TRANSPORTATION RESEARCH RECORD 797

Transit Planning and Management

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page 17, column 2, reference 4
Change "1976" to "1966"

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page 36, column 2, line 20
Change "\$6000" to "\$660 000"

Transportation Research Record 790

page 74, column 1, Equation 1
Change to "$Y = b_0X_0 + b_1X_1 + b_2X_2 + b_3X_1^2 + b_4X_2^2 + b_5X_1X_2$"

page 75, column 1, Table 1
Change "Variable" column to
"Variable
X_0
X_1
X_2
X_1^2
X_2^2
R^2"

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page 2, column 2
Insert the following before the last paragraph:

"The speakers present papers that indicate how they have taken steps to reduce such adversary relationships in contractual work, and provide various evaluations of the resulting work. The various papers are placed in proper perspective to provide an overall introductory picture of the subjects to follow this introduction. Three teams of three authors each present viewpoints on three projects, and two authors add their thinking to the seminar."

"This seminar examines three other projects, each of which is addressed by three speakers with three different points of view, namely the owner's, the contractor's, and the engineer's or the Federal Highway Administration's representative. The projects are

1. West Virginia Department of Highways Quality Assurance Program;
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3. Pittsburgh's South Busway.

"In addition we have

1. A paper by two researchers from Virginia.
2. Some thoughts by a service engineer of a large corporation who is constantly out in the field looking at all these problems and thus is in a position to observe what is going on."

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page ii, price should be \$7.20

Transportation Research Record 816

page 34, Table 6, line 9, column "Realistic Saving"
Footnote b-Change to "0 to 3.8"
Change "Annual liters of fuel saved . . ." to "1000's of liters of fuel saved annually . . ."

page 29, column 1, line 21
Change "millileters" to "milliliters"

Transportation Research Record 834

page ii
Change subject areas to 13, 15, 25
Change mode to 01 only

Preprint Volume for the National Seminar on Portland Cement Concrete Pavement Recycling and Rehabilitation

page 94, column 2, last line
Change "a 0.241-cm (3/4-in.)" to "0.241-cm (0.095-in.) diamond sawblades at 1.9 cm (3/4 in.)"

page 96, column 2, paragraph 2, line 3
Change "(3/15-in.)" to "(3/16-in.)"

page 98, Figure 33, line 3
Change "apepar" to "appear"

page 98, column 2, line 5 below Figure 35
Change "(51,000 sq. yds.)" to "(57,000 sq. yds.)"

NCHRP Report 238

title page, author's name
Change "Shebr" to "Shelar"

NCHRP Synthesis of Highway Practice 66

page 5, caption for Figure 3
Change to ". . . as a type II . . ."

NCHRP Synthesis of Highway Practice 69

Foreword, page iv
Delete paragraph 3

page 13, Table 2, item 2.6
Change formula to $T_t = \Sigma P_i(t_i + \sqrt{h})$

page 41, column 2
Change formula to $T_t = \Sigma P_i(t_i + \sqrt{h})$

page 45, Table 15, title
Change to "GUIDELINES FOR SERVICE CHANGES: (Port Authority of Allegheny County)"

page 86, box under Toronto, item 2-6
Change formula to $T_t = \Sigma P_i(t_i + \sqrt{h})$

NCHRP Synthesis of Highway Practice 76

page 2, line 5
Change "$50" to "$25"

page 7, column 2
Change "i = 1" to "l = 1"

i=l to i=1

page 13, Table 9, under Pennsylvania
Change "10%" to "100%"

page 16, column 1, line 18
Change "$50" to "$25"

page 23, column 1, line 29
Change "$50" to "$25"

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Strategic Planning as a Transit Management Tool

WALTER CHERWONY AND MICHAEL G. FERRERI

Transit systems are faced with rapidly rising deficits and growing opposition to increased taxes to underwrite subsidies. This financial situation is placing greater emphasis on systems to manage their operations more prudently and effectively. To maintain this vital service within realistic financial constraints, transit managers will have to rely on sound management techniques in the allocation of scarce resources. Numerous researchers have identified and applied techniques to assess the performance of individual transit routes. However, the industry has not fully exploited management tools used by the private sector to allocate resources. One such analytical tool employed by the business community is a strategic planning device originally formulated by the Boston Consulting Group. The unique aspect of this device is the way in which a role is assigned to each product line or division within the context of an integrated portfolio strategy. Two primary indices are used in the analysis—market share and revenue growth rate. This paper provides an overview of this approach in the private sector and its application to a transit system in which individual bus routes comprise the portfolio. Definitions associated with the strategic planning approach are established for the transit system. By use of data for the Birmingham, Alabama, bus system, the feasibility and desirability of adopting strategic planning for transit system are tested. Routes were categorized on the basis of this technique, and guidelines were established for the appropriate allocation of resources based on the analysis. The results of the analysis demonstrate the suitability of this analytical framework from the private sector to transit. The unusual aspect of the analysis is that it is revenue based and provides a novel way to view transit performance. By assessing all routes within a dynamic (trend) and global framework, it provides a useful diagnostic tool for transit managers.

The urban transit industry in the decades since the end of World War II has experienced three distinct eras. The first was a period of steady decline and deterioration of transit systems that could be attributed to the emergence of the private automobile, rising affluence, urban sprawl, and relatively low energy costs. During this time, transit in America was provided primarily by private operators who relied solely on fare-box revenues to support operations and capital investment. In response to a steady decline in ridership, operators decreased service and raised fares, which in turn further reduced patronage. After nearly a decade of this cycle of declining ridership and service, most privately owned urban transit systems were confronted with the realization that it was virtually impossible to continue to exist as a private enterprise.

This realization was communicated to the public and led to the second era, in which public investments of progressively greater sums were made in transit. This renaissance period witnessed a rapid expansion of service both in terms of frequency and route coverage. Ongoing with this jump in service levels was a substantial program of fleet replacement and expansion, as well as a rejuvenation of other fixed facilities. The result of this capital-intensive effort was a reversal in the secular decline in ridership and the restoration of public transportation as a feasible mode of urban transport. The results were impressive; however, so were the costs to local, state, and federal governments.

Transit systems, faced with rapidly rising costs, modest increases in patronage and revenue, and growing public opposition to taxes, entered the third era. This period is witnessing an attempt by transit operators to hold on to the ridership gains achieved earlier with only limited expansion of service. This situation will place greater emphasis on systems to more prudently and effectively manage their operations. The first era was characterized by cost cutting, the second period by rejuvenation of services and facilities, and the third era will be governed by resource allocation. This reflects the need to maintain a vital public service within realistic financial constraints.

To accomplish this objective, transit managers will have to rely on sound management techniques in the allocation of scarce resources. Numerous researchers have identified and applied techniques to assess performance, including development of individual route financial statistics, in response to transit management's needs (1). However, the industry has not fully exploited management tools used by the private sector to allocate resources (which are every bit as scarce) primarily because the measures that come to mind, such as earnings per share, return on investment, stock price/earnings ratios, and cash flow, imply allocation of profits--a nonexistent commodity in transit.

However, on closer examination, the private sector does possess an inventory of tools that could be adopted by transit managers. One such technique is strategic planning that is used by multiproduct or multidivision companies to guide investment decisions. This competitive analysis is in many ways analogous to urban transit systems if the products or divisions are viewed as the transit routes that compete with each other for limited funds to underwrite operating subsidies and capital investments.

The adaptation and application of strategic planning to transit resource analysis is presented for the Birmingham Jefferson County Transit Authority (BJCTA) (Birmingham, Alabama). For the analysis period presented in this paper, this system operated approximately 4.7 million vehicle miles, transported 9.8 million riders, and owned a fleet of 200 buses.

STRATEGIC PLANNING METHOD

Corporations are faced with decisions regarding investment either among different product lines or different companies or divisions within a conglomerate. For this reason, there is a need for a technique or procedure to perform this competitive analysis on an integrated basis. A tool that has been employed in the business community is a strategic planning device originally formulated by the Boston Consulting Group (2). The unique aspect of this device is the way in which a role is assigned to each product or division within the context of an integrated portfolio strategy. Product roles are viewed in terms of each product or division position relative to its competitors (market share) and its cash-flow potential (sales growth rate). These two indices are used in recognition of the unique situation that faces each product or division. The differences between products or divisions can then be used to determine which should be used to generate cash and which should receive investment funds generated by other units.

The key element of this approach is the construction of a growth market share matrix chart. As shown in Figure 1, the diagram represents the portfolio of products or division by a series of spots and dots. The ordinate of this chart is merely the growth rate in sales, expressed as a percentage. Relative market share (abscissa) has been defined as the ratio of a product or division's dollar sales in relation to the industry's largest competitor (3). For example, a product that had sales of $3.2 million while that of the largest competitor was $9.6 million would have a relative market share of 0.33.

Relative market shares of less than one are observed where a particular product or division is not the industry leader and does not have the largest market share. An index value of greater than one will occur for markets in which the product or division is the sales leader. By using information on each product or division, the results are plotted on the matrix chart of the growth--market share. To distinguish the different sales volumes, the diameter of the circle for each product or division is proportional to the dollar sales. In this way, the chart depicts three unique data items--sales growth, market share, and sales volume.

The use of this approach relies on the well-established relationship between market share and profitability. Because high market share normally implies high profitability, the preferred position is to have market dominance in high-growth markets. Since it is more difficult and costly to increase market share in low-growth markets, a desired element of the strategy is to use cash generated in low-growth markets to invest in the high-growth markets to attempt to increase market share. Obviously, other factors must be considered, such as the cost of achieving market dominance; however, the strategic planning approach does provide an analytical framework to assess performance and make decisions.

Another element of the approach is to classify each element of the portfolio into one of the four broad categories depicted in Figure 2, as follows:

1. Cash cows: Products or divisions that have a high market share and a low growth rate should generate substantial amounts of cash that, strategically, should not be reinvested. In essence, the market dominance implies substantial profits that are not needed to be invested in that industry because of the present competitive edge and relative stability of the total market. In view of the low growth rate, reinvestment would not appear prudent. For these reasons, products or divisions that fall into this category are used to generate cash for investments elsewhere in the portfolio.

2. Dogs: This identification describes products or divisions that have a low market share and a slow growth rate. Because of the slow growth, further investment to increase market share would not be prudent. Also, any modest cash flow usually is used to maintain present market share. For these reasons, products or divisions that fall into this category are often called "cash traps."

3. Problem children: Products or divisions that have low market share and a high growth rate require considerable investment to maintain and increase market share. Because of the high growth rate, they have the potential to eventually become cash cows.

4. Stars: The units in a portfolio that have both high market share and growth fall into this category. Although they generate large amounts of cash because of their market share, they also require considerable cash to maintain market share in a high-growth environment.

As noted previously, the growth-market share matrix provides a framework for portraying products or divisions within a portfolio, as well as a system to classify each element. Further, all industries are subject to the product life cycle in that, as any industry matures, the growth rate tends to decline. Given only enough investment to maintain market share, all products or divisions fall vertical to become either cash cows or dogs, depending on their market position prior to the growth market sharing. Problem children without adequate investment to increase market share will become dogs. With sufficient investment, they can move horizontally and become stars, which then become cash cows. These cash cows are then used to generate investment funds for financing market share increases for problem children. As shown in Figure 2, this sequence repre-

Figure 1. Typical diversified portfolio for a growth-market share matrix.

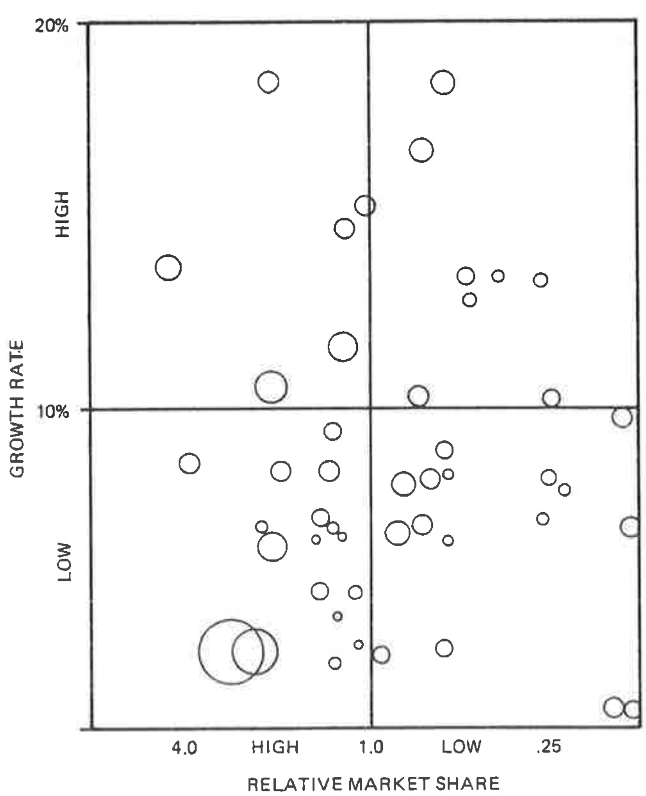
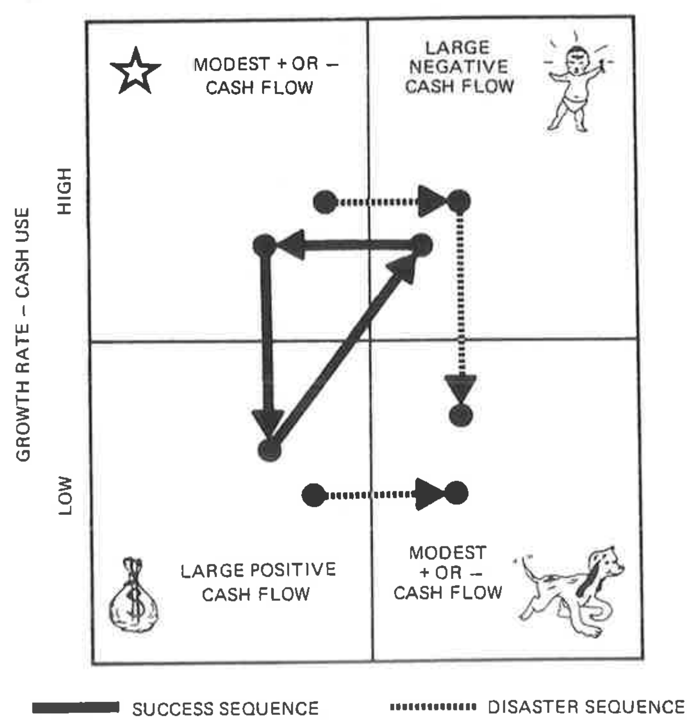


Figure 2. Cash flow and sequences.



sents a successful pattern for a multiproduct or multidivision firm. Also presented on this illustration are two disaster sequences. A weak competitive situation and insufficient investment could turn a cash cow into a dog or a star into a problem child, which could then become a dog with a maturing industry. In general, products or divisions that are dogs should only be maintained in a portfolio as long as they require no investment. They are prime candidates for elimination from the product or division portfolio.

TRANSIT APPLICATION AND RESULTS

The strategic planning approach described was developed for planning in the private sector; however, this technique would appear to have relevance to urban transit systems. One point to keep in mind is that private corporations are striving to maximize profit, but a transit system is attempting to use resources effectively and to provide a vital social service to the community. Nonetheless, the analytical framework to assess performance, categorize elements of the portfolio, and make investment decisions are all necessary elements of transit planning. One advantage of this approach is that it is dynamic in that it examines performance with respect to time. Most transit analysis tools, such as cost centers, are oriented to a single point in time (i.e., a snapshot). For this reason, this strategic planning approach was applied to the BJCTA. This system was selected for the analysis based primarily on the availability of data from an ongoing study. Also, because it is a bus-only system and its size is 200 buses, it is typical of many transit systems throughout the country.

The first step in the analysis was to prepare the growth-market share matrix. Needless to say, some liberties were taken in defining transit terms to be analogous to private sector corporations. In public transportation, the portfolio consists of individual bus routes that comprise the system. In Birmingham, 20 routes are operated, which are analogous to products or divisions. Fare-box revenue for each route was taken as the measure of sales. The growth rate was computed as a percentage change in revenue between two consecutive time periods.

Of greater difficulty is the selection of a transit definition for relative market share. The most technically correct term would be the modal split for the service territory of each route because the dominant competition to the bus system is the private automobile. Since this information would be difficult and costly to obtain, modal split was not selected to determine relative market share. Instead, the relative market share was defined as the ratio of each route's revenue to the average route revenue of the system. This average was merely computed as the total system revenue divided by the number of routes. The selection of this definition appears appropriate in view of the competitive nature of resource allocation among routes, the availability of data, and ease of computation.

Another aspect of the approach is the concept of cash flow and investment among elements in the portfolio. In transit, the analogous term to cash flow is deficit, which becomes the extent of tax subsidy or investment in a particular route. Because of limited funds to underwrite system deficits, the routes compete with one another within a constrained financial situation. A decision to provide more service on one route implies less service on another. The internal cross subsidization among routes is analogous to transfer of funds between product lines or divisions in the private sector. The data used in this analysis for the Birmingham transit system are presented in Table 1. This information was then plotted on the growth-market share matrix for each route. The current revenue was used to determine the size of the circle that depicts each route. One difference is that relative market share was not plotted on a logarithmic scale. As shown in Figure 3, one advantage of this approach is that it portrays considerable information about the system bus routes quickly and conveniently. Another feature of the approach is that it is revenue-oriented, which is different from other analysis techniques that focus primarily on transit costs.

The next step in the application of the strategic planning approach to transit is the selection of axes to divide all 20 routes into one of four categories. For growth rate, the relative performance of each route (low or high) was made with respect to the system's revenue growth--9.1 percent. Since relative market share was based on the system average, the axes for this indication were merely one.

Application of this reference system to Birmingham's bus routes produces the following results:

Category	Routes Number	Routes Percent
Cash cows	2	10
Dogs	7	35
Problem children	4	20
Stars	7	35
Total	20	

As might be expected, there is a wide variation in route performance. Also of interest is that nearly three-fourths of the routes are either stars or dogs.

In many respects, the interpretation of each route category is similar to the private sector model, as follows:

1. Cash cows: Routes in this category would be bus lines in well-established transit territories. Typically, a relatively high level of service is provided to capture riders and this produces a high relative market share. The low growth rate is consistent with the well-established territory and further substantial expansion would not produce a proportional gain in riders. In essence, the market penetration for these routes has attained a limiting value. Planning of service for these routes would not be aggressive.
2. Dogs: These routes exhibit stable conditions in that revenue growth is low. Similar to the private sector, these routes should be maintained as long as they do not require a disproportionate share of tax support. Unlike the private sector model, transit routes provide a definite social service and, for this reason, financial considerations are not the only criteria for service. Planning for these routes would be to carefully monitor their performance to ensure that they do not drain the system financially.
3. Problem children: Routes in this category would suggest transit territories that are susceptible to exploitation. The high growth rate indicates that opportunities for service expansion are present. Typical transit territories for these routes would include areas in the region that are experiencing rapid population or employment growth. For this reason, these routes should be studied actively, and an aggressive planning program of expansion should be pursued. Such a transit-development program for these routes could convert these routes into the system's stars.
4. Stars: These routes exhibit both a high growth rate and large relative market share. Ser-

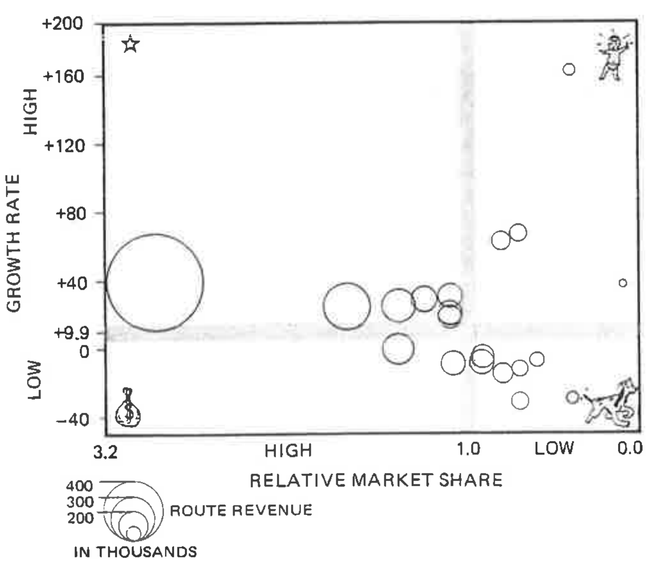
vice planning and expansion for these routes and their territories would be limited in comparison to the activities for the problem children routes. Care should be exercised by transit planners to ensure that service is not expanded too greatly because the territory will mature and the high growth rate cannot be maintained. By carefully monitoring route performance and balancing growth of revenues and service, these routes can become cash cows.

Table 1. Input data to strategic planning analysis.

Route	Revenue ($000s) Prior	Revenue ($000s) Current	Growth Rate (%)	Relative Market Share
1	191.8	239.0	24.6	1.4
2	155.2	200.8	29.4	1.2
3	71.1	119.1	67.6	0.7
4	162.9	178.0	9.3	1.1
5	403.2	508.6	26.2	3.0
6	170.1	162.7	-4.3	1.0
7	256.8	295.8	15.2	1.7
8	179.9	122.2	-32.1	0.7
9	185.4	138.5	-25.3	0.8
10	182.6	166.8	-8.6	1.0
11	16.9	22.8	35.4	0.1
12	106.8	75.2	-29.6	0.4
13	143.5	186.2	29.7	1.1
14	231.2	235.2	1.7	1.4
15	94.1	93.3	-0.9	0.6
16	80.8	130.7	61.7	0.8
17	25.9	67.7	162.1	0.4
18	155.1	180.4	16.3	1.1
19	181.6	170.9	-5.9	1.0
20	125.8	110.0	-12.6	0.7
Total	3120.7	3403.9	9.1	

Note: All values have been rounded.

Figure 3. BJCTA transit route portfolio.



A summary of planning efforts and service expansion follows:

Category	Planning Effort	Service Change
Cash cow	Modest, primarily monitoring	Limited expansion, primarily fine tuning
Dogs	Modest, primarily monitoring	Limited reduction, with service justified on basis of social need or system connectivity
Problem children	Extensive, exploring opportunities for expansion	Substantial expansion
Stars	Less extensive, attempting to balance expansion with expected declining growth rate	Modest expansion, trying to achieve equilibrium between service and revenue as market matures

As described above, the strategic planning approach provides a useful framework for assessing route performance and providing guidance in determining the extent of planning efforts, the appropriate service expansion programs, and resource allocation. One point to keep in mind in applying the strategic planning approach to urban transit systems is that the analysis by routes should be consolidated to permit appropriate actions by transit territories.

From the previous discussion, it would appear that the strategic planning technique has direct application to urban transit systems. To confirm the applicability of this approach, operating and financial results for the 20 routes were combined into the four strategic planning categories. As shown in Table 2, five key operating and financial parameters were computed for each category and presented in terms of the one success and two disaster sequences described previously. In terms of the success sequence (problem child to star to cash cow), all indices would be favorably impacted. In all cases, passenger and revenue productivity would increase while the operating ratio (cost/revenue) would decline.

The first disaster sequence (cash cow to dog) would result in unfavorable changes in the system performance for the five measures. For the other disaster sequence (star to problem child to dog), the results for the BJCTA system require closer scrutiny. For all five measures, the sequence from star to problem child would result in an unfavorable change in the measures. However, the disaster sequence from problem child to dog would, in fact, produce a favorable shift in the performance measures. Two factors can be cited for this situation. The first is that the routes classified as dogs in strategic planning are routes in established transit territories that are experiencing little or no growth in population or jobs that would contrib-

Table 2. Success and disaster sequences.

Factor	Success Sequence: Problem Child →	Star →	Cash Cow	Disaster Sequences: Cash Cow →	Dog and	Star →	Problem Child →	Dog
Revenue/mile ($)	0.67	0.72	0.82	0.82	0.71	0.72	0.67	0.71
Revenue/h ($)	8.44	10.54	10.90	10.90	9.40	10.54	8.44	9.40
Passengers/mile	1.94	1.97	2.45	2.45	2.17	1.97	1.94	2.17
Passengers/h	24.46	29.12	32.51	32.51	28.62	29.12	24.46	28.62
Operating ratio	1.99	1.63	1.59	1.59	1.80	1.63	1.99	1.80

ute to an increase in transit use. Further, the nomenclature in strategic planning refers to performance in terms of growth and relative market share. Also, routes in this category are indicative of relatively stable and small routes that are described from the standpoint of providing mobility to a community and ensuring system connectivity.

Second, the real question in terms of success or disaster is whether the problem child routes are converted to either stars or dogs. It is these possible outcomes that account for these routes being so named. Aggressive planning and service expansion for the problem child routes can result in these bus lines becoming stars. Failure to make this correct management decision will result in the problem child routes becoming dogs. Thus, the question is the comparison of the performance measures presented in Table 2 for routes classified as stars and dogs. For all measures except passengers per mile, the preferred sequence is to convert problem children to stars rather than dogs. The seeming anomaly for passengers per mile is attributable to differing operating speeds.

From the previous discussion, it would appear that the strategic planning approach can be applied successfully to urban transit systems.

CONCLUSIONS

The results of the analysis in applying the strategic planning approach to the BJCTA represent only a single case study. Nonetheless, the success of the application and the fact that the Birmingham system is typical of transit systems throughout the nation would suggest the following conclusions:

1. The analytic framework provided by the strategic planning technique in the private sector for multiproduct or multidivision corporations is directly analogous to the urban transport system. In the latter case, the portfolio consists of the individual routes.
2. Because of the limited resources for transit planning and services, as well as internal cross-subsidization, the transit system routes are in competition with one another.
3. By providing a revenue-based analysis technique, the approach provides a novel way of analyzing transit performance.
4. Another advantage of this approach is that it is truly strategic in nature. All routes are analyzed within a consistent framework and this approach affords an opportunity for overall system optimization. Other approaches, such as ordinal ranking and cost centers, can only provide suboptimal investment decisions.
5. By recognizing the dynamics of the urban environment in general and the bus system in particular, the approach provides greater insight into system performance than might be possible with the traditional procedures that examine the transit system at only a single point in time (i.e., a snapshot).
6. By assessing individual routes within a dynamic and global framework, the allocation of system planning and service resources can be made to achieve specific future results.
7. Similar to all such management tools, the strategic planning approach is diagnostic. Plans and programs must be formulated and implemented to remedy route and service deficiencies and exploit opportunities.

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Future Directions for Public Transportation: A Basis for Decision

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The future direction of public transport must be viewed in the context of the major forces that will influence our society. We identify four major forces to consider: population demographics and dispersion, energy cost and availability, overall economics, and technological change. Factors that could far transcend the single personal transport issue (e.g., world war) are purposely not addressed. Within the context of personal and economic forces at work in our society, we recommend that less emphasis be placed on competition between transit and automobile and much more be placed on articulation, system efficiency, and balanced transportation. We recognize that personal, individual transportation will continue to play a major role. The technology and fuel of such transportation may change, but not its basic role. The counterforces do not exist, and nontransportation factors so overshadow the issue at hand that it is not logical to attempt to manufacture them. Much can be done, however, with innovative use of urban personal transportation.

This long-range study is based on a report that was prepared to assist the Urban Mass Transportation Administration (1). It deals with the mobility needs of the American population in the year 2000 and the implications for public transportation. In order to gain a perspective on the time period involved, note that the year 2000 is not any further away from 1981 than was the year 1962. From the point of view of planning transportation facilities (including such long-lasting investments as highways and railways) 19 years is a very short period indeed.

The basic problem, of course, is that there is simply no objective way of knowing what conditions will be like in the year 2000. Many methods exist for attempting to form improved and better-founded opinions on this subject. Some of these methods go by names such as modeling, trend extrapolation, and Delphi. Yet, every one of these methods turns out, on examination, to rest entirely on subjective judgments made in the present by people who, in the nature of things, cannot possibly have any hard information about the future.

It is relevant to consider both the most-reasonable scenarios and some worst-case possibilities. However, contingency planning for a range of disasters and impacts with implications far beyond the scale of the transportation system alone was neither appropriate nor desirable in the transportation-oriented study undertaken. In accordance with the analyses and judgments of the team undertaking this effort, the following factors were selected as being of prime importance in the development of scenarios for public transportation planning purposes:

1. Population growth and dispersion,
2. Energy cost and availability,
3. General economic factors, and
4. Technological advances.

The technological factors considered were communication in place of transportation, new modes, new modal hardware, and new efficiencies. This paper considers the other factors because the technology has not been such that major issues are raised in the present context.

Prior to considering the results of the scenario building, it is important to note the historical development of transportation and place it in the perspective of evolving city settlements. Public transportation and the automobile are then seen not as natural rivals, but as technological innovations that respond to the varied economic and life-style preferences of individuals.

HISTORICAL PREFERENCES

Both inter- and intra-urban transportation systems have popularly been viewed as perhaps the most-important technological factors in supporting the growth and vitality of American cities. Although this is clearly true, it should not be overlooked that these technological innovations not only served the vast goods and personal mobility needs necessary for great urban settlements to exist; they also expanded the concepts of personal and economic freedom, previously confined to the scale of either the farm, frontier, or compact city.

Preferences for lower-density life-styles have persisted in the nation and dominated the desires, if not always the realm of possible actions, of many Americans. Public transportation modes especially need to be viewed as innovations that expanded the life-style options for increasing numbers of people. The rise and decline of transit ridership need also to be placed into context: Ridership expanded until the automobile developed as a more successful means of fulfilling two largely inseparable needs--mobility and lower-density life-style.

The earliest American cities were settled and developed in response to technological innovation, especially inter-city transportation developments (e.g., steamboat, canal, and railroad). Internally, urban transportation modes satisfied mobility needs of huge, dense populations, but they also released pent-up preferences for lower-density life-styles. A succession of technologies (e.g., horse-drawn streetcars, cable cars, electric streetcars, subways and elevator trains, buses, and automobiles) allowed more and more people to move further away from the city core. These modes allowed greater range for a given travel time budget and were coupled with continual real cost decreases and rising affluence.

Population dispersion to outlying areas was supported by various forms of public transit since at least the 1850s. These urban transportation technologies allowed increasing numbers of people to escape living in crowded centers of cities since, previously, walking to work was the only modal option. This movement, however, is not easily discerned; even though the rate of population dispersion from the centers of cities has been relatively constant since the middle of the nineteenth century, those who emigrated to suburbia were immediately replaced by waves of rural and foreign immigrants. The flow to the outlying areas was supported by mass transit, while the influx of immigrants from rural areas and overseas was supported by railroads and steamboats. Only the cutoff of massive foreign immigration and the decline of the rural farm population in the twentieth century allowed the underlying trend to emerge clearly.

Public transportation has suffered greatly in the last 30 years. The historical decline of ridership (the heart of the problem) is placed not in the late 1940s but in the late 1920s. The forces that caused this decline actually began to appear some 70 years prior, in the midnineteenth century. Only the extreme, anomalous conditions of the Depression and the Second World War, which masked this trend, have left some transportation planners with the spurious goal of returning to the "natural" ridership levels of the 1940s.

POPULATION DEMOGRAPHICS AND DISPERSION

The future shape of urban settlements must rely on (a) historical precedent, (b) proliferation of automobiles and supporting highway system, and (c) population demographics. These factors will be as important in favoring continued dispersion from high-density centers as were the baby-boom post-World War II years. Dispersion (largely reserved in the past to suburban areas adjacent to urban centers) will assume an even bolder appearance, in the shape of growth in

1. The sunbelt,
2. Small cities and rural areas, and
3. Independent suburban communities.

If such dispersion exists, implications for public transit are clear: Although high-density settlements will not disappear and may possibly level off in terms of relative losses, a growing portion of the population will be settled in areas not amenable to cost-effective service by conventional transit modes.

To set the context, it is important to note the continued major role of a large population in the family-formation years. This is a factor that is even more important than the growing number of elderly, to which we are well sensitized. The overall population shift can then be viewed in terms of the continued needs of this group, and economic and social forces that transcend the single issue of personal transport. Business is relocating because of changing industrial technology, space availability and cost, labor availability and skill, climate, energy availability, and transport of goods. Life-style preferences actually reinforce this in many cases.

We recognize the rebirth and special advantages of classic urban areas and large cities. Their uniqueness and value are not questioned, nor are the modal advantages within those configurations. However, these are but a few elements in an evolving future and do not signify a major counterforce. We also recognize the modal energy advantages of conventional public transport for personal transportation. Again, however, the total petroleum-based energy advantage may lie with lower-density, automobile-dependent clustered configurations that have alternative energy forms for home and industry and not with the classical high densities (2).

Demographics

For the purpose of understanding mobility patterns and needs, population growth must be viewed not simply in terms of numbers but also in terms of composition. Aside from immigrants, all those who will be 20 years or older in the year 2000 are already born and reside in the United States. Much, therefore, is known about the probable composition of the population. The population will be aging, as numerous reports and census figures have documented (3). However, it is equally important to emphasize the significant growth in absolute numbers of the segment of the population most concerned with family formation.

In 1943, the baby boom began as the number of annual births reached 3.8 million (4,5). Previously, births in the United States had dropped from more than 3 million in 1921 to 2.4 million in 1933, and births never exceeded 2.6 million throughout the 1930s. But, beginning in 1943 and lasting for nearly 30 years, annual births never dropped below 3.2 million. After falling slightly, annual births returned to 3.8 million in 1951 and continued to rise until they peaked at 4.3 million in 1957. The decline was slow, receded to around 3.7 million during the late 1960s and dropped below 3.2 million only after 1972.

The baby-boom period should be best considered in terms of size of cohorts (i.e., annual births) rather than birth rates. The enormous bulge in the age distribution caused by the baby-boom years is moving through the population, over time, as if on a conveyor belt. The rapid rise in cohort size from 1943 to 1957 was a major factor in suburbanization as young postwar families moved for the sake of available homes and space, better schools, grass in the backyard, less traffic in the street, and "a good place for the kids to grow up."

The last of the 3.2 million cohorts will not reach 30 until 2002. If current patterns persist, most of these women will not choose between job and motherhood (6); they can have both. But for most people, this usually means having only one or two children and returning to work. But even the birth of one child usually means commitment to a less-dense life-style, one more easily found in the suburbs, small towns, or rural areas. There is a need for more square feet of housing at a price that can be afforded, more open space for play, better schools, and all the other amenities that families that have only one child still desire (7). High-density living, often very attractive to marrieds without children or singles in their late twenties, is often sacrificed to new priorities, if incomes permit, when a child is born. The new priorities created by the birth of the first child become much more pressing if there is a second child. There need not be a third or fourth child, as was typical during the 1950s, for life-style changes to become imminent.

This enormous force--the former baby boom that is becoming and will continue to become a nesting generation--virtually guarantees continued low-density growth. The mass movement of this segment of the population (over 30, male and female) will also continue to attract more industries to locations closer to their labor force, which will further ensure the maintenance and growth of low-density settlements.

Dispersion

All three movements toward low-density settlements are closely connected. If all three are not considered, apparent indications seem to break down. For instance, the population growth rate in the South during the 1970s was actually below what it was from 1960 to 1970, and certain areas of the so-called snowbelt are gaining population at a greater rate than the national average (8). Yet, neither fact belies that a shift toward the sunbelt is occurring. In the first instance, despite a lower growth rate than in the previous decade, Southern population grew at a rate 28 times greater than that of the Northeast states from 1970 to 1977 (8). In the second case, the population increase has occurred almost entirely within nonmetropolitan areas of snowbelt states, and the metropolitan bulwarks of Northeastern states lost population over the last seven years (8).

The move toward low-density settlements does not mean that the country will become decidedly rural, at least not by the year 2000. Most rural growth has been in the exurbs of urban areas. However, the advantages of urbanization appear erodable to the resident population. Metropolitan areas can and do reach economic maturity, and depreciating manufacturing plants and housing stocks play primary roles in driving much new investment and population outward. Currently, as rural areas are no longer considered isolated and backward, strong latent residential preferences are more likely to be fulfilled.

Much has been said in recent years about the growth in the sunbelt. The factors that drive this overall pattern (i.e., economics, space, labor, climate, intercity transportation, and collection-distribution) far exceed those directly affected by intraurban person-transport facilities and service.

In addition to the aggregate shifts, consider the nonmetropolitan pattern. Prior to the 1970s and, except for a brief number of years during the Depression, metropolitan growth has exceeded nonmetropolitan growth rates since 1820 (9). In the 1970s, however, a dramatic shift occurred. The nonmetropolitan growth rate as of 1976 was nearly twice that of metropolitan counties--8 percent versus 4.7 percent (10). Although a considerable amount of this growth occurred in nonmetropolitan counties adjacent to standard metropolitan statistical areas (SMSAs) (possibly better characterized as suburbanization rather than rural migration), freestanding rural counties indicated significant growth and net migration gains. Thus, both suburban and developing small urban growth is a fact to contend with.

ENERGY COST AND AVAILABILITY

The fuel crises of 1973-1974 and 1979 demonstrated dramatically how sensitive our society is to perturbations in its gasoline supply. Alternative means of moving individuals were sought. Public transportation offers a much more efficient alternative in terms of British thermal units per seat mile and also, at typical peak loadings, per passenger mile.

To the extent that the lower-density pattern cited above is inconsistent with the feasible deployment of public transportation, it would follow that the energy problem is a substantial counterforce to that lower-density pattern. Simply put, if public transportation is necessary to move people, and if low density cannot support public transportation effectively, then a substantial force would be working against the low-density pattern. The evidence of 1973-1974 and 1979 and the subsequent rises in gasoline prices are commonly cited as support for this reasoning. However, a closer inspection of these postulates is required.

The study on which this paper is based considered two distinct supply scenarios: (a) a steady but significant increase in price and (b) an abrupt reduction in supply, regardless of price. Other scenarios were considered, but were deemed to be variations of these or less probable. Indeed, the first of these is judged to be the most probable of all such scenarios. The second is improbable but has effects that justify special attention and consideration.

The dramatic increases in gasoline prices are well documented. The discomfort that they have caused is without question. Nonetheless, it is also true that automobiles are becoming more efficient, driven by federal mandates and market forces, and that the real dollar costs (corrected for inflation) are not as dramatic. Thus, real, constant-dollar cost of fuel per passenger mile can actually decrease in some scenarios. Figure 1 illustrates some computations under the assumption of orderly, adaptive change.

We readily acknowledge the circular reasoning implicit in this situation. Petroleum supply is a major political concern in our society. Sharp petroleum price increases are primary causes for the inflation we are experiencing. Thus, they are responsible for driving up the overall cost of living, which mitigates the relative cost of the gasoline price increases.

Despite the overall problem, the individual will perceive a much less dramatic relative choice to avoid the automobile than we might generally expect. We conclude that there may be major user-generated forces for more-efficient vehicles or for alternate fuels but not comparable forces to forsake the individual, personal vehicle.

The problem that is of special interest is not the steady adaptation and change just depicted, with some influence on transit (perceived as significant only relative to transit's minor present role) but rather the less likely scenario of a dramatic and rapid decrease in supply.

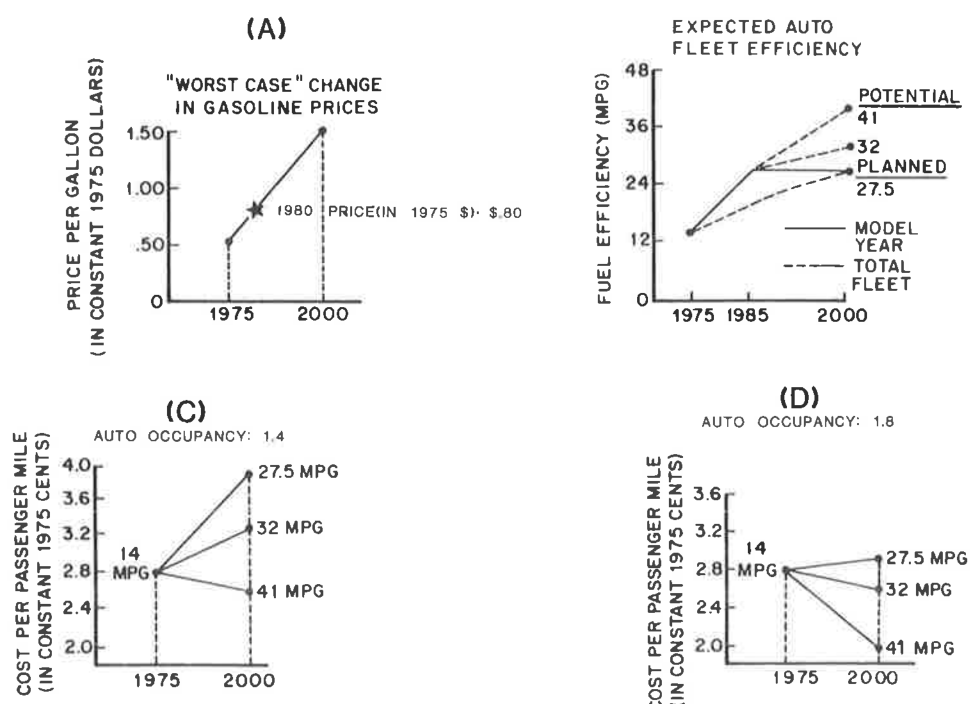
The political and economic forces that can bring about such a decrease are clear. Moreover, the political and economic dangers are so real that some agree that we should impose the restriction on ourselves. Further, we must recognize that an attempt to protect internal supplies to industry and to home heating may lead to a disproportionate impact on the personal transport sector. A decrease of 10 percent and even 20-30 percent in the motor vehicle component must be seriously considered.

The essential problem is that trip needs must be met with a decreased energy supply, so as not to disrupt the economy. Response options can include greater efficiency in automobile trips, more public transportation, and a return to higher densities.

Greater efficiency within the automobile mode can be achieved with carpooling, vanpooling, elimination of unnecessary trips, packaging of other trips, and other measures. At the level of 10 percent reduction in supply, the existing trip patterns and occupancies are such that the disruption can be overcome relatively easily. As the reduction in oil supply approaches 25 percent, the core of necessary trips will be affected seriously and measures that rely on packaging and efficiency within automobiles become less feasible as the total solution.

Public transportation can respond, but, for the most part, it cannot be with rail transit. Some service options can be improved on existing systems, but most areas neither have rail transit nor could they implement it in the required time frame. In most areas the principal response must come from buses, vans, and paratransit, including more innovative uses of private automobiles.

Figure 1. Impact of energy cost increases, improved automobile efficiency, and automobile occupancy on cost per passenger mile.



The need for buses can be met, despite current delivery lags, for one important reason: The automotive industry will clearly be hurt significantly by a decreased demand for automobiles (because serious fuel supply problems are part of this scenario) and it must move rapidly to new markets. Buses, vans, and related vehicles represent this opportunity, and the production knowledge and experience exist to make such production alterations.

Rights-of-way also exist. Existing roads can be converted to busways and high-occupancy-vehicles-only systems. Institutional problems such as insurance for pooled riding and for vans and paratransit vehicles as well as possible franchise infringements can be overcome.

More basic than these responses can be the return to high-density areas or the development of new high-density areas or local clusters. Certainly some of this will occur. However, the fact that there is such a massive infrastructure of lower-density development (privately held by individuals and, for most, the major capital investment of their lives) is a major force. (Moreover, the capital requirement for rehabilitation or construction of new, dense housing for all these persons would be immense.) For every seller, there must be a buyer or abandonment. In addition to this reality, the American preference for an individual holding is historic and characterizes our national development.

The realignment of people may lead to shorter trip lengths, and higher-density clusters may be inserted in areas, but it is reasonable to expect that the future will contain the basic housing structure and preferences that now exist. Depending on the level of the petroleum constraint, some balance of efficient use of automobiles and bus or van transit and paratransit will be the preponderant response.

Given a significant transit role in meeting the immediate problem, one must then ask whether the fact that the infrastructure is in place will then lead to a permanently enhanced role for transit. One can even think in terms of providing more efficient transit (e.g., rail construction initiated now), in anticipation of this new structure and need.

At the same time, many energy alternatives that are now infeasible due to cost or implausible because of societal priorties will become attractive and can be pursued, particularly on a crash basis. Alternative fuels from coal, oil shale, and some renewable sources can be manufactured. Electric vehicles can be manufactured in a major effort. Nuclear reactors can be built to supply the necessary energy, as the current 8-10 year building period conceivably could be greatly reduced.

One must also recognize that the basic density infrastructure and historic preferences will exist. Further, usable fuel alternatives will also exist. They can be cost effective due to new relative costs and technological advances. Synthetic fuels and electric vehicles represent the two major opportunities. Industry can reorient and provide one or the other or both as the primary market response. The costs of transit can represent a major difficulty by the second decade, particularly the labor intensiveness of the bus-oriented response. A probable response, therefore, is a dissipation of the enhanced transit-paratransit ridership and a return to private vehicles, albeit in a new form. The dissipation will be not unlike that that followed World War II. Indeed, both the postwar period and the years following such a disruption have common characteristics: a period of special problems that limit the availability of the automobile, but which technology or the passage of time can overcome.

ECONOMIC FACTORS

Our best estimate is that U.S. economic growth will continue on its long-term path. Aberrations in economic growth in two key industries--automotive and petrochemicals--are possible due to energy considerations, but the likelihood that major disruptions would occur is small. However, government support may be necessary. When added to other such support (necessary to increase investment in energy sources, pollution abatement, and improved social welfare), a substantial amount of private capital investment could be diverted, causing a possible fall off in productivity growth. Yet, as the nation becomes increasingly linked to a service economy, productivity and even real gross national product (GNP) are less-accurate indices of long-term trends in the well-being of society (11). Therefore, we do not expect there to be unmanageable business cycles or severe trade deficits that will alter long-term trends. Such a scenario implies no changes in the public transportation-automobile picture thus presented. There is, however, one alternative economic scenario that is a highly probable alternative: stagflation. This merits special discussion, for a number of transportation observers have judged that this phenomenon might lead to a resurgence of mass transit.

Stagflation is the simultaneous existence of high unemployment and high inflation. Some people believe that stagflation induces transit use, because the reduced level of economic activity coupled with (and partially caused by) higher petroleum costs will make transit more attractive in two separate ways: (a) an income effect and (b) a substitution effect. The lowered disposable real personal income and relatively tight money policies (high interest rates instituted to control inflation) would lower automobile sales, because fewer persons could afford the relatively large capital outlay and associated fixed expenses (e.g., insurance). In addition, the increases in the price of gasoline relative to transit fares would cause a substitution of conventional transit modes for private cars.

Although there is some justification for this type of connection between oil-fed stagflation and mode choice, other urban transportation scenarios can also be hypothesized around stagflation that are at least equally plausible and that would reduce transit use. The prime factors are that, as work trips decrease, costs increase and nonfare income decreases.

Unemployment under stagflation most directly reduces work trips--the dominant transit trip purpose and crucial travel market for transit systems, especially outside the transit-dependent cities (e.g., Chicago, New York, and Boston).

The public transit sector is not spared the effects of inflation, for the costs of labor, equipment, construction, and energy all increase operating expenses. All of this occurs while the economic slowdown produces a leveling off or even reduction of tax revenues needed to offset rising deficits.

Fare increases and service cuts, both of which lead to reduced ridership, could very likely happen if the necessary nonfare support were no longer forthcoming. In addition, it cannot be assumed that the population is dispersed in a way that makes the switch from private to public modes of transportation possible. The postwar residential land use patterns, geared around the flexibility of the private automobile, are not well served by the relatively fixed characteristics of conventional transit, even if economic conditions were to make it relatively more attractive than the private automobile.

Based on these considerations, it is very difficult and probably erroneous to label stagflation as an economic scenario that would bring riders back to transit and gradually turn private automobiles into vestigial machinery. The counterargument seems more justified, especially when the impacts on both ridership demand and tax revenues are considered. There is also the potential for alternative energy actions (e.g., renewable fuels, increased domestic oil, and coal production) and the substantial and very probable increase in automotive energy efficiency that will help that mode ride out the cost impacts of stagflation.

CONCLUSIONS

The major scenarios of the future of urban America considered in this paper, based on the most influential and plausible trends, all point toward a continued and even strengthened trend to lower-density living. This is due to a number of societal forces that could not be realistically reversed or impeded by any feasible public transportation policy. However, there are opportunities for conventional transit to be efficiently implemented or expanded, but such modes cannot (and should not) be expected to reverse the overall decentralization trend.

For the purposes of providing efficient mobility to the population, planners should pay particular attention to novel uses of the automobile and to novel implementations of paratransit in low-density environments. Every effort should be made to (a) improve the energy efficiency of the automobile and (b) create situations where the tremendous excess capacity in automobiles can be used through expanded ridesharing. The use of transit policies as a counterforce to the growth of these low-density areas is not deemed possible, due to the major societal forces at work. More importantly, agencies that try to emphasize conventional transit modes in such areas will essentially be providing incentives for inefficient transportation, because the world of low-density urban and suburban regions is simply not amenable to such high-density modes.

The various capabilities of automobiles, paratransit modes, and conventional transit services must be applied only in those markets that they can serve efficiently. Single-passenger automobiles should be dissuaded, for example, from rush-hour trips into central cities, and conventional bus services should not be supported in low-density areas that are served more suitably by private automobiles or various paratransit services.

The atmosphere of modal competition, especially between the private automobile and conventional transit modes, must be replaced by one that

1. Accepts the capabilities of each mode,
2. Accepts the nature of the demand for each, and
3. Stresses the coordination and effective articulation of existing and planned transportation networks.

To some, any conclusion that does not advocate high-density transportation and the infrastructure that supports it is an abdication of our responsibility as planners. To those, we must simply observe that sound planning must be consistent with underlying social choice. In the present context of transportation, we have identified population composition and preferences and private sector economic decisions that are massive forces moving the nation in certain directions. We have also reasoned that the likelihood that substantial increases in automobile operating costs will act as a notable counterforce is virtually nonexistent.

We note that this is an overall prognosis that addresses the substantial lower-density areas--cities, towns, and suburbs, which represent the areas of significant growth. The older urban areas, with their high-density infrastructure, represent an alternative that some will continue to elect. Future transportation assessments must not overlook these existing areas, even if they are not the primary direction of development.

The fact that conventional transit modes are incapable of meeting the mobility needs of the newer urban areas, and currently handle roughly five percent of the nation's total trips, does not mean that they do not play a crucial transportation role in dense urban areas, including service between lower-density areas (by use of paratransit modes for passenger collection and distribution). The decline of such regional urban centers as New York, Boston, and Chicago may have leveled off, and most experts feel that they will be able to maintain these somewhat lower levels of population. Conventional transit already exists in these areas, and upgrading (and possible expansion) of these networks is both necessary and justified. In addition, every effort should be made to provide the necessary paratransit support services to expand the effectiveness of fixed-guideway systems, especially those only recently developed or still under construction. However, we feel that a mere replication of such conventional systems cannot significantly stem the longstanding social and economic trends toward decentralization, and must be augmented by new paratransit concepts, including the private automobile itself, in lower-density areas. Indeed, these systems may, themselves, be links for clusters with a general lower-density area development.

In closing, we note that the abrupt-reduction-in-supply scenario would provide an incidental by-product: The scale on which transit and paratransit would have to be implemented gives opportunity for efficiencies, economies of scale, and innovations that did not previously exist or that now exist in most real-world environments. In our judgment, the innovations must be in implementing comparable levels of service to the automobile at comparable cost. The comparable level of service requires much attention to articulation of services, with good frequency of service. Certainly some such innovations can be thought out and planned, even without such an unpleasant scenario, and should be developed. It follows that some of these will be by-products of contingency planning, which is itself justified considering the severity of the abrupt-reduction-in-supply scenario.

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Effect of Environmental Factors on the Efficiency of Public Transit Service

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As part of efforts to improve the productivity of public transit systems, performance-evaluation techniques have received a great deal of attention among transit analysts. Development of performance-evaluation methodologies applicable to groups of systems has been limited by the issue of comparability. Transit performance is thought to be sensitive to the environment in which the system operates. Because operating conditions vary from one system to another, performance comparisons may not be appropriate. However, the extent to which operating conditions affect performance has not yet been established. By using a sample of 30 California fixed-route transit systems, this paper examines the effect of environmental and institutional factors on efficiency. Operating conditions are found to have a significant impact on transit efficiency and, therefore, these factors must be identified and controlled for when performance comparisons are made. Significant improvements in the efficiency of transit systems will require the cooperation and efforts of both transit operators and policymakers.

During the past decade, public transportation policy underwent a major shift from support of massive capital improvements to an emphasis on maintenance and improvement of existing services. In an effort to put a lid on rapidly escalating costs and subsidy requirements, better management of the transportation system, aimed at more effective use of the system, became a major focus of public transit policy. Under the rubric of transportation system management (TSM), a number of transportation and traffic engineering improvement techniques were implemented, and interest was renewed in developing ways to evaluate the performance of public transit services.

Research in public transit evaluation began with the development of indicators that measure different aspects of performance, such as labor use or cost efficiency. These indicators were found to be useful for identifying areas of potential improvement within the transit organization and for monitoring progress toward specified goals (1-3). It became apparent, however, that performance indicators had limited utility for performance evaluations between transit operators, primarily because the extent of comparability between transit firms had not yet been established. Performance comparisons between different transit modes, such as between fixed rail and conventional buses, are limited because of differences in technology and type of service provided. Within the same transit mode, the issue of comparability centers on the locational differences that exist among public transit systems. In general, transit systems are organized as spatial monopolies, and therefore, each operates in an environment that is to some extent unique. Locational differences between public transit systems are an important consideration for two reasons. First, the institutional framework through which transit service is provided varies from place to place. Second, public transit service interfaces with the operating environment on two levels. On the supply side, it must operate within the structure of the existing transportation network; on the demand side, its ability to compete with other modes is a function of both population characteristics and existing travel patterns. Because of these place-specific variations, analysts have maintained that the comparability of transit system performamce is severely constrained. If performance comparisons are to be made, environmental factors that affect performance must be identified and taken into account. This paper analyzes the extent to which the operating environment affects the performance efficiency of fixed-route transit service.

ANALYTICAL FRAMEWORK

In an ideal world of full information, the appropriate model for such an analysis would be one in which transit performance is conceptualized as a function of two sets of factors: those within the control of the operator or manager and those outside operator control. Performance evaluation should be aimed at the first set of factors; it should evaluate the outcomes of decisions the transit firm has made. Unfortunately, the extent of operator control is difficult to determine. Although the internal operations of the transit organization are clearly under the control of transit management, labor union work rules may create constraints on efficient labor use, and federally mandated lift-equipped buses may generate additional maintenance costs and reduce fuel efficiency. In addition, decisions about service parameters, such as route realignments or fare changes, are generally subject to external review and approval.

Since the actual extent of operator control is not easily determined (and may also vary from place to place), a more workable model of performance is one that thinks of performance as a function of environmental and institutional factors as well as the managerial expertise of the firm. Institutional factors are those that derive from the firm itself, such as organization size and age of the firm. Environmental factors are those that derive from the operating environment, such as population density, level of traffic congestion, or size of the service area.

There is no reason to assume that environmental and institutional factors have a uniform effect on every aspect of performance. More likely is that the importance of different factors varies from one indicator to another. Thus, performance indicators are analyzed individually, by using a regression model of the form,

$$Y_k = \alpha_0 + \beta_i X_i + \gamma_j X_j + u \qquad (1)$$

where Y_k is the kth performance indicator, $\beta_i X_i$ are institutional factors, and $\gamma_j X_j$ are environmental factors. Each indicator is a linear combination of these factors, and managerial expertise (individual firm differences) is treated as a residual.

The empirical research reported here was conducted on a sample of 30 California fixed-route transit operators. Operating data for the 1976-1977 fiscal year were gathered via operator interviews, audit reports, and California State Department of Transportation records. Demographic and geographic data, gathered from several state and federal sources, were matched to the service area of each operator. In spite of its small size, this set of transit systems represents a wide range of operating conditions and, therefore, provides an appropriate basis for analysis.

EFFICIENCY INDICATORS

Transit performance is a multifaceted concept that may be divided into three areas: efficiency, effectiveness, and impact. Efficiency refers to the production of transit services and measures the transit firms' use of inputs in the process of providing service. Effectiveness measures the extent of service consumption, and impact refers to the indirect effects of transit service on the environment. This discussion is restricted to performance efficiency. Performance efficiency can be measured in two ways. Production efficiency measures the extent of efficient use of specific inputs, such as labor or vehicles, in the service production process. Cost efficiency measures the ratio of expenses paid to all inputs to output produced, or the dollar cost of each output unit.

Three efficiency indicators were selected for analysis. Revenue vehicle hours per employee (RVh/EMP), where employees are computed in full-time equivalents, measures the efficiency of labor use. Labor is by far the most important input in the transit service provision process, as labor costs make up about 80 percent of transit operating costs (4). Thus, service efficiency is primarily determined by the way in which the transit firm uses its labor force. The indicator is affected both by the use efficiency of driver personnel (i.e., by how closely paid driver hours match revenue service hours), and by the proportion of non-service-producing personnel within the firm. As non-service-producing personnel increase, the indicator decreases in value.

The indicator selected to measure the efficiency of vehicle use is revenue vehicle hours per maximum vehicle hours (RVh/MAXVh). There are two important aspects of vehicle use. One is the size of the fleet relative to service needs, and the other is vehicle reliability. The size of the fleet is primarily determined by peak vehicle needs. As the peak to base ratio increases, the average service hours produced per vehicle declines. Similarly, vehicle productivity also depends on the firm's hours of operation. The maximum amount of service each vehicle can produce is determined by the number of hours per day that service is available. In an effort to control for the effect of different service hours (hours of operation), revenue vehicle hours are measured as a proportion of maximum possible vehicle hours, or the average revenue hours produced per vehicle as a fraction of the total possible hours each vehicle could be in service. Vehicle use is a less important determinant of transit efficiency than labor use, because vehicles account for a much smaller proportion (less than 15 percent) of operating costs. Nevertheless, the effect of vehicle use on overall efficiency is not inconsequential.

The third efficiency indicator is operating expense per revenue vehicle hour (OPEXP/RVh). It is the bottom line production indicator because it measures the firm's ability to combine all inputs to efficiently produce revenue service. Because it measures cost per unit of output, lower values imply greater efficiency. Descriptive statistics for the three efficiency indicators are presented in Table 1.

The unit of output selected for the performance indicators is revenue vehicle hours because it is less affected by network characteristics than is revenue vehicle miles. Traffic congestion, for example, reduces system speed, and as speed declines, it takes more time and therefore more inputs to produce a given quantity of vehicle miles. By using vehicle hours, these external effects are minimized.

ANALYSIS

Labor Use

Factors that affect the efficiency of labor use were organization size, age of the firm, and the area wage rate, as shown in Equation 2. Figures in parenthesis are t-ratios, and figures in brackets are beta coefficients.

$$\begin{aligned}\text{RVh/EMP} = 145 &- 0.186\ \text{VEH}\{(2.5)[0.31]\} - 165\ \text{OPAGE}\{(2.6)[0.30]\} \\ &- 73.1\ \text{PEAK}\{(1.3)[0.15]\} + 541\ \text{SMALLSIZE}\{(5.2)[0.87]\} \\ &+ 34.5\ \text{MEDSIZE}\{(3.6)[0.62]\} + 1.02\ \text{WAGE}\{(3.5)[0.42]\} \qquad (2)\end{aligned}$$

$R^2 = 0.74$, $N = 30$.

where

VEH = number of vehicles (organization size);
OPAGE = age of firm, dummy; 1 = began operation 1972 or after, 0 otherwise;
PEAK = peak to base ratio;
SMALLSIZE = dummy for small service area; 1 = 100 000 population, 0 otherwise;
MEDSIZE = dummy for medium service area; 1 = 100 000 to 500 000 population, 0 otherwise; and
WAGE = area average monthly wage rate.

This equation indicates that labor efficiency is

Table 1. Descriptive statistics of performance indicators.

Statistic	RVh/EMP	RVh/MAXVh	OPEXP/RVh ($)
Mean	1222.77	0.48	20.70
SD	279.83	0.19	7.34
Minimum	702.14	0.15	11.28
Maximum	1733.21	1.00	42.73

determined, to a large extent, by factors outside the control of the transit operator. The one variable in the equation that is subject to operator control, the peak to base ratio, is insignificant, although the sign is in the expected direction. As the peak to base ratio increases, the efficiency of labor use decreases, mainly because work rules that limit split shifts and spread time reduce the revenue service produced per driver.

Organization size is strongly correlated with size of the area in which the firm operates. If all transit firms provided the same density of service (units of service per unit of area), the two size variables would be perfectly correlated. In fact, density of service does vary and the simple correlation between organization size and service area size is 0.65. In order to minimize the problem of multicollinearity, dummy variables were used for service area size. The effect of all size variables is negative: Efficiency of labor use declines both with increasing organization size and increasing service area size.

These results contradict recent research, which indicates that there are no diseconomies or economies of scale in bus transit service (5). That is, size should have no effect on efficiency. There are several possible explanations for the results observed here. First, they may simply be the result of this particular sample, in which several small operators are very efficient. Second, large operators may provide a different type of service than do small operators. Large firms, which operate in large metropolitan areas, provide more peak-period service and generally have longer service hours, which require additional supervisory shifts. The spatial distribution of services also may increase with size. As routes become longer and more dispersed, coordination of drivers and vehicles may become more difficult, and deadhead time may increase. All of these factors could reduce the efficiency of labor use. Finally, many transit analysts claim that very large transit systems, like other public institutions, tend to become top heavy with administrative personnel and, therefore, less labor efficient.

Some of the negative effect of size observed here can be attributed to what is frequently called the "municipal effect." Although all of the sample firms are public operations, some are owned by municipalities and others are organized as independent transit districts or authorities. Municipally owned firms frequently benefit from integration with other municipal operations by sharing administrative services and overhead costs. In some cases, only actual service inputs are assigned to the transit operation, and the overhead is absorbed by other departments. Thus, municipal firms tend to score higher on measures of efficiency of labor use than do nonmunicipal firms. In this sample, the municipal firms are also small firms.

Equation 2 also indicates that new firms are less labor efficient than old firms. New firms operate in areas that were either passed over by private enterprise (presumably for good economic reasons), or in areas of recent population growth, that is, low-density suburban areas. Suburban areas are characterized by dispersed travel patterns and low transit demand. These firms must attract ridership through substantial marketing and planning efforts. New firms also tend to be rapidly growing firms. Service is expanded into new areas, and service frequency increases as ridership is established. These planning and expansion efforts require substantial administrative staff. By increasing the proportion of nonservice-producing employees, new firms produce less revenue service per employee.

The area wage rate appears to have a positive effect on efficiency of labor use. From an economic standpoint, this is an expected result. As the cost of labor increases, the efficient firm tries to increase labor productivity. The interpretation here is that transit workers are willing to substitute higher pay for less stringent work rules, and consequently, firms that pay higher wages are able to use labor more efficiently. Thus, if size and age of firm are held constant, higher wage rates induce more efficient use of labor.

One of the major beneficiaries of the conversion of the transit industry from private to public ownership has been the transit labor force. Increased wages and benefits, job protection, and a legislative mandate to determine work rules and conditions have come with public subsidies. To the extent that unionized firms are subject to more stringent work rules and employee benefits, unionized firms would be expected to be less efficient than nonunion firms. In fact, a unionization variable was found to have no significant relationship with efficiency of labor use. Apparently the influence of unions is more complex. Transit properties operate under different union contracts, and some contracts are no doubt more restrictive (from the point of view of management) than others. The crucial factor seems to be the degree to which work rules conflict with requirements for service provision. For example, spread time limitations would affect firms that provide highly peaked service more than firms that do not. It is the degree to which the labor contract constrains the efficient use of transit employees that is important rather than the simple fact of unionization.

Vehicle Use

Hours of service (the number of hours per week in which service is available) provided by the transit operator proved to be the primary determinant of vehicle use in spite of the fact that the form of the indicator was chosen so as to control for this factor (Equation 3). The hours-of-service variable may be interpreted as a more general service variable because high peak to base ratios are correlated with long service hours.

$$RVh/MAXVh = 0.937 - 0.698\ HRSERVC\{(6.26)[0.76]\} \quad (3)$$

$R^2 = 0.58$, $N = 29$.

where HRSERVC = hours of service measured as a fraction of total hours (168) per week.

These results indicate that, as the hours of operation increase, the quantity of service provided per hour decreases. This reduction in vehicle use, which comes with longer hours, is not necessarily inefficient. If it is assumed that transit firms always choose to operate during the hours of highest demand first then, as service hours are extended, less service per hour should be provided. A firm that provides 24-h service, for example, would provide less nighttime service than daytime service and, thus, would have a lower rate of vehicle use than does a firm that provides 12 h/day service, all other things being equal. It would no doubt be even less efficient to run more buses when little service demand exists. Thus, the indicator must be evaluated in the context of service parameters. Note that service parameters are related to environmental variables. Equation 4 indicates that the service area characteristics of size and population density have a significant effect on hours of service; large, high-density areas are associated with the longest service hours.

$$\begin{aligned} HRSERVC = 1.03 &- 0.310\ SMALLSIZE\{(5.3)[0.67]\} \\ &- 0.244\ MEDSIZE\{(4.7)[0.60]\} \\ &- 0.301\ MEDDEN\{(5.3)[0.72]\} \\ &- 0.180\ LOWDEN\{(3.3)[0.42]\} \end{aligned} \quad (4)$$

$R^2 = 0.72$, $N = 30$.

where MEDDEN = 1 if density is 3000-6000 people/mile^2, 0 otherwise; and LOWDEN = 1 if density is <3000 people/mile^2, 0 otherwise.

The variation in service hours may be interpreted as a reasonable response to transit market conditions. Firms that operate in small cities, where few commercial activities take place during evening or nighttime hours, may restrict service accordingly. Firms that operate in large central cities, on the other hand, may provide long service hours not only to service the higher level of evening and weekend activity, but also to provide service to a relatively concentrated population of transit dependents. Moreover, large, central city systems (i.e., older systems) have not cut back service hours but have reduced frequency of service in response to declining demand.

The analysis here has shown that the efficiency of vehicle use is largely determined by service parameters, and that service parameters are in turn related to environmental characteristics. Presumably, these characteristics are indicative of the demand for transit service that exists in the area, and operators and sponsors are responding to this demand. Service parameters are determined by the transit firm's perception of demand for service and the sponsor's (i.e., funding agency) perception of transit needs. The appropriateness of the parameters chosen must be evaluated in terms of system (and sponsor) goals and objectives and in terms of system effectiveness. Consequently, the efficiency of vehicle use must be evaluated within the context of the goals of the sponsor and operator.

The vehicle use indicator (RVh/MAXVh) was not successful in controlling for service parameters. The analysis, however, did reveal the extent to which these service parameters affect vehicle use. In order to better measure this aspect of performance, more specific indicators, such as the ratio of peak vehicles to total in-service vehicles, or revenue vehicle hours per scheduled service hours, might be more informative and appropriate.

Operating Expense per Revenue Vehicle Hour

Cost efficiency measures the efficient use of all input factors. Because labor is the predominant factor in transit service, labor use, in large part, determines the cost of providing transit service. Consequently, factors that affect the efficiency of labor use should also affect cost efficiency. In general, this proved to be the case, as Equation 5 illustrates. Significant factors that affect cost efficiency were found to be the peak to base ratio, organization size, age of the firm, and unionization. The impact of firm age is easily explained: New firms tend to have higher unit costs because of the additional overhead required to develop and establish new operations and also perhaps because of the spatially dispersed configuration of new suburban services, as described earlier.

$$\begin{aligned} OPEXP/RVh = 4.48 &+ 7.27\ PEAK\{(4.6)[0.59]\} \\ &+ 0.063\ VEH\{(3.4)[0.42]\} + 3.72\ OPAGE\{(2.0)[0.24]\} \\ &+ 4.55\ UNION\{(2.0)[0.24]\} \end{aligned} \quad (5)$$

$R^2 = 0.63$, $N = 28$.

where UNION = 1 if unionized firm, 0 otherwise. The union variable adds an interesting dimension to the explanation of cost efficiency. The effect of unionization on wages may be much stronger than its effect on labor productivity. In fact, although only five of the sample of properties are nonunion, the average operating cost per hour for this group is $14.21, or 31 percent less than that of the whole sample average, which was $20.70. Thus, although nonunion firms may be no more able to use their labor efficiently (and indeed may have less incentive to do so), they achieve lower unit costs as the result of low wage rates.

The peak to base ratio emerged as a major factor that affects cost efficiency, in spite of the fact that it was not a significant variable in the labor use efficiency equation. To some extent, this is due to a peculiarity of this sample, in which one firm has a peak to base ratio of 4 (compared to the average of 1.3) and operating cost per hour of $42.73. When this case is removed, the peak variable is reduced in magnitude and significance. Although the peak to base ratio has, at best, a weak negative effect on efficiency of labor use, it, like long hours of service, has a strong negative effect on vehicle use. Its combined influence on both aspects of production efficiency results in significantly higher unit operating costs for firms that provide highly peaked service. The peak to base ratio is positively correlated with population density and traffic congestion, and consequently may be considered to represent more generalized environmental effects associated with services heavily oriented toward a central city.

Finally, the effect of size on cost efficiency is negative. Note that the organization size variable that appears in Equation 5 is interchangeable with other measures of size, such as size or population of service area. Thus, the variable is picking up both institutional and environmental effects. Given that these results are again contrary to findings of constant returns in bus transit, how can they be explained?

Part of the explanation may be that the size variable reflects other factors. As pointed out in the discussion of the labor use efficiency indicator (RVh/EMP), smaller properties are generally municipal properties and municipal properties are able to hold down costs by integrating transit services with other municipal operations.

It is frequently maintained that it is not size that generates higher costs but rather the higher wage rates that prevail in larger (metropolitan) areas that push up the cost of labor and, therefore, result in higher costs for large operators. The results of this research indicate that the size relationship cannot be attributed to the effect of the general wage rate. First, although all of the largest firms in the sample operate in large urban areas, some of the smaller firms also operate in large urban areas, and presumably face the same high wage rates. However, these smaller firms are more cost efficient than the large firms, though generally less cost efficient than their counterparts that operate in smaller cities. In other words, the effect of the wage rate on cost efficiency is minimal at best. Second, if the size variable actually reflects the general wage rate, then it should have had no significant effect on a pure (i.e., cost-free) measure of efficiency such as RVh/EMP.

In light of the results presented here, other possible explanations must be developed. One explanation may be called a union power hypothesis. Large transit systems may be less effective at the bargaining table because of their sensitivity to labor strikes. Transit strikes in large urban areas inconvenience center city commuters and leave concentrations of transit dependents with no means of transportation. Because they are dependent on public opinion for political support, large systems may be more willing to accept higher wages and more restrictive work rules in order to avoid service interruptions. Over the years, this process may have resulted in more stringent union contracts (and therefore better working conditions for employees) among large transit operations.

A second explanation might be called a service hypothesis. Large transit firms provide more peak service, longer service hours, and more route miles than do smaller operators. The complexity of the route system and its spatial extent may create inefficiencies for large transit systems. As the route system becomes spatially dispersed, more deadhead time may result, which in turn leads to less efficient use of labor and, therefore, higher costs. The fact that the suburban systems (which have more dispersed route patterns) have somewhat higher operating costs and lower efficiency of labor use than do the large urban systems (where service focuses on a central business district) lends support to the argument.

Another consequence of large size relates to the spatial arrangement of fixed facilities. Large transit operations usually have multiple plant sites. Because of logistical problems involved in organizing bus movements within the facility and because of the distances involved in traveling between service routes and the garage, the entire fleet cannot be housed at a single facility. These multiple facilities may add to overhead, and therefore lead to reduced efficiency of labor use and increased costs.

CONCLUSIONS

The analysis of three performance efficiency indicators suggests that environmental and institutional factors have a major effect on the performance of public transit systems. The extent to which performance is affected by external factors has important policy implications. Transit operators have long maintained that the comparability of transit systems is limited because of differences in operating conditions. This research supports that position and shows that many factors must be controlled if valid performance comparisons are to be made between transit systems. As public sponsors move toward tying subsidy allocations to performance standards (as has already begun in Pennsylvania and New York), it will be necessary to identify all the significant variables that affect performance and determine the extent to which performance improvements are within the control of the operator.

This paper has concentrated on only one aspect of performance, but it is one that transit analysts have considered to be relatively unaffected by environmental factors. Performance effectiveness, which measures the consumption of transit service, depends on market conditions and fare policy as well as on the ability of the firm to provide a service that matches local travel demands. This analysis has shown that market conditions have an indirect effect on efficiency as well, by means of the parameters of service--the hours in which service is available and the amount of peak service provided. These decisions are made in response to service demands as perceived not only by the transit operator but also by sponsoring agencies and institutions.

In addition to service parameters, the major factors identified here that affect performance efficiency are size (both organizational size and service area size), age of the firm, unionization, and the general wage rate. Of these, only the wage rate can be considered to be a truly exogeneous factor. All the others have been influenced to some degree by public policy. Firm size is determined by the quantity of service provided. During the past decade, improvement in the quality of transit service and provision of greater accessibility throughout the urban area have been major federal policy goals that have resulted in more hours and miles of service.

Efficiency is not discouraged by encouraging the production of more transit service and increasing the size of transit firms. However, federal policy has also encouraged the spatial dispersion of service by providing subsidies on the basis of service area populations. Federal policy has also enabled the development of powerful transit unions. Both of these conditions adversely affect performance efficiency. At the same time, transit firms have been able to maintain their monopolistic position. Clearly, differentiated service areas prevent competition among operators, and restrictions on the provision of transit services by other providers (i.e., private providers) protect operators from competition from other sources. Again, these conditions have been fostered by public policies of service planning and coordination.

The fact that many of the factors that affect efficiency can be associated with existing public transit policy suggests that the extent of transit operator control is limited and that significant improvements in service efficiency will require the cooperation of both operators and policymakers. If union work rules severely constrain the use of transit labor, then some way must be found to mitigate their effect. If labor-management negotiations are not a feasible option (that is, if relaxation of work rules must be compensated by commensurately higher wages), then the more costly forms of transit service (peak service or off-hour service) will either have to be reduced or, as recently suggested by Oram (5), provided by other sources (i.e., private contractors). Similarly, if new services add disproportionately to costs, the expansion of transit service into new areas should be reevaluated.

In recognition of the need to rebuild and maintain the industry, public support for transit has been provided with the expectation that ridership would recover once service was improved. However, ridership gains have proven to be small compared to increases in service costs. If transit services are to be maintained and improved, the efficiency of subsidized transit must be increased. This research indicates that efficiency is largely a function of transit service policy and the distribution of services in time and space. Efficiency improvements will require adjustments in public policy as well as changes in the distribution of services.

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Abridgment

Modeling Transit Service Areas

JEROME M. LUTIN, MATTHEW LIOTINE, AND THOMAS M. ASH

Transit access is defined as a measure of the ability or propensity of a population to use transit. Transit access modes are usually defined as walking, park-and-ride, kiss-and-ride, paratransit feeder, transit-feeder, taxi, or bicycle. This research is directed toward the development of tools for planning access to transit systems that address the impact of access characteristics on ridership and aid in the normative definition of the area served by transit. A methodology to evaluate and plan for access is developed. Nonlinear models based on empirical data are developed to estimate cumulative distributions for (a) walk to local bus, (b) walk to suburban bus, (c) walk to express bus, (d) park-and-ride to express commuter rail, and (e) park-and-ride to express bus. Equations are presented that can be used to determine ridership percentages that originate within user-specified times or distances around a transit stop, and the access distances or time within which normatively specified ridership percentages originate.

The means of getting to and from transit systems and the ease or difficulty with which that portion of the journey is made can affect the traveler's decision to use transit as much as can conditions and service on the system itself (1). That portion of a journey that is spent on the transit vehicle or waiting at stops is known as the line-haul portion of the trip. Those portions of the journey spent in getting to the transit system from the trip origin and to the destination from the transit system are know as the access-egress portions of the trip, or simply the access portion. Thus, accessibility to transit, or transit access, deals with characteristics of the trip portions not on the transit system.

Planning for transit access is becoming more of a concern for transit planners. Given the impact of access characteristics on ridership and the need for a normative definition of the service area accessed by transit, the development of a methodology to evaluate and plan for access is being undertaken. This research is directed toward the establishment of empirical tools for planning access to transit systems.

DEFINITION OF TRANSIT SERVICE AREAS

That portion of the urban area from which a transit line derives its patronage is known as its service area. No universal quantitative definition of transit service area can be given because its limits are not fixed, except by the habits (actual or expected) of the transit patrons. A service area centered on a transit stop, or transit line, varies in radius according to the characteristics of the line-haul mode, mode of access, and socioeconomic characteristics of the population to be served. In practice, service area boundaries can be described as follows:

1. Empirically--as the inclusive boundary for the xth percentile of origins and destinations observed for patrons that use a stop, or
2. Normatively--as the arc of maximum distance for convenient or desirable travel to the transit stop.

The terms tributary area or commuter shed have also been used to describe service area. Two of the most-important questions that face transit planners are, How far from the transit line does one draw the boundary of the service area? and, What is the relationship between this distance and some standard of desirable transit accessibility?

DEVELOPMENT OF MODELS OF TRANSIT SERVICE AREAS

The objective of this research is to develop a concept that could be used by planners to determine a set of service area standards (2). These standards could be applied to existing and proposed transit systems to determine the proportion of the urban area served by a transit system. It is known that many factors, such as destinations served, transit travel time, frequency of service, hours of service, fare, security, reliability, accommodations for handicapped, and comfort, must be considered in judging whether transit service is available to an individual. However, access distances and service areas should be included among system evaluation criteria and, indeed, are among the most basic indicators of transit availability.

Development of useful standards for service areas requires the answering of a fundamental question, How close to a transit stop or station should a given location be in order for one to consider that location well-served by transit? One must also define the appropriate unit for measuring closeness. It is not within the scope of this report to unequivocally state specific standards. Rather, we will examine data obtained from a variety of sources and present models that show the cumulative percentile of transit riders included within a given distance or travel-time interval from a transit stop, as derived from observed behavior. These models can then be used in two ways. First, such a model could be used to determine, for a given location at a distnce from a transit line, the percentile access distance score for that location. Second, given a desired percentile score to be used as a normative access standard, the model can be used to find the radius that can be used to determine the normative service area boundary for that transit line.

In order to ensure that accurate and useful models would be developed, it was decided to stratify models by three modes of access: (a) pedestrian, (b) park-and-ride, and (c) kiss-and-ride. Within these three classes, models were further stratified by line-haul mode. For pedestrian access, models were estimated for local bus service in urban and suburban contexts and for express bus. For automobile-access modes, models were estimated for commuter rail and express bus; express bus models were estimated for service from both remote and peripheral parking lots. All pedestrian and commuter rail models were estimated on the basis of distance only; distance was expressed in feet for the former and miles for the latter. All express bus with automobile-access models were estimated for both distance in miles and time in minutes. The aforementioned stratifications were limited by the availability of data. Consequently, no urban rail transit models could be calibrated due to the lack of suitable data.

Empirical Data and Modeling Process

The models presented are developed from access travel distance data (access model was walk) for bus routes in Vancouver, British Columbia; Washington, D.C.; and St. Louis, Missouri, and from access travel distance or access travel time data (access mode was automobile) for commuter rail and express bus service in northeastern New Jersey. Models for seven combinations of access and transit modes are offered:

1. Walk to urban bus,
2. Walk to suburban bus,
3. Walk to express bus,
4. Park-and-ride to commuter rail
5. Park-and-ride to express bus,
6. Kiss-and-ride to commuter rail, and
7. Kiss-and-ride to express bus.

Data for items 1-3 were derived from Peterson (Washington, D.C.) (3), the Bi-State Development Agency of the Missouri-Illinois Metropolitan District (St. Louis) (4), and Piper (Vancouver) (5). The data used to model items 4 and 5 were derived from access distributions around six representative commuter rail stations and four representative express bus stops in northeastern New Jersey. The access distributions were computed from the data collected in surveys conducted at rail stations and express bus park-and-ride lots by the Port Authority of New York and New Jersey between 1974 and 1976.

The curves presented represent access distributions around transit stops in terms of a cumulative percentile distribution or less than ogive. For a given access mode, a cumulative percentile distribution is constructed by summing the percentages of transit riders whose access trips originated within each distance or time interval. The cumulative percentile distribution is not a means of determining access modal split; rather, it shows what percentage of transit patrons who use access mode (y) made access trips of less than access distance (f) or access time (t).

After inspecting the data, we determined that nonlinear models would provide more explanation of the variance than would linear models. However, there were no compelling theoretical reasons to favor one particular nonlinear model over another. Thus, a family of eight alternative model specifications was proposed. An interactive curve-fitting program was written that permitted one to select a data subset and pick one of the model specifications. The program transformed the models into linear form and solved for the parameters by using a least-mean-squares regression technique. R^2 and standard error of estimate (SEE) statistics were computed for fitted models in the nonlinear form by using untransformed variables. The interactive curve-fitting program produced scatter plots of the data with the fitted model curve superimposed, as shown in Figures 1-14. Models were chosen through an iterative process by testing alternative forms and selecting the equation that produced the highest R^2 and lowest SEE. Note, however, that the use of least-squares regression for fitting models that have been linearized by taking logarithms may not produce the best estimates of model parameters. A generalized maximum likelihood approach is recommended (6). Also note that those models, such as the quadratic form, that do not have an asymptote at 100 percent are valid only for data in the appropriate ranges.

Application of the Models

For a given access mode and an access distance, the planner can use the calibrated models to estimate the percentage of transit patrons who originate within the given access distance by using the particular access mode. The models in Equations 1-14 are reformulated with cumulative ridership percentile (y, as a percent rather than a decimal) as the independent varible. These expressions enable the planner to estimate the access distance or time, from which comes a given percentage of transit patrons who use a given mode. For example, the median access distance or time to a transit stop for a given access mode is easily estimated. Also, the planner could determine the radius of the service area (f, d, or t) that corresponds to a particular market penetration for ridership. These calculations would help transit planners to determine the level of service that a transit system or line provides to the community.

Pedestrian Access

Distance to local urban bus stops outside the central business district (CBD):

$$f = 2095.3 - 21\,515\sqrt{0.009\,17 - 0.000\,092\,96\,Y_{pu}} \quad 0 \leqslant Y_{pu} \leqslant 98.6 \qquad (1)$$

Distance to local suburban bus stops:

$$f = [-488/(\ln Y_{ps} - 4.771)] \quad 0 < Y_{ps} \leqslant 100 \qquad (2)$$

Distance to express bus stops:

$$f = \exp\,[(Y_{pe} + 127.4)/28.6] \quad 0 \leqslant Y_{pe} \leqslant 100 \qquad (3)$$

Park-and-Ride Access

Distance to commuter rail stations:

$$d = -2.073/(\ln Y_{ar} - 4.723) \quad 0 \leqslant Y_{ar} \leqslant 100 \qquad (4)$$

Time to commuter rail stations:

$$t = 13.98 + 4.737\,\ln[Y_{cr}/(100 - Y_{cr})] \quad 0 < Y_{cr} < 100 \qquad (5)$$

Distance to remote express bus stops:

$$d = -1.751/(\ln Y_{ae}' - 4.664) \quad 0 < Y_{ae}' \leqslant 100 \qquad (6)$$

Time to remote express bus stops:

$$t = 36.57 - 5.696\sqrt{39.63 - 0.3511\,Y_{ae'}} \quad 0 \leqslant Y_{ae'} \leqslant 100 \quad (7)$$

Distance to peripheral bus stops:

$$d = -12.47/(\ln Y_{ae''} - 4.881) \quad 0 < Y_{ae'} \leqslant 100 \quad (8)$$

Time to peripheral bus stops:

$$t = 64.42 - 16.90\sqrt{12.097 - 0.1183\,Y_{ae''}} \quad 0 \leqslant Y_{ae''} \leqslant 100 \quad (9)$$

Kiss-and-Ride Access

Distance to commuter rail stations:

$$d = -1.438/(\ln Y_{kr} - 4.788) \quad 0 \leqslant Y_{kr} \leqslant 100 \quad (10)$$

Distance to remote express bus stops:

$$d = -0.9301/(\ln Y_{ke'} - 4.635) \quad 0 \leqslant Y_{ke'} \leqslant 100 \quad (11)$$

Time to remote express bus stops:

$$t = -6.522/(\ln Y_{ke'} - 4.818) \quad 0 < Y_{ke'} \leqslant 100 \quad (12)$$

Distance to peripheral express bus stops:

$$d = -9.711/(\ln Y_{ke''} - 4.796) \quad 0 < Y_{ke''} \leqslant 100 \quad (13)$$

Figure 1. Cumulative ridership percentiles: pedestrian access distribution for local urban bus stops.

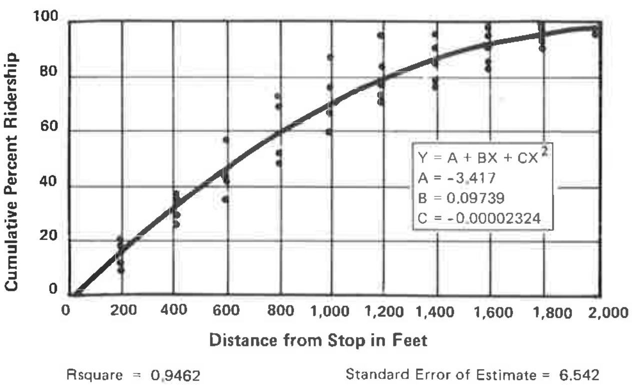


Figure 2. Cumulative ridership percentiles: pedestrian access distribution for local suburban bus stops.

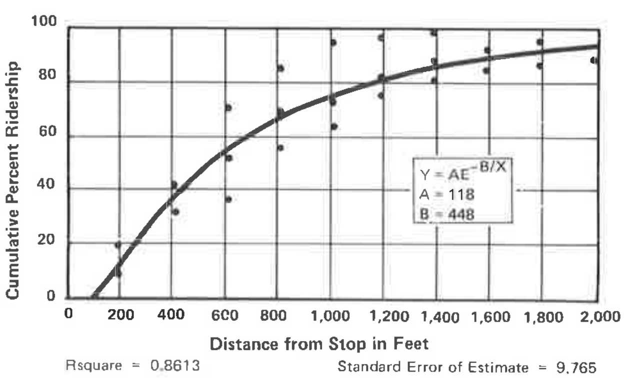


Figure 3. Cumulative ridership percentiles: pedestrian access distribution for express bus stops.

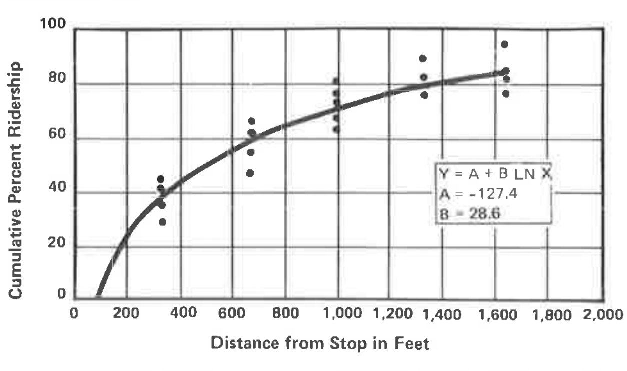


Figure 4. Cumulative ridership percentiles: park-and-ride automobile drive access distribution for commuter rail stations (excluding Jersey Avenue).

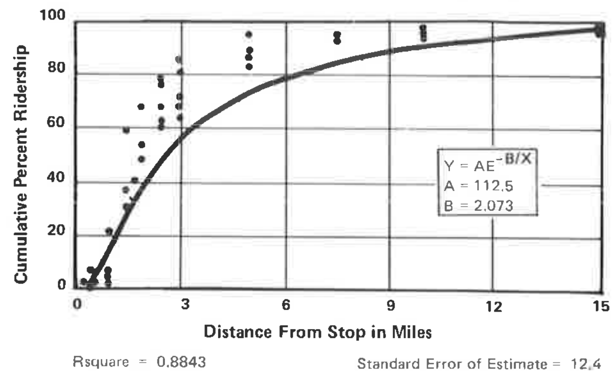


Figure 5. Cumulative ridership percentiles: park-and-ride carpool passenger access distribution for commuter rail stations (excluding Jersey Avenue).

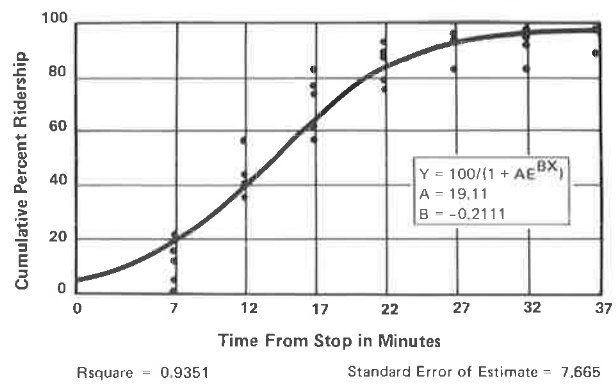
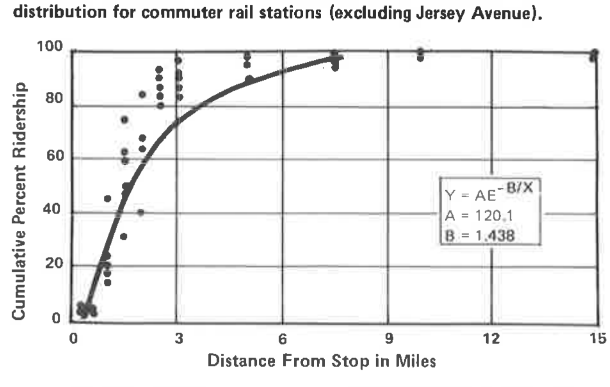


Figure 6. Cumulative ridership percentiles: kiss-and-ride automobile distribution for commuter rail stations (excluding Jersey Avenue).



Time to peripheral express bus stops:

$$t = 57.59 - 15.34\sqrt{12.70 - 0.1304\,Y_{ke''}} \qquad 0 \leq Y_{ke''} \leq 97.4 \qquad (14)$$

where

Y_c = cumulative ridership percentile for mode by access mode combination c,
f = walking distance in feet between origin by destination and bus stop at y,
d = driving distance in miles between origin and transit stop at y, and
t = driving distance in minutes between origin and transit stop at y.

CONCLUSIONS

The accuracy and applicability of these models are restricted by the limitations on the data from which these models were constructed. The data, and thus the models, do not make explicit impacts of station or stop competition, street patterns around the stop, ridership habits of the stop's patrons, socio-economic status of the stop's patrons, downtown parking rates, or highway congestion. The only independent variables used in the models presented are transit access trip distance and transit access trip time.

Figure 7. Cumulative ridership percentiles: park-and-ride automobile drive access time distribution for remote express bus stops.

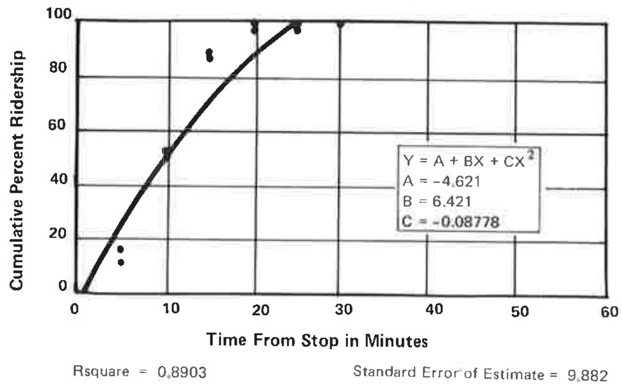


Figure 8. Cumulative ridership percentiles: park-and-ride automobile driver access time distribution for peripheral express bus stops.

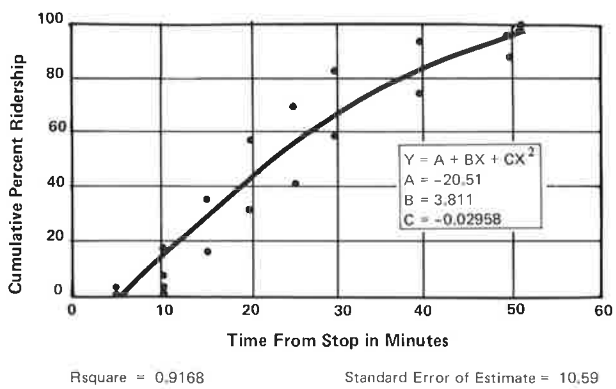


Figure 9. Cumulative ridership percentiles: park-and-ride automobile driver access distance distribution for remote express bus stops.

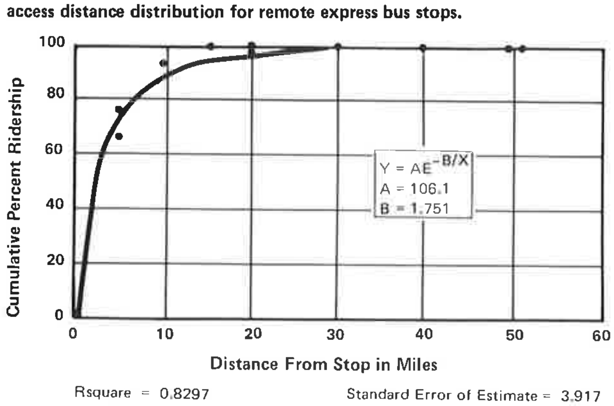


Figure 10. Cumulative ridership percentiles: park-and-ride automobile driver access distance distribution for peripheral express bus stops.

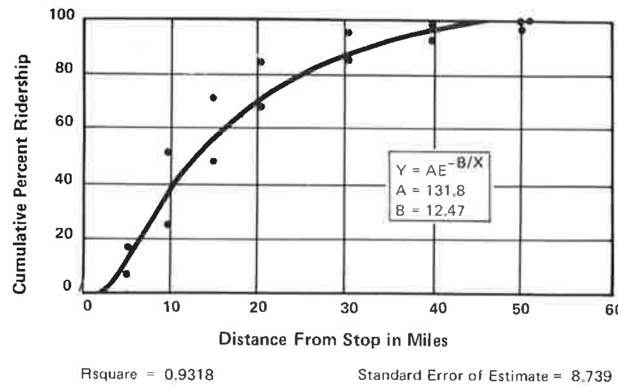


Figure 11. Cumulative ridership percentiles: kiss-and-ride access time distribution for remote express bus stops.

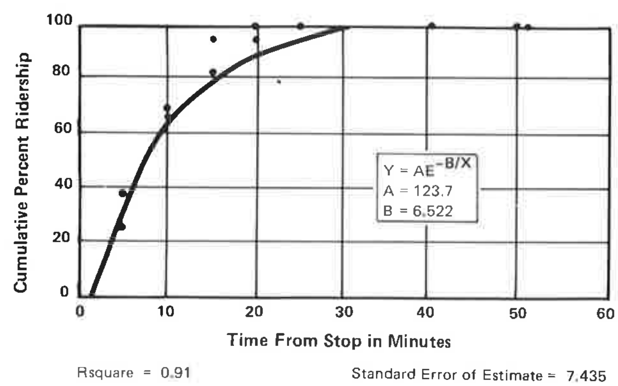


Figure 12. Cumulative ridership percentiles: kiss-and-ride access time distribution for peripheral express bus stops.

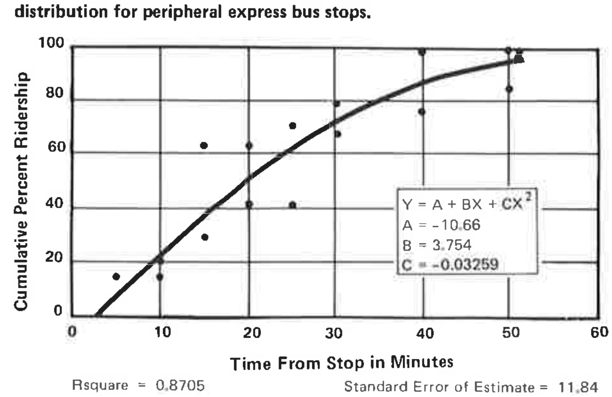


Figure 13. Cumulative ridership percentiles: kiss-and-ride access distance distribution for remote express bus stops.

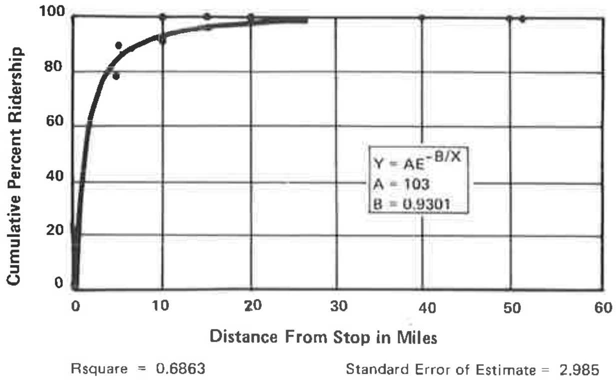
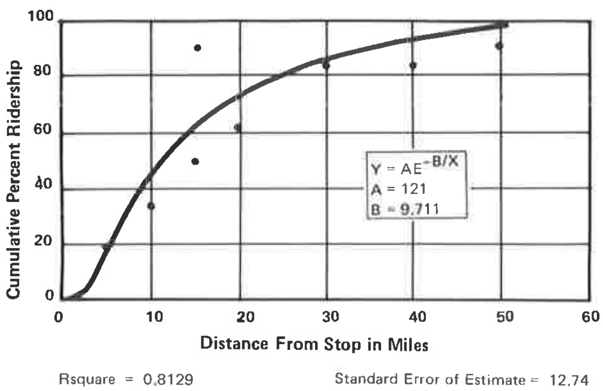


Figure 14. Cumulative ridership percentiles: kiss-and-ride automobile drops access distance distribution for peripheral express bus stops.



These models describe access distributions around an average stop for a given combination of access mode, transit mode, and urban location. They are therefore applicable on a systemwide or areawide basis. As such, these models will be useful in estimating the overall penetration of a transit service market. These models will not aid in making specific decisions about route location or in estimating specific trade-offs between shorter line-haul times and shorter access times.

Models were constructed for all combinations of transit mode and access mode on which data were obtained. These were as follows:

1. Walk to local bus service in an urban location,
2. Walk to local bus service in a suburban location,
3. Walk to express bus service,
4. Park-and-ride to commuter rail service,
5. Park-and-ride to express bus service,
6. Kiss-and-ride to commuter rail service, and
7. Kiss-and-ride to express bus service.

Data were not obtained on subway service or feeder bus service.

Of the combinations examined, some produced better-fitting models than did others. All of the models that describe automobile access distributions for express bus stations were hampered by a lack of data, once the data were divided into remote lot data and peripheral lot data. Thus, although curves were derived that fit the data well, the automobile access distributions for express bus service models are suspect. Perhaps the best models were those that describe walking distance to local bus service in urban locations, walking distance to express bus service, and automobile rider driving times to commuter rail service. Each of these models exhibited a high R^2 and a standard error under 8 percent, which means that each describes the data well and has good predictive capabilities. It is expected that future research and data collection could yield even better estimates. In the use of these models, the individual planner must make the crucial decisions about the appropriate standards to use.

ACKNOWLEDGMENT

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Abridgment

Demand Analysis of New York Subway System

C.J. KHISTY AND P.J. KAFTANSKI

An econometric analysis of the New York City subway system for the period from 1946 to 1978 is presented in this paper. The purpose of this analysis is to identify those variables that affect mass transit ridership. The multiple regression technique was used. In addition, a stepwise regression was performed to determine which of the independent variables explains the greatest variation in transit ridership. The annual subway ridership is the dependent variable; the independent variables are the transit fare, the level of employment in Manhattan's central business district, the aggregate personal income of New York City's residents, the number of automobile registrations in New York City, and an index of business activity for New York City. Analysis of the results reveals that automobile registrations and central business district employment are the most significant variables that affect subway ridership. The results of this study indicate that capacity restrictions on automobile use, urban development change, and increasing the monetary value of automobile ownership will increase transit ridership.

The purpose of this study is to test the relation between mass transit ridership and the variables that influence ridership in the New York City subway system and then to suggest policy decisions, based on this analysis, to improve transit ridership. This is of utmost importance in terms of federal and state funding of the system, since the New York City Transit Authority forecasts that its operating deficit for this system would approximate $55.3 million in fiscal 1981 and $78.1 million in 1982 (1). The authority believes that these deficits can be made up through additional federal aid and an increase in fare revenue or through expenditure reduction. Alternative solutions are offered based on this study's empirical findings. These solutions center around the concept of increasing mass transit ridership.

PREVIOUS STUDIES

Transit need is a derived demand. In light of this demand, there have been many observations of the significant characteristics that affect mass transit ridership. The First National City Bank (now known as Citibank), in its profile study of New York City, observed that a 50 percent increase in the transit fare in January 1970 resulted in a 5 percent reduction in ridership (2, p. 140). Automobile ownership is also a highly significant factor. For example, the restrictions placed on automobile use during World War II resulted in a decrease in urban automobile travel by approximately 25 percent. One-third of the people who decreased their automobile travel shifted to public transportation (3, p. 6). Pushkarev and Zupan's study indicates that, for trips to the downtown area of New York City, 83.7 percent of zero-car households, 36.7 percent of one-car households, and 15.4 percent of two- or more-car households used mass transit (4, p. 53). Mass transit carries more than 82 percent of all central business district (CBD) workers in New York City. This suggests that capacity restraints significantly influence transit demand. Population density also affects transit use. A higher density encourages public transportation use and discourages automobile use. Transit use is minimal when the density varies between 1 and 7 dwelling units (DUs) per acre, increases sharply when the density is about 7 DUs/acre, and one-half of the trips are made by transit when the density is greater than 60 DUs/acre (3, p. 6).

Other determinants of transit use could be classified as psychological. These include time, convenience, and comfort (5). Uncertainty of arrival of public transport vehicles and the probability of accidents can also be considered (6, p. 90). These criteria are probably reflected in the public's demand that mass transit facilities and operations provide convenient access to central city locations (e.g., work, school, and shopping). It appears that the main characteristics that influence modal choice are the automobile's ability to provide the traveler with a sense of ownership, free availability, prestige, and comfort (7, p. 22).

The most relevant study (and the one we used as a comparison) is the one conducted by Pushkarev and Zupan for the Regional Plan Association of New York (8). An aggregative time-series analysis (multiple regression) for the years 1947-1975 for the New York City subway system revealed that subway ridership is positively correlated with the level of CBD employment and the level of service (measured in car miles) and is negatively related to automobile registrations and the subway fare (in constant dollars). These variables explain roughly 80 percent of the variation in subway rides.

METHODOLOGY

The analysis covers the years 1946-1978 and considers annual subway ridership as the dependent variable. The independent variables include the transit fare, the level of employment in Manhattan's CBD, aggregate personal income of New York City's residents, the number of automobile registrations in New York City, and an index of business activity for New York City. The business activity index is a measure of the physical output of goods and services in the private sector that consists of (a) factory output; (b) retail activity; (c) wholesale activity; (d) service activity; (e) finance, insurance, and real estate activity; (f) transportation, communication, and public utilities activity; and (g) construction activity.

Statistical Procedure

The method of analysis used in the generalized least-squares procedure is a log-linear or constant elasticity form. The selection of this form is based on the belief that (a) the proposed relationship is linear in nature, (b) the elasticities of transit demand with respect to the independent variables are of great importance in formulating transit policy, and (c) the transformation of the data into a linear function reduces some of the potential problems of a nonlinear function.

This study's form was

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$$

where Y is the total number of rides recorded on the subway system of New York City in year t and x_1 through x_5 are the total values of the independent variables recorded in year t - 1. The elasticities with respect to each independent variable are b_1 through b_5 with the constant term a.

In addition to the generalized least-squares procedure, a stepwise regression was performed to determine which of the independent variables explains

Table 1. Multiple regression results.

Equation	Fare: Constant Dollars, X_1	Fare: Current Dollars, X_1	Automobile Registration, X_2	Personal Income: Constant, X_3	Personal Income: Current, X_3	CBD Employment, X_4	Business Index, X_5	R^2	F Value
1a[a]								0.9432	244.75
1b	-0.2035	...	-0.3008	...	...	...	...		
Std. error	0.0273	...	0.0632	...	...	...	...		
F level	55.58	...	22.64	...	...	...	...		
2a[a]								0.9694	475.12
2b	...	-0.2247	-0.2190	...	...	...	...		
Std. error	...	0.0196	0.0486	...	...	...	...		
F level	...	131.49	20.34	...	...	...	...		
3a[b]								0.9480	157.91
3b	...	-0.2743	-0.3548	...	0.0922	...	...		
Std. error	...	0.0443	0.1007	...	0.0669	...	...		
F level	...	38.34	12.42	...	1.90	...	...		
4a[c]								0.9556	123.84
4b	...	-0.1933	-0.3776	...	0.0353	0.5332	...		
Std. error	...	0.0436	0.1737	...	0.0708	0.1781	...		
F level	...	19.62	4.73	...	0.25	8.97	...		
5a[d]								0.9585	64.60
5b	...	-0.1267	-0.2599	...	-0.0492	0.7082	-0.0411		
Std. error	...	0.0697	0.2595	...	0.1331	0.2780	0.2422		
F level	...	3.30	1.00	...	0.14	6.49	0.03		
6a[b]								0.9227	103.44
6b	-0.2081	...	-0.6849	0.2972	...	...	...		
Std. error	0.0268	...	0.1424	0.1196	...	...	...		
F level	60.26	...	23.13	6.18	...	...	...		

[a]Covers 1946-1978. [b]Covers 1949-1978. [c]Covers 1951-1978. [d]Covers 1959-1978.

Table 2. Stepwise regression results.

Independent Variable	Equation	Total R^2
Fare (constant)	1A	0.9143
Fare (constant) and automobile registrations		0.9505
Fare	2A	0.9486
Fare and automobile registrations		0.9694
Fare	3A	0.9188
Fare and automobile registrations		0.9442
Fare, automobile registrations, and personal income		0.9480
Fare	4A	0.9362
Fare and CBD employment		0.9409
Fare, CBD employment, and automobile registrations		0.9551
Fare, CBD employment, automobile registrations, and personal income		0.9556
Fare	5A	0.9155
Fare and CBD employment		0.9406
Fare, CBD employment, and automobile registrations		0.9579
Fare, CBD employment, automobile registrations, and personal income		0.9584
Fare, CBD employment, automobile registrations, personal income, and business index		0.9585
Fare (constant)	6A	0.8353
Fare (constant) and automobile registrations		0.9043
Fare (constant), automobile registrations, and personal income (constant)		0.9227

the greatest variation in transit ridership.

Results

The results of this analysis are summarized in Tables 1-3. All of the equations are significant in explaining transit ridership as measured by each model's F-value at the 99 percent significance level. However, not all of the variables are significant at the 99 percent significance level. Those that are not significant are current personal income in Equation 3, personal income and automobile registrations in Equation 4, and all the variables in Equation 5 (although, at the 0.975 percent level of significance, CBD employment is significant). Autocorrelation is not a problem.

In comparing the elasticity measures of Pushkarev and Zupan's results, some interesting differences appear. Their fare (constant dollar) elasticity measure was -0.12; however, this study reveals that the elasticity with respect to the constant dollar fare is -0.2035 from 1946 to 1978. This implies that subway ridership is more price elastic than previously thought. It is also obvious that the raising or lowering of fares does not contribute to the goals of improving ridership levels and promoting the financial stability of the system.

The elastic measure for automobile registrations differs from Pushkarev and Zupan's study. Their measure is -0.25. This study's measure is -0.219 in Equation 2, -0.3548 in Equation 3, and -0.3776 in Equation 4. As the period of analysis shortens, the elasticity measure becomes less inelastic. This suggests that automobile ownership has a stronger impact on subway ridership than does the fare, especially in the short run. However, part of this trend in elasticity may be due to the increasing level of automobile ownership in New York City. Car ownership increased from approximately 605 000 vehicles in 1945 to 1 500 000 in 1977. As automobile ownership increases, its use as a mode of transportation increases, which makes the trade-off between automobile use and mass transit more significant. Personal income is not a significant variable in determining the overall ridership level.

Pushkarev and Zupan's elasticity measure is 0.7543 for CBD employment. This study's elasticity measures are 0.5332 and 0.7082 in Equations 4 and 5, respectively. This suggests that the level of employment is the most influential variable that affects mass transit ridership in the short run. This would suggest that policies designed to increase employment opportunities in New York City or designed to improve areas that attract people (e.g., parks or cultural areas) would have the effect of increasing mass transit use. But any policy should downplay major improvements in terms of providing

Table 3. Determination of each variable's significance.

Equation	Independent Variable	t-Value	Required t-Value at	t-Statistic	Significant
1	Fare, current dollars	7.46	0.99;30	2.457	Yes
	Automobile registrations	4.76	0.99;30	2.457	Yes
2	Fare, constant dollars	11.47	0.99;30	2.457	Yes
	Automobile registrations	4.51	0.99;30	2.457	Yes
3	Fare, current dollars	6.19	0.99;26	2.479	Yes
	Income, current dollars	1.38	0.99;26	2.479	No
	Automobile registrations	3.52	0.99;26	2.479	Yes
4	Fare, current dollars	4.43	0.99;23	2.50	Yes
	CBD employment	2.99	0.99;23	2.50	Yes
	Income, current dollars	0.50	0.99;23	2.50	No
	Automobile registrations	2.17	0.99;23	2.50	No
5	Fare, current dollars	1.82	0.99;14	2.624	No
	CBD employment	2.55	0.99;14	2.624	No
	Income, current dollars	0.37	0.99;14	2.624	No
	Automobile registrations	1.0	0.99;14	2.624	No
	Business index	0.17	0.99;14	2.624	No
6	Fare, constant dollars	7.76	0.99;30	2.457	Yes
	Income, constant dollars	2.49	0.99;30	2.457	Yes
	Automobile registrations	4.81	0.99;30	2.457	Yes

access to these areas via the automobile. If adequate automobile facilities are part of the policy to improve areas that attract trips, the incentive for using mass transit is diminished.

The last variable in the model is the business activity index. The regression results indicate that this variable is not significant.

Based on the results of this study, policymakers should concentrate on just two variables: CBD employment and automobile registrations.

This analysis is an improvement over the Pushkarev and Zupan model because the equations and the individual elasticity coefficients are more significant, and it accounts for a larger percentage of transit ridership variation with fewer independent variables.

RECOMMENDATIONS AND CONCLUSIONS

The main conclusions of this study are that mass transit ridership is a function of CBD employment and the level of automobile registrations. Therefore, policies implemented to increase mass transit ridership should

1. Create more employment opportunities than currently exist in New York City's CBD and
2. Convince travelers who use the automobile in New York City to switch their modal choice to mass transit.

This can be accomplished through the following means:

1. Implementation of congestion pricing in the CBD,
2. Limitation of the number of parking facilities available in the commercial and retail areas of New York City,
3. Expansion of park-and-ride facilities in the outlying areas of New York City,
4. Improvement of the attraction zones,
5. Imposition of tolls on bridges leading into Manhattan from Queens and Brooklyn, and
6. Informational campaign designed to elicit the public's cooperation in implementing the above strategies.

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Abridgment

Transit User Identification in an Employer-Based Subsidy Program

EDWARD J. KANNEL, RICHARD YUN-HAO WOO, AND STEPHEN J. POLITO

A transit assistance program was provided to all state employees in Iowa to encourage public transit use and to decrease the demand for parking facilities. The state subsidized 50 percent of the cost of monthly passes. The objectives of this paper are to identify the distinguishing characteristics of program subscribers and nonsubscribers and the consistency of factors in different cities. Discriminant analysis models were used to identify the relative importance of socioeconomic, transportation, and attitudinal factors. The most important characteristic for distinguishing between users and nonusers was the attitudinal variable. Socioeconomic factors were generally more important discriminating variables than were transportation supply factors. Transit cost was the policy variable manipulated by the transit subsidy program, but cost differences were not significant in the discriminant models once the attitudinal factor was already included. The discriminant models correctly classified approximately 80 percent of the users and nonusers in the city in which they were calibrated as well as in the other cities studied. The results suggest that, even though the transit service and community characteristics are variable, consistency in the behavioral responses is sufficient to allow transfer of information from city to city. However, the models from the research are not forecasting tools for general application because they are based on nonproportionate sample sizes.

A statewide transit subsidy program was undertaken by Iowa in 1978 to encourage state employees to use public transit. The primary impetus for the program was the desire to reduce the need for parking spaces around the state capitol office buildings in Des Moines. However, the program allowed state employees in all cities to purchase monthly passes at 50 percent below the regular monthly price. In return, the employees were to agree not to park in a state-owned lot. As part of a research project to evaluate the program, an effort was made to identify characteristics that distinguished program subscribers (users) from nonsubscribers (nonusers) (1). The intent was to (a) define the socioeconomic, attitudinal, and transportation supply factors that would improve ridership forecasts and (b) identify characteristics that could be emphasized when developing marketing programs in a unique employee group.

Several researchers have compared the socioeconomic, demographic, transportation, and attitudinal characteristics of traditional transit riders with the characteristics of the nonuser population. However, the relative importance of these factors has been judged to be different in the studies. For example, Hartgen (2) and Howe and Cohen (3) found situational factors to be more important than attitudinal factors. On the other hand, Dobson and Tischer (4) noted that socioeconomic and transportation variables were less important than personal perception for describing behavioral differences. Spear (5) developed a general attitudinal variable related to convenience and noted that the variable increased the goodness-of-fit statistics, but the attitudinal variable did not increase the predictive capability of the model.

The differences in the conclusions from these studies may be attributable to specific differences in survey methodology, analytical tools, trip purposes, or the population subsamples selected for analysis. Because the Iowa subsidy program addressed a unique group of potential riders, we were interested in determining whether program subscribers exhibited the general characteristics attributed to transit riders examined in the more traditional transit market. State employees are not in population groups normally categorized as transit users: They are generally between 18 and 65 years of age, they have higher incomes than average transit users, and they have reasonable access to transportation.

The subsidy program provided an opportunity not only to evaluate subscriber and nonsubscriber differences in one transit system, but the program provided a unique opportunity to evaluate the ridership in different cities in which there were variations in transit and highway system supply.

STUDY DESIGN

Sample Selection

Although employees in 18 cities were eligible to participate in the subsidy program, more than 94 percent of the 1167 subscribers lived in Des Moines (301), Iowa City (768), and Ames (33). The Ames area represented only a small fraction of the total users, but it was included in the analysis because one of the three major state universities and the department of transportation are located there. All users in Des Moines and Ames and 330 users in Iowa City were surveyed. A comparable number of nonusers who live within three blocks of a transit line were also selected. The models used only employees who had access to both automobile and bus modes. The final sample included 99, 98, and 12 subscribers from Des Moines, Iowa City, and Ames, respectively. There were also 75, 26, and 20 nonsubscribers from the same cities.

Variables Included in the Analyses

The socioeconomic data obtained in the surveys were standard elements, including age, sex, family size, employed persons, automobile ownership and availability, and income. Age and income were reported in one of five categories.

Transportation data included automobile and bus travel times and costs as well as waiting, walking, and pick-up times for each mode. Travel times were recorded as one-way times and later translated to round-trip times. Costs were recorded as daily costs including daily parking charges. The daily bus costs were automatically coded by the researchers, who assumed that the subsidized pass was used 20 days/month.

Attitudinal study concepts were used in this study, but no attempt was made to define new psychological constructs based on the factoring of responses from the employees. Instead, we selected a series of statements about service components of automobile and bus travel and measured the affection or bias of the respondents toward the basic modes. The statements selected were based on other research as well as on current issues. The employees were asked to identify the degree to which they agreed or disagreed with statements related to travel time cost, parking issues, fuel savings, and others. Each of the 12 statements was analyzed by using a five-point successive-category scale; a composite score (ATTSUM) was developed to assess the degree to which individuals have positive or negative reactions to bus and automobile travel. The higher the ATTSUM score (maximum of 60), the more positive was the reaction to public transit.

The variable definitions are cited in the list below. Note that all times are in minutes for a one-way trip. The line-haul time is total time minus excess time.

BTT--Total bus travel time;
BWA--Bus walking and waiting time (excess time);
AUTT--Total automobile travel time;
AUPUT--Automobile pick-up and walking time (excess time);
TIMDF--Time difference (BTT minus AUTT);
COSDF--Cost difference in cents (daily bus costs minus automobile costs);
LHDF--Line-haul time difference (bus time minus automobile time);
ATTSUM--Composite attitude score;
AGE--Age (five categories, converted to years in the tables);
SEX--Sex;
FS--Family size;
EMP--Number of other household members who are employed;
LIC--Licensed driver (yes or no);
CAR--Number of cars, pickups, and vans in the household;
AVA--Automobile availability for the work trip (yes or no);
INC--Income (five categories, converted to dollars in the tables);
BLK1--Number of blocks from home to bus stop;
BLK2--Number of blocks from bus stop to office; and
TRF--Transfer required (yes or no).

The average reported values are shown in Table 1. The program subscribers were noted to possess characteristics similar to those of the traditional transit rider. The users are generally younger, from smaller families that have lower automobile ownership rates and lower incomes than the nonusers. Also, subscribers perceived automobile time and costs to be greater than did nonusers, and nonusers perceived bus times to be longer than did the users. In actuality, the researchers could not identify any reason for real differences to exist in these elements.

DISCRIMINANT ANALYSIS IN CHOICE BEHAVIOR

The modeling objective for this research was to focus on employee characteristics that could be used to identify those employees who would be most likely to participate in the transit assistance program. The actual coefficients of a particular model were not the major concern because the employee sample being analyzed did not represent a sample of the entire employee population. Therefore, the model was not expected to be directly applicable to other general populations. The discriminant model, which addresses the principal objective of group classification, was used in this study.

The statistical package for the social sciences (SPSS) computer program DISCRIMINANT was used to develop the models and the statistical measures. The overall models were evaluated by chi-square statistics. Because it is possible to have an overall model that is highly significant, but contains variables that do not make a significant contribution to the discriminating power of the model, individual F-statistics are computed for each variable. Any variable that is not important at a specified significance level may be eliminated. During the exploratory phases the researchers allowed liberal inclusion levels in order to determine the general order of importance of the explanatory variables. The variables that were significant at the five percent level or better are marked in the tables.

Discriminant Model Results

Several models were developed that allowed different combinations of variables to enter the equation in each of the cities. Table 2 shows the results of the models that allowed all variables to enter the model; however, only the variables entered at the 0.05 significance level are shown. The predominant variable in the discriminant function for all cities was the attitudinal variable. None of the transportation characteristics were significant in Des Moines and only bus travel-time factors distinguished between users and nonusers in Iowa City and Ames. BWA was a significant deterrent to nonusers in Iowa City, where peak-period headways average 30 min and where there are more transfers required than in Des Moines, where headways are 15 min. The Ames model included BTT, but an anomaly was noted. Although BTT entered the model after ATTSUM was already included, the differences between users' and nonusers' BTT were not significant when analyzed alone.

Transportation cost, the policy variable manipulated by the subsidy program, was never a significant discriminator once the attitudinal factor was included. Therefore, other models were constructed to force this cost variable into the model. Those models suggested that the average nonuser placed a value on time that exceeded the bus cost savings even if the fare had been zero.

Model Consistency Between Cities

The models were able to classify approximately 80 percent of the employees into the correct user and nonuser group in each city. Researchers had hypothesized that sufficient behavioral similarities existed among employees such that information obtained from the employees in one city might be applicable for estimating travel choices in other cities. The hypothesis was tested by applying the discriminant model for each city in the other two cities. This is equivalent to a hold-out sample used to verify an original model, but it is even more demanding because the samples were not selected from the same populations. The degree to which a model correctly classifies users and nonusers in other cities was taken as a measure of transferability of the models.

The results are given in Table 3. One finds generally favorable, but not overwhelming, capability in classifying employees in cities other than the one for which the model was developed. Five of the 12 cells are either no better than or significantly poorer than a random choice, 50-50 assignment. However, three of those five cells are from predictions in Ames or by using the Ames model. We noted earlier that the sample size here was small and that an internal inconsistency was evident in the model. These discrepancies were, therefore, not considered further. The greater concern was that the Des Moines model underpredicted Iowa City nonusers, and the Iowa City model underpredicted Des Moines and Ames users. To try to identify why this happened, a case-by-case review of every nonuser in Iowa City whom the Des Moines model had predicted to be a user was completed. The review indicated that 8 of the 14 nonusers who were misclassified had positive attitudes toward the service, which caused the models to classify them as

Table 1. Average statistics for independent variables considered in discriminant models.

	Des Moines		Iowa City		Ames	
Variable	User	Nonuser	User	Nonuser	User	Nonuser
BTT	33.4	42.5	24.1	27.9	23.7	25.1
BWA	9.1	10.9	6.7	10.5	8.5	10.0
AUTT	19.2	17.9	15.4	13.2	13.7	10.6
AUPUT	5.0	4.2	5.2	3.6	3.8	3.1
TIMDF	14.2	24.6	8.6	14.7	10.0	14.4
COSDF	-90.9	-57.3	-103.5	-71.4	-25.0	-24.4
LHDF	10.1	17.8	7.2	7.8	5.3	7.6
ATTSUM	46.1	37.2	48.5	41.3	43.5	34.8
BLK1	1.5	2.0	0.9	1.5	1.5	1.8
BLK2	1.2	1.1	1.1	1.4	0.7	1.6
AGE	38	42	33	40	42	43
SEX, male %	50	50	42	65	67	80
FS	2.2	2.6	2.6	2.5	2.3	2.4
EMP	0.7	1.0	0.7	0.7	0.8	0.9
LIC, yes %	100	100	99	96	100	95
CAR	1.5	1.8	1.4	1.5	1.5	1.6
AVA, yes %	90	100	89	96	90	100
INC, $000s	21.9	25.1	18.7	27.3	25.8	26.0

Table 2. Summary of discriminant analysis.

City	Variables Included in Model, in Order[a]	Residual Variance (%)	Percentage Classified Correctly	
			User	Nonuser
Des Moines	ATTSUM, CAR, AGE	54	80	84
Iowa City	ATTSUM, INC, BWA	62	81	77
Ames	ATTSUM, BTT, BLK2	44	100	80

[a]Variables were significant at the 0.05 level.

Table 3. Transferability of model results among cities.

City	Group Classified	Percentage of Correct Classifications for Models		
		Des Moines	Iowa City	Ames
Des Moines	User	80	57	94
	Nonuser	84	91	23
Iowa City	User	92	81	95
	Nonuser	46	77	30
Ames	User	75	25	100
	Nonuser	85	90	80

users; but, in fact, they could not use the bus due to personal or work-related conditions. In effect, these persons did not have the transit choice available that was assumed to exist by the researchers.

Overall, the percentage of correct classification was 78 percent. The weighted average is nearly the same as the value obtained from the models applied only in the city in which they were calibrated.

SUMMARY AND CONCLUSIONS

In this research the attitudinal responses of employees were predominant in the models for classifying employees into user and nonuser groups. The models correctly classified approximately 80 percent of the cases in each user group and the classification capability fell off only slightly when the models were applied in different cities.

This research began after the subsidy program was initiated so the models discussed here are not truly forecasting. The cause and effect relationship between response pattern and mode choice can never be truly established; however, we thought that the detailed modal response developed in the study can assist the planner in identifying ridership potential much more effectively than would the "would you ride if" questions frequently used. It is recommended that employees could be grouped by using the current transit riders as the user group base. Employees who responded in patterns similar to transit riders would represent the market segment most likely to try transit when offered an incentive. A follow-up analysis indicated the possibility of using mean and variance data rather than the more sophisticated discriminant models. A cut-off point for participation was estimated to be one standard deviation unit below the mean ATTSUM score of the current bus users. By using this base, approximately 80 percent of the Des Moines respondents would have been classified correctly.

ACKNOWLEDGMENT

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Abridgment

Caracas Metro: A Luxury?

DANIEL SPERLING

Concentration of population is increasing in less developed countries, bringing with it paralyzing traffic congestion. Many cities have responded by designing and constructing expensive rail rapid transit systems. One of those cities is Caracas, Venezuela. In many ways Caracas approximates the ideal city for fixed-rail rapid transit: Linear land use patterns, rapid growth, lack of expansion space, and excessive congestion all seem to reinforce that observation. In this paper, the rationale for the Metro is explored as to its validity in terms of urban form, costs, benefits, and possible alternatives. Metro's route layout will best serve the more affluent and not the poor, accessibility to jobs will not be increased significantly, and Metro's design conflicts with the city's more recently articulated objectives of spatial and economic decentralization. Concerns for rational planning and judicious public spending were shunted aside, and the notion of a prestigious public work and availability of easy financing was allowed to dictate the decision to construct. Commitments to inflexible and costly underground rail systems, especially in countries of the Third World, may not be advisable in many cases. Many low-cost and moderate-cost strategies could provide equivalent or greater benefits at much lower cost. Strategies for expanding transportation opportunities and efficiencies could benefit from greater imagination, expertise, and political will.

Buoyed by its windfall oil wealth, Venezuela decided in 1975 to build a modern rail rapid transit system in its capitol city. To civic and political leaders it promised glamour and sophistication; to urban and transportation planners it promised resolution of overwhelming traffic congestion. Although conventional planning wisdom asserted that Caracas was the ideal city for a rapid transit system, an updated view suggests that the huge investment and ongoing subsidies may overwhelm the modest benefits. This case study serves to illuminate some neglected but critical issues associated with selection of urban rail systems.

NEED FOR TRANSIT

Although its population size is not inordinately large compared with that of most major cities in Latin America and Asia, Caracas is faced with restrictive physical barriers to continued growth. Constraints of land availability and rapidly escalating costs of public services (partly due to the difficulty of serving hillside developments) oppose the forces of expansion. Because Caracas lies in narrow valleys, pinched between mountain ranges, it has been forced to increase population densities to extremely high levels; much of the growth has pushed on to previously undeveloped and fragile hillsides. Topography has historically concentrated city growth into a linear pattern, punctuated by a series of activity centers stretched in an east-west orientation.

Almost all recent geographic expansion has been in illegal ranchos, squatter settlements that blanket the precipitous slopes around the valleys, or in bedroom suburbs located over the hills south of the city. Although data are inconsistent, the general belief is that more than 30 percent of the people live in ranchos.

Automobile ownership in Caracas is high and increasing at a rapid rate. In 1975 more than 10 percent of the population owned cars--a higher rate than in Buenos Aires, Singapore, Sao Paulo, and most other cities in the developing world (1). The rate has been increasing in Caracas at more than 15 percent/year, which is considerably higher than the population growth rate. Even the recently constructed large network of arterials and freeways is not able to accommodate the boom in automobile use, partly because more than 50 percent of all trips are by automobile. In view of the dense urbanization and high level of automobile use, it is not surprising that Caracas's congestion levels are among the world's most severe. (The severity of congestion is highlighted by visual observations that bumper-to-bumper traffic persists 12 h/day and by data that indicate almost constant vehicle flows from early morning to evening.)

METRO DE CARACAS

The Metro rapid transit system was conceived as the backbone of an integrated and coordinated transportation system. Bus routes were redesigned to serve as feeder lines. Four interconnecting lines were designed to comprise a rapid transit system of 50 km and 50 stations, as shown in Figure 1. However, only the longest line, which follows the major east-west corridor, has been funded. The expected completion date is in 1983. The line being built is 20 km long and has 22 stations, 19 of them underground. This first line is expected to cost more than $2 billion, almost 10 times greater than the initial estimate of $250 million.

No firm plans have been accepted for the second, third, and fourth lines. This examination is therefore limited to the first line, since it is the only line that will be constructed in the near future.

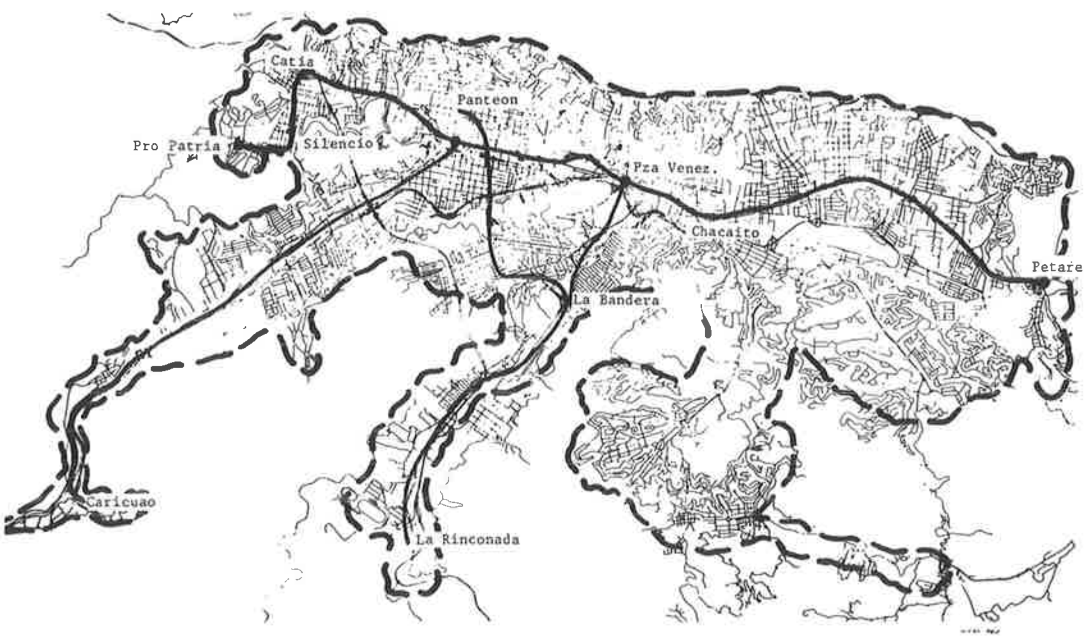
Benefits

The principal reason for building Metro is to ease congestion in the central corridor. High-speed trains on exclusive rights-of-way will bolster corridor capacity significantly. Benefits are expected to accrue to both Metro users and nonusers. Metro users would benefit from considerable time savings because of stifling congestion levels and cost savings because Metro fares will be less than automobile-operating costs. Nonusers would benefit from decreased congestion on the roadways, because each Metro rider represents one less trip on surface roads.

Designers predict that more than 50 percent of all benefits (operating costs and time savings) accrue to nonusers, mostly to car drivers and car passengers (2). They predict that about 40 percent of all peak-hour travelers will be carried by Metro; 77 percent of them will transfer to or from other modes (3). Their studies indicate that most of these Metro users will be diverted from surface public transit and relatively few from automobiles (2).

Added travel capacity might allow more growth to occur in the central corridor. The linear development pattern would be reinforced if more persons were able to reach employment centers along the corridor. Designers predict that Metro's added capacity generates a social benefit. Perhaps the greatest significance of Metro is for the large concentration of poor people who live in Catia, a large district located several kilometers from the city center at the western end of the Metro line. Catia residents would enjoy greater mobility and a higher level of accessibility with direct rapid service to the many jobs and services located along

Figure 1. Configuration of Caracas Metro system.



the central corridor of Caracas.

Doubts and Mitigating Factors

Considerable changes have occurred since the 1950s, when planning for Metro began. In the 1950s and 1960s people were just becoming conscious of the ramifications and costs associated with the rapid growth of Caracas, particularly in transportation. Continued demolition to provide more freeways and arterials was judged intolerable, and so Metro was born. But much of the planning and analysis was narrowly limited and short-sighted. Planners rationalized the rapid transit system almost entirely on expected savings in time and operating costs (2). Little attempt was made to analyze the fixed-route Metro system within the context of changing perceptions and growth patterns of the city, which is an especially embarrassing deficiency when viewed in light of the urban and regional decentralization plans and policies of the Fifth National Plan (1976-1980). We now see that, even as major activities are relocating away from the center and growth patterns are being reoriented toward the south of the country, the very expensive and permanently fixed alignment of Metro is being built exclusively to serve the already overburdened central corridor. Metro's alignment seems to contradict and conflict with the long-term spatial objectives of city officials.

Metro is not particularly suited to the needs of lower-income people. This assertion is based on an analysis of current (1975) use patterns of buses, which serve as rough (but probably reliable) estimates of poor people's transit requirements. Generally speaking, the buses' shabbiness and the social stigma attached to bus transit effectively render it a service almost exclusively for the poor. Similarly, por puesto (modern vans that operate as jitney vehicles) use patterns reflect needs of people who have moderately higher incomes, roughly classifiable as middle income. Por puesto service is more comfortable, flexible, faster, expensive, and directly responsive to desires of dispersed middle-class commuters. In any case, current transit users, primarily of buses and to a much less extent of por puestos, are expected to be Metro's typical riders.

Figures 2 (4) and 3 (4), indicate current demand for bus transit services. Clearly, the city center (El Silencio) is the major node of attraction. The overwhelming majority of bus trips, however, is distributed through a vast network in and around roughly a 3 km radius of the center (more than 90 percent of all bus trips are less than 6 km) (4). Few transit trips are generated in the entire eastern half of the city, including the central corridor between Petare (at the eastern end of the Metro line) and the center, which indicates that the Metro line is not especially responsive to the needs of the poorer people and that it will, in fact, serve a very small proportion of trips made by poorer people. On the other hand, trip volume patterns of por puestos, as shown in Figures 4 (4) and 5 (4), indicate that the trip lengths of the higher-income por puesto passengers are much longer and more oriented in the east-west direction.

Two observations can be made from this analysis:

1. Metro's route alignment is better suited to higher-income than to lower-income residents and
2. Metro's flat-fare policy would favor the higher-income commuters who live in the more attractive neighborhoods located farther from the center, because the poor, who now use buses or walk, would be paying the same fare as wealthy patrons but for much shorter trips.

Operation of the highly mechanized Metro line will be costly. The government will be obligated to either keep fares low to attract low-income riders, requiring a hefty and continuous subsidy, or to raise fares, thereby precluding poor people from sharing the benefits.

The expensive, capital-intensive nature of Metro has several ramifications. A large amount of foreign financing will be needed, and a large amount of the equipment and services must be purchased abroad, thus the level of foreign dependency will be increased. Furthermore, compared with conventional bus transit, Metro will employ relatively few people.

Clearly the objectives and justification of Metro

Figure 2. Caracas 1975 estimated person trips by bus: volumes more than 4000/day from and to Chacaito and Petare.

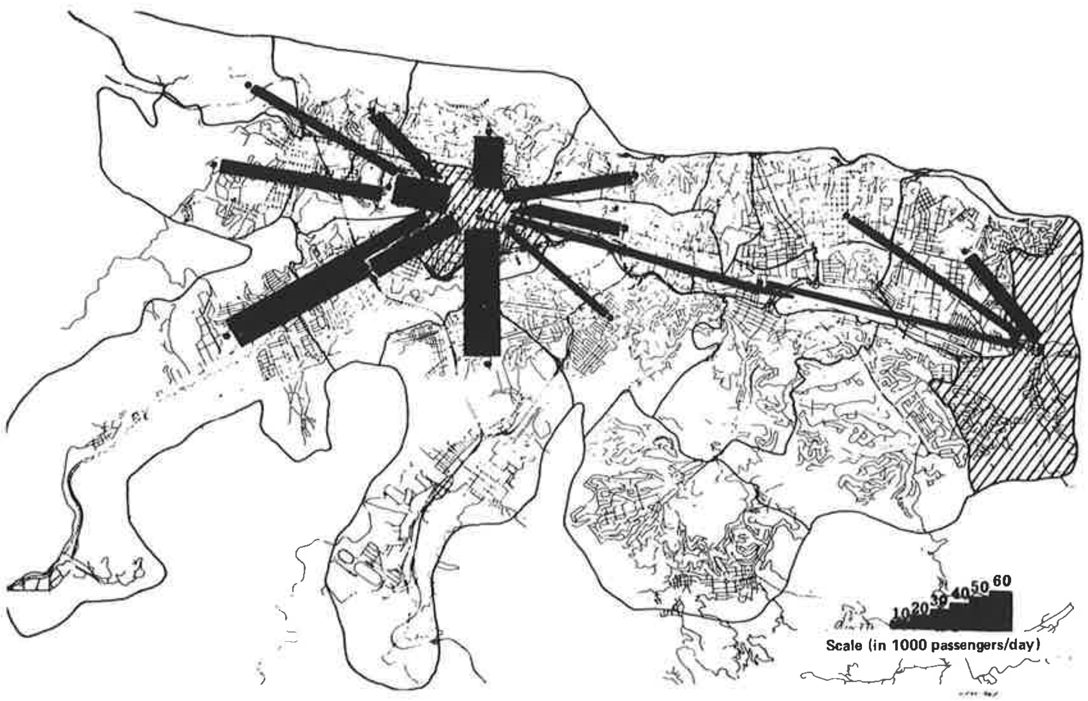
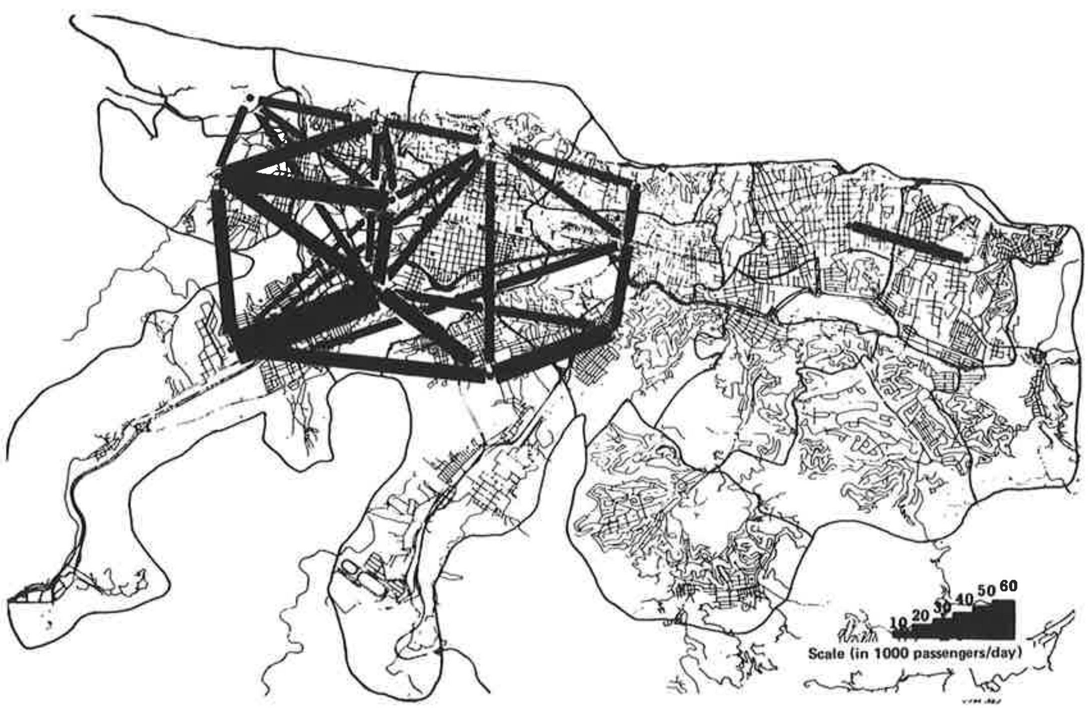


Figure 3. Caracas 1976 estimated person trips by bus: volumes more than 4000/day from all other zones.



are strained. Some people might say, however, that there really is no alternative; this is partly true. No one technology could provide the same capacity within the same physical constraints on land availability. There are, though, arrays of alternate options for increasing road use, personal interactions, and freight movements that require little or no additional construction. These options include better signalization, separation of vehicle types, improved surface transit operations, better enforcement, and improved mail and telephone service. Because each option is itself a subject of investigation, none will be described here. But note that the potential for decreasing congestion is truly enormous, to a large extent because present efficiency is low.

CONCLUSIONS AND POLICY IMPLICATIONS

Availability of easy financing, the complexities of

Figure 4. Caracas 1975 estimated person trips by por puesto: volumes more than 4000/day from and to Silencio, Chacaito, and Petare.

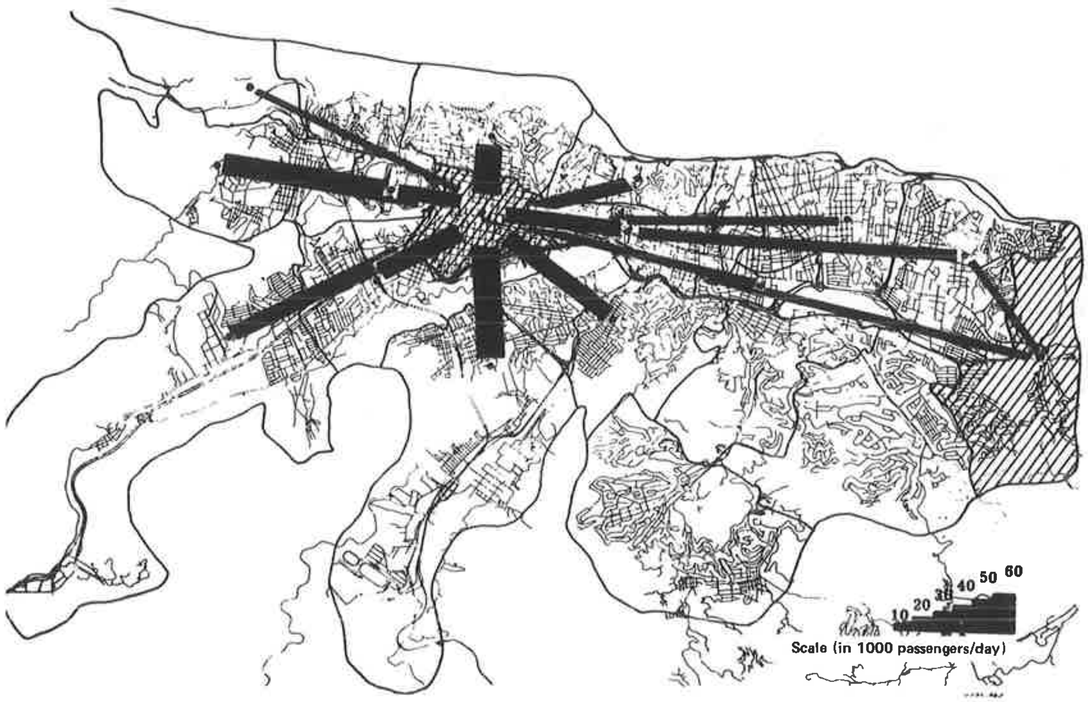
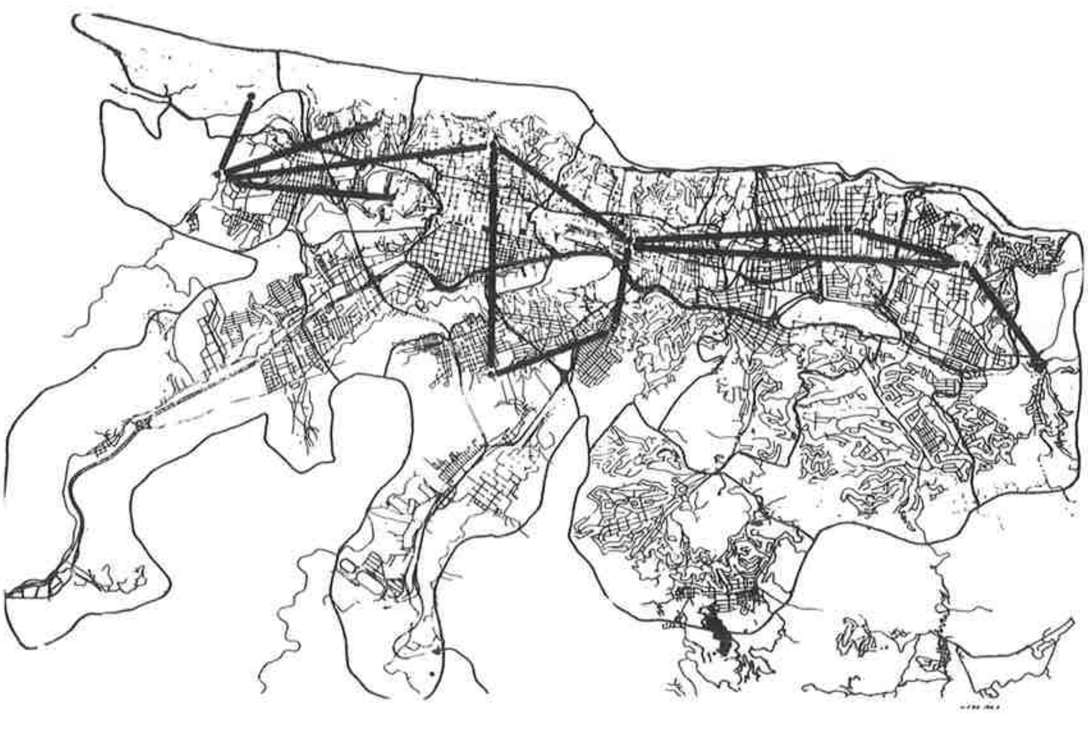


Figure 5. Caracas 1975 estimated person trips by por puesto: volumes more than 4000/day to and from all other zones.



correcting and improving the existing transportation system, and the prestige associated with a subway were the real forces that ensured widespread support for Metro. Doubt is cast on the appropriateness of Metro by its high cost, the availability of a vast array of alternative low-cost options, and its failure to support the attainment of several high-priority objectives. Metro will not benefit the poorer people; only a small percentage of bus trips, the principal means of travel for the poor, can be transferred to Metro's routes, and only then at a higher cost to user and operator.

Neither will Metro divert many people from their cars. It will not significantly increase accessibility to jobs, it will not stimulate any significant growth, and it will not increase mobility for many people. Perhaps most important for the long run, it will directly conflict with policies and objectives for decentralizing and deconcentrating services and jobs.

The planning and design of Metro was conducted within rather narrow confines. Designers overly simplified a problem and proposed a conventional static solution for a dynamic urban environment. The eventual approval of Metro was politically motivated, based on infatuation with expensive, modern technology. In short, Metro, which has a multibillion-dollar price tag, is a difficult project to justify.

The experience in Caracas is not unique. Similar scenarios are unfolding around the world. Cities are confronted with unprecedented urban growth and traffic congestion they are not prepared for and are unable to handle. It has become increasingly clear that the solution to strangling traffic jams is not more highways. The costs are just too great. City officials, in desperation, have grasped at the promises of rail transit technology. This sense of desperation, however, often results in inadequate assessment of other alternatives.

Strategies for expanding transportation opportunities and efficiencies have suffered from lack of imagination, expertise, and political will. In Caracas, as elsewhere, low-cost strategies (including parking and vehicle restraints) and increased governmental intervention in public transport, face opposition from labor unions, merchants, and transit operators and owners. Moderate-cost strategies, including special lanes and roads for buses and trucks, have not gained widespread acceptance. And so Caracas, just as other cities are inclined to do, adopted the Metro option, almost to the exclusion of alternate strategies.

Other cities can learn from Caracas. Critical comparative analysis of costs and benefits of rail transit systems and less costly and possibly more effective alternate projects should lead to improved transit service rather than improved transit monuments.

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Abridgment

Implementation of a New Transit Funding Procedure in Minnesota

JOSEPH J. KERN AND ROBERT M. WORKS

The Minnesota Department of Transportation (MnDOT) is responsible for administering state and federal transit and paratransit grant programs that provide operating and capital assistance to more than 60 public and private agencies. The amount of state subsidy has increased from $20 million in state FY 1978 to about $32 million for FY 1981. The tremendous growth in the state subsidy has forced a revision in the subsidy-allocation policy. MnDOT has previously covered two-thirds of the operating deficit for each transit system. This discretionary deficit-based procedure implied no upper limit for the state subsidy as system deficits skyrocketed. A new procedure for subsidy allocation is proposed so that maximum levels of state participation will be established for systems grouped by the service area population. These maximum levels, expressed as a percentage of total operating cost, vary according to the size of the service area. The actual deficit incurred up to the policy maximum level will be subsidized in most cases with federal, state, and local dollars at the rate of 3:2:1. Beyond this level, unmatched local dollars are required to cover any additional deficit. The maximums imply a reasonable level of fare-box revenue that all systems must attain either through the fare box or local levy.

Minnesota has provided funds for the operation of public transportation services since 1974. In July 1977, the Minnesota Department of Transportation (MnDOT) began administration of the transit and paratransit grant programs. Since that time, the amount of state subsidy has increased from $20 million/year to a projected expenditure of about $32 million in state FY 1981. During this same period, the number of projects that receive state assistance has grown from 20 to more than 60. MnDOT is responsible for administration of 10 state-funded grant programs, including a capital equipment program and a statewide rideshare program. Programs funded by Sections 18 and 16(b)2 of the Urban Mass Transportation Act of 1964, as amended, are also administered by MnDOT.

The rapid expansion of public transportation services and the failure of user fees to keep pace with increasing operating costs have led to an increasing dependence on state subsidies. In recent years in Minnesota, local budget overruns (caused in part by rapidly escalating labor and fuel costs) have been covered by MnDOT so that service cuts have been avoided. This practice has promoted the image of a never-ending supply of state subsidy dollars, so grant recipients are not forced to manage budgets. The prospect of tight public money in the near future is forcing MnDOT to confront the subsidy-allocation problem.

This paper identifies the existing subsidy-allocation procedures employed by MnDOT's Office of Transit Administration (OTA) and a proposed alternative for the future. The Minnesota legislature, which establishes program funding levels every two years, will address the transit subsidy issue in the 1981 session. This new procedure will be presented at that time for consideration.

EXISTING CONDITIONS

Public and private organizations are eligible to receive public transportation assistance from MnDOT. In general, the state can cover up to two-thirds of the operating deficit of a transit system, and the remainder is matched by the grant recipient. There are no state requirements for fare levels or service performance. Most of the grants are discretionary; OTA distributes the funds to applicants who successfully meet the application criteria as defined by the agency rules.

Several exceptions exist to the above-mentioned procedure within the Minneapolis-St. Paul metropolitan area. The Twin Cities Metropolitan Transit Commission (MTC) receives its funding for line-haul service based on the number of passengers carried, and a special appropriation is made for the provision of accessible services for the handicapped. Two private transit operators in the Twin Cities receive state funds for up to 65 percent of the total operating cost; the difference is covered by the fare box.

The mechanism used by MnDOT to provide operating assistance is a one-year contract that specifies the state subsidy amount, the payment schedule, the local share, and the project management plan. Applications for transit and paratransit services are accepted throughout the year in order to avoid overloading of the small administrative staff. Such a practice presented no problem when the supply of state dollars exceeded the demand; but as the demand grew, management of the legislated appropriations became increasingly more difficult. This is evidenced by the recent appearance by OTA at the state legislature to request additional subsidy dollars for FY 1980/81.

As the number of grant recipients increased, it became more difficult to budget for future expenditures. Staggered state contract dates that had one-year terms began to overlap state fiscal periods. Because of this, it was nearly impossible to get an accurate accounting of fiscal balances.

The discretionary nature of the programs has also yielded problems because grant applicants are free to challenge the equity of the funding-allocation decisions made by OTA grant administrators. To date, few objections have been raised, but the potential grows as the demand for state dollars increases. Similar charges could be issued by unsuccessful applicants for Sections 18 and 16(b)2 funds, because these programs are essentially discretionary.

New applications for service have recently been rejected due to the lack of adequate state funds; this has increased the pressure on OTA staff to generate cost savings in existing systems. Such savings are supposedly derived through increased operating efficiencies, and this would allow for new system development. In theory this might work, but such savings are difficult to identify when no performance standards are in place. Even with a standardized reporting requirement in place, such standards have been dismissed by OTA staff as the range of services (1100 buses in urban areas to 1 bus in rural areas) preclude reasonableness. Thus, without additional subsidy dollars from the state legislature or a significant increase in administrative staff to attest to operating efficiencies, the funding of new systems would be increasingly more difficult.

The original legislative action provided a tremendous amount of flexibility for the development of transit and paratransit services within the state, but a significant number of procedural problems exist that require immediate attention:

1. State transit dollars are not being allocated as equitably as possible throughout the state as perceived by grant recipients,

2. The pure deficit funding procedures that exist provide little incentive for budget control at the local level,

3. Budget overruns create reactionary transit fund requests as in the past legislative session, and

4. Current procedures require more state bureaucratic control and involvement, when control and responsibility should lie with the local system management.

NEW SUBSIDY-ALLOCATION PROCEDURE

OTA and the Urban Institute of Washington, D.C., have developed a new procedure for the allocation of state subsidy dollars that will alleviate the shortcomings of the previous procedures. With this new procedure, OTA will spend more time in providing technical assistance to systems in an effort to develop efficient services and the grant recipients will take more responsibility for system management.

The first element of the new procedure was to consolidate all of the existing operating grant programs into a single transit fund. OTA believes that it is not necessary to delineate transit or paratransit services as a precondition of funding. That is, the merging of these funds will afford a local community the opportunity to develop the type of service it needs. OTA will then act as the facilitator by providing matching financial support and technical assistance.

All systems are categorized by their service area population. The large-urbanized category will contain systems that have population in the service area of 100 000 and above. The small-urbanized category is for systems in the 50 000 to 100 000 range; the small-urban category is 2500 to 50 000; and the rural category is for areas that have less than 2500 population. In addition, two unique categories are created temporarily for intercity services and elderly and handicapped services.

Elderly and handicapped services will be funded separately only in the urbanized-area classes. These systems need not exist in the other categories because MnDOT is striving to develop accessible services. Thus, a grant recipient in the small-urban category will not be able to request a special elderly and handicapped system to be funded under different circumstances. Instead, the general public system would be required to be accessible or a special service would have to be provided under the terms in effect for that size category. The need for a separate category for elderly and handicapped services for the urbanized classes can be justified by the expense of providing transitional service to facilitate the requirements of Section 504 of the Rehabilitation Act of 1973. This category will not be required when full accessibility is reached in the line-haul systems.

After the categories were determined, a subsidy limit was established for each category. This level, which is expressed as a percentage of the total operating cost, identifies the maximum point up to which the state will participate in a subsidy dollar matching program. The subsidy limits are 55 percent for large-urbanized systems, 75 percent for small-urbanized and small-urban systems, 85 percent for rural systems, 90 percent for elderly and handicapped systems, and 65 percent for intercity services. Each subsidy limit was determined by reviewing the calendar year 1980 average subsidy requirements. Thus, the 55 percent limit for the large-urbanized systems implies that 45 percent of the total operating cost is covered by fare-box receipts.

The subsidy limit does not represent the amount of the state grant. Instead, this represents the point up to which the state will participate with the local governments in a matching program at the rate of 2:1, after available federal funds have been used. Any actual deficit that remains above the subsidy limit must be covered entirely with unmatched local dollars. This could arise if the implied level of fare-box revenue is not achieved. Any systems that currently receive state funds in excess of that allowed under the subsidy limit procedure will be forced to bring the deficits into line. Systems currently below the subsidy limits are encouraged to stay at that level so that the amount of local match is minimized. At the same time, these systems are assured that state matching dollars are available up to the subsidy limit should they wish to expand services.

This procedure requires that all system budgets be submitted concurrently to MnDOT. After review by MnDOT, the approved preliminary budgets are summed to yield the total state subsidy required. If this total is within the legislated appropriation, system budgets are approved for funding. If the total state subsidy required exceeds the state appropriation, additional funds can be secured from the legislature or the subsidy limits will be revised downward until the required state subsidy matches the appropriation.

In this way, new systems will be accepted into the state system and receive an equal share of the funds. New systems could mean less state subsidy for some existing systems unless additional funds are committed by the legislature. But as the amount of state subsidy decreases and the local share increases, areas will be forced to become more efficient in order to minimize the local share. Some areas that are not strongly committed to public transportation services might abandon services, but such drastic decisions will rarely be made. In order for new systems to be competitive, extensive preoperational planning should be completed. This could be funded from existing planning funds at the state and federal levels. This should increase the chances for success and will exhibit to MnDOT a strong local commitment.

Some significant benefits that can be derived by adopting this new procedure follow.

MnDOT will be able to

1. Administer public transportation program funds with explicit policy direction from the legislature,
2. Treat all similar recipients equally,
3. Improve state budget programming and planning because information on all systems will be available at the same time, and
4. Concentrate on improving specific system's performance and on implementing service and management innovations.

The legislature will gain the following:

1. Assurance that all recipient funding is determined fairly and in a manner that provides incentives for local efficiency;
2. Direct policy control over subsidy levels;
3. Influence over the systems' fare levels, but recipients will set fares; and
4. Consideration of longer-term overall direction and general funding level of state program.

Recipients will

1. Establish their own service and fare objective,
2. Be assured that similar recipients will be considered and funded on an equal basis,
3. Be encouraged to improve their planning and budgeting process,
4. Be encouraged to operate efficiently,
5. Obtain funds to implement innovative service and management improvements, and
6. Receive the state funds at the beginning of the operating year.

IMPLEMENTATION STEPS

It is proposed that only local units of government or transit authorities will contract directly with MnDOT. This guarantees a local match for services including special elderly and handicapped projects and intercity services. In metropolitan areas where a multitude of services might exist, one agency will be designated as the grant recipient. This agency will then be responsible for the distribution of state subsidy dollars, federal dollars, and taxing authority revenue to eligible systems. In this way, overlapping, competing, and inefficient services will be phased out.

The proposal will require additional local dollars at some point in time if the deficit incurred exceeds the subsidy limit. To avoid serious problems with the existing grant recipients, a hold-harmless period is proposed. This will hold the level of state funding constant for a period of time until the local governments are prepared to assume more responsibility for their service.

A basic requirement for MnDOT will be to help local government sponsors and system managers improve their planning and budgeting processes. System managers and decision makers will have to plan and operate their systems to meet their community objectives while living with a yearly fixed state contribution. MnDOT will need to establish useful, standard budget-building procedures and an administrative manual to help local managers plan, budget, market, operate, and evaluate their services.

A performance incentive program would also be available to help local public transportation managers improve their service effectiveness. All eligible recipients could apply for this discretionary program and MnDOT could fund up to 90 percent of the costs of worthwhile experiments. Recipients would be able to implement innovative management and performance improvement approaches as well as to test new service or fare changes. The program would be aimed at encouraging innovations that, if successful, could be funded permanently and transferred to other parts of the state.

SUMMARY

This new funding program will require each recipient's planning and programming processes to consider a longer time horizon than the next year or two. To properly plan for vehicle replacement and major service or fare changes, each recipient should establish objectives and cost and revenue projections for up to a five-year period. Each year a recipient should assess the benefits of the service relative to the costs and determine whether there are more cost-effective ways to obtain the benefits. Although MnDOT can provide technical and financial assistance to help recipients develop more cost-effective services, only local decision makers can assess whether the services are worth the required local funding committment.

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Performance Evaluation for Discretionary Grant Transit Programs

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Discretionary grant programs have been popular with state legislatures as a mechanism for extending the benefits of transit programs to small cities and rural areas as well as for stimulating innovations in urban areas. This article analyzes state discretionary grant transit programs in California and Minnesota by using the criterion of effective administration. The purpose is to develop a framework for understanding administrative problems that result when state discretionary transit programs do not have adequate objectives. Without explicit objectives, selection, monitoring, evaluation, and overall management are weak. Project performance is reduced and scarce public funds are wasted. Recommendations include the following: (a) legislatures should make explicit the mission and goals of discretionary programs, (b) administrative agencies should define measurable objectives and administrative guidelines, and (c) local grant recipients should be granted funds only after specific objectives and performance standards have been presented.

Although this research is based on the Minnesota and California discretionary grant programs, the framework is general and applicable to other states. The intent is not to advocate or reject the discretionary method or to criticize programs in these two states. Rather, the purpose is to clarify problems and to make recommendations to strengthen the discretionary method as a feasible alternative for allocation of state transit funds.

DISCRETIONARY ALLOCATION PROCEDURES

The distinction between discretionary and nondiscretionary or formula allocation methods is a matter of degree rather than precise categories. In discretionary programs, state agency administrators exercise choice in subsidy decisions, whereas in nondiscretionary programs funds are allocated according to some formula such as population or proportion of annual deficit. Discretionary programs are attractive for states that have specific program objectives. Examples of such objectives include demonstrating innovative transit techniques, providing service to target groups, such as the elderly, or focusing on particular transit-related problems, such as automobile congestion during peak hours.

Although administrative discretion may be unconstrained by formulas, there are degrees of constraint caused by formal rules or informal influence. Even a program based on reimbursement of deficits, as in Minnesota, is discretionary only to the degree that funds are available for the program. When local requirements are less than or equal to funds, decisions are not required and the program is nondiscretionary. However, when demand is greater than funds, administrators are forced to accept or reject everything from line items on budgets to cost overruns and entire projects. The California transit demonstration program, authorized under Senate Bill 283, (California Statutes of 1975, chapter 1130) is more discretionary because it allows greater administrative choice within the funds appropriated. Legislative and agency goals are general, there are no match requirements, and project selection is primarily subject to informal criteria.

Administration of Discretionary Programs

To understand the administrative problems caused by inadequate objectives in state discretionary programs, we must consider the activities of and relations among the state legislature, the state administrative agency, and the local grant recipient. Figure 1 is a general model of these activities and relations. By enabling laws, the legislature determines a policy direction and the long-range goals for the program. The legislature also approves funding. Legislative goals might include improved mobility for the transit disadvantaged, development of rural paratransit, bus replacement, or reductions in automobile pollution, congestion, and fuel consumption.

The agency should follow this policy direction and develop specific program objectives, guidelines, and procedures to administer the program. These objectives are derived from the legislative goals and are stated in specific, often quantified, terms. Guidelines and procedures, particularly for project selection, should reflect legislative priorities and provide for the orderly implementation of the program. Agency discretion is subject to the enabling laws and the agency's own regulations.

Applicants (counties, cities, and transit districts) are informed of program objectives through agency guidelines. To ensure selection of their projects, applicants conform to agency objectives and indirectly to legislative goals. The agency then accepts or rejects applications by using criteria defined in the guidelines.

The overall administration of the program involves a system of interrelated elements. Figure 1 illustrates the interdependence of goals and objectives at the three levels. For example, a rural transit district's objective to provide 2000 annual trips to nutrition centers for elderly residents would be consistent with a legislature's goal to meet the needs of the transit dependent and an agency's objective to coordinate and improve services provided by several social-service groups.

Agency objectives and project guidelines aid in the selection of local recipients and in the development of performance objectives and standards and procedures for monitoring performance. Through these procedures the legislature intends to achieve maximum transit performance. Performance includes two elements--efficiency and effectiveness. Efficiency concerns the processes by which transit services are produced, particularly through the relationship of inputs to produced outputs (1). Effectiveness concerns the extent to which service consumed corresponds to the goals and objectives established for it by government (Figure 2).

Clearly stated objectives are essential when discretionary grants are intended to demonstrate transit techniques. A project that has vague or ambiguous objectives is valueless as a demonstration. Because the goal of any demonstration is to learn something, outcomes must be evaluated according to these objectives. Only when we understand why a particular outcome resulted and how it affected the project's objectives will we learn something about the technology or technique being demonstrated (2).

Failure to provide explicit objectives causes problems within the objective-setting subsystem and

Figure 1. Model of discretionary grant program.

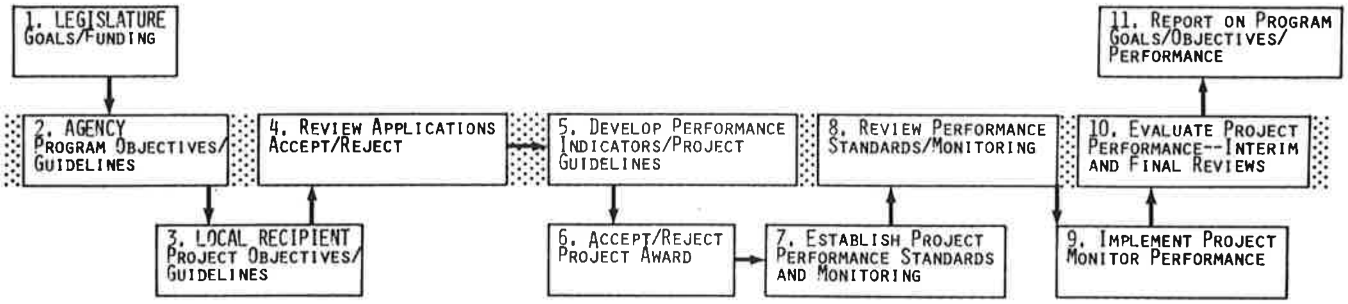
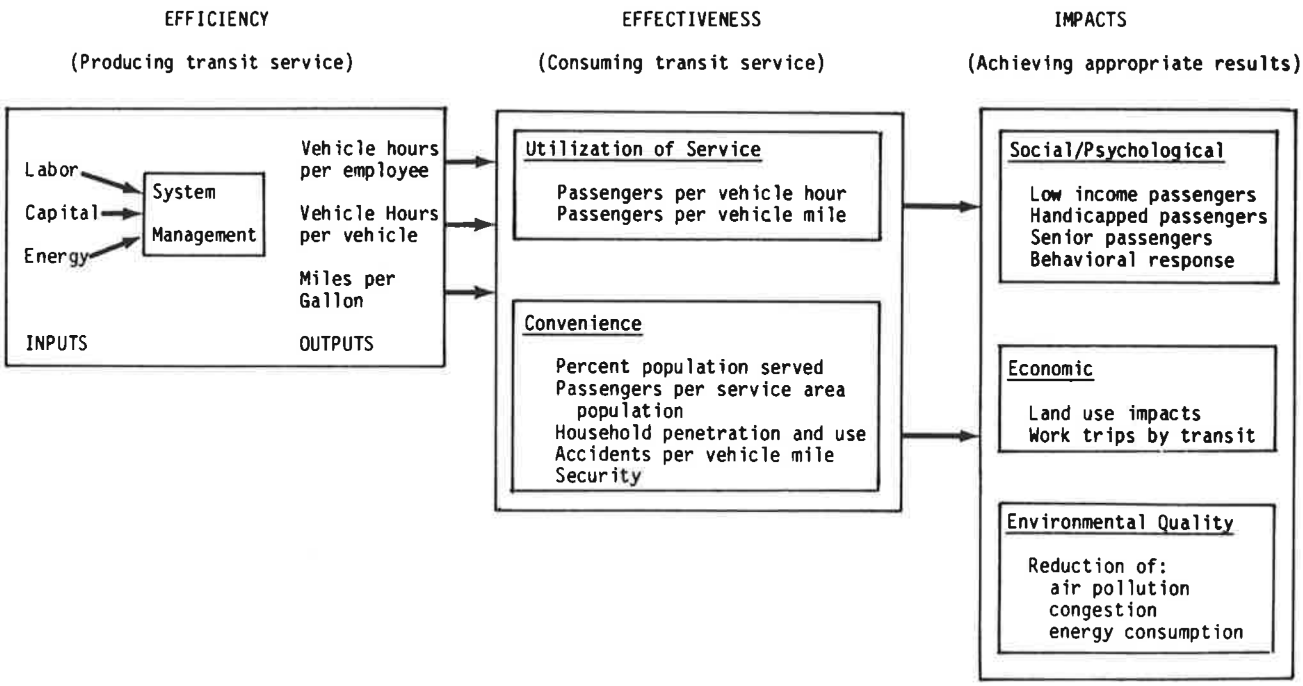


Figure 2. Framework of system performance.



ultimately reduces overall program performance. The California and Minnesota programs illustrate the validity of this assertion. Problems that result from inadequate objectives are identified and changes are recommended in (a) project selection, (b) project evaluation, and (c) monitoring and accountability.

California and Minnesota Programs

Although the California Senate Bill 283 and the Minnesota Department of Transportation (MnDOT) deficit subsidy programs have important differences, both employ procedures that approximate the objective-setting and administrative model in Figure 1. Also, both are examples of different types of discretionary programs. In each state, legislatures set program policy and goals, MnDOT and the California Department of Transportation (Caltrans) develop program objectives and guidelines, and local recipients set project objectives in their applications.

The Minnesota deficit subsidy program allows less administrative discretion than does that of California. Funds are available only for operating costs, and a one-third local funding match is required. Agency administrators have discretion in project selection and determination of levels of support. MnDOT administrators make frequent decisions on whether or not to fund cost overruns and new or continuing projects. This degree of discretion will increase as local demands increase and administrators are required to make more decisions.

CALIFORNIA SENATE BILL 283 PROGRAM

In 1975 the California legislature passed Senate Bill 283, which established a three-year program that provides funding assistance for demonstration projects. The program included the following sections:

Section 5: bus transportation demonstration projects--$2 million,
Section 6: rural public transportation demonstration projects--$1 million, and
Section 9: public transportation projects--$1 million.

The legislature set several goals for the program. Projects were to include, but not be limited to, projects to determine the following:

1. Disincentives for motor vehicle and low-occu-

pancy motor vehicle use,

2. Programs for low-mobility groups,
3. Effects of rules on transportation systems,
4. Effects of publicly owned transportation systems in competition with private systems,
5. Improved transit management,
6. Coordinated service techniques, and
7. The feasibility and demonstration of a single-coordinated social-service delivery system.

Funds were also allocated for rural projects to include, but not be limited to, dial-a-ride services and other paratransit systems capable of offering flexible scheduling and routing and of being operational within six months of approval.

Senate Bill 283 directed Caltrans to adopt guidelines for allocation of funds and project evaluation. The Caltrans guidelines repeated the above objectives, specified the content of applications, and listed project eligibility and selection criteria. Applications were to include the following:

1. Statement of what is to be demonstrated and expected results and benefits,
2. Description of project activities,
3. Data to establish a need for the project,
4. Project schedule and plans for continuation beyond the demonstration period,
5. Identification of participating organizations,
6. Proposed project budget and a breakdown of fund sources, and
7. Description of how project will be monitored and the guidelines for project evaluation.

Projects were to be selected based on a rating assigned by using criteria that include the following:

1. Relative cost-effectiveness,
2. Consistency with local and regional plans,
3. Compatibility with community needs,
4. Quality of proposed evaluation guidelines,
5. Relevancy of expected results and benefits of the project to other localities,
6. Degree of innovation, and
7. Ability of the applicant to manage, monitor, and report on the project.

Project Selection

The Senate Bill 283 program developed agency objectives and application guidelines consistent with legislative goals and required applicants to specify objectives. Problems arose in selecting projects. The selection criteria were not strictly related to the legislative and agency goals, and when they were, they relied on subjective criteria. For example, cost-effectiveness is the weakest concept in transit performance measurement. It confuses input with consumption measures so that low-cost, but underused, projects are regarded as favorably as high-cost, heavily used projects. Also, consistency with local and regional plans and compatibility with community needs are too subjective to have been useful in project selection. Projects were selected that were (a) inconsistent with goals and objectives, (b) did not meet local needs, or (c) were proposed to meet nonexistent needs. Limited success of the initial demonstration projects can be explained by poor project selection as well as by problems of monitoring, evaluation, and administrative control.

One Senate Bill 283 project used its grant to continue funding an existing recreational bus project. Contrary to the proposal, the project was neither a demonstration of an innovative transit technique nor was it clearly directed toward a transit-dependent group. The project's objective to "expand the horizons" of a low-income group was too vague to determine whether enough expected benefits would be gained to justify funding. More details must be provided on the types, numbers, and needs of individuals to be served. For example, the project did not distinguish target from nontarget riders and transit funds were used to subsidize ongoing recreational service to the general public. Although these results should have been detected through monitoring and evaluation, improved project selection based on clear and accurate objectives would have restructured this project.

Other projects were approved with unrealistic and overly ambitious objectives. A project to research constraints to paratransit and to collect data on current and duplicated service and unmet needs set objectives far out of proportion to its funding. By selection of a project that could accomplish only a fraction of its stated objectives, Caltrans reduced its ability to direct funds toward a demonstration of specific applications.

Projects were also approved that had vague and ambiguous objectives. A regional agency project to coordinate demand-responsive transportation provided by local social agencies confused ends and means. Coordination was listed as an objective, without stating how improvements over existing services or satisfaction of community needs would be achieved. The intended objective--to reduce duplication and costs of existing service--had to be implied. Existing duplication was not shown in the application nor were measurements taken to establish that the project was successful in reducing costs. Confusion among participating groups over what coordination actually meant resulted in disagreement over what the project was intended to accomplish. Only when the project was completed was it apparent that (a) many services had been coordinated before the project, (b) several agencies were disinterested in coordination as defined by the regional agency, and (c) participating agencies did not separate transportation costs from total agency expenditures, which made evaluation of cost efficiency difficult.

Other projects faced serious problems because of a failure to define needs and other relevant background information in the application. This occurred despite guideline requirements that information be provided on needs, participating organizations, and other data necessary to evaluate the application. A brokerage project had few riders because its subsidized rides suffered from competition from existing free service provided by the transit district and social agencies. The project relied heavily on referrals from apartment managers, taxi companies, and social-service agencies. Refusal of these groups to cooperate, competitive services, and problems under a previous project at the same site should have been determined before the grant was made. Caltrans might have used this information to conclude that brokerage should have been demonstrated at another site.

Project selection should have required clear and consistent objectives, demonstration of existing needs, cooperation of involved groups, and an understanding between Caltrans and recipients of how performance would be demonstrated. Applicants should also have been requested to submit information on project constraints. By approving projects that have unrealistic or ambiguous objectives, Caltrans reduced its ability to control specific transit applications to be demonstrated under the program and to monitor project progress.

Political influence was also responsible for selection of some projects. In discretionary programs, administrators are under considerable pressure to spread the projects around. Clearly defined, quantitative objectives and selection criteria limit the political role in project selection. They can assist a state agency to respond professionally to requests by elected representatives.

Project Evaluation

Problems associated with evaluation are related to the failure to define needs and objectives. Evaluation is not possible unless there are standards or targets against which to measure actual performance. Thorough evaluation requires

1. Explicit objectives, quantified whenever possible;
2. Techniques for measuring both the efficiency and effectiveness of each project; and
3. Appropriate data collection and reporting.

If a project is designed to provide elderly persons with trips to social-service agencies, this performance must be targeted in objectives, measured, and evaluated. Efficiency indicators of miles and hours and costs per mile and hours of service are important, but do not give a complete picture of effectiveness and services consumed by or needs met for the target group.

Many projects were funded without clear evaluation criteria, contrary to guideline requirements. One project provided objectives that met program requirements but not evaluation criteria. In review of this project, it was not possible to determine cost-effectiveness. Another project had cost-control objectives that could be evaluated with efficiency measures. However, evaluation was limited because there were no target cost standards to define acceptable performance.

Inadequate data reports also limited evaluation. Outside funds were combined with Senate Bill 283 funds, and program funds were spent in ways other than those specified in applications. Consequently, it is difficult to distinguish what Senate Bill 283 inputs produced particular outputs. Inadequate budget requirements and lack of periodic audits reduced data available for evaluation. As a result, important conclusions on applications of transit techniques to specific types of communities were ultimately lost.

Control and Accountability

Periodic data reports and agency monitoring would have revealed that one project offered service indiscriminately to the general public rather than exclusively to the target group. It would also have been possible to predict cost overruns on some projects and the exhaustion of a 12-month budget in 9 months on another project. In one project, program costs were not distinguished from normal operating costs, which made it difficult to distinguish project from general funds and to determine exactly what was accomplished. Early detection of these problems through periodic monitoring and comparison of actual to expected performance and expenses would have allowed Caltrans to work with local managers to make adjustments. In many cases this might have resulted in improved performance.

The structural lines between Caltrans, their district offices, and regional planning agencies are not strong lines of control and accountability. The administrative responsibility of each agency for the program is not clear. Regional agencies certified projects for consistency with short- and long-range plans, but had no formal role in project development or monitoring. District offices assisted in preparation of applications, but faced possible conflicts of interest when asked to monitor projects because they solicited and sometimes designed projects. Recipients were largely left to themselves. Without a requirement for matching local funds, there was little motivation for local control.

The Senate Bill 283 program's control and accountability problems indicate that neither state nor local management was effective. Both were diminished by the program's structure. Community involvement and concern were less likely because no local funds were spent. Local operators lacked clear incentives to administer competently or to improve performance. And performance criteria were seldom defined in a way to facilitate control or evaluation.

MINNESOTA EXURBAN SUBSIDY PROGRAM

The 25 exurban transit projects subsidized by MnDOT under the Public Transit Operating Assistance Program (1977-1979) illustrated problems similar to those described for California. Excluded were all Twin Cities metropolitan transit operations and all projects funded under the Paratransit Demonstration Program. During the 1977-1979 biennium, $4 million was allocated and used to assist these exurban systems with operating expenses. For the biennium, these subsidized systems provided for 8 505 000 bus miles in 161 transit vehicles that carried approximately 14 178 000 unlinked passenger trips.

These projects can be divided into two types. The first is regular fixed-route, including projects as diverse as the 101 bus system in Duluth and the single bus system in Becker County, which follows a fixed but different schedule each day. The second is paratransit, including projects as diverse as subsidized taxi and volunteer driver programs, dial-a-ride, and route-deviation projects.

Legislative goals for the program are stated in Minnesota Statutes (1976), Section 174.21. These are to increase vehicle occupancy; to reduce the use of single-occupant vehicles and the associated congestion, pollution, energy consumption, highway damage, and other costs; and to increase the productivity and efficiency of transit systems.

Objectives relevant to the regular route program are stated in the 1978 MnDOT state transportation plan. These include the following:

1. Coordination of transportation service,
2. Cooperation with intercity bus lines,
3. Alleviation of transportation problems of the elderly and handicapped, and
4. Encouragement and sponsoring of ridesharing programs.

MnDOT has final authority to grant financial assistance not to exceed two-thirds of the operating deficit to the exurban projects and may require local contributions as a condition for receiving the grant.

The typical project receives annual grants for two-thirds of its operating costs. However, the program is partly discretionary, since recipients must apply annually and receive grants subject to MnDOT approval. Administrators exercise discretion over costs, including budget line items, service changes, overruns, and new projects.

MnDOT has responsibility to establish the procedures and standards for review and approval of applications, and for evaluating and monitoring performance (Minnesota Code of Agency Rules, Vol. 14, Sections 1.4025-1.4028). Each application for a grant must include a description of local organizational structures, a management plan, and a financial statement.

Project Selection

The MnDOT program was unable to limit selection and allocation to projects whose objectives were clear, realistic, and consistent with program objectives. Local objectives were formed independently because recipients lacked a clear idea of MnDOT program objectives. Small projects often had unstated or very general objectives. Many objectives must be implied from route and fare policies that appeared to direct service to particular groups. Grants to subsidize service to elderly, handicapped, and low-income student groups were clearly consistent with MnDOT's objectives. Other grants used to provide tourist shuttles and $0.10 rides to middle-income commuters were not clearly consistent with program objectives. One planner stated that the goals of the project were to survive, to be feasible in the future, and to maximize receipt of state and federal funds. If these projects had other unstated objectives or if results were intended to be consistent with MnDOT objectives, this should have been explicit.

The MnDOT program required less information than Caltrans did of its applicants. MnDOT required a needs statement, but what it received was of varying quality. The range was from a consultant's formal needs assessment, which detailed trip patterns and age and income group mobility, to a brief letter from a local official who had an opinion on local needs. Incomplete needs assessment was a particular problem when a project had objectives that were not clearly consistent with those of MnDOT. Grants to subsidize a group such as middle-income commuters in one community, and not in others, must be justified by documenting particular congestion, pollution, or other local problems.

MnDOT lacked prioritized objectives and guidelines that would have assisted in project selection and amendments. Guidelines would have allowed administrators to make more routine decisions and to justify them.

Evaluation Problems

MnDOT evaluation also was limited by lack of specific performance standards for each project and data reports that precluded comparison because definition of data items was not consistent between projects. Evaluation was primarily of efficiency, which can be indicated through simple ratios. MnDOT required all projects to report data on revenues, operating costs, and service outputs of passenger trips, vehicle miles, and, in some cases, vehicle hours. Input-output ratios provided useful information on current costs and trends and a reasonable evaluation of those projects that had objectives to provide rides to large numbers of passengers in the most economical manner. The result of overall evaluation was a table of performance measures for all projects. This encouraged unfair comparison between the low passenger cost of urban projects with the high costs of rural projects. Objectives other than cost items were not successfully evaluated. For example, MnDOT was not able to evaluate how well projects satisfied objectives that direct service to target groups, such as transit dependents, or to target destinations, such as social-service centers.

Control and Accountability

As with the California program, the links between MnDOT and its grant recipients did not represent strong lines of control and accountability. This is in contrast to the structure and roles represented in Figure 1.

MnDOT expected that concern for community funds invested would result in local control and evaluation of transit services. However, several factors reduced local control. Local staffs and techniques were limited, and evaluation was usually limited to ratio measures. MnDOT allowed recipients, and recipients allowed their contractors, to proceed independently until complaints occurred. This resulted in a form of crisis management rather than routine evaluation, anticipation of problems, and timely agency intervention. MnDOT exercised some control through good personal relations between individuals who represented the agency and the recipients. However, this is not a reliable source of management control.

OBJECTIVES AND EVALUATION

The California and Minnesota case studies illustrate how administrative problems occur when objectives are not explicit. As a result, selection, monitoring, evaluation, and overall management of projects are weak. Ultimately, project performance is reduced and scarce public funds are wasted.

Project Selection

The process through which significant and realizable projects are distinguished from weak projects is diminished by unclear policy directions and goals from legislatures, vague agency objectives, and incomplete guidelines. Priorities for goals (such as reduced pollution, demonstration of innovative techniques, or target group mobility) should be communicated by the legislature to the agency either through legislation or with the appropriation. The agency should develop specific and quantified objectives to meet the legislature's program goals and administrative procedures for implementing the program. Lack of legislative direction forces agency administrators to set policy through decisions that should be made at a political level. It creates a climate in which administrators are cautious about making decisions that result in tentativeness and inconsistency that deters progress toward state goals.

Weak projects can be selected even when there is an attempt to state clear goals and objectives and to provide selection criteria. Failure to collect thorough and accurate information on the community background for the proposed project can result in approval of redundant proposals or the continuation of experiments that have failed. Information is required on community needs, participating and affected groups and their attitudes toward the project, and whether similar projects have been attempted and, if so, the results. Complete needs assessment and identification of constraints are expensive and controversial and will not be undertaken unless applicants believe that this information will help to qualify their project.

State agencies face two important constraints in their attempts to improve project selection. First, local information and state audits for accuracy are limited by lack of resources. Second, despite thorough information and concise objectives, there is no assurance that project operators will attempt what they have set for themselves unless there are incentives and monitoring. However, agencies contribute to selection difficulties with imprecise objectives. Without explicit program objectives and guidelines, applicants neither feel obligated nor able to state objectives other than superficially.

The evaluation of discretionary programs is not possible without standards against which to measure performance. Without explicit agency objectives, the legislature cannot evaluate the program. And without specific targets for each project, it is not possible to evaluate performance and provide a complete description of accomplishments.

Performance evaluation requires analysis of efficiency, effectiveness, and impact (Figure 2). In both California and Minnesota, evaluation was primarily of efficiency as indicated through input-output ratios. Objectives other than efficiency were not successfully evaluated, although they were specified in authorizing legislation. Evaluation of impacts, such as reduced automobile use, improved environmental quality, or demonstration of innovative techniques, must be completed if these are the results that the project sought to achieve. Although it will always be difficult to measure these impacts, it can be accomplished if measures are defined when submitted for funding.

Expenditure of scarce funds for one project rather than another cannot be justified, and conclusions on important demonstrations cannot be reached without evaluation of effectiveness and impacts. This can only be done by establishing explicit program and project objectives, because effectiveness and impact indicators evaluate accomplishment against some guideline or standard. Explicit objectives can be expressed in terms of performance measures, including standards for trips or miles of service to be provided for target groups. The same performance measures can then be used to measure results. Mere restatement of what happened is insufficient. We need to understand why performance guidelines were or were not achieved.

A formal evaluation should be conducted before applications are approved. Objectives selected must have measurable results and a clear understanding of expected performance must exist. Reports should be required that are performance oriented, periodic, and provide complete information on expenditures. There should be a quarterly monitoring of expenditures to ensure that funds are spent for the purposes for which they were allocated. Each discretionary program should have an audit guide developed for this purpose. Evaluation should be continuous and permit the state to assist project managers as problems are detected.

Discussion

G. Gray

Although I am not in complete agreement with all the statements given in the paper, I am in substantial accord with the recommendations as given in the abstract. There are a few errors or ambiguities in the write-up as it relates to the Caltrans program, but they are inconsequential and do not affect the value of the work.

There are, however, three aspects of the California program that I feel need further explanation and comment. They are the program background, its success, and implementation considerations.

PROGRAM BACKGROUND

The program was the result of legislation originated during the fuel crisis of 1974. Several separate bills were combined late in the legislative year with less-than-perfect coordination. This resulted in some conflicts between the various parts of the act. A number of studies and programs were contained in the final bill. These ranged from a hydrogen bus demonstration project to studies of the feasibility of several rail passenger services. Funding for departmental costs was provided for some of the items, but unfortunately not for others, including the three items reported in this paper. This combining of some 10 or 11 prior bills also resulted in nonuniformity of program goals, reporting requirements, responsible agencies, and similar onerous conditions in the final legislation. My point is that the first key to a good discretionary program is good legislation. Nonetheless, the act did provide funding for innovation in demonstration projects for public transportation.

The California program developed criteria for program selection through the active involvement of an advisory group that represented diverse interests. Project selection was structured by restricted funding and based on attempts at band-aid solutions by local agencies. It is not realistic to expect project selection to be completely separate from the political process.

SUCCESS?

Sixty-one projects were eventually funded. Six of these were still using program funds in February 1981, although the original three-year program expired July 1, 1979. Of the 17 projects that involved implementation of new transit services, all but one are operating at this writing. These 16 have been successful in obtaining other funding. This is a phenomenal success rate for demonstration projects. It is in sharp contrast to the reported 5-15 percent survival rate reported by the Rand Corporation in some federal programs to improve education.

Although a number of projects were of questionable innovative value, the projects did conform to the general legislative direction. Remember that innovation, like beauty, is in the eye of the beholder. In small urban and rural areas that have limited transit experience, the definition of what is innovative is much more liberal. By strict definition, but in recognition of this, some of the projects could be classified as deployment rather than development of demonstration in nature.

Innovative projects included projects that involved subsidized taxi, bus driver training, coordinated marketing among six major transit systems, transit education for schools, organized hitchhiking, and implementation of the broker concept. The projects varied widely in funding level as well as concept. The smallest project was provided just $4000 and the largest was given $300 000 in state funds. This divergence in project size influences the depth and extent of evaluation. This is not recognized in the paper. In fact, the paper implies that all projects should be handled in the same way. I feel some discretion must be exercised.

Only about one-half of the projects have been completed long enough to evaluate. The status of the program as of February 1981 is given in Table 1. Overall success in the three sections of the program, in my opinion, is secure. The magnitude of that success must be determined later, after the program has been completed a sufficient length of time to have full impact.

IMPLEMENTATION CONSIDERATIONS

The biggest single problem Caltrans had with the

Table 1. Status of California programs.

Funding Statute	Projects Funded			Projects Evaluated	
	Funded	Completed	Dropped	2/20/81	7/1/81
Section 5	33	22	3	18	27
Section 6	17	16	0	13	16
Section 9	11	7	1	3	3
Total	61	45	4	34	46

program was in trying to implement it without funding being provided for its administration. It took more than a year to correct this oversight, and that meant that the implementation moved very slowly since the resources that could be diverted to this new activity for almost one-half the legislatively established life were severely limited. This problem was compounded by the requirements of the other sections of the legislation, as the relatively small number of staff available and competent to carry out the combined responsibilities, even with funding available, was limited.

This very real problem is largely ignored in the paper, although it does address the lack of resources constraints from a different view. In my opinion, to ensure a reasonable chance of success, planners of such programs, and especially those responsible for legislation, need to be cognizant of the abilities of the responsible organizations to carry out the program. If that is in doubt, provisions for alternatives (i.e., contracting the work) need to be in the legislation.

Authors' Closure

Information provided by George Gray contributes to our thesis that professionals must assist legislators in thinking through the entire discretionary grant process before the legislation is passed. Legislation usually results from a crisis situation. Insufficient consideration is given to either program objectives or the staff required to disburse funds and monitor results. Our purpose was not to single out California and Minnesota, but to use examples to help other state agencies improve discretionary grant programs. Adequate staffing is essential and George Gray has helped by emphasizing an element that we had overlooked.

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Use of Productivity Measures in Projecting Bus and Rail Transit Operating Expenditures

JAMES M. HOLEC, JR., AND ROBERT L. PESKIN

This paper presents a model for projecting bus and rail operating costs that incorporates measures of productivity and performance typically used in the transit industry. The model was based on the recent experience of large, North American bus and modern rail transit operations as well as on data from vehicle manufacturers. A set of equations is presented that describes costs in specific aspects of operations and maintenance functions as a function of the quantity of service provided (e.g., vehicle miles and platform hours). Examples of the application of the model for the Houston Transitway Alternatives Analysis are presented. Areas for further model development and research are discussed briefly.

This paper presents a model for projecting bus and rail transit operating costs that incorporates measures of productivity and performance typically used in the transit industry. The model was based on the recent experience of large North American bus and modern rail transit operators as well as on data from vehicle manufacturers. This model, intended for use in the evaluation of regional transportation plans, was applied in the Houston Transitway Alternatives Analysis (HTAA). The project was performed by a team of consultants for the Metropolitan Transit Authority (MTA) of Harris County, Texas. Although some aspects of the model are specific to Houston, many aspects are applicable to the evaluation of alternative transit plans in other urban areas.

The remainder of this paper discusses the general approach and the structure of the model. The reasoning behind the selection of various model coefficient values is discussed in detail, particularly in those areas where the current Houston bus operating experience is deficient. The paper concludes with a brief discussion of the application of the model in the HTAA and the applicability of the overall approach for other planning and financial analysis studies for other transit properties.

APPROACH

Transportation planners have long struggled with the problem of estimating future operating expenditures for transit systems that are undergoing alternatives analysis. Typically, two general approaches have been used: engineered costs and historical unit costs. Engineered costs are estimates based on a complete inventory of staffing and material requirements for specific activities (i.e., estimates that relate the cost of vehicle operations to its component costs). Historical costs deal with aggregate costs. They are estimates that relate the cost of vehicle operations to unit costs for similar vehicles and operating conditions in the past.

The advantage of disaggregating the costs, as in engineered costs, is that components are identified and causes of change in cost might be easily discerned. An engineered cost approach also enables the analyst to take into account unique characteristics of the activity that is being examined and to identify the effects of changes in items such as labor contracts or material arrangements.

The advantage of aggregate costs, as in historical costs, is that no component, however minute, would be overlooked. Historical costs take into account items that may be overlooked when the engineered cost approach is used, such as slack time, overhead, and waste.

The distinctive advantages of both of these methods were obtained in preparing estimates of bus and rail operating expenditures for HTAA. The HTAA operating cost estimating approach is based on historical unit costs decomposed to reflect productivity measures and specific-resource cost components. It therefore approaches the advantages of engineered costs; that is, it makes changes in cost more transparent and permits the analyst to more explicitly take into account unique characteristics in the operating systems considered in the alternatives analysis process. At the same time, it avoids the shortcomings of the engineered cost approach, by reflecting the uncertainty of operations and maintenance activity because the experiences of actual operating systems are used.

The basis for this cost estimating approach is derived from recent work (1-3) in the area of transit performance evaluation. Outside the context of the alternatives analysis process, it offers transit management an easily adaptable technique for service planning and, with refinement, could be extended for use by smalland medium-sized systems as a budgeting aid.

GENERAL STRUCTURE OF MODEL

The model is comprised of a set of equations intended to compute all costs specifically attributable to various important aspects of bus or rail operation. They are, therefore, both mutually exclusive and complete. Costs are expressed in terms of values that describe, in general, the quantity of service provided, computed in the course of the planning process (e.g., annual vehicle miles). Four types of equations are presented:

1. Formulations of labor cost for major cost components,
2. Formulations of materials and supplies costs for major cost components,
3. Formulations of combined labor plus materials and supplies costs for minor cost components, and
4. Formulations of general and administrative costs.

The labor cost formulations are of the form:

$$\text{Labor cost} = \text{unit of service} \times \text{labor productivity factor} \times \text{cost per unit of labor} \times \text{staff burden} \times \text{fringe multiplier} \times \text{direct expenses multiplier} \quad (1)$$

The subcomponent terms used in this form are defined as follows:

1. Unit of service = number of vehicle miles, vehicle (or train) hours, station hours, or number of vehicles based on the estimate used in defining the alternative. The cost models are intended to model costs per unit of service provided rather than per unit of service used (e.g., per passenger or per passenger mile) because most costs are incurred by supplying the service rather than by how many passengers use it.
2. Labor productivity factor = number of nonsupervisory personnel or personnel hours required to adequately staff each unit of service provided. This factor implicitly considers the impacts of worker efficiency, need for training, and scheduled and unscheduled absenteeism.
3. Cost per unit = wage per hour (or per year) for the nonsupervisory employees who provide the basic service. This is usually the wage for vehicle operators and mechanics and includes average wages (straight wages plus overtime, vacation, and sick pay). It does not include expenses for fringe benefits (such as pension funds, social security, or insurance).
4. Staff burden = ratio by which operator or mechanic wages are multiplied to compute total wages and salaries for total staff including supervisors and administrative and support staff.
5. Fringe multiplier = ratio by which total wages and salaries are multiplied to account for fringe benefits.
6. Direct cost multiplier = ratio by which wages, salaries, and fringe benefits are multiplied to account for direct expenses for office supplies and related items.

OPERATING COST COMPONENTS

The computations of operating cost for bus and rail transit are specified in such a way that data obtained from various sources could be used to evaluate the coefficients and specific values for Houston (such as wages and fringe benefits) may be included. The data sources include the following:

1. Transit property annual reports;
2. Transit property budgets;
3. Reports that fulfill requirements of Section 15 of the Urban Mass Transportation Act of 1964, as amended;
4. Other correspondence and reports supplied by transit properties contacted; and
5. Data supplied by transit vehicle manufacturers.

The data used to create the operating cost models are based on the experience of North American transit operators that are representative of the type of operation anticipated in Houston. Bus operating data came primarily from the operators of large bus fleets:

1. Washington Metropolitan Area Transit Authority (WMATA),
2. Southern California Rapid Transit District (SCRTD),
3. Alameda-Contra Costa Transit (AC Transit),
4. Southeastern Pennsylvania Transit Authority (SEPTA),
5. Chicago Transit Authority (CTA),
6. Greater Cleveland Regional Transit Authority,
7. Metropolitan Atlanta Rapid Transit Authority (MARTA),
8. Milwaukee County Transit System,
9. Southeastern Michigan Transit Authority (SEMTA),
10. Baltimore Mass Transit Administration (MTA), and
11. Seattle Metro.

Rail transit operating cost components are based on the operating experience of the following newer rail systems:

1. WMATA,
2. Bay Area Rapid Transit District (BART),
3. Port Authority Transit Corporation (PATCO-Lindenwold Line),
4. Toronto Transit Commission, and
5. Edmonton Transit.

The rail operating experience of older systems, such as CTA, SEPTA, Port Authority Trans Hudson Corporation (PATH), New York City Transit Authority (NYCTA), and Massachusetts Bay Transit Authority (MBTA) are not considered to be representative of the newer technology to be employed in Houston. The limited operating experience of MARTA is considered to be insufficient and possibly misleading.

Much of the operating cost model structure and values of the components are based on the experience of WMATA because WMATA was able to supply detailed budget data on manpower and materials and supplies expenses; further, WMATA provides the type of guideway plus feeder bus service similar to most of the guideway alternatives under consideration in Houston.

Bus Operating Costs Components

Details of the major cost components computed for the bus systems in each of the alternatives are presented in Figure 1. Notice that the first term in each formulation is the unit of service provided, as defined in the planning process. This is multiplied by other factors of productivity and cost. The coefficient values for each of these factors is presented directly below each factor. The coefficients represent, in general, the cost for operating a mixed fleet of new-look buses of various ages and advance design buses. Specific values for articulated buses are also noted in Figure 1. Bus operating cost components include the following:

1. Bus operating labor--Wages, salaries, and fringe benefits for bus operators, bus supervisors, and support staff and related direct expenses;
2. Terminal operating labor--Wages, salaries, and fringe benefits for information kiosk agents at large activity center bus terminals, supervisors, and support staff and related direct expenses (we assumed that one agent will staff each large terminal kiosk);
3. Vehicle maintenance labor--Wages, salaries, and fringe benefits for vehicle mechanics, supervisors, and support personnel;
4. Vehicle maintenance materials and supplies--Direct costs for parts, tires and tubes, lubricants, garage maintenance, and related expenses;
5. Right-of-way (ROW) maintenance labor and materials and supplies--Wages, salaries, and fringe benefits of maintenance personnel and direct expenses for roadway, structure, and lighting repair, and maintenance on the exclusive busways;
6. Station maintenance labor and materials and supplies--Wages, salaries, and fringe benefits for maintenance personnel and direct expenses for building repair, cleaning, and utilities or large activity center terminals and suburban guideway stations;
7. Parking lot maintenance labor and materials and supplies--Wages, salaries, and fringe benefits for maintenance personnel and direct expenses for surface lots at suburban transitway stations (we assumed that no fee is charged for the use of parking lots; therefore, no costs for parking meters or cashiers are included);
8. Fuel--Cost for diesel fuel consumed by vehicles;
9. Claims--Cost for workers' compensation and third-party casualty and liability claims and the costs to administer those claims; and
10. General and administrative--A percentage of the sum of the above costs to cover costs that cannot be allocated to any other cost components directly.

Rail Operating Cost Components

The major cost components computed for the rail rapid transit and light rail transit systems are described in detail in Figures 2 and 3. The coefficients represent operating costs for the new, highly automated heavy and light rail transit systems that are currently planned or operating in San Francisco, Washington, Atlanta, Miami, Toronto, Edmonton, Baltimore, and Lindenwold (Philadelphia). Rail operating cost components include the following:

1. Rail operating labor--Wages, salaries, and fringe benefits for train operators (revenue service and yards and interlockings), supervisors, and support staff (we assumed that only one operator per train is required, i.e., no conductor or ticket collector);
2. Station operating labor--Wages, salaries, and fringe benefits for station agents, supervisors, and support staff and related direct costs (we assumed that each station mezzanine will have a full-time agent);
3. Vehicle maintenance labor--Wages, salaries, and fringe benefits for vehicle mechanics, helpers and cleaners, supervisors, and support staff for vehicle inspection repair and maintenance;
4. ROW systems maintenance labor--Wages, salaries, and fringe benefits for mechanics, helpers, supervisors, and support staff for maintenance to track and structure and rail systems [automatic train control (ATC), power, communications, and computer];
5. Station maintenance labor--Wages, salaries, and fringe benefits for mechanics, janitors, supervisors, and support staff for station cleaning, repair, and maintenance;
6. Vehicle maintenance materials and supplies--Direct costs for lubricants, contract maintenance, and maintenance and repair parts;
7. ROW and systems maintenance materials and supplies--Direct costs for track and structure, ATC, communications, power, and computer repair and maintenance;
8. Station maintenance materials and supplies--Direct costs for station cleaning materials, escalator and elevator maintenance, and lighting and ventilation parts;
9. Parking lot maintenance labor and materials supplies--Same as for bus;
10. Propulsion energy--Electrical power consumed by rail vehicles including traction motors, lighting, and air conditioning;
11. Station energy--Electrical power consumed by stations for lighting, air conditioning, escalators, and other uses;
12. Claims--Same as for bus;
13. Revenue collection labor and materials and supplies--Wages, salaries, and fringe benefits for revenue collection teams and accompanying security teams and for supervisors, support staff, and related direct costs; labor and direct costs for farecards and maintenance of automatic fare collection equipment are also included [revenue collection costs for bus operations are included in bus maintenance (farebox pullers) and bus general and administrative (counting)];
14. Security labor and materials and supplies--Wages, salaries, and fringe benefits for station and train surveillance by officers and for supervisors, support staff, and related direct

Figure 1. Bus operating cost model factors (coefficient values are in 1979 dollars).

Cost Item	Variable	× Factor	× Factor	× Factor	× Factor	× Factor	× Factor
Vehicle Operating Labor	Platform Hours	Payroll Hours / Platform Hour	Operator Wage / Payroll Hour	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		From: 1.33 in 1980 (MTA) To: 1.36 in 1984 (WMATA)	$7.15 MTA Add $0.50 for articulated buses	From: 1.17 (MTA) in 1980 To: 1.07 (WMATA) in 1988	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.005 WMATA	
Terminal Operating Labor	Busway Terminals	Total Agent-Years / Terminal	Agent Wage / Person-Year	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		4.76 (WMATA experience @ 20 hr/day)	$14,861 MTA (=bus operators)	1.062 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.003 WMATA	
Vehicle Maintenance Labor	Total Vehicle Miles	Mechanic-Years / Million Veh-miles	Mechanic Wage / Person-Year	Staff Burden	Fringe Multiplier		
		Nominal From: 20.6 in 1980, 1981 To: 12.4 in 1988 (Indust. Avg) High From: 20.6 in 1980, 1981 To: 16.8 in 1988 (CTA)	$17,360 in 1980 (MTA) $17,860 in 1981, 1982 $18,860 in 1983, 1984 $19,860 in 1985, 1986 $20,818 in 1987 (WMATA)	From: 1.41 in 1980, 1981 (MTA) To: 1.07 in 1988 (WMATA)	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
Vehicle Maintenance Materials & Supplies	Total Vehicle Miles	$ / Vehicle-Mile					
		From: $0.260 (MTA) in 1980 To: Nominal = Standard = 0.095-Indust. Avg.........Articulated = 0.124 (Standard x 1.3)...in 1988 High = Standard = 0.120-WMATA..................Articulated = 0.155 (Standard x 1.3)...in 1988					
ROW Maintenance Labor and Materials & Supplies	Route Miles	$ / Route-Mile					
		$8,000 TSDMPT Estimate					
Terminal Maintenance Labor and Materials & Supplies	Busway Terminals	$ / Terminal					
		Nominal = $21,223 High = $24,464 (Assumes 1 mechanic plus 21% materials & suppplies cost)					
Suburban Station Maintenance Labor and Materials & Supplies	Suburban Stations	$ / Station					
		Nominal = $10,611 High = $12,232 (Assumes 0.5 mechanic plus 21% materials & supplies cost)					
Parking Lot Maintenance Labor and Materials & Supplies	Parking Spaces	$ / Space					
		Nominal = $89 (Avg. Miami and Montgomery Co., MD) High = $102-Montgomery Co., MD.					
Fuel	Total Vehicle Miles	Gallons / Vehicle-mile			$ / gallon		
		Standard Articulated	Surface 0.25 (Avg) 0.36 (CTA)	Guideway 0.125 (CUTS Manual @ 40 mph) 0.137 (Standard plus 10%)	$.76 MTA		
Workers Compensation Claims	Total Vehicle Miles	#Claims Paid / Million Veh-mi	Avg Award / Claim Paid	Avg Labor & Exp / Claim Paid			
		Surface: Nominal = 34-MTA High = 37-WMATA Guideway: Nominal = 8 High = 10 (Assumes guideway accident rate = arterial/freeway rate = 1/4 surface rate - CUTS Manual)	$1,001 MTA	$124 MTA			
Third Party Casualty and Liability Claims	Revenue Vehicle Miles	#Claims Paid / Million Rev-mi	Avg Award / Claim Paid	Avg Labor & Exp / Claim Paid			
		Surface = 61-WMATA Guideway = 15 (Assumes guideway accident rate = arterial/freeway rate = 1/4 surface rate - CUTS Manual)	Nominal = $673 (Avg of MTA and WMATA) High = $977-WMATA	$124 MTA			
Security Labor and Materials and Supplies	Suburban Stations, Park-n-Ride Lots, Mall Terminals	Officers / Station	Shifts Required	Officer Wage / Person-Year	Staff Burden	Fringe Multiplier	Direct Expense Multiplier
		0.333 WMATA	5.2 WMATA: 24-hr. coverage plus absentees - Rail System	$10,459 WMATA	1.506 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.03 WMATA
General and Administrative	Total of Above	G&A Multiplier					
		From: 0.328 (MTA) in 1980 To: 0.152 (WMATA) in 1988					

Figure 2. Rail rapid transit cost model factors (coefficient values are in 1979 dollars).

Vehicle Operating Labor	Platform Hours	Payroll Hours / Platform Hour	Operator Wage / Payroll Hour	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		1.33 WMATA	$7.15 MTA	2.49 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.009 WMATA	
Station Operating Labor	Mezzanines	Total Agent-Years / Mezzanine	Agent Wage / Person-Year	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		4.76 (WMATA experience with 20 hr/day)	$14,861 MTA (=bus operator)	1.062 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.003 WMATA	
Vehicle Maintenance Labor - Inspection	Active Vehicles (Including Spares)	Mechanics / Vehicle	Mechanic Wage / Person-Year	Staff Burden	Fringe Multiplier		
		0.627 WMATA	$18,323 WMATA	1.128 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
Vehicle Maintenance Labor - Repair & Maintenance	Total Vehicle Miles	Mechanics / Million Veh-mi	Mechanic Wage / Person-Year	Staff Burden	Fringe Multiplier		
		6.65 WMATA	$18,323 WMATA	1.128 MATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
ROW and Systems Maintenance Labor	Single Track Miles	Mechanic / Track-mile	Mechanic Wage / Person-Year	Staff Burden	Fringe Multiplier		
		5.164 WMATA	$17,510 WMATA	1.251 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
Station Maintenance Labor	Mezzanines	Non-Superv. Pers / Mezzanines	Avg Wage / Person-Year	Staff Burden	Fringe Multiplier		
		2.71 WMATA	$13,751 WMATA	1.191 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
Vehicle Maintenance Materials & Supplies	Total Vehicle Miles	$ / Vehicle-mile					
		Nominal = $0.163 (Avg BART and WMATA) High = $0.220-WMATA					
ROW and Systems Maintenance Materials & Supplies	Single Track Miles	$ / Track-mile					
		Nominal = $22,290 (Avg BART and WMATA) High = $31,098-WMATA					
Station Maintenance Materials & Supplies	Stations	$ / Station					
		$64,269 WMATA					
Parking Lot Maintenance Labor and Materials & Supplies	Parking Spaces	$ / Space					
		Nominal = $89 (Avg of Miami and Montgomery Co. MD) High = $102-Montgomery Co., MD					
Propulsion Energy	Total Vehicle Miles	Kilowatt-Hours / Vehicle-mile	$ / Kilowatt-Hour				
		Low = 8.29-BART High = 9.8-WMATA	$0.031 HL&P				
Station Energy-Subway	Subway Stations	Operating Hours / Year	Kilowatt-Hours / Station-Hour	$ / Kilowatt Hour			
		7300 20 hrs/day 365 days/year	614 WMATA experience plus DMJM A/C estimate	$0.031 HL&P			
Station Energy-At grade & Elevated	Surface Stations	Operating Hours / Year	Kilowatt Hours / Station-Hour	$ / Kilowatt-Hour			
		7300 20 hrs/day 365 days/year	66 WMATA (Fall '79 Avg)	$0.031 HL&P			
Workers Compensations Claims	Total Vehicle Miles	#Claims Paid / Million Veh-mi	Avg Award / Claim Paid	Avg Labor & Exp / Claim Paid			
		37 WMATA	$1,001 MTA	$124 MTA			
Third party Casualty and Liability Claims	Revenue Vehicle Miles	#Claims Paid / Million Rev-mi	Avg Award / Claim Paid	Avg Labor & Exp / Claim Paid			
		6.12 WMATA	Nominal = $796 (Avg MTA and WMATA) High = $1,184 WMATA	$124 MTA			
Revenue Collection Team Labor	Stations	Collection Pers / Station	Avg Wage / Person-Year	Staff Burden	Fringe Multiplier		
		0.8 WMATA	$14,861 MTA (=bus operators)	1.122 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987		
AFC Maintenance Labor and Materials & Supplies	Mezzanine	Mechanics / Mezzanine	Mechanic Wage / Person-Year	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		0.68 WMATA	$18,240 WMATA	1.226 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.9 WMATA	
Revenue Protection Labor	Stations	Police Officers / Station	Officer Wage / Person-Year	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier	
		1.37 WMATA	$10,459 WMATA	1.244 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.03 WMATA	
Security Labor	Stations	Police Officers / Station	Shifts Required	Office Wage / Person Year	Staff Burden	Fringe Multiplier	Direct Expenses Multiplier
		0.333 WMATA	5.2 WMATA: 24-Hour Coverage and absentees	$10,459 WMATA	1.506 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987	1.03 WMATA
General and Administrative	Total of above costs	G&A Multiplier					
		0.170					

Figure 3. Light rail transit operating cost model factors that are different from those for rail rapid transit (coefficient values are in 1979 dollars).

Cost Component	Quantity	Factor	Factor	Factor	Factor
Vehicle Maintenance Labor (Combined Inspection and Repair & Maintenance)	Total Vehicle Miles	× Mechanics / Million Veh-mi	× Mechanic Wage / Person-Year	× Staff Burden	× Fringe Multiplier
		20 Toronto	$18,323 WMATA	1.118 WMATA	1.20 in 1980 From: 1.24 in 1981 To: 1.30 in 1987
Vehicle Maintenance Materials & Supplies	Total Vehicle Miles	× $ / Vehicle-mile			
		Nominal = $0.080 (Avg of Toronto and Edmonton High = $0.114-Edmonton			
Station Maintenance Materials & Supplier	Mall Stations	$ / Station			
		$18,304 WMATA experience (no escalation maintenance, etc.)			
Propulsion Energy	Total Vehicle Miles	× Kilowatt-Hours / Vehicle-mile	× $ / Kilowatt-Hour		
		10.0 Siemens, Boeing Vertol	$0.031 HL&P		
Stations Energy (Mall Stations)	Mall Stations	× Operating-Hours / Year	× Kilowatt-Hours / Station-Hour	× $ / Kilowatt-Hour	
		7,300 20 Hrs/Day 365 Days/Year	15 Estimate based on WMATA experience	$0.031 HL&P	

expenses (security costs for bus operations are included in bus general and administrative); and

15. General and administrative--A percentage of the sum of the above costs to cover costs that cannot be allocated to any other cost component directly.

SELECTION OF NOMINAL COEFFICIENT VALUES

Figures 1-3 present the computations for two estimates of operating cost. The nominal, or expected, value is based on assumptions regarding improved worker productivity and reduced unit direct costs anticipated to occur, particularly as the bus fleet grows. For some components, a high value represents the case where less optimistic improvements over the current MTA operation occur. When no change from the nominal cost is expected, the nominal and high values are the same. In the analysis of alternatives, the difference between the nominal and high values is treated as a cost contingency. In the discussion below, arguments are presented regarding the selection of nominal and high values for the cost model coefficients and the reasoning behind assumptions concerning anticipated improvements from the current operation.

Selection of Productivity Values

Improvements in worker productivity are expected to have the greatest impact on operating costs. These productivity factors are as follows.

Bus Payroll Hours per Platform Hour

The current MTA value of 1.33 is expected to decrease slightly as relatively more peak-period, express service is introduced. The type of service envisioned is representative of current WMATA operations (1.36).

Bus Vehicle Operating Labor Staff Burden

The current MTA value of 1.17 is expected to decrease as the bus fleet expands and the overhead burden of supervisors and clerical and administrative staff is spread thinner. The large bus operations of WMATA have a power value of 1.07, and we assume that the MTA will achieve this value.

Bus Mechanics per Million Vehicle Miles

The current MTA value of 20.6 is high and is apparently due, in part, to inadequate bus maintenance facilities. The nominal value of 12.4 is the average for the following operators of relatively large bus fleets:

System	Bus Mechanics per Million Vehicle Miles
WMATA	13.3
AC Transit	7.8
CTA	16.8
SCRTD	11.3
Seattle Metro	13.4
MARTA	11.9

CTA, which has the highest value, represents one of the best-administered maintenance programs, although its buses serve primarily slower urban routes.

Bus Vehicle Maintenance Labor Staff Burden

As the bus fleet expands, the administrative staff will be spread thinner. Thus, the current MTA value of 1.41 will be reduced. The WMATA value of 1.07 is considered representative.

In general, productivity improvements for bus operations are expected to occur gradually. No improvement is expected until after 1982, when the Kashmere heavy maintenance facility opens. The transition is assumed to be completed by 1988 when the first busways begin operation.

Selection of Representative Wage Values

Certain job classifications are expected to experience increases in real dollar wages due to the need for the MTA to compete with the private sector for highly trained technical staff. The wages selected for the most important labor cost components are discussed below.

Rail and Bus Vehicle Operators and Station Agents

The current MTA real dollar wages for bus drivers are expected to remain constant. The top hourly wage is currently among the highest in the state. As with WMATA, rail car operators' and station agents' wages are approximately the same as those of bus drivers.

Bus Mechanic Wages

MTA is currently experiencing some difficulty in hiring sufficiently trained diesel mechanics due to the relatively low wages offered compared with those in the private sector. In order to attract the large number of mechanics necessary to serve the expanding bus fleet, it is assumed the annual wage will increase with each contract negotiation as follows:

Year	Annual Wage (1979 dollars)
1980	17 360--MTA wage
1981-1982	17 860
1983-1984	18 860
1985-1986	19 860
1987-1995	20 818--WMATA wage

Rail Mechanic Wages

All rail maintenance nonsupervisory employee wages are assumed to be equal to the WMATA value. These positions (in vehicle, station, right-of-way, and ATC maintenance) require highly skilled mechanics and technicians who command a fairly high wage in the private sector. We assumed that current MTA wages for bus mechanics would not attract these personnel.

Selection of Fringe Multiplier Value

The 1980 MTA multiplier value of 1.20 will increase to 1.24 in 1981 due to a doubling of MTA's contribution to the pension fund. We anticipate that this value will increase further, as it has with other transit properties. A value of 1.30 in 1987 (slightly higher than the WMATA current value) is assumed.

Selection of Other Direct Cost Values

Nominal and high values were selected for the following cost components.

Bus Vehicle Maintenance Materials and Supplies Cost per Vehicle Mile

The current MTA value of 0.26 is relatively high and is expected to fall as improved maintenance practices are implemented for the larger fleet and new maintenance facilities. A nominal value of 0.095, achieved by 1988, is representative of the industry. A high value of 0.120 is also achieved by 1988, the value for WMATA.

Heavy Rail Vehicle Maintenance Materials and Supplies Cost per Vehicle Mile

The nominal value of 0.163 is the average for BART and WMATA. The high value of 0.220 is the WMATA value.

Heavy Rail Right-of-Way and Systems Maintenance Materials and Supplies Cost per Vehicle Mile

The nominal value of 22 290 is the average for BART and WMATA. The high value of 31 098 is the WMATA value.

Light Rail Vehicle Maintenance Materials and Supplies Cost per Vehicle Mile

The nominal value of 0.080 is the average for Edmonton and Toronto. The high value of 0.114 is the Edmonton value.

Parking Lot Maintenance Materials and Supplies Cost per Parking Space

The nominal value of 89 is the average for Miami, Florida, and Montgomery County, Maryland. The high value of 102 is the Montgomery County value.

Selection of General and Administrative Factor

The current MTA value of 0.328 is extraordinarily high for a medium-sized bus-only transit operation. This can be explained by the large administrative staff that performs many of the functions found in larger, multimodal properties. These additional functions include the following:

1. Contraflow operation,
2. Metro lift (elderly and handicapped service),
3. Customer service (ticket sales and telephone information), and
4. Program development (particularly of long-range regional transportation planning).

We anticipate that, as the bus fleet expands, the absolute value of these administrative costs will not increase and will reduce in relative terms over time. For bus operations this value is assumed to approach the lower WMATA value of 0.152 by 1988, when bus guiding operations begin. The value for rail operations (0.170) is the WMATA rail value.

APPLICATION OF COST MODEL

The bus and rail transit cost models described above were applied to the priority corridor alternatives in the phase 2 HTAA. The following alternatives were considered (4):

1. Base--Extensive improvements in the level of service provided by surface bus operations with express service provided on two currently programmed busways and on freeway contraflow lanes.
2. Low capital--Express bus service on narrow, one-way busways built primarily in conjunction with state-funded freeway reconstruction projects supplemented by extensive feeder bus service.
3. Busway--Express bus service on wide, two-way busways in all major transportation corridors supplemented by extensive feeder bus service.
4. Heavy rail--Conventional heavy rail (rail rapid transit) service from a tunnel in the central business district (CBD) to two major activity centers via aerial structure in the travel corridor of greatest demand. Express bus service similar to the busway alternative in all other corridors. Both heavy rail and busways supplemented by extensive feeder bus service.
5. Light rail with CBD tunnel--Light rail transit service from a tunnel in the CBD to two major activity centers, with a spur that penetrates the larger activity center, via aerial structure in the travel corridor of greatest demand. Express bus service similar to the busway alternative in all other corridors. Both light rail and busways supplemented by extensive feeder bus service.
6. Light rail with CBD mall--Light rail transit service from a contraflow, one-way pair surface street operation in the CBD to two major activity centers via aerial structure in the travel corridor of greatest demand; express bus service similar to the busway alternative in all other corridors. Both light rail and busways are supplemented by extensive feeder bus service.

All alternatives included two CBD bus transit malls and an extensive park-and-ride program. Further, all alternatives are designed to provide similar levels of service in terms of residential feeder bus route spacing and headways and in terms of connectivity to major activity centers.

Detailed results of the operating cost analysis for the bus and rail (if any) components for each alternative in 1995 (the design year) are shown in Tables 1-4. A summary of the combined 1995 nominal operating costs is given in the table below. These costs include differential inflation effects for each cost component (5). [Note: Costs are given in 1979 dollars.]

	Operating Cost ($000 000s)		
Alternative	Bus	Rail	Total
Base	181.53		181.53
Low capital	209.86		209.86
Busway	210.30		210.30

Table 1. Bus physical and operating characteristics for Houston Transitway alternatives in 1995.

System Characteristic	Base	Low Capital	Busway	Heavy Rail	Light Rail CBD	
					Tunnel	Mall
Active vehicles	2 004.0	2 174.0	2 171.0	1 857.0	1 828.0	1 820.0
Standard	2 004.0	2 174.0	2 171.0	1 857.0	1 828.0	1 820.0
Articulated	0.0	0.0	0.0	0.0	0.0	0.0
Platform hours (000 000s)	5.572	6.177	5.987	5.318	5.206	5.193
Standard	5.572	6.177	5.987	5.318	5.206	5.193
Articulated	0.0	0.0	0.0	0.0	0.0	0.0
Total vehicle miles (000 000s)	73.855	89.317	103.901	88.915	85.773	86.408
Standard surface	73.855	85.119	59.618	58.643	56.830	57.317
Standard guideway	0.0	4.198	44.283	30.272	28.943	29.091
Articulated surface	0.0	0.0	0.0	0.0	0.0	0.0
Articulated guideway	0.0	0.0	0.0	0.0	0.0	0.0
Revenue vehicle miles (000 000s)	65.810	79.726	92.849	79.362	76.535	77.106
Route miles guideway	21.0	87.6	102.6	91.3	89.4	91.3
Activity center terminals	7.0	6.0	6.0	5.0	4.0	5.0
Suburban stations	23.0	46.0	48.0	39.0	39.0	39.0
Parking spaces	21 000.0	21 000.0	21 000.0	15 500.0	15 500.0	15 500.0

Table 2. Bus operating costs for Houston Transitway alternatives in 1995.

Cost Component	Base ($000 000s)		Low Capital ($000 000s)		Busway ($000 000s)		Heavy Rail ($000 000s)		Light Rail CBD ($000 000s) Tunnel		Light Rail CBD ($000 000s) Mall	
	Nominal	High	Nominal	High	Nominal	High	Nominal	High	Nominal	High	Nominal	High
Vehicle operating labor	75.74	82.82	83.97	91.82	81.39	88.99	72.29	79.05	70.77	77.38	70.59	77.19
Terminal operating labor	0.69	0.69	0.59	0.59	0.59	0.59	0.49	0.49	0.40	0.40	0.49	0.49
Vehicle maintenance labor	29.80	40.38	36.04	48.83	41.92	56.80	35.88	48.61	34.61	46.89	34.87	47.24
Vehicle maintenance materials and supplies	7.02	8.86	8.49	10.72	9.87	12.47	8.45	10.67	8.15	10.29	8.21	10.37
ROW maintenance labor and materials and supplies	0.17	0.17	0.70	0.70	0.82	0.82	0.73	0.73	0.72	0.72	0.73	0.73
Station maintenance labor and materials and supplies	0.39	0.45	0.62	0.71	0.64	0.73	0.52	0.60	0.50	0.57	0.52	0.60
Parking lot maintenance labor and materials and supplies	1.87	2.14	1.87	2.14	1.87	2.14	1.38	1.58	1.38	1.58	1.38	1.58
Fuel	35.43	47.28	41.84	55.84	39.22	52.34	35.39	47.23	34.20	45.65	34.47	46.01
Claims	8.77	10.77	10.24	12.58	8.36	10.36	7.84	9.69	7.58	9.37	7.65	9.45
Security labor and materials and supplies	0.84	0.84	1.46	1.46	1.52	1.52	1.24	1.24	1.21	1.21	1.24	1.24
Subtotal	160.72	194.41	185.81	225.38	186.20	226.77	164.21	199.89	159.51	194.06	160.14	194.89
General and administrative	20.80	25.16	24.05	29.17	24.10	29.35	21.25	25.87	20.64	25.12	20.73	25.22
Total	181.53	219.57	209.86	254.55	210.30	256.12	185.46	225.76	180.15	219.18	180.87	220.12

Note: Costs are given in 1979 dollars.

Alternative	Operating Cost ($000 000s) Bus	Rail	Total
Heavy rail	185.46	23.99	209.45
Light rail CBD			
Tunnel	180.15	32.16	212.31
Mall	180.87	27.75	208.62

Several brief observations can be made regarding the performance of the model in this application. The base alternative has lower costs than the other alternatives due to relatively lower quantity of service provided (measured in terms of both vehicle miles and hours) compared with the other alternatives. The low-capital alternative, although it provides a similar level of service as the busway and rail alternatives, does so with substantially less service on bus guideways. The resulting lower speeds result in more platform hours (and thus greater vehicle operating costs) and fuel consumption (and thus greater fuel costs).

The costs for the rail alternatives demonstrate the trade-offs involved in replacing bus service in the priority corridor with rail service. For example, the heavy rail alternative, which uses trains of high capacity and only one operator, reduces the

Table 3. Rail physical and operating characteristics for Houston Transitway alternatives in 1995.

System Characteristic	Heavy Rail	Light Rail CBD Tunnel	Light Rail CBD Mall
Platform hours (000 000s)	0.058	0.118	0.110
Total vehicle miles (000 000s)	5.736	6.253	5.035
Revenue vehicle miles (000 000s)	5.700	6.170	4.976
Active vehicles	90.0	118.0	102.0
Track miles	33.1	42.9	37.9
Total stations	13.0	18.0	16.0
Subway	2.0	2.0	0.0
Surface	11.0	16.0	12.0
Mall	0.0	0.0	4.0
Mezzanines	15.0	20.0	20.0
Parking spaces	5500.0	5500.0	5500.0

Table 4. Rail operating costs for Houston Transitway alternatives in 1995.

			Light Rail CBD ($000 000s)			
	Heavy Rail ($000 000s)		Tunnel		Mall	
Cost Component	Nominal	High	Nominal	High	Nominal	High
Vehicle operating labor	1.80	1.80	3.66	3.66	3.42	3.42
Station operating labor	1.47	1.47	1.96	1.96	1.96	1.96
Vehicle maintenance labor	2.81	2.81	4.24	4.24	3.42	3.42
ROW and systems maintenance labor	5.63	5.63	7.30	7.30	6.45	6.45
Station maintenance labor	0.87	0.87	1.15	1.15	1.15	1.15
Vehicle maintenance materials and supplies	0.93	1.26	0.50	0.71	0.40	0.57
ROW and systems maintenance materials and supplies	0.74	1.03	0.96	1.33	0.84	1.18
Station maintenance materials and supplies	0.84	0.84	1.16	1.16	0.84	0.84
Parking lot maintenance labor and materials and supplies	0.49	0.56	0.49	0.56	0.49	0.56
Propulsion energy	2.66	2.89	3.21	3.21	2.59	2.59
Station energy	0.73	0.73	0.86	0.86	0.32	0.32
Claims	0.39	0.41	0.42	0.44	0.34	0.36
Revenue collection labor and materials and supplies	1.12	1.12	1.52	1.52	1.43	1.43
Security labor and materials and supplies	0.47	0.47	0.66	0.66	0.58	0.58
Subtotal	20.95	21.89	28.09	28.78	24.24	24.84
General and administrative	3.03	3.17	4.07	4.17	3.51	3.60
Total	23.99	25.06	32.16	32.94	27.75	28.43

Note: Costs are given in 1979 dollars.

total expense for vehicle operator labor (i.e., bus and rail operators combined) compared with the busway alternative. However, the rail technology adds maintenance costs not experienced in a bus-only system. Another example can be seen in the light rail CBD mall alternative that provides service similar to that of the heavy rail alternative but requires greater vehicle operator costs. This is due to the need for more platform hours as a result of scheduling shorter trains, a requirement imposed by the short block length in downtown Houston and the resulting use of shorter trains.

CONCLUSION

The model presented in this paper has two distinguishing features. First, it is based on formulations of expense categories that use standard transit industry measures of productivity and performance on service delivery. These formulations permit the analyst to test the sensitivity of cost projections to underlying assumptions and to display the results of these tests in a clear and understandable manner. They also permit the analyst to vary the values of these productivity parameters over time to allow for anticipated improvements or deterioration in performance at the outset.

Second, the model is based on formulations of expense categories that can easily be adapted to and calibrated by using data from the Section 15 chart of accounts. This feature of the model suggests the potential for more general applications in midrange financial planning for transit systems.

Many opportunities remain in the development of this type of cost-projection tool. Of particular interest, when comparing larger and smaller transit properties, is the need to identify those components of cost that are fixed. The model presented in this paper is completely variable-cost based. We recognize that some areas of transit operations are relatively independent of the quantity of service provided and should not be treated as a variable cost.

The model is currently being applied for WMATA in projecting operating costs for FY 1981-1990. Further investigation is being conducted regarding the structure of the cost formulations and the values of the model coefficients. Among the many anticipated model improvements are the following:

1. Detailed estimation of the costs of rail electrical power that explicitly consider demand charges, which result in greater costs per kilowatt hour during periods of peak use;
2. Identification of rail right-of-way costs specifically attributable to incremental track miles, passenger stations (and mezzanines), or power substations; and
3. Fixed administrative costs, both in specific operations and maintenance costs components and in the general and administrative overhead cost component.

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Abridgment

Constrained Matching Procedure for Allocating Public Transportation Assistance in Minnesota

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As public transportation subsidy costs increase, federal, state, and local decision makers become more concerned about the effectiveness, fairness, and efficiency of subsidy-allocation procedures. This paper describes a new allocation approach, developed for the Minnesota Department of Transportation, that matches each local subsidy dollar with two state dollars, up to a policy maximum percentage of the total operating costs. Based on a review of the experience in several states and recent proposals for the federal program, we discuss four general subsidy-allocation criteria—equity, efficiency incentives, administrative practicality, and managerial dynamics. Advantages and disadvantages of the constrained matching approach and four other methods are then presented. We also describe the application of the new approach.

Until the early 1970s, user fares covered almost all of the operating costs of public transportation services, and few states or communities provided public subsidies for these services. Currently, however, fares rarely cover the full costs of the services desired by citizens, and increasing amounts of federal, state, and local funds are being committed to subsidizing public transportation systems. Rapidly escalating public transportation costs alarm state and local decision makers and, as competition for public funds has increased, they have sought ways of limiting the growth in subsidy payments to public transportation.

This paper describes a new subsidy-allocation procedure that was developed for the Minnesota Department of Transportation (MnDOT). Based on experience in other states and at the federal level and on four criteria for assessing subsidy-allocation procedures, we present the advantages and disadvantages of five alternative approaches. We present proposals for a new allocation method based on matching local funds to a policy maximum percentage of total operating costs. A complete documentation of these proposals is available (1).

REVIEW OF ALTERNATIVE ALLOCATION APPROACHES

A comprehensive survey in 1978 found 22 states that have 50 programs that provide operating assistance for public transportation services (2). Almost half (23 programs) based the subsidy on deficits in one way or another. Usually, the amount of subsidy was a portion of the net deficit after receipt of federal funds. The next most common procedure (10 programs) was to base subsidies on the amount of funds received from provisions of Section 5 of the Urban Mass Transportation Act of 1964, as amended. Other methods reported included formulas based on patronage, vehicle miles, population or population density, and operating expenses. More recently, California, New York, and the U.S. Department of Transportation have made or proposed various modifications to these procedures (3-5). Pennsylvania has begun to apply performance measures to funding programs.

Criteria for Assessing Allocation Procedures

Four criteria are helpful for assessing allocation schemes: equity, efficiency incentives, administrative practicality, and managerial dynamics (6). One could also assess different allocation approaches based on their effectiveness in meeting the objectives of the subsidy program, but two major limitations make this assessment criterion infeasible:

1. Political and technical problems of determining for any subsidy program specific, quantifiable objectives and their trade-offs and
2. Difficulty of estimating accurately what impacts different subsidy approaches will have on service levels and the resultant ridership or other objectives.

Equity is an important allocation consideration. Subsidy recipients in similar situations should be treated alike. The problem is how to determine what are similar situations and how to deal with very different ones. Establishment of what is equitable can be very difficult; for example, Is a fair process that may lead to unequal outcomes equitable? Should funding be equalized based on population, state taxes contributed, system ridership, or some measure of service such as vehicle hours? There is also a generally held concern that public subsidy programs should use general tax revenues to help lower-income groups rather than the more affluent. However, given the multiple objectives of public transportation programs, the subsidies often benefit different population groups unequally. Legislatures must consider various aspects of fairness and, through discussion and negotiation, establish an equitable procedure. Any procedure can, of course, be challenged in court by affected parties who claim unequal treatment.

The efficiency incentives are significant, both for the recipients and the administering agency. A basic problem is to guarantee whatever support is necessary to ensure a minimum level of performance in meeting program objectives while motivating recipients to improve their performance. Allocation schemes that are independent of system performance, such as distribution by population, do not encourage or reward economic efficiency. On the other hand, direct subsidization of operating deficits can penalize efficient operations and encourage inefficiency. If recipients receive subsidies without commiting their own funds, they also may have less incentive to control costs.

Administrative practicality must be considered: The costs of administration for the subsidizing agency and the recipients should be minimized. Administrative costs typically include the following: collection and processing of the data to determine the subsidy, determination and enforcement of program regulations, and auditing. If service or ridership data are required for allocation, then some effort will be necessary to check data reliability. A related administrative aspect desirable to both the subsidizing agency and the recipients is predictability of funding levels over future years.

The fourth criterion, managerial dynamics, addresses the question of how the allocation procedure will influence future public transportation services and the industry that provides them. How will a subsidy program influence the continuity of public transportation services and providers? Does a program help the subsidizing agency (and the general public) determine whether program objectives are being met? Are recipients more or less accountable for their performance? Can public transportation managers influence the outcome of their efforts, can they innovate and respond to changing demand or operating conditions? What are the implications for the recruitment of new managers?

Brief Assessment of Five Potential Allocation Procedures

We have selected five basic approaches to the allocation of public transportation assistance. In consideration of the general criteria discussed previously, we take the perspective of a state legislature and present a list of the primary advantages and disadvantages for each.

The potential procedures include the following:

1. Allocation of total state funding to cities or counties by a formula based on demographic characteristics such as population and population density,
2. Coverage of a fixed portion of the nonfederal operating deficit,
3. Coverage of a fixed portion of the total operating costs,
4. Matching of state funds to local funds (two state dollars to every local dollar, for example) with a limit on the percentage of operating costs that can be matched, and
5. Allocation of some proportion of the total funding according to system performance criteria (perhaps based on showing improvement from year to year or by meeting normative standards).

The pros and cons of these approaches are presented in Table 1.

RECOMMENDED SUBSIDY-ALLOCATION PROCEDURE

The basic allocation procedure provides all eligible recipients (local governments or agencies) with two state assistance dollars for each local dollar applied to operating costs, up to a policy maximum on the percentage of total costs that are subsidized. Operating costs above the state policy maximum must be covered by user revenues or other sources of funds without state matching.

In some cases, state and local operating assistance will be equally matched with Section 5 funds; one local dollar will be matched with two state dollars and three federal dollars. However, the amount of federal assistance available to each area is limited: Federal funds in each urban area are set by the Urban Mass Transportation Administration (UMTA) Section 5 allocations, and in nonurban areas they are limited by the total funds allocated by Section 18 of the Urban Mass Transportation Act of 1964, as amended, to the state.

The state policy maximum percentages will be established for groups of recipients who have similar population size, such as urban or rural, or for recipients that provide certain services, such as those exclusively for the elderly or handicapped. Each recipient will continue to select, with technical advice from MnDOT, the type of service (such as dial-a-ride or fixed route) based on local conditions and cost-effectiveness criteria. State subsidy policy will not directly influence which types of service are appropriate for different communities.

The legislature will consider the amount committed by local recipients and appropriate state funds. If state funds are not expected to be sufficient to match all of the local funds committed, then MnDOT can lower the policy maximums. Thus local recipients will either have to increase fares, reduce total costs, or contribute additional unmatched local funds.

Local recipients will be primarily responsible for the planning and management of their transportation programs. Based on local objectives, they will prepare annual plans and budgets under a new local budget review process.

Efficiency Incentives of the New Procedure

The proposed subsidy mechanism does not provide any

Table 1. Advantages and disadvantages of potential allocation procedures.

Allocation Procedure	Advantages	Disadvantages
Demographic formula	Objectives totally locally determined; everyone receives funds, equitably based on demographic criteria; easy to administer; funding is predictable	Funding not directly related to areas' public transportation needs or to systems' performance; no incentives for managers
Cover fixed portion of deficit	Objectives locally determined; related to systems' financial needs; easy to administer	Inefficient systems receive more funds; encourages larger deficits; total funding is unpredictable; no efficiency incentives for managers; may encourage low fares
Cover fixed portion of costs	Objectives locally determined; related to systems' financial needs; easy to administer; may encourage more realistic fares	May encourage higher costs; total funding is unpredictable; not related to systems' performance
Match state to local funds	Objectives locally determined; related to local funding commitment; all recipients' funds equally matched by state funds; relatively easy to administer	Higher-income areas may receive more funds; not related directly to system performance
Portion of funds allocated by performance measures	Directly related to systems' performance; may provide incentives to improve management	May influence local objectives; requires considerable data; funding is unpredictable; difficult to administer; hard to establish and interpret meaningful measures

direct state financial incentives or rewards to local system managers because we believe that administration of such incentives would be much too time consuming and costly for MnDOT. If managers are able to operate their systems below the approved budgets, the systems will receive the state match for the funds spent and not the total state funds approved in their annual budget. If the costs exceed the approved budget, then the entire overrun is a local responsibility. There are also no bonus payments for meeting ridership or other performance goals.

The primary incentives for efficiency are that unmatched local dollars will be required beyond the established policy maximum and local dollars will be necessary for any cost overruns. Local managers and decision makers should be more critical of new service proposals and more concerned about poorly performing existing services as their systems approach or exceed the policy maximums. Every dollar saved above the maximum is a local savings and it will be a clear objective for managers to minimize inefficient services.

MnDOT will continue to provide technical assistance and advice on ways to improve services and cost-effectiveness and will critically review and evaluate each system during the annual budgeting process. A performance incentive program also has been proposed to fund worthwhile local experiments and to recognize innovative managers. The recipients will have the primary responsibility, however, for obtaining and rewarding good managers who plan, budget, and operate services effectively.

Allocating Federal Section 18 Subsidies for Nonurban Areas

These funds can be allocated in the same way as state subsidies by using the proposed procedures. All of the eligibile recipients of Section 18 funds will submit their preliminary operating budgets to MnDOT. Section 18 operating funds can be used to cover up to half of the system's operating deficits. The preliminary budgets will show state and local subsidy dollars matched one for one by Section 18 dollars. MnDOT will compare the total Section 18 dollars allotment set aside for operating assistance. If the former total is less than or equal to the latter, then all of the eligible recipients can be encouraged to proceed with their preliminary budget levels. If not, MnDOT will ration the available Section 18 operating funds by establishing a federal policy maximum on the percentage of total operating costs to which Section 18 funds can contribute. Above this percentage recipients will have to rely on local subsidy dollars matched by state dollars (up to the state policy maximum), unmatched local dollars, and revenues.

Each year, as the amount of Section 18 funds grows the number of eligible systems increases, or the total operating costs change, the federal maximum percentage may change. However, all systems will continue to receive a share of the available federal funds on the same basis.

Proposed Recipient Categories and Policy Maximum Percentages

A primary consideration in allocating assistance is that similar recipients should be treated equally. Recipients can have different demographic characteristics, such as population and geographic travel patterns, institutional arrangements, and transportation supply conditions. For example, recipients in rural areas have lower trip densities and longer trip lengths, less complex public agencies, and fewer transportation providers than do recipients in a large metropolitan area. Because many of the major differences in demographic and institutional influences on public transportation services can be characterized by the population of an area, recipients should be grouped primarily by population of the service area.

The current state funding provides a starting point for determining the allocation among the various groups of recipients. By examining the percentages of total costs subsidized for systems in each category, one can select a reasonable figure for the policy maximum. The intent is to set a level commensurate with current total state funding in each category. Some recipients now will be over and some under this level, but over the years all recipients will tend toward the standard maximum subsidy percentage for their category. For those initially over the maximum, the spending of unmatched local dollars will encourage them to consider raising fares, improving management, and reducing costs. For those currently below the limit, each local subsidy dollar will be matched with state or federal dollars, so local governments will tend to increase their contributions until the policy maximum is reached.

Although the distributions of the recipients' current funding and subsidy levels provide guidance on establishing the maximum levels, the final setting of maximum levels must be a policy determination based on an assessment of the funding commitments of the different groups of recipients and the near- and longer-term state budget priorities. Once the initial policy maximums are set, a procedure could be adopted for adjusting the policy maximums to allocate future state funding adjustments. One option would be to specify that all policy maximums should be increased or reduced in the same proportion. The policy maximums can be changed directly at any time, of course, to bring the state funding level in line with local commitments. This provides for a state subsidy policy under which all recipients can clearly understand how longer-term state budget changes will affect them.

A detailed discussion of the specification of the policy maxima, and the technical and political implementation issues addressed in Minnesota, can be found in Kern and Works in a paper in this Record.

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Analysis of Transit Performance Measures Used in New York State

ROBERT J. ZERRILLO, CAROL A. KECK, AND NORMAN R. SCHNEIDER

A recent study by the New York State Department of Transportation developed transit performance measures to be applied to the full range of the state's transit operations. This paper expands on this initial effort by examining: (a) factors that affect the 15 performance measures developed previously; (b) the interrelationships between measures; (c) the ability of the measures to describe changes in operator performance; and (d) the feasibility of using multimodal measures. The results of this analysis show that the 15 performance measures were not highly intercorrelated or influenced by the component variables used to compute them. The levels of a number of measures did not differ significantly among service types, which suggests their use in multimodal performance evaluations. A preliminary review of the performance levels for the second year reveals the usefulness of the measures as a diagnostic tool to identify possible operator performance problems. Operator levels in future years will be monitored to chart industry changes and to identify the need to modify the department's acceptable and desirable attainment levels.

The massive federal, state, and local investment in public transportation in recent years has led to an increased desire by all levels of government to monitor the impacts of these funds. A number of studies have addressed this need in relation to transit operating assistance and have advocated the use of transit performance measures to evaluate the effectiveness of this assistance (1,2). However, much of the past research into the development of performance measures has suffered from a common problem--that of the collection and use of accurate, reliable, and consistent data. The current collection and dissemination of Urban Mass Transportation Act of 1964, as amended, Section 15 transit operating data should help to alleviate this problem and greatly aid and increase research in this area.

A recent effort by the New York State Department of Transportation (NYSDOT) resulted in the development of transit performance measures to be applied to the full range of the state's transit operations (1). Achievement of at least acceptable levels of performance on each of the appropriate measures is necessary to ensure receipt of all operating aid funds to which an operator is eligible (3). Transit operating data collected by the department from all systems that participate in the state's transit operating assistance program contain many operating statistics not available to earlier researchers (such as employee hours and passenger miles).

This paper expands on initial department efforts by examining, in detail, factors that affect the 15 performance measures developed in 1979. Included are (a) an analysis of the relation between the performance measures and the component variables used to compute the measures; (b) the affect factors outside the control of the transit operator have on the performance measures; (c) interrelationships among the performance measures; and (d) the ability of the measures to describe changes in operator performance. This effort also addresses concerns about the desirability and feasibility of developing and using multimodal performance measures expressed by the transit operators and the planning and research communities after the department's earlier study in this area was publicized.

BACKGROUND

Recent efforts to develop transit performance measures grew from earlier research that described the need for such evaluations. Gilbert and Dajani examined the perspectives from which transit service could be evaluated (federal, state, local government, user, and operator) and outlined a framework for developing performance measures (4). A study by Allen and DiCesare identified possible criteria for measuring the level and quality of transit service (5). Work by Tomazinis and others described in detail the methods, problems, and requirements of creating transit efficiency measures (6). The Proceedings of the First National Conference on Transit Performance outlined the issues and problems involved in studying transit performance and presented recommendations for developing performance measures (7). Innumerable other reports have also described the issues involved in transit performance evaluation and presented possible measures for use in evaluations or as criteria for funding programs (8-10).

One of the first studies to develop and analyze performance measures for a large number of transit operators was by Fielding and Glauthier (11). This work was later extended to compare various California operations against the overall performance of all transit systems studied (2). These efforts were hindered by the unavailability of operating data, which resulted in the use of statistics such as the number of employees and passengers carried rather than more descriptive measures such as employee hours and passenger miles. Despite this problem, these and other similar efforts were valuable in that they not only developed sound performance measures but also analyzed factors that could affect the levels of the performance measures developed.

The NYSDOT effort described the background that led to the development of a set of 15 multimodal performance measures for use in New York State (1). These measures were developed for application to all modes, service types, and sizes of transit operations that participate in the state's operating assistance program. The 15 measures of efficiency, economy, and effectiveness developed are listed in Table 1 along with the mean level and standard deviation of each measure, based on data for state FY 1978/79. The definitions of some terms used in the analysis appear elsewhere (1). Due partly to the range of values and differing distributions of operator levels for each measure, the New York State program evaluates operator performance in relation to an empirically derived minimum level of attainment, not a statistically calculated level. The performance measures are applied in sets so as not to penalize any mode, size, or type of service. As a time series of data becomes available, levels of attainment can be assessed annually to identify trends of individual operators, groups of operators, or the state as a whole. This type of analysis may result in a reassessment of the desirable and acceptable threshold levels initially selected.

Table 1. Performance measures developed for use with New York State transit systems.

Performance Measure (abbreviation)	Overall Mean	SD
Efficiency		
Revenue capacity hours per employee hour (cap hr/emp hr)	31.2	17.4
Revenue capacity miles per employee hour (cap mi/emp hr)	516.8	335.5
Revenue vehicle hours per vehicle (veh hr/veh)	1878.8	891.5
Revenue vehicle miles per vehicle (veh mi/veh)	30 924	15 808
Economy		
Operating cost per capacity mile (cost/cap mi)	0.030	0.020
Operating cost per capacity hour (cost/cap hr)	0.511	0.365
Operating revenue per operating cost (rev/cost)	0.603	0.367
Operating revenue and excess local assistance per passenger mile (rev and local/pass mi)	0.182	0.259
Effectiveness		
Revenue passengers per revenue capacity hour (pass/cap hr)	0.355	0.194
Revenue passenger miles per revenue capacity hour (pass mi/cap hr)	3.70	4.53
Revenue passenger miles per capacity mile (pass mi/cap mi)	0.183	0.139
Operating cost per revenue passenger mile (cost/pass mi)	0.325	0.517
Deficit per revenue passenger mile (deficit/pass mi)	0.188	0.460
Revenue passengers per employee hour (pass/emp hr)	10.82	7.95
Revenue passenger miles per employee hour (pass mi/emp hr)	98.27	113.97

ANALYSIS OF PERFORMANCE MEASURE CORRELATIONS

A first step in the current analysis was to determine the relation of each of the 15 performance measures to the component data from which they were derived, as well as their relation to a series of variables generally considered outside the control of the transit operator. These variables include the following:

1. Public or private fleet ownership,
2. Total vehicle fleet size,
3. Average passenger trip length,
4. Average fare per passenger,
5. Population served (estimated for local services only),
6. Density of area served (estimated for local services only), and
7. Average vehicle speed.

A correlation matrix of the 15 performance measures and these variables was used to determine the degree of any such relationships. Table 2 summarizes the results of that analysis. Only one of the 15 measures (pass mi/cap hr) was found to be highly correlated (correlation coefficient greater than 0.70) with any other variable. Its correlation to both average passenger trip length and average vehicle speed is not surprising because they are ultimately components of the measure itself. Average passenger trip length, average vehicle speed, and average fare per passenger were moderately correlated with many of the performance measures. Several measures (cost/cap mi, rev and local/pass mi, cost/pass mi, and deficit/pass mi) were neither highly or moderately correlated with any of the variables analyzed, which indicates their particular suitability for intermodal evaluations. Both the population served and density of service area variables were not appreciably correlated with any of the performance measures, and, in fact, had essentially zero correlation with all but two measures (cap hr/emp hr and pass/emp hr). This suggests that the performance measures used in this study are not significantly affected by city size or density.

Surprisingly, none of the component variables (such as total passengers, capacity miles of service, or total employee hours) were highly or even moderately correlated with any performance measure. This indicates that a transit system's operating performance is probably not related to the absolute values of any of these variables. More simply, the size of an operation did not have a direct bearing on its performance.

Table 2. Correlation of performance measures with other variables.

Performance Measure (abbreviation)	Correlation: High	Correlation: Moderate
Cap hr/emp hr	None	Speed −0.35
Cap mi/emp hr	None	Speed 0.39 Trip length 0.32
Veh hr/veh	None	Speed −0.42
Veh mi/veh	None	Speed 0.43 Trip length 0.40 Fare per passenger 0.32
Cost/cap mi	None	None
Cost/cap hr	None	Speed 0.47 Trip length 0.42 Fare per passenger 0.37
Rev/cost	None	Trip length 0.50 Fare per passenger 0.45 Public versus private 0.48
Rev and local/pass mi	None	None
Pass/cap hr	None	Trip length −0.36 Fare per passenger −0.34
Pass mi/cap hr	Trip length 0.79 Speed 0.72	Fare per passenger 0.58
Pass mi/cap mi	None	Trip length 0.53 Fare per passenger 0.34
Cost/pass mi	None	None
Deficit/pass mi	None	None
Pass/emp hr	None	Speed −0.46 Trip length −0.36 Fare per passenger −0.36
Pass mi/emp hr	None	Trip length 0.59 Speed 0.44 Fare per passenger 0.36

The correlation matrix also provides support for the department's initial use of pairs of performance measures to account for obvious differences in service types (e.g., local versus intercity) (1). For example, the capacity mile per employee hour ratio is positively correlated with speed and trip lengths, and so favors commuter and intercity services, but the capacity hour per employee hour ratio is negatively correlated with speed, thus favoring local services. Similar comparisons can be found in the other instances where this pairing of measures was used in the evaluation.

Next, the interrelationship among the performance measures was analyzed. By examining the resulting correlations presented in Table 3 we note that few performance measures are highly correlated with other measures. Not surprisingly, most of the related measures are those that are companion measures (e.g., operating revenue plus excess local assistance and operating cost). In general, the efficiency measures are not highly related to either the economy or effectiveness measures, which supports the opinion that efficient service does not ensure effective service (4).

Among the more significant correlations found in the matrix is the relationship of the revenue to cost ratio, as well as the revenue and local assistance per passenger mile ratio, to most of the effectiveness measures. This intuitively should be the case because more-effective service is characterized by higher passenger use, which generally results in more operating revenue per unit of service than is the case for less-effective services.

The passengers to capacity hour ratio is not correlated with most of the performance ratios, but tends to increase as efficiency (in terms of cap mi/emp hr and veh mi/veh) decreases, thus favoring locally oriented services. On the other hand, passenger miles per capacity hour is correlated with most other measures and favors intercity and commuter services due to significantly longer trip lengths that are reflected in the passenger mile component. The passenger to employee hour ratio is moderately correlated with capacity hour ratios (which favors local service), but passenger miles per employee hour is usually correlated with capacity mile ratios. Note that, as in the passengers per capacity hour and passenger miles per capacity hour correlations, passengers per employee hour and passenger miles per employee hour are not correlated with each other. This phenomenon appears to be due to the range of the absolute data used to construct the ratios and its impact on the various ratios.

In general, then, the original intents of NYSDOT to (a) select measures that were relatively if not entirely independent of one another, (b) select measures that were not surrogates for conditions over which the operator has little or no control, and (c) pair measures to minimize or eliminate intuitive or known differences related to service type, all appear to have been adequately addressed by the 15 measures.

Analysis of Performance Measures by Service Type

The aggregation of mode and service types to develop multimodal performance measures and set levels of attainment for New York State systems also raises the issue of comparability of performance levels across various service types. Figures 1-3 indicate graphically, for each performance measure, the mean level of each service type (fixed-route local, commuter, intercity, and demand responsive), the overall mean level (for all service types combined), and the acceptable and desirable levels of attainment as determined by NYSDOT. The shaded portion of each graph depicts one standard deviation from the overall mean to give an indication of the dispersion of values for each measure.

In nearly all of the cases, the average level of attainment of each service type on each measure is within one standard deviation of the overall mean. Only demand-responsive services appear to deviate significantly from the overall mean, and then only on 8 of the 15 measures. Similarly, when compared with the established levels of acceptability and desirability, the service types (on the average) indicate general acceptability. The six cases where the service type averages do not meet the accepted levels of attainment (cap hr/emp hr, cap mi/emp hr, cost/cap hr, rev/cost, deficit/pass mi, and pass/emp hr) can be explained by either the significance of a few operators or the anticipated results of a particular service type. Demand-responsive services, for example, do not as a group meet the acceptable level for capacity hours per employee hour. Such a result is not surprising when the vehicle passenger capacities of the demand-responsive services (9-25 passengers) are compared with that of other service types (45-80 passengers). Also, the results of demand-responsive service for several of the performance measures would be adversely affected by the type of area served (generally, population and densities low enough to not support regular fixed-route service) and by the quality of service provided (door to door) for the price paid.

Note that Figures 1-3, as well as rankings of the individual operations for each measure, reveal a great deal of overlap among the performance levels of operators of different service types. These overlaps continue to suggest that aggregation of the service types for evaluation purposes is not unreasonable.

Table 3. Correlation coefficients for performance measures.

Performance Measure (abbreviation)	Cap hr/ emp hr	Cap mi/ emp hr	Veh hr/ veh	Veh mi/ veh	Cost/ cap mi	Cost/ cap hr	Rev/ cost	Rev and local/ pass mi	Pass/ cap hr	Pass mi/cap hr	Pass mi/cap mi	Cost/ pass mi	Deficit/ pass mi	Pass/ emp hr	Pass mi/ emp hr
Cap hr/emp hr	1.00														
Cap mi/emp hr	0.64	1.00													
Veh hr/veh	0.35	-[a]	1.00												
Veh mi/veh	-[a]	0.25	0.55	1.00											
Cost/cap mi	-0.21	-0.42	-[a]	-[a]	1.00										
Cost/cap hr	-0.48	-0.19	-0.20	-[a]	0.66	1.00									
Rev/cost	-[a]	0.20	-[a]	-[a]	-[a]	-[a]	1.00								
Rev and local/ pass mi	-[a]	-0.26	-[a]	-[a]	0.49	0.25	-[a]	1.00							
Pass/cap hr	-[a]	-0.28	-[a]	-0.38	-[a]	-[a]	-[a]	-[a]	1.00						
Pass mi/cap hr	-0.22	0.24	-0.36	-[a]	-[a]	0.44	0.45	-0.28	-[a]	1.00					
Pass mi/cap mi	-[a]	-[a]	-0.20	-[a]	-[a]	0.26	0.45	-0.38	-[a]	0.77	1.00				
Cost/pass mi	-[a]	-0.24	-[a]	-[a]	0.45	-[a]	-0.32	0.90	-[a]	-0.30	-0.41	1.00			
Deficit/pass mi	-[a]	-0.22	-[a]	-[a]	0.41	-[a]	-0.42	0.80	-[a]	-0.24	-0.34	0.96	1.00		
Pass/emp hr	0.64	-[a]	-[a]	-0.30	-[a]	-0.44	-[a]	-[a]	0.63	-[a]	-[a]	-0.21	-0.23	1.00	
Pass mi/emp hr	0.28	0.66	-0.20	-[a]	-[a]	-[a]	0.40	-0.29	-[a]	0.70	0.67	-0.32	-0.27	-[a]	1.00

[a]Not significant.

Analysis of Performance Measures Over Time

Operator performance levels for the second year will provide insight into how well the evaluation measures describe changes in operating performance. It will also give an indication of the overall direction of change of each performance measure and signal the possible need to modify levels of acceptable and desirable attainment or to adjust current policies that may be responsible.

Figure 1. Efficiency measure levels by service type.

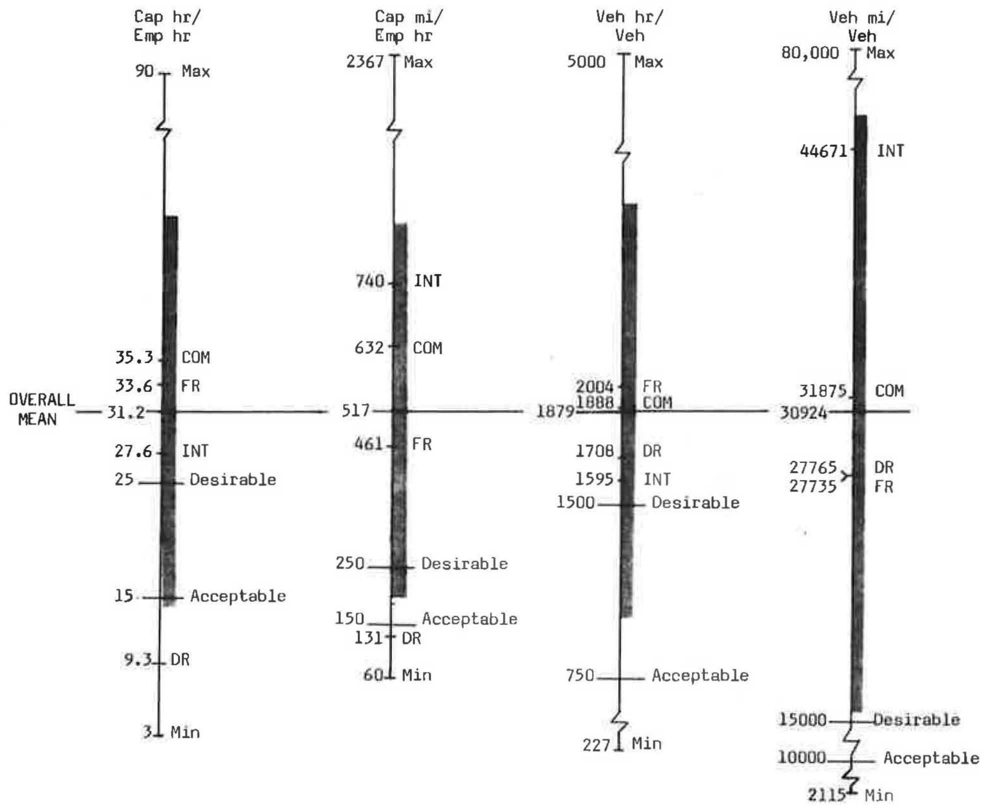


Figure 2. Economy measure levels by service type.

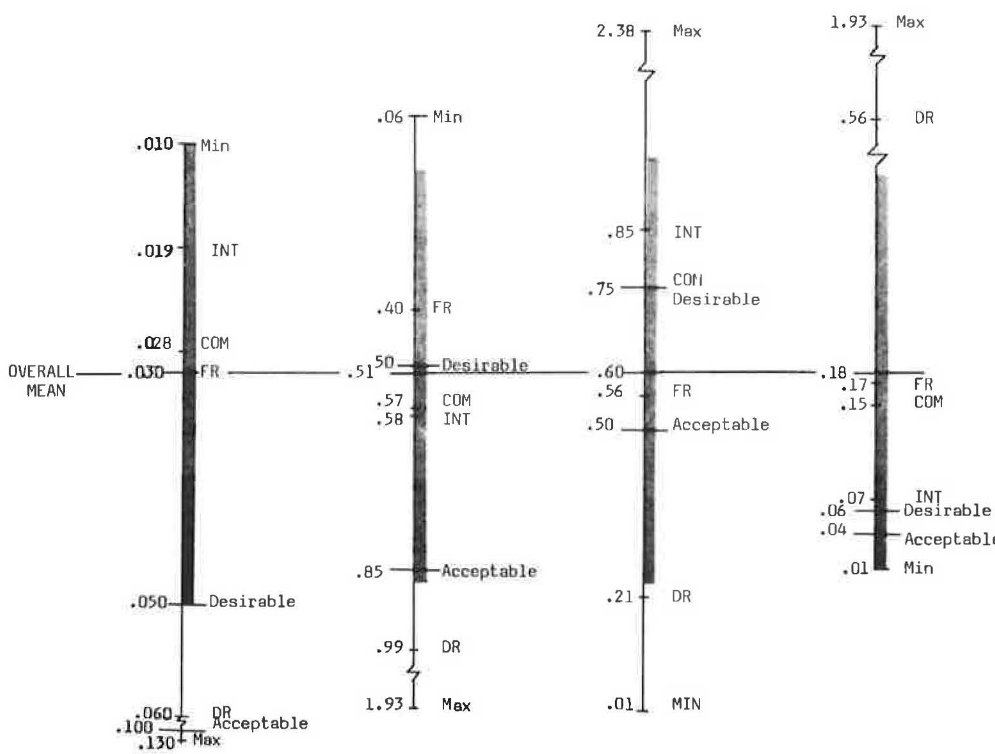
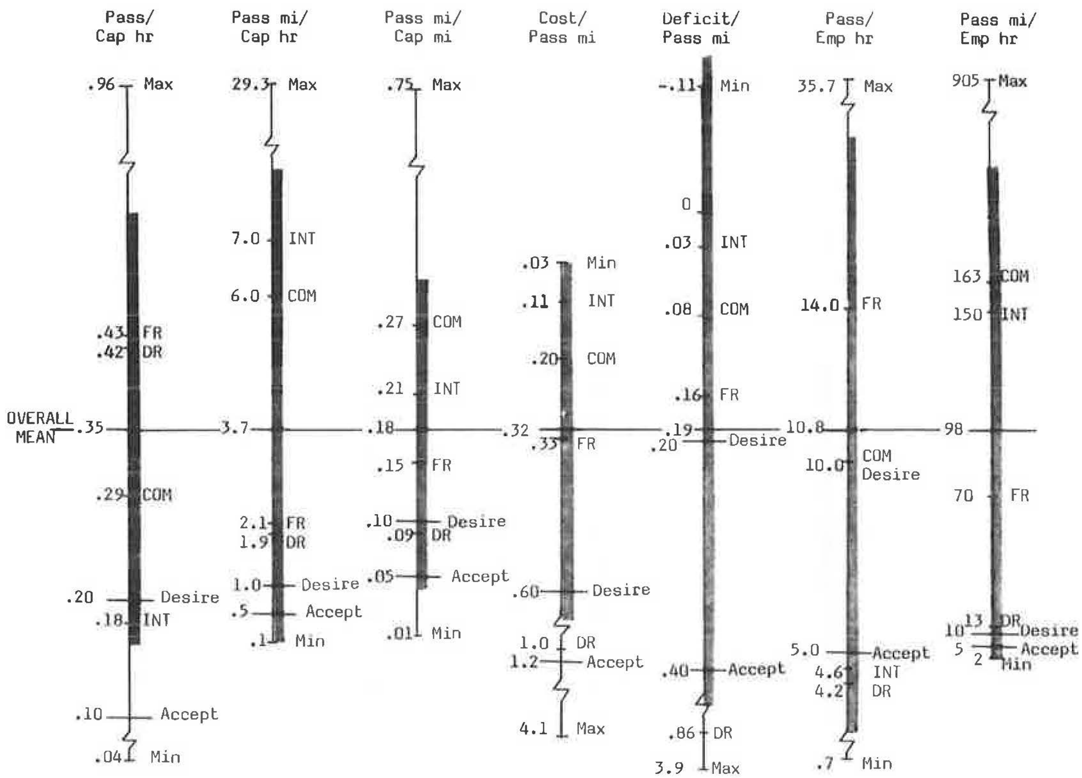


Figure 3. Effectiveness levels by service type.



As a preliminary review of second-year change, four major regional transportation authorities in New York State were analyzed. Changes in performance in the second year are shown in Table 4. The actual levels of each measure are shown in Table 5. Remaining operations will be analyzed as operating data for the second year become available.

The four transit authorities generally improved their performance on 7 of the 15 measures over the previous year's level. On two other measures, cost per capacity mile and cost per capacity hour, the four operators increased in an unfavorable direction. There was no consistent trend, and in some cases considerable variation among operators, on the remaining six measures.

Some comment on the apparent reasons for the results shown in Table 4 is worthwhile. The large increase in capacity hour per employee hour and capacity miles per employee hour for operator D is caused by the decrease in total employee hours over the previous year, since all four operators generally increased vehicle miles and vehicle hours of service. The remaining efficiency measures increased slightly for all operators.

The cost per capacity mile and cost per capacity hour ratios increased because the increase in total operating costs outweighed the capacity mile and hour changes. Changes in revenue to cost ratios varied by operator and can best be explained by the change in the effectiveness measures. All operators increased passengers and passenger miles carried; however, two operators (B and D) had twice the increase of the next operator. This, coupled with the corresponding larger increase in passengers per employee hour and passenger miles per employee hour in these areas, results in an increase (or lower decline) in the operating revenue to cost ratio. Also, the operating cost component has an affect on the revenue to cost ratio. Operator C had a larger

Table 4. Percentage change in performance levels in second year.

Performance Measure (abbreviation)	Operator A[a]	Operator B[b]	Operator C	Operator D[b]	Favorable Direction	Overall Direction for Four Areas
Cap hr/emp hr	-[c]	+3	-3	+17	Increase	Varies
Cap mi/emp hr	-[c]	+8	+2	+12	Increase	Increase
Veh hr/veh	+2	-5	+2	+6	Increase	Varies
Veh mi/veh	+1	-[c]	+7	+2	Increase	Increase
Cost/cap mi	+10	+10	+21	+8	Decrease	Increase
Cost/cap hr	+12	+13	+25	+2	Decrease	Increase
Rev/cost	-2	-4	-12	+7	Increase	Varies
Rev and local/ pass mi	+7	-9	+4	-3	Increase	Varies
Pass/cap hr	+5	+34	+10	+14	Increase	Increase
Pass mi/cap hr	+6	+33	+10	+14	Increase	Increase
Pass mi/cap mi	+6	+27	+5	+19	Increase	Increase
Cost/pass mi	+6	-15	+14	-10	Decrease	Varies
Deficit/pass mi	+9	-13	+27	-15	Decrease	Varies
Pass/emp hr	+6	+38	+7	+34	Increase	Increase
Pass mi/emp hr	+6	+38	+7	+34	Increase	Increase

Notes: Total vehicle miles of service for operator A were 10 335; for operator B, 7395; for operator C, 6381; and for operator D, 4459.
Total passengers carried for operator A were 36 462; for operator B, 20 579; for operator C, 13 901; and for operator D, 13 025.

[a]Operator had fare increase during the operating year.
[b]Operator had fare increase near the end of the operating year.
[c]Change was less than one percent.

increase in operating cost than did the other operators, thus the revenue to cost ratio was adversely impacted. Operator A showed a somewhat lower percentage change in performance measure levels than did the other operators but appears to maintain its revenue to cost ratio due to a fare increase midway through the operating year combined with no loss in ridership. This operator expects to raise its revenue to cost ratio in the third year of the evaluation program. Note that the operator that

Table 5. Comparison of first- and second-year's performance levels.

Performance Measure (abbreviation)	Operator A 1978	Operator A 1979	Operator B 1978	Operator B 1979	Operator C 1978	Operator C 1979	Operator D 1978	Operator D 1979	Acceptable Level	Desirable Level
Cap hr/emp hr	31.67	31.67	36.46	37.57	41.08	39.81	31.45	36.83	15	25
Cap mi/emp hr	349.3	347.4	433.6	470.1	491.5	500.7	376.6	423.3	150	250
Veh hr/veh	1951	1992	2445	2327	2109	2150	2200	2337	750	1500
Veh mi/veh	21 530	21 850	29 091	29 116	25 227	27 037	26 342	26 863	10 000	15 000
Cost/cap mi	0.030	0.033	0.029	0.032	0.024	0.029	0.024	0.026	0.10	0.05
Cost/cap hr	0.327	0.367	0.350	0.397	0.287	0.360	0.290	0.297	0.85	0.50
Rev/cost	0.57	0.56	0.50	0.48	0.51	0.45	0.44	0.47	0.50	0.75
Rev and local/pass mi	0.086	0.092	0.139	0.127	0.094	0.098	0.087	0.084	0.04	0.06
Pass/cap hr	0.425	0.448	0.367	0.490	0.371	0.409	0.377	0.430	0.10	0.20
Pass mi/cap hr	2.123	2.241	1.285	1.716	1.483	1.636	1.584	1.808	0.50	1.00
Pass mi/cap mi	0.192	0.240	0.108	0.137	0.124	0.130	0.132	0.157	0.05	0.10
Cost/pass mi	0.154	0.164	0.272	0.231	0.193	0.220	0.183	0.164	1.20	0.60
Deficit/pass mi	0.066	0.072	0.137	0.119	0.095	0.121	0.102	0.087	0.40	0.20
Pass/emp hr	13.44	14.20	13.38	18.42	15.23	16.28	11.86	15.85	5	10
Pass mi/emp hr	67.20	71.00	46.83	64.48	60.92	65.12	49.82	66.58	5	10

has the best effectiveness measure levels in Table 5 (operator A) has the highest revenue to cost ratio.

This preliminary analysis suggests that the use of performance measures can provide a method for identifying changing conditions (e.g., operator A's fare increase) or impending problem areas (e.g., operator C's unusually large increase in operating costs) that should be addressed. The fact that trends in the magnitude of some of the performance measures can be ascertained even from this small sample also suggests that a routine review of acceptable and desirable levels of attainment is necessary and that, perhaps, a periodic change in those levels may be required. It is at best difficult, if not impossible, to say whether the fact that the state has made the attainment of acceptable performance criteria a condition for the receipt of state operating assistance played, or will play, any role in influencing the performance trends.

CONCLUSION

This research continues to support the multimodal transit performance measures developed in New York State as useful tools in evaluating a transit operator's performance. The 15 performance measures were found not to be highly intercorrelated, which indicates that operator performance on one measure does not significantly influence performance on all measures. As a result, the performance measures do, in fact, measure the aspects of transit performance that they were intended to, without being influenced by other measures. This analysis has also shown that efficiency measures were not highly related to the other performance measures, which indicates that efficient transit operations may not necessarily be the most effective or economical. Component variables used to calculate the ratios were not found to influence operating performance, which indicates that the overall size of an operation does not necessarily influence performance. Apparently, most transit operations are now closely tailored to their operating area conditions to provide an economical, efficient, and effective service that the specific area can support.

Perhaps the most interesting result of this study is the comparability of performance levels of various service types. A number of measures do not differ significantly between service types, which suggests the multimodal, multiservice use of performance evaluations. The multimodal use of these measures will be monitored closely to ensure that no particular service is discriminated against.

A preliminary look at the levels of performance for the second year reveals the direction of change of each measure and suggests that further work in this area is warranted to identify desirable methods to establish appropriate attainment levels for systems as they develop. The analysis has also shown that the evaluation measures may be used as a diagnostic tool to identify possible operator performance problems.

Overall, this paper has extended earlier research by presenting relative magnitudes of the relation between the performance measures and the variables that may affect them.

FUTURE RESEARCH

Many transit professionals agree that measuring and evaluating operating performance is important. A policy statement issued by the American Public Transit Association recommends establishment of performance measures at the local level (12). It has also published a report on current use of performance evaluation among various sizes and types of transit operations (13). Several New York State transit operators are currently studying improved management information systems and the development and implementation of overall system and individual route performance evaluation methods.

Research in the area of transit performance should be intensified with the availability of Section 15 data. The potential increased quality and consistency of this data will aid these efforts. Topics for future research should include the following:

1. Analysis of performance measures over time to monitor change, reasons for change, and to adjust levels of attainment when appropriate;
2. Use of performance measures to identify services that would benefit from more in-depth study;
3. Determination of the transferability of the performance measures developed in New York State to other areas;
4. Analysis of the potential for other groupings of performance measures, such as by trip length, ownership type, or speed; and
5. Development of methods to relate these, or other, performance evaluation measures to local goals, objectives, and operating conditions.

To assist in the operator-evaluation effort, the department is requesting that each major transit system submit a service (evaluation) plan. The initial submission will obtain information on transit system goals and objectives, service coordination, and service problems and needs. These service plans will add to the comprehensiveness of the evaluation program by identifying local factors that were not easily recognizable in the operating data collected and used in the preceding analysis.

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Abridgment

Use of Service Evaluation Plans to Analyze New York State Transit Systems

ROBERT J. ZERRILLO

Recent state legislation mandated that the New York State Department of Transportation develop a transit service evaluation plan reporting requirement to be used along with transit performance measures in the evaluation of the state's major transit systems. This paper describes the development of the service plan submission and summarizes the results of the plan submittals for the first year. The results of the two reporting groups of transit systems (public authorities and county sponsors) are compared on each of four topics (use of goals and objectives, operating performance evaluation, service coordination, and service problems and needs). It is concluded that the service plans provide a basis for relating transit system performance to local service objectives and operating conditions and also for improving the performance monitoring of New York State's major transit systems.

A number of recent studies have advocated the use of transit performance measures to evaluate the efficiency and effectiveness of publicly funded transit service (1,2). Many of these studies as well as the American Public Transit Association (APTA) have recommended that performance evaluations must be made in light of the goals and objectives of the transit system and the local conditions that affect service (3). The New York State Department of Transportation (NYSDOT) began a performance evaluation program in 1979 under a state legislative mandate to certify the performance of transit operators that participate in the state operating assistance program (1). The operating and financial data used to evaluate performance were obtained through annual surveys of transit operators. However, these data alone did not reveal the complete transit operating picture.

In recognition of the need to obtain other nonstatistical information from state-sponsored transit services to supplement the department's existing performance evaluation program and to relate operating performance to local goals, objectives, and special conditions, NYSDOT implemented a service plan reporting requirement for 1980 (4). This paper describes the development of the transit service plan submission for the initial year, presents a comparison of the plans received by the two distinct groups that submitted responses, and recommends ways in which the service plans can be used by NYSDOT and local governments.

BACKGROUND AND DEVELOPMENT OF QUESTIONNAIRE

The 1980-1981 New York State transit operating assistance appropriation legislation requires the department of transportation to certify as to the economy, efficiency, and effectiveness of each major public transportation system (those systems that annually carry more than one million passengers or operate more than one million vehicle miles of service) that receives state operating assistance funds. A major system could be a regional public transportation authority or a county or municipal sponsor of one or more publicly or privately operated transit services. Seventeen of the state's 62 systems qualified as major systems in state FY 1979/80. These 17 systems carried 99 percent of the passengers, operated 98 percent of the vehicle miles, and received about 99 percent of operating funds in the state. These major systems were required to submit a service plan to the department to be used in conjunction with the performance evaluation measures in the certification process.

The objectives of the service plan submission for the first year were to enable the department and the regional authorities or sponsors of transit service to better monitor and evaluate the performance of the state's major systems and to develop an understanding of local or regional transit service objectives, problems, and immediate needs. Many of these same objectives are cited as components of a management performance audit in a recent report by Smerk and others (5).

The service plan requirement for the initial year contained a series of questions to be answered by each major system. The questionnaire distributed to public authorities (who both own and operate the transit service in an urbanized area and receive state operating assistance funds directly) differed slightly from that sent to county sponsors whose transit service is provided through contract with one or more private (or occasionally public) carriers and who act as a conduit for state assistance to these operators. Both questionnaires covered the following general topics:

1. Transit service objectives--What are the local objectives for providing transit service? and To what extent are local objectives achieved?
2. Transit system and route performance evaluation--Is system and route evaluation done? What measures are used? and How often is it performed?
3. Transit service coordination--Is there coordination with other local services and with intercity services? and
4. Transit service problems and needs--What are they? and What are short-term service plans?

The resulting information will be used by the department to develop an overview of existing transit services and service objectives in the state, to determine the extent to which service evaluation techniques are established and used, to obtain an overview of current coordination of transit services, and to determine transit problems, needs, and short-term plans for service improvement.

DESCRIPTION OF MAJOR SYSTEMS

There are five regional (multicounty) transportation authorities in New York State that serve the largest urban areas--New York City, Buffalo, Rochester, Albany (capital district), and Syracuse. All operate local bus services and several also operate their region's rapid rail, commuter rail, airport, and port facilities. These authorities receive federal and state operating and capital assistance directly and also receive local subsidies from counties within their jurisdiction.

The department of transportation is involved in transit planning in these areas through a number of mechanisms, including the following:

1. Metropolitan planning organization activities such as planning work programs and development of transportation improvement programs;
2. State operating and capital assistance program administration, evaluation, and development of assistance recommendations to the state legislature; and
3. Federal operating and capital grant review and approval.

A sixth transit authority in the Utica urban area is considered a regional authority for this analysis because its organization and relationship with NYSDOT more closely resemble that of a regional transportation authority than of a county sponsor.

Transit service in nonauthority areas of New York State is provided through local service contracts with public or private transit operators. These operators are eligible to receive state operating assistance if sponsored by a county or municipality in which service is provided (6). Only that portion of transit service provided within the sponsoring county or municipality is eligible for state assistance, and the local government is required to match a portion of state funds. The nature of this relationship resulted in the development of a slightly different set of questions for the county sponsors because they are not directly responsible for transit operation in their area in the same sense as is a regional transportation authority. The questions probed the extent to which the counties are in control, or aware, of various aspects of the transit services provided in their county and receiving state (and local) funds through county sponsorship. All but one of the counties that qualified as a major system is in the metropolitan New York City area; that county is Broome, which sponsors the Binghamton area transit operator.

County-sponsored transit services are basically of two types. Two counties, Nassau and Broome, actually own the large portion of the transit operations in the county (essentially one local, fixed-route service), and the remaining counties contract with a number of private operators for transit services. The services provided include local, fixed-route, commuter, intercity, and demand-responsive services.

COMPARISON OF AUTHORITY AND COUNTY SPONSOR SERVICE PLANS

The service plan submissions for the first year provide considerable insight into several aspects of each authority's and county's transit operation, such as use of performance evaluation techniques and service coordination. The results obtained from the questionnaires reveal a number of interesting differences between public authorities and county sponsors of transit service. The following sections briefly summarize the authority and county responses to each group of questions. Note that only 16 of the 17 major systems are compared because the combined service plan for the Metropolitan Transit Authority (MTA) (New York City metropolitan area) covered commuter rail and subway-bus service rather than treating each service individually.

Goals and Objectives

Both the public authorities and county sponsors have similar goals and objectives for providing transit service. The level of detail of the service objectives developed differs between the two groups and also among operators in each group. Responses to the questionnaire are as follows:

Question	Regional Transportation Authorities (N = 6) Yes	No	County Sponsors (N = 10) Yes	No
Has service objectives	5	1	10	
Satisfied with achievement	4	2	5	1

The response of county sponsors to the question about the existence of service objectives illustrates that service objectives often appear in service contracts with private operators. Note that four county sponsors did not answer whether they were satisfied with achievements. The lack of a response cannot be used to infer any other answer to the question asked.

Counties that have more active county transportation departments or recent county transportation plans have more refined and explicitly stated transit service goals and objectives that are similar to those of most authorities. The results in the table above show that both groups reported general satisfaction with the achievement of objectives to date. Those that were not satisfied stated the cause and potential solution of why achievement was unsatisfactory.

System and Route Performance Evaluation

Questions on transit performance evaluation were of particular interest because of recent NYSDOT work in this area. This is one area of considerable difference between authority and county responses, as is evident from Table 1. Whereas most authorities and counties evaluate their entire system performance, fewer counties did route evaluation or used performance measures (indicators).

Most regional authorities monitor system performance at least annually. The monitoring consists of collection and analysis of both overall operating and financial statistics and efficiency and effectiveness measures. Performance evaluation seemed a particularly relevant topic; all authorities studied either local transit service standards or data-collection improvements. One authority is currently developing route performance evaluation techniques and is planning on developing computer programs for use in monitoring performance.

Most counties do not currently have performance evaluation programs as sophisticated as those of most authorities. The extent of performance evaluation also differs greatly among counties. Those that own their transit services, such as the municipal systems in Broome and Nassau Counties, do system performance and route performance evaluation periodically. The counties that sponsor private operators do some data collection for system or route evaluation for occasional county transit plans or to comply with data-reporting requirements of NYSDOT or Section 15 of the Urban Mass Transportation Act of 1964, as amended. Westchester County, which has extensive private operator service and an active county transportation department, collects monthly route data from sponsored operators to thoroughly monitor system and route performance. Many counties were generally unaware of the extent to which each sponsored operator evaluates its own system or routes other than evaluations to comply with state or federal regulations. The extent of individual operator performance evaluation will be explored further in next year's annual operator data-collection effort.

Service Coordination

Since the public authorities provide the vast majority of transit service in their respective areas, coordination or duplication with other local services is not a particular problem, as can be seen in Table 2. Five of the six authorities report that most local services in their area are fairly well coordinated. One notable exception to this is the MTA's bus and subway systems, whose services parallel one another in many areas. Although both the bus and subway routes serve identical areas in some instances, their operations appear to serve different travel markets. Subway riders usually are longer-distance travelers; bus riders characteristically make more and shorter trips. In essence, then, the bus and subway systems are providing different services to the public and do not, therefore, overlap as greatly as they first appear to.

Most counties that sponsor a number of private transit operators, or one large public operator, do not encounter service duplication or overlap difficulties. However, some of the service schedules are not coordinated between sponsored operators. Ser-

Table 1. Comparison of performance evaluation questions for regional transportation authority versus county-sponsored service plans.

Question	Regional Transportation Authority Evaluations (N = 6) Detailed	Moderate	Little	County Sponsors Evaluations (N = 10) Detailed	Moderate	Little
Is system performance evaluated?	4	1	1	5	1	4
Is route performance evaluated?	3		3[a]	3	2	5
Are performance indicators used?	4		2[a]	2	4	4

[a]One operator is currently developing an extensive management information system and route monitoring program.

Table 2. Comparison of service coordination questions for regional transportation authority versus county-sponsored service plans.

Question	Regional Transportation Authority Service Coordination (N = 6) Most Are	Few Are	Did Not Address	County Sponsors Service Coordination (N = 10) Most Are	Few Are	Did Not Address
Are services coordinated with other local services?	5	1		7	3	
Are services coordinated with elderly and handicapped services, not including social-service agencies?	2	4		1	3	6[a]
Are services coordinated with intercity services?	3	1	2[a]	3	4	3[a]

[a]Did not address this question when responding to questionnaire. This cannot be used to infer any other answer to the question asked.

vice coordination in these counties has come about through past private operator arrangements and county involvement through subsidization.

Both the counties and the authorities report varying success in coordinating specialized transit services in their area or in coordinating these services with the regular fixed-route service. The two groups of systems appear to have reasonable success in coordinating local transit service with intercity and commuter transportation services. Services between counties are generally well coordinated because many of the same intercity operators provide these services in each county. Most authorities and counties attempt to coordinate their services with other modes (intercity rail and air service) where these other modes exist and where transit service to these terminals is not adequately supplied by private operators.

Service Problems and Needs

Answers to questions asked concerning service problems and needs also differ between regional authorities and county sponsors. As is shown in the table below, most authorities and counties agree that equipment age and replacement are problems as is the lack of funds and equipment for additional or new services.

Major Service Problems and Needs	Cited by Regional Transporation Authorities (N = 6)	Cited by County Sponsors (N = 10)
Dedicated funding source	4	0
Equipment replacement	5	5
Trained staff	4	2
Peak overcrowding	3	2
New or additional service	4	6

Nearly every service plan cites the need for overall increases in the levels of federal, state, and local assistance to keep pace with rapidly rising costs. However, only the authority group consistently called for the development of a permanent, predictable, and increasing source of transit funding; often the authorities listed this as the single most important need. Finding and keeping trained staff and relieving peak-period overcrowding were also important needs cited by authorities but rarely mentioned by county sponsors.

CONCLUSIONS AND RECOMMENDATIONS

The service plan submissions for the first year, though they differ greatly in the level of detail, have provided NYSDOT with considerable information on the major systems that provide transit service in the state. The plans reveal the different role public authorities and county sponsors play in providing transit service and the different level of detail used in monitoring the performance of that service. The responses provide a basis on which to begin to relate transit system performance to local service objectives and operating conditions. These local factors are not discernible in routine operating and financial data collection.

The results of these first plans reveal that there appears to be adequate planning of major transit services. Performance evaluation is done reasonably by most systems, though most counties do not currently have evaluation programs as sophisticated as those of the public authorities. Service coordination was one area that was found lacking in both groups. The authorities and counties differed most in the detail of performance evaluation and in service problems and needs.

Through the service plans, the extent of transit performance evaluation and service coordination was determined and specific area shortcomings were recognized. Localities (sponsors) deficient in evaluating their transit systems' performance will be encouraged (and assisted when necessary) to improve performance monitoring techniques. Experiences of one transit system that may benefit other similar systems will be studied and brought to the attention of other local transit agencies. By improving local performance evaluation efforts, potential service problems can be identified more quickly and corrective or preventative action taken. We hope that these efforts will improve the quality of local transit service and ensure the greatest possible transit service payoff per subsidy dollar.

The service plans will be modified in future years to better meet NYSDOT needs for collecting transit system information and to improve the current performance evaluation program.

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Management of Public Transportation Systems in the 1980s: The Emergence of Paraprivate Transportation

RAY A. MUNDY

Management of public transportation systems in the 1980s will be a major challenge for urban areas. Their operating scenarios, financial support, and general feasibility will be severely tested. The present heavy subsidy of transit is not expected to continue. Just as much of the U.S. industry has had to specialize its product offerings in a competitive market place, so will transit systems. This will mean the expansion of paratransit activities and the inclusion of paraprivate transportation options. This paper attempts to assist public transportation officials in thinking through their innovative alternatives and provide the rationale for the alternatives they adopt. How these newer, specialized forms of public transportation alternatives are integrated into existing traditional transit operations will be the major managerial and official focus for much of this decade. Those areas that are successful in broadening their concept of public transportation to include these innovations will breathe new life and vitality into their local transportation systems. Those who do not will continue to teeter from one financial crisis to another. Clearly, public transportation officials at all levels need to ask themselves, "What are we trying to do?", and restructure to accomplish these goals. We can no longer continue to use nineteenth-century work rules and early twentieth-century technology as we stumble toward the twenty-first century.

Public transportation systems underwent numerous changes in their ownership, financial support, and level of expectation during the 1970s. The majority of private urban transit systems was purchased with public money. Most are now heavily subsidized from public operating funds, and they are expected to be all things to all people. Public announcements are periodically made on how public transit can solve the energy crisis, reduce pollution, or improve urban mobility. Unfortunately, although the 1970s brought an influx of public funds to the transit industry, its competitive position to the private automobile has remained constant. Just as the 1950s and 1960s were the facilities-building era of the highway systems, the 1970s were the facilities-building years of publicly owned transit systems. The management of these combined facilities will be the major transportation challenge that faces officials in the 1980s. Thus, the purpose of this paper is (a) to develop the status quo of these combined facilities, (b) to demonstrate the need for a change in direction, and (c) to prescribe a management strategy for public transportation programs in the 1980s.

TRANSIT--THE PRESENT CASE

Although budgets for public transit greatly increased yearly in the 1970s, the expansion of local support taxes appears to have reached an end. Between 1969 and 1979, public transit deficits rose from a few thousand dollars to more than $3 billion (1). These deficits were financed through local tax levies and general funds. However, transit costs are increasing at an annual rate of two to three times that of local municipal budgets (1). The industrialized cities of the Northeast, which have eroding tax bases, appear to be hardest hit. The recessionary squeeze will restrict the total supply of transit services for the 1980s. Even through the expansive years of the 1970s, however, the actual supply of transit services (i.e., vehicle miles operated) remained relatively constant (1). With the slackening of local financial support, transit management will find it necessary to review service offerings for possible elimination.

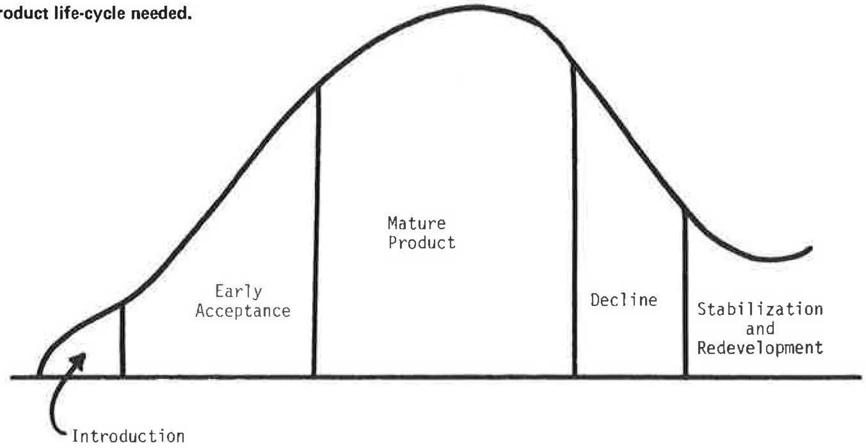
Some of this activity may prove healthy to the industry. Ironically, during the 1970s, although new vehicles and facilities were purchased with public money, minimal operational improvements were made by traditional transit systems. For nearly a century, transit management had geared its operations to serve the peak commuter markets. The major emphasis in route development, equipment design and use, and labor work rules was on efficient service for the peak commuter demand. With the advent of massive public support, a new mission and market were added to public transportation--the transportation disadvantaged. The transportation disadvantaged include not only the economically disadvantaged but also the physically disadvantaged. Unfortunately, the management of many public transit systems, burdened by the day-to-day operational problems of managing peak transit demand, underestimated this new responsibility and its implications. Their major efforts were consumed with the enormous task of gearing up for the peak-time commuter market with new vehicles, new garage facilities, and new rail systems.

Sadly, this continued preoccupation with ridership numbers was doomed for reasons beyond the control of mass transit management. The flight of people and jobs from the urban core and dense corridors to suburban industrial parks and residential areas continued and increased during the 1970s. Instead of work trips to a city center or a few major industrial sites, trips from lower-density dwelling units to other low-density areas were the norm. During the 1970s, suburb-to-suburb trips became the majority of all work trips and represented two-thirds of all work trips in urban areas (2). Due to the many origins and destinations created by such trip patterns, the attracting of this ridership to traditional mass transit became impossible, extraordinarily expensive, or both. Thus, although public treasuries pumped billions of dollars into local public transit systems (which by management decision were used to support the peak-time commuter trip), transit lost 40 percent or more of its market share. During the 1970s, transit's mode split of the peak-time commuter market decreased nationwide from 10 percent to 6 percent (2).

In marketing terms, the transit industry in the United States had been in a state of mature product decline (see Figure 1). Without massive federal, state, and local assistance, the transit industry would have gone out of business. However, fresh capital and operating funds gave transit a chance for stabilization and redevelopment of new product and service offerings that would appeal to the public in the remaining decades of the century. Unfortunately, this redevelopment has not taken place. Public support for transit may have sealed its fate and that of transit management by insisting on the public utility concept of viewing public transit as solely fixed-route, fixed-schedule services that blanket an urban area in either a grid or spoke-wheel network.

The concept of paratransit was begrudgingly introduced into transit, but this was only because traditional transit feared the loss of governmental support if it did not provide more specialized ser-

Figure 1. Product life-cycle needed.



vices in the form of demand-responsive scheduling and smaller vehicles for certain transportation-disadvantaged markets. Today such expenditures account for a relatively small amount of total transit expenditures. Thus, traditional services were mandated to be modified to make them accessible to some physically handicapped individuals--primarily individuals in wheelchairs. Now the same level of services that lost market share in the 1970s will be made available to the physically disadvantaged in the 1980s.

Ironically, traditional transit has been marketed during the 1970s to the tax-paying public as highly energy efficient. One constantly hears that a mass transit bus can remove 40 automobiles from the highway or that the train is energy efficient. Unfortunately, such claims are often exaggerated. It is true that transit theoretically can be highly energy efficient when traveling at capacity. However, due to deadheading, low density, and lightly used off-peak services, the average occupancy of a public bus per vehicle mile in the United States is only three persons, and the average occupancy per train mile is six. In reality, it is not what transit can do, but what it actually does, that determines the fuel efficiency of the mode.

A more formal work on the fuel and cost efficiencies of transit has been carried out by an Urban Mass Transportation Administration supported study conducted by System Design Concepts, Inc. (3). The report analyzes the specific energy used in three representative high-density corridors that serve Cincinnati, Ohio; Washington, D.C.; and Philadelphia, Pennsylvania. The results are shown in Table 1 (3). As shown, traditional transit, even in these dense corridors, conserved appreciably less fuel than did carpools and vanpools. Similar results were generalized for the nation as a whole in a recent Congressional Budget Office report (4). If one reviews the program cost savings estimated for travelers in these three corridors (see Table 1), the implications are obvious. The total travel savings are slight for conventional bus and even negative for rail service. As one does similar studies on lower-density corridors, the energy and cost savings will decrease substantially. Also, as the report states, the future will get even worse (3).

> Moreover, the energy benefits offered by many modes are derived from the difference between their consumption rates and those of automobiles. As automobile efficiency improves, there is a decrease in the energy savings potential of other modes. For example, if automobiles average 26.5 miles/gal (which is expected to be reached in 10 years), the average potential energy savings offered by conventional bus service is only about one-third as large as at present, if other factors remain constant.

Table 1. Energy and cost-effectiveness of urban transportation modes.

Mode	Program Energy[a] (BTUs/passenger-mile)	Program Cost Savings[b] ($/passenger-mile)
Carpool	4700	+0.15
Vanpool	7970	+0.23
Conventional bus	2890	+0.02
Express bus	2000	+0.04
Heavy rail, old	NA	NA
Heavy rail, new	730	-0.30
Light rail	890	-0.37

[a] Program energy represents the approximate average expected energy savings attributable to a mode in travel markets for which that mode is likely to be a serious candidate for implementation. Each mode's energy consumption in a market is compared with alternative modes that would otherwise be used in that market in order to obtain the estimated energy savings. Comparative judgments as to the energy savings of two or more travel modes in a particular travel corridor cannot be made with these numbers because they were computed with data from different travel markets.
[b] Program savings represent the approximate average expected cost savings attributable to a mode in travel markets for which that mode is likely to be a serious candidate for implementation. Each mode's costs in a market are compared with the costs of alternative modes that would otherwise be used in that market in order to obtain the estimated cost savings. Costs are given in 1977 dollars. Comparative judgments as to the cost savings of two or more travel modes in a particular travel corridor cannot be made with these numbers because they were computed with data from different travel markets.

Ironically, massive public assistance may have stimulated some of these inefficiencies. By providing public funds, many transit systems were compelled to provide some services to all of the political jurisdictions irrespective of density or demand for services. The rationale was that tax-paying subdivisions needed transit services the same as they needed police and fire protection. Indeed, many transit systems of the 1970s passed bond and taxing levies to expand their local systems into regional authorities. When one considers that the supply of transit (i.e., bus miles) has remained constant throughout the decade, the only conclusion is that the same supply is being spread over a larger geographical area and that service to the high-density corridors previously served has been decreased.

Clearly, there is a felt need for a change in direction. Continuance of the same managerial actions will mean that transit will lose the opportunity presented by its public infusion of funds in the 1970s. Public transit must position itself on a solid base for future rebuilding. Unfortunately, the demand for fuel-efficient, high-occupancy vehicles will accelerate in the 1980s. It is imperative that appropriate legislative frameworks, management strategies, and the political sense to realize them be developed.

TRANSPORTATION DEMAND IN THE 1980s

The demand for transportation, in general, and commuter transportation, specifically, will increase greatly in the 1980s. The table below shows projections for automobile use in the future. Note that the term automobile excludes vans, light trucks, and campers.

Item	1975	1985	2000
Automobiles (000 000s)	95	118	148
Licensed drivers (000 000s)	120	151	177
Automobiles per licensed driver	0.73	0.78	0.84
Vehicle miles of travel (000 000 000 000s)	1.03	1.43	1.80
Vehicle miles of travel per licensed driver (000s)	7.9	9.5	10.2
Urban driving under congested conditions (%)	10	14	24
Transit ridership (000 000 000s)	5.6	6.5	6.5

According to a study prepared by the Office of Technology Assessment (5) concerning the future use of the automobile, the number of licensed drivers will increase from 120 million to 151 million by 1985 (see the table above). The number of automobiles will increase by 20 percent in the 10-year period from 1975 to 1985 (5). Many of these new licensees and automobiles will be driven by new female drivers as the proportion of women in the working commuter market increases. Given this increased demand and the limited ability to supply additional roadway and traditional mass transit options, it is little wonder that the report projects that 24 percent of all the urban miles driven by the year 2000 will be driven under highly congested conditions. Mass transit ridership is expected to increase by only 20 percent through 1985 and then not to increase at all between 1985 and 2000. Because of declining local funds and increasing transportation demand, public transportation officials face a critical dilemma of how to accommodate increases in demand with declining real dollars. Fortunately, there are ways to do this if one broadens the concept of public transportation to include the active management of all public transportation facilities and the vehicles that use them.

Broadening the Public Transportation Concept

For nearly a decade, the public utility approach to public mass transportation has tended to divide all transportation offerings into two groupings--private transportation and for-hire or regulated carriers. Regulated carriers were further defined as common, contract, and, in some cases (such as vehicles used for religious purposes), exempt carriage. Similar to other transport modes that have been heavily regulated as to entry, exit, fares, and service offering, mass transit initially flourished. But within the past three decades, mass transit has crumbled into financial ruin in the face of unregulated private competition in the form of private automobiles. Little could be done by the regulators to protect the mass transit markets so long as the private automobiles did not hold themselves out to carry others for a fare. Such jitney operations were banned in all but a few areas in the 1920s and 1930s. The effect of such ordinances is that even today it is illegal for one to receive compensation above a reasonable amount for shared expenses for the trip. In essence, a commuter can accept a fare for driving only if the total amount received does not exceed the cost of the trip (i.e., variable cost of gasoline, depreciation on the vehicle, and other related fixed costs).

Through stated public policy, a common-carrier public-utility concept of mass transit that makes it illegal for commuters to charge more than the proportional cost of the trip is being used. Thus, incentives for private transportation are held to a minimum. It is known that additional peak-time transit service is proportionally more expensive, in terms of public subsidy, to provide. But regulators insist on protecting this market from other sources that would need no subsidy.

In retrospect, the public policy of exercising no regulatory authority over the use of the private automobile may not be a prudent strategy. The cost of owning and operating several automobiles has become increasingly expensive to struggling families that are hard pressed by inflation and slow economic growth. The cost of foreign oil to fuel primarily automobiles now exceeds $80 billion/year. The annual carnage on the highways averages 50 000 fatalities/year to say nothing of injuries, hospital bills, human pain, and suffering. Through regulation, a gray area or subeconomy to public mass transportation has been created. For lack of a better name, this category could be referred to as paraprivate transportation.

Paraprivate Transportation

As shown in the table below, regulators have attempted to deal with transportation suppliers as either common or contract carriage or exempt private carriage.

Mode	Regulatory Classification
Traditional transit	Common carrier
Paratransit	
Dial-a-ride	Common carrier
Taxi	Common carrier
Limousine	Common carrier
Subscription bus	Contract carrier
Subscription van, for hire	Contract carrier
Paraprivate	
Carpool	Private, exempt
Vanpool	Private, exempt
Buspool	Private, contract carrier
Automobile	Private, nonregulated

The middle ground, that of private individuals who supply transportation services on a quasi-business basis (the paraprivate sector), has really had no convenient regulatory classification and thus, by definition, could not and should not exist, primarily because it blurs the distinction between nonregulated and regulated carriage. Only in the latter part of the 1970s did most states deregulate privately operated vanpools from their previous position as common carriers, and then only under the condition that they operate at no more than a break-even or share-the-cost basis. Mass transit management has naturally feared carpools and especially vanpools as threatening to remove riders from mass transit systems. Only recently have these highly fuel-efficient modes been given limited emphasis by public transportation officials. Clearly, the successful mass transportation strategy would be to use these newly developed paraprivate modes to assist in accomplishing the mass transportation objectives of reduced energy consumption and congestion as well as cheaper, more-effective means of commuter transportation. For profit, exempt carpools, vanpools, and buspools could add enormous peak-time mass transportation capacity at little or no additional cost to the public.

PRESCRIPTION FOR IMPROVEMENT

If these paraprivate modes can be used to serve the growing peak demand and even some of the existing demand, transit management could then turn its efforts toward building a better off-peak base for transit development. Better services for nonwork trips such as medical, recreational, and social-service trips could be developed. Greater attention could be given to transit amenities such as benches, shelters, integration with community activities, and street signing systems that inform patrons how to use the system. Finally, with pressure relieved from having to expand the peak-time system, appropriate marketing of the systems could be undertaken. In many cities the local public transportation system is still a mystery to many.

Development of paraprivate transportation modes would bring about other major long-term benefits to transit. Initially it spreads the responsibility and cost of providing peak-time transportation to employment centers that, by their operational nature, cause the peak-time problem. In essence, the approach says, "You helped create the problem, now let's work together to solve it."

As government and private employers become actively involved in encouraging, administering, and assisting paraprivate modes such as carpooling, vanpooling, and even buspooling, major pressures for highway expansion can be relieved. Moreover, as more people share driving or riding in a vanpool or buspool, corridors of high-occupancy-vehicle use can and will develop. Research on these modes has shown that individuals who would not trade their singly driven automobile for transit might initially try carpooling. Over a period of time, some of these carpools will evolve into vanpools and later buspools. Such a phenomenon is labeled the "step-function approach to mass transportation" (see Figure 2). Such an approach recognizes that the personal private automobile is the preferred mode; but through conditioning of the marketplace over a period of time, some individuals can be coaxed away from this preferred mode. In essence, paraprivate modes can be used effectively over time to prepare a corridor or area for mass transit once sufficient volume is reached. Such a strategy used to its fullest could be used to develop future light rail corridors.

Highway and transportation officials can take actions to encourage paraprivate modes. High-occupancy-vehicle lanes can be the focus of new construction or use of present roadway capacity where more than two lanes per direction exist. The emphasis should be on occupied seat miles per gallon. This would give the same preference to a four-person, subcompact automobile carpool as it would to a full transit bus. Both would achieve 160 occupied seat-miles/gal of fuel. The bus, which averages 4 miles/gal, would carry 40 individuals, and the automobile, capable of achieving 40 miles/gal, would carry four passengers. Obviously, it is how the vehicle is used, not the vehicle itself, that is important.

Targeting efforts to the long-distance commuter should also be a major emphasis of the paraprivate approach for the 1980s. As shown in the table below (6), 27 percent of the workers who travel 11 miles or more are responsible for nearly 70 percent of the vehicle miles traveled.

One-Way Trip Length (miles)	Workers (%)	Home to Work Vehicles Miles of Travel (%)	Projected Travel Time (min)
≤5	52.1	13.9	≤15
6-10	20.9	17.8	16.25
≥11	27	68.3	≥16

Such targeting need not be difficult. These are real monetary benefits for the individual. As shown in Table 2, an individual can save as much as $246/month by carpooling and $266/month by vanpooling. Few government programs are able to demonstrate such returns on public dollar investment.

Figure 2. Public transportation step function.

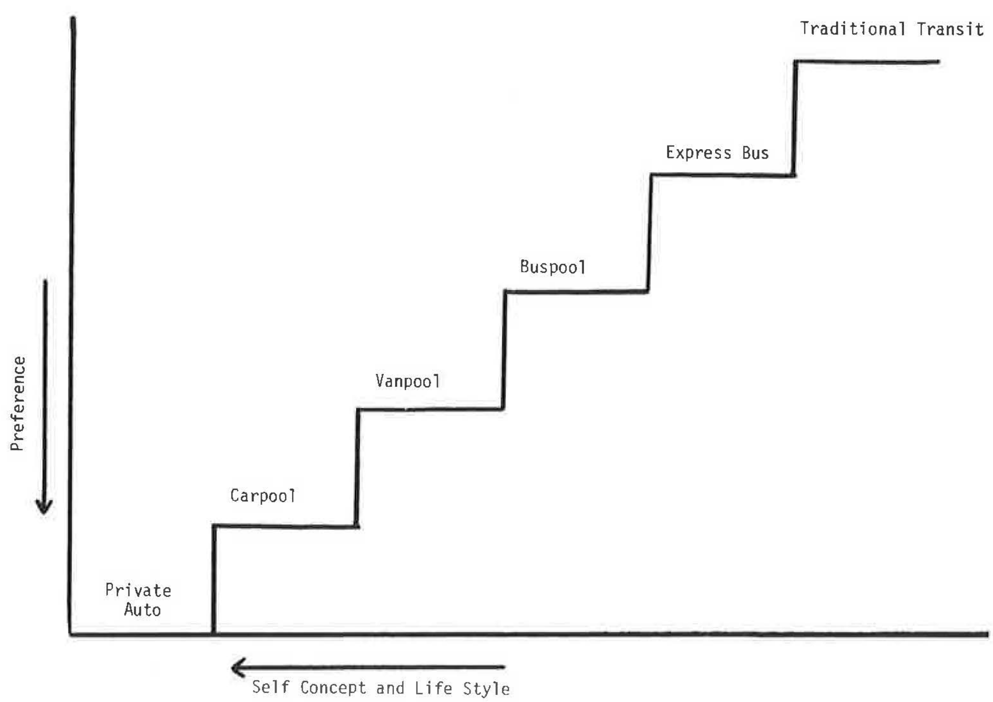


Table 2. Estimated monthly cost for daily round trips.

	Cost per Month ($)						
Choice of Travel	10 Miles	20 Miles	30 Miles	40 Miles	50 Miles	60 Miles	70 Miles
Drive alone	45	90	135	180	225	270	315
Carpool of two persons	23	45	68	90	113	135	158
Carpool of four persons	11	23	34	45	56	68	79
Vanpool	37	41	44	48	52	55	59

Note: Table adapted from Federal Highway Administration statistics.

Even greater economies can be achieved if administration and financial support for these paraprivate options can be shifted in part (or in the case of large employers, totally) to the employment centers themselves. The nation's largest employer, the federal government, has already moved in this direction through Executive Order, Circular No. A118, which deals with federal employee parking facilities. In addition to mandating the collection of appropriate charges for federal employee parking, it also mandates the establishment of an employee transportation coordinator at every federal facility that employs more than 100 persons. In accordance with President Carter's memorandum of February 1, 1980, these employee transportation coordinators are to give priority parking to carpools and vanpools, to establish favorable van financing terms, to facilitate ridesharing matches, and to disseminate mass transit information. Many private firms have developed such programs as employee fringe benefits. Much more, however, is still needed. Nearly 65 percent of all workers drive alone to work. Many more could share the ride or become a member of a paraprivate transportation mode. Ironically, there would be an abundance of passenger seats, parking spaces, and roadway capacity if all vehicles, space, and highway networks were used efficiently. It is time to manage facilities far more productively than previously has been expected. Instead of planning and building for vehicles per hour per lane, concentration should be on persons per vehicle per hour per lane.

SUMMARY

The management of public transportation systems in the 1980s will be a challenge for transit and transportation officials. The concept of public transportation will expand to include paraprivate modes, just as it expanded to include paratransit modes in the 1970s. The broadening to include paraprivate modes, however, will bring a more fundamental change in the management strategy. Management will be forced to abandon the concept that only publicly owned and operated services comprise the public transportation system. In fact, management will be encouraged to do so by governmental authorities that are burdened by local tax pressures. Unlike traditional transit costs, costs of paraprivate options will be shared with employers as they are encouraged to set up and administer their own employee transportation programs. Such a change presents interesting challenges to state and local regulatory bodies. Resistance to these changes is natural; but in the end the rationale of these modes and their preference will prevail.

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Coordinating Transportation: The Logistics Solution

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One of the primary problems of the poor, handicapped, and elderly, especially if they live in rural and suburban areas, is transportation. More than 116 federal programs have been developed in an attempt to correct this transportation deficiency. However, due to the large number of programs, there have been charges of duplication of services. This has brought about calls for consolidation, even though consolidation is the least-efficient and least-effective form of coordination. The purpose of this paper is to emphasize that coordination of transportation service is totally different from the coordination of plans to build fixed facilities, organization to coordinate funding from many categorical grant programs, or organization to coordinate a well-defined production activity such as transportation. A second purpose is to emphasize that the large organizations that have been concerned with both the effectiveness of transportation as well as the efficiency of transportation are using the logistics approach to coordination whether they be government (military) or private (business). The third purpose of this paper is to emphasize some of the inherent weaknesses of consolidated transportation programs and to suggest some alternative approaches to coordination.

Transportation increasingly concerns the elderly, handicapped, young, and poor, and both the cost of transportation and the pressure to reduce government expenditures are increasing rapidly. The financial rejuvenation of traditional transit systems has allowed traditional transit systems to do an excellent job of linking the suburbs and the central business district (CBD) (1). Unfortunately, transit seldom serves the non-CBD-oriented trips or trips for individuals who cannot get to bus stops or who need escort service. Many social-service agencies must provide transportation if social-service beneficiaries are to have access to essential social services. Social-service transportation, usually funded by categorical programs, has created a large number of vehicles operated by many different agencies, including schools, senior-citizen nutrition programs, sheltered workshops, public housing agencies, private nonprofit groups, churches, and volunteer groups. The increasing cost of providing this specialized transportation has now brought legislation that mandates the coordination of publicly funded transportation. Those who propose the legislation usually identify the existing programs as fragmented and overlapping and charge that they provide duplicate, and thus costly, service. The intent of this legislation is very simple: Improve the management of the transportation provided so it is less costly and ensure that public funds are not used simply to replace private, nonprofit transportation or the extended helping networks of family, friends, and neighbors.

Unfortunately, it is easier to understand legislative intent than it is to statutorially define an organizational structure to carry it out. Therefore, the legislature generally assigns an organization such as the department of transportation or the department of human services to be responsible for coordinating all government-funded transportation.

Although the need to coordinate is not new, the tendency has been to use traditional coordination procedures without considering whether the techniques apply.

There are many different approaches to coordinate activities, but four categories will effectively illustrate the general range of approaches:

1. The fixed-facility coordination model--Engineers and planners develop detailed plans for building large facilities (e.g., subways, airports, and roads) that affect large groups of people, cross political jurisdictions, and defy dismantling once constructed. The resultant elaborate and continuing planning processes require review and approval of any action from each affected political entity. This model makes a simple bus route change or the location of an Interstate highway equally complicated.
2. The funding coordination model--Human service agencies have typically sought funding from many sources in order to implement a program. (There are more than 116 different federal programs that fund transportation alone.) Frequently, an umbrella agency, eligible for funding from multiple sources, aggregates funds to obtain enough to actually operate a program. This model organizes transportation coordination to obtain funds rather than to improve management.
3. The operations coordination model--This model requires well-defined demand and a single transportation provider. The operations manager can select the ideal vehicle and the ideal facility and select and train drivers to transport the predefined demand. Coordination for constant demand simplifies operations. This model reflects the age-old conflict between the production sector that wants continuous, stable operations and the users who want a variety of products to meet their individual needs.
4. The logistics-coordination model--Large organizations for which transportation is a means, not an end, developed the fourth coordination model. During World War II the military realized that what was important was whether transportation actually accomplished the mission--for example, moving troops to France, fuel to the tanks in North Africa, or the wounded to appropriate medical care--not who provided the transportation.

In the first three models, one centralized organization coordinates the political review process, receives public funds, and provides all services. The emphasis is on the organization that provides the service (the means), rather than on the resource-effective provision of transportation (the results). In the fourth model, business, confronted with the profit squeeze of the early 1960s, used transportation coordination to reduce cost while actually improving the level of service [see, for example, Taff, Heskett and others, Mossman and Morton, and Bowersox and others (2-5)]. The logistics model developed by these groups recognized three important concepts:

1. Transportation users have a wide variety of service needs,
2. The service that is provided must be tailored to meet the user's need if it is to be effective, and
3. The end results required, not the transportation service currently being used, should dictate the type of service.

Unlike transportation operators, who view their role as providing transportation, logistics managers view themselves as giving time and place utility to a person or product. Unless the person (or product) is in the right place at the right time, the logistics manager has not been effective. If the resultant cost is too high, the logistics manager has not been efficient. Business and the military rely on the logistician to accomplish the job, in the most cost-efficient manner, according to the service levels set by the organization. To accomplish the organization's mission, the logistician must select from the common-carrier modes (e.g., motor carrier, rail carrier, water carrier, or air carrier) contract carriers, self-operated private carriers, mail or parcel services and the associated functional areas of warehousing, inventory management, packaging, and information systems to form the combination of alternatives that will yield the optimal mix of service and cost.

METHODS FOR INCREASING TRANSPORTATION EFFICIENCY

There are five management methods for increasing transportation efficiency:

1. Increase vehicle load factors--Fill empty seats on vehicles that are already in operation to increase efficiency. Thus, airlines offer low-cost standby tickets and the Federal Highway Administration promotes commuter ridesharing.
2. Increase time use of transportation resources--The use of existing, underemployed resources is an excellent source of low-cost transportation. Tour buses are excellent providers of commuter service and school bus operators are a potential source of midday, evening, weekend, and summer service.
3. Reduce deadheading--Deadhead (or nonproductive mileage) serves no function other than to stage vehicles. Deadheading characterizes the centralized

transportation provider who stores the vehicle at a centralized facility only to drive empty to the first pickup point and from the last discharge point. When a rural community has to pay empty mileage on an intercity charter bus from its staging area in a large city 100 miles away or a rural human service agency incurs the cost of driving an empty van out to a person's home to bring them back to an agency activity, deadheading is very costly.

4. Realize economies of scale--The concept of economies of scale is well-recognized by government, which has an almost implicit faith that bigger is better. This is the fundamental assumption that translates the legislative mandate to coordinate into the consolidation of all transportation under one provider organization to eliminate duplication. Ironically, numerous studies show that few, if any, economies of scale exist in actual vehicle operation. There are, however, economies in terminal operations, risk-management programs, marketing, dispatching, insurance, and other support services. The existence of line-haul economies of scale is questionable in most modes, including trucking, intercity buses, airlines, and maritime transportation.

5. Increase the ability to respond to changing user needs--Organizations frequently must balance the interests of their clients and the short-run interests of their employees, managers, and suppliers. In businesses, the marketing department usually sets customer service levels. (Marketing realizes that a decline in service levels leads to lost sales.) In the military, the strategic unit determines the service level required of the logistics organization. Unfortunately, specialized transportation has neither the market pressures of private industry nor the well-defined mission of the military to counteract the pressures of the operational interest. The tendency is to protect the organization from user-requested change.

COORDINATION VERSUS CONSOLIDATION

The fixed-facility, funding, and operational models of coordination focus on the organization rather than on management strategies for making transportation more effective and efficient. This facilitates the political review process, melds with the umbrella-agency funding concept, and makes one group responsible for providing all transportation. This preoccupation with defining the organization that should operate special-services transportation distracts attention from the two basic questions:

1. Is the organization providing the service that the social-service agencies and their program beneficiaries actually need? and
2. Is the organization using the resources efficiently?

To differentiate between the consolidated approach to transportation and the logistics approach to coordination, consider how each group addresses the first three principles of transportation management.

The consolidated transportation organization practices selective provision of transportation to contain cost, but the logistic organization practices selective procurement of transportation to control cost. In the first case, the way the service is provided is paramount. In the logistics approach, meeting the needs of the user is paramount. The table below shows how these orientations differ.

Management Objective	Consolidated Provider	Logistics Coordination
Increase load factor	Only accept trips where surplus capacity exists; ignore new service requests until existing vehicles are full	Look for existing providers who are already making the trip but have excess capacity
Increase vehicle use	Aggressively look for trips that can be transported during agency's low-demand period or reduce peak-period demand (peak shaving)	Look for existing or potential providers who have underused capacity when trips need to be supplied
Decrease deadheading	Discourage or eliminate trips that require extensive deadheading	Look for existing or potential providers who have vehicles and drivers already staged near the trip origin

The consolidated provider controls costs by limiting the types of transportation it will provide. It may provide transportation on rigid schedules, to terminals or pickup areas only, or to restricted categorical groups or geographical areas and may exclude escort or support services. The freight industry has used a selective marketing approach that only solicits freight that will improve the directional balance of their freight.

When coordination is interpreted to mean consolidation, it, in effect, gives the designated provider a mandate to operate all transportation regardless of its effectiveness or potential efficiency. If the service is inadequate, the funding agency is expected to increase funding on the assumption that the service is provided efficiently because there is only one provider. If the service is too costly, then the provider must reduce the level of service because alternative methods of obtaining service are outside of the consolidation frame of mind.

However, when transportation coordination focuses on managerial coordination of all available and potential resources by using the logistics approach, as in the military and business, then the emphasis is on the following:

1. Defining the range of services needed by various user groups,
2. Finding (or cultivating) providers of the required service, and
3. Developing a feedback system that measures the effectiveness and efficiency of the service.

Two additional concepts will also become part of the logistics management approach:

1. The systems concept views transportation as simply one component of the total trip, including scheduling of service (information), specialized support, and terminals (waiting areas for passengers). (A consolidated operator of transportation, on the other hand, emphasizes the transportation system independently of the user.)
2. Transportation is integrated into planning the primary product or service at the earliest possible moment. The provision of time and place utility is as important as the design and funding of the

program itself and should be considered as part of the delivery of the service. In the case of special services, the transportation component should be part of the initial legislation, organizational structure, intake process, and budgeting procedure.

The purpose of this paper is to emphasize that the coordination of transportation services differs among organizations in the coordination of planning for fixed facilities, coordination of funds from diverse categorical grant programs, or coordination of a well-defined production activity. A second purpose is to emphasize that the organizations that have been concerned with the effectiveness of transportation, as well as the efficiency of transportation, have adopted the logistics approach, whether they be government (military) or private (business). The third purpose of this paper is to emphasize some of the inherent weaknesses in the consolidation of transportation programs and to suggest some alternative approaches. The remainder of the paper will address the third purpose.

INHERENT WEAKNESS OF CONSOLIDATING TRANSPORTATION OPERATIONS

Some major institutional issues affect consolidated transportation programs.

Operation for Benefit of Employees Rather than for Users

Under the law, there are two basic contractual forms--the buyer-seller contract, in which one party purchases something from another party, and the employer-employee contract. In law, the buyer-seller contract is clearly an arm's length relationship. If a seller does not meet fully all the terms of the contract, the purchaser (especially where the purchaser is a public employee acting on behalf of government) has a strong obligation to take corrective action.

The employer-employee contract, on the other hand, is considered to be a protective relationship. If a manager does not operate a department in a manner that will keep the employees happy, the manager will come under severe criticism. Where there is a single provider and where competition is prohibited, the service will quickly come to be operated primarily for the benefit of the employees rather than for the benefit of the user, unless there is a buyer-seller contract between the provider of the service and the customers who use or pay for the service. Thus, a consolidated transportation service will often adhere to employee preferences and pressures rather than to consumer preferences on hours of operation, amount of passenger assistance provided, and other key service variables.

Lack of Accountability

There are basically two ways to make a monopoly accountable to its constituency--through the establishment of an oversight organization, such as a regulatory body, or through the control of funds. One often-mentioned problem with oversight bodies is that, with time, they tend to identify with the needs of the groups they regulate rather than with the consumers (6). One reliable system for keeping a service accountable to the needs of its customers is to give the customers (or their agents) control of the flow of funds to the provider. Allocation of government funds directly to the provider, rather than to the clients or agencies, eliminates the incentive for the provider to adapt to the evolving needs of the agencies or their clients.

Lack of Incentive to Innovate

A major charge made against monopolies is that they lose the incentive to innovate except in very well-defined areas (7). (Where rate of return is regulated, there may be an incentive to innovate in capital-intensive areas.) For example, not until the U.S. Supreme Court held that the telephone company must allow competitors to connect equipment to the public utility's lines did the customer get plug-in telephones, computerized telephone dialing, and multifunctional telephone sets. The designation of a single provider of transportation service for all government retards the development of innovative solutions.

Potential Conflicts of Interest Within Regional Transit Authorities

Although regional transit authorities (RTAs) can overcome many of the jurisdictional problems that plague transportation, they may create even greater problems. Where RTAs oversee the operation of a specific transportation system but do not have responsibility for raising the money to operate the system, RTA members frequently find themselves in a very difficult position. First, they may not perceive any way to control the cost of operation. Therefore, lobbying city or state legislative bodies for funds becomes the only way RTA members can work personally to improve service to the community. Thus, RTAs become publicly supported lobbying organizations that provide service in limited ways but remain the authorities on public transportation matters. Because other transportation options are illegal, legislatures must continually increase funding or be viewed as insensitive to the needs of the elderly, the handicapped, the poor, or the emotionally disturbed. It becomes pure pressure politics.

Organization of RTAs to be fully self-supporting through fares, RTA-imposed taxes, or some other revenue sources that are subject to continual public review, may build more discipline into the cost of providing service, but monopolistic restrictions on innovation are still very real.

Many RTAs, especially those in small communities, contract with a company to manage the public transportation system. Since there is a strong desire to put all possible funds into the provision of service, the RTA board often requires that the resident manager also be the executive director of the authority. This appointment may be official, as in Chattanooga, Tennessee, or de facto, as in Knoxville, Tennessee. Thus, the contract management firm is forced to be the city's spokesperson on transportation matters. The authority may then expect the resident manager to develop policies for them to approve. This places the contractor in the position of regulating competitors (e.g., taxis, limousines, and social-service providers), recommending budgets, and proposing needed changes in operation, contracts, laws, and ordinances. This is much like having a building contractor speak for the city on all zoning matters and also enforce the building code. This is not a criticism of contract management firms but rather a criticism of RTA boards that do not maintain an arms-length relationship with the contractors and that abdicate their policymaking responsibilities by not having their own policymaking staff to administer the contract (8).

Tendency of Capital Grant and Bond Programs to Build Organizations Rather than to Provide Service

Government bodies tend to be capital oriented. Legislative bodies appropriate funds for highways, hospitals, airports, or schools. Constituents can see the return for their money cast in concrete and steel. However, legislative bodies fund organizations reluctantly because payroll is an increasing annual expense that does not have visibility.

To provide transportation service, the government grants capital for vehicle purchases, but then it must fund an organization to take title to the vehicle, to operate it, and to insure it. Operating costs over the life of the vehicle usually exceed capital costs. Thus, the capital grant creates an organization that must be continued with new operating funding. To maintain flexibility, government should not give capital grants but fund the purchases of transportation as needed.

One RTA sought a capital project to justify a bond issue. This RTA thought that the responsibility for the bond issue would guarantee its continued existence.

Tendency to Fund Agencies Rather than Services

Efforts to establish a single, consolidated transportation service often result in the community funding of an agency rather than a necessary service. Budget requests were based on the dollars required to maintain or expand the organization, not on the number of trips required. Thus, a single agency not only restricts options but has a tendency to obtain funding to perpetuate itself.

Tendency of Public Accounting Procedures to Distort the Cost of Providing Service with Public Funds

Because public accounting procedures are designed with two major goals, the public accounting system differentiates between operating funds and capital funds. First, the system of accounts is established by program to ensure that the funds are spent in accordance with laws or authorized budgets. Second, the accounting system is designed to ensure that the governmental unit does not overspend the funds authorized in any one period. Thus, the accounting system does not show the trade-offs between capital and operating cost, allocation of depreciation among various agencies, or the time value of money. Therefore, the governmental accounting system is designed neither to price services nor to determine whether the appropriate levels of service are obtained economically. Government relies on the various contracting procedures to ensure a fair price for the services; but in transportation, the process is circumvented when there is only one provider (9).

Consolidated Transportation Funding Programs Bypass Local Public Officials

Local consolidated transportation providers may deal directly with the state or federal funding agencies and structure proposals and plans without involving local public officials in the planning, operation, or evaluation of the service. If 75-90 percent federal money is available, local public officials may approve the organization and application simply because their community "might as well get the funds". With little local money required, public officials often have little involvement in the review, evaluation, and oversight of the project. The placing of a local official or citizen on a board or authority to oversee the consolidated operation is only effective if that person becomes heavily involved.

Consolidated Transportation Programs Replace Private Efforts

The inability of traditional transportation providers to meet all transportation needs fully has given rise to church and charitable transportation programs such as those provided by the Easter Seals Society, United Cerebral Palsy, and the Young Men's Christian Association. In addition, informal neighborhood arrangements have developed. The funding of consolidated transportation operations by government curtails private initiatives. For example, charitable organizations will not operate transportation services at $2.00-$5.00/trip when they can give their members (or beneficiaries) $0.50 tickets to ride the publicly funded system and force the public to absorb the deficit. Thus, charities still receive credit for giving riders the tickets and avoid all of the operating headaches. Government may intend to supply funds to augment service to those who have special needs but quickly finds that it has doubled the cost of the services, replaced private funds with public funds, and has become the primary provider of transportation rather than the provider of last resort, which it desired to be.

Alternative Model Based on Logistics Coordination

The logistics model suggests that the locality establish a logistics manager, a transportation coordinator-broker who uses the basic principles of logistics management. Businesses may centralize or decentralize the logistics function as appropriate, depending on potential service or cost benefits.

ORGANIZING FOR LOGISTICS COORDINATION

During the last three or four years, there has been extensive experimentation with brokerage organizations that attempt to bring buyers and sellers of transportation together. These programs have done much to eliminate the idea that consolidation is the only solution. There is a need, however, to develop a full set of principles for coordinating public transportation programs. There is a need to identify contracting procedures, approaches to cultivating new providers, procedures for assigning management responsibility and system accountability to each actor in the transportation channel, and new carrier-evaluation procedures. As a means of providing insight into some innovative approaches, an overview of successful coordination projects is presented below.

Camden County, New Jersey

The welfare board of Camden County had a $2500/month budget to provide transportation to its clients (95 percent of whom are eligible by Titles 19 and 20 of the Social Security Act of 1935, as amended). Instead of buying vehicles, hiring staff, and setting up an in-house maintenance facility (staff alone would have exhausted the budget), the board indicated that it would pay on-call volunteers to transport clients. According to information from Joe Calanero of the Camden County Welfare Board, the board currently has 20 regular volunteer drivers plus a long list of applicants. The 20 regular on-call volunteer drivers must meet rigorous standards and often have better qualifications than full-time drivers in other programs. One driver, for example, is an X-ray technician who did not like working at the hospital because she wanted evenings and weekends home with her husband and children. The on-call volunteers usually provide escort service, which includes helping patients from their homes, staying with them while they are receiving medical treatments, and picking up prescriptions. Backup volunteers provide service when the regular volunteer cannot. On-call service is available 24 h/day, seven days a week, at $0.20-$0.25/mile ($0.125-$0.155/km), approximately 50 percent of the cost of taxicab fare. Administrative cost is virtually nil. (The county has complete flexibility in the use of funds and does not incur vehicle or organizational operating costs.) All maintenance, vehicles, fuel, and supplies are provided by the volunteers.

States of Montana and South Dakota

Unlike Camden, New Jersey, Montana and South Dakota have many rural counties that have low population densities. In many of these counties, the county officials will hire farmers, housewives, off-duty police, firefighters, or others to provide on-call, part-time transportation in their own vehicles. The county usually pays the minimum wage plus $0.20/mile ($0.124/km) to the provider. These part-time providers are especially important in Montana because of the number of small, scattered communities and the long distances involved in the typical trip. Traditional rural transit systems would not be possible due to extremely high costs.

According to information supplied by Barbara Garrett of the Montana Department of Community Affairs and Planning and Don Daughtee of the South Dakota Association of Senior Citizens, some counties have quasi volunteers located in two or more of the county's communities (see Figure 1). If an agency operated its own vehicle, it would probably be garaged in the local town. If client A and client Z need transportation to the doctor's office in town, the agency would have to run empty (deadhead) from the town to A's home, take A to town, drive empty to Z's home, and then take Z to town. By having quasi volunteer 1 pick up A and quasi volunteer 2 pick up Z, only one-half as many miles are traveled.

If A, B, C, and D need to go to a congregate meal site in town, volunteer 1 can bring them in and help with serving the meal while waiting for the return trip. At the same time, volunteer 2 can pick up W, X, Y, and Z and bring them to the meal site. The agency would have to operate two vehicles, which would have two drivers, over twice the mileage to provide the same service, because by the time one vehicle could deliver A, B, C, and D to the meal site, the meal would be over by the time it returned with W, X, Y, and Z.

By simply locating on-call quasi volunteers who will provide transportation for a fee in each rural neighborhood, the county can establish a highly efficient, personal, high-capacity, responsive system without the high administrative cost and institutional problems of the consolidated operations. This plan also provides supplemental income to many underemployed individuals. In addition, such a neighborhood program is not impersonal.

Knox County School Board

The Knox County, Tennessee, School Board owns no vehicles (only two special education vans); instead it uses private contractors. No contractor can have more than four contracts (each vehicle is a separate contract), and the contractors must drive one of them personally if he or she provides more than two vehicles. The purchase of a new vehicle will result in new four-year contracts, and that contract serves as security for 100 percent funding from any local bank. Drivers are paid $13.25/seat per month plus $0.48/mile for a 66-passenger bus. The supervisor of transportation locates all routes, assigns each route to a specific contractor, conducts safety inspections, organizes training programs, and answers all questions and complaints from parents. According to Bill Orr of the Knox County School System, the total overhead cost to the county is $53 000/year (for three people) for the supervisor of transportation's office. In 1979, 110 contractors provided 221 buses (12 804 seats) for 1350 daily runs that carried 26 000 students (52 000 trips)/day. Cost per pupil is the lowest in the state. The equipment is mostly new; many contractors used Bluebird buses equipped with radial tires, chrome hubcaps, two-way radios, and deluxe seats. The school board requires that the buses be available 175 days/year, Monday through Friday, from 7:00 a.m. to 8:30 a.m. and from 2:15 p.m. to 4:30 p.m. The buses are free at all other times for making additional trips. As a result, many contractors are willing to provide transportation to schools, churches, scouts, 4-H clubs, and other groups that desire service during nonschool hours between 8:30 a.m. and 2:15 p.m. The drivers are willing to transport senior citizens any time they feel that they can avoid being in conflict with the Public Service Commission, the Interstate Commerce Commission, or the Knoxville Transit Authority. Where groups want specialized equipment, school bus operators are more than willing to purchase vans or other equipment. Because the contractors are already in business, they perceive very little risk in expansion.

Fulton County, Georgia

In Fulton County, Georgia, local clubs decided to attack the problem of the isolation of senior citizens. Fulton County is part of the Metropolitan Atlanta Regional Transportation Authority (MARTA) system. Many senior citizens wanted to make local trips to neighborhood shopping centers. Local shopping centers established a special senior-citizen shopping day each week. MARTA agreed to provide special senior-citizen bus runs specified by the county coordinator if the county guaranteed a minimum of 12 passengers. Local churches donated their buses and volunteer drivers to transport senior citizens. Senior citizens contributed to offset the cost of operating the church bus service. Civic clubs (such as the Civitan Club) contributed for any senior citizen who was unable to do so.

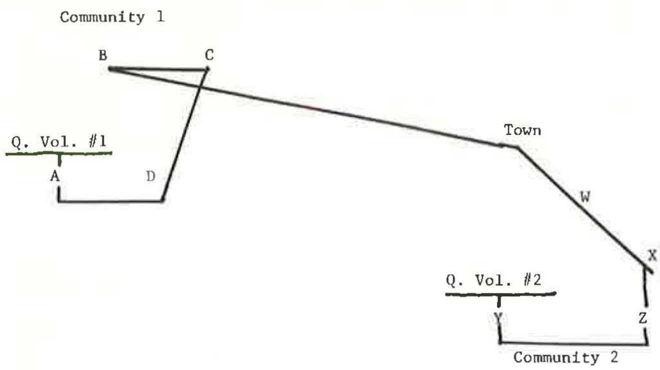
The promoter of this program thinks that this type of activity helps to rekindle a spirit of personal involvement in solving local problems within church and benevolent organizations. This is necessary for the growth of these organizations. One individual said that he personally thought that "one of the problems with contemporary society was that government was trying to professionalize all community service activities so that individuals, religious organizations, and benevolent societies no longer had a chance to meet the needs."

According to Edward Hogan, the county administrator's office is pleased with the service and wants to hire coordinators to work with other civic clubs, churches, and communities to establish similar programs in the rest of the county. He thinks that this vital neighborhood service augments and feeds to the MARTA subway system, now under construction, and supplements feeder service to collection points along traditional transit routes.

Hypothetical Model for a Rural Community

These four case studies describe innovations that work. Based on these concepts, a hypothetical plan

Figure 1. Location of on-call quasi-volunteers and clients.



could be developed for establishing a program for a rural community that we will call Smallsville. Smallsville is located on the old highway between two major cities. Although these two cities are only 180 miles (290 km) apart, the mountain terrain and crooked highways created a 7-h trip over the old highway. The new Interstate highway, which bypasses Smallsville by 35 miles (56 km), has reduced travel time to 3 h 15 min. If intercity buses travel the new Interstate, they are highly competitive with airline travel and can attract passengers. Smallsville, however, is concerned that if the intercity buses stop serving the community, the community will be further isolated. Therefore, the community brought strong political and citizen pressures on the state Public Service Commission to force Greyhound and Trailways to continue to use the old route. Consequently, the intercity bus service is not competitive; ridership is declining; Smallsville has an unwilling, captive provider; and fuel is wasted due to the circuitous miles operated on each trip. Furthermore, if residents of Smallsville want charter bus service, they have to pay deadhead (empty) mileage from the terminal in the major city in addition to standard charter rates.

The traditional approach is to lobby for subsidies for the intercity bus carriers and to lobby for funds to start a rural transportation system. However, if Smallsville would apply the basic logistics principles, it could find many new options available that may not even require public funds.

For example, the county school board owns and operates 80 school buses. The county school board could implement a Knox County-type of school bus program by selling three to four buses to each of several private contractors. Purchase of the buses would give the contractor an initial two-year contract. The sale of 12-25 buses would generate $100 000-$200 000 new dollars for the school board and it would put four to six small bus businesses into operation.

The city then could approach the intercity bus industry and offer to withdraw all opposition to abandonment of service to Smallsville if the intercity bus companies would do the following:

1. Establish a bus stop (commission agent) at a service station or motel on the Interstate highway exit nearest to Smallsville,
2. Enter into an agreement with one or more of the new school bus companies to operate package express and passenger pickup in Smallsville and surrounding communities and to interline with Greyhound and Trailways at the new Interstate highway stop,
3. Support requests by the new school bus companies for permission to operate charter bus service to and from the Smallsville area, and
4. Allow social-service agencies to negotiate contracts with the new bus companies to provide for transportation of senior citizens, handicapped persons, and any other rural group, as needed.

In essence, this approach would generate a new local industry that has four or more competitors that could provide school bus service, charter service, fixed-route service, package express service, specialized service, and any other options desired. Local companies better understand local needs. The school board contract would provide a basic guarantee of business, so it would be relatively risk free for the entrepreneur to obtain specialized vehicles or to expand. But most important, public monies would be used to purchase service, not to build organizations. Government and social-service agencies would maintain control over the service that was provided. In addition, the existence of competition would ensure a high quality of service.

SUMMARY

The desire for transportation coordination is simply a desire for more efficient and effective transportation. It is basically a resource-management problem. Legislators and public administrators find themselves in the same position as the military during World War II. The military leaders had no desire to be burdened with the details of supply and transportation, but wanted only to work out strategies to accomplish their mission. Unfortunately, they found that the limitations of these support services set the limits on their strategic options. The reorganization of the military logistics activity recognized these restrictions. Today social-service agencies are in the identical dilemma, with little desire to be involved in transportation but faced with severe restrictions on their ability to accomplish their mission because of transportation problems. If the consolidation model--the very heart of the public utility approach to transportation--had worked for traditional transit, social-service agencies would not be in this dilemma. The resolution of the dilemma lies in the lesson that history taught business and the military: The gist of that lesson is the logistics-coordination model. We should heed that lesson well.

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Abridgment

Evaluation of Pupil Transportation Routing Procedures

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The process of choosing a method for reviewing and designing the route structure of pupil transportation systems for rural and suburban areas was investigated. The available techniques for school bus routing were reviewed and divided into three general categories: (a) manual procedures, (b) computer-assisted manual design methods, and (c) computerized design programs. An evaluation framework is presented for application by school districts in selecting the most appropriate school bus routing procedure to use in their areas. The application of the evaluation model in a selected school district is described. The study results indicate that the computer-assisted methods are best suited for the majority of school districts, except for only the very large and very small areas. Future work should be directed to improving on these interactive computer-assisted methods.

This paper addresses a problem that rural and suburban school districts face in the early stages of reviewing the route structure of their school bus system--that of selecting a particular technique to use in studying their transportation system. The options available are reviewed and a strategy is developed whereby districts can rationally select a method best suited to their particular needs and resources. A case study is shown for Albemarle County, Virginia.

CATEGORIES OF ROUTING METHODS

School bus routing methods are ways of determining the sequence of stops school buses make in picking up and delivering students to their respective schools. A wide variety of techniques is available for school bus routing that may be divided into three general categories:

1. Manual procedures,
2. Computer-assisted manual design methods, and
3. Computerized design programs.

For comparative purposes, a subclassification is made for methods that use computers to design the routes: (a) methods that are implemented and used by the school district and (b) methods that are provided by consulting services and purchased yearly by the school districts.

Manual methods are those that use only pencil, paper, maps, and, perhaps, handheld calculators to develop school bus routes. As a class, manual methods are used in all but a small minority of school districts today. Usually no formal procedural steps are followed; routes are typically developed by intuition and experience.

As a category, the manual methods offer the potential advantage of allowing for consideration of a variety of local conditions that are often unquantifiable and undocumented. To be effective, however, the manual methods can be extremely tedious and time consuming. As a result, most manual routing efforts consider only minor modifications to historically derived routes rather than systemwide evaluations.

Computer-assisted manual school bus routing methods use computer programs to assist in the manual design of routes. The computer programs are used to generate performance statistics for the routes that are manually designed. These measures typically include disaggregate and summary statistics on travel time, passenger volume, and mileage. Examples of the computer programs include (a) the Urban Mass Transportation Administration (UMTA) Urban Transportation Planning System (UTPS), (b) statistical package for the social sciences (SPSS), and (c) a variety of specially written computer-program-assisted manual methods (1-3).

The primary advantage of the computer-assisted methods over the manual methods is that they provide individual route and system statistics quickly and easily. This feature facilitates the examination of different routing configurations and the implications of different policy options, an operation that is virtually impossible by the use of a completely manual method.

Computerized school bus routing methods are those that use computer algorithms or programs in the actual design of school bus routes. The major difference between the methods and the computer-assisted manual methods is that they use a computer algorithm for route design but the latter rely on individual judgment.

The algorithms and programs that were developed to design school bus routes are based on one of the following approaches:

1. The traveling salesman approach (4,5);
2. The vehicle delivery or, as its solution became known as, the savings approach (6-9); and
3. The random approach (10).

All require a systematic documentation of (a) the street network in terms of links, nodes, and travel times or distances between nodes; (b) the bus stop locations and their respective numbers of students that correspond to each school; and (c) parameters for constraints, such as bus fleet size and capacities (11).

In the United States today, a relatively small number of districts have fully computerized their school bus routing process. Some have tried and have since abandoned the computer method and returned to manually developed school bus routes. The reasons for abandonment vary, though they are generally a combination of the following: (a) insufficient manpower on the local level to accurately gather all data, (b) lack of commitment of local school officials and transportation supervisors, (c) inadequate memory and calculating power on the computers used, (d) high turnover rate and lack of experience of computer staff, (e) discontinued interest of several firms that had formerly provided school bus routing consulting service, and (f) dissatisfaction with the results.

Those districts that have successful computer systems are very enthusiastic about them. They cite the relative ease in updating the various data files and in using the computerized systems to develop routes for their districts each year after implementation as primary benefits of the method.

Computer school bus methods, however, are not recommended for all school districts. Because of the high initial costs, they are generally more suited for large school districts where potential savings in the pupil transportation systems would more likely equal or exceed the implementation costs.

FRAMEWORK FOR SELECTING ROUTING METHOD

The evaluation framework for selecting a routing method developed here is a two-step procedure. The first step involves an assessment of the pupil transportation needs and resources of the community followed by the evaluation and selection of the general category of school bus routing method that best matches these needs and resources. In the second step, specific methods that are available in each of the general categories are examined.

To evaluate the categories of methods and the methods within each category, several sets of criteria or measures of effectiveness were developed. In each case, they were designed to reflect the various resource requirements and capabilities of the different approaches. Nine basic measures of effectiveness were developed for comparing the general categories of methods. They are as follows:

1. Implementation period refers to the approximate time period needed to acquire and implement that category of methods,
2. Ownership cost refers to the monetary cost for the purchase of methods,
3. Data-gathering manpower refers to the person-months needed for data gathering,
4. Method implementation manpower refers to the person-months of computer staff required for method implementation,
5. Computer facilities are the type of computer facility needed to implement and use the method,
6. Recurring cost refers to the cost (rental or consulting fee) for each subsequent year,
7. Recurring manpower refers to the person-months needed in each subsequent year for the development of routes,
8. Efficiency refers to the relative efficiency of the routes produced (for a given size bus fleet), and
9. Flexibility of method refers to the relative ease of using this category of methods to evaluate the effects on the route structure when changes are made in the constraints and policies.

Based on these criteria, a comparison between the different categories of methods is shown in Table 1. Information on the various resources required and method effectiveness were obtained from the literature, discussions with school bus routing consultants, and in-house assessments. As shown in the table, no single method is clearly superior. Trade-offs must be analyzed, primarily in the area of resources required versus effectiveness.

Table 1. Comparison of school bus routing methods by category.

Criterion	Manual	Computer Assisted	Owned Computer	Service Computer
Implementation period (months)	2	2-6	8-12	6-8
Ownership costs ($)	0	100-1000	2000 to 80 000	45 000 to 100 000
Data gathering (person-months)	0-1	1-3	4-6	3-4
Method implementation (person-months)	1-3	1-3	4-12	1
Computer facilities	None	Small to large computer	Large computer	None
Recurring costs ($)	0	0	0-200/month[a]	30 000-60 000
Recurring manpower (person-months)	1-3	1-3	1-2	0.5
Efficiency				
<20 buses	Good	Good	Good	Good
20-100 buses	Fair	Good	Good	Good
>100 buses	Poor	Fair	Good	Good
Flexibility	Poor	Fair	Good	Good

[a]Rental fee.

Once a general category of methods has been selected, specified methods available in that category are evaluated for application. Criteria for this phase of the evaluation process were developed for all but the category of manual methods. Criteria were not developed for manual methods because manual methods vary substantially in application and thereby defy convenient description, and the merits and the successful applications of manual methods are almost entirely dependent on the users. For the remaining methods, two separate sets of evaluation criteria were developed.

For the evaluation of computer-assisted methods and owned-computer methods a common set of criteria is used. They include the first seven criteria that were used to compare the general categories of methods plus consideration of the success in prior applications.

A different set of criteria is used for the evaluation of service-computer methods. Services are provided by consulting firms, usually on a yearly contractual basis, to develop school bus routes. Data could be gathered by either the school district or the consulting firm, however, the development of routes and the production of reports for administrators, transportation supervisors, drivers, students, and parents are done only by the consulting firm. The criteria that summarize the attributes of the service computer methods for comparison include the measures defined previously, implementation period, data-gathering manpower, implementation costs, the success of prior applications, plus the following added considerations:

1. Reputation of the firm refers to the experience of the firm in school bus routing and the assurance that the firm will continue to provide service in this area,
2. Purchase option refers to whether the firm offers the option of selling the method and training the district's personnel to use the method to develop the school bus routes locally,
3. Purchase cost refers to the capital cost involved for purchase of the method (computer software and documentation), and
4. Computer facilities refers to the type of computer the school district needs if the method is purchased for local implementation.

APPLICATION

Selection of Method

To apply the framework developed above to the selection of a routing method it was first necessary to identify the resources available. For this task, the pupil transportation system of Albemarle County, Virgina, was chosen as a case study (12). The various resources available were determined from discussions with local school officials and are numbered below according to the criteria for the evaluation of the general categories of methods.

1. A maximum of four months was available for method implementation,
2. A maximum of $1000 was available for method purchase,
3. Approximately three person-months were available for both data gathering and method implementation,
4. See item 3,
5. The computer at the University of Virginia (a CDC Cyber 172) was available,
6. No funds were set aside for recurring costs in subsequent years, and

7. About one full month of the transportation supervisor's time is available for school bus routing in each subsequent year.

When this information was compared with the attributes of the general categories of methods (see Table 1), the category of computer-assisted methods was selected, primarily on the basis of the resource limitations of time, money, and manpower.

The specific methods available to the Albemarle School District in the category of computer-assisted methods are the SPSS-assisted manual method and a specially written program-assisted manual method. These two methods are compared in the table below, by using the criteria developed for the evaluation of computer-assisted methods.

Criteria	SPSS	Specially Written Program
Implementation period (months)	3	3
Ownership costs ($)	0	0
Data-gathering manpower (person-months)	1	1
Method implementation manpower (person-months)	0.5	2
Computer facilities	Computer with SPSS installed	Any computer
Recurring costs ($)	Minimal	Minimal
Recurring manpower (person-months)	1.5	1.5
Success in prior application	None	None

As can be seen, the SPSS-assisted manual method was found superior because it required less implementation manpower. Consequently, the SPSS-assisted manual method was selected to develop Albemarle's school bus routes for the 1979-1980 school year.

Results of the Application

Several significant results were noted in the application of the method to the Albemarle County school system. As expected, the computerized features of the method provided an organized and rapid determination of the disaggregate and summary statistics necessary for the evaluation of the various routing alternatives. This made it a relatively simple task to assess the implications of changing various policy constraints (e.g., changing school starting times) and to identify the inefficiencies of the current routing configuration.

The final routes selected represent a significant net savings potential to the county. The number of buses required was reduced by nearly 20 percent and there was a 57 percent reduction in the number of vacant seats. These reductions were achieved with only a 10 percent (4.6 min) increase in the average trip length.

That the case study application was completed within the resources estimated for that method is also significant. Thus, for the current case study, substantial improvements were provided at a very low cost. These costs were recoverable many times over within the next year of operation.

CONCLUSIONS

Although only one case study has been presented, when it is considered with the framework developed for selecting among the various methods, important implications for further effort in this area are apparent.

The computer-assisted method was found to be well suited for an extremely wide variety of school districts, excluding only the very large and very small areas. As a general class of methods, they make use of the better features of the completely manual and fully computerized methods while not incorporating their inherent disadvantages. Moreover, the computer-assisted method provides an interactive facility to help plan, manage, and critique local bus systems at several levels. The method is responsive to local concerns, policy level planning, and design considerations. It is interactive in that computer feedback is provided for the manually designed routes.

Finally, it is evident that much additional work is needed in this area. The general framework developed here identifies only the basic concept of the computer-assisted methods. The case study presented demonstrates only that the general approach can produce operationally efficient routes. The work that remains, therefore, includes the development of various computer programs and extensive application testing. A sufficient number of approaches should be used to adequately explore the various person-computer interface arrangements. Although the cost of such development and testing will not be small, it should be more than offset by the savings realized by the school bus systems used as case studies.

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Abridgment

Post-Bus for Rural Passenger Transportation and Rural Mail Delivery: An Idea Whose Time Has Come

DALE E. ADAMS

Rural areas have a growing need for public transportation, but service is declining due to high costs and diminishing subsidies. The U.S. Postal Service faces similar problems with its rural service. A number of European countries faced similar problems and have solved them, to some extent, by combining public transportation with mail deliveries. Several studies have shown that this approach may be successful in this country. The possibility of reducing the cost of providing both services by combining them demands experimentation.

Rural areas have become increasingly isolated in the last several decades. Declines in rural population and the competition of urban shopping centers have caused the demise of many small-town stores and service enterprises. The resulting rural job loss has been compounded by declining agricultural employment, which has forced many rural residents to commute to urban job locations. Social services, which are important to rural as well as urban residents, locate in cities and large towns where most clients live. Many rural communities have become "bedroom towns" and rural citizens are now dependent in many ways on a distant urban center.

These trends have created a hardship for the rural poor, elderly, handicapped, and young, who cannot operate or afford an automobile. Unfortunately, public transit has been unable to alleviate this problem. Low, dispersed demand and long distances make commercial bus services unprofitable in rural areas. Government-sponsored transportation is costly and funds for it are scarce and decreasing. Certainly this instability warrants the investigation of new approaches to fulfilling the growing transportation needs of rural residents.

THE POST-BUS CONCEPT

One possible approach is to combine rural transit with the conveyance of mail between post offices. Postal service, like transportation, is a deficit operation in rural areas. Since both public transportation and postal services involve similar driver and vehicle costs, there would appear to be potential savings for both (and a reduction in the overall need for government subsidies) if one driver and one vehicle could perform the duties of both mail delivery and passenger transport.

Highway contract routes (commonly known as star routes) are contracted mail pickup and delivery routes that serve most rural post offices. In general, star route carriers make runs twice a day to outlying post offices from either a regional mail processing center or a larger post office. Often these distribution points are also regional retail and human service centers. If passenger service were added to highway contract routes, they could take rural residents into regional centers in the morning and return them to outlying towns in the afternoon.

Another advantage of bus service on star routes is the suitability of post offices as bus stops. Most have a heated lobby where passengers could wait out of the weather. Also, post office clerks would be on hand to answer questions and, perhaps, also to sell tickets. Post offices already provide other community services, such as passport registration and food stamp distribution, so the addition of bus stop services is not unthinkable. Dale Massie, director of Appalachian Ohio Regional Transit Association, a rural system that uses post offices as bus stops, remarks that rural post offices are generally the focal points of rural communication and, therefore, make ideal focal points for rural transportation.

No U.S. Postal Service regulation prohibits the combination of star route service with passenger transportation. In fact, the U.S. Postal Service may pursue contracts with passenger common carriers when their routes and schedules fit postal service needs (39 U.S. Code 5214). A star route contractor may be an individual, a partnership, or a corporation (1). Contractors must abide by the rules and regulations of the Basic Transportation Services Contract General Provisions. Concerning passenger service, the provisions require the following (2):

> The mail shall not be delayed to accommodate passengers .... The mail shall be transported in an enclosed, water-proof compartment, equipped with secure locking devices .... If the contractor is authorized to carry passengers, the mail must be carried in a compartment separate from the passengers so that they cannot have access to the mail.

The idea of combining mail and passenger delivery is not new. For instance, the stage coaches of early America performed both duties. In more recent times the postal departments of Britain, Switzerland, Finland, and Sweden have established motorized Post-bus service. The continental services are the oldest; they began between 1910 and 1930. Swedish and Finnish Post-buses operate in rural areas and use vehicles that range in size from 9 to 55 seats (3,4). The Swedish and Finnish buses are owned and operated by the respective postal services. In Switzerland, the post office contracts some routes to private carriers (5).

British Post-buses have operated since the late 1960s (6). The majority of British Post-buses are similar to their continental counterparts; they provide a basic two-way service to and from a town or village. British services differ, however, in that almost all involve house-to-house delivery and collection rather than simply the transportation of bulk mail. The first morning service of a typical British Post-bus will be the delivery run, which perhaps takes two or more hours to cover a 15-mile route. The minibus will then return to base, stopping only to drop off or pick up passengers. An afternoon run follows. This will be a fast run out to the distant end; stops are made on the return journey only for passengers and to collect mail from post offices and wayside mail boxes.

Most of the British Post-buses are in Scotland. There, 126 buses provide a basic public transit service over more than 2500 miles of road. Most of the areas served were without passenger transportation only a few years ago (7). According to the Scottish Postal Board, Post-buses provide a small but useful supplement to post office revenue in areas where traditional postal services are inevitably uneconomic. They do all this at minimum cost to the government or local authorities.

Prime responsibility for providing conventional public transportation in Scotland has been with the Scottish Transport Group. Inevitably, its services require substantial financial support from the local authority and can, therefore, only be justified where there is adequate demand for passenger transportation. This means that Scottish Transport buses, like our intercity buses, link main population centers and serve the more sparsely populated areas directly on those links but do not, for the most part, provide services in the rural areas off the main routes.

In 1971 the Scottish Postal Board recognized that vans used for household mail delivery were valuable resources that were sadly underused. Since a vehicle and driver were needed for basic postal delivery and collection services, the major part of the cost of providing a bus service was already committed. A new government bus grant enabled the post office to buy 11-seater minibuses for little more than the cost of delivery vans. Qualification for a public transportation fuel tax rebate meant that running costs were no higher and, in some cases, even lower. In these circumstances the passenger fares became a net contribution to the cost of running the postal service in rural Scotland, and the development of the Post-bus service in isolated areas became more an imperative than an opportunity.

Our counterpart to the adapted British service, rural mail delivery, does not currently appear to be feasible for transporting passengers, mainly because only once-a-day service is offered. However, highway contract routes do provide similar opportunities to solve similar public transportation problems in rural areas.

U.S. STUDIES

The California Department of Transportation has studied the feasibility of passenger service along star routes for rural communities near the city of Redding, a regional commercial center (8). The three star routes investigated originate in Redding in the morning, go out in three separate directions to serve the outlying post offices, and return to Redding in the late afternoon or early evening. The feasibility study was based on contractor operation of passenger service by using six-passenger crew-cab pickup trucks. Estimates of costs and revenues showed potential for increased contractor earnings if passenger service were offered.

Although the project's final report was enthusiastic, nothing further has been done to establish the service. This is mainly because a subsequent study concluded that demand would be low due to the morning-outbound, afternoon-inbound nature of the routes, which is the opposite of that desired for rural transportation service.

West Virginia's Department of Welfare undertook a more-extensive endeavor in the design of a Post-bus demonstration program for rural Pocahontas County (9). The study proposed that the county be served entirely by a Post-bus system, thus providing a controlled experiment. The regional transportation authority would contract for passenger transportation with the individual star route contractors, therefore the regional transportation authority could manage and coordinate transit services without being responsible for mail transportation. Practically all of the star routes chosen make only one trip from their home post office a day. Five of the six routes deliver household mail along their circuit in addition to bulk post office deliveries. The study noted that the routes were not ideal for passenger service, but could be improved by minor changes that would not significantly alter the postal service's distribution network.

The study determined that seven vehicles would be required, each with right-side driver placement, partitions to separate the driver and mail storage areas from the passengers, heavy-duty construction, and access convenient for the elderly and handicapped. The cost of these along with other expenses, such as contractor payments and vehicle maintenance, was found to exceed estimated revenues, which would include fares and lease fees paid by the contractors for the vehicles. A 50-percent subsidy would be required, but the study claimed that this was lower than the projected subsidies of other operations.

The West Virginia project has also not reached the implementation stage, primarily due to the U.S. Postal Service's unwillingness to participate. The postal service noted no insurmountable legal hurdles in the plan but believed that the administrative problems would be monumental.

Both the California and West Virginia studies chose star routes that are not typical of routes in many parts of the country. Two trips a day are made to all but the smaller, more remote post offices. Box delivery is occasionally a part of star route contracts, but normally it is done by postal employees on rural delivery routes. The choice of star routes with these conditions hurt West Virginia's design study, but its greatest fault was in proposing such an extravagant demonstration project. Certainly the postal service cannot be expected to willingly allow such changes in their services for only a trial period and with no apparent benefit to them.

DEMONSTRATION IS NEEDED

The cooperation of the U.S. Postal Service would be helpful, if not necessary, for establishing Post-bus service. Many star route contractors would be reluctant to initiate passenger service themselves or contract under a transportation authority without postal service approval. A transportation authority could efficiently agree on and work out the details of a combination of services directly with the postal service. In addition, changes in route or schedule would improve many highway contract routes for passenger transportation. The postal service would rightly expect rewards for its involvement, perhaps in the form of reduced contract costs or simply improved public relations.

A Post-bus demonstration that uses an ideal highway contract route would show the benefits and problems for the postal service and public transportation providers. The State College, Pennsylvania, Sectional Center, a postal service substate management area, offers several highway contract routes that do not need route or schedule changes, which would make a demonstration easier for the U.S. Postal Service to accept (Figure 1). Highway Contract Route (HCR) 16831 (Table 1) could provide five-day passenger service to and from State College, a regional commercial and human services center. HCR 16866 (Table 2) could provide similar service for Philipsburg, a regional subcenter. These and other routes in the State College area will be rebid or renegotiated for new four-year contract periods this year, which makes this a good time for setting up a demonstration.

Perhaps a contract between a local municipality

Figure 1. Sectional center in State College, PA.

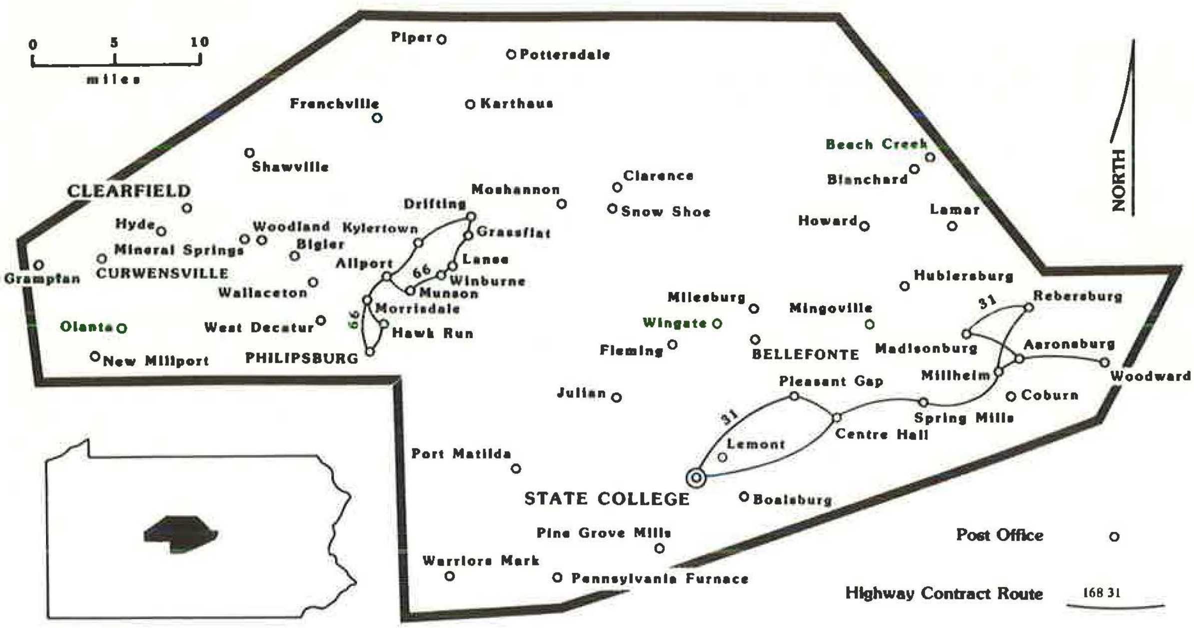

Table 1. Demonstration schedule: State College - Woodward, PA HCR 16831.

	Outbound Trip Times (read down)[a]			Inbound Trip Times (read up)[a]		
Bus Stop	Trip 1[b]	Trip 3[c]	Trip 5[d]	Trip 2[b]	Trip 4[d]	Trip 6[c]
State College	0705	1425	1425	1020	1725	1725
Pleasant Gap	-	-	-	1005	1710	1710
Centre Hall	0740	1500	1500	0950	1655	1655
Spring Mills	0800	1520	1520	0935	1640	1640
Millheim	0820	1540	1540	0920	1625	1625
Rebersburg	0830	1550	1550	-	1615	1615
Madisonburg	0840	1600	1600	-	1605	1605
Aaronsburg	0850	-	-	0915	-	-
Woodward	0900	-	-	0905	-	-

Note: The trip distance is 35.7 miles for trips 3, 4, 5, and 6; 46.0 miles for trip 1; and 31.2 miles for trip 2.
[a]Based on 24-h clock.
[b]Frequency = daily except Saturday, Sunday, and holidays.
[c]Frequency = Saturday except holidays.
[d]Frequency = daily except Sunday and holidays.

Table 2. Demonstration schedule: Philipsburg - Kylertown, PA HCR 16866.

	Outbound Trip Times (read down)[a]			Inbound Trip Times (read up)[a]		
Bus Stop	Trip 1[b]	Trip 3[c]	Trip 5[b]	Trip 2[b]	Trip 4[c]	Trip 6[b]
Philipsburg	0810	0810	1510	1000	1700	1700
Hawk Run	0820	0820	-	-	1650	1650
Morrisdale	0830	0830	1520	0945	1640	1640
Allport	0835	0835	1525	0940	1635	1635
Munson	0845	0845	1535	-	1625	-
Winburne	0855	0855	1545	-	1615	-
Lanse	0900	0900	1550	-	1610	-
Grassflat	0910	0910	1600	-	1600	-
Drifting	0920	0920	1610	-	1550	-
Kylertown	0930	0930	1620	0935	1540	1625

Note: The trip distance is 23.8 miles for trips 1, 2, 3, and 4; 22.9 miles for trip 5; and 9.9 miles for trip 6.
[a]Based on 24-h clock.
[b]Frequency = daily except Saturday, Sunday, and holidays.
[c]Frequency = Saturday except holidays.

or transportation authority and the star route contractor could become part of the rebidding or renegotiation process. The postal service and the local transportation provider would agree on a division of costs and resolve conflicts of the two services. The contractor would then be simultaneously responsible for the mail delivery and passenger service contracts. The sale of tickets by post office clerks could also be arranged. Since the postal service has accounting procedures for the return of fees for such things as passports to the proper federal agencies, the return of fares to the transportation authority should pose no problem.

CONCLUSIONS

In the United States, rural areas are becoming economically more difficult to provide with postal service and public transportation. European governments faced similar problems and have solved them, to some extent, by combining the two services. Highway contract routes appear capable of providing passenger transportation here. The possibility and probability that total government outlays for passenger transportation and mail transportation could be reduced by combining the two services demand experimentation with Post-bus service.

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