

operating costs. This will mandate a knowledge of the prevailing state of the art in bus cost-estimation procedures. It is anticipated that with greater emphasis on this topic, further enhancements and innovative approaches to estimating transit costs will evolve.

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A more complete discussion of the concepts presented in this paper is available elsewhere (9).

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Potential Impacts of Transit Service Changes Based on Analytical Service Standards

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The results of a hypothetical case study of the Hartford, Connecticut, bus transit system in which service and fares are redesigned based on service standards derived from an analytical optimization model are presented. The key variables in the analysis are route spacing, headway, fare, and route length for both local and express routes. Three different sets of possible local objectives are treated, which place varying emphasis on profit (or deficit) and user benefits. Comparisons of the results with the existing system are made, and several policy issues are addressed. The analysis concludes that major increases in productivity are technically possible, based in large part on route restructuring and the introduction of substantial express service. Because relatively large changes from current operations are entailed, equity and political feasibility may be large issues in making the proposed changes.

The next decade promises to be a period of transition in urban transportation services. Urban public transportation was provided by private firms in most U.S. cities until the mid-1960s when most systems came under public management and subsidization. Few major changes in bus operating policies or system design have been made in this period of public ownership except for maintaining fares at a lower level than a private firm would have required. This strategy may be reassessed in many cities in the next decade for two major reasons. First, transit deficits have grown sharply over the levels originally anticipated when the systems became public operations. In 1965 the total U.S. transit deficit

was \$11 million and revenues covered 99 percent of expenses. However, in 1977 the U.S. transit deficit had risen to \$2 billion and the percentage of operating expenses covered by farebox revenues had dropped to 53 percent (1). Part of this rapid increase in deficits had been absorbed by the federal government, but already tight state and municipal budgets will be forced to absorb most of the additional operating losses that may occur. This is likely to lead to consideration of service reductions, fare increases, and means of increasing productivity at the local level.

A second major impetus to the analysis of bus systems is energy policy. Expansions in bus service may reduce urban transportation energy requirements, but the deficits of such service require that any expansion in service must be designed very carefully to maintain economic feasibility.

SUMMARY OF SERVICE AND FARE STANDARDS METHODOLOGY

In this case study, the Hartford, Connecticut, system was redesigned according to service standards based on three sets of goals (or objective functions), and the results were compared with current operations. The case study treats peak-hour service only for simplicity. The service standards are

based on optimization model results described in two previous papers (2,3). The model incorporates components that correspond to demand, supply, cost, revenue, and benefit models--the same set of components used by the traditional transportation planning process.

A linear approximation to a disaggregate logit model is used as the demand function. In the peak-period service standards used in this paper, only modal choice is considered; however, the results are valid for a general linear demand function. The measure of net user benefits (consumers' surplus) is based on the linear demand function. A simple cost model based on bus hours of service is used. Revenue, service level, and load-factor equations complete the basic model. These submodels are expressed as a series of equations for which optimal results are found through calculus and the technique of Lagrange multipliers [see Kocur and Hendrickson (2) for a description of the technical details].

Service and fare standards are developed for three objective functions:

1. Maximize profit or, in some circumstances, minimize deficit, subject to the constraint that a positive number of passengers must be carried;
2. Maximize a weighted sum of operator profit and net user benefit; and
3. Maximize net user benefit subject to a deficit constraint.

The second and third functions are possibly representative of current transit objective functions; the first is included primarily as a limiting case.

The service standards that emerge from these analyses are average values of the variables over the service area, expressed as equations into which local values of parameters such as demand coefficients, unit costs, operating speed, and population density are substituted. For example, the average headway for a profit-maximizing (deficit-minimizing) operator on local routes in an area of constant density is derived to be the following:

$$h = (4ca_4/3jk^2vpa_2A)^{1/3} \quad (1)$$

where

- h = headway (minutes);
- c = bus operating cost (cents/minute);
- a_4 = demand coefficient of fare;
- j = average walk speed (miles per minute);
- k = ratio of expected user wait time to headway;
- v = local bus speed, including stops (miles per minute);
- p = average trip density by all modes to the central business district (CBD) (trips per square mile per minute);
- a_2 = demand coefficient of out-of-vehicle (wait-and-walk) time; and
- A = constant in demand model.

These results vary by objective and are also affected by the operation of express service in the area and by trip or population density distribution.

The service standards for route spacing are functions of the same variables as headway, with very similar relations. In general, the express and local headway and spacing standards are proportional to the cube root of most of the parameters. Because the magnitude of some of the parameters is not known with precision, this robustness is reassuring. The fare standard for the same case given above is as follows:

$$f = -A/2a_4 - (4ca_2^2k/3jvpa_4^2A)^{1/3} \quad (2)$$

The express-fare standard is similar. A warrant for operating express service is also included in the standards and depends strongly on the ratio of express speed to local speed. Generally, if express speed is 25-50 percent faster than local speed, express service is warranted. Formal vehicle-size standards have not yet been developed for the cases treated in this paper, although average passenger loads are displayed in the tables below to show the vehicle type required. Vehicle-size standards have been derived for simpler cases (2), and similar results are expected to hold in more complex ones.

These service standards are intended only to set the broad outlines of transit operations. Detailed route locations, schedules, and stop locations must still be decided by the operator based on experience, the constraints of available streets, variations in population density and markets, and so on. These standards also differ from the usual ones in that they specify average values rather than minimum standards. In this view, average standards are set to obtain maximum service effectiveness while minimum standards are set to address equity issues. Because equity issues are generally best dealt with outside the realm of technical analysis, they are not considered in this paper. The actual systems described in this paper follow the average standards closely.

DESCRIPTION OF CURRENT TRANSIT SYSTEM

The Hartford urbanized area has a population of almost 500 000; it is the 53rd largest urbanized area in the United States. Public transportation is provided by a bus system operated by Connecticut Transit, which is funded by the Connecticut Department of Transportation (ConnDOT). In 1980 the system operated a fleet of 257 buses over 40 local and 14 express routes. The system carried approximately 10 500 passengers in the peak hour and about 1 500 000 passengers/month. Monthly operating costs were approximately \$1 500 000 and monthly operating revenues were about \$700 000, resulting in an operating ratio of just under 50 percent. The base fare was \$0.50, with zone fare increments of \$0.25 for a few long local routes and most express routes. (Fares were raised on March 1, 1980, from a previous level of \$0.35.) Average operating cost per vehicle hour is about \$30, according to monthly issues of One Month Comparison of Existing Systems published by ConnDOT.

Figure 1 shows the current local bus service in Hartford. Almost all express routes are operated as park-and-ride services from suburban parking lots. Because this paper does not address the design of park-and-ride services and because these services operate from isolated points beyond the general service area, they are not considered further.

The local routes serve roughly a 6-mile radius around the CBD. The Connecticut River divides the area into two sectors. On the more densely populated west side, which includes Hartford, more transit service is provided than on the east side. Thirty-one local routes operate on the west side with an average headway of about 15 min in the peak period. If these routes are assumed to serve an area of π radians (half a circle), the average spacing between them is $\pi/31$ or 0.101 radians. Nine routes operate on the east side at an average peak headway of about 21 min. Assuming that these routes serve an area of 0.8π radians (40 percent of a circle), the average spacing is 0.279 radians.

Peak-hour service employs approximately 140 buses for west-side local routes and about 40 vehicles for east-side routes. At an operating cost of \$30/bus hour, this yields a cost of approximately \$5400 for

Figure 3. Linear approximation to logit modal-choice model.

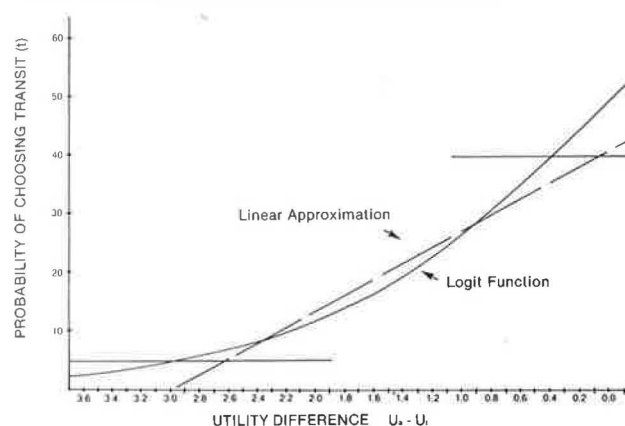


Table 2. Hartford validation results, peak hour.

Item	West Side		East Side	
	Model	Actual	Model	Actual
Transit ridership	5039	5480	1242	1394
Transit revenue (\$)	2520	2740	621	697
Transit cost (\$)	4298	4200	1125	1200
Transit net user benefit (\$)	5171	--	1074	--
Avg transit passenger load per bus	42	44	50	45

Table 3. Profit maximization with express and local service.

Item	West Side	East Side	Total
Route length (miles)			
Local	4.0	3.6	--
Express	7.0	6.2	--
Route spacing (radians)			
Local	0.445	0.682	--
Express	0.328	0.517	--
Route headway (minutes)			
Local	14.0	19.3	--
Express	17.3	24.3	--
Fare (\$)			
Local	1.20	1.08	--
Express	1.27	1.09	--
Peak revenue (\$)			
Local	1898	359	2257
Express	2143	422	2565
Peak ridership			
Local	1576	332	1908
Express	1690	387	2077
Peak costs (\$)			
Local	731	246	977
Express	992	319	1311
Net user benefit (\$)			
Local	842	154	996
Express	1089	196	1285
Profit (\$)			
Local	1167	113	1280
Express	1511	103	1254
Passenger load per bus			
Local	52	29	--
Express	51	32	--

where

- t = transit modal share;
- U_a = automobile utility;
- U_t = transit utility;
- x_1 = automobile out-of-vehicle time (8 min);
- x_2 = automobile in-vehicle time (computed at 24 mph plus 8 min access time);
- x_3 = automobile operating cost (computed at 16¢/mile plus 67.5¢ parking);

- x_4 = transit wait time (minutes), computed at 0.4 times headway;
- x_5 = transit walk time (minutes), computed at 3 mph from route spacing;
- x_6 = transit in-vehicle time (minutes); and
- x_7 = transit fare (cents).

The logit model is approximated by a linear function as shown in Figure 3. The logit function is S shaped; only its right-hand half with transit modal shares less than 50 percent is shown. The linear approximation was chosen by inspection to fit a range of modal splits from 5 to 40 percent fairly closely, as this is felt to be the range of interest.

These demand coefficients correspond to the following elasticities of transit use when the transit modal share is 20 percent and all variables are at their mean values:

1. Wait and walk time: -0.60,
2. In-vehicle travel time: -0.25, and
3. Fare: -0.35.

This linear modal-choice model together with the linear trip-density function were validated on the current Hartford data to ensure that the approximation errors were tolerable. The results are given in Table 2. Predicted ridership is 6-8 percent too low in both the east and west sectors, but predicted costs are quite close to actual values. Transit net user benefit (or consumers' surplus) cannot be measured, so no comparison with actual benefits is possible; this figure is reported as a base of comparison for later policy options.

The linear modal-choice model and the linear trip-density function form the basis of the simple sketch-planning model used to estimate the impacts of implementing the service and fare standards described below; it is also described in Kocur (6).

SYSTEM DESIGNS FOR ALTERNATIVE OBJECTIVE FUNCTIONS

A series of analyses was conducted to design transit services for the Hartford area within 8 miles of the CBD. The analyses consider service standards based on all three objective functions, each with local and express service.

Profit Maximization with Express and Local Service

In this analysis, a set of service standards is computed and applied based on the assumption that profit maximization (excluding capital costs) is the system objective. Service standards are computed for eight variables: local headway, route spacing, fare, and route length, and express headway, route spacing, fare, and route length. These values are given in Table 3 with separate values for the west and east sides, as the service patterns are quite

Figure 4. General structure of transit service based on analytical service standards.



different. The express speed of 20 mph possible in Hartford due to its extensive expressway network is double the average local speed of 10 mph in the peak, so express service is warranted according to one of the equations in the service standards.

The transit service area, under these standards, is divided into two concentric rings that encompass roughly equal numbers of trips to the CBD, as shown in Figure 4. The inner ring is served by local routes. The outer ring is served by routes that, on inbound trips, begin at the outer edge of the area, make local stops until reaching the boundary of the local service area, and then run express (nonstop) to the CBD. Transfer points are established at the local and express service-area boundary for intra-corridor trips.

On the west side, the area within 4 miles of the CBD is served by local routes, and the area 4-7 miles from the CBD is served by express routes. The express routes make local stops in the outer area but then run express (without stops) on an expressway facility for the last 4 miles to the CBD. The 7 local routes are spaced 0.445 radians apart, which results in an average walk time of 5.6 min or an average walk distance of 0.28 mile. The local routes operate at 14-min headways and charge a one-way fare of \$1.20.

The west-side express routes are spaced 0.328 radians apart, which results in an average walk time of 6.9 min or an average walk distance of 0.35 mile. The express routes operate at 17.3-min headways and charge a one-way fare of \$1.27, only \$0.07 more than the local routes. Express routes have higher speeds and are thus more attractive relative to local service in this regard, but they also have wider route spacings and longer headways. Because the standard fare is strongly dependent on the service quality, these offsetting effects decrease the fare differential from local service.

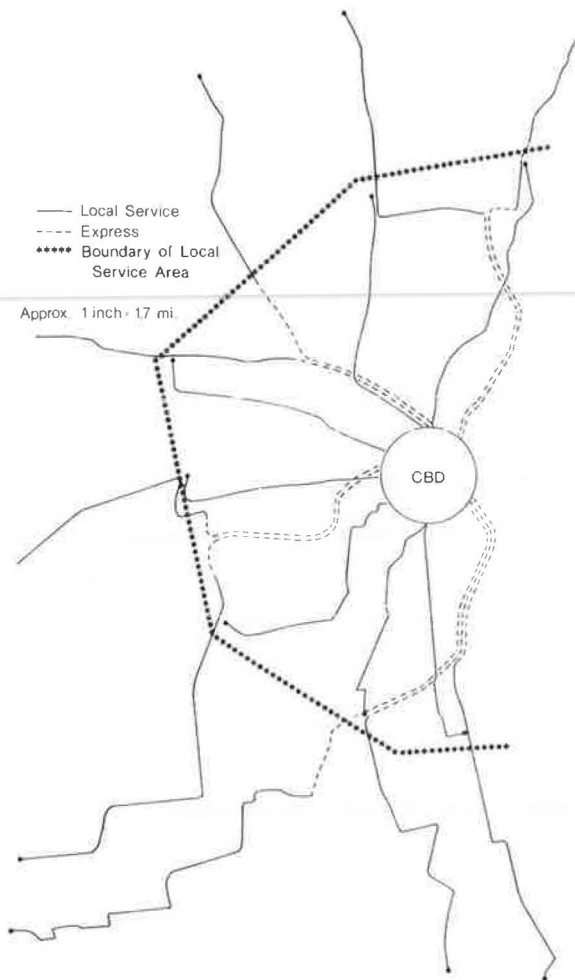
East-side results follow a similar pattern, although with a smaller service area and lower service levels due to the lower trip density. The express fare is about the same as the local fare because the express headways and route spacing are so much poorer than the local ones.

Figure 5 shows a route pattern based on these results. It is quite different than the current service. Routes are much more widely spaced in the inner area, which provides a lower level of service than the current system. In the express zone, however, there is more service than currently provided. These results raise equity issues in the distribution of transit service and its benefits and costs.

These services are then assessed by using a sketch-planning model, which predicts the impacts given in Table 3. The peak-hour ridership is 3985 as opposed to the current total of 6874, almost a 50 percent reduction. Revenues are \$4822 as opposed to the current \$3437, a 40 percent increase. Operating costs are \$2288, a reduction of over 50 percent. Net user benefits are estimated to be \$2281 as opposed to the current \$6245, a reduction of over 60 percent. Average passenger loads are near 50 on the west side and 30 on the east side.

These results are, of course, quite extreme. This is due principally to the use of an objective function that is unlikely to represent current transit goals in most cities, and possibly also to the extension of the demand coefficients beyond the range of data on which they were originally calibrated. The traveler reaction to the long walk distances that emerge from the model may be quite different than their reactions to the shorter distances they now walk. However, recalling that these service standards are functions of the cube root of the de-

Figure 5. Route structure for profit maximization (west side only).



mand parameter for walk time, the walk coefficient would have to be in error by a factor of 8 to halve the route spacing, which still leaves an average walk distance of 0.14 mile or a walk time of 2.8 min. In general, the issue of sensitivity to walk distance is one on which demand models and operators have different beliefs.

Profit Maximization with All Local Service

Table 4 gives the results of profit maximization with all local service to contrast it with the express- and local-service patterns. The major differences are that the service area is slightly smaller, headways and route spacing are a compromise between the separate express and local optima, fares are slightly lower, and passenger loads per bus are much higher. The load of 85 found for the west side exceeds the capacity of standard buses and suggests the use of articulated buses. The all-local-system case is inferior to the express system in all impacts, even if the heroic assumption is maintained that unit operating costs and average speeds are equal for standard and articulated buses. Operating profit is \$2379 instead of \$2570 and user benefits are \$2149 instead of \$2298.

In fact, the magnitude of the passenger loads in this all-local case (and the all-local case for other objectives) may suggest the consideration of articulated buses in areas of similar or higher density than Hartford. If express service can be

Table 4. Profit maximization with all local service.

Item	West Side	East Side	Total
Local route length (miles)	6.8	5.8	--
Local route spacing (radians)	0.328	0.491	--
Local route headway (minutes)	15.5	20.8	--
Local fare (\$)	1.17	1.05	--
Local peak revenue (\$)	3678	713	4391
Local peak ridership	3146	682	3828
Local peak costs (\$)	1504	508	2012
Local net user benefit (\$)	1810	339	2149
Local profit (\$)	2174	205	2379
Local passenger load per bus	85	46	--

Table 5. Maximization of profit plus half of net user benefit with express and local service.

Item	West Side	East Side	Total
Route length (miles)			
Local	4.1	3.8	--
Express	7.2	6.5	--
Route spacing (radians)			
Local	0.396	0.596	--
Express	0.290	0.447	--
Route headway (minutes)			
Local	12.8	17.6	--
Express	15.7	22.1	--
Fare (\$)			
Local	0.82	0.75	--
Express	0.87	0.77	--
Peak revenue (\$)			
Local	1905	390	2295
Express	2019	441	2460
Peak ridership			
Local	2316	522	2838
Express	2314	576	2890
Peak costs (\$)			
Local	922	324	1246
Express	1265	427	1692
Net user benefit (\$)			
Local	1751	351	2102
Express	2068	429	2497
Profit (\$)			
Local	983	66	1049
Express	754	14	768
Objective value (\$)	3646	470	4116
Passenger load per bus			
Local	62	36	--
Express	56	38	--

operated, it appears that this option dominates the all-local articulated-bus option on the technical grounds being considered.

Maximization of Weighted Profit plus Net User Benefit with Express and Local Service

Table 5 gives the results of adopting service standards to achieve the objective of maximizing the sum of operator profit and net user benefit, with user benefit being weighed only half as much as profit. Compared with the profit-maximization objective, the service area is larger, the route spacings and headways are improved, and fares are lower. Compared with the current system, there is less local service but more express service.

Ridership is 5728 in the peak hour, slightly lower than the current level of 6874. Revenues are \$4755 as opposed to the current \$3437, and costs are \$2938 instead of approximately \$5400. Thus, an operating profit of \$1817 is still obtained. Net user benefits are \$4599 as opposed to the current \$6245.

Many of the same patterns appear in these results as in the previous case. Route spacings are quite wide, which results in an average walk of 5.1 min

Table 6. Maximization of net user benefit, subject to break-even financial constraint, with express and local service.

Item	West Side	East Side	Total
Route length (miles)			
Local	4.2	3.8	--
Express	7.3	6.6	--
Route spacing (radians)			
Local	0.362	0.580	--
Express	0.264	0.434	--
Route headway (minutes)			
Local	11.8	17.3	--
Express	14.5	21.6	--
Fare (\$)			
Local	0.39	0.66	--
Express	0.42	0.68	--
Peak revenue (\$)			
Local	1227	376	1603
Express	1243	422	1665
Peak ridership			
Local	3121	570	3691
Express	2964	621	3585
Peak cost (\$)			
Local	1108	342	1450
Express	1532	453	1985
Net user benefit (\$)			
Local	3103	413	3516
Express	3432	499	3931
Profit (\$)			
Local	119	34	153
Express	-289	-31	-320
Passenger load per bus			
Local	71	38	--
Express	60	39	--
Shadow price (Y ₂)	1.23	1.70	--

(0.26 mile) for west-side local users and 6.3 min (0.32 mile) for west-side express users. Headways are fairly long and fares are somewhat higher than the current \$0.50 fare. Passenger loads per bus are relatively high but not beyond the capacity of standard buses with standees.

Thus, a substantially different operating policy results from this analysis than the status quo: 60 percent of all service operated is express, route spacings are about triple the current ones, fares are about 50 percent higher, and an operating profit is made.

Maximization of Net User Benefit, Subject to Break-Even Financial Constraint, with Express and Local Service

Table 6 gives the results of applying service standards to achieve the objective of maximizing net user benefits subject to a break-even financial constraint in the peak period. Again, express and local services are warranted. The west-side service is very similar to the previous case except that a lower, \$0.40 fare is charged. The service area is the largest of any of the cases examined, and the headways, fares, and route spacings are the lowest. Even so, the average walk time is 4.8 min (0.24 mile) for west local routes and 5.9 min (0.30 mile) for west express routes. One other impact measure can be computed in this case--the shadow price related to the break-even financial constraint. The approximate shadow price is \$1.23, which is interpreted that an extra dollar of subsidy would produce \$1.23 in extra net user benefit. This measure can help decisionmakers in assessing the level of deficit they are willing to support.

The total ridership in this case is 7276, slightly higher than the current 6874. Revenues are \$3268 as opposed to the current \$3437. Costs are approximately \$3435 as opposed to the current \$5400. (The deficit is \$167, which is an approximation error.) Net user benefits increase to \$7447 from an estimated \$6245 in the current system.

This solution demonstrates a system in which fares are approximately equal to current fares and which operates at a break-even level instead of only covering two-thirds of its peak-hour operating costs as does the current system. Net user benefits and ridership increase over current levels, and passenger loads are quite manageable, although large vehicles are required for west-side local service.

This result emerges because routes are widely spaced in the inner area where little ridership is lost through these changes, while service is improved over current levels in the express zone where considerable ridership can be gained. The express service lowers running times significantly that, in turn, reduces costs, increases ridership, and allows a higher fare to be charged, which generates more revenue. Even in the express zone, however, routes are widely spaced.

CONCLUSIONS

Several general conclusions can be drawn from this assessment of service and fare standards, and other conclusions can be drawn with reference to specific objectives. These conclusions can be viewed as general directions of change for which there is significant analytical support, but detailed recommendations must be based on further analysis and consideration of institutional factors.

It appears that service standards can be used to improve the productivity and performance of transit systems substantially. Especially in the area of route structure, many current systems do not appear to have been assessed or designed systematically and general restructuring could provide substantial benefits. A possible substantial expansion of express service and a coordinated fare policy to reinforce the service objectives are also key elements of the standards.

Bus transit systems may also be able to substantially improve their financial performance, at least in peak periods. This result comes from possibly raising fares above current levels, increasing average route spacings (or distance between routes) substantially over current levels, leaving headways near typical current levels, and operating over half of total transit service as express service. Under some sets of goals, little or no user benefit is sacrificed to attain these financial results.

Average passenger loads per bus at the peak load point in the peak direction under these operating strategies are typically near the capacity of standard bus vehicles. In areas in which express service is not feasible due to lack of expressways or other suitable roadways, all routes must be operated in local service; these generally produce passenger loads higher than the capacity of standard buses. In these cases, either headways and route spacing must be decreased to meet capacity requirements or larger vehicles must be used. It is possible that low-cost light-rail transit systems might be effective alternatives in high-density areas in which express service cannot be offered, but that analysis is not carried out in this paper.

Major issues of equity and the distribution of benefits are raised by the analysis. For most cities, the analysis implies service cuts for the inner area in which many carless and low-income people live, and service expansions or at least smaller service cuts in the relatively more affluent and mobile outer sections of the city or suburbs. However, it must be noted that these results are based on demand-model parameters that do not treat market segments such as low-income groups separately but assume that all travelers in the city are iden-

tical. These equity issues must be addressed seriously if any service charges are considered by a local area. This is a function for minimum service standards.

Turning to objective-specific findings, the profit-maximizing standard fare is over \$1.00 (in 1980 dollars) in most cases. Typical headways of 15-20 min and average distances of about 1 mile between routes result, which are larger than current practice in Hartford and most other cities. Revenue-to-operating cost ratios near 1.5 in the peak period appear possible.

The objective of maximizing the weighted sum of operator profit and net user benefit yields a range of service standards, depending on the weight placed on net user benefit. In most areas, standard bus vehicles will be filled to capacity under this objective. About 60 percent more service is operated in this case than in the profit-maximizing case. As the weight placed on benefit decreases, the solutions approach the profit-maximizing case. Even with net user benefit weighted at half the value of operator profit, the transit system may still make a small operating profit in the peak period at fares slightly higher than current levels.

The third objective of maximizing net transit user benefits subject to a deficit constraint was examined by using a break-even criterion. Results are similar to the previous case with benefit weighted less than profit.

To summarize, the analysis suggests that major restructuring of transit routes, fares, and headways is possible, and that service standards can be a vehicle for making these changes. A heavier reliance is placed on users' walking to bus stops, substantial express service is initiated, and some level of operating profitability (at least in peak periods) appears possible. These major changes may result in disbenefits to inner-area residents and increased benefits to outer-area residents. Systematic analysis of transit service nevertheless appears to have significant potential for increasing transit productivity, benefits, and financial performance.

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Abridgment

Assessing User Needs in Design of a Management Information System for Rural Public Transportation Services

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The feasibility of designing a comprehensive management information system (MIS), which will assist in the performance of management and operations tasks involved in the provision of rural public transportation, depends on the definition and understanding of the relations among information gathering, processing, and reporting activities and those areas of administration and operations that might avail themselves of the advantages of a comprehensive MIS. The initial analysis of user needs and constraints, which is the focus of this paper, should indicate in specific terms the ways in which an MIS will contribute to the performance of information-related activities within the transportation operation. A step-by-step process is outlined to provide guidance to the initial MIS development activities and to assist in the structuring of a low-cost, comprehensive, and efficient MIS that will meet the information gathering, processing, and reporting requirements of rural public transportation authorities and operators.

The development of information gathering and processing techniques and the construction and maintenance of data sets for the purposes of administering and operating public transportation services are becoming ever more important objectives for government agencies, transportation authorities, operators, and the riding public. Current fiscal constraints, energy shortages, and the resulting emphasis on service efficiency and productivity are leading to increased dependency on the availability of appropriate and accessible information for transportation policymaking and management.

The continued viability of public transportation, particularly in rural areas where the service population is widely dispersed, where costs per trip tend to be high, and where systems are currently facing reductions in operating subsidies (Section 18 funds, Urban Mass Transportation Act of 1964, as amended) as well as other cutbacks in local, state, and human service agency budgets, rests especially on the ability of those who are responsible for the delivery of services to monitor carefully both the technical and social efficiency of these systems. The design and implementation of a comprehensive management information system (MIS), the advantages of which have long been recognized in the private sector, which will meet the data requirements of rural transportation agencies with full recognition of the limited financial and personnel resources available to such agencies, is a key factor in the maintenance of efficient and coordinated programs.

For the purposes of this paper, we have grouped the major management information needs of regional and local public transportation agencies and operators in rural areas into four general areas of activity:

1. Billing and accounting needs (1-3),
2. Monitoring and evaluating needs (4, and Section 15 of the Urban Mass Transportation Act of 1964, as amended),
3. Reporting requirements (5), and
4. Routing, scheduling, and dispatching needs (6).

Particularly in smaller transit facilities, these four broad categories encompass the minimum information-related activities that must occur to meet funding and report-filing regulations and ensure effective delivery of service.

MIS OBJECTIVES

Once the decision has been made to investigate the possibilities of designing a comprehensive MIS, and the proposal has been justified in the light of other uses for the start-up funds and time elsewhere in the operation, the process of identifying system objectives, constraints, and desirable features may begin (7). MIS objectives should be defined as specific targets that indicate how the MIS will support various aspects of the transit service and should be expressed in terms of what managers and operators will be able to do once their information requirements have been satisfied.

Thus, the basic sequential flow of the MIS development process is initiated with an analysis of existing data needs and current system capabilities and deficiencies. Participants in this first definitive step might categorize information system deficiencies as either those gaps that result from what information is lacking in the current system or as deficiencies in the structure, organization, storage, or use of information.

A review of the work tasks and schedules of each employee, including managers, bookkeepers, dispatchers, drivers, and others, and the information requirements that correlate to their tasks will reveal both the data needs and the deficiencies in the data and/or data structure that may be present in the existing system. As a result of this effort, the preliminary outlines of the MIS that might be designed to maintain and manipulate the necessary information and the specific technology and personnel required to process the information will become evident. The delineation of appropriate questions for the transit manager to ask with regard to specific goals in each category will aid in the clarification of the point along the simple-complex spec-