected values where appropriate.

1.7 PROJECTS CHOSEN FOR STUDY

This study examines the accuracy of forecasts prepared for ten major transit capital improvement projects constructed with partial federal financing in nine urban areas during the period 1971-1987. Each of these projects included the construction of a fixed transit guideway using one of three rail technologies: conventional rail rapid transit (also called "heavy rail" or "metrorail"); modern "light rail" transit; or an automated "people-mover" system operating on a fixed guideway.

The specific projects studied were chosen partly because the planning processes through which they were selected produced extensive documentation of their forecast costs and performance, although the detail and usefulness of forecast documents varied considerably among them. More importantly, each project exemplifies the federally-sponsored effort to expand the role played by high-capacity, fixed-guideway transit service in the nation's cities, and the ten projects reviewed comprise a significant share of federally-financed investment in major transit capital improvements during the past two decades.[7]

Table 1-1 presents information on the scope and timing of the four heavy rail, four light rail, and two downtown people-mover (DPM) projects reviewed for this study. As the "Scope of Project Studied" section of the table indicates, these systems vary in extent from relatively short loops contained entirely within the downtown areas of Miami and Detroit, to multiple-line rapid transit systems serving several major radial travel corridors in Washington, DC and Atlanta. In between these extremes are six light and

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[7] *Total federal support for these ten projects amounted to more than $7 billion during the period studied, and some of these cities continued to receive federal financing for additional new rail construction after the projects studied here were completed. Thus, these projects collectively represent well over half of the federal commitment to expand the availability of rail transit service in the nation's cities. As part of this same commitment, federal assistance has also supported extension and rehabilitation of most of the nation's older rail transit systems. Although the reconstruction of Pittsburgh's South Hills streetcar line to modern light rail standards is an example of this latter effort, it was included in this study because the necessary reconstruction was so extensive that it was subjected to the same planning process as that used for the other nine completely new rail transit projects studied.*

Table 1-1.
CHARACTERISTICS OF RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Scope of Project Studied										
Number of Lines	4	2	1	1	1	1	1	1	1	1
Total Miles	60.5	26.8	7.6	21.0	6.4	10.5	15.1[1]	18.3[2]	2.0	2.9
Stations	57	26	9	20	14	13	24	28	9	13
Vehicles	414	198	72	71	27	55	26	26	11	12
Year When Project Reached Scope Studied										
Forecast Year	1977	1977	1978	1983	1982	1983	1985	1985	1983	1983
Actual Year	1985	1986	1983	1985	1986	1987	1986	1987	1986	1987
Year to Which Data Reported in this Study Apply[3]										
Forecast Data	1977	1978	1980	1985	1995	1985	1990	2000	1985	1985
Actual Data	1986	1987	1987	1988	1989	1989	1989	1988	1988	1988

[1] *Total line length; includes 1.1 miles of single track and 14.0 miles of double track.*

[2] *Total line length; includes 11.0 miles of single track and 7.3 miles of double track.*

[3] *Most "actual" data apply to transit operators' fiscal years ending during the calendar year indicated.*

heavy rail systems ranging widely in total length, each of which comprised what its planners viewed as the initial phase of an ultimately more extensive rail transit system. Construction of additional line mileage has actually progressed in Washington, Atlanta, and Baltimore, and planning for extensions of the initial projects reviewed in this study is actively underway in other areas.

1.8 COMPARING FORECAST AND ACTUAL DATA

Table 1-1 also reports the dates to which the forecast and actual data for each project apply. The long delays experienced between planning and constructing rapid transit systems in Washington, Atlanta, and Baltimore present particular difficulties in comparing forecast costs and ridership to their actual values.[8] The approach taken here was to identify stages of the systems ultimately planned for which separate forecasts were prepared, and to compare these forecasts to their actual values during a recent period when each system attained a scope closely resembling that to which these forecasts apply.

For example, the 60.5-mile, 57-station configuration of the Washington system that operated from December, 1984 through June 1986 (when the next line extension was opened for service) closely resembled the 62.1-mile, 60-station system originally scheduled to begin operation in December of 1976. Thus, this analysis compares forecast capital spending through December, 1976 to actual outlays through December, 1984 (after making appropriate adjustments to reflect the varying purchasing power of different years' outlays). And as Table 1-1 indicates, ridership and operating expenses projected for the Washington Metrorail system during 1977 are compared to their actual values during a 12-month period ending June 30, 1986 (the Washington Metropolitan Area Transit Authority's fiscal year 1986).[9]

Table 1-1 also reports that each of the other projects studied reached its planned scope at a date much closer to that originally anticipated (no doubt partly because of their considerably smaller scale compared to those in Washington and Atlanta). However, the table also indicates that a few of these projects have been completed so recently that the time span between the start of service and collection of actual data is shorter than the interval between their projected completion dates and the years to which forecast data apply.

For example, forecasts of ridership and operating statistics prepared for Portland's Banfield light rail line applied to the year 1990, by which time the

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8 *This difficulty arises primarily because the actual pace of construction on each system lagged considerably behind that originally planned, but also partly because each was still under construction at the time of this study.*

9 *Similarly, the 26.8-mile, 26-station section (including Phases A, B1, B2, C1N, and C1S) of Atlanta's heavy rail system that was in operation from August 1986 through June 1987 compares closely to the 27.2-mile segment of the Metropolitan Atlanta Rapid Transit Authority (MARTA) rail system (Phases 3 through 8 of the original phasing plan) originally projected to be completed during mid-1977 and to operate until early 1978, when Phase 9 was expected to be completed. Although some complicated adjustments to the construction cost and ridership forecasts prepared for the 1978 version of the system are required, this study compares the resulting forecasts to their actual values as reported by MARTA for its fiscal year 1987, a 12-month period ending June 30, 1987 and thus coinciding almost exactly with the period during which 26.8 miles of the system were in operation. Assessing the accuracy of forecasts prepared for the 7.6-mile Section A of Baltimore's Phase I rail project, which operated from November 1983 until Section B of the project opened in July 1987, is somewhat simpler, because separate forecasts for Section A were prepared as part of the planning process that led to the design and selection of the Phase I project.*

line was anticipated to be in its fifth year of full-scale operation. Yet because operation of the complete line did not begin until September 1986, the most recent actual data that are available apply to a period beginning only about two years after its completion. This problem is even more acute for the recently completed light rail projects in Buffalo and Sacramento, for which forecast data apply to the years 1995 and 2000, while actual data apply to their operators' fiscal years ending during 1989, as Table 1-1 reports.

The resulting "newness" of these projects may cause their operating costs to be lower than their expected longer-term levels, either because their originally planned service levels have not yet been attained, or because some important components of these systems are presently in low-maintenance phases of their lifetimes.[10] At the same time, however, ridership has probably not reached the equilibrium levels that ultimately will be associated with demographic conditions and transit service levels anticipated during the forecast year. Thus, particular caution is required in comparing forecast and actual ridership and operating expenses for rail projects in Buffalo, Portland, and Sacramento, where actual data apply to a considerably "newer" system than do forecast values.

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[10] In some cases, major system components such as vehicles are either under warranty, or are actually being maintained by manufacturer personnel assigned temporarily to the operating agency. In either case, some maintenance expenses may not appear on the records of the operating authority, so that published operating expenses will appear artificially low in relation to their longer-term level.

2. RIDERSHIP FORECASTS

2.1 MEASURES OF RIDERSHIP

This study compares forecast and actual values of three measures of each newly-constructed rail line or systems' effect on transit ridership. Each measure conveys important but different information about the transportation and related benefits stemming from the substantial investment in new rail transit capacity represented by each of the ten projects studied. The three measures used are:

(1) Average weekday passengers carried by the rail transit line or system. This measure, which corresponds to the number of daily passenger trips that use the rail line for part or all of their distance, is the most widely-cited indicator of the anticipated and actual use of a new transit facility. It reflects the intensity with which an investment in expanded transit capacity or performance is actually utilized by travelers. By itself, however, it does not convey a complete picture of the effects of the investment, because it does not measure the proportion of these trips that would not have been made without the transit investment, or that would have been made using other transit modes or routes.

(2) Total ridership by all transit modes, measured either for the corridor served by a rail project or for the entire urban area (depending both on data availability and on whether the project encompasses more than a single line). This study measures total transit ridership by the number of average weekday door-to-door passenger trips that utilize transit for some part of their distance.[1] This measure provides a summary indicator of how closely the actual performance of an urban area's transit system -- including one or more new rail lines -- compares to that originally anticipated during the planning process that led to the selection of a rail project.

(3) The <u>change</u> in total transit ridership accompanying introduction of a new transit facility. This measure removes any effect on total ridership of

[1] *These are often referred to as "linked trips," and were often formerly referred to as "revenue passenger trips." A single such trip may thus utilize more than one transit vehicle, and thus entail multiple boardings or "unlinked" transit trips.*

former transit users simply changing modes or routes after the introduction of rail service.[2] Thus, it excludes trips formerly made by bus transit which are diverted to a new rail line for all or part of their distance as rail assumes the line-haul function within the corridor and bus service is relegated to a primarily "feeder" role. This measure thereby indicates the number of new transit riders accompanying an investment in new rail transit service, which is the single best index of the magnitude of transportation benefits that can be attributed directly to such an investment.

2.2 COMPARING FORECAST AND ACTUAL RIDERSHIP

Using these three ridership measures, comparisons can be made between forecast ridership and its actual level following each project's completion (after allowing a "breaking-in" period for transit operations and ridership to reach an equilibrium). This study also attempts to determine to what extent differences between forecast and actual rail patronage are attributable to errors in projecting future values of variables that serve as inputs to the models used to forecast ridership.

2.2.1 Rail Passengers

Table 2-1 reports the forecast and actual numbers of passengers carried by each new rail facility on a typical weekday.[3] As it indicates, only for Washington, D.C.'s extensive Metro system has actual ridership reached as much as half of its originally forecast level. There, the number of passengers it carried during 1986 was 28% below that forecast to use a similar system expected to operate during 1977. Elsewhere, comparisons between forecast

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[2] *Benefits may accrue to many but not all of these riders (e.g., reduced travel times, increased passenger comfort), but many of these benefits are very difficult to measure, and they generally are not advanced during project planning and development as primary motivations for the project.*

[3] *The only forecast of ridership on Atlanta's heavy rail system that was reported in its original planning documents applied to the year 1995, by which time the complete 53.2-mile system serving four counties was expected to have been in operation for nearly 15 years. This forecast was for 472,860 rail transit trips on an average weekday, a level more than two and one-half times the actual rail ridership figure for 1987 reported in Table 2-1. (This forecast is derived from those for total transit ridership on an average weekday and the fraction of those trips projected to use the planned rail system, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, p. 150). As discussed subsequently, however, Table 2-1 also reports that total Atlanta-area transit ridership during 1987 -- including trips made by both bus and rail -- actually exceeded that forecast to use a system serving two of these four counties during 1978, which included a planned rail component very similar to that in operation during 1987.*

Table 2-1.
FORECAST AND ACTUAL RIDERSHIP
FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in this Table Apply[1]										
Forecast data	1977	1978	1980	1985	1995	1985	1990	2000	1985	1985
Actual Data	1986	1987	1987	1988	1989	1989	1989	1989	1988	1988
Weekday Rail Passengers (thousands)										
Forecast	569.6	NF	103.0	239.9	92.0	90.5[2]	42.5	50.0	41.0	67.7
Actual	411.6	184.5	42.6	35.4	29.2	30.6[2]	19.7	14.4	10.8	11.3
% difference	-28%	--	-59%	-85%	-68%	-66%	-54%	-71%	-74%	-83%
Weekday Systemwide Transit Trips After Completion of Rail Project[3] (thousands)										
Forecast	796.8	228.4	NF	650.9	184.0	93.7	264.0	112.0	--	--
Actual	697.7	247.0	302.5	169.7	93.2	45.9	126.9	43.3	--	--
% difference	-12%	8%	--	-74%	-49%	-51%	-52%	-61%		
Weekday Systemwide Ridership Impact of Rail Service[3] (thousands)										
Forecast	NF	99.1	NF	262.9	81.0	NF	51.3	13.0	--	--
Actual	281.3	36.9	37.3	-25.8	-0.4	6.3	11.5	-4.2	--	--
% difference	--	-63%	--	--	--	--	-78%	--		

1 *Most "actual" data apply to transit operators' fiscal years ending during the calendar year indicated.*

2 *Forecast ridership for Pittsburgh apply to "Stage I" light rail line only; actual ridership figure applies to combined total for "Stage I" and "Stage II" lines.*

3 *Measured by "linked transit trips" or "originating passengers;" each corresponds to door-to-door trips. Pittsburgh data apply to South Hills corridor only.*

NF indicates that no published forecast of a data item was obtainable.

and actual rail ridership are considerably less favorable. In Baltimore and Portland, the actual number of passengers carried by new rail lines is respectively 59% and 54% below that originally forecast, while actual ridership on Miami's Metrorail and downtown "Metromover" projects, Pittsburgh's reconstructed light rail line, and Detroit's downtown people mover ranges from 66% to 85% below its forecast level. Finally, the light rail lines in Buffalo and Sacramento each presently carry 68% and 71% fewer passengers than the numbers forecast ultimately to use them, although in both cases the forecast horizon remains a number of years in the future.[4,5]

Ridership on Washington's rail system may compare relatively favorably to its forecast level partly because of the delay in constructing it, during which the metropolitan area experienced considerable employment growth. (As Table 1-1 showed, there was an eight year delay between the projected and actual dates at which Washington's rail system reached the scale studied in this report.) Employment in Washington, D.C.'s downtown area was forecast to reach 343,000 by 1975, two years before the area's rail system was sched-

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4 *Because the year to which the original ridership forecast (published in 1981) for Sacramento's light rail line applies (the year 2000) remains so far in the future, it is difficult to evaluate the line's performance on the basis of how actual ridership compares to this forecast figure. However, a forecast of 28,000 average weekday rail passengers during the year 1985, which was then expected to be the first full year of operations for the completed line, was subsequently prepared by consultants to the local agency responsible for planning the project and issued in 1983. At that time, UMTA advocated using a forecast of 20,500 average weekday rail riders, which was described by local Sacramento-area planners as "...surely representing the minimum the Sacramento region can expect from the LRT system." (see Urban Mass Transportation Administration and Sacramento Transit Development Agency, Sacramento Light Rail Transit Project: Final Environmental Impact Statement, August 1983, p. 2-32). The actual weekday ridership figure of 14,400 during the Sacramento Regional Transit District's Fiscal year 1989 (shown in Table 2-1), the second full year of actual operations for the completed line, remains 48% below the 1985 forecast supported by local planners, and 30% below that advocated by UMTA.*

5 *The actual rail ridership figures reported in Table 2-1 for light rail lines in Buffalo, Portland, and Sacramento each include substantial numbers of passengers who travel within free or reduced-fare zones in the downtown areas they serve. In Buffalo, for example, a 1987 survey of rail riders indicated that more than 20% traveled within the downtown free-fare zone, while during the Niagara Frontier Transportation Authority's (NFTA) Fiscal year 1989, fare-free riders within downtown plus those transferring to the light rail line from buses (who also board free) together represented nearly half of the line's total ridership (calculated from NFTA, "Summary of 1987 Rail Rider Survey," July 1987, p. 7, and information supplied by NFTA Service Planning Department, August 18, 1989). It is not clear whether the effect of free or reduced fares on the number of such trips was incorporated in the forecasts of ridership prepared for these three light rail lines. If it was not, then the comparisons of their forecast and actual ridership reported in Table 2-1 overstate the closeness of these projects' anticipated and actual performance in attracting ridership in the corridors they serve.*

uled to reach a scope similar to that analyzed in this study.[6] But by 1985, when the system actually reached this scope, downtown employment had reached 426,000, or nearly 20% above the level that a rail system of this extent was expected to serve.[7] Because downtown employment is probably the single most important demographic factor influencing ridership on the area's radially-oriented rapid transit system, actual 1986 rail system ridership reported in Table 2-1 compares more favorably with its forecast 1977 level than it would with a forecast of ridership based on actual employment in downtown Washington during 1986.[8]

2.2.2 Total Transit Ridership

Table 2-1 also reports the forecast and actual levels of total weekday ridership by all transit modes in the urban areas served by each of the eight heavy and light rail transit projects studied.[9] Total transit ridership is

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[6] *Forecast for "Sector 0," reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968, February 1969, p. 3. As defined in this study, Sector 0 is the area of downtown Washington bounded on the north by S Street, NW; on the east by Florida Avenue, NW-NE, and 4th Street, NE-SE; on the south by North Carolina Avenue, I-95, and Railroad Bridge; and on the west by the Potomac River, Rock Creek, P Street, and Florida Avenue, NW.* *See p. 3, footnote 1.*

[7] *The 426,000 estimate of "Sector 0" employment during 1985 was provided by the Metropolitan Washington Council of Governments. Since employment in downtown Washington was growing rapidly during this period, the 1986 figure no doubt exceeded the 426,000 level. This definition of Sector 0 to which this estimate refers differs slightly from that for which the 1975 employment forecast was previously reported, in that it is bounded on the north by U Street rather than S Street. Thus, it represents a slight overestimate of employment in the area of downtown for which the 1975 forecast was reported. The rate of growth in downtown employment implicit in the 1975 forecast would have brought it to a level of approximately 361,000 by 1977, the year when Washington was expected to be served by a 62-mile rail system. The 1985 figure of 426,000, which represented the approximate level of downtown employment slightly before the area's rail system actually reached this extent, was thus 18% above the implied 1977 forecast level.*

[8] *No such forecast is available, however, because the area's rail system was projected to be considerably more extensive than the version studied here by the time downtown employment was expected to reach the 426,000 level.*

[9] *Because ridership on the two DPM systems is so localized within their respective downtown service areas, it is difficult to measure their actual contributions to total transit ridership in Miami and Detroit. Furthermore, it is difficult to infer forecasts of total areawide transit ridership with these systems in operation from the available planning documents. Thus Table 2-1 does not attempt to compare forecast and actual areawide transit ridership with these systems in place, or to estimate the changes in ridership accompanying their construction. However, it does appear that the forecasts of both rail boardings and total transit ridership prepared for the Miami heavy rail system assumed that a downtown distributor line at least as extensive as the*

measured by the number of door-to-door trips that utilize one or more transit modes for part of their total distance, a definition that corresponds to the concept of "linked passenger trips" in common use among transit operators and analysts.[10]

As Table 2-1 indicates, actual total transit ridership in six of the seven urban areas or corridors for which this comparison can be made is below its forecast level.[11] The prominent exception is Atlanta, where the number of average weekday transit trips during 1987 -- when 26.8 miles of its rail line were in operation -- was 8% above that forecast for 1978, when the system was expected to reach approximately this scope. In Washington, DC, actual transit ridership in 1986 -- with 60.5 miles of its planned rail system in place -- was within 12% of that forecast for a similar system originally anticipated to operate during 1977. In both of these cases, however, the closeness of this comparison may result partly from the influence on transit ridership of growth in downtown employment and service area population that occurred between the time each city's rail system was projected to become this extensive, and the date when this actually occurred.

In contrast, Table 2-1 reports that in Miami, total transit ridership during 1988 -- with both the Metrorail and downtown Metromover projects in operation -- was 74% below its originally forecast level. In Pittsburgh's South Hills corridor, the actual level of ridership during 1989 (the second full year of complete operation of the reconstructed line) was 51% below that forecast for 1985, originally expected to be the second year of light rail operations in the corridor. Actual 1989 transit ridership is also approximately half of that forecast to occur in Buffalo and Portland, and 61% below its

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current "Metromover" would be built as part of the overall project. In addition, the Detroit DPM system was apparently anticipated to be part of a much more extensive transit network serving downtown Detroit than actually operates today, including more extensive bus service, a light rail transit line, and commuter rail service from some suburban areas.

10 *Because each door-to-door trip may entail two or more separate boardings of transit vehicles to complete, ridership measures based on vehicle boardings, such as "unlinked passenger trips," are not meaningful measures of the ridership experienced by an entire transit system, particularly one that includes multiple rail lines or bus and rail service operating in an interconnected network.*

11 *Because of the complexity and geographic scope of Pittsburgh's transit system, the "systemwide" data reported for Pittsburgh in Table 2-1 as well as in subsequent tables include only the South Hills travel corridor, in which the reconstructed light rail line operates together with streetcar and bus service (including both local bus routes and bus lines utilizing the corridor's South Busway facility). Although the rail projects in Baltimore, Buffalo, and Portland also serve only a single corridor, each is a considerably more important component of its urban area's overall transit system, and its contribution to corridor ridership was originally expected to be an important influence on systemwide transit use. In any case, comparable forecast and actual data were not obtainable for the individual corridors served by each of these lines, so that systemwide comparisons must be relied upon to assess their effects on ridership.*

originally anticipated levels in Sacramento, although the year to which ridership forecasts applied has not yet been reached in any of these three cities, as the table indicates.

Table 2-1 shows that for each of the six urban areas where this comparison can be made, actual total transit ridership compares more favorably to its forecast value than does actual ridership on the rail facility itself. This probably occurs largely because there is some level of bus transit usage that is not affected significantly by the rail project, with the result that changes in total ridership are less volatile and easier to forecast than changes in ridership due only to introduction of the new rail service. This result also suggests that current utilization of bus transit services operating in these six urban areas may be closer to the originally anticipated levels than is actual utilization of most of these new rail facilities.

2.2.3 Changes in Transit Ridership

Finally, Table 2-1 compares forecast and actual changes in total transit ridership accompanying each rail project. Although this measure provides the most reliable index of transportation and related benefits stemming from the improvement in transit service as new rail facilities are introduced, a new facility's forecast and actual effects on total transit ridership are both difficult to isolate. The forecast impact of each rail project on total transit ridership reported in Table 2-1 is measured by the difference between forecast transit ridership with the rail project in service, and that with an all-bus transit improvement alternative that was rejected in favor of the rail project.[12]

Since the present level of transit ridership without the rail facility cannot be measured, however, it is impossible to develop a precisely comparable "with versus without" measure of the actual impact of each rail project on system-wide transit ridership. Instead, Table 2-1 measures the actual impacts of recent rail investments on transit ridership by the change in total transit ridership in each urban area from its level immediately prior to the start of rail service.[13] Thus, for example, the actual impact of the

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[12] *Wherever possible, the bus alternative against which the impact of the rail project on transit ridership was measured was chosen to be a high-performance bus transit alternative incorporating some capital investment and extensive use of "Transportation System Management" (TSM) techniques designed to improve transit performance. Because forecast ridership on such an alternative is typically higher than that forecast for the conventional bus or "do-nothing" alternative, this choice has the effect of minimizing the forecast contribution to total transit ridership of the rail alternative that was chosen.*

[13] *Using actual pre-rail transit ridership as the baseline for these calculations tends to overstate the actual contributions of rail projects to increased transit ridership in cities experiencing growth (such as Washington, Atlanta, and Sacramento), and to understate their contributions where population and downtown employment are declining (as, for example, in*

first 26.8-mile segment of Atlanta's rail transit system on area-wide transit ridership is measured by the difference between actual total ridership during 1987 (249,300, as reported in Table 2-1), and total Atlanta-area transit ridership during 1979, the last full year of all-bus service.[14]

As Table 2-1 shows, the 1978 forecast of 228,400 daily Atlanta-area transit trips during 1978, when a 27-mile rail system was expected to operate, represented 99,100 more riders than were projected to ride the area's transit system during that year if no rail system were constructed. While actual transit ridership during 1987 -- when the area's rail system reached roughly this extent -- totaled 247,000 daily trips, this figure represented an increase of only 36,900 riders from the number carried by the area's bus system during 1979. The actual contribution to total transit ridership made by Atlanta's first 27 miles of its planned rail transit system was thus 63% below its anticipated impact on total ridership, as Table 2-1 indicates.

The table also indicates that very substantial growth in areawide transit ridership accompanied construction of the first sixty miles of Washington, D.C.'s Metrorail system, although no forecast of its ridership impact is available for comparison. While much smaller than that experienced in Washington, the actual change in transit ridership accompanying construction of the first section of Baltimore's heavy rail line approached that experienced in Atlanta, reaching 37,300 daily trips (approximately 14% of the area's pre-rail total ridership level). Increases in total transit ridership have also accompanied the introduction of light rail transit in Portland and Pittsburgh (where light rail replaced existing streetcar service), although in the former case the increase has fallen considerably short of that originally anticipated.

In contrast, Table 2-1 shows that although increases in region-wide transit ridership were also forecast to result from investments in rail transit lines serving Miami, Buffalo, and Sacramento, ridership actually declined rather than increased over the period spanning the introduction of rail transit

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Buffalo and Detroit). As with its previously discussed effects on rail patronage, this arises because any effect on systemwide transit ridership of demographic changes that occurred between the year each project was scheduled to reach its forecast configuration and the year when it actually did, is implicitly included in the ridership figure for the latter year. Thus, it is also counted as part of the actual change in ridership accompanying construction of the rail system when that change is estimated by the difference between "pre-rail" and "post-rail" ridership levels, as it is in Table 2-1. As a result, the change in ridership attributable to the presence of the rail project is over- or under-stated by this measure, depending on whether demographic growth or decline occurred during the interval between its scheduled and actual completion.

[14] *Service on the Atlanta rail system began on June 30, 1979, according to the chronology reported in Metropolitan Atlanta Rapid Transit Authority (MARTA), Division of Service Planning and Scheduling, "Key Dates," July 1988, p. 1. Because this date was the last day of the Authority's Fiscal Year 1979, that year was chosen as the last full year of bus-only operations. (MARTA data reported in this document indicate that Fiscal Year 1979 rail system ridership totaled 19,000 passengers, all of whom presumably rode the system on its initial day of service.)*

service, although the decline in Buffalo was very slight.[15] While the year to which forecasts applied remains many years away in both Buffalo and Sacramento, the current trend in transit ridership in these two cities makes it appear unlikely that these forecast values will ultimately be reached. In two of these three cities (Miami and Sacramento), the decision to invest in rail transit was made during a period of growing transit use, yet the subsequent introduction of rail service occurred in a period of declining ridership -- a trend that rail service has been unable by itself to reverse.[16] In Buffalo, however, the substantial increase in ridership anticipated to result from the

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[15] *Certainly a variety of factors other than the introduction of rail service influences these comparisons, most notably demographic developments that affect the market for transit service. Nevertheless, the actual or even potential impact of such trends on future transit ridership appears rarely to be considered realistically when investments in high-capacity transit facilities are being considered. As an illustration, local planners in Portland selected a light rail alternative in preference to an exclusive busway alternative with slightly higher forecast ridership, partly because the rail line's unused capacity would allow it to accommodate growth in ridership that might occur for unforseen reasons. See Banfield Transitway Project: Draft Environmental Impact Statement, Volume 1, February 1978, Table 9, p. 159, and Banfield Transitway Project: Final Environmental Impact Statement, p. 2-54. However, no similar discussion of the risk that ridership might be lower than that forecast, or of the implications of such a risk for the choice among transit alternatives, is reported in any of the planning documents prepared for this project.*

[16] *In Buffalo, the number of transit trips carried by Niagara Frontier Transportation Authority (NFTA) buses during 1984 (the last full year before limited rail service began), declined about 5% from the level reported nearly a decade earlier, when planning for the area's light rail transit system was underway. The 1984 ridership figure of 27.48 million trips was estimated from total passenger boardings reported in National Urban Mass Transportation Statistics: Section 15 Annual Report, 1985, Table 3.16, p. 3-28, together with an estimate of the fraction of those boardings that represented transfers during 1984, supplied by NFTA personnel. The earlier figure of 28.91 million transit trips during 1975 is reported in American Public Transit Association, Transit Operating Report, 1976, p. D-131. Interestingly, a reference to historically declining transit ridership in the Buffalo metropolitan area is included in the Draft Environmental Impact Statement prepared for the area's light rail line (see p. 3-2), yet each rail project analyzed--including the selected "Minimum Light Rail Rapid Transit" project -- was forecast to reverse this trend, in most cases producing more than a doubling of ridership by 1995 (see Table 3-3, p. 3-20; Table 3-6, p. 3-29; and Table 3-7, p. 3-31).*

In contrast, total transit boardings reported by Miami's Metro Dade County Transit Authority rose from 61.4 to 76.1 million between 1975 and 1981, or by almost 24%, although they declined 16% (to 64.1 million) over the next two years. (See American Public Transit Association, Transit Operating Report, 1976, p. D-109, and National Urban Mass Transportation Statistics: Section 15 Annual Report, 1981, Table 2.17.2, p. 2-186, and 1983, Table 3.16, p. 3-278.) In Sacramento, the number of transit trips carried on a typical weekday grew from 51,200 to 65,500 (or 28%) between 1979 and 1981, but declined over the next two years to a level (50,000 per average weekday) slightly below their 1979 total. (See U.S. Urban Mass Transportation Administration and Sacramento Transit Development Agency, Sacramento Light Rail Transit Project: Final Environmental Impact Statement, August 1983, Exhibit 2-20, following p. 2-29.)

investment in rail transit approved by local decision-makers would have represented a reversal of the urban area's historical decline in transit use.[17]

2.3 CAUSES OF FORECASTING ERRORS

Although urban travel demand forecasting -- and particularly transit patronage estimation -- is not an exact science, procedures had become quite sophisticated even by the time ridership forecasts were produced for the earliest rail projects encompassed by this study.[18] In the usual version of this process, transit patronage forecasts are the product of a sequence of models used to analyze and predict aggregate travel volume in an urban area, the geographic distribution of trip-making, the levels of transit travel in specific corridors, and ultimately, patronage on individual routes or services. Errors in forecasting the outputs of this process, such as those documented in Table 2-1, thus can arise either because exogenous inputs (such as demographic variables or transit service levels) are incorrectly forecast, or because the structure of the models themselves or their application in the forecasting process introduces errors.

The critical inputs into the process of forecasting ridership on a proposed new rail line or system can be divided into three categories:

(1) Demographic factors, such as downtown employment and population in the corridors where transit lines are to be located. Because these variables influence the size of the total market for transportation services, they exercise a critical influences on the total corridor travel volumes from which a new transit service draws ridership.

(2) Transit service and fares. The share of travel attracted to a new transit service will depend primarily on how transit performance and fares compare to the convenience and cost of automobile travel, against which transit must compete to attract riders. Rail transit performance is defined not only by the frequency and speed of the rail service, but also by the cost and convenience of potential riders' access to the rail system. This in turn depends on the coverage and frequency of feeder bus routes providing access to and from rail transit stations (as well as the fares charged for its use), the availability and price of parking for "park-and-ride" rail patrons, and the convenience of access offered at

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[17] *See Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor -- Technical Report, June 1976, Figure II-3, p. 29.*

[18] *The earliest patronage forecasts prepared for a system closely resembling one of those reviewed in this study were prepared using methods strikingly similar to those in widespread use today. See Washington, D.C. 1980 Rail Rapid Transit Patronage Forecast, prepared for the National Capital Transportation Agency by Alan M. Voorhees Associates, July 1967.*

rail stations for "drop-off" automobile passengers and those transferring from feeder buses.

(3) Automobile costs and travel speeds. The third important category of inputs to the transit ridership forecasting process is the speed, cost, and convenience of operating and parking an automobile, the primary mode competing with transit for patronage.

Subsequent sections document the errors in projecting the future values of each of these inputs into the ridership forecasting process, and explore the possible contributions of these errors to the divergence between forecast and actual rail transit ridership previously reported in Table 2-1.

2.3.1 Demographic Factors

Table 2-2 compares the forecast values of demographic factors, transit service levels and fares, and automobile costs that were used in preparing patronage forecasts for each of the ten rail projects included in this study to their subsequent actual values. As with the comparisons of forecast and actual rail boardings discussed earlier, the forecast data it presents apply to a year somewhat after each project was expected to reach full operation, while most actual data apply to a year following its actual opening by a roughly equal time interval.

The table indicates that forecasts of the two basic demographic variables influencing travel volumes in the areas served by new rail projects -- population and downtown employment -- compare very favorably to their actual values.[19] Only in a few instances do errors in demographic projections appear sufficiently large to contribute significantly to over-estimation of future ridership. In Buffalo, for example, future downtown employment and population in the corridor were over-estimated by 39% and 20%, while in Detroit, downtown and employment was over-estimated by 16%. Yet no other demographic variable was over-estimated by more than 10%, and Table 2-2 shows that in some urban areas the future value of population or employment was under-estimated, errors that by themselves would have caused actual ridership on their rail lines to exceed forecast values.

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[19] *The service area for single-line rail projects was defined as the corridor in which the line operates, while for multiple-line projects the service area was assumed to be the entire urban area. For the two downtown "people-mover" systems, the service area was assumed to be approximately the area enclosed by the loop each makes. Because resident population in these primarily commercial areas is small, and because visitors comprise a substantial proportion of the ridership on both DPM systems studied, the number of hotel rooms in the service area is reported by Table 2-2 in place of the area's resident population.*

Table 2-2.
FORECAST AND ACTUAL VALUES OF FACTORS INFLUENCING RAIL TRANSIT RIDERSHIP

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in this Table Apply										
Forecast data	1977	1978	1980	1985	1995	1985	1990	2000	1985	1985
Actual data	1986	1987	1987	1988	1989	1989	1989	1988	1988	1988
Demographic Factors										
Service area population[1] (thousands)										
Forecast	3,230	1,257	NF	1,736	645	163	149	573	2.1	9.7
Actual	2,928	1,181	347	1,791	536	181	126	520	2.8	10.8
Downtown employment[2] (thousands)										
Forecast	360.8	184.4	NF	74.1	71.0	145.3	83.4	115.9	55.8	126.3
Actual	426.2	170.2	NA	82.0	50.9	147.4	84.4	126.9	50.2	108.9
Rail Service and Fares										
Peak rail headways (minutes)										
Forecast	2-4	1.5	4.0	6.0	2.8	1.0-1.7	5-10	7.5	NF	1.2
Actual	3-6	6.0	6.0	6.0	6.0	3.0	7-15	15.0	3.0	3.0
Speed in passenger service (mph)										
Forecast	33.9	35.0	NF	30.8	22.5	15.8	25.4	24.0	12.7	12.6
Actual	29.3	32.8	30.4	33.2	17.5	16.2	19.6	20.5	9.9	12.4
Average fare[3]										
Forecast	$1.22	$0.26	$1.21	$1.03	$0.86	$0.89	$0.52	$0.58	$0.22	$0.30
Actual	$1.05	$0.56	$0.93	$0.82	$0.69	$1.00	$0.66	$0.60	$0.15	$0.50

1 *Service area for single-line systems is defined as the corridor in which the line operates; service area for multiple-line systems is defined as the entire urban area. For DPM systems, the service area is defined as the immediate downtown area served by each system.*

2 *The definitions of the downtown area used in planning Miami's heavy rail and people-mover projects differ slightly, thus accounting for differences in their forecasts of downtown employment during 1985.*

3 *In most cases, forecast and actual values represent the average fare actually paid by rail riders; reflects any fare surcharges paid by rail riders who use feeder bus service, as well as fare reductions due to use of multi-ride passes, fare discounts for specific rider groups, etc.*

NF indicates no forecast of a data item was obtainable from published sources.

Table 2-2. (Continued)

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
Feeder Bus Service and Use								
Number of suburban rail stations served								
Forecast	41	27	NF	NF	13	6	12	20
Actual	56	27	9	18	12	6	11	15
Total number of feeder routes								
Forecast	166	103	NF	NF	40	26	49	NF
Actual	323	127	58	40	36	15	33	57
Peak bus headways at rail stations (minutes)								
Forecast	2-40	10	NF	1,042[4]	11.5	86[5]	588[5]	399[5]
Actual	5-15	8-36	468[5]	401[4]	15.0	57[5]	280[5]	91[5]
% of rail riders using feeder buses								
Forecast	57%	54%	55%	36%	32%	37%	40%	37%
Actual	31%	65%	49%	18%	33-41%[6]	6%	21%	20-57%[6]
Auto Cost Assumptions (1988 dollars)								
Operating cost per mile								
Forecast	$0.07[7]	$0.26	NF	$0.14	$0.34	NF	$0.13	$0.24
Actual	$0.08[7]	$0.15	$0.15	$0.16	$0.16	$0.16	$0.16	$0.16
Downtown parking cost (all day)								
Forecast	$2.40	$2.60	NF	$2.50	$3.35	NF	$2.90	$4.25
Actual	$5.50	$2.25	$3.50	$2.25	$3.00	$3.10	$4.00	$5.00

4 *Total number of buses in peak service. Difference between forecast and actual peak feeder bus headways is assumed to be proportional to difference between forecast and actual buses in peak service.*

5 *Number of peak-hour bus arrivals at suburban stations. Difference between forecast and actual peak feeder bus headways is assumed to be proportional to difference between forecast and actual peak bus arrivals.*

6 *Range for inbound rail passengers boarding at suburban stations.*

7 *Direct operating expenses (gasoline, oil, and tire wear) only.*

NF indicates no forecast of a data item was obtainable from published sources.

2.3.2 Transit Service Levels

With few exceptions, rail service and fare levels were also projected remarkably accurately in planning the ten projects reviewed, as Table 2-2 indicates. Although the actual frequency of rail service during peak travel periods falls well short of that forecast in Atlanta, Buffalo, and Pittsburgh, it remains within the range that passengers apparently regard as representing high-quality service.[20] Only in Portland and Sacramento do the differences between planned and actual service frequencies appear sufficient to make rail service significantly less convenient -- and thus less heavily patronized-- than planners originally anticipated. Yet even in these two cities, the effect of differences between actual and planned service frequencies may be less pronounced than the comparisons in Table 2-2 suggest, because some coordination of schedules between feeder bus routes and rail lines has been achieved in these cities.[21]

Table 2-2 also shows that actual operating speeds compare fairly closely to those originally forecast, and even exceed forecast speeds in some cases. Thus while rail passengers in some cities may experience somewhat longer waiting times than were originally anticipated, their travel times aboard rail vehicles appear to correspond closely to those projected when planning for rail service. Finally, only the actual fares paid by rail passengers in Atlanta, Portland, and Detroit appear to exceed significantly their forecast levels, while in Washington, Baltimore, Miami, and Buffalo, actual fares are somewhat below those on which rail patronage estimates were based.

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[20] *Most research has found that passengers are willing to arrive randomly at transit stops when vehicles are scheduled to arrive approximately every ten minutes or more frequently, because even the maximum possible waiting time is tolerably short. When service is less frequent, travelers are usually found to attempt to schedule their arrivals at transit stops to result in shorter waiting times than would result from arriving randomly. For an extended discussion of such behavior, see J.K. Jolliffe and T.P. Hutchinson, "A Behavioral Explanation of the Association Between Bus and Passenger Arrivals at a Bus Stop," Transportation Science, 9:4 (1975), pp.248-282. The influence of passengers' arrival strategies on the waiting times they actually experience is explored in Mark A. Turnquist, "A Model for Investigating the Effects of Service Frequency and Reliability on Bus Passenger Waiting Times," Transportation Research Record, Number 663 (1978), pp. 70-73.*

[21] *Planners who participated in ridership forecasting for Portland's light rail line have indicated that the coordination of bus and rail schedules was assumed to result in a maximum waiting time of two minutes for bus-to-rail transfers. Although such "timed transfers" have apparently only been fully implemented at two of the line's five major bus transfer stations, examination of current schedules for Portland bus and light rail service indicates that scheduled bus-rail transfer times during peak periods rarely exceed ten minutes. While rail service in Sacramento was originally planned to employ such "timed transfers" between bus feeder routes and their rail lines, resulting in shorter bus-rail transfer times than those implied by planned rail and feeder bus frequencies, it is not clear how extensively this practice has actually been implemented.*

In contrast to the accuracy with which demographic factors and rail service levels have been anticipated, Table 2-2 shows that actual feeder bus service to suburban stations on the eight radially-oriented rail projects studied has more often fallen short of its forecast levels.[22] This difference seems likely to contribute most to explaining the gap between forecast and actual rail ridership in Miami and Sacramento, where the numbers of buses operating in feeder service during peak periods appear to be much smaller than was originally anticipated. Current feeder bus coverage also appears to be somewhat less extensive and frequent than originally planned in Buffalo and Portland, as Table 2-2 shows.[23]

2.3.3 Automobile Costs

Table 2-2 also shows that assumptions regarding the cost of operating and parking automobiles -- two major determinants of the demand for transit travel -- probably did not contribute significantly to the large errors in forecasting rail ridership. Projections of dramatically higher future energy prices, which were commonly advanced during the two oil price shocks of the 1970s, no doubt influenced the substantial over-estimation of future auto operating costs by planners in Atlanta, Buffalo, and (to a lesser extent) Sacramento. However, these predictions of rapidly escalating oil prices were by no means universally accepted, since Table 2-2 shows that future automobile operating costs were anticipated fairly accurately in most other cities where planning for major new rail transit projects occurred at the same time.

The table also shows that future parking costs for downtown commuters were over-estimated in Atlanta, Miami, and Buffalo, but only by $0.25-0.35 per day, or about 10% in each case. In the other three cases for which data enable this comparison, future parking prices were under-estimated; particularly large under-estimates were made by planners in Washington and Portland. Thus if parking costs had been predicted more accurately, transit ridership forecasts would have been even higher than those that influenced planners in some of these cities to recommend major investments in rail transit facilities.

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22 *Since the two "people-movers" function primarily as distributor and circulator systems within the downtown areas they serve, the levels of feeder bus service and automobile costs (except perhaps downtown parking costs) are probably not important influences on their ridership.*

23 *Interestingly, in Miami, Buffalo, and Sacramento, the numbers of rail riders who arrive at stations by feeder bus are lower than those planned only in approximate proportion to these cities' substantial differences between projected and actual rail patronage, while the lower level of feeder bus service in Portland appears to have reduced both rail ridership and the fraction of rail passengers who use feeder bus service. That fraction is also considerably below its forecast value in Washington and Pittsburgh, although apparently for reasons other than less extensive feeder route coverage and lower service frequency than were forecast, since these match closely their planned levels.*

2.3.4 Overall Assessment of Input Errors

In order to develop a rough estimate of the contribution of errors in projecting these input variables to errors in ridership forecasts, the percent error in forecasting each variable in Table 2-2 was multiplied by the estimated elasticity of demand for rail transit travel with respect to that variable.[24] The resulting figure provides an estimate of the percentage error in the forecast of rail ridership contributed by the error in estimating the future value of that variable.[25]

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[24] *The elasticity of demand for transit service is a measure of the sensitivity of ridership to changes in the values of variables thought to influence ridership. Specifically, it measures the percentage change in ridership as a proportion of any stated percentage change in the value of a variable that influences ridership. Thus, for example, if the elasticity of demand for rail transit service with respect to the cost of operating an automobile is +0.1 (the value assumed in this study), a 10% increase in the cost of operating an automobile is thought to result in a 1% (calculated as 0.1 of 10%) increase in transit ridership. Similarly, if the elasticity of demand for rail transit service with respect to its service "headway," or scheduled time interval between trains, is -0.2 (again the value adopted in this study), a 20% increase in rail service headways is assumed to a 4% decline in rail transit ridership.*

[25] *This procedure is adapted from that described in Daniel Brand and Joy L. Benham, "Elasticity-Based Method for Forecasting Travel on Current Urban Transportation Alternatives," Transportation Research Record, Number 895 (1982), pp. 32-37. In performing these calculations, transit ridership was assumed to be directly proportional to both service area population and downtown employment; thus, whatever percentage error was made in forecasting either of these measures was assumed to result in the same percentage error in forecasting ridership. (This amounts to assuming that the elasticity of transit demand with respect to each of these variables is +1.0.) Unfortunately, even where detailed documentation of ridership forecasting models and procedures was available, transit ridership elasticities implied by the models employed were generally not reported explicitly. Thus the procedure used here was forced to rely on published estimates of transit demand elasticities. The specific elasticity values employed in these calculations were:*

Rail Headway	*-0.2*
Rail Operating Speed	*+0.2*
Rail Fare	*-0.3*
Feeder Bus Headway	*-0.4*
Auto Operating Cost	*+0.1*
Parking Cost	*+0.4*

These estimates were derived from a review of literature summarized in: Ecosometrics, Inc., Patronage Impacts of Changes in Transit Fares and Services, September 1980; Y. Chan and F.L. Ou, "A Tabulation of Demand Elasticities for Urban Travel Forecasting," paper presented to the 57th annual meeting of the Transportation Research Board, January 1978; and John Pucher and Jerome Rothenberg, "The Potential of Pricing Solutions to Urban Transportation Problems: An Empirical Survey of Travel Demand Responsiveness to Components of Real Price," paper presented to the 58th annual meeting of the Transportation Research Board, January 1979. While the range of plausible values of each of these parameters has been shown by research summarized in these references to be fairly wide, the specific values employed here were selected to maximize the

The individual contributions of errors in forecasting each variable in Table 2-2 were then summed to determine their cumulative effect on the forecast of rail ridership, which was in turn expressed as a fraction of the gap between the forecast and actual values of average weekday rail passengers (reported previously in Table 2-1). These calculations indicate that the input errors documented in Table 2-2 explain less than half of the observed gap between predicted and actual weekday rail passengers, except in Buffalo (where errors in the input assumptions appear sufficient to account for the entire difference between forecast and actual rail ridership) and Portland.

In the only two other cases (Sacramento and Detroit) where a significant fraction of the difference between forecast and actual rail ridership can be explained by errors in forecasting the ridership models' inputs, these differences are so large that a substantial absolute "ridership gap" still remains unexplained after accounting for these errors. For two of the ten projects studied -- those in Baltimore and Pittsburgh -- the errors in forecasting input variables documented in Table 2-2 appear to account for almost none of the difference between forecast and actual rail ridership. Finally, in the cases of Washington's Metrorail system and Miami's Metrorail and Metromover projects, the effect of errors in forecasting these input variables would have been to cause actual rail ridership to exceed its forecast value.

In short, it appears that only rarely can an important share of the large differences between forecast and actual rail ridership be attributed to errors in projecting variables that served as inputs to the patronage forecasting process. Instead, these errors must have arisen from other less obvious sources, including the structure of the ridership forecasting models themselves, the way in which they were applied, or the misinterpretation of their numerical outputs during the planning process.[26] Whatever its exact sources, the consistent over-estimation of future ridership on recent rail transit projects suggests that the levels of travel and related benefits currently provided by these substantial investments are generally far below those that originally led local planners and political officials to make them.

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estimated contribution of errors in forecasting these variables to the overestimation of ridership. (That is, the largest plausible numerical magnitudes of these elasticities were selected from the ranges of uncertainty indicated by the studies that were reviewed.) This procedure results in an upper bound on the fraction of the difference between forecast and actual ridership that can be explained by errors in forecasting the input variables reported in Table 2-2. Thus, it is particularly surprising that the estimated contribution of errors in forecasting these variables to the overestimation of rail ridership appears to be so small.

[26] *Errors arising from the way in which these models were applied, such as in the design and coding of transit networks, are extremely difficult to detect, yet they may be a major source of the ridership forecasting errors documented in this study.*

3. CAPITAL OUTLAYS FOR RAIL TRANSIT PROJECTS

This chapter compares the forecast and actual values of two measures of capital costs for each of the ten projects that were examined:

(1) The sum of actual or "nominal" dollar outlays for acquiring right-of-way, constructing fixed facilities, and purchasing vehicles.[1] This measure is denominated in dollars of various years spanning each project's construction period.

(2) The constant-dollar or "real" expenditures that are equivalent to these actual outlays. This measure, which expresses the equivalent value of the time stream of actual outlays in the dollars of a single year (in this study, 1988), adjusts expenditures for the effects of inflation.

The definition of capital costs for implementing the rail transit projects reviewed in this study includes outlays for acquiring and improving the right-of-way on which rail lines operate; constructing the guideway, stations, and associated fixed facilities (power distribution and signal systems, vehicle servicing and storage facilities, etc.); and purchasing rail vehicles.[2]

Engineering studies prepared to support capital cost estimation at the comparatively early phase in the planning process from which the forecasts

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1 *In order to reduce potential confusion with the "actual" measures that are compared to forecast values, the term "nominal" dollar outlays (rather than "actual" dollars) is used to refer to this measure. This study avoids using the term "cash flows" because not all of the resources employed to construct transit projects were acquired through cash transactions.*

2 *These costs should also include any new capital outlays for buses and the fixed facilities they utilize that are required to implement the bus feeder service planned to support each rail facility. However, these additional capital costs were typically not forecast in planning the projects reviewed in this study, and were often difficult to identify even where they were included in cost projections. Furthermore, their actual value is difficult to identify once new rail service has been introduced, since most bus routes and facilities are used jointly to provide rail feeder and local passenger service, thereby imposing extreme difficulties in allocating their costs between these two functions. For these reasons, they are excluded from the measures of forecast and actual capital costs examined in this study.*

reviewed here were drawn are necessarily limited in their detail. Thus, it is reasonable to expect some errors (both under- and overestimates) in forecasting project capital costs and the financial flows associated with the planned schedules for their construction. Nevertheless, comparing the forecast and actual values of both real and nominal capital outlays still should provide important information about the performance of planners in forecasting the real economic costs of constructing and equipping rail facilities, as well as in financial planning for the implementation of these projects.

3.1 FORECAST AND ACTUAL CAPITAL OUTLAYS

Table 3-1 reports the forecast and actual values of total capital outlays for each rail transit project included in this study, measured both in nominal dollars and in their 1988 dollar equivalents. In comparing the forecast and actual values of these two measures, it is important to understand how each was calculated. Planning documents obtained for each project reported a constant-dollar forecast of its capital cost, usually denominated in the dollars of a year during which the planning process was underway, as well as (with one exception) a projected construction schedule and rate of inflation over that period.

The constant-dollar forecast of capital outlays reported in these documents was first converted to the 1988-dollar equivalent that appears in Table 3-1, using the change in the economy-wide general price level that occurred between the forecast year and 1988.[3] This same forecast was also converted to the nominal-dollar forecast of project capital outlays reported in the table, by applying the projected rate of inflation in construction costs to each year's outlays anticipated in the proposed construction schedule for the project.

Both of the "actual" outlay figures reported in Table 3-1 were derived from accounting records provided by local agencies responsible for management of the various projects, and by the Urban Mass Transportation Administration's Office of Grants Management. The actual value of nominal-dollar capital outlays appearing in Table 3-1 is simply the sum of each year's recorded capital spending on the project, together with the estimated monetary value of resources employed in implementing the project, but for which no cash payments were made.[4] Finally, the 1988-dollar measure of actual project capital outlays is obtained by first converting each year's recorded outlays to its equivalent in 1988 dollars, using the change in the economy-wide price

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[3] *This change is measured by the percentage increase over this period in the implicit price deflator for the Gross National Product, as reported in U.S. Department of Commerce, Survey of Current Business, various issues.*

[4] *The most common such resources were rights-of-way donated to the project by its owners, and staff assistance in project management provided by local government agencies, including the transit agency that operates the project.*

Table 3-1.
FORECAST AND ACTUAL CAPITAL OUTLAYS FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland[1]	Sacramento	Miami	Detroit
	Period During Which Capital Outlays Were Made									
Forecast	1969-76	72-77	73-78	78-83	78-82	79-83	81-85	82-85	81-83	81-83
Actual	1971-85	75-86	74-83	79-85	79-86	80-87	82-87	83-87	82-86	83-87
	Total Capital Outlays in Nominal Dollars (millions)									
Forecast	1,713	793	405	795	336	NF	188	147	77	109
Actual	4,375	1,838	790	1,042	536	537	240	172	153	197
% Difference	156%	132%	95%	31%	59%	--	28%	17%	99%	80%
	Equivalent Total Capital Outlays in 1988 Dollars (millions)									
Forecast	4,352	1,723	804	1,008	478	699	172	165	84	144
Actual	7,968	2,720	1,289	1,341	722	622	266	188	175	215
% Difference	83%	58%	60%	33%	51%	-11%	55%	13%	106%	50%

[1] Capital cost data for Portland reflect a reallocation of certain elements of a joint highway-transit construction project from its highway to its transit component between the publication of the forecasts reported here and completion of the project. The comparisons reported in this table thus overstate the difference between forecast and actual capital costs for the project's transit component.

NF indicates no forecast of a data item was obtainable from published sources.

level between that year and 1988, and then summing these figures over the project's construction history.

As Table 3-1 indicates, actual capital outlays for the ten rail transit projects reviewed typically were well above those forecast, regardless of whether their nominal or 1988 dollar values are compared. When measured by their 1988 dollar equivalents -- an indicator that isolates planners' accuracy in projecting the economic value of resources used to implement each project -- the table shows that capital outlays for Pittsburgh's light rail line were actually 11% below their forecast value. Yet by this same measure, real cost overruns were experienced in constructing and equipping the nine other rail projects studied. These constant-dollar cost overruns ranged from 13% for Sacramento's recently completed light rail line, to as much as 106% for the downtown Metromover system constructed in Miami.

Table 3-1 also shows that while total nominal-dollar capital outlays for constructing Sacramento's light rail line were within 17% of their forecast level, cost overruns on eight other projects ranged from a low of 28% for Portland's light rail line to as much as 156% for the first 60.5 miles of the Washington, DC rail system.[5,6] These nominal-dollar differences capture the effects not only of errors in estimating the real economic cost of each project's capital facilities, but also of errors in financial planning for its implementation, including activities such as construction scheduling, project management, and forecasting the pace of price inflation over a project's anticipated construction schedule.

3.2 FACTORS CONTRIBUTING TO CAPITAL COST OVERRUNS

The capital cost overruns documented in Table 3-1 are sufficiently large to suggest that most projects must have differed in some important aspects-- such as their physical characteristics or implementation schedules -- from those that were originally envisioned by planners. In order to explore this hypothesis, Table 3-2 compares the planned and actual physical characteristics of each project, as well as important details of their originally anticipated and actual construction schedules.

3.2.1 Changes in Project Scope

Changes in the planned scope of each project such as those documented in the table affect both the real economic cost of the resources entailed in constructing it, as well as the corresponding actual or nominal dollar outlays entailed in purchasing those resources. In contrast, changes to the planned schedule for implementing a project affect only the nominal dollar outlays that result, since these changes do not change the magnitude of the resources committed (or their value in constant dollars) to construct and equip the project. Similarly, unanticipated escalation in construction and equipment prices affects only the cash or nominal dollar outlays entailed in implementing

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5 *No nominal-dollar forecast of capital outlays could be estimated for Pittsburgh's light rail line because its planning documents specified no schedule of construction outlays or anticipated rate of inflation.*

6 *Because actual capital cost data for Portland reflect the reallocation of certain elements of a joint highway-transit construction project from its highway to its transit component, the comparisons reported in Table 3-1 overstate slightly the difference between forecast and actual capital costs for that city's light rail project.*

Table 3-2.
SCOPE CHANGES AND ERRORS IN FINANCIAL PLANNING FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
					Changes in Project Scope					
Total line-miles										
Planned	62.1	27.2	8.5	20.5	6.4	10.5	14.4[1]	18.8[1]	1.9	3.1
Actual	60.5	26.8	7.6	21.0	6.4	10.5	15.1[1]	18.3[1]	2.0	2.9
Number of stations										
Planned	62	27	10	21	14	12	21	28	10	13
Actual	57	26	9	20	14	13	24	28	9	13
Number of vehicles										
Planned	372	209	NF	NF	47	50	30	39	NF	NF
Actual	414	198	72	71	27	55	26	26	11	12
					Start of Construction					
Planned	1969	1972	1973	1978	1978	1979	1981	1982	1981	1981
Actual	1971	1975	1974	1979	1979	1980	1982	1983	1982	1983
					Years to Reach Scope Studied					
Planned	8	6	6	6	5	5	5	3	3	3
Actual	15	12	12	7	8	8	6	5	5	5
					Annual Inflation Rate in Construction Costs					
Forecast	3.1%	6.2%	NF	7.0%	7.8%	NF	8.5%	6.0%	NF	9.0%
Actual[2]	7.3%	6.1%	6.7%	4.3%	6.0%	4.3%	2.7%	2.8%	2.0%	3.3%

[1] *Total line length, including single and double track sections. Forecast and actual double track line-miles are 12.9 and 14.0 for Portland, and 9.2 and 7.3 for Sacramento.*

[2] *"Actual" measure is average annual rate of increase in McGraw-Hill Construction Cost index for urban area over period extending from forecast start year through actual completion year.*

NF indicates no forecast of a data item was obtainable from published sources.

a project, without changing the underlying or "real" economic value of the land, construction services, and equipment required to construct the project.[7]

As Table 3-2 indicates, changes in the physical characteristics of these projects between their planning and construction stages were generally quite minor, with the exception of vehicle purchases for certain projects. Virtually all of the ten projects surveyed were built to within a few tenths of a mile of their planned line lengths, while the number of stations constructed as part of each project closely matched the number planned. And while vehicle purchases substantially exceeded their planned number in both Washington and

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[7] *Each of these last two statements is actually a slight oversimplification. Delays in a project's construction schedule reduce the discounted present value of the future flow of constant dollar outlays necessary to build and equip it, by deferring part of those outlays to later years. Inclusion of an appropriate discount rate produces a more inclusive measure of the "real" cost of the resources a project consumes, since as the date when the commitment of resources must actually be made is postponed farther into the future, the equivalent or present value of that commitment declines. Yet delays in construction outlays for a transit improvement project also postpone the start of its operation by the cumulative time delay in completing the project, thus simultaneously reducing the present value of the transportation and other benefits it provides by at least as much as it reduces the comparable measure of costs. A fully correct benefit-cost analysis of each project would incorporate the differential effect of delays on the "real" values of both costs and benefits. As an example of its importance, while Table 3-1 shows that the constant dollar cost overrun in constructing the first 26.8 miles of Atlanta's heavy rail system was 58%, the discounted value of the actual stream of constant dollar outlays exceeded the discounted value of its forecast counterpart by only 27% when both are evaluated at a discount rate of 10%. This is because actual outlays, while larger in total, occurred over the period from 1975 to 1986, rather than from 1973 to 1977, as originally anticipated. At the same time, however, the start of the time stream of benefits provided by the project was also postponed significantly, thus reducing their value when that measure is appropriately discounted.*

Furthermore, escalation in the price level for construction services can be partitioned into two components: (1) inflation in the economy-wide price level; and (2) changes in the price of construction services relative to the general price level. Changes in the general price level, or "pure" price inflation, do not increase the real economic cost of the resources consumed by an investment project such as those studied. However, changes in the price of construction services relative to this general price level have apparently been positive over the period spanned by this study, since all available measures of the price of purchasing an hypothetical "unit" of such services have risen more rapidly than have most broad-based indices of economy-wide prices. (For example, the McGraw-Hill Construction Cost Index and the R.S. Means Construction Cost Deflator increased at average annual rates of 6.2% and 6.4% from 1971 through 1988, the period covered by this study, while the Gross National Product Implicit Price Deflator, the broadest measure of economy-wide price changes, rose at an annual rate of 6.1%.) The result has been an increase in the "real" cost per unit of construction services, measured by the value of other consumption and investment opportunities that must be sacrificed to acquire such an hypothetical unit. Although this analysis does not attempt to estimate separately the contribution of this phenomenon to differences between the forecast and actual cost of constructing rail projects, this contribution is likely to be minor compared to the magnitude of typical cost overruns documented in Table 3-1, since increases in the price of construction services have been only slightly more rapid than those in the general price level.

Atlanta, actual purchases were considerably fewer than originally planned in Buffalo, Portland, and Sacramento, changes that by themselves would have reduced capital outlays for these projects.

On the basis of the differences between planned and actual project scope shown in Table 3-2, it appears that very little if any of the substantial real cost overruns experienced in building most of these projects can be ascribed to expansions in scale between their planning and construction phases. Thus, planners of most of these projects must have made very serious errors in forecasting either the physical resources necessary to construct and equip them, or the real economic value of these resources at the time planning was underway.[8]

3.2.2 Construction Scheduling and Financial Planning

Table 3-2 also shows that while changes or errors in construction schedules and financial planning for each project were consistently larger than changes in its planned physical configuration, they were still generally modest. As the table indicates, construction on each of the ten projects except those in Washington and Atlanta began within one year of its planned start. However, the table also shows that the initial segments of the Washington, Atlanta, and Baltimore rail systems, as well as the light rail lines in Buffalo and Pittsburgh, required considerably longer to complete than was originally anticipated.

Perhaps most interesting, Table 3-2 reveals that while planners of the Washington rail system substantially underestimated the rate of construction cost inflation that would occur during completion of its initial phases, in every other case where explicit forecasts were reported, planners overestimated the escalation to which anticipated project expenditures would be subjected. Again, this error by itself would have led to overestimates of the forecast nominal dollar capital outlays entailed in constructing these systems,

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[8] *Detailed estimates of the unit costs of constructing heavy and light rail transit facilities are reported in an earlier study by the Transportation Systems Center; see Don H. Pickrell, "The Costs of Constructing New Rail Transit Systems," Transportation Research Record, Number 1006, 1985, pp. 48-55. (No comparable estimates of the unit costs of constructing "people-mover" facilities appear to be available.) By updating these estimates to their equivalent in 1988 dollars and applying them to the changes in line mileage, stations, and vehicles reported in Table 3-1, it is possible to estimate how much these scope changes contributed to actual 1988 dollar capital outlays for each project, and, thereby, to the excess of actual outlays over their planned total. These calculations suggest that while scope changes may have accounted for slightly more than a quarter of the relatively modest real cost overrun on Portland's light rail line, in no other case did these changes explain more than 10% of the 1988 dollar cost overrun documented in Table 3-1. In fact, in Washington, Baltimore, Miami, and Sacramento, these scope changes should have made rail projects less costly to implement, making the very large real cost overruns experienced in building them even more difficult to explain.*

a particularly surprising finding in light of the systematic tendency to underestimate these outlays that was documented in Table 3-1.

3.2.3 Relative Contributions to Cost Overruns

Table 3-3 reports estimates of the contributions of errors in forecasting construction cost inflation, delays in starting construction, and changes in planned construction schedules to the nominal dollar cost overruns for these ten projects. The individual contributions of each of these financial planning errors were estimated by "simulating" how annual nominal dollar capital outlays and their cumulative total for each project would have differed from their forecast values if all variables other than the one under consideration had been forecast correctly.

Thus, for example, the contribution of "unanticipated inflation" reported in Table 3-3 represents the difference between cumulative capital outlays at the actual and forecast inflation rates, assuming that the planned schedule of "real" capital outlays had been adhered to exactly. The negative entries in this category for most projects indicate that since actual inflation proceeded more slowly than was forecast, actual nominal-dollar capital outlays would have been lower than those forecast if construction of the project had proceeded according to its planned schedule.

As Table 3-3 indicates, both delays in the start of construction and lengthening of planned construction schedules added to the nominal dollar capital outlays experienced by each project studied, in some cases significantly.[9] The table also shows that the combination errors in projecting construction cost inflation and these schedule changes accounted for a significant share (24-32%) of nominal dollar cost overruns for four of the projects studied. Thus, at least in these few cases, errors in financial planning -- a particularly difficult activity for public works construction projects -- apparently did contribute significantly to the large nominal dollar cost overruns that occurred.

In others, however, planners' errors in forecasting inflation should have reduced actual project outlays sufficiently to offset the consequences of delays in construction scheduling and the added costs of any scope changes, as shown by the estimated overall negative net contributions of all factors

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[9] *Of course, society's ability to finance these capital outlays also increases with such delays, since incomes are denominated in dollars that are subject to the same inflationary forces, except insofar as prices for construction services rise more rapidly than the economy-wide general price level. Whether government revenue sources that are used to fund such projects actually rise with inflation at the same rate as do project expenses is less clear, because their growth depends on the particular mix of taxes funding individual government expenditure programs. However, if equal taxation "effort" were sustained in real terms, revenues would grow at the same pace as project costs, again notwithstanding increases in the price of construction services relative to the general price level.*

Table 3-3.
ESTIMATED CONTRIBUTIONS OF ERRORS IN FINANCIAL PLANNING TO CAPITAL COST OVERRUNS FOR RAIL PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Unanticipated Inflation										
$ Amount	307	-3	--	-63	-35	--	-29	-13	-14	-12
% of overrun	12%	<1%	--	-26%	-18%	--	-56%	-53%	-19%	-16%
Delay in Start Date										
$ Amount	351	157	47	56	27	20	16	9	13	22
% of overrun	13%	15%	12%	23%	14%	26%	31%	36%	17%	29%
Construction Schedule Changes[1]										
$ Amount	195	94	50	2	-11	27	9	1	7	12
% of overrun	7%	9%	13%	1%	-6%	35%	18%	5%	9%	16%
Total Explained by Above Factors										
$ Amount	853	248	97	-5	-19	47	-4	-3	6	22
% of overrun	32%	24%	25%	-2%	-10%	--	-7%	-12%	7%	29%

1 Includes lengthening of construction schedule and changes in the time pattern of expenditures from those planned.

shown in Table 3-3.[10] Again, these estimated negative contributions of scope changes and financial planning errors to the difference between forecast and actual capital outlays makes the cost overruns experienced on these projects more rather than less difficult to understand.

10 As the table indicates, in some cases scope changes should actually have worked with inflation forecasting errors to reduce rather than increase project capital outlays in nominal dollar as well as in the "real" or constant dollar terms discussed previously.

3.3 FINANCING OF CAPITAL OUTLAYS

A final aspect of the comparison between forecast and actual investment outlays for these projects concerns the planned and actual financing of capital spending, particularly its distribution among various levels of government. Table 3-4 reports forecast and actual dollar outlays by federal, state, and local governments to finance capital spending on each of the ten rail transit projects studied.[11] As it shows, the federal government has financed a substantial share of capital outlays for each project: federal assistance under a variety of funding mechanisms has ranged from 53% to 83% of actual project outlays, and from $81 million to nearly $3 billion in nominal dollar terms.[12] Actual federal outlays in support of these ten projects totaled about $7.1 billion, although the equivalent of this figure in 1988 dollars would be considerably higher because much of it was denominated in the higher-valued dollars of previous years.[13]

Financing of the remaining share of capital outlays varied widely among these projects, as Table 3-4 also indicates. In nearly every case, either state <u>or</u> local government apparently assumed the dominant role in financing the non-federal share of project costs, with only Sacramento's light rail project receiving substantial support from <u>both</u> state and local government.[14] Local financial support amounted to 5% or less of actual capital outlays necessary to construct and equip five of the ten projects studied: those in Baltimore, Buffalo, Pittsburgh, Portland, and Detroit. As the table also shows, the maximum actual dollar value of local assistance for these five projects was $18 million, a surprisingly modest level of local government support considering the highly localized nature of benefits from transit investments.

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[11] *The actual financing of Portland's light rail project reported in Table 3-4 is estimated from federal, state, and local government contributions to the total cost of a joint highway-transit project. Because most federal and state assistance for the project financed construction of both its highway and transit components, it is not possible to isolate their contributions to its transit component.*

[12] *Federal funding mechanisms include discretionary capital grants under UMTA's Section 3 program, formula capital assistance under its more recently enacted Section 9 program, "trade-ins" of Interstate Highway spending authority for transit capital funding, and direct Congressional appropriations to fund capital outlays for Washington's Metrorail system.*

[13] *Assuming that the pace at which federal funds were spent equalled that for other project funding sources, the 1988 dollar value of actual federal outlays can be estimated by applying the federal share of actual funding for each project (from Table 3-4) to its 1988 dollar cost (from Table 3-1); the resulting estimate of the 1988 dollar value of federal contributions to these ten projects is nearly $11 billion.*

[14] *The planned financing of Miami's Metrorail system incorporated substantial support from both state and local government, but information on their actual financial contributions has not yet been made available.*

Table 3-4.
FORECAST AND ACTUAL FINANCING OF RAIL PROJECT CAPITAL OUTLAYS BY LEVEL OF GOVERNMENT

Level of Government	Heavy Rail Transit Projects: Washington	Atlanta	Baltimore	Miami	Light Rail Transit Projects: Buffalo	Pittsburgh	Portland	Sacramento	DPM Projects: Miami	Detroit
Nominal Dollar Outlays (millions)										
Federal										
Forecast	769	529	270	613	268	NF	155	95	61	95
Actual	2,917	1,227	627	722	421	429	200	101	81	156
Difference	2,148	698	357	109	153	--	45	5	20	61
State										
Forecast	--	0	135	76	68	NF	22	0	8	24
Actual	--	0	162	NA	109	89	28	27	NA	39
Difference	--	0	28	--	41	--	6	27	--	15
Local										
Forecast	944	264	0	106	0	NF	11	52	8	0
Actual	1,458	611	0	NA	6	18	12	44	NA	2
Difference	514	347	0	--	6	--	1	-8	--	2
Total										
Forecast	1,713	793	405	795	336	NF	188	147	77	109
Actual	4,375	1,838	790	1,042	536	537	240	172	153	197
Difference	2,662	1,045	385	247	200	--	52	49	76	88
Percent Distribution of Outlays										
Federal										
Forecast	45%	67%	67%	77%	80%	80%	82%	65%	54%	80%
Actual	67%	67%	79%	69%	79%	80%	83%	57%	53%	79%
Overrun	81%	67%	93%	44%	76%	80%	86%	19%	27%	78%
State										
Forecast	--	0%	33%	10%	20%	17%	12%	0%	7%	20%
Actual	--	0%	21%	NA	20%	17%	12%	18%	NA	20%
Overrun	--	0%	7%	--	21%	17%	12%	109%	--	20%
Local										
Forecast	55%	33%	0%	13%	0%	3%	6%	35%	39%	0%
Actual	33%	33%	0%	NA	1%	3%	5%	25%	NA	1%
Overrun	19%	33%	0%	--	3%	3%	2%	--	--	2%

NF indicates no forecast of a data item was obtainable from published sources.

Finally, Table 3-4 illustrates that until recently, the federal treasury has borne much of the burden of financing the large cost overruns that have characterized most of these projects. As shown, the federal government has financed three-quarters or more of the cost overruns experienced by six of the ten projects, including four of the five on which these overruns exceeded the hundred-million dollar mark. In fact, the table suggests that the financing mechanisms incorporated in federal capital assistance programs, sometimes resulted in the federal treasury absorbing a share of cost overruns that substantially exceeded its originally planned share of the project's total cost!

More recently, however, the declining federal share of cost overruns on projects in Miami and (particularly) Sacramento appears to indicate that some of the financial risk of cost overruns has been transferred from the federal government to state and local governments. This has been achieved partly through the use of "full-funding" agreements, which place a dollar ceiling on federal contributions to a project's capital cost, rather than committing the federal government to finance a specified share of total capital outlays for a project.[15]

3.4 ASSESSING CAPITAL COST FORECASTS

The accuracy of capital cost forecasts for the ten rail transit projects reviewed here appears to have been quite poor. Except for Pittsburgh's light rail reconstruction effort, these projects all significantly exceeded their original forecasts of the "real" or constant dollar outlays that would be required to build and equip them. Furthermore, changes in the physical specifications of these eight projects appear to explain very little if any of the substantial real cost overruns they experienced.

Similarly, the actual or nominal dollar outlays required to construct rail facilities and purchase vehicles typically have far exceeded their original forecasts, and only in a few cases does a significant fraction of these overruns seem to be attributable to errors in financial planning. Yet comparatively little of the burden of financing these substantial cost overruns appears to have fallen on the local government agencies whose planners and decision-making officials designed, selected, and managed the implementation of these projects; instead, it has been borne primarily by federal taxpayers.

These projects were typically selected from among competing alternatives because they promised dramatically improved transit service and substantial ridership increases, in return for initial investments that were originally anticipated to be only modestly higher than those required to implement less promising transit improvement projects. Yet in most cases the actual capital

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15 *The effectiveness of such agreements in controlling cost escalation may be limited, however, by the fact that they are typically not entered into until well after the local choice among projects has been made, by which time the estimated cost of constructing the selected project has often escalated considerably from the level that led local officials to choose it.*

outlays that have been required to implement these projects have been sharply higher than those originally anticipated, as the preceding analysis indicates. Together with the wide divergence between the anticipated and actual ridership levels these projects have experienced -- and their resulting modest contributions to overall transit ridership in the cities that have chosen to build them -- these cost overruns raise serious questions about the advisability of decisions currently being considered in many U.S. cities to proceed with major new rail transit investments.

4. OPERATING EXPENSES

This chapter compares forecast and actual values of two important measures of the operating expenses associated with the ten rail transit projects studied.[1] First, it explores how actual service levels and operating expenses for rail service (excluding expenses incurred in operating supporting feeder bus service) compare to their originally anticipated levels. This comparison provides important information about differences in unit operating expenses from their anticipated levels, the contributions of these differences to errors in forecasting total operating expenses, and the possible sources of error in forecasting unit costs.

Second, it investigates the actual effect of new rail service on total transit operating expenses in each urban area, and compares this to forecasts of how systemwide operating expenses would change when the selected rail project was completed. In some instances, reducing systemwide operating expenses by replacing bus service with rail service was advanced as one of the major reasons for selection of a rail project as the locally preferred alternative. This comparison provides some indication of whether this objective has actually been realized.

4.1 RAIL OPERATING EXPENSES

Table 4-1 compares the forecast and actual values of annual operating expenses for rail service provided by each of the ten projects studied, with both values expressed in 1988 dollars to remove the effects of errors in forecasting price inflation. As it shows, actual rail operating expenses are above those forecast in every case except Sacramento's light rail line, for which 1988 operating expenses were 10% below the level expected to be reached in the year 2000. Actual operating expenses for Buffalo's light rail line were within 12% of those forecast, although the forecast level of expenses was not expected to be reached until 1995.

Table 4-1 also shows that actual expenses ranged from 42% to 47% above their forecast values for three of the ten projects: Miami's Metrorail line,

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[1] *As used here, the term operating expenses includes all expenses for vehicle operations, vehicle and non-vehicle maintenance, and administration.*

Table 4-1.
FORECAST AND ACTUAL OPERATING EXPENSES FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in This Table Apply[1]										
Forecast data	1977	1978	1980	1985	1995	1985	1990	2000	1985	1985
Actual data	1986	1987	1987	1988	1989	1989	1989	1988	1988	1988
Annual Rail Operating Expense (millions of 1988 dollars)										
Forecast	66.3	13.2	NF	26.5	10.4	NF	3.8	7.7	2.5	7.4
Actual	199.9	40.3	21.7	37.5	11.6	8.1	5.8	6.9	4.6	10.9
% difference	202%	205%	--	42%	12%	--	45%	-10%	84%	47%
Annual Vehicle-Miles of Rail Service (millions)										
Forecast	29.2	6.6	NF	15.4	1.9	NF	1.1	1.1	1.0	1.4
Actual	27.9	12.5	2.1	5.1	0.9	1.0	1.4	0.6	0.4	0.6
% difference	-4%	89%	--	-67%	-53%	--	27%	-45%	-60%	-57%
Operating Expense per Rail Vehicle-Mile (1988 dollars)										
Forecast	2.27	1.99	NF	1.72	5.55	NF	3.56	7.07	2.53	5.42
Actual	7.16	3.21	10.48	7.28	12.65	7.74	4.05	11.49	11.52	17.36
% difference	215%	60%	--	323%	128%	--	14%	63%	356%	220%
Operating Expense per Rail Vehicle-Hour (1988 dollars)										
Forecast	NF	62.53	NF	NF	110.53	NF	81.86	152.42	NF	68.81
Actual	159.58	76.68	179.21	203.88	137.89	111.26	61.06	206.18	117.32	223.16
% difference	--	23%	--	--	25%	--	-25%	35%	--	224%
Average Rail Operating Speed[2] (miles per hour)										
Forecast	NF	31.3	NF	NF	19.9	NF	23.0	21.6	NF	12.7
Actual	23.0	23.9	17.1	28.0	10.9	14.4	15.1	17.9	10.2	12.9

1 *Most "actual" data apply to transit operators' fiscal years ending during the calendar year indicated.*

2 *Overall average operating speed, including passenger and non-revenue service; figures differ from those reported in Table 2-2, which refer to passenger service only.*

NF indicates no forecast of a data item was obtainable from published sources.

Portland's light rail line, and the Detroit people mover. However, in two of the three remaining cases for which forecast and actual operating costs can be compared, actual expenses are more than 200% above those forecast. Furthermore, except perhaps for the two downtown people-mover systems, both forecast and actual data understate the full costs of operating rail service, because they omit the costs of operating the networks of feeder bus service on which they rely to generate much of their ridership.[2,3]

While actual operating expenses would be expected to exceed those forecast if the level of rail service actually provided is higher than that originally anticipated, Table 4-1 shows that this is the case only in Atlanta -- where service is nearly double the level anticipated -- and in Portland.[4] For most other projects, actual vehicle-miles of service are more typically only one-third to slightly over half of those originally planned, although the 1986 service level operated on the Washington heavy rail system approached the level planned for 1977, when a similar system was expected to operate.

The apparently contradictory findings of generally higher rail operating expenses despite lower service levels than were forecast are reconciled by the fact that operating expenses per unit of rail service are sharply higher than those forecast for every project except Portland's light rail line. As Table 4-1 shows, expenses per vehicle-mile ranged from 60% to 356% above those originally anticipated for seven other rail projects, even after adjusting for the effects of inflation since these forecasts were prepared.

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[2] *Feeder bus costs are difficult to identify for two reasons. First, transit operating expense accounts generally do not include measures of operating expenses for individual routes, and these can only be approximated using conventional cost allocation techniques. Second, and more importantly, most bus routes that provide rail feeder service also simultaneously provide local or crosstown service, so that most of their operating expenses are shared by these two forms of service. Thus it would be extremely difficult to identify separately the expenses incurred in operating feeder services, even if transit expense accounts were available in sufficient detail to permit accurate estimation of route-level operating expenses.*

[3] *Because both the forecast and actual operating expense data reported in Table 4-1 apply to very new systems, they are also likely to understate the average value of these expenses over the lifetimes of these systems; however, this should not affect the reliability of the resulting comparisons.*

[4] *The finding that Atlanta's actual 1987 service level was almost double that anticipated for a system approximately equal in scope to that forecast to operate during 1978 is difficult to reconcile with data reported in Table 2-2, which showed that actual peak period rail service frequencies were considerably lower than those anticipated. Although it does appear that actual service hours and non-peak service frequencies are much higher than those originally anticipated, it seems unlikely that this difference alone could offset the apparently lower peak service levels sufficiently to account for the difference between forecast and actual vehicle-miles reported in Table 4-1.*

4.2 SOURCES OF HIGHER UNIT OPERATING EXPENSES

Actual operating expenses per vehicle-mile of rail service can diverge from those forecast for two basic reasons. First, purchase prices for the two major inputs used in transit operations -- labor and energy -- may be higher than originally anticipated, or the productivity with which these inputs are used to produce rail service may be lower than was projected.[5] If input prices exceed those originally anticipated or productivity is lower than expected, rail operating expenses per vehicle-hour will exceed their forecast value, thereby causing expenses per vehicle-mile to do so as well.

As Table 4-1 indicates, the limited number of comparisons that can be made suggest that actual operating expenses per vehicle-hour -- again with the exception of Portland's light rail line -- are typically 25% to 35% higher than their forecast values. While these comparisons are considerably closer than those of forecast and actual expenses per vehicle-mile, they nevertheless suggest that planners underestimated labor compensation levels or energy prices, while overestimating the productivity with which rail transit operations could utilize these inputs.[6]

Second, even if actual input prices and productivity levels matched those forecast, expenses per vehicle-mile could have exceeded their projected levels because current train speeds are lower than those predicted when planning rail operations. In fact, as Table 4-1 shows, actual operating speeds are slower than those projected in virtually every case for which forecasts were available. Actual operating speeds are significantly slower than those forecast in Atlanta, Buffalo, Portland, and Sacramento, while Detroit's people mover operates at a slightly higher speed than was anticipated. Except in Portland -- where expenses per vehicle-mile are only slightly above those forecast despite much slower rail operating speeds -- these slower speeds have magnified the effect of higher hourly operating expenses, thereby resulting in expenses per vehicle-mile that are sharply higher than those originally forecast.

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5 *Labor and energy together typically account for 75% to 90% of the costs of operating rail transit service; see for example Urban Mass Transportation Administration, National Urban Mass Transportation Statistics: 1986 Section 15 Annual Report, Table 3.08, pp. 3-91 to 3-130.*

6 *The limited data that are available from forecast documents indicate that prices for electrical energy are actually considerably lower than those projected, while the energy efficiency of rail transit vehicles exceeds that anticipated. Because each of these developments by itself would have made actual operating expenses per vehicle-hour lower than those forecast, the explanation for higher hourly expenses must lie with increased labor compensation rates and lower labor productivity (as evidenced by higher staffing levels). In fact, planners' "over-optimism" in projecting labor compensation and productivity levels must have been sufficient to offset the reductions in hourly operating costs from their forecast levels that otherwise would have resulted from lower energy prices and improved energy efficiency of rail vehicles.*

4.3 IMPACTS ON SYSTEMWIDE OPERATING EXPENSES

A major rationale for choosing a rail project over less capital-intensive alternatives was often that the former would reduce total operating expenses incurred for providing a comparable level of transit service, or allow a higher service level to be within a limited operating budget. Thus, an important question is how the rail projects studied here actually affected system-wide operating expenses for transit service.[7] Since systemwide operating expenses also can increase due to other service expansions that are implemented when new rail service is introduced, it is important -- although extremely difficult -- to isolate the changes in total operating expenses associated with the introduction of rail service from those resulting from other service changes.

Table 4-2 compares each urban area's forecast and actual total annual transit operating expenses with rail service in operation. (Both figures are adjusted to their 1988 dollar equivalents in order to eliminate the effect of unanticipated inflation.) In most cases where they can be made, these comparisons are much closer than those of forecast and actual rail operating expenses reported in Table 4-1. In fact, total operating expenses are actually below those forecast in Buffalo and Sacramento -- substantially so in the latter case -- although those forecast levels were not expected to be reached until well after the most recent year for which actual data are available.

This result suggests that reductions in operating expenses for bus service may have been nearly sufficient to offset the sharply higher actual rail operating expenses that were documented in Table 4-1. However, it is not possible to infer from the information presented here whether those savings were achieved through reductions in bus service beyond those that resulted from replacement of buses by rail transit in corridors where this occurred. The generally lower level of actual bus feeder service than was originally forecast to accompany most projects (see Table 2-2) does suggest that cuts in bus service may have occurred beyond those planned in connection with the introduction of rail service. Such service reductions may have been an important mechanism for achieving these savings, and would thus account partly for the relatively close correspondence between forecast and actual total operating expenses shown in the table.

Table 4-2 also attempts to identify the impact of introducing rail service on total transit operating expenses. As with the analysis of these projects' impacts on total transit ridership reported earlier (see Table 2-1), this table measures each city's actual change in total operating expenses between the last year before rail service began, and actual expenses with the project in

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7 *Because the rationale of reduced operating expenses does not appear to have been a major justification for the decision to build the two downtown people-mover systems, and because their impact on system-wide transit operating expenses is extremely difficult to isolate, they are omitted from the analysis that follows.*

Table 4-2.
FORECAST AND ACTUAL IMPACTS OF RAIL PROJECTS ON SYSTEMWIDE TRANSIT OPERATING EXPENSES

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
Year to Which Data Reported in This Table Apply[1]								
Forecast data	1977	1978	1980	1985	1995	1985	1990	2000
Actual data	1986	1987	1987	1988	1989	1989	1989	1988
Annual Operating Expenses After Completion of Rail Project[2] (millions of 1988 dollars)								
Forecast	434.5	63.0	NF	121.1	54.9	13.9	NF	71.8
Actual	447.3	136.5	121.5	136.0	53.9	22.2	67.1	34.2
% difference	3%	117%	--	12%	-4%	60%	--	-52%
Annual Operating Expense Impact of Rail Service[2] (millions of 1988 dollars)								
Forecast	NF	NF	NF	33.9	4.7	NF	0.6	-2.1
Actual	228.5	53.8	14.7	46.0	13.7	1.4	4.6	5.6
% difference	--	--	--	36%	191%	--	667%	--

1 Most "Actual" data apply to transit operators' fiscal years ending during the calendar year indicated.
2 Pittsburgh data are for South Hills corridor only; all others are system-wide figures.
NF indicates no forecast of a data item was obtainable from published sources.

operation.[8] This actual change is compared to the difference between the forecast levels of total operating expenses with the rail option that was actually chosen, and a high service level bus transit alternative that was rejected in favor of the rail option.

8 Because a number of years was required to construct each of the projects studied here, measuring the actual change in operating expenses with regard to a "before rail" baseline unavoidably mixes the effects of rail service on transit operating expenses with those of other changes in transit service that may have taken place during the intervening period.

In the few cases where these comparisons can be made, rail projects' actual impacts on systemwide operating expenses have been somewhat larger than was originally anticipated, although the absolute dollar differences are not large relative to those measured elsewhere in this study. However, Table 4-2 shows that the actual impact on systemwide operating expenses of inaugurating rail service has represented a substantial increase from their "pre-rail" level in Washington, Atlanta, and Miami. Since bus service levels remained fairly stable or declined slightly in most of these urban areas over the period when rail service was introduced, it does not appear that the savings in total transit operating expenses that were often anticipated to result from substituting rail for bus service have been widely realized.

This is a significant finding, because it implies that the substantial capital costs of constructing and equipping rail lines represent only part of the outlays necessary to implement new rail transit service. In combination with the previously documented capital cost overruns experienced in implementing most of the projects studied here (see Table 3-1), it appears that most local efforts to improve the quality of transit service by substituting rail for bus service have been dramatically more costly than planners of these projects originally anticipated.

5. THE COST-EFFECTIVENESS OF RAIL TRANSIT INVESTMENTS

This chapter compares the costs of implementing and operating rail transit projects to the ridership they have generated. Specifically, it estimates the cost per rail passenger carried and per new transit trip that have resulted from federally-assisted investments in new rail transit projects in the nine cities studied. (Neither of the cost-effectiveness measures examined in this study corresponds exactly to that presently employed by UMTA to screen candidate projects identified by local transit planners. Thus, they should not be compared directly to the cost-effectiveness indices prepared for projects now in their planning stages.[1])

This chapter also compares the actual values of these cost-effectiveness measures to those computed from the forecasts of costs and ridership that were prepared for each rail transit project. These comparisons suggest that the per-passenger costs of at which these projects have generated rail ridership and -- more importantly -- new transit usage have been quite high, both in dollar terms and in comparison to their original forecasts.

5.1 COST PER RAIL PASSENGER

Table 5-1 illustrates the computation of forecast and actual costs per passenger carried by each of the ten projects studied, using the information developed in previous chapters. The forecast and actual figures for average weekday rail boardings shown in Table 5-1 were previously reported in Table 2-1. Next, Table 5-1 repeats the figures for forecast and actual project capital outlays denominated in 1988 dollars, which previously appeared in Table 3-1. The forecast and actual values of annual rail operating expenses reported next in Table 5-1, which are also expressed in terms of 1988 dollars, appeared previously in Table 4-1.

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[1] *The primary difference is that the cost-effectiveness measured employed by UMTA in screening proposed projects allows the monetized value of travel time savings to existing transit riders to be deducted from the annualized costs of each project. In contrast, the cost-effectiveness measure employed in this study makes no allowance for time savings or other benefits to those who traveled by transit prior to the introduction of rail service.*

Table 5-1.
FORECAST AND ACTUAL COST PER PASSENGER FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Weekday Rail Passengers (thousands)										
Forecast	569.6	NF	103.0	239.9	92.0	90.5	42.5	50.0	41.0	67.7
Actual	411.6	184.5	42.6	35.4	29.2	30.6	19.7	14.4	10.8	11.3
% difference	-28%	--	-59%	-85%	-68%	-66%	-54%	-71%	-74%	-83%
Rail Project Capital Cost (millions of 1988 dollars)										
Forecast	4,352	1,723	804	1,008	478	699	172	165	84	144
Actual	7,968	2,720	1,289	1,341	722	622	266	188	175	215
% difference	83%	58%	60%	33%	51%	-11%	55%	13%	106%	50%
Annual Rail Operating Expense (millions of 1988 dollars)										
Forecast	66.3	13.2	NF	26.5	10.4	NF	3.8	7.7	2.5	7.4
Actual	199.9	40.3	21.7	37.5	11.6	8.1	5.8	6.9	4.6	10.9
% difference	202%	205%	--	42%	12%	--	45%	-10%	84%	47%
Equivalent Annual Total Cost of Rail Service[1] (millions of 1988 dollars)										
Forecast	511.3	189.4	NF	129.6	59.3	NF	21.4	24.6	11.1	22.1
Actual	1,014.7	318.4	153.5	174.6	85.4	71.7	33.0	26.1	22.5	32.9
% difference	98%	68%	--	35%	44%	--	54%	6%	103%	49%
Equivalent Total Cost per Rail Passenger[2] (1988 dollars)										
Forecast	3.04	NF	NF	1.73	2.15	NF	1.68	1.53	0.90	1.14
Actual	8.75	5.93	12.92	16.77	10.57	7.94	5.19	6.53	7.11	10.21
% difference	188%	--	--	872%	392%	--	209%	328%	693%	795%

[1] *Sum of (1) annualized value of "Rail Project Capital Cost," computed using a 40-year lifetime and a discount rate of 10% per year, and (2) "Annual Rail Operating Expense."*

Table 5-1. (Continued)

2 *"Equivalent Annual Total Cost of Rail Service," divided by annual equivalent of "Weekday Rail Passengers," computed using numbers of average weekday equivalents per year derived from annual total and average weekday rail ridership reported by project operators.*

NF indicates no forecast of a data item was obtainable from published sources.

The equivalent annual total cost for rail service appearing in Table 5-1 is estimated by first applying a capital recovery factor (CRF) to each of the forecast and actual rail project capital outlays, to determine the annual cost that, if paid every year over its assumed lifetime, would be equivalent to that initial capital outlay.[2] The resulting equivalent annual capital cost for each project is then added to the annual operating expense for rail service, to determine the equivalent annual total cost of rail service reported in Table 5-1. The forecast and actual values of this measure are then divided by the respective forecast and actual numbers of annual rail passengers that are equivalent to the weekday figures reported in the table, to arrive at the figures for forecast and actual cost per rail passenger.[3]

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2 *Capital recovery factors, the values of which depend on both the projected lifetime of project assets and the appropriate interest or discount rate, capture both components of the annual equivalent cost of a capital asset. These include depreciation, or the decline in the value of services it is capable of providing due to a combination of usage and age, and the opportunity cost of the capital that is unavailable for other uses because it remains invested in the asset. In computing the capital recovery factors used here, a lifetime of forty years is assumed, which is intended to represent a composite of replacement periods for rights-of-way (which have infinitely long lives, at least theoretically), guideway structures and stations (typically thirty to fifty years), vehicles (approximately twenty-five years), and ancillary facilities such as train control and communications equipment (some components of which appear to have much shorter lifetimes). The discount rate employed is 10%, the rate federal agencies are directed by the Office of Management and Budget to employ in evaluating government projects. This rate is also employed by UMTA in evaluating the cost-effectiveness of proposed local transit investments.*

3 *Forecast average weekday rail ridership figures are converted to their annual equivalent values using annualization factors computed from forecasts of total annual and average weekday rail ridership reported in planning documents for each project. Actual average weekday rail ridership figures are converted to their annual equivalent values using annualization factors computed from actual total annual and average weekday rail ridership reported by each project's operator. The forecast values of these annualization factors ranged from 286 to 322, and averaged 302 for the nine projects for which rail ridership was forecast, while their actual values ranged from 276 to 323, averaging 289 weekday equivalents per year for the ten projects studied. Similarly, in constructing Table 5-2, new transit trips per average weekday were converted to their annual equivalents using annualization factors derived from forecast and actual total annual and average weekday areawide transit ridership in each urban area. The forecast values of these*

As indicated previously, the capital outlays shown for each project typically understate the capital investment in new and expanded transit service, because they omit concurrent outlays for buses and bus-related fixed facilities necessary to provide the feeder service that generates some rail ridership. Similarly, the rail operating expenses that appear in Table 5-1 omit expenses for operating bus feeder service. Thus, the resulting total and per-passenger cost figures reported in the table understate the true values of these measures.[4]

As Table 5-1 shows, the costs per rail passenger derived from forecasts of capital outlays, operating expenses, and ridership for the ten rail projects studied range from $0.90 to slightly over $3.00. (All of these figures are expressed in 1988 dollars.) However, the actual values of this index of cost-effectiveness are all considerably above this level, ranging from somewhat over $5.00 to nearly $17.00 for the ten projects studied. In the seven cases where these can be compared to forecast values, actual costs per passenger range from 188% to almost 900% above their corresponding forecast values. The passenger-weighted average forecast cost per rail passenger expected to be carried by the seven projects for which this figure could be computed was $2.35, while the weighted average of actual costs per rail passenger for the ten projects studied was $8.56, a figure more than 260% higher.[5]

Errors in projecting this measure of these projects' cost-effectiveness represent a composite of previously documented errors in forecasting each of the three components that enter into its calculation: capital outlays; rail operating expenses; and passengers carried. Because no project achieved actual values of ridership, capital outlays, and operating expenses that were each close to those forecast, actual cost per rail passenger diverged considerably from the value implied by forecasts of these variables for every project studied.

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annualization factors for areawide transit ridership ranged from 295 to 322, averaging 303, while their actual values range from 276 to 310, and average 294.

4 *Even if these omissions could be remedied, this calculation would still produce a significant underestimate of the true long-run equivalent cost per passenger for another, more subtle reason. This occurs because it fails to recognize explicitly the time periods during which different cost components and ridership occur, and as a result cannot take account of the fact that capital outlays (as well as some operating expenses) occur earlier in time than does ridership. For a detailed discussion of the correct method for computing cost-effectiveness measures that explicitly recognize the timing of costs and ridership, as well as several suggested approximations to the correct measure (of which the method applied here provides the closest approximation), see Douglass B. Lee, Major Capital Investment Planning Guidance: Cost-Effectiveness, Staff Study SS-49-0.89., Transportation Systems Center, February 1989, pp. 10-24.*

5 *The weighted average actual cost per passenger for the same seven projects where a forecast cost per passenger could be calculated was $9.19, or 291% above the average forecast value of $2.35.*

Interestingly, when measured in percentage terms, the closest correspondence between forecast and actual cost per rail passenger was achieved by what was by far the most costly project studied, Washington, D.C.'s extensive Metrorail system. Although both capital outlays and operating expenses for this project substantially exceeded their forecast values, its ridership was considerably closer to its anticipated level than was the case for any other project where an original ridership forecast was available. While the Washington system exhibited the highest forecast as well as one of the highest actual costs per passenger, the increase from forecast to actual levels thus represented a smaller percentage of the former than for any other project.

In contrast, the percentage divergence between forecast and actual costs per rider was among the largest observed for the two relatively small downtown people-mover projects. This resulted partly because these two projects had the by far lowest forecast costs per rail passenger, so that any increase from forecast to actual levels represented a larger percentage error. Nevertheless, both projects experienced large dollar increases between their forecast and actual cost-effectiveness, primarily because their actual ridership levels were so far below those originally anticipated.

The closest dollar correspondence between forecast and actual cost per passenger (a difference of $5.00) was exhibited by Portland's light rail project, reflecting its consistent achievement of actual cost and ridership that were among the closest to their forecast values of the ten projects studied. The largest dollar escalation of cost per passenger from forecast to actual values occurred for Miami's heavy rail system, primarily as a result of the very large difference between its projected and current levels of ridership. Particularly large dollar gaps between these values also arose for the projects in Buffalo and Detroit, both of which experienced large capital cost overruns in addition to actual ridership levels well short of those initially forecast.

5.2 COST PER NEW TRANSIT TRIP

Another important measure of cost-effectiveness is the cost per new transit trip associated with the investment in expanded transit service represented by each of the projects studied here. Table 5-2 uses the previously reported information on new transit trips (from Table 2-1), rail project capital outlays (Table 3-1), and the impact of introducing rail service on systemwide operating costs (Table 4-2) to estimate this measure of cost-effectiveness for the eight heavy and light rail transit projects studied.[6]

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6 *As indicated previously, the two downtown people-mover projects are so small in the context of their respective areawide transit systems that their effects on total transit ridership and operating expenses are difficult to detect. Thus this index of cost-effectiveness was not computed separately for these two projects. However, the Metrorail and downtown Metromover projects in Miami were treated as a single combined investment in computing the forecast and actual cost-effectiveness measures reported for Miami in Table 5-2.*

Table 5-2.
FORECAST AND ACTUAL COST PER NEW TRANSIT TRIP FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
New Transit Trips per Average Weekday (thousands)								
Forecast	NF	99.1	NF	262.9	81.0	NF	51.3	13.0
Actual	281.3	36.9	37.3	-25.8	-0.4	6.3	11.5	-4.2
% difference	--	-63%	--	--	--	--	-78%	--
Rail Project Capital Cost (millions of 1988 dollars)								
Forecast	4,352	1,723	804	1,092	478	699	172	165
Actual	7,968	2,720	1,289	1,516	722	622	266	188
% difference	83%	58%	60%	39%	51%	-11%	55%	13%
Annual Operating Expense Impact of Rail Project (millions of 1988 dollars)								
Forecast	NF	NF	NF	33.9	4.7	NF	0.6	-2.1
Actual	228.5	53.8	14.7	46.0	13.7	1.4	4.6	5.6
% difference	--	--	--	36%	191%	--	667%	--
Equivalent Annual Total Cost Impact of Rail Project[1] (millions of 1988 dollars)								
Forecast	NF	NF	NF	137.0	53.6	NF	17.6	14.8
Actual	1,043.3	331.9	146.5	183.1	87.5	65.0	31.8	24.8
% difference	--	--	--	34%	63%	--	81%	68%
Equivalent Total Cost per New Transit Trip[2] (1988 dollars)								
Forecast	NF	NF	NF	1.67	2.20	NF	1.14	3.53
Actual	11.97	29.47	13.56	--	--	34.64	9.49	--
% difference	--	--	--	--	--	--	731%	--

Table 5-2. (Continued)

1 *Sum of (1) annualized value of "Rail Project Capital Cost," computed using a 40-year lifetime and a discount rate of 10% per year, and (2) "Annual Operating Expense Impact of Rail Project."*

2 *"Equivalent Annual Total Cost Impact of Rail Project," divided by annualized value of "New Transit Trips per Average Weekday," computed using numbers of average weekday equivalents per year derived from annual total and average weekday total transit ridership reported by project operators.*

NF indicates no forecast of a data item was obtainable from published sources.

As with the calculation of cost per rail boarding discussed above, new transit trips per average weekday are first annualized by multiplying by the assumed number of equivalent average weekdays comprising a year. Next, the equivalent annual capital cost of the rail project is calculated exactly as in Table 5-1, by applying the appropriate capital recovery factor to the 1988 dollar value of project capital costs. The annual operating expense impact of the rail project is then added to this equivalent annual capital cost to determine its equivalent annual <u>total</u> cost impact on its urban area's transit system.[7] Finally, this total cost increase is divided by the annual equivalent of new transit ridership to obtain the estimated cost per new transit trip accompanying the introduction of rail service.

As Table 5-2 indicates, the number of instances where a forecast of cost per new transit rider could be inferred was limited, since the forecast impacts of some projects on ridership and operating expenses could not be determined. The four forecast values that could be calculated ranged from a low of $1.14 for Portland's Banfield light rail project, to as high as $3.53 for Sacramento's slightly more extensive light rail line. In contrast, however, the actual per-passenger costs of new transit ridership associated with these projects were each considerably higher.

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7 *This quantity understates the true total cost impact of the rail project because it omits capital outlays for bus system improvements that were made in conjunction with the rail project, and which acted in conjunction with the introduction of rail service to generate the change in total transit ridership used to compute this measure of cost-effectiveness. Bus system capital outlays are omitted from this analysis because both forecast and actual data on their magnitude are difficult to obtain, and because they are likely to be small in comparison to capital outlays for the rail projects themselves. For example, capital outlays to improve Miami's bus system totaled roughly $30 million (in 1988 dollars) over the period during which the change in ridership reported in the table occurred, only about 2% of the combined capital outlays for constructing its rail and DPM systems. In addition, much of the cost of bus service improvements associated with the changes in total transit ridership analyzed here is likely to consist of increased operating expenses for expanded feeder and other bus service, which is captured in the annual operating expense impact of the rail project, and is thus reflected in the estimated cost per new transit rider.*

Only Portland's light rail investment was accompanied by growth in transit ridership at a cost of less than $10.00 per new trip (estimated to be approximately $9.50, as Table 5-2 shows), while even the impressive ridership gains coinciding with the advent of rail service in Washington and Baltimore were achieved at costs per new trip well above this threshold. Although ridership gains accompanying the advent of rail service in Atlanta were similarly impressive, the cost at which they were attained approached $30.00 per new trip, while that of the more modest ridership gain in Pittsburgh substantially exceeded the $30.00 per trip figure. Finally, in the three remaining cases -- Miami, Buffalo, and Sacramento -- no actual value of cost per new transit trip can even be computed, because system-wide transit ridership in these cities actually declined as rail service was introduced.

The collective performance of these investments in generating new transit ridership does not compare favorably to the cost-effectiveness of other means that have been employed to increase transit ridership in some of these same urban areas. For example, prior to the introduction of rail service in Atlanta, a combination of service improvements and fare reductions resulted in an increase in bus ridership about one-fifth as large as the actual increase accompanying construction of the part of its rail system studied here, at a cost per new rider less than 15% of that reported in Table 5-2.[8] Similarly, during the time planning was underway for Portland's light rail project, that area's transit operator implemented a variety of service improvements that increased ridership by nearly 40%, at a cost per new trip of only about $1.00 when expressed in 1988 dollars.[9] Although this figure compares closely to the forecast cost per new transit trip that was expected to coincide with construction of its light rail line, it is substantially below the actual cost per new trip accompanying that project.

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[8] *Meyer and Gomez-Ibanez report that service improvements and a substantial fare reduction (from 40 cents to 15 cents) increased Atlanta bus ridership by approximately 8.2 million trips from 1971 to 1972, while increasing the area's operating deficit for bus services by approximately $12 million. (See John R. Meyer and Jose A. Gomez-Ibanez, Autos, Transit, and Cities, Cambridge, Massachusetts, Harvard University Press, p. 49.) Thus, these changes increased total bus operating costs by less than $13.25 million (the $12 million increase in the operating deficit plus the roughly $1.25 million in additional revenue contributed by new riders, since part of the increase in the deficit stemmed from reducing the fare for previous riders by $0.25.) Assigning the full $13.25 million to the 8.2 million new trips results in a cost per new transit trip of $1.61 in 1972 dollars, equivalent to about $4.20 in 1988 dollars. Although this figure may be a substantial over-estimate of the cost at which bus service improvements increased transit ridership, it still amounts to less than 15% of the actual cost per new transit passenger accompanying the first 26.8 miles of heavy rail constructed in Atlanta, which as Table 5-2 reports exceeded $28.00 when expressed in 1988 dollars.*

[9] *Estimated from information reported in Increasing Transit Ridership: The Experience of Seven Cities, Office of Policy and Program Development, Urban Mass Transportation Administration, 1976.*

It would of course be shortsighted to evaluate the desirability of these investments on such a cost-effectiveness criterion alone, since these projects may have produced valuable benefits to former users of existing bus transit routes that were replaced by rail service, even if they were not accompanied by increased overall transit ridership. Nevertheless, the selection of nearly every rail project studied was justified to a major degree by projections that it would contribute to significant growth in areawide transit ridership at costs that appeared moderate by comparison.

Yet the analysis summarized in Table 5-2 indicates that even where increased transit ridership and other attendant benefits have been achieved, investments in new rail transit service appear to have been a much more costly way of attaining these objectives than was originally projected. In addition, these investments appear to have been a less cost-effective way of increasing transit ridership than other means that have been successfully employed by transit operators, including those in some of the same cities that subsequently chose to make major capital investments in new rail transit facilities.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 FORECASTING ERRORS AND THEIR SOURCES

Virtually all of the cost and ridership forecasts prepared for the ten projects reviewed in this study have proven to be extremely inaccurate. This is shown in Table 6-1, which summarizes errors in forecasts of rail passengers, total transit ridership, nominal and constant-dollar capital outlays, and total and unit operating expenses that were previously reported in Tables 2-1, 3-1, and 4-1. In addition, Table 6-1 reports the range, average, and standard deviation of percentage errors in the forecasts of each of these variables that were prepared for the ten projects included in this study.

6.1.1 Ridership

None of the nine projects for which a forecast of rail ridership was available has achieved a level of actual ridership that approaches this forecast. While rail ridership in Washington is closest to that forecast, its 1986 level was still 28% below that originally projected for the size of rail system (approximately 60 miles) operated during that year. As discussed previously, however, the closeness of this comparison is probably aided by significant population and employment growth during the nine-year delay between the anticipated and actual years when Washington's rail system reached this extent. In contrast, rail ridership currently appears to be somewhat less than half of that initially forecast in Baltimore and Portland, and from 66% to 85% below its forecast level for six of the other projects reviewed.[1]

Forecasts of total transit ridership with these projects in operation were slightly more accurate than those of rail ridership. This probably occurred partly because much of the bus service operating in these urban areas at the time these forecasts were prepared was unaffected by their decisions to construct rail lines. As a result, more accurate forecasts of ridership on

[1] *In Buffalo, Portland, and Sacramento, the years to which rail and total transit ridership forecasts applied (1995, 1990, and 2000, respectively) have not yet been reached. Thus, it is still possible -- although at this time it appears extremely unlikely -- that actual ridership levels will ultimately rise to their forecast levels by the time these cities' respective "horizon years" are reached.*

Table 6-1.
SUMMARY OF PERCENTAGE FORECASTING ERRORS FOR RECENT RAIL TRANSIT PROJECTS

All errors computed as 100 * (actual - forecast) / forecast

	Weekday Rail Boardings	Weekday Total Transit Trips	Total Capital Outlays (nominal $)	Total Capital Outlays (1988 $)	Rail Operating Expenses (1988 $) Annual	Rail Operating Expenses (1988 $) per Veh-Mile	Rail Operating Expenses (1988 $) per Veh-Hour
			Heavy Rail				
Washington	-28%	-12%	156%	83%	202%	215%	NF
Atlanta	NF	8%	132%	58%	205%	60%	23%
Baltimore	-59%	NF	95%	60%	NF	NF	NF
Miami	-85%	-74%	31%	33%	42%	323%	NF
			Light Rail				
Buffalo	-68%	-49%	59%	51%	12%	128%	25%
Pittsburgh	-66%	-51%	NF	-11%	NF	NF	NF
Portland	-54%	-52%	28%	55%	45%	14%	-25%
Sacramento	-71%	-61%	17%	13%	-10%	63%	35%
			DPM Projects				
Miami	-74%	NF	99%	106%	84%	356%	NF
Detroit	-83%	NF	80%	50%	47%	220%	224%
			Summary of Absolute Percentage Errors				
No. of projects	9	7	9	10	8	8	5
Low error	28%	8%	17%	11%	10%	14%	23%
High error	85%	74%	156%	106%	205%	356%	224%
Average	65%	44%	77%	52%	81%	172%	66%
Std. deviation	17%	25%	48%	29%	79%	127%	88%

NF indicates no forecast of a data item was obtainable from published sources.

these relatively stable services may have partly offset errors in projecting ridership in travel corridors where new rail lines replaced bus services. Nevertheless, four of the seven urban areas for which forecast and actual total transit ridership can be compared have attained less than half of the projected levels of total transit use with their rail projects in operation.

6.1.2 Capital Outlays

Actual capital outlays measured in nominal or "year of expenditure" dollars exceeded those forecast -- often by very substantial amounts -- for all nine projects for which forecasts were prepared. Delays in starting projects and lengthening of their planned construction schedules contributed significantly to most projects' cost overruns, by exposing capital outlays to a more prolonged period of inflation than had been anticipated. While an underestimate of future inflation also contributed substantially to the nominal-dollar cost overrun experienced in constructing one system, in every other instance actual inflation rates were lower than those projected, thus partly offsetting the effects of construction schedule delays.

A potentially more meaningful assessment of the accuracy of capital cost forecasts can be made by comparing forecast and actual capital outlays with both denominated in the constant dollars of a common base year. When forecast and actual outlays are compared on this basis, only one of the ten projects (Pittsburgh's reconstruction of its South Hills streetcar line to modern light rail standards) was actually completed for less than its forecast cost. Although actual constant-dollar capital outlays for Sacramento's light rail line were within 13% of those originally forecast, the remaining seven projects experienced constant-dollar capital cost overruns ranging from 33% to as high as 106%. Changes in the major physical dimensions or scope of these projects do not appear to have contributed significantly to these cost overruns; in fact, the effect of such changes in most cases should have been to reduce rather than to increase their construction costs.

6.1.3 Operating Expenses

The accuracy of operating expense forecasts prepared for the ten projects studied varied considerably. When expressed in constant dollars to remove the effect of errors in forecasting inflation, actual yearly operating expenses for Sacramento's light rail line are actually 10% below those forecast, while those for Buffalo's light rail line are within 12 percent of their forecast level. In both cities, however, the actual level of rail service operated is significantly less than the projected service levels reflected in forecasts of rail operating expenses, partly because their forecast service levels were not expected to be reached until 1995 (in Buffalo) and 2000 (in Sacramento). In addition, the "newness" of both of these systems suggests that even without increases in the level of rail service, operating expenses are likely to be considerably higher by the time their forecast horizon years are actually reached.

At the other extreme, actual annual operating expenses for the heavy rail projects in Washington and Atlanta each exceeded those originally projected by more than 200 percent, while those for Miami's Metromover project were 84% above their anticipated level. Errors in forecasting operating expenses for Miami's Metrorail line, Portland's light rail line, and Detroit's people mover were more modest: actual yearly expenses to operate these three projects range from 42 to 47 percent above those forecast, as Table 6-1 reports. The widespread underestimation of future operating expenses was not typically a result of discrepancies between the originally projected and actual levels of rail service operated. Only two systems -- those in Atlanta and Portland -- actually operated more vehicle-miles of service than was originally planned, and even in these two cases the difference between planned and actual service levels is insufficient to account fully for the difference between forecast and actual rail operating expenses.

The effect of errors in service level assumptions can be eliminated by comparing projected and actual expenses per unit of service operated. For five of the eight projects for which forecasts were available, actual operating expenses per vehicle-mile are more than twice the respective forecast value, and in four of these five cases, the actual figure was over three times that forecast. In the few cases where they were prepared, forecasts of operating expenses per vehicle-hour typically proved to be more accurate: expenses per vehicle-hour for Portland's light rail line are 25% below those originally forecast, while those for three other projects are within 35 percent of those forecast. This limited evidence thus suggests that errors in forecasting the average speed of rail vehicle operations may have been the most important factor contributing to consistent underestimation of operating expenses per vehicle-mile of rail service.

6.1.4 Cost-Effectiveness

The combined effect of consistent overestimation of future ridership, coupled with recurring underestimation of construction and operating costs, was a dramatic underestimation of the actual cost per rail passenger and per new transit trip for each of the projects studied. As Table 5-1 showed previously, forecasts of the total cost per rail passenger expected to be carried -- including the annualized value of forecast capital outlays and projected future rail operating expenses -- ranged from slightly under $1.00 to just over $3.00 (expressed in 1988 dollars) for seven of the ten projects reviewed in this study. Yet the actual ridership, construction costs, and operating expenses experienced by these ten projects resulted in costs per rail passenger ranging from slightly more than $5.50 to well over $16.00. Expressed in percent terms, actual costs per rail passenger for seven projects ranged from 187 percent to more than 800 percent above those implied by the forecasts of ridership, capital outlays, and operating expenses that were relied upon by local officials in evaluating and selecting them.

Similarly, the actual cost per new transit trip accompanying the introduction of rail transit service -- a more meaningful measure of the cost-effectiveness of these investments -- was sharply higher than originally anticipated in the single case where both be calculated.[2] In the remaining three cities where a rail project's forecast impact on system-wide costs and ridership could be calculated, total transit ridership actually declined with the inauguration of rail service, so that no actual cost per new transit trip could be estimated. Most important, in the five cases where actual costs per new transit trip could be calculated, the resulting figures ranged from over $9.00 to more than $28.00 per new trip, with the highest values occurring in the few cities (Washington, Atlanta, and Baltimore) where substantial increases in transit ridership accompanied the introduction of new rail service.

6.1.5 Sources of Forecast Errors

Errors in projecting the various input variables that influenced the ridership and cost forecasts prepared for these projects appear to explain very little of the typically wide margins separating forecast and actual levels of cost and ridership. While there is certainly room for improvement in the accuracy with which these inputs are projected, the models and associated procedures used to forecast ridership and cost apparently also introduced significant errors into the estimates on which local decision-makers relied in choosing a preferred alternative. Improved forecasting models and procedures may thus be as important as further refinements in planners' ability to project variables that serve as inputs to the models currently used to predict transit ridership, construction costs, and operating expenses.

6.2 FORECASTING ERRORS AND CHOICES AMONG PROJECTS

The accuracy of forecasts prepared for alternatives that were rejected in favor of the selected rail investments cannot be evaluated, because no actual data are available for alternatives that were studied but not implemented. Thus, it is difficult to judge whether the substantial errors in forecasting ridership and costs for the rail projects reviewed here led decision-makers to select these projects when more accurate forecasts might have led them to prefer other alternatives. However, it does appear that the divergence between forecast and actual cost per rail passenger or per new transit trip for some of the projects that were selected is larger than the entire range of values of these cost-effectiveness measures over all of the alternatives to which they were compared.

For example, the planning process that led to the selection of Buffalo's "Minimum Light Rail Rapid Transit Line" considered a total of 26 bus, heavy rail, conventional light rail, and high-capital light rail transit alternatives

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[2] *As noted earlier, no attempt was made to estimate separately the effect on systemwide transit ridership of the two DPM projects, which are of very limited geographic scope. However, since Miami's downtown Metromover project was originally designed to operate in conjunction with the city's Metrorail line, these two projects were treated together for purposes of comparing their forecast and actual cost-effectiveness in generating new transit ridership.*

designed to improve transit service in the Buffalo-Amherst corridor. The highest cost per transit passenger projected for any of these alternatives was $4.51 -- considerably above the $1.12 cost per passenger forecast for the lowest-cost bus alternative. (These figures are computed using the same discount rate and asset lifetime assumptions used to calculate those reported in Table 5-1, and are also expressed in 1988 dollars.) Yet, as Table 5-1 indicated previously, the actual $10.17 cost per rail passenger for the selected alternative was well above the $2.15 per passenger forecast for that project. Thus, the divergence between forecast and actual cost per passenger for the selected project ($10.17 minus $2.15, or $8.02) was 237% of the range between the lowest and highest forecast values of cost per passenger for the 26 alternatives considered (which was $4.51 minus $1.12, or $3.39).[3]

Thus unless cost and ridership forecasts prepared for each of the rejected alternatives were as unreliable as those prepared for the projects that were actually chosen in each case, it appears likely that the previously documented errors may have led local decision-makers to choose projects in some instances that would not have appeared to be the most desirable if more accurate forecasts had been available. It is important to recognize that this would still have been the case even if forecasts prepared for each of the alternatives studied were subject to the same degree of inaccuracy, since the systematic tendency to over-estimate ridership and under-estimate capital and operating costs documented in this report produces a bias toward the choice of capital-intensive transit improvements such as rail lines.

This bias arises because, as a variety of studies has shown, rail becomes the economically preferred transit mode only when its substantial capital costs and fixed operating expenses (such as those for line and station maintenance) can be spread over large passenger volumes.[4] Thus, even if cost and ridership forecasts prepared for transit improvement projects entailing investments

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3 *These figures were computed from U.S. Department of Transportation, Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Transit Project, May 1977, Table 3-2. p. 3-13, Table 3-3, p. 3-20, Table 3-6, p. 3-29, and Table 3-7, p. 3-31; and Niagara Frontier Transportation Authority, Evaluation of Transit Alternatives: Buffalo-Amherst-Tonawandas Corridor, February 1976, Table D-2, p. 56.*

4 *The earliest such study is reported in John R. Meyer, John F. Kain, and Martin Wohl, The Urban Transportation Problem, Cambridge, Massachusetts, Harvard University Press, 1965, chapters 8-11. Several subsequent studies arrive at the same conclusion, although for a variety of reasons they differ regarding the exact ridership threshold at which rail becomes the most cost-effective transit mode. These studies include: Theodore E. Keeler, Kenneth A. Small, and Associates, The Full Costs of Urban Transport, Part III: Automobile Costs and Final Intermodal Cost Comparisons, Monograph No. 21, Institute of Urban and Regional Development, University of California, Berkeley, July 1975; J. Hayden Boyd, Norman J. Asher, and Elliot S. Wetzler, "Non-Technological Innovation in Urban Transportation: A Comparison of Some Alternatives," Journal of Urban Economics, Vol. 5, No. 1, January 1978, pp. 1-20; and Boris Pushkarev, with Jeffrey M. Zupan and Robert S. Cumella, Urban Rail in America: An Exploration of Criteria for Fixed Guideway Transit, Bloomington, Indiana, Indiana University Press, 1979.*

in different transit modes or technologies can be expected to be equally over-optimistic -- that is, to represent equal proportional over-estimates of future ridership and under-estimates of costs -- the planning process still will be biased toward selection of the highest-capital alternatives under consideration.[5]

6.3 IMPROVING THE ACCURACY OF FORECASTS

The prevalence and magnitude of errors in ridership and cost forecasts documented in this report suggest the need for substantial improvements in the reliability of forecasts prepared in support of future choices among projects. It should be possible to reduce substantially the magnitude of future errors by combining technical improvements in the preparation of forecasts with stronger incentives for local agencies planning these projects to develop more realistic projections of their costs and future ridership.

Specifically, the accuracy of ridership and cost forecasts prepared for proposed transit improvement projects might be improved by certain changes in the way these projections are developed and reviewed. These include:

(1) Bringing the forecasting "horizon" -- i.e., the future year to which ridership and operating cost forecasts apply -- closer to the present.

(2) Developing procedures that allow the effect on forecasts of projected future values of specific individual causal factors to be isolated and highlighted for critical examination by interested observers, including those who are not necessarily familiar with the technical procedures used to develop forecasts.

(3) Conducting sensitivity analyses for validating forecasting models and for examining the effects of alternative assumptions affecting cost and ridership projections.

(4) Checking the realism of construction and operating cost forecasts, ridership forecasts, and inputs to these forecasts, by comparing them to the record established by previous projects and by soliciting expert review of their reliability.

Most of these recommended changes have been informally incorporated into the UMTA-prescribed process for planning and developing major transit capital projects, as a product of the continued evolution of that process in response to experience gained in planning and implementing past transit investments, including those reviewed in this study. Their incorporation into

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[5] *This tendency is of course aggravated by the availability of federal assistance for up to 75% of the capital costs of constructing and equipping transit projects, thereby offering the largest dollar value of capital assistance to localities that select the most capital-intensive transit projects.*

the procedures local planning agencies are directed to follow in developing and presenting ridership and cost forecasts, together with various other modifications of the project development process, has recently been formally recommended by UMTA.[6]

In particular, the magnitude of previously documented errors demonstrates the importance of performing sensitivity analyses to examine the potential impacts of errors in cost and ridership forecasts -- and on projected cost-effectiveness -- for the alternatives under consideration. Since errors may arise from uncertain input assumptions, imperfect forecasting models and procedures, or from a variety of other sources, it is important for decision makers to appreciate the extreme uncertainty surrounding such forecasts. It is equally important for planners and decision makers to understand the implications of such errors for the relative cost-effectiveness of the various alternatives under consideration, and thus for the choice of a locally preferred project from among the alternatives under consideration.

6.3.1 Ridership Forecasts

The results of this study suggest a number of potential areas for improving generally the preparation and assessment of ridership forecasts. These include:

(1) Use of a nearer "horizon" year for preparing ridership forecasts. An extreme and variant of this is the preparation of "opening day" forecasts using current values or near future forecasts of population, employment, and transportation system characteristics and transit service levels, now strongly encouraged as part of the UMTA planning process for major transit projects.

(2) Systematic examination of the impact on ridership forecasts of variation in individual input assumptions over plausible ranges.

(3) Evaluation of the reasonableness of forecast results by reference to empirical data available for similar projects and urban areas, and revision of forecasts using adjusted procedures or input assumptions where significant departures from documented experience cannot be readily justified.

The "Horizon" Year. One prominent source of the consistent over-estimation of future transit ridership appears to be errors in forecasting the variables that serve as inputs to the travel demand forecasting models. Forecasts of the future values of these inputs -- which consist of demographic and economic variables, transit performance levels, and automobile

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[6] *See Urban Mass Transportation Administration, 49 CFR Part 611, "Major Capital Investment Projects; Proposed Rulemaking,"* Federal Register, *April 25, 1989.*

travel conditions and costs -- could be made more accurate by shortening the period between their preparation and the future year to which they apply. This should reduce the number of major developments during the intervening period, which sometimes extends to twenty years in current practice, that can cause projections of these input variables to be inaccurate, such as changes in the performance of the local economy, or reorientation of travel patterns in response to changing geographic distributions of jobs and population.

Base Year "Forecasts". An extreme variant of this recommendation would be to prepare ridership forecasts under current demographic and automobile travel conditions -- i.e., as if each proposed transit project could be implemented in today's transportation environment. This would entail using current population and employment levels and their geographic distributions, together with existing automobile operating expenses, parking charges, and travel speeds, to project hypothetical transit ridership as if each proposed project could be implemented immediately.

This procedure would provide a more realistic estimate of the increased ridership that would result from the service characteristics associated with each of the proposed transit improvements, since it would separate these increases from those due to growth in overall travel demand resulting simply from population and employment growth. It also would eliminate the influence on ridership projections of common assumptions regarding future increases in automobile operating costs and reductions in travel speeds, which often fail to materialize. Such assumptions are difficult for decision-makers to dispute when they are offered by experienced transportation professionals, yet are inherently extremely uncertain.

Some planners are likely to resist using existing demographic patterns and automobile travel conditions as inputs for "forecasting" ridership on proposed transit systems, since anticipated demographic growth and increased highway traffic congestion often are among their reasons for contemplating major investments in transit capacity and performance. In addition, it is often argued that these investments will induce (or at least contribute to) the future demographic changes expected to produce expanded transit travel.

However, the intent would not be to replace the conventional estimates of future-year ridership, but to focus decision-makers' attention more directly upon the major changes in transit service characteristics that are anticipated to result from each of the alternatives being considered. This will assist in identifying differences among each alternatives' contribution to increased transit ridership among that arise from their different service characteristics, rather than from sources of increased ridership -- such as population growth or increasing costs for automobile travel -- that are shared by all of the options under study. At the same time, another advantage of this procedure would be that once models, networks, and associated forecasting procedures were tested and validated using base year inputs, they could be used with greater confidence to predict ridership growth that is likely to result from anticipated future demographic and economic developments, changes in automobile operating costs and service levels, and other influences on ridership to which each of the alternatives under study is more or less equally subject.

Sensitivity to Assumed Changes in Transit Service Characteristics. Whatever forecasting models and procedures are used, it is useful to examine the sensitivity of their results to plausible variation in the values of specific inputs to these procedures, such as the characteristics of transit service expected to result under each alternative, future costs for automobile travel, and prospective demographic trends. This type of sensitivity analysis can be very helpful both for refining detailed forecasting models and procedures, and for examining the likely effects on ridership of uncertainty regarding such factors as population and employment growth, transit service levels that can result from implementing each alternative under consideration, and the convenience and expense of traveling by automobile.

The use of simplified elasticity-based procedures seems particularly well suited for this activity, although sensitivity analysis also can be performed using a variety of other modeling approaches.[7] In general, the degree to which sensitivity testing should and can be carried out will depend on initial results (with greater sensitivity of results to input values implying the need for testing a wider range of these values), and on the associated analysis costs. With increasingly widespread use of microcomputer-based transportation forecasting models, which offer considerable potential for reducing the response time and computing costs associated with the use of these models, schedules and budgets ought to permit a reasonable degree of such testing.

Reasonableness Checks on Ridership Forecasts. Regardless of the procedures and assumptions used, it is also important to evaluate forecast results in terms of their reasonableness, defined generally in terms of actual data observed elsewhere in similar situations. This need is highlighted by the large discrepancies found in this study between forecast and actual ridership and costs, and ought to be routine practice. Where forecast results differ significantly from those values observed for similar completed systems elsewhere, the implication must be that: (1) there is something genuinely unusual about the system under study that can reasonably explain these differences; (2) there are significant problems with the forecasting models and procedures that need to be addressed before a decision is made; or (3) significant changes are needed in one or more of the input assumptions used to generate the forecasts in question.

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[7] *See, for example, Daniel Brand and Joy L. Benham, "Elasticity-Based Method for Forecasting Travel on Current Urban Transportation Alternatives," Transportation Research Record, Number 895 (1982), pp. 32-37.*

6.3.2 Capital and Operating Cost Forecasts

Improvements also are clearly needed in terms of the accuracy with which capital costs and operating expenses are forecast. Yet the procedures for producing these forecasts, especially those prepared for a range of alternatives at a comparatively early stage in the planning process, appear to be more varied and less refined than those used to project future ridership. Thus, it is more difficult to identify specific sources of error in producing forecasts of capital costs and operating expenses, and the most effective avenues for improving their accuracy are likely to entail more extensive reasonableness checks. Improved accuracy also should result from increasing the financial consequences for local transit planning and operating agencies of producing and accepting unrealistically low cost projections.

More Detailed Engineering Prior to Project Selection. Probably the most step to improve the accuracy of capital cost estimates prepared to support local officials' choices among alternate transit improvement projects would be to conduct additional engineering studies prior to their selection of a preferred option. The more detailed specification of alternative projects' physical configurations, vehicle and other equipment complements, and operating plans that would presumably result from such studies should facilitate more accurate estimation of their capital costs and future operating expenses than has characterized the projects reviewed in this study.

Although such "conceptual engineering" would not necessarily entail the level of detail used for subsequent study of the locally preferred alternative in the Preliminary Engineering phase of the project development process (see Figure 1-1), it should allow local officials to choose from among a set of alternatives on the basis of more reliable forecasts of their initial capital costs and ultimate operating expenses. The set of these alternatives could first be reduced to a manageable number by initial screening on the basis of less detailed ridership and cost estimates like those now in use, in order to economize on time and other resources dedicated to the planning process. Surprisingly, while local agencies participating in the UMTA planning process were first encouraged to engage in more detailed pre-decision engineering studies nearly a decade ago, no agency has yet elected to conduct such studies for more than a single alternative.

Reasonableness Checks for Cost Forecasts. The reasonableness of capital cost and operating expense forecasts prepared for proposed rail transit projects is also comparatively easy to check against the record established by similar, recently-constructed projects such as those included in this study. A previous Transportation Systems Center study used capital cost data from recent rail transit projects to estimate "standardized" unit costs for rail facilities (lines and stations), which differed according to both the technology employed (light or heavy rail) and the vertical alignment (at-grade, in tunnel, or elevated).[8] These estimates, updated to incorporate the additional information provided by subsequent rail projects, could easily serve for performing reasonableness checks on forecasts of the costs of building future rail transit facilities.[9]

Yet the previous study found that, with only a single exception, every rail project then under construction or in the final stages of planning was forecast to cost considerably less than the experience of previous similar projects would have suggested. Thus, use of these unit costs to check the reasonableness of future cost forecasts probably would have to be required by UMTA as part of its guidelines for local agencies conducting the planning process for major transit investments. Furthermore, this requirement would need to be carefully structured so as to place on local agencies that selected preferred projects with unreasonably low capital or operating cost forecasts a "burden of proof" requiring them to demonstrate why their forecasts should be accepted by UMTA when they appeared to conflict with the experience of previous projects.

In addition, representative ranges of unit costs would have to be developed to check the reasonableness of operating expenses projected for proposed rail transit projects (including bus and other related transit systems). Detailed operating and maintenance expense data are readily available from the "Section 15" data base maintained by UMTA. Of particular interest would be unit operating and maintenance expenses (per vehicle-mile and vehicle-hour), both for various types of bus service and for recently completed rail projects. Comparable data for older rail systems would provide additional insight regarding increases in maintenance expenses likely to be incurred as equipment ages and warranties expire.

6.3.3 Expert Review and Oversight of Project Activities

Another potentially effective strategy for establishing the reliability of cost and ridership forecasts, as well as of the assumptions and models used to generate them, is to subject them to review and verification by independent experts. Although such a review of each urban area's forecasting efforts is presently conducted by UMTA staff members, the growing number of projects for which planning is actively underway, together with a reduction in resources available for this effort, has reduced the scope and depth of review activities that can be performed. Supplementing their oversight efforts by

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[8] *See Don H. Pickrell, Estimating the Costs of Constructing New Rail Transit Facilities, Staff Study SS-64-U.5, Transportation Systems Center, May 1985; also published as "The Costs of Constructing New Rail Transit Systems," Transportation Research Record, Number 1006 (1985), pp. 48-55.*

[9] *In addition, UMTA presently has underway a more up-to-date and detailed study of unit construction costs for rail transit projects, the results of which are intended to be useful in this capacity.*

convening independent experts empowered to review and propose modifications to forecasting procedures and input assumptions could substantially increase the reliability of information that will ultimately be used to support local officials' choices among alternative projects.

For example, local agencies responsible for conducting the UMTA planning process could be required to designate a peer review panel with responsibility for assessing the credibility of input assumptions, technical procedures, and forecast results when they are still subject to review and revision. The responsibilities and powers of individual members comprising such a panel would need to be clarified prior to their selection, but wider use of such groups offers the potential for bringing valuable judgement and experience to bear in generating reliable information to support local decision-makers' choices among alternative transit improvement projects.

Once projects have been selected and arrangements for financing their implementation have been completed, independent expertise in activities such as construction management, testing of completed systems, and actual initiation of service could also be employed by local agencies serving as project sponsors. Such expertise has recently been provided to sponsors of some recent federally-financed rail transit construction projects by Project Management Oversight (PMO) contractors designated by UMTA, who have been retained to engage in specific assistance and oversight activities agreed to by UMTA and the local project sponsor, often after construction-related problems have been identified. More widespread use of PMO contractors, including their designation before problems have arisen with project construction timetables or financing, may thus be a potentially useful strategy for bringing independent expertise to bear on post-planning project implementation activities.

6.4 ACKNOWLEDGING UNCERTAINTY IN FORECASTS

The errors in forecasting ridership and costs for the ten projects reviewed as part of this study were so large that they appear unlikely to be eliminated completely by these largely technical changes in the procedures for developing and reviewing forecasts. Recognizing this situation, it seems prudent that both ridership and cost forecasts prepared to support future choices among alternative projects be prepared and presented in a manner that explicitly recognizes the existence of uncertainty about whether their exact values will be achieved. Perhaps most important, this recognition also needs to be conveyed by planners to the local political officials that will ultimately rely on these forecasts to choose among alternative projects, as well as to the more general public.

6.4.1 Acknowledging Uncertainty in Ridership Forecasts

One obvious way to acknowledge that such uncertainty surrounds even the most carefully prepared and assiduously reviewed projections of ridership would be to report a range of ridership levels that could reasonably be expected to result from implementing each project under consideration. While in principle it is also be possible to construct ridership forecasts in a manner that yields an accompanying mathematical probability that actual ridership will fall within the stated range, this additional refinement is probably less valuable than simply acknowledging that uncertainty in achieving any specific level of predicted ridership levels exists, and cannot be eliminated. This acknowledgement seems likely to be adequately conveyed simply by expressing forecast ridership for each alternative as a range rather than as a single point value.

This procedure will of course complicate the calculation and interpretation of the cost-effectiveness measures local project sponsors are required by UMTA regulations to prepare and report as part of the "Alternatives Analysis" procedure.[10] By introducing similar uncertainty into the computed measures of cost-effectiveness, it may result in situations where alternative projects cannot be unambiguously ranked on the basis of their anticipated performance. Even in such extreme cases, however, this will simply represent a formal acknowledgement that the actual cost-effectiveness of each alternative under consideration cannot be predicted with certainty, and that even on the basis of such a carefully-defined mathematical measure, a preferred alternative cannot always be uniquely determined. Since a wide variety of other criteria -- many of which are difficult to measure, and some even to articulate-- also enter into planners' and public officials' selection of the locally preferred alternative, changing the presentation of ridership forecasts and resulting cost-effectiveness measures to recognize explicitly the existence of uncertainty seems unlikely to introduce undue additional complication into the already complex process of choosing a preferred project.

6.4.2 Increasing Contingency Allowances to Cover Cost Escalation

Recognizing that capital cost estimation and financial planning for major public works projects such as the construction of rail transit lines is an inherently difficult and risky activity, it seems prudent in project budgeting to provide contingency allowances that are adequate to cover capital cost escalation of the magnitude typically experienced by such projects.[11] On the basis of the results reported in this study, it is obvious that such contingency allowances have been consistently inadequate to allow local project

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10 For a description of these indices and procedures for their calculation and presentation, see Urban Mass Transportation Administration, 49 CFR Part 98, "Major Capital Investment Policy," Federal Register, May 18, 1984.

11 Such allowances are not to be confused with those provided to cover projected escalation in construction outlays stemming from increasing prices for construction services or purchased equipment (such as rail vehicles). Contingency allowances are intended to cover such developments as unforeseeable but necessary changes in project scope or design, underestimation of "real" project costs, delays in the project schedule, and errors in projecting the pace of inflation.

sponsors to absorb unforeseen developments without incurring major increases in their projects' budgets, and should be increased substantially for future projects if they are to serve their conventional purpose.

Contingency allowances for the ten projects reviewed in this study have typically ranged from five percent to ten percent of estimated project costs, and in some cases have been well below the five percent figure. Yet the typical provision necessary to accommodate unforeseen developments in constructing one of these projects without necessitating an increase in its preconstruction budget would have been approximately eighty percent of its estimated nominal-dollar capital cost.[12] Experience with projects currently under construction also suggests that such allowances may have been inadequate even for more recently planned and budgeted projects. For example, a Project Management Oversight consultant has recently estimated that the cost overrun likely to be experienced in constructing the first segment of Los Angeles' Metrorail line exceeds two hundred percent of the contingency allowance included in the project's original budget.[13]

Although it is difficult to specify the size of contingency allowance that should be provided in capital budgeting for future transit projects, it does appear that some increase in those historically provided is warranted. The most prudent course would probably be for UMTA to draw upon the experience of other major public works projects, in combination with the record established by past major transit capital projects (including those reviewed here), to establish guidelines for the size of reasonable contingency allowances in relation to foreseeable project expenditures. Even within the scope of major capital grant programs administered by the various other branches of the U.S. Department of Transportation, there probably exists considerable project budgeting and oversight experience that could be called upon to develop guidelines for more realistic estimation of adequate contingency provisions in budgeting for future federally-supported transit investments.

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12 *This figure is calculated from the average 77% nominal-dollar cost overrun for nine of the ten projects, shown in Table 6-1, and the estimate that the typical actual contingency allowance included in this budget was equal to 5% of other projected costs.*

13 *Deloitte/Kellogg Joint Venture, "Report on a Review of the Financial Disposition and Schedule of the Metro rail MOS-1 Project," prepared for Los Angeles County Transportation Commission, July 1989, p. 7.*

APPENDIX. DATA SOURCES

This appendix documents the sources of all data appearing in tables presented in the text of this report. The format of each table is displayed first, using note numbers instead of the actual data; following each table, original sources and any adjustments made to each data item are referenced to these note numbers.

Source Notes for Table 1-1. CHARACTERISTICS OF RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Scope of Project Studied										
Number of Lines	1	2	3	4	5	6	7	8	9	10
Total Miles	11	12	13	14	15	16	17	18	19	20
Stations	21	22	23	24	25	26	27	28	29	30
Vehicles	31	32	33	34	35	36	37	38	39	40
Year When Project Reached Scope Studied										
Forecast Year	41	42	43	44	45	46	47	48	49	50
Actual Year	51	52	53	54	55	56	57	58	59	60
Year to Which Data Reported in this Study Apply										
Forecast Data	61	62	63	64	65	66	67	68	69	70
Actual Data	71	72	73	74	75	76	77	78	79	80

Source Notes for Table 1-1.

1. Washington Metropolitan Area Transit Authority (WMATA), "METRO Fact Card," June 1987.
2. Metropolitan Atlanta Rapid Transit Authority (MARTA), Bus and Rail System Map, January 1986.
3. DMJM/RKE, "The Baltimore Metro," undated, p. 4.
4. Metro-Dade Transit Agency (MDTA), Transit Map of Metro Dade County, Effective April 3, 1988.
5. Niagara Frontier Transportation Authority (NFTA), "Rail Transit Facts," undated, p. 2.
6. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.
7. Tri-County Metropolitan Transportation District of Oregon (Tri-Met), Transportation Map, April 3-September 3, 1988.
8. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-1.
9. MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.
10. Fluor Daniel, Inc., Final Report on Project Management Oversight for the Detroit Central Automated Transit System, May 25, 1989, p. 1-2.
11. Calculated from schedule of line segment opening dates and lengths reported in WMATA, "METRO Fact Card," June 1987.
12. Calculated from distances to Five Points station reported in MARTA, "A Guide to MARTA," undated.
13. DMJM/RKE, "The Baltimore Metro," undated, p. 4.
14. Measured from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.
15. NFTA, "Rail Transit Facts," undated, p. 2.
16. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.
17. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 403.
18. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-1.
19. Measured from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.
20. Fluor Daniel, Inc., Final Report on Project Management Oversight for the Detroit Central Automated Transit System, May 25, 1989, p. 1-2.
21. Calculated from schedule of opening dates reported in WMATA, "METRO Fact Card," June 1987.

22. Counted from MARTA, Bus and Rail System Route Map, January 1985.

23. DMJM/RKE, "The Baltimore Metro," undated, p. 4.

24. Counted from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

25. NFTA, "Rail Transit Facts," undated, p. 2.

26. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.

27. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 005, p. 3.

28. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-1.

29. Counted from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

30. Fluor Daniel, Inc., Final Report on Project Management Oversight for the Detroit Central Automated Transit System, May 25, 1989, p. 1-2.

31. WMATA, FY 1988 Approved Budget: Financial Program and Summaries, Volume 1, p. 46.

32. MARTA, Fiscal Year 1987 Section 15 Submission, Form 003.

33. DMJM/RKE, "The Baltimore Metro," undated, p. 12.

34. MDTA, Fiscal Year 1987 Section 15 submission, Form 003.

35. NFTA, "Rail Transit Facts," p. 3.

36. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 47.

37. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 003.

38. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.C.

39. MDTA, Fiscal Year 1987 Section 15 submission, Form 003.

40. Fluor Daniel, Inc., Final Report on Project Management Oversight for the Detroit Central Automated Transit System, May 25, 1989, p. 1-2.

41. Phases 1-4 of the Washington Metrorail system, totaling 62.1 miles, were projected to be completed in December, 1976, and to operate until March 1978; W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure III-2, p. 7, and p. 81.

42. Phases 3-8 of the approved two-county Atlanta rail system (Phases 1 and 2 did not entail rail construction) were scheduled to be completed by mid-1977, bringing the system to 27.2 rail route-miles, and to operate until Phase 9 was completed in early 1978; see Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, pp. 217-220 and Figure 5-1, p. 219.

43. The 7.6-mile Section A of Baltimore's planned Phase I rail line was scheduled to be completed during 1978; see Baltimore Mass Transit Authority (MTA) and Maryland Department of Transportation, Final Application of the Maryland Department of Transportation for a Mass Transportation Capital Improvement Grant, July 1972, p. E-2.

44. The 20.5-mile Stage I Miami rail line was expected to open for service during 1983; see Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55.

45. The 6.4-mile Buffalo light rail rapid transit line was projected to begin operation in January, 1982; see Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Figure 4-4, p. 4-12.

46. Pittsburgh's Stage 1 light rail transit reconstruction project was anticipated to be completed during 1983; see Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, Figure IV-12, p. IV-34, and p. IV-33.

47. Portland's Banfield light rail project was expected to reach full operation during early 1985; see Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, p. 3-16.

48. Each of the alternative transit improvement projects originally considered for Sacramento was assumed to be completed by the end of 1985; see Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, p. 3-78. Subsequent documents anticipated that the selected light rail project would be completed by mid-1985; see Urban Mass Transportation Administration and Sacramento Transit Development Agency (STDA), Sacramento Light Rail Transit Project Final Environmental Impact Statement, August 1983, Exhibit 2-24, and pp. 2-43 to 2-44.

49. Construction on Miami's downtown Metromover system was anticipated to begin during 1982, and to reach its midpoint by January, 1983; see Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-67. Thus it appears that the project was expected to be completed sometime during 1984.

50. Construction of Detroit's downtown people mover system was expected to be completed in time to begin service on the system during late 1983; see Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-41.

51. From December 15, 1984, until June 7, 1986, 60.46 miles of the Washington Metrorail system operated, serving 57 stations; see WMATA, "METRO Fact Card," June 1987.

52. On August 16, 1986, the MARTA rail system's South Line was opened to East Point station, bringing the system to 26.8 miles; see MARTA, Division of Service Planning and Scheduling, "Metropolitan Atlanta Rapid Transit Authority: Key Dates," July, 1988.

53. Service on Section A of the planned Baltimore Phase I rail system began on November 21, 1983, and continued until Section B opened for service on July 20, 1987; see DMJM/RKE, "The Baltimore Metro," undated, P. 4.

54. Stage I of the Miami Metrorail line reached full operation during May of 1985; see "Miami's New Metromover," METRO Magazine, May/June 1986, p. 22.

55. The Buffalo light rail line reached full operation on November 26, 1986; see NFTA, "Rail Transit Facts," undated, p. 4.

56. Pittsburgh's Stage I light rail project reached full-scale operation on May 22, 1987; see William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.

57. Revenue service on Portland's completed Banfield light rail line began September 8, 1986; see Tri-Met, Fiscal Year 1987 Section 15 submission, Form 005, p. 1.

58. Sacramento's light rail line began revenue service over its full length on September 5, 1987; see Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-2.

59. Phase I of Miami's downtown Metromover opened for service on April 17, 1986; see "Miami's New Metromover," METRO Magazine, May/June 1986, p. 22.

60. Detroit's downtown people mover began revenue service to 12 of the 13 planned stations during August 1987, with the thirteenth station scheduled to open during late 1988; see Cambridge Systematics, Inc., Advanced Technology Deployment Appraisal: Draft Final Report, prepared for Office of Technical Assistance, Urban Mass Transportation Administration, April 1988, p. 2-4.

61. Forecast data refer to the 62.1-mile Washington Metrorail system (Phases 1-4) originally scheduled to operate from December, 1976, through March, 1978, reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969 (see Figure III-2, p. 7, and p. 81 for planned construction phasing). Forecast data reported in this study are daily averages over this period or annual totals for calendar year 1977.

62. Forecast data refer to the 27.2 miles of the two-county MARTA rail system (originally Phases 3-8) expected to be completed by mid-1977, as reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971 (see pp. 217-220 and Figure 5-1, p. 219 for planned construction phasing). Forecast data reported in this study are daily averages or annual totals for calendar year 1978.

63. Forecast data refer to Section A of Baltimore's planned Phase I rail line, which was originally scheduled to be completed during 1978, as reported in Baltimore MTA and Maryland Department of Transportation, Final Application of the Maryland Department of Transportation for a Mass Transportation Capital Improvement Grant, July 1972 (see p. E-2 for planned schedule). Forecast data reported in this document are daily averages or annual totals for calendar year 1980.

64. Stage I of Miami's Metrorail line was originally expected to open for service during 1983, as reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978 (see p. V-55 for proposed schedule). Forecast data for the line reported in this document apply to calendar year 1985, and apparently assume the presence of a downtown circulator system operating in conjunction with the Metrorail line.

65. Buffalo's light rail rapid transit line was originally projected to begin operation in January, 1982, as reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977 (see Figure 4-4, p. 4-12 for project schedule). Although forecasts of selected variables were reported in that document for the period 1982-95, a comprehensive set of forecast data was developed only for 1995, and it was on the basis of 1995 forecasts that alternatives were compared and evaluated. Thus forecast data reported in this study are daily averages or annual totals for calendar year 1995.

66. Pittsburgh's Stage 1 light rail transit reconstruction project was originally anticipated to be completed during 1983, as reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978 (see Figure IV-12, p. IV-34 for anticipated project schedule). Forecast data reported for the project in that document are daily averages or annual totals for calendar year 1985.

67. Portland's Banfield light rail project was originally expected to reach full operation during early 1985, as reported in Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, (see p. 3-16 for discussion of project schedule). Forecast data for the project reported in that document and related planning studies are daily averages or annual totals for 1990.

68. Planners anticipated that each of the transit improvement alternatives to which Sacramento's light rail project was compared could be completed by 1985, as reported in U.S. Department of Transportation and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, p. 3-78. However, all forecasts on the basis of which these alternatives were compared and evaluated applied to the year 2000.

69. Miami's downtown Metromover project was apparently expected to be completed during 1984, as indicated in Urban Mass Transportation Administration, and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980 (see p. 2-67 for construction plan). Forecast data for the project reported in that document are daily averages or annual totals for calendar year 1985, and reflect the presence of the complete Stage I Metrorail line.

70. Service on the complete Detroit downtown people mover system was expected to begin during late 1983, as reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980 (see p. II-41 for proposed schedule). Forecast ridership-related data reported in that document refer variously to 1985 and 1990, while operating data refer to 1985; forecast data reported in this study are daily averages or annual totals for calendar year 1985.

71. Actual data for the Washington system are reported for WMATA's Fiscal Year 1986 (the period from July 1, 1985 through June 30, 1986), during which 60.46 miles of the planned Metrorail system were in service.

72. Actual data for the Atlanta system are reported for MARTA Fiscal Year 1987 (July 1, 1986 through June 30, 1987); on August 16, 1986) Atlanta's rail system reached 26.8 miles, and remained at that extent throughout the remainder of MARTA's Fiscal Year 1987.

73. Actual data for the Baltimore system are reported for the Baltimore Mass Transit Administration's Fiscal Year 1987 (July 1, 1986 through June 30, 1987), during which rail service was operated on the 7.6-mile Section A of the Authority's Phase I system.

74. Actual data for the Miami Stage I Metrorail line are reported for the Dade County Transit Authority's Fiscal Year 1988 (October 1, 1987 through September 30, 1988), during which both the 21-mile Stage I Metrorail line (which reached full operation during May of 1985) and Phase I of the downtown Metromover system (which opened on April 17, 1986) operated.

75. Actual data for the 6.4-mile Buffalo light rail line, which reached full operation during November, 1986, are reported for NFTA Fiscal Year 1988-89 (April 1, 1988 through March 31, 1989).

76. Except where noted, actual data for Pittsburgh's Stage I light rail project, which began full operation on May 22, 1987, are reported for the Port Authority of Allegheny County (PAT) Fiscal Year 1989 (July 1, 1988 through June 30, 1989).

77. Actual data for Portland's Banfield light rail line, which began full operation during September, 1986, are reported for Tri-Met Fiscal Year 1989 (July 1, 1988 through June 30, 1989).

78. Actual data for Sacramento's light rail line, which began operation on one of its two branches on March 12, 1987, and on the other branch on September 15, 1987 are reported for the Sacramento Regional Transit District's Fiscal Year 1988 (July 1, 1987 through June 30, 1988).

79. Actual data for Miami's downtown Metromover system are reported for the Dade County Transit Authority's Fiscal Year 1988 (October 1, 1987 through September 30, 1988), during which both the 21-mile Stage I Miami Metrorail line (which reached full operation during May of 1985) and Phase I of the downtown Metromover system (which opened on April 17, 1986) operated.

80. Actual data for Detroit's downtown people mover system are daily averages or annualized-equivalents reported by the Detroit Transportation Corporation (DTC), the system's operator, for the period from August 1987 through June, 1988. During this period, 12 of the system's planned 13 stations were in service.

Source Notes for Table 2-1.
FORECAST AND ACTUAL RIDERSHIP FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in This Table Apply										
Forecast data	See source notes to Table 1-1									
Actual data	See source notes to Table 1-1									
Weekday Rail Passengers (thousands)										
Forecast	1	NF	2	3	4	5	6	7	8	9
Actual	10	11	12	13	14	15	16	17	18	19
Weekday Systemwide Transit Trips After Completion of Rail Project (thousands)										
Forecast	20	21	NF	22	23	24	25	26	--	--
Actual	27	28	29	30	31	32	33	34	--	--
Weekday Systemwide Ridership Impact of Rail Service (thousands)										
Year	NF	35	NF	36	37	NF	38	39	--	--
Riders	40	41	42	43	44	45	46	47	--	--

NF indicates that no published forecast of a data item was obtainable.

Source Notes for Table 2-1.

1. Calculated from forecast of rail ridership for Phase 4 of the Washington Metrorail system, which was expected to operate during 1977, reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table IX-6, p. 71. Converted to average weekday figure using 294.9 average weekday equivalents per year, the weighted average of annualization factors eeported in Table IX-1, p. 65, using as weights the distribution of rail passengers by access and egress mode projected for 1975, reported in Table VIII-4, p. 63. The resulting ridership forecast is consistent with approximately linear growth between forecasts reported for 1975 and 1990 in Table VIII-4, p. 63, and Table IX-4, p. 68.

2. Lower limit of range of forecast average daily boardings during 1980 on Metro Section A only, reported in Baltimore MTA, Baltimore Region Rapid Transit System: Phase I Report, Project T9-6, January 1974, Figure 37. Because the range of forecasts reported is intended to account for possible losses in ridership due to scope changes, and the line actually built was shorter than that originally planned, the lower limit of this range appears to be the appropriate forecast.

3. Forecast of 1985 average daily rail ridership ("guideway trips"), reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program - Stage I Rapid Transit System, May 1977, Table IV-16, p. IV-56.

4. Derived from estimate of 184,000 average weekday transit trips (for the selected "Minimum LRRT" alternative) during 1995, reported in U.S. Department of Transportation, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-7, p. 3-31; and the estimate that 50% of transit trips are forecast to be rail-only or bus-rail trips, each of which thus entails one rail passenger trip, reported in NFTA, Evaluation of Transit Alternatives: Buffalo-Amherst-Tonawandas Corridor, February 1976, Table D-2, p. 56.

5. Sum of Stage I LRT daily boarding forecasts by stop for 1985, reported in U.S. Department of Transportation, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, August 1978, Table V-4, p. V-12. This table also appears as U.S. Department of Transportation, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, Table V-4, p. V-12.

6. Forecast of average daily light rail passenger boardings during 1990, reported in Tri-Met, East Side Transit Operations, December 1977, Table 5, p. 37.

7. Forecast of average daily LRV trips with light rail in both Folsom and I-80 corridors ("Alternative 4C: LRT/LRT"), reported in U.S. Department of Transportation and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 50, p. 4-30.

8. Forecast of average "workday" (presumably weekday) passenger boardings on Metromover, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, pp. 2-45 and 2-46.

9. Forecast of average daily people-mover trips during 1990, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-42. Although this figure is for 1990, a subsequent document (Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980) predicts 1985 revenue at $6,089,000, with an average fare of $0.30 in that year. The implied 1985 forecast of average weekday ridership is 67,700 based on 300 weekday equivalents per year.

10. Average weekday equivalent of rail-only plus bus-rail trips during July 1985-June 1986 (WMATA Fiscal Year 1986), reported in WMATA, FY 1988 Approved Budget: Financial Program and Sum-

maries, Volume 1, p. 52. Converted from annual total to average weekday figure using 281.6 average weekday equivalents per year, the ratio of annual to average weekday Metrorail ridership reported in WMATA, "Bus and Rail Ridership," Office of Planning, December 1988, p. 1.

11. Average weekday equivalent of rail passengers ("rail entries") carried during July 1986-June 1987 (MARTA Fiscal Year 1987), supplied by MARTA personnel by telephone, August 31, 1988. Converted from annual total to average weekday figure using 291.2 average weekday equivalents per year, the ratio of annual total to average weekday rail boardings ("rail unlinked trips") during FY1987, reported in MARTA, FY1987 Section 15 Submission, Form 407.

12. Average daily unlinked rail trips during July 1986-June 1987 (Baltimore MTA Fiscal Year 1987), reported in Baltimore MTA, FY1987 Section 15 Submission, Form 407.

13. Average daily unlinked trips on the Miami Metrorail system during October 1987-September 1988 (Metro Dade Transit Agency Fiscal Year 1988), reported in Metro Dade Transit Agency, FY1988 Section 15 submission, Form 407.

14. Derived from estimate of annual rail passengers for April 1988-March 1989 (NFTA Fiscal Year 1988-89), provided by NFTA Planning Department, August 18, 1989, annualized assuming 276 average weekday equivalents per year, the ratio of annual total to average weekday unlinked bus trips for FY1988-89, reported in NFTA, FY1988-89 Section 15 submission, Form 406.

15. Average weekday light rail passengers during July 1988-June 1989 (PAT Fiscal Year 1989), reported in PAT, Service Development Department, "Ridership Analysis for June 1989," Fiscal Year 1989 Ridership (page not numbered).

16. Average weekday light rail boardings during July 1988-June 1989 (Tri-Met Fiscal Year 1989), reported in Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 6.

17. Average daily unlinked rail trips during July 1988-June 1989 (SRTD Fiscal Year 1989), reported in SRTD, FY1989 Section 15 submission, Form 407.

18. Average daily unlinked rail trips on the Miami Metromover system during October 1987-September 1988 (Metro Dade Transit Agency Fiscal Year 1988), reported in Metro Dade Transit Agency, FY1988 Section 15 submission, Form 407.

19. Average weekday boardings on the Detroit people-mover for September 1987 through April 1988, reported in DTC, internal memorandum, May 6, 1988 (page not numbered).

20. Forecast of total daily transit ridership during 1977, derived from interpolation between total annual transit ridership forecasts for 1975 and 1990 reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table VIII-4, p. 63, Table IX-3, p. 67, and Table IX-4, p. 68. Converted from annual total to average weekday figure using 295.2 average weekday equivalents per year, the weighted average of annualization factors reported in Table IX-1, p. 65, using as weights the distribution of all transit passengers by access and line-haul modes projected for 1975, reported in Table Viii-4, p. 63.

21. Average weekday equivalent of total annual ridership projected to occur during 1978, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary

Engineering, Volume I, December 1971, Table 4-30, p. 215. Converted from annual total to average weekday figure using 296.0 weekday equivalents per year, the ratio of annual total to average weekday revenue passengers forecast for 1983, reported in Table 4-26, p. 207.

22. Forecast of average daily linked trips during 1985, computed from forecast of 1985 average daily total transit boardings ("Total Modal Trips") divided by average number of boardings per linked trip ("Average # Transfers"), reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program - Stage I Rapid Transit System, May 1977, Table IV-16, p. IV-56.

23. Forecast of average weekday transit trips during 1995 with the selected alternative (the "Minimum LRRT" alternative), reported in U.S. Department of Transportation, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-7, p. 3-31.

24. Forecast of average weekday South Hills corridor transit trips during 1985, derived from U.S. Department of Transportation, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, pp. V-2 and V-11, and Table V-4, p. V-12; assumes average daily corridor transit ridership was forecast to grow at the same rate as average daily light rail ridership from 1985 through 2000 (no explicit forecast of total corridor ridership was reported for 1985).

25. Forecast of total daily transit trips during 1990 for alternative #5-1 (LRT on Burnside Street), reported in Tri-Met, Travel Demand Forecasts, May 1978, Appendix D-4 (page not numbered).

26. Forecast of average daily total transit trips during 2000 with light rail in both Folsom and I-80 corridors "Alternative 4C: LRT/LRT"), reported in U.S. Department of Transportation and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 50, p. 4-30.

27. Average weekday equivalent of total transit trips for Fiscal Year 1986, reported in WMATA, FY 1988 Approved Budget: Financial Program and Summaries, Volume 1, p. 52. Converted from annual total to average weekday figure using 309.9 average weekday equivalents per year, calculated as the weighted average of the ratios of annual to average weekday Metrorail and Metrobus ridership during FY 1986, reported in WMATA, "Bus and Rail Ridership," Office of Planning, December 1988, p. 1, using as weights the shares of bus-only and rail-only plus bus-rail trips in total transit ridership.

28. Average weekday equivalent of linked trips for Fiscal Year 1987, reported in MARTA, "Patronage History -- Revenue," Transit Operations Department, July 1988. Converted from annual total to average weekday figure using 305.3 weekday equivalents per year, the ratio of annual total to average weekday revenue passengers during FY1989, reported in MARTA, "Facts About MARTA."

29. Estimated from average weekday unlinked trip data reported in Baltimore MTA, Fiscal Year 1987 Section 15 submission, Forms 406 and 407, and estimates of average transfers per linked trip and fraction of rail trips using bus access, provided by MTA personnel.

30. Estimated from average weekday unlinked trip data reported in Metro Dade Transit Agency, FY1988 Section 15 submission, Forms 406 and 407, and intermodal transfer percentages derived

from Metro Dade Transit Agency, "Transit Ridership Report," October 1987, Table 4, p. 5, Table 4A, p. 6, Table 6, p. 9, and Table 8, p. 12.

31. Estimate of average weekday linked transit trips, derived from estimated annual unlinked transit trips for FY1988-89, adjusted to linked trips using ratio of estimated FY1987-88 linked trips to FY1987-88 unlinked trips; both estimates provided by NFTA Planning Department, August 18, 1989. Converted from annual total to average weekday figure using 276 average weekday e-quivalents per year, the ration of annual total to average weekday unlinked bus trips during FY1988-89, reported in NFTA FY1988-89 Section 15 submission, Form 406.

32. Estimate of average weekday (linked) transit trips, derived from data on total boardings and transfers reported in PAT, Service Development Department, "Ridership Analysis for June 1989," Average Weekday Ridership by Corridor and Registration by Location (pages not numbered).

33. Average weekday originating transit trips, reported in Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 1.

34. Estimate of average weekday (linked) transit trips, derived from average weekday unlinked bus and rail trip data for Fiscal Year 1989 and estimate of average transfers per linked trip supplied by Sacramento Regional Transit District personnel in telephone conversation, September 1989.

35. Calculated from item 21 minus forecast of average daily Atlanta-area transit ridership without rail service during 1978 (129,300), interpolated from 1970 actual daily transit ridership and 1995 forecast daily ridership without rail service reported in Parsons Brinckerhoff-Tudor-Bechtel, <u>Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I</u>, December 1971, p. 244, assuming constant annual percentage growth between those two years.

36. Calculated from item 22 minus forecast of average weekday system-wide ridership (388,000) for "Low-Cost Bus" alternative (Alternative 0), reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, <u>Preliminary Draft E-nvironmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System</u>, May 1977, Table III-1, p. III-17.

37. Calculated from item 23 minus forecast of average weekday total transit ridership (103,000) for the "Improved Bus" alternative, reported in Urban Mass Transportation Administration, <u>Draft En-vironmental Impact Statement: Buffalo Light Rail Rapid Transit Project</u>, June 1977, Table 3-2, p. 3-13.

38. Calculated from item 25 minus average daily total transit ridership forecast (212,714) for Alter-native #2 ("Low-Cost Improvements"), reported in Tri-Met, <u>Travel Demand Forecasts</u>, Appendix D-4 (page not numbered).

39. Calculated from item 26 minus forecast of average weekday area-wide transit ridership with TSM improvements in both I-80 and Folsom corridors ("Alternative 2: TSM/TSM"), reported in U.S. Department of Transportation and Sacramento Area Council of Governments, <u>Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California</u>, April 1981, Table 50, p. 4-30.

40. Calculated from item 27 minus average weekday system-wide transit trips during WMATA FY1975, the last full year of bus-only service (estimated to be 416,400), derived from American Public Transit Association, Transit Operating Report, 1975, p. D-189 (annual ridership converted to average weekday estimate using 295 average weekday equivalents per year, the figure projected for 1975; see note 20 to Table 2-1).

41. Calculated from item 28 minus average weekday system-wide transit trips during MARTA FY1979, the last full year of bus-only service, derived from MARTA, Division of Service Planning and Scheduling, "Patronage History -- Revenue (Linked)," July 1988 (annual ridership during 1979 converted to average weekday estimate using 300 average weekday equivalents per year).

42. Calculated from item 29 minus average weekday system-wide ridership during Baltimore MTA FY1983, the last full year of bus-only service, derived from National Urban Mass Transportation Statistics: 1983 Section 15 Report, Table 3.16, p. 3-276, and estimate of average number of transfers per linked trip for 1983 supplied by Baltimore MTA personnel (annual ridership converted to average weekday estimate using 300 average weekday equivalents per year).

43. Calculated from item 30 minus average weekday system-wide ridership during Metro-Dade TA FY1983, the last full year of bus-only service, estimated from unlinked trip data reported in National Urban Mass Transportation Statistics: 1983 Section 15 Report, Table 3.16, p. 3-278, and estimate of average transfers per linked trip derived from American Public Transit Association, 1976 Transit Operating Report, p. D-109, and American Public Transit Association, 1977 Transit Operating Report, p. D-105 (annual ridership converted to average weekday estimate using 300 average weekday equivalents per year).

44. Calculated from item 31 minus average weekday system-wide ridership during NFTA FY1983-84, the last full year of bus-only service, derived from National Urban Mass Transportation Statistics: 1984 Section 15 Report, Table 3.16, p. 3-312, and estimate of average number of transfers per linked trip for 1984 supplied by NFTA Planning Department personnel (annual ridership converted to average weekday estimate using 280 average weekday equivalents per year, the ration of annual total to average weekday unlinked bus trips during FY1983-84, reported in NFTA, FY1983-84 Section 15 submission, Form 406).

45. Calculated from item 32 minus average weekday South Hills corridor ridership during PAT FY1986, the last full year of bus-only service, derived from average weekday boardings and transfer counts reported in PAT, Service Development Department, "June 1987/1986 Ridership Summary," Average Weekday Passenger Comparison -- Corridor Summary" (page not numbered).

46. Calculated from item 33 minus average weekday system-wide ridership (115,400) during Tri-Met FY1986, the last full year of all-bus service, reported in Tri-Met, "June 1987 Monthly Performance Report," July 20, 1987, p. 1.

47. Calculated from item 34 minus average weekday system-wide ridership during SRTD FY1986, the last full year of bus-only service, derived from unlinked trip data reported in National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.16, p. 3-289, and estimate of average transfers per linked trip supplied by SRTD personnel (annual ridership converted to average weekday estimate using 300 average weekday equivalents per year).

Source Notes for Table 2-2.
FORECAST AND ACTUAL VALUES OF FACTORS INFLUENCING RAIL PROJECT RIDERSHIP

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in this Table Apply										
Forecast data	See source notes to Table 1-1									
Actual data	See source notes to Table 1-1									
Demographic Factors										
Service area population (thousands)										
Forecast	1	2	NF	3	4	5	6	7	8	9
Actual	10	11	12	13	14	15	16	17	18	19
Downtown employment (thousands)										
Forecast	20	21	NF	22	23	24	25	26	27	28
Actual	29	30	NA	31	32	33	34	35	36	37
Rail Service and Fares										
Peak rail headways (minutes)										
Forecast	38	39	40	41	42	43	44	45	NF	46
Actual	47	48	49	50	51	52	53	54	55	56
Speed in passenger service (mph)										
Forecast	57	58	NF	59	60	61	62	63	64	65
Actual	66	67	68	69	70	71	72	73	74	75
Average fare (1988 dollars)										
Forecast	76	77	78	79	80	81	82	83	84	85
Actual	86	87	88	89	90	91	92	93	94	95

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 2-2 (continued).

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
Feeder Bus Service and Use								
Number of rail stations served								
Forecast	96	97	NF	NF	98	99	100	101
Actual	102	103	104	105	106	107	108	109
Total number of feeder routes								
Forecast	110	111	NF	NF	112	113	114	NF
Actual	115	116	117	118	119	120	121	122
Peak bus headways at rail stations (minutes)								
Forecast	123	124	NF	125	126	127	128	129
Actual	130	131	132	133	134	135	136	137
% of rail riders using feeder buses								
Forecast	138	139	140	141	142	143	144	145
Actual	146	147	148	149	150	151	152	153
Auto Cost Assumptions (1988 dollars)								
Operating cost per mile								
Forecast	154	155	NF	156	157	NF	158	159
Actual	160	161	162	163	164	165	166	167
Downtown parking cost (all day)								
Forecast	168	169	NF	170	171	NF	172	173
Actual	174	175	176	177	178	179	180	181

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 2-2.

1. Population forecast for Washington, D.C. metropolitan area during 1977, interpolated from forecasts of 3.1 million for 1975 and 4.2 million for 1990 assuming a constant annual percentage growth rate between these years. The metropolitan area is area defined to include the District of Columbia, Alexandria, Arlington County, Fairfax County, Montgomery County, and Prince Georges County, an area considerably more extensive than that served by the version of the system expected to operate during 1977. These forecasts and the assumption of linear population growth between 1975 and 1990 are reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, pp. 2 and 4.

2. Interpolated from 1970 actual and 1983 forecast populations of Fulton and DeKalb Counties, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-5, p. 137, assuming constant annual percentage growth between those dates.

3. Forecast of 1985 Dade County population, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, Figure II-3, p. II-8. On p. II-7 of that document, the original source of this forecast is reported as the Dade County Comprehensive Development Master Plan Annual Report (CDMP) of 1976.

4. The population forecasts underlying the 1995 travel demand and transit use estimates used to compare alternative transit improvement projects for Buffalo are reported in Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Report, June 1976, Table II-6, p. 62, and Table II-7, p. 64. While this document presents a variety of other population forecats for different geographic areas, the discussion on p. 47 clearly indicates that those appearing in Table II-6 were used to prepare the travel demand and transit ridership estimates on the basis of which alternatives were compared. However, no measures of actual population are available for a geographic area corresponding exactly to the definition of the Buffalo-Amherst corridor to which these forecasts apply. The corridor population forecast reported in Table 2-2 of this study was calculated as the sum of 1995 population forecasts for Buffalo, Amherst, and Tonawandas prepared by the Erie and Niagara Counties Regional Planning Board, reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 2-10, pp. 2-24 to 2-25. The resulting forecast exceeds that on which ridership forecasts were based by about 7%, apparently because it includes a small part of the City of Buffalo that was excluded from the original corridor definition.

5. Interpolated from corridor population estimate for 1975 and forecast for the year 2000, reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, pp. 2-6, 2-9, and Table II-2, p. 2-10, assuming a constant annual percentage growth rate between those two years. Year 2000 forecasts included a 19% decline in population from its estimated 1975 level in City of Pittsburgh neighborhoods encompassed by the South Hills corridor (Allentown, Beechview, Banksville, Brookline, Beltzhoover, and Mt. Washington-Duquesne Heights), and approximately stable population in suburban

communities making up the remainder of the corridor (Castle Shannon, Bether Park, Dormont, Mt. Lebanon, and Upper St. Clair).

6. Sum of 1990 forecast populations for 29 Census tracts comprising the Banfield Expressway and Burnside Street Corridors. Population forecasts for individual Census tracts reported in Tri-Met, Planning and Development Department, Travel Demand Forecasts, May 1978, Appendix B-1, "Sketch Planning Data Base" (pages not numbered).

7. Year 2000 forecast for Sacramento Northeast corridor (including Citrus Heights, Arden-Arcade, North Highlands, Carmichael, North Sacramento, Sacramento Central City, Roseville, Fair Oaks, Orangevale, Rio Linda, and South Natomas), reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 32, p. 4-6.

8. Forecast of 1985 resident population in Miami CBD, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 3-9. This estimate reflects a more restrictive definition of the CBD than that used in forecasting ridership on the Metrorail line.

9. Interpolated from estimated 1978 resident population and forecast 1990 resident population in the DPM service area, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. III-10, assuming constant annual percentage growth rate between those years.

10. Population estimate for the Washington Metropolitan Statistical Area during 1986, less estimated 1986 populations of Loudon, Prince William, Calvert, Charles, Frederick, and Stafford Counties. These estimates are reported in Metropolitan Washington Council of Governments, "Economic Trends in Metropolitan Washington," April 1987, pp. 5 and 7. The resulting estimate applies to an area nearly identical to that for which forecast population was reported.

11. Estimated population of Fulton and DeKalb Counties on April 1, 1987, provided by Ms. Phyllis Summers, Atlanta Regional Commission, June 9, 1988.

12. Estimate of 1980 population in corridor served by Section A of Baltimore rail line, reported in Baltimore Regional Planning Commission, "Section A Baltimore Metro Impact Study: A Before and After Comparison," Staff Paper 54, September 1987, p. 33.

13. Estimate of Dade County population during December 1986, provided by Metro-Dade Planning Department, August 31, 1988. Agrees closely with estimated 1986 Dade County population reported in U.S. Department of Commerce, Statistical Abstract of the United States, 1988, December 1987, Table

14. Estimate of actual population of Buffalo, Amherst, and Tonawanda on July 1, 1986, prepared by U.S. Bureau of the Census, provided by Erie and Niagara Counties Regional Planning Board, September 1, 1989.

15. Estimate of actual 1985 corridor population, reported in Southwestern Pennsylvania Regional Planning Commission (SWPRC), Population, Households, and Employment: 1985, 1990, and 2000, May 1988. The definition of the South Hills Corridor to which this estimate applies differs slightly from that for which population forecasts were prepared during the planning process for the project.

16. Total estimated 1987 population of 29 Census tracts comprising the Banfield Expressway and Burnside Street Corridors. Population estimates for individual Census tracts provided by Metropolitan Service District of Portland, Oregon, Data Services Division.

17. Estimate of actual 1989 population for Sacramento Northeast corridor (see note 7 above for corridor definition), provided by Sacramento Area Council of Governments, August 28, 1989.

18. Estimated 1985 resident population of Miami CBD during 1985, reported in Miami Downtown Development Authority, "DDAfacts," January 1986.

19. Interpolated from estimated 1985 resident population and forecast 1990 resident population of DPM service area, provided by Coordinator, Long Range Transportation Planning, DTC.

20. Employment forecast for "Sector 0" of the District of Columbia during 1977, interpolated from forecasts of 343,000 for 1975 and 501,000 for 1990 assuming a constant annual percentage growth rate between these years. "Sector 0" is defined as the area bounded on the North by S Street, NW; on the east by Florida Avenue, NW-NE, and 4th Street, NE-SE; on the south by North Carolina Avenue, I-95, and Railroad Bridge; and on the west by the Potomac River, Rock Creek, P Street, and Florida Avenue, NW. These forecasts and the assumption of linear employment growth between 1975 and 1990 are reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, pp. 3 and 4; the definition of "Sector)' is reported on p. 3, fn. 1.

21. Interpolated from 1970 actual and 1983 forecast employment for "Superzone 1," reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-8, p. 145, assuming constant annual percentage growth between those years. "Superzone 1" was anticipated to be approximately equivalent to Atlanta's CBD by the time its rail system was completed; see p. 136.

22. Forecast of 1985 employment in districts 1 (Miami CBD) and 3 (remainder of downtown), reported in Dade County Office of Transportation Administration, Metropolitan Dade County Transit Improvement Program: Development and Calibration of Mode Choice Models, Volume I, August 1975, Appendix D2, p. 204. The original source of this forecast is reported as Dade County Comprehensive Development Plan; thus, it appears to be consistent with the forecast of Dade County population used to forecast rail system ridership.

23. Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Report, June 1976, p. 34 and Table II-9, p. 65. The area labeled "Sub-Zone Group 1" in these forecasts corresponds to the Buffalo CBD, as indicated in Figure II-15, p. 66.

24. Interpolated from estimate of actual CBD employment during 1975 and year 2000 forecast of CBD employment, reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit

Reconstruction: Draft Environmental Impact Statement, July 1978, p. 5-148, assuming constant annual percentage growth rate between those years.

25. Sum of 1990 forecast employment in 5 Census tracts comprising the Portland CBD. Employment forecasts for individual Census tracts reported in Tri-Met, Planning and Development Department, Travel Demand Forecasts, May 1978, Appendix B-1, "Sketch Planning Data Base" (pages not numbered).

26. Year 2000 employment forecast for Central City of Sacramento urbanized area, reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 33, p. 4-7. The definition of the "Central City" to which this forecast applies is not specified in this document.

27. Forecast of 1985 employment in Miami CBD, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 3-10. This estimate reflects a more restrictive definition of the CBD than that used in forecasting ridership on the Metrorail line.

28. Interpolated from estimated 1978 employment and forecast 1990 employment in the DPM service area, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. III-10, assuming constant annual percentage growth rate between those years.

29. Employment estimate for Washington CBD during 1986, provided by Metropolitan Washington Council of Governments, August 31, 1988. The definition of the CBD to which this estimate applies differs slightly from that in the forecast, in that it is bounded on the north by U Street rather than by S Street. As a result, this figure applies to a slightly larger area than does the forecast, and gives a slight overestimate of actual 1986 employment in the area referred to by the forecast.

30. Estimated from 1970-85 employment growth in zones of one-half mile radius surrounding five CBD-area stations, reported in Atlanta Regional Commission, "Employment Analysis: Transit Station Areas and the Atlanta Region, 1970-85," September 1987, pp. B-3, B-4, B-5, and 9-42. Total employment growth in the five station areas (which together accounted for 53% of "Superzone 1" employment during 1970) between 1970 and 1985 was 9.88%, or 0.63% per year. Assuming that this same growth rate applied to "Superzone 1" employment and continued until 1987, its employment would have reached approximately 170,200 by 1987.

31. Estimate of employment in downtown Miami during 1985, reported in Miami Downtown Development Authority, "DDAfacts," January 1986. The definition of downtown to which this estimate applies, which is considerably larger than CBD, appears to correspond closely to that for which forecast employment was reported.

32. Interpolated from estimate of actual 1980 CBD employment and "base case" forecast of 1990 CBD employment prepared by Buffalo Regional Center, obtained from Buffalo Department of City Planning, September 1988.

33. Estimate of actual 1985 CBD employment, reported in Southwestern Pennsylvania Regional Planning Commission (SWPRC), Population, Households, and Employment: 1985, 1990, and 2000, May 1988.

34. Total estimated 1987 employment in 5 Census tracts comprising the Portland CBD. Employment estimates for individual Census tracts provided by Metropolitan Service District of Portland, Oregon, Data Services Division.

35. Derived from estimate of actual wage and salary employment in Sacramento County during December, 1987, provided by Employment Data and Research Division, California State Employment Development Department, August 28, 1989. Assumes that the relationship between wage and salary employment in Sacramento County and total employment in the Sacramento urbanized area during December 1987 is the same as that during 1980, and that the Central City of the Sacramento urbanized area represented 26% of total urbanized area employment during December 1987. (The Central City was estimated to include 28% of total urbanized area employment during 1980, a figure that was forecast to decline to 22% by the year 2000; see Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 33, p. 4-7.)

36. Estimate of employment in Miami CBD during 1985, reported in Miami Downtown Development Authority, "DDAfacts," January 1986. The definition of the CBD to which this estimate applies completely encompasses the Metromover loop, and appears to correspond closely to that for which forecast employment was reported.

37. Interpolated from estimated 1985 actual employment and 1990 forecast employment in DPM service area, provided by Coordinator, Long Range Transportation Planning, DTC.

38. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure XI-1, p. 82. Peak-period headways on individual branches projected to be in service during 1977 were four minutes, resulting in cumulative headways of two minutes on central parts of the system, where two lines operated using a single track.

39. Ninety-second headways were assumed during both future years (1983 and 1995) for which detailed forecasts of rail system ridership were prepared; see Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, pp. 116 and 117.

40. Federal Highway Administration and Urban Mass Transportation Administration, Final Environmental Impact Statement: Relocated U.S. Route 140, Baltimore City Line to Reisterstown and Phase 1 Rapid Transit, Baltimore City Line to Owings Mills, Baltimore County, Maryland, January 1977, p. D-27.

41. Reported in Dade County Office of Transportation Administration, Metropolitan Dade County Transit Improvement Program: Development and Calibration of Mode Choice Models, Volume I, August 1975, Appendix D7, p. 226. Reported figure is forecast of peak headway for line 2, which is identical to that actually built, although cumulative headways resulting from multiple-

line service on most of the route actually built would probably have been shorter than 6 minutes.

42. Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Report, June 1976, Table VI-5, p. 189.

43. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. 4-25.

44. Five-minute peak headways were planned for the segment of the corridor closes to downtown (the Banfield corridor), with 10-minute headways planned for the outer (Burnside Street) segment of the line; see Federal Highway Administration and Oregon State Highway Division, Banfield Transitway Draft Environmental Impact Statement, February 1978, p. 119.

45. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, p. 3-39.

46. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. II-49.

47. WMATA, "All About the Metro System," September 1986. Peak period headways on most individual branches in service during 1986 were six minutes, resulting in cumulative headways of three minutes on central parts of the system.

48. MARTA, System Map, January 1987.

49. Baltimore MTA, System Map, September 1987.

50. MDTA, Transit Map of Metro-Dade County, Effective April 3, 1988.

51. NFTA, "Rail Transit Facts," undated, p. 3.

52. PAT, Timetable for Subway -- Local, 1988.

53. Tri-Country Metropolitan Transportation District of Oregon, Transportation Guide and Map for the Portland Metropolitan Area, April 3-September 3, 1988, pp. 59-62. Peak period headways vary along the route, with more frequent service operated on the segment of the line closer to downtown.

54. Sacramento Regional Transit District, RT Metro Light Rail Timetable, January 1988.

55. Estimate supplied by Operations Planning and Scheduling Division, MDTA, August 17, 1988.

56. Reported in DTC, "The People Mover -- Detroit in Motion," undated.

57. Calculated from projected running and dwell times and planned station spacings reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure XI-2, p. 83. Figure is overall average for parts of the system expected to operate during 1977.

58. Estimated from sample travel times for trips using rail system reported in MARTA, Summary Response to Guidelines for Capital Grant Project Selection, September 1972.

59. Calculated from travel speed forecasts reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, Table IV-3, p. IV-26. These forecasts are repeated in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. IV-14.

60. Reported in Niagara Frontier Transportation Authority, Metro Construction Division, Evaluation of Transit Alternatives, Buffalo-Amherst-Tonawandas Corridor: Staff Conclusions and Recommendations, February 1976, Table D-1, p. 55. Agrees closely with speeds computed from forecast travel times for the full 6.4-mile route reported in Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Report, June 1976, Table Vi-6, p. 189, and in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 5-60.

61. Computed from forecast travel time between South Hills Village and downtown Pittsburgh (Steel Plaza) of 37.4 minutes, reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. 4-24.

62. Calculated from forecast travel time of 34 minutes from downtown Portland (apparently Pioneer Square) to Gresham terminal, reported in Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, Table 11, p.165.

63. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 12, p. 3-57.

64. Calculated from forecast round trip time on Metromover loop reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-17.

65. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. II-15.

66. Calculated from station-to-station travel times reported in WMATA, "All About the Metro System," September 1986. Figure is overall average for system operating during 1986.

67. Computed from travel times and distances reported in Metropolitan Atlanta Rapid transit Authority, "A Guide to MARTA," undated; figure is average for all system in service during 1987.

68. Computed from travel times and distances between stations reported in Baltimore MTA, System Map, September 1987.

69. Calculated from scheduled travel time of 38 minutes for complete 21-mile route, reported in MDTA, Transit Map of Metro-Dade County, Effective April 3, 1988.

70. Computed from scheduled travel time of 22 minutes for the full 6.4-mile route reported in NFTA, Metro Rail Schedule, effective March 20, 1988.

71. Computed from scheduled travel time of 35 minutes between South Hills Village and downtown Pittsburgh (Steel Plaza) reported in PAT, Timetable for Route 42S (via Beechview), 1988.

72. Calculated from scheduled peak period travel time of 46 minutes from downtown Portland (pioneer Square South) to Cleveland Avenue (line terminus), reported in Tri-Country Metropolitan Transportation District of Oregon, Transportation Guide and Map for the Portland Metropolitan Area, April 3-September 3, 1988, pp. 61-62.

73. Computed from scheduled end-to-end travel time of 53.5 minutes reported in Sacramento Regional Transit District, RT Metro Light Rail Timetable, January 1988.

74. Calculated from estimates of train-miles and train-hours of revenue service, reported in MDTA, Fiscal Year 1987 Section 15 Submission, Form 407. (Because the Metromover guideway forms a complete loop, the average speed of trains in revenue service closely approximates the speed of passenger service.)

75. Calculated from time to make full circuit (including station dwell times) reported in DTC, "The People Mover -- Detroit in Motion," undated.

76. Average fare of $0.38 in 1968 dollars, reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, p. 71. This and all other figures originally stated in other years' dollars were converted to 1988 dollar equivalent using the change in the Implicit Price Deflator for Gross National Product reported in U.S. Department of Commerce, Survey of Current Business, various issues.

77. Average current-dollar fare of $0.15 during 1978, estimated from Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-30, p. 215, and Table 5-3, p. 234, converted to 1988 dollar equivalent.

78. Projected adult base fare during 1980 reported in Maryland Department of Transportation, Final Application for a Mass Transportation Capital Improvement Grant Under the Urban Mass Transportation Act of 1964, July 1972, p. B-1, converted to 1988 dollar equivalent.

79. Forecast of $0.50 (apparently in 1975 dollars), reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977; converted to 1988 dollar equivalent. (The same figure appears without reference to the dollars in which it is denominated, in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55. This reference also states that the fare will increase 4% per year from the initial level of $0.50, in which case it would have reached $0.63 during 1985. The equivalent of this figure in 1988 dollars is $0.69.)

80. Forecast average fare revenue per originating passenger of $0.38 (in 1974 dollars), reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-7, p. 3-31, note 2; converted to 1988 dollar equivalent.

81. Projected basic adult fare from Washington Junction to downtown Pittsburgh, reported in Urban Mass Transportation Administration, "Memorandum of Approval -- Capital Grant PA-03-0095," April 1979, p. 3; converted to 1988 dollar equivalent.

82. Average fares of $0.33 for work trips and $0.27 for non-work trips (in 1976 dollars) are reported to have been used to develop 1990 ridership forecasts for the alternatives from which the Banfield LRT project was selected; see "Banfield Patronage Estimates," Tri-Met Inter-Office Memorandum, December 2, 1980. Assuming that one-third of all trips were forecast to be work trips, while the remaining two-thirds were forecast to be non-work trips, the overall average fare projected for 1990 would have been $0.29; this figure was then converted to its 1988 dollar equivalent.

83. Average fare of $0.35 (in 1980 dollars), reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 100, p. 4-192; converted to 1988 dollar equivalent.

84. Forecast fare was $0.25 (apparently in 1985 dollars), as reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-50. However, that reference also indicates that transfers from Metrorail to the Metromover would be free, while Metromover riders would be entitled to a 25-cent discount upon transferring to Metrorail. Since about 20% of Metromover riders were forecast to use the Metromover in conjunction with trips on Metrorail, the implicit forecast of the average fare paid by Metromover riders would have been approximately $0.20 (in 1985 dollars); this estimate was then converted to its 1988 dollar equivalent.

85. Forecast of 1985 base fare, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. III-7; converted to 1988 dollar equivalent.

86. WMATA, FY 1988 Approved Budget: Financial Program and Summaries, Volume I, p. 46.

87. Average actual fare during the period from September 1986 to August 1987, when 26.2 miles of Atlanta's rail system were in operation; reported in MARTA, "Monthly Statistics Summary," September 1987; converted to 1988 dollar equivalent.

88. Adult base fare for rail travel during 1987, reported on Baltimore Mass Transit Administration, System Map, September 1987; converted to 1988 dollar equivalent.

89. Average fare paid by Metrorail riders excluding Monthly, Employee, and Special Pass users. Computed from total cash revenue paid by boarding passengers and number of fare-paying passengers boarding Metrorail, reported in MDTA, "Transit Ridership Report," October 1987, Table 4, p. 5, and Table 4A, p. 6.

90. Fiscal Year 1988 total fare revenue of $18.99 million, reported in NFTA, "Statement of Revenues and Expenses: Fiscal Year 1988," June 1988, divided by estimated FY88 revenue passenger trips of 91.5 million, reported in Table 2-1.

91. Basic adult fare from Washington Junction to downtown Pittsburgh, from PAT, Timetable for Route 42S (via Beechview), 1988.

92. Average fare (apparently per originating passenger trip) during Fiscal Year 1989, reported in Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 2.

93. Estimate of average fare during 1988 reported in Sacramento Area Council of Governments, "Model Factors," March 17, 1988.

94. Average fare paid by Metromover riders excluding Monthly, Employee, and Special Pass users. Computed from total cash revenue paid by boarding passengers, number of fare-paying passengers boarding Metromover, and number of passengers transferring free from Metrorail to Metrmover, reported in MDTA, "Transit Ridership Report," October 1987, Table 6, p. 9.

95. Basic adult fare during 1988, reported in "Rails Move People for Fun But No Profit,: Detroit Free Press, July 29, 1988, p. 3A.

96. Estimated from W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure IV-1, p. 15.

97. Estimated from Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Figure 4-4, p. 121. This figure shows proposed bus feeder routes for 1995; 1978 feeder routes were assumed to be identical to 1995 routes for those stations projected to be in service during 1978, as indicated in discussion of service implementation phasing on pp. 217-220.

98. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 5-4, pp. 5-23 to 5-24.

99. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, Table V-5, p. V-13.

100. Counted from Tri-Met, Planning and development Department, Light Rail Transit Station Zones, December 1977, Table 7, p. 30, and Table 13, p. 43.

101. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 58, p. 4-46, and Table 60, p. 4-52.

102. Counted from WMATA, Metro System Route Map, effective February 1986.

103. Counted from MARTA, System Map, January 1987.

104. Counted from Baltimore Mass Transit Administration, System Map, September 1987.

105. Counted from MDTA, Transit Map of Metro-Dade County, April 1988.

106. Counted from NFTA, Metro Map, 1988.

107. Counted from PAT, 1988 System Map.

108. Counted from Tri-Met, Transportation Guide and Map, April 3-September 3, 1988.

109. Counted from Sacramento Regional Transit District, System Map, July 1988.

110. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table IV-1, p. 16. Figure is for planned 1990 feeder service, and thus overstates number of feeder routes serving stations expected to be in operation during the forecast year.

111. Estimated from Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Figure 4-4, p. 121. This figure shows proposed bus feeder routes for 1995; 1978 feeder routes were assumed to be identical to 1995 routes for those stations projected to be in service during 1978, as indicated in discussion of service implementation phasing on pp. 217-220.

112. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 5-4, pp. 5-23 to 5-24.

113. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, Table V-5, p. V-13.

114. Counted from Tri-Met, Planning and development Department, Light Rail Transit Station Zones, December 1977, Table 7, p. 30, and Table 13, p. 43.

115. Counted from WMATA, Metro System Route Map, effective February 1986. Figure includes only feeder routes serving stations in operation during 1986, and is thus not strictly comparable to forecast.

116. Counted from MARTA, System Map, January 1987.

117. Counted from Baltimore Mass Transit Administration, System Map, September 1987, and Metro--Owings Mills to Charles Center, February 1988.

118. Counted from MDTA, Transit Map of Metro-Dade County, April 1988.

119. Counted from NFTA, Metro Map, 1988.

120. Counted from PAT, 1988 System Map, and Bus Route Timetables (various routes).

121. Counted from Tri-Met, Transportation Guide and Map, April 3-September 3, 1988.

122. Counted from Sacramento Regional Transit District, System Map, July 1988.

123. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table IV-3, p. 17. Figure is for planned 1990 feeder service.

124. All of the stations expected to be in service during 1978 lie inside the region's beltway (I-285), where peak hour bus headways were expected to average approximately 10 minutes; see Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, p. 122.

125. The number of buses required to operate the network of local and feeder bus service planned to accompany alternative A-7, which closely resembles the Metrorail line actually built, was estimated to be 1,146. Because this figure includes a 10% spare allowance, the number of buses expected to operate in peak service was apparently 1,042. However, this is an overestimate of vehicles in peak hour feeder service, since it includes those in non-feeder local service. This estimate is reported in Dade County Office of Transportation Administration, Metropolitan Dade County Transit Improvement Program: Bus feeder an Parking Supports Assessment, October 1976, p. 17.

126. Average for all planned feeder routes (range of planned headways for individual routes is 6-60 minutes), reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 5-4, pp. 5-23 to 5-24.

127. Calculated from Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, Table V-5, p. V-13.

128. Calculated from Tri-Met, Planning and development Department, Light Rail Transit Station Zones, December 1977, Table 1, p. 4, and Table 2, p. 5.

129. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 58, p. 4-46, and Table 60, p. 4-52.

130. Estimated from timetables for a sample of WMATA bus routes serving rail stations in operation during 1986.

131. Estimated from range of peak hour service frequencies for individual feeder routes reported on MARTA, System Map, January 1987.

132. Calculated from Baltimore Mass Transit Administration, System Map, September 1987, and Metro--Owings Mills to Charles Center, February 1988.

133. Number of buses in peak service on a typical weekday, reported in Metro Dade TA, Fiscal Year 1988 Section 15 submission, Form 406.

134. Average headway implied by total of 147 peak-hour bus arrivals (in both directions) at 12 stations receiving feeder bus service, computed from NFTA 1988 Route Schedules.

135. Calculated from PAT, 1988 System Map, and Bus Route Timetables (various routes).

136. Calculated from bus route timetables contained in Tri-Met, Transportation Guide and Map, April 3-September 3, 1988.

137. Calculated from scheduled bus services reported in Sacramento Regional Transit District, Connections: Sacramento Light Rail and Bus Schedule, January 1988.

138. Estimated from W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table VIII-4, p. 63. Data reported in that table apply to 1975, when 44.7 miles of the proposed system were expected to be in operation, and may thus slightly understate the fraction of riders expected to use feeder buses to access the 62.1-mile system expected to operate during 1977.

139. Computed from data reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-22, pp. 197-198, and Table 4-23, p. 200. Figure is average for five stations for which both forecast and actual transfer percentages are available; average for all stations for which forecasts are reported is slightly higher.

140. Average for stations outside downtown, calculated from Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, pp. 7-11.

141. Forecast for unidentified year after completion of Metrorail line, reported in Dade County Office of Transportation Administration, Metropolitan Dade County Transit Improvement Program: Bus Feeder and Parking Supports Assessment, October 1976, p. 10. Since Metrorail access figures reported in this reference omit transfers from Metromover, they appear to apply to suburban-to-downtown trips.

142. Computed from forecast of rail passengers arriving at stations by feeder bus, reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 5-4, pp. 5-23 to 5-24.

143. Calculated from Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, Table V-4, p. V-12.

144. Percent of rail riders transferring to feeder buses during P.M. peak hour at stations outside downtown area. Calculated from Tri-Met, Planning and development Department, Light Rail Transit Station Zones, December 1977, Table 1, p. 4, and Table 2, p. 5.

145. Weighted average for stations outside downtown, computed from Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 41, p. 4-21, Table 42, p. 4-22, Table 58, p. 4-46, and Table 60, p. 4-52.

146. Calculated from data reported in WMATA, FY 1988 Approved Budget: Financial Program and Summaries, Volume I, p. 52. Figure reported is "Bus/Rail Trips" as a percent of "Bus/Rail Trips" plus "Rail Only Trips" for FY 1986.

147. Computed from data reported in MARTA, "Mode of Access to MARTA Stations," June 4, 1985. Figure is for 1985, and applies to five stations for which both forecast and actual transfer percentages were reported.

148. Average for stations outside downtown, reported in Baltimore Mass Transit Administration, "Metro Highlights -- Summary of Origin-Destination Survey," 1987.

149. Percent of passengers boarding Metrorail at stations outside downtown Miami who transfer from buses, calculated from MDTA, "Transit Ridership report," October 1987, Table 4, p. 5.

150. Range for stations outside downtown, reported in NFTA, "Summary of 1987 Rail Rider Survey," July 1987, p. 9.

151. Calculated from PAT, Service Development Department, "Ridership Analysis for May 1988," Corridor Summary (page not numbered), and p. 4.

152. Difference between Fiscal Year 1988 average weekday LRT "boarding rides" and "originating rides," expressed as a percent of "boarding rides." Calculated from Tri-Met, "Revised June Monthly Performance Report," July 27, 1988, p. 6.

153. J.D. Franz Research, Survey of Transit Riders and the Community, conducted for Dona Foran on behalf of Sacramento Regional Transit District, September 1987, Tables 8 and 9. Figures are not strictly comparable to forecast, because forecast applies to morning peak hour, while actual data apply for the entire day.

154. Derived from example reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure VII-3, p. 41. Figure includes only direct operating expenses (gasoline, oil, and tire wear; see p. 44 for discussion), adjusted to equivalent value in 1988 dollars using the change in the Implicit Price Deflator for Gross National Product reported in U.S. Department of Commerce, Survey of Current Business, various issues.

155. Estimated from example reported in MARTA, "Rapid Transit Facts and Figures," undated document apparently prepared for 1971 Rapid Transit Referendum, p. 7.

156. Forecast of $0.07 per mile (in 1976 dollars), reported in Kaiser Transit Group, Priority Engineering and Operational Analyses: Final Report, Dade County Transportation Improvement Program-Stage I, October 1976, p. III-24; figure repeated in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, p. IV-55. Ridership forecasts prepared for Miami's Metrorail project after it was selected as the preferred alternative apparently assumed much higher auto operating costs. However, these references clearly indicate that the assumption used to generate the ridership forecasts reported in these documents, on which the choice among alternatives was based, was the $0.07 per mile figure; this figure was then converted to its 1988 dollar equivalent.

157. Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Appendices, January 1976, p. B-7; converted to 1988 dollar equivalent.

158. Auto operating costs of $0.07 per mile (in 1976 dollars) are reported to have been used to develop 1990 ridership forecasts for the alternatives from which the Banfield LRT project was selected; see "Banfield Patronage Estimates," Tri-Met Inter-Office Memorandum, December 2, 1980; converted to 1988 dollar equivalent.

159. Year 2000 forecast of $0.061 (in 1968 dollars), reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, p. 4-23; converted to 1988 dollar equivalent.

160. American Automobile Association, "Your Driving Costs," 1986 edition; includes gasoline, oil, and tire wear only. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

161. American Automobile Association, "Your Driving Costs," 1987 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

162. American Automobile Association, "Your Driving Costs," 1987 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

163. American Automobile Association, "Your Driving Costs," 1988 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

164. American Automobile Association, "Your Driving Costs," 1989 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

165. American Automobile Association, "Your Driving Costs," 1989 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

166. American Automobile Association, "Your Driving Costs," 1989 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses.

167. American Automobile Association, "Your Driving Costs," 1988 edition. Not adjusted for local variation in fuel costs, insurance expenses, taxes and registration fees, or other components of operating expenses. (Agrees closely with estimate currently employed in Sacramento travel demand modeling, reported in Sacramento Area Council of Governments, "Model Factors," March 17, 1988.)

168. Estimated from relationships of parking costs and extent of availability of free parking to employment density reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure VII-4, p.43, together with average employment density implied by forecast of 1977 employment in downtown Washington reported above. Adjusted to equivalent value in 1988 dollars using the change in the Implicit Price Deflator for Gross National Product reported in U.S. Department of Commerce, Survey of Current Business, various issues.

169. Estimated from example reported in MARTA, "Rapid Transit Facts and Figures," undated document apparently prepared for 1971 Rapid Transit Referendum, p. 7. Adjusted to equivalent value in 1988 dollars using the change in the Implicit Price Deflator for Gross National Product reported in U.S. Department of Commerce, Survey of Current Business, various issues.

170. Weighted average of assumed daily and one-hour parking costs during 1985, reported in Dade County Office of Transportation Administration, Metropolitan Dade County Transit Improvement Program: Development and Calibration of Mode Choice Models, Volume I, August 1975, Appendix D5, p. 209. As indicated in that reference, daily parking costs are assumed to be paid by those making work trips, whereas the projected one-hour parking cost is assumed to apply for all non-work trips. In computing this figure, the weights used are the projected 1985 fractions of work and all other trips reported in Figure 77, p. 140 of this document; the resulting figure was converted to its 1988 dollar equivalent.

171. Niagara Frontier Transportation Authority and Alan M. Voorhees & Associates, Inc., Metro for Buffalo: Transit Alternatives for the Buffalo-Amherst Corridor, Technical Appendices, January 1976, p. B-9; converted to 1988 dollar equivalent.

172. Forecast average 1990 long-term (all day) parking price in the Portland CBD of $1.50 (in 1976 dollars), reported in Tri-Met, Planning and Development Department, Travel Demand Forecasts, May 1978, Table 21 (page not numbered); converted to 1988 dollar equivalent.

173. Year 2000 forecast of $2.98 (in 1980 dollars), reported in Sacramento Area Council of Governments, Sacramento Northeast Corridor Alternatives Analysis/EIS: Working Paper Number 4A, 1980, p. 39; converted to 1988 dollar equivalent.

174. Estimated from JHK & Associates, "Development-Related Ridership Survey: Final Report," prepared for WMATA, March 1978, Table 3, p. 23.

175. Average daily downtown parking fee during July 1984, reported in MARTA, "Parking Fees at MARTA Parking Lots," undated; converted to 1988 dollar equivalent.

176. Estimate of average daily downtown parking fee during 1985 reported in Baltimore Regional Planning Commission, Baltimore Metro Impact Study: Documentation of Baseline Conditions Prior to Operation, Technical Memorandum 51, May 1985, p. 42.

177. Lower end of range of advertised all-day parking rates in downtown during 1985, reported in Miami Downtown Development Authority, "DDAfacts," January 1986.

178. Estimate of daily downtown parking rates reported in The Buffalo News, June 24, 1988; original source not reported.

179. Midpoint of estimated 1988 daily parking prices for Pittsburgh CBD core and CBD fringe areas, provided by Southwestern Pennsylvania Regional Planning Commission.

180. Estimate of average price for all-day parking in Portland CBD during 1988, supplied by Metropolitan Service District of Portland, Oregon, Data Services Division.

181. Estimate of average daily parking cost in Sacramento CBD currently employed in Sacramento travel demand modeling, reported in Sacramento Area Council of Governments, "Model Factors," March 17, 1988.

Source Notes for Table 3-1.
FORECAST AND ACTUAL CAPITAL OUTLAYS FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Wash-ington	Atlanta	Balt-imore	Miami	Buffalo	Pitts-burgh	Port-land[1]	Sacra-mento	Miami	Detroit
	Period During Which Capital Outlays Were Made									
Forecast	1	2	3	4	5	6	7	8	9	10
Actual	11	12	13	14	15	16	17	18	19	20
	Total Capital Outlays in Nominal Dollars (millions)									
Forecast	21	22	23	24	25	NF	26	27	28	29
Actual	30	31	32	33	34	35	36	37	38	39
	Equivalent Total Capital Outlays in 1988 Dollars (millions)									
Forecast	40	41	42	43	44	45	46	47	48	49
Actual	50	51	52	53	54	55	56	57	58	59

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 3-1.

1. DeLeuw, Cather & Co. and Harry Weese & Associates, Preliminary Design and Capital Costs: Adopted Regional System, February 1969, p. 73. The schedule of capital outlays reported in this reference anticipates spending beginning considerably earlier (1969 versus 1972) than those reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure III-2, p. 7, and p. 81 (which are inconsistent). The discrepancy is apparently explained by the fact that pre-construction capital outlays, such as those for right-of-way acquisition and preparation, were scheduled to begin considerably before actual construction activity.

2. Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Figure 5-1, p. 219, and pp. 217-220.

3. Time span of planned capital spending reported in Baltimore Mass Transit Authority (MTA) and Maryland Department of Transportation, Final Application of the Maryland Department of Transportation for a Mass Transportation Capital Improvement Grant, July 1972, p. E-2. Dates refer to Baltimore MTA fiscal years.

4. Projected time span of construction for Stage I Metrorail project, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Final Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1978, p. XI-49.

5. Time span of activities including right-of-way acquisition, line construction, equipment installation, and testing, shown in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Figure 4-4, p. 4-12.

6. Projected schedule for equipment procurement and facilities construction, estimated from Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, Figure IV-12, p. IV-34. The year during which these activities would begin is not explicitly identified in Figure IV-12, but construction was planned to begin immediately after approval of the Final Environmental Impact Statement (published in December 1978) and granting of a federal funding commitment; see p. IV-33.

7. Time span encompassed by projected schedule of outlays in individual spending categories, presented in Tri-Met, Banfield Light Rail Project Grant Application, June 1980, Figure 3 (page not numbered).

8. Time span form earliest possible start of construction to assumed completion date, reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, p. 3-78.

9. Estimated from projected start date of construction, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-51, and total time span of construction inferred from projected start year and midpoint of construction activities, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-67.

10. Time span from anticipated beginning of construction to projected start of revenue service, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, pp. II-41.

11. Derived from schedule of actual capital expenditures for individual rail system components reported in WMATA, Notes to Financial Statements.

12. Time span of actual capital outlays for Phases A, B, C1N, and C1S of Atlanta rail system, reported in MARTA, "History of Incurred Cost by MACS Code: 6/30/75 - 6/30/87," and "MACS Code Summary Reports" for MARTA Fiscal Years 1981-86, supplied by MARTA Budget Control Branch, June 1988.

13. Time span of actual spending for Phase A of Baltimore rail system, reported in Urban Mass Transportation Administration, "Memorandum of Approval -- Capital Grant MD-03-0004-00/14." (need date)

14. Reported in communication accompanying "Rapid Transit Stage I (Metrorail): Expenditures by MACS Code Summary -- Grant FL-03-0036," supplied by Management Services Division, MDTA, May 17, 1988.

15. Time span of actual capital outlays derived from Urban Mass Transportation Administration Memoranda of Approval for Capital Grants NY-03-3187, NY-03-0184-00/01, NY-03-0156-00/01, NY-03-0072-00/11, NY-03-0188-00/01, and NY-90-0001-02.

16. Estimated from Urban Mass Transportation Administration, Memorandum of Approval for Capital Grant PA-03-0095, Amendments 0 through 14.

17. Reported in "Banfield Project Year-by-Year Expenditure", document supplied by Engineering and Project Development Department, Tri-Met (Tri-Met), December 1988; dates refer to Tri-Met fiscal years. (Very small outlays were also made during Fiscal Years 1981 and 1989.)

18. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. 1-6.

19. Reported in communication accompanying "Downtown Component of Metrorail (Metromover): Expenditures by MACS Code Summary -- Grant FL-03-00350, FL-90-0006, FL-90-X016, and FL-90-X042," supplied by Management Services Division, MDTA, May 17, 1988.

20. Time span between construction groundbreaking and start of revenue service, reported in Cambridge Systematics, Inc., Advanced Technology Deployment Appraisal Project: Draft Final Report, prepared for Office of Technical Assistance, Urban Mass Transportation Administration, April 1988, p. 2-4.

21. Derived from constant-dollar estimates of construction costs for individual system components, together with projected schedule for constructing individual system elements and anticipated escalation in yearly construction outlays due to inflation, reported in DeLeuw, Cather & Co. and Harry Weese & Associates, Preliminary Design and Capital Costs: Adopted Regional System, February 1969, pp. 73 and 75.

22. Projected capital outlays including escalation due to anticipated inflation for Phases 3-8 (Phases 1 and 2 represented bus system improvements not related to rail construction), less planned outlays for busways included in original cost estimate but not constructed. Derived from Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, pp. 43-45, Table 5, p. 49. Table 6, p. 50, and Table 7, p. 59.

23. Projected capital outlays including escalation due to anticipated inflation, reported in Baltimore Mass Transit Authority (MTA) and Maryland Department of Transportation, Final Application of

the Maryland Department of Transportation for a Mass Transportation Capital Improvement Grant, July 1972, p. E-2. Dates refer to Baltimore MTA fiscal years.

24. Estimated actual construction outlays for Stage I Metrorail line including escalation due to anticipated inflation, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55.

25. Projected capital outlays including escalation due to anticipated inflation, reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 4-1, p. 4-8.

26. Projected capital outlays including escalation due to anticipated inflation, reported in Tri-Met, Banfield Light Rail Project Grant Application, June 1980, p. 9a. This estimate is based on a revised constant-dollar forecast prepared after the project was selected, which significantly exceeds the original constant-dollar forecast used to derive item 46 below. However, no forecast of actual capital outlays including escalation due to inflation was prepared using the original constant-dollar forecast of capital spending.

27. Derived from forecast of LRT-related capital outlays in constant dollars, together with projected schedule of combined capital outlays for LRT construction and bus system improvements, escalated to reflect 6% inflation. These figures are reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 23, p. 3-79, and Table 96, p. 4-186.

28. Total project cost estimate including escalation due to anticipated inflation, less projected outlays for local buses, circulator buses, and open-air tram, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-52.

29. Total project cost estimate including inflation due to anticipated inflation, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. IV-14.

30. Derived from schedule of actual capital expenditures for individual rail system components reported in WMATA, Notes to Financial Statements. Excludes expenditures for construction work in progress on portions of rail system not in service during WMATA Fiscal Year 1986.

31. Derived from MARTA, "History of Incurred Cost by MACS Code: 6/30/75 - 6/30/87," and "MACS Code Summary Reports" for MARTA Fiscal Years 1981-86, supplied by MARTA Budget Control Branch, June 1988.

32. Estimated from Urban Mass Transportation Administration Memorandum of Approval for Capital Grant MD-03-0004-00/14.

33. Sum of expenditures reported in "Rapid Transit Stage I (Metrorail): Expenditures by MACS Code Summary -- Grant FL-03-0036," supplied by Management Services Division, MDTA, May 17, 1988.

34. Estimated from NFTA, LRRT Project Review for Second Quarter of FY 1988: Summary of Project Costs, March 1988, p. 3 and 7, and additional capital spending data reported in Urban Mass Transportation Administration Memoranda of Approval for Capital Grants NY-03-0188-00/01 and NY-90-0001-02.

35. Reported in Urban Mass Transportation Administration, Memorandum of Approval for Capital Grant PA-03-0095, Amendment 14, March 1987, p. 2.

36. Reported in "Banfield Project Year-by-Year Expenditure", document supplied by Engineering and Project Development Department, Tri-Met, December 1988. This figure reflects the reallocation of certain elements of a joint highway-transit project from the highway element of the project, to which they were originally assigned, to its transit element. The difference between items 26 and 36 thus overstates the difference between forecast and actual nominal-dollar capital outlays for the transit element of the project.

37. Reported in Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.C.

38. Sum of construction-related expenditures reported in "Downtown Component of Metrorail (Metromover): Expenditures by MACS Code Summary -- Grant FL-03-00350, FL-90-0006, FL-90-X016, and FL-90-X042," supplied by Management Services Division, MDTA, May 17, 1988.

39. Sum of current-dollar construction outlays through March 31, 1988, reported in Turner Construction Company, "Detroit Downtown People-Mover: Project Funding/Cost Report (Summary)," report to Urban Mass Transportation Administration, March 31, 1988.

40. Derived from constant-dollar estimates of construction costs for individual system components, together with projected schedule for constructing individual system elements, reported in DeLeuw, Cather & Co. and Harry Weese & Associates, Preliminary Design and Capital Costs: Adopted Regional System, February 1969, p. 73. Projected annual outlays converted to 1988 dollar equivalent.

41. Derived from schedule of projected current-dollar capital outlays (see item 22 above) by removing escalation due to inflation, which was anticipated to average 6.2% annually over the construction period; see Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, p. 52; converted to 1988 dollar equivalent.

42. Derived from schedule of projected current-dollar capital outlays for Phase A. Since the inflation rate included in this forecast was not explicitly stated, each year's anticipated current-dollar outlay was converted to 1988 dollar equivalent. The resulting figure mis-estimates the 1988-dollar value of planned capital expenditures to the extent that the inflation forecast included in planned current-dollar outlays differed from actual inflation over the planned construction period.

43. Derived from schedule of projected current-dollar capital outlays (see item 24 above) by removing escalation due to inflation, which in earlier planning documents was anticipated to account for 33% of projected current-dollar outlays for the selected alternative; see Kaiser Transit

Group, Priority Engineering and Operational Analyses: Final Report, Dade County Transportation Improvement Program - Stage I, October 1976, p. IV-24. The resulting estimate was converted to 1988 dollar equivalent.

44. Projected capital outlays in 1974 dollars, reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 4-1, p. 4-8, converted to 1988 dollar equivalent.

45. Projected capital outlays in 1977 dollars, reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, Table IV-4, P. IV-29, converted to 1988 dollar equivalent. Upper end of possible range of capital costs chosen to reflect choice of most costly downtown alignment.

46. Original forecast of capital outlays in 1978 dollars, reported in Parsons Brinckerhoff Quade & Douglas, Inc., and Louis T. Klauder & Associates, Capital Cost Estimates/Operations & Maintenance Costs, Technical Memorandum No. 10, Banfield Light Rail Project, July 1980, p. 30; converted to 1988 dollar equivalent. The original source of this estimate is not reported in this reference.

47. Projected capital outlays in 1980 dollars, reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 23. p. 3-79, converted to 1988 dollar equivalent.

48. Projected capital outlays in 1980 dollars, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-52, converted to 1988 dollar equivalent.

49. Projected constant-dollar construction outlays estimated from forecast of current-dollar outlays (see item 29) and anticipated inflation rate reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. IV-14, assuming constant-dollar outlays were to be spread uniformly over the anticipated three-year construction period (see item 10). The resulting estimate of projected constant-dollar outlays was converted to 1988 dollar equivalent.

50. Derived from schedule of actual capital expenditures for elements of rail system in service during WMATA Fiscal Year 1986 (see item 30), converted to 1988 dollar equivalent.

51. Derived from schedule of actual capital expenditures for Phases A, B, C1N, and C1S of Atlanta rail system (see item 31), converted to 1988 dollar equivalent.

52. Derived from schedule of actual capital expenditures for Phase A of Baltimore rail system (see item 32), converted to 1988 dollar equivalent.

53. Annual project outlays estimated from schedule of capital appropriations for Stage I Metrorail line under UMTA Section 3 discretionary capital grant program (which accounted for 69% of

total project outlays), provided by Office of Grants Management, Urban Mass Transportation Administration. The resulting estimates were converted to 1988 dollar equivalent.

54. Schedule of current-dollar capital outlays estimated from Urban Mass Transportation Administration Memoranda of Approval for Capital Grants NY-03-3187, NY-03-0184-00/01, NY-03-0156-00/01, NY-03-0072-00/11, NY-03-0188-00/01, NY-90-0001-02; converted to 1988 dollar equivalent.

55. Schedule of current-dollar capital outlays estimated from Urban Mass Transportation Administration, Memorandum of Approval for Capital Grant PA-03-0095, Amendments 0 through 14; converted to 1988 dollar equivalent.

56. Schedule of current-dollar capital outlays estimated from total transit-related outlays, reported in "Banfield Project Year-by-Year Expenditure," and schedule of combined highway-transit project outlays reported in "Banfield Project Year-by-Year Expenditure;" both documents supplied by Engineering and Project Development Department, Tri-Met, December 1988. Estimates of annual current-dollar capital outlays were converted to 1988 dollar equivalent. The resulting figure reflects the reallocation of certain elements of a joint highway-transit project from the highway element of the project, to which they were originally assigned, to its transit element. The difference between items 46 and 56 thus overstates the difference between forecast and actual nominal-dollar capital outlays for the transit element of the project.

57. Schedule of current-dollar capital outlays estimated from total project obligations and time pattern of approved federal grant amendments, reported in Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.C., and p. 1-6. Resulting estimate converted to 1988 dollar equivalent.

58. Approximate schedule of actual capital expenditures for Metromover project estimated from "Downtown Component of Metrorail (Metromover): Expenditures by MACS Code Summary--Grant FL-03-00350, FL-90-0006, FL-90-X016, and FL-90-X042," and accompanying communication, supplied by Management Services Division, MDTA, May 17, 1988. Resulting estimate converted to 1988 dollar equivalent.

59. Approximate schedule of actual capital expenditures estimated from total outlays reported in Turner Construction Company, "Detroit Downtown People-Mover: Project Funding/Cost Report (Summary)," March 31, 1988, and actual time span of project construction (see item 20), assuming a uniform rate of spending. Resulting estimate converted to 1988 dollar equivalent.

Source Notes for Table 3-2.
SCOPE CHANGES AND ERRORS IN FINANCIAL PLANNING FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Changes in Project Scope										
Total line-miles										
Planned	1	2	3	4	5	6	7	8	9	10
Actual	11	12	13	14	15	16	17	18	19	20
Number of stations										
Planned	21	22	23	24	25	26	27	28	29	30
Actual	31	32	33	34	35	36	37	38	39	40
Number of vehicles										
Planned	41	42	NF	NF	43	44	45	46	NF	NF
Actual	47	48	49	50	51	52	53	54	55	56
Start of Construction										
Planned	(See notes to Table 3-1.)									
Actual	(See notes to Table 3-1.)									
Years to Reach Scope Studied										
Planned	(See notes to Table 3-1.)									
Actual	(See notes to Table 3-1.)									
Annual Inflation Rate in Construction Costs										
Forecast	57	58	NF	59	60	NF	61	62	NF	63
Actual	64	65	66	67	68	69	70	71	72	73

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 3-2.

1. Projected route-miles in service from December 1976 to March 1978, reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, p. 81.

2. Projected rail route miles in operation during 1978, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-30. p. 215. Disagrees slightly with figure of 26.8 miles derived from planned spacings between stations anticipated to be in service during 1978, reported in Table B-2, pp. 240-242.

3. Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, p. 4.

4. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, p. V-1.

5. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-24, p. 3-22, and p. 3-24.

6. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. IV-1.

7. Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, p. 118.

8. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 15, p. 3-62.

9. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-33.

10. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, pp. iii-iv.

11. Calculated from schedule of line segment opening dates and lengths reported in WMATA, "METRO Fact Card," June 1987.

12. Calculated from distances to Five Points station reported in MARTA, "A Guide to MARTA," undated.

13. DMJM/RKE, "The Baltimore Metro," undated, p. 4.

14. Measured from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

15. NFTA, "Rail Transit Facts," undated, p. 2.

16. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.

17. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 403.

18. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-1.

19. Measured from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

20. Cambridge Systematics, Inc., Advanced Technology Deployment Appraisal Project: Draft Final Report, prepared for Office of Technical Assistance, Urban Mass Transportation Administration, April 1988, p. 2-4.

21. Counted from assumed phasing of construction and map of planned system, in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Figure III-1, p. 5, and Figure III-2, p. 7.

22. Counted from planned phasing of construction and line-by-line listing of stations, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, pp. 218-220, and Table B-2, pp. 240-242.

23. Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, p. 5.

24. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, pp. V-1 and V-6. It is unclear whether the capital cost forecasts for the project reported in Table 3-1, which are drawn from the subsequent Draft Environmental Impact Statement (published January 1978), apply to a 21 or 22-station version of the project. However, this document -- on which the choice of the locally preferred alternative appears to be based -- clearly indicates that the preferred system was planned to include 21 stations.

25. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-4, p. 3-22.

26. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. IV-11. In addition, 17 stops consisting of a simple platform and passenger shelter were planned for the reconstructed line.

27. Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, p. 118. This number includes 6 downtown

stations, the number planned for the downtown distribution alternative most closely resembling that actually constructed.

28. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 12, p. 3-57.

29. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-33.

30. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. II-32.

31. Calculated from schedule of line segment opening dates reported in WMATA, "METRO Fact Card," June 1987.

32. Counted from MARTA, Bus and Rail System Route Map, January 1985.

33. DMJM/RKE, "The Baltimore Metro," undated, p. 4.

34. Counted from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

35. NFTA, "Rail Transit Facts," undated, p. 2.

36. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 43.

37. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 005, p. 3.

38. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, p. ES-1.

39. Counted from MDTA, Transit Map of Metro Dade County, Effective April 3, 1988.

40. Cambridge Systematics, Inc., Advanced Technology Deployment Appraisal Project: Draft Final Report, prepared for Office of Technical Assistance, Urban Mass Transportation Administration, April 1988, p. 2-4.

41. Projected number of vehicles required during 1977, when 62.1 route-miles were expected to operate, reported in W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, p. 84.

42. Estimated from projected peak period headways, train lengths, and operating speeds for segments of system projected to be in service during 1978, reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-12, p. 161, Table 4-13, p. 163, and Table B-2, pp. 240-242. Includes spare vehicle requirement of 10% of vehicles necessary to operate anticipated schedule of peak service.

43. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 4-1, p. 4-8.

44. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. IV-9.

45. Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Final Environmental Impact Statement, August 1980, p. 118.

46. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 13, p. 3-60.

47. WMATA, FY 1988 Approved Budget: Financial Program and Summaries, Volume 1, p. 46.

48. MARTA, Fiscal Year 1987 Section 15 Submission, Form 003.

49. DMJM/RKE, "The Baltimore Metro," undated, p. 12.

50. MDTA, Fiscal Year 1987 Section 15 submission, Form 003.

51. NFTA, "Rail Transit Facts," p. 3.

52. William D. Middleton, "Pittsburgh Awaits 'T'-Day," Railway Age, May 1987, p. 47.

53. Tri-Met, Fiscal Year 1987 Section 15 submission, Form 003.

54. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.C.

55. MDTA, Fiscal Year 1987 Section 15 submission, Form 003.

56. Cambridge Systematics, Inc., Advanced Technology Deployment Appraisal Project: Draft Final Report, prepared for Office of Technical Assistance, Urban Mass Transportation Administration, April 1988, p. 2-4.

57. Average annual inflation rate projected for the period 1969-76, estimated from annual dollar amounts of cost escalation due to inflation and annual spending denominated in base year dollars, reported in DeLeuw, Cather & Co. and Harry Weese & Associates, Preliminary Design and Capital Costs: Adopted Regional System, February 1969, p. 75. The resulting estimate is somewhat lower than the 5% annual inflation rate referred to in this reference, which applies to the anticipated construction period for the entire system.

58. Average annual inflation rate anticipated over construction period for entire system (projected to be 1972-1980), reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, p. 225.

59. Annual inflation rate assumed for years 1977 and beyond in Kaiser Transit Group, Priority Engineering and Operational Analyses: Final Report, Dade County Transportation Improvement Program - Stage I, October 1976, p. V-11. Subsequent planning documents, including both draft and final environmental impact statements prepared for the project, reported no explicit forecasts of inflation, although most cost estimates were reported in escalated dollars incorporating projected future inflation.

60. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 4-1, p. 4-8.

61. Tri-Met, Banfield Light Rail Project Grant Application, June 1980, p. 9a.

62. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 96, p. 4-186. Although this figure represents the lower bound of the range of estimates considered, it corresponds closely to the inflation rate of 7% specified in Urban Mass Transportation Administration and Sacramento Transit Development Agency, Sacramento Light Rail Transit Project: Final Environmental Impact Statement, August 1983, p. 2-43.

63. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, p. IV-16.

64. Compound annual growth rate in McGraw-Hill Construction Cost Index for Baltimore (nearest urban area for which Index is reported), December 1968 through December 1985, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

65. Compound annual growth rate in McGraw-Hill Construction Cost Index for Atlanta, December 1971 through December 1986, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

66. Compound annual growth rate in McGraw-Hill Construction Cost Index for Baltimore, December 1972 through December 1983, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

67. Compound annual growth rate in McGraw-Hill Construction Cost Index for Atlanta (nearest urban area for which Index is reported), December 1978 through December 1985, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

68. Compound annual growth rate in McGraw-Hill Construction Cost Index for Cleveland (nearest urban area for which Index is reported), December 1977 through December 1986, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

69. Compound annual growth rate in McGraw-Hill Construction Cost Index for Pittsburgh, December 1978 through December 1987, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

70. Compound annual growth rate in McGraw-Hill Construction Cost Index for Seattle (nearest urban

area for which Index is reported), December 1980 through December 1986, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

71. Compound annual growth rate in McGraw-Hill Construction Cost Index for San Francisco (nearest urban area for which Index is reported), March 1983 through March 1987, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

72. Compound annual growth rate in McGraw-Hill Construction Cost Index for Atlanta (nearest urban area for which Index is reported), June 1981 through June 1986, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

73. Compound annual growth rate in McGraw-Hill Construction Cost Index for Detroit, June 1981 through June 1987, computed from index values reported in ENR, March 23, 1989, pp. 56-59.

Source Notes for Table 3-3.
ESTIMATED CONTRIBUTIONS OF ERRORS IN FINANCIAL PLANNING TO CAPITAL COST OVERRUNS FOR RAIL PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Wash-ington	Atlanta	Balt-imore	Miami	Buffalo	Pitts-burgh	Port-land	Sacra-mento	Miami	Detroit
Unanticipated Inflation										
$ Amount	Calculated by authors using procedure described in text									
% of overrun	Calculated by authors using procedure described in text									
Delay in Start Date										
$ Amount	Calculated by authors using procedure described in text									
% of overrun	Calculated by authors using procedure described in text									
Construction Schedule Changes										
$ Amount	Calculated by authors using procedure described in text									
% of overrun	Calculated by authors using procedure described in text									
Total Explained by Above Factors										
$ Amount	Calculated by authors using procedure described in text									
% of overrun	Calculated by authors using procedure described in text									

Source Notes for Table 3-4.
FORECAST AND ACTUAL FINANCING OF RAIL PROJECT CAPITAL OUTLAYS BY LEVEL OF GOVERNMENT

Level of Government	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Nominal Dollar Outlays (millions)										
Federal										
Forecast	1	2	3	4	5	NF	6	7	8	9
Actual	10	11	12	13	14	15	16	17	18	19
State										
Forecast	--	20	21	22	23	NF	24	25	26	27
Actual	--	28	29	NA	30	31	32	33	NA	34
Local										
Forecast	35	36	37	38	39	NF	40	41	42	43
Actual	44	45	46	NA	47	48	49	50	NA	51
Total										
Forecast	See source notes to Table 3-1									
Actual	See source notes to Table 3-1									
Percent Distribution of Outlays										
Federal										
Forecast	52	53	54	55	56	57	58	59	60	61
Actual	62	63	64	65	66	67	68	69	70	71
Overrun	Calculated from "Forecast" and "Actual" Federal and Total outlays									
State										
Forecast	--	72	73	74	75	76	77	78	79	80
Actual	--	81	82	NA	83	84	85	86	NA	87
Overrun	Calculated from "Forecast" and "Actual" State and Total outlays									
Local										
Forecast	88	89	90	91	92	93	94	95	96	97
Actual	98	99	100	NA	101	102	103	104	NA	105
Overrun	Calculated from "Forecast" and "Actual" Local and Total outlays									

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 3-4.

1. Calculated from forecasts of total project outlays and federal share (see item 55 below).

2. Calculated from forecasts of total project outlays and federal share (see item 56 below).

3. Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, p. 1.

4. Calculated from forecasts of total project outlays and federal share (see item 58 below).

5. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

6. Tri-Met, Banfield Light Rail Project Grant Application, June 1980, p. 6.

7. Calculated from financing plan reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 95, p. 4-176.

8. Calculated from forecasts of total project outlays and federal share (see item 63 below).

9. Calculated from forecasts of total project outlays and federal share (see item 64 below).

10. Calculated from actual total project outlays and actual federal share (see item 65 below).

11. Calculated from actual total project outlays and actual federal share (see item 66 below).

12. Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant MD-03-0004-00/14."

13. Estimated from federal capital appropriations for Stage I Metrorail line under UMTA Section 3 capital grant program, provided by UMTA Office of Grants Management.

14. Estimated from Memoranda of Approval for grants comprising federal contribution to project financing, and NFTA, "LRRT Project Review for Second Quarter of FY 1988: Summary of Project Costs," March 1988, p. 1.

15. Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant PA-03-0095, Amendment #14," March 1987, p. 2.

16. Calculated from actual total project outlays and actual federal share (see item 71 below).

17. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.B. Includes $3.2 million in project costs unfunded as of that date but assumed to be federally funded.

18. Estimated from federal capital appropriations for Metromover project under UMTA Section 3, Section 9, and Section 9A grant programs, provided by UMTA Office of Grants Management.

19. Federally-funded project outlays through March 31, 1988, reported in Turner Construction Company, "Detroit Downtown People-Mover: Project Funding/Cost Report (Summary)," report to Urban Mass Transportation Administration, March 31, 1988.

20. The non-federal share of projected capital outlays was anticipated to be financed completely from local sales tax revenue; see Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, pp. 56-58.

21. Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, p. 2.

22. Calculated from forecasts of total project outlays and state share (see item 77 below).

23. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

24. Tri-Met, Banfield Light Rail Project Grant Application, June 1980, p. 6.

25. No state contribution to LRT construction or vehicle acquisition is included in the financing plan reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 95, p. 4-176.

26. Calculated from forecasts of total project outlays and state share (see item 82 below).

27. Calculated from forecasts of total project outlays and state share (see item 83 below).

28. No state contribution is included in the funding for construction of Phases A, B, and C reported in Urban Mass Transportation Administration, "Memorandum of Approval: UMTA Discretionary Capital Assistance Grant, Project No. GA-03-0032," June 30, 1988, p. 4.

29. Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant MD-03-0004-00/14."

30. Estimated from Memoranda of Approval for grants comprising federal contribution to project financing, and NFTA, "LRRT Project Review for Second Quarter of FY 1988: Summary of Project Costs," March 1988, p. 1.

31. Estimated from Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant PA-03-0095, Amendment #14." March 1987, p. 2. Assumes that the non-federal contribution consisted of the same proportional contributions by state and local government as those forecast.

32. Calculated from actual total project outlays and actual state share (see item 88 below).

33. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit 1.B.

34. State contribution to project construction outlays through March 31, 1988, reported in Turner Construction Company, "Detroit Downtown People-Mover: Project Funding/Cost Report (Summary)," report to Urban Mass Transportation Administration, March 31, 1988.

35. Calculated from forecasts of total project outlays and local share (see item 91 below).

36. Calculated from forecasts of total project outlays and local share (see item 92 below).

37. The planned federal and state contributions discussed in Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, pp. 1-2, were anticipated to fully fund construction of the project.

38. Calculated from forecasts of total project outlays and local share (see item 94 below).

39. The non-federal share of project funding was anticipated to be met entirely with state funds; see Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

40. Tri-Met, Banfield Light Rail Project Grant Application, June 1980, p. 6.

41. Calculated from financing plan reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, table 95, p. 4-176.

42. Calculated from forecasts of total project outlays and local share (see item 99 below).

43. The proposed funding breakdown reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-41, includes no local contribution.

44. Calculated from actual values of total project outlays and local share (see item 101 below).

45. Calculated from actual values of total project outlays and local share (see item 102 below).

46. No local contribution is included in the funding breakdown for Section A reported in Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant MD-03-0004-00/14."

47. Estimated from Memoranda of Approval for grants comprising federal contribution to project financing, and NFTA, "LRRT Project Review for Second Quarter of FY 1988: Summary of Project Costs," March 1988, p. 1. Includes 4.7 million in project costs unfunded as of that date but assumed to be financed locally.

48. Estimated from Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant PA-03-0095, Amendment #14," March 1987, p. 2. Assumes that the non-federal contribution consisted of the same proportional contributions by state and local government as those forecast.

49. Calculated from actual total project outlays and actual local share (see item 106 below).

50. Hill International, Inc., Final Report: Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, April 1988, Exhibit I.B. Includes $3.4 million in project costs unfunded as of that date but assumed to be locally funded.

51. Local contribution to project construction outlays through March 31, 1988, reported in Turner Construction Company, "Detroit Downtown People-Mover: Project Funding/Cost Report (Summary)," report to Urban Mass Transportation Administration, March 31, 1988.

52. Estimated from originally proposed funding for complete Washington Metrorail system, reported in U.S. Department of Transportation, "Financial Review: Member Jurisdictions of the Washington Metropolitan Area Transit Authority," February 1987, p. 2.

53. Federal share of projected capital outlays through 1977, computed from Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, Table 7, p. 59. Although this figure includes the federal share of outlays to purchase the assets of the Atlanta Transit System, p. 56 of this document indicates that federal grants were also anticipated to cover two-thirds of the capital cost of constructing the rail system itself.

54. Computed from anticipated federal contribution (see item 3 above) and forecast total project cost.

55. Anticipated federal share of funding for Stage I Metrorail line reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55.

56. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

57. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, p. IV-28.

58. Computed from anticipated federal contribution (see item 7 above) and forecast total project cost.

59. Computed from anticipated federal contribution (see item 8 above) and forecast total project cost.

60. Estimated from proposed funding reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-52. Assumes that $24 million contribution reprogrammed from Metrorail project included federal, state, and local shares reported in items 58, 77, and 94 of this table.

61. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-41.

62. Federal share of total funding for Washington Metrorail construction through WMATA Fiscal year 1985, calculated from WMATA, FY 1988 Approved Budget: Financial Program and Summaries -- Volume 1, Schedule B, p. 97.

63. Estimated from federal and total outlays to construct Phases A, B, and C of the Atlanta rail system reported in Urban Mass Transportation Administration, "Memorandum of Approval: UMTA Discretionary Capital Assistance Grant, Project No. GA-03-0032," June 30, 1988, p. 4. Assumes that the federal share of construction costs for Phases C1N and C1S is equal to that for the entire Phase C (18.98%).

64. Calculated from actual federal contribution (item 13 above) and total project cost.

65. Calculated from actual federal contribution (item 14 above) and total project cost.

66. Calculated from actual federal contribution (item 15 above) and total project cost.

67. Calculated from actual federal contribution (item 16 above) and total project cost.

68. Federal share of total funding for joint light rail construction-highway improvement project, calculated from Tri-Met, "Banfield Light Rail Funding Sources," December 1, 1987.

69. Calculated from actual federal contribution (item 18 above) and total project cost.

70. Calculated from actual federal contribution (item 19 above) and total project cost.

71. Calculated from actual federal contribution (item 20 above) and total project cost.

72. The non-federal share of projected capital outlays was anticipated to be financed completely from local sales tax revenue; see Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, pp. 56-58.

73. Computed from anticipated state contribution (see item 22 above) and forecast total project cost.

74. Anticipated state share of funding for Stage I Metrorail line reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55.

75. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

76. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, p. V-29.

77. Computed from anticipated state contribution (see item 26 above) and forecast total project cost.

78. No state contribution to LRT construction or vehicle acquisition is included in the financing plan reported in Urban Mass Transportation Administration and Sacramento Area Council of

Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 95, p. 4-176.

79. Estimated from proposed funding reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-52. Assumes that $24 million contribution reprogrammed from Metrorail project included federal, state, and local shares reported in items 58, 77, and 94 of this table.

80. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-41.

81. No state contribution is included in the funding for construction of Phases A, B, and C reported in Urban Mass Transportation Administration, "Memorandum of Approval: UMTA Discretionary Capital Assistance Grant, Project No. GA-03-0032," June 30, 1988, p. 4.

82. Calculated from actual state contribution (item 31 above) and total project cost.

83. Calculated from actual state contribution (item 32 above) and total project cost.

84. Calculated from actual state contribution (item 33 above) and total project cost.

85. State share of total funding for joint light rail construction-highway improvement project, calculated from Tri-Met, "Banfield Light Rail Funding Sources," December 1, 1987.

86. Calculated from actual state contribution (item 35 above) and total project cost.

87. Calculated from actual state contribution (item 36 above) and total project cost.

88. Estimated from originally proposed funding for complete Washington Metrorail system, reported in U.S. Department of Transportation, "Financial Review: Member Jurisdictions of the Washington Metropolitan Area Transit Authority," February 1987, p. 2.

89. Non-federal share of projected capital outlays, which was anticipated to be funded from local sales tax revenue; see Parsons Brinckerhoff-Tudor-Bechtel, Metropolitan Atlanta Rapid Transit Plan, Report PBTB A-71.1, September 1971, pp. 56-58.

90. The planned federal and state contributions discussed in Urban Mass Transportation Administration, Baltimore Region Rapid Transit System - Phase 1, Section A: Final Environmental Impact Statement, September 1972, pp. 1-2, were anticipated to fully fund construction of the project.

91. Anticipated local share of funding for Stage I Metrorail line reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55.

92. The non-federal share of project funding was anticipated to be met entirely with state funds;

see Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, p. 4-7.

93. Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Final Environmental Impact Statement, December 1978, p. V-29.

94. Computed from anticipated local contribution (see item 43 above) and forecast total project cost.

95. Computed from anticipated local contribution (see item 44 above) and forecast total project cost.

96. Estimated from proposed funding reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Draft Environmental Impact Statement, May 1980, p. 2-52. Assumes that $24 million contribution reprogrammed from Metrorail project included federal, state, and local shares reported in items 58, 77, and 94 of this table.

97. The proposed funding breakdown reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. II-41, includes no local contribution.

98. Local share of total funding for Washington Metrorail construction through WMATA Fiscal year 1985, calculated from WMATA, FY 1988 Approved Budget: Financial Program and Summaries--Volume 1, Schedule B, p. 97. Includes contributions by the States of Maryland and Virginia that cannot be separately identified.

99. Estimated from federal and local outlays to construct Phases A, B, and C of the Atlanta rail system reported in Urban Mass Transportation Administration, "Memorandum of Approval: UMTA Discretionary Capital Assistance Grant, Project No. GA-03-0032," June 30, 1988, p. 4. Assumes that the federal share of construction costs for Phases C1N and C1S is equal to that for the entire Phase C (18.98%).

100. No local contribution is included in the funding breakdown for Section A reported in Urban Mass Transportation Administration, "Memorandum of Approval: Capital Grant MD-03-0004-00/14."

101. Calculated from actual local contribution (item 50 above) and total project cost.

102. Calculated from actual local contribution (item 51 above) and total project cost.

103. Local share of total funding for joint light rail construction-highway improvement project, calculated from Tri-Met, "Banfield Light Rail Funding Sources," December 1, 1987.

104. Calculated from actual local contribution (item 53 above) and total project cost.

105. Calculated from actual local contribution (item 54 above) and total project cost.

Source Notes for Table 4-1.
FORECAST AND ACTUAL OPERATING EXPENSES FOR RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Year to Which Data Reported in This Table Apply										
Forecast data	See source notes to Table 1-1									
Actual data	See source notes to Table 1-1									
Annual Rail Operating Expense (millions of 1988 dollars)										
Forecast	1	2	NF	3	4	NF	5	6	7	8
Actual	9	10	11	12	13	14	15	16	17	18
Annual Vehicle-Miles of Rail Service (millions)										
Forecast	19	20	NF	21	22	NF	23	24	25	26
Actual	27	28	29	30	31	32	33	34	35	36
Operating Expense per Rail Vehicle-Mile (1988 dollars)										
Forecast	37	38	NF	39	40	NF	41	42	43	44
Actual	45	46	47	48	49	50	51	52	53	54
Operating Expense per Rail Vehicle-Hour (1988 dollars)										
Forecast	NF	55	NF	NF	56	NF	57	58	NF	59
Actual	60	61	62	63	64	65	66	67	68	69
Average Rail Operating Speed (miles per hour)										
Forecast	NF	70	NF	NF	71	NF	72	73	NF	74
Actual	75	76	77	78	79	80	81	82	83	84

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 4-1.

1. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, Febru-

ary 1969, p. 87. Forecast of $20,528,900 (in 1968 dollars) for 1977; converted to 1988 dollar equivalent.

2. Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-30, p. 215; converted to 1988 dollar equivalent.

3. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Final Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1978, p. V-64; converted to 1988 dollar equivalent.

4. Niagara Frontier Transportation Authority, Metro Construction Division, Evaluation of Transit Alternatives, Buffalo-Amherst-Tonawandas Corridor: Staff Conclusions and Recommendations, February 1976, Table D-3, p. 57; converted to 1988 dollar equivalent.

5. Tri-Met Planning and Development Department, East Side Transit Operations, December 1977, Table 6, p. 40. Forecast daily operating cost figure annualized assuming 300 average weekday equivalents per year, the figure implied by the relationship of annual to daily forecasts reported in Tables 6 and 7, and converted to 1988 dollars.

6. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 30, p. 3-93; converted to 1988 dollar equivalent.

7. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-68; converted to 1988 dollar equivalent.

8. Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Draft Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, March 1980, p. IV-16; converted to 1988 dollar equivalent.

9. National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.07, p. 3-56; converted to 1988 dollar equivalent.

10. Sum of operating expenses for July 1986-June 1987 (Fiscal Year 1987), reported in MARTA, "Monthly Statistics Summary;" converted to 1988 dollar equivalent.

11. Baltimore MTA FY1987 Section 15 submission, Form 310.

12. Metro-Dade TA FY1988 Section 15 submission, Form 310.

13. NFTA FY1988-89 Section 15 submission, Form 312.

14. Estimated from PAT, "Operating and Capital Improvement Budgets: FY1989," p. 103, and fraction of combined LRT/streetcar operating expenses attributable to LRT during FY1988, derived from Allen D. Biehler, "'The Great Debate:' Exclusive Busway versus Light Rail -- A COmparison of New Fixed Guideways," PAT, May 1988, p. 8.

15. Calculated from Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 6.

16. Estimate of LRT operating expenses for FY1988 provided by SRTD, Rapid Transit Operations Support Department, July 1988.

17. Metro-Dade TA FY1988 Section 15 submission, Form 310.

18. Operating budget for FY1988, provided by Detroit Transportation Corporation.

19. Calculated from items 1 and 37.

20. Calculated from items 2 and 38.

21. No explicit forecast reported. Derived from forecasts of 140 million Kwh annual energy consumption for mainline rail operations and 9.10 Kwh per vehicle-mile, reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Final Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1978, pp. VI-45 and IV-31.

22. Niagara Frontier Transportation Authority, Metro Construction Division, Evaluation of Transit Alternatives, Buffalo-Amherst-Tonawandas Corridor: Staff Conclusions and Recommendations, February 1976, Table D-1, p. 55. Annualized assuming 300 average weekday equivalents per year.

23. Tri-Met Planning and Development Department, East Side Transit Operations, December 1977, Table 6, p. 40. Forecast daily vehicle-miles figure annualized assuming 300 average weekday equivalents per year, the figure implied by the relationship of annual to daily forecasts reported in Tables 6 and 7.

24. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 14, p. 3-61.

25. Calculated from items 7 and 43.

26. Estimated from forecasts of route length, time to complete circuit, service headways, train length, and hours of operation per week, reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, pp. iii, II-15, II-46, and II-49.

27. National Urban Mass Transportation Statistics: 1986 Section 15 Report, , Table 3.16, p. 3-284.

28. MARTA, Transit Operations Department, "Miles History" (undated).

29. Baltimore MTA FY1987 Section 15 submission, Form 407.

30. Metro-Dade TA FY1988 Section 15 submission, Form 407.

31. NFTA FY1988-89 Section 15 submission, Form 407.

32. Computed from PAT, "Operating and Capital Improvement Budgets: FY1989," p. 102, using estimated fraction of combined LRT/streetcar vehicle-miles and vehicle-hours that represents LRT service, supplied by PAT Planning Department.

33. Calculated train-hours of service during FY1989 reported in Tri-Met, "June 1989 Monthly Performance Report," June 1989, p. 6, and estimate of average train length derived from FY1988 service data provided by Manager, Financial Planning, Tri-Met, October 18, 1988.

34. Estimate of vehicle-miles of service for FY1988, provided by SRTD, Scheduling Department.

35. Metro-Dade TA FY1988 Section 15 submission, Form 407.

36. Estimated from actual route length, time to complete circuit, service headways, train length, and hours of operation per week for FY1988, reported by DTC.

37. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table XI-1, p. 90. Figure is for 44.7-mile system planned for 1975, converted to 1988 dollar equivalent.

38. Figure for 56.2-mile "Benchmark System" expected to operate during 1983 (no forecast available for 1977); converted to 1988 dollar equivalent.

39. Calculated from items 3 and 21.

40. Calculated from items 5 and 22.

41. Calculated from items 5 and 23.

42. Calculated from items 6 and 24.

43. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, The Miami Downtown People Mover Final Environmental Impact Statement, November 1980, p. 2-68; converted to 1988 dollar equivalent.

44. Calculated from items 8 and 26.

45. Calculated from items 9 and 27.

46. Calculated from items 10 and 28.

47. Calculated from items 11 and 29.

48. Calculated from items 12 and 30.

49. Calculated from items 13 and 31.

50. Calculated from items 14 and 32.

51. Calculated from items 15 and 33.

52. Calculated from items 16 and 34.

53. Calculated from items 17 and 35.

54. Calculated from items 18 and 36.

55. Calculated from item 1 and forecast of vehicle-hours implied by items 19 and 73.

56. Calculated from item 4 and forecast of 314 daily vehicle-hours reported in Niagara Frontier Transportation Authority, Metro Construction Division, Evaluation of Transit Alternatives, Buffalo-Amherst-Tonawandas Corridor: Staff Conclusions and Recommendations, February 1976, Table D-1, p. 55. Annualized assuming 300 average weekday equivalents per year.

57. Calculated from item 5 and forecast of vehicle-hours of service derived from Tri-Met Planning and Development Department, East Side Transit Operations, December 1977, Table 6, p. 40. Forecast daily vehicle-hours figure annualized assuming 300 average weekday equivalents per year, the figure implied by the relationship of annual to daily forecasts reported in Tables 6 and 7.

58. Calculated from item 6 and forecast of annual vehicle-hours of service reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 14, p. 3-61.

59. Estimated from item 8 and forecast of annual vehicle-hours of service, derived from forecasts of route length, time to complete circuit, and service headways reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, pp. iii, II-15, II-46, and II-49.

60. Calculated from item 9 and vehicle-hours of service for FY1986 reported in National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.16, p. 284.

61. Calculated from item 10 and vehicle-hours of service for FY1987 derived from MARTA, "Monthly Statistics Summary."

62. Calculated from item 11 and vehicle-hours of service reported in Baltimore MTA FY1987 Section 15 submission, Form 407.

63. Calculated from item 12 and vehicle-hours of service reported in Metro-Dade TA FY1988 Section 15 submission, Form 407.

64. Calculated from item 13 and vehicle-hours of service reported in NFTA FY1988-89 Section 15 submission, Form 407.

65. Calculated from item 14 and estimate of vehicle-hours of LRT service, constructed from PAT, "Operating and Capital Improvement Budgets: FY1989," p. 102, using estimated fraction of com-

bined LRT/streetcar vehicle-miles and vehicle-hours that represents LRT service, supplied by PAT Planning Department.

66. Calculated from item 15 and estimate of vehicle-hours of service for FY1989, derived from Tri-Met, "June 1989 Monthly Performance Report," June 1989, p. 6, and estimate of average train length derived from FY1988 service data provided by Manager, Financial Planning, Tri-Met, October 18, 1988.

67. Calculated from item 16 and estimate of vehicle-hours of service for FY1988, provided by SRTD Scheduling Department.

68. Calculated from item 17 and vehicle-hours of service reported in Metro-Dade TA FY1987 Section 15 submission, Form 407.

69. Calculated from item 18 and vehicle-hours of service for FY1988, derived from actual values of route length, time to complete circuit, and service headways reported by DTC.

70. Calculated from forecasts of weekday vehicle-miles and vehicle-hours for 1983 "Benchmark System," reported in Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-13, p. 163.

71. Calculated from forecasts of daily vehicle-miles and vehicle-hours of service reported in Niagara Frontier Transportation Authority, Metro Construction Division, Evaluation of Transit Alternatives, Buffalo-Amherst-Tonawandas Corridor: Staff Conclusions and Recommendations, February 1976, Table D-1, p. 55.

72. Calculated from forecasts of vehicle-miles and vehicle-hours of service reported in Tri-Met Planning and Development Department, East Side Transit Operations, December 1977, Table 6, p. 40.

73. Calculated from forecasts of vehicle-miles and vehicle-hours of service reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 14, p. 3-61.

74. Estimated from forecast route length and time to complete circuit reported in Urban Mass Transportation Administration and Southeastern Michigan Transportation Authority, Final Environmental Impact Statement: Downtown People Mover, Detroit, Michigan, December 1980, pp. iii and II-15.

75. Calculated from vehicle-miles and vehicle-hours of service for FY1986 reported in National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.16, p. 3-284.

76. Calculated from item 28 and vehicle-hours of service for FY1987 derived from MARTA, "Monthly Statistics Summary."

77. Calculated from item 29 and vehicle-hours of service reported in Baltimore MTA FY1987 Section 15 submission, Form 407.

78. Calculated from vehicle-miles and vehicle-hours of service reported in Metro-Dade TA FY1988 Section 15 submission, Form 407.

79. Calculated from vehicle-miles and vehicle-hours of service reported in NFTA FY1988-89 Section 15 submission, Form 407.

80. Calculated from estimates of LRT vehicle-miles and vehicle-hours of service, constructed from PAT, "Operating and Capital Improvement Budgets: FY1989," p. 102, using estimated fraction of combined LRT/streetcar vehicle-miles and vehicle-hours that represents LRT service, supplied by PAT Planning Department.

81. Calculated from train-hours and train-miles of service for FY1989, reported in Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 6.

82. Calculated from estimates of vehicle-miles and vehicle-hours of service for FY1988, provided by SRTD Scheduling Department.

83. Calculated from vehicle-miles and vehicle-hours of service reported in Metro-Dade TA FY1988 Section 15 submission, Form 407.

84. Estimated from actual route length and scheduled time to complete circuit, reported in DTC, "The People Mover -- Detroit in Motion," (undated).

Source Notes for Table 4-2.
FORECAST AND ACTUAL IMPACTS OF RAIL PROJECTS ON SYSTEMWIDE TRANSIT OPERATING EXPENSES

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
Year to Which Data Reported in This Table Apply								
Forecast data	See source notes to Table 1-1							
Actual data	See source notes to Table 1-1							
Total Annual Operating Expenses After Completion of Rail Project (millions of 1988 dollars)								
Forecast	1	2	NF	3	4	5	NF	6
Actual	7	8	9	10	11	12	13	14
Total Annual Operating Expense Impact of Rail Service (millions of 1988 dollars)								
Forecast	NF	NF	NF	15	16	NF	17	18
Actual	19	20	21	22	23	24	25	26

NF indicates no forecast of a data item was obtainable from published sources.

Source Notes for Table 4-2.

1. W.C. Gilman & Co., Inc., and Alan M. Voorhees & Associates, Inc., Traffic, Revenue, and Operating Costs: Adopted Regional System, 1968 (Revised February, 1969), prepared for WMATA, February 1969, Table X-5, p. 77, and p. 89; converted to 1988 dollar equivalent.

2. Parsons Brinckerhoff-Tudor-Bechtel, Long Range Rapid Transit System Planning and Preliminary Engineering, Volume I, December 1971, Table 4-30, p. 215; converted to 1988 dollar equivalent.

3. Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Rapid Transit System, January 1978, p. V-55; converted to 1988 dollar equivalent.

4. Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-7, p. 3-31; converted to 1988 dollar equivalent.

5. Estimate of combined LRT operating expenses for Stage I and Stage II lines reported in Urban Mass Transportation Administration, Pittsburgh Light Rail Transit Reconstruction: Draft Environmental Impact Statement, July 1978, p. IV-33; converted to 1988 dollar equivalent.

6. Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 30, p. 3-93; converted to 1988 dollar equivalent.

7. National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.08, p. 3-91; converted to 1988 dollar equivalent.

8. Estimate for FY1987 derived from MARTA, "Monthly Statistics Summary," February 1988; converted to 1988 dollar equivalent.

9. Baltimore MTA FY1987 Section 15 submission, Form 310; converted to 1988 dollar equivalent.

10. Metro-Dade TA FY1988 Section 15 submission, Form 310.

11. NFTA FY1988-89 Section 15 submission, Form 312.

12. PAT, "Operating and Capital Improvement Budgets: FY1989," p. 103.

13. Calculated from Tri-Met, "June 1989 Monthly Performance Report," July 20, 1989, p. 2.

14. Estimate of FY1988 system-wide operating expenses provided by SRTD, Rapid Transit Operations Support Department, July 1988.

15. Calculated from item 3 and forecast of system-wide operating expenses for Low-Cost All Bus Alternative ("Alternative 0"), reported in Urban Mass Transportation Administration and Metropolitan Dade County Office of Transportation Administration, Preliminary Draft Environmental Impact Statement: Metropolitan Dade County Transportation Improvement Program, Stage I Rapid Transit System, May 1977, Table III-1, p. III-17; latter figure converted to 1988 dollar equivalent.

16. Calculated from item 4 and forecast of system-wide operating expenses for "Advanced Bus Alternative," reported in Urban Mass Transportation Administration, Draft Environmental Impact Statement: Buffalo Light Rail Rapid Transit Project, June 1977, Table 3-2, p. 3-13; latter figure converted to 1988 dollar equivalent.

17. Difference between annual operating expenses for East Side Transit Services under "LRT--Burnside" and "Low Cost Improvements" alternatives, reported in Federal Highway Administration, Urban Mass Transportation Administration, Oregon State Highway Division, and Tri-County Metropolitan Transportation District, Banfield Transitway Project: Draft Environmental Impact Statement, February 1978, Table 16, p. 206; converted to 1988 dollar equivalent.

18. Calculated from item 6 and forecast of system-wide operating expenses for "Alternative 2: TSM/-TSM," reported in Urban Mass Transportation Administration and Sacramento Area Council of Governments, Draft Alternatives Analysis/Environmental Impact Statement/Environmental Impact Report on Prospective Interstate Substitution Transportation Improvements in North-East Sacramento, California, April 1981, Table 30, p. 3-93; latter figure converted to 1988 dollar equivalent.

19. Calculated from item 7 and WMATA system-wide operating expenses during FY1975, last year of all-bus service, reported in American Public Transit Association, Transit Operating Report, 1975, p. D-188; latter figure converted to 1988 dollar equivalent.

20. Calculated from item 8 and MARTA system-wide operating expenses during FY1979, last year of all-bus service, reported in American Public Transit Association, Transit Operating Report, 1980, p. C-11; latter figure converted to 1988 dollar equivalent.

21. Calculated from item 9 and Baltimore MTA system-wide operating expenses during FY1983, last year of all-bus service, reported in National Urban Mass Transportation Statistics: 1983 Section 15 Report, Table 3.08, p. 3-70; latter figure converted to 1988 dollar equivalent.

22. Calculated from item 10 and Metro-Dade TA system-wide operating expenses during FY1983, last year of all-bus service, reported in National Urban Mass Transportation Statistics: 1983 Section 15 Report, Table 3.08, p. 3-70; latter figure converted to 1988 dollar equivalent.

23. Calculated from item 11 and NFTA system-wide operating expenses during FY1984, last year of all-bus service, reported in National Urban Mass Transportation Statistics: 1984 Section 15 Report, Table 3.07, p. 3-53; latter figure converted to 1988 dollar equivalent.

24. Calculated from item 12 and PAT streetcar operating expenses during FY1986, last year prior to inauguration of limited LRT service, reported in National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.07, p. 3-57; latter figure converted to 1988 dollar equivalent.

25. Calculated from item 13 and Tri-Met system-wide operating expenses during FY1986, last year of all-bus service, estimated from "June 1987 Monthly Performance Report," July 20, 1987, p. 2; latter figure converted to 1988 dollar equivalent.

26. Calculated from item 14 and SRTD system-wide operating expenses during FY1986, last year of all-bus service, reported in National Urban Mass Transportation Statistics: 1986 Section 15 Report, Table 3.07, p. 3-62; latter figure converted to 1988 dollar equivalent.

Source Notes for Table 5-1.
FORECAST AND ACTUAL COST PER PASSENGER FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects				DPM Projects	
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento	Miami	Detroit
Weekday Rail Passengers (thousands)										
Forecast	See source notes to Table 2-1									
Actual	See source notes to Table 2-1									
Rail Project Capital Cost (millions of 1988 dollars)										
Forecast	See source notes to Table 3-1									
Actual	See source notes to Table 3-1									
Annual Rail Operating Expense (millions of 1988 dollars)										
Forecast	See source notes to Table 4-1									
Actual	See source notes to Table 4-1									
Equivalent Annual Total Cost of Rail Service (millions of 1988 dollars)										
Forecast	Calculated by authors using procedure described in text									
Actual	Calculated by authors using procedure described in text									
Equivalent Total Cost per Rail Passenger (1988 dollars)										
Forecast	Calculated by authors using procedure described in text									
Actual	Calculated by authors using procedure described in text									

Source Notes for Table 5-2.
FORECAST AND ACTUAL COST PER NEW TRANSIT TRIP FOR RECENT RAIL TRANSIT PROJECTS

	Heavy Rail Transit Projects				Light Rail Transit Projects			
	Washington	Atlanta	Baltimore	Miami	Buffalo	Pittsburgh	Portland	Sacramento
New Transit Trips per Average Weekday (thousands)								
Forecast	See source notes to Table 2-1							
Actual	See source notes to Table 2-1							
Rail Project Capital Cost (millions of 1988 dollars)								
Forecast	See source notes to Table 3-1							
Actual	See source notes to Table 3-1							
Annual Operating Expense Impact of Rail Project (millions of 1988 dollars)								
Forecast	See source notes to Table 4-2							
Actual	See source notes to Table 4-2							
Equivalent Annual Total Cost Impact of Rail Project (millions of 1988 dollars)								
Forecast	Calculated by authors using procedure described in text							
Actual	Calculated by authors using procedure described in text							
Equivalent Total Cost per New Transit Trip (1988 dollars)								
Forecast	Calculated by authors using procedure described in text							
Actual	Calculated by authors using procedure described in text							

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