Strategy For Implementing Integrated Regional Transit

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The recent desire for expanded urban public transportation generated by increased environmental and energy awareness and by the negative impact of extensive freeway construction has increased interest in the more efficient use of existing transportation facilities and in finding more cost-effective means of improving and expanding public transit service. A promising solution to these problems is in restructured conventional and paratransit services that are operated as comprehensive regional transit systems integrated operationally, physically, and institutionally. This paper examines the implications of embarking on a 10-year strategy to implement such a system. Three levels of ridership response are assumed, and their effects on system scale and operating policy decisions at biennial intervals are studied. The operating cost and deficit implications of these three response levels are then traced, yielding insight into the feasibility of an evolutionary strategy. It is concluded that, if a high ridership response results, the dual goals of expanded and improved transit service and reduced operation deficits can both be accomplished.

The role of transit in providing travel services in the metropolitan areas of the United States has been dramatically altered in the last quarter century. During the 1950s and early 1960s, extensive highway investments, including urban portions of the Interstate highway program, enabled swift private-mode travel to and within suburban areas, fostering the dispersal of all kinds of development in many urban areas (1). By the late 1960s, the high capital, social, and environmental costs of this policy had generated sufficient opposition to slow or halt many urban freeway developments (2). A dramatic reversal of the steady neglect and decline of public transportation was sought in the early 1970s to achieve broader environmental and planning goals. Transit authorities in several cities became active in planning or constructing heavy rail systems, and in extending conventional bus and paratransit services. However, this expansion in service and coverage, coupled with inflated operating costs, has led to increased operating deficits in most major systems (Figure 1). Faced with a general financial squeeze, many municipalities have reduced service in an attempt to reduce transit subsidies, and turned to state and federal governments for transit operating assistance. At the same time, the regionalization of transit operating agencies has brought pressure from suburban communities to expand their local transit service, which is often a difficult task because of the low residential densities and dispersed travel patterns of suburban development.

Responding to these diverse pressures, the U.S. Department of Transportation has shown increased concern with improving the planning and operation of urban transportation systems. Two visible manifestations are the transportation systems management element (3), now required in the 3-C planning process, and the service and methods demonstration program (4). The department is also continuing its research on improved transit operating strategies. The object of these efforts is to meet the goals of both of the major thrusts of this decade: transit expansion and deficit reduction.

POTENTIAL OF INTEGRATED TRANSIT

One of the most promising strategies is the implementation of integrated regional transit service. This concept, expanding on the tenet that different conditions will require different transit modes and operating policies (5, 6), consists of the coordinated operation of a variety of modes and suppliers. Transit service would be reconfigured to improve service in the cities and expanded to provide effective coverage in the suburbs.

Full integration, however, goes beyond the coordination of spatially diverse transit services. An integrated regional system should be able to respond to temporal changes in travel volumes and patterns, both those occurring during each day (i.e., between peak and off-peak travel) and slower changes caused by urban development and transportation policy. In a number of metropolitan areas, the institutional environment would have to be broadened to allow both the coordination of system components and their operational responsiveness to diverse demands.

The potential of integrated regional transit has been examined under the sponsorship of the U.S. Department of Transportation (7). The thrust of the overall study was the estimation of the impacts of dramatic increases in transit patronage on system structure and performance. Models, including express bus, exclusive lane operation, subscription service, dial-a-ride, and several route-based feeder options, were developed to examine the cost and service attributes of a variety of system components. These models were used to test integrated public transit systems operating in a typical medium-size metropolitan area (population 800 000) over a range of assumed ridership levels. The primary findings of this typical-city analysis were that, as regional modal split increases,

1. Significant but rapidly diminishing economies of scale exist;
2. Significant travel-time improvements are possible, but private-mode service is not matched in many markets;
3. Hybrid modes operating with characteristics of both fixed-route and demand-responsive transit are desirable in many local service areas; and
4. The dedication of certain roadway facilities to transit is appropriate.

The analysis provided insight into system design and operation at different levels of transit patronage, which enabled the study of such questions as, How much of the region should be served? What modes should be operated? and Where? Snapshots of a potential evolution of an integrated transit system derived from this analysis are shown in Figure 2. The analysis suggested that a transition from system A (similar to today's typical fixed-route system) to system C (an integrated transit system carrying a significantly larger share of regional trips) was possible, and could be accomplished in an incremental and orderly manner. Because of uncertainties in system operation and ridership response, however, some questions remained unanswered: How much of the transition is feasible? and What are the consequences of trying? The second phase of the study (7), reported below, addressed these questions.

INCREMENTAL EXPANSION

A strategy for implementing an integrated regional transit system over a 10-year period (Figure 3) was examined. The strategy is incremental, i.e., it is a series of 2-year investments or steps, each designed in the light of the market response to the previous steps.

STRATEGY COMPONENTS

In designing each step, the planner has seven categories of measures at his disposal.

Group 0 measures consist of the measures required prior to the development of an expanded and integrated transit system and were not explicitly included in this investigation. They include an overhaul of the institutions and regulations under which transit service is provided. Management effectiveness is increased, equitable and reasonable labor agreements are negotiated, system maintenance facilities are upgraded, and passenger and system security is ensured.

Group 1 measures revamp routes and schedules so that transfers are coordinated and service is geared to the rhythms of the urban system. Unified user charges to reflect differences in trip distance, time of day, quality of service, and type of user are developed. Prepaid passes are made readily available. Routes, vehicle destinations, and boarding and alighting zones are clearly indicated. Easily read maps and schedules for the system, service areas (neighborhoods), and routes are distributed, and an information center is established.

Group 2 measures expand the system to serve new users. A larger fleet allows new circumferential routes, denser radial routes, more frequent service, and expansion into the suburbs, including the introduction of flexibly routed, demand-responsive local services. Midday and evening services are substantially improved, better using the transit system capital and labor resources.

Group 3 measures increase the efficiency of and accessibility to public transit operation through fixed-facility expansion. They include the dedication of existing roadway to the exclusive use of transit (or high-occupancy vehicles, including van pools and car pools), the construction of new rights-of-way for the sole use of transit, the installation of traffic control devices for priority treatment for transit vehicles on arterials and freeway ramps, and the use of off-vehicle fare collection at high-volume points, all of which improve driver and fleet productivity. Suburban transfer and terminal facilities designed to serve a wide range of transit access modes—park-and-ride, park-and-pool, feeder bus, and walking—are constructed to tap potential network economies.

Group 4 measures are external measures that encourage the efficient use of the metropolitan area transportation infrastructure. Flexible and staggered work hours lessen the ratio of peak to off-peak travel, thereby improving fleet utilization. Car-pool-incentive programs promote the efficient movement of those trip makers who are not diverted to public transportation. Major activity center circulation improvements (such as covered walkways, grade-separated passageways, and moving platforms) reduce the relatively inefficient use of line-haul vehicles for distribution and internal circulation.

Group 5 measures consist of automobile disincentives such as automobile-restricted zones, increased parking fees in major activity centers, and automobile-congestion tolling.

Group 6 measures consist of transit deficit-reduction measures such as fare increases and the conversion of some doorstep local transit services to hybrid and fixed-route operations.

These measures form the building blocks for the incremental steps of the expansion strategy shown conceptually in Figure 3. The measures in categories 0 and 1 would be implemented at the beginning, with the others implemented in varying degrees throughout the strategy according to the insights gained in previous analyses (6, 7, 8) and experiments.

RIDERSHIP RESPONSES

Instead of an approach that predicts the market response to each step of the transit improvement strategy, a parametric approach was taken. Alternative levels of response were assumed (the end points of the linear growth functions are shown below) and were combined with a corresponding series of actions to form three divergent evolutionary paths.

Time and Response	Modal Split (%)		
	Daily	Peak	Off-Peak
Year 0	5	10	3.5
Year 10			
Low response	7.5	15	5
Medium response	15	25	10
High response	25	40	20

At the beginning of the strategy, the daily modal split in the region is 5 percent, which is typical of many medium-size urban areas. The high-response path assumes that a fivefold increase in transit ridership and a complete integrated regional system are achieved by the end of the transit improvement program. In the moderate-response path, a final modal split of only 15 percent precludes the service densities possible in the high-response path, although a regional coverage system can be operated. Finally, the low-response path assumes only a 50 percent increase in transit ridership, reflecting a public that is generally unresponsive to improvements in transit service and extensions in coverage. In this case, the final system would not serve all geographic markets in the region.

STRATEGY RESULTS

The financial consequences of the three expansion paths, including the deficits resulting from a range of fare policies, were traced. As the starting point, the average operating costs (assuming constant base-year prices) at each step in the 10-year strategy are plotted in Figure 4. Economies of scale are generated in all three paths, with the largest economies accompanying high ridership response.

The first fare policy is that of a flat 50-cent door-to-door average fare (regardless of how many transfers may be required) until the eighth year when it is increased to 55 cents. The deficits for this fare policy are also shown in Figure 4. While none of the paths produces a surplus, significant decreases in the per-passenger deficit occur after the fourth year with the medium and high ridership responses, and after the eighth year with the low response.

The total daily (i.e., typical weekday) operating costs and deficits of this fare policy are plotted in Figure 5. The total operating costs clearly rise, but due to economies of scale, the increase is less rapid than is the ridership. More significant are the deficit curves, which indicate that embarking on a major transit improvement strategy does not necessarily result in a runaway operating deficit. The deficits occurring during the 10-year period, while significant, act as seed money.

Figure 1. Trends in transit deficits.

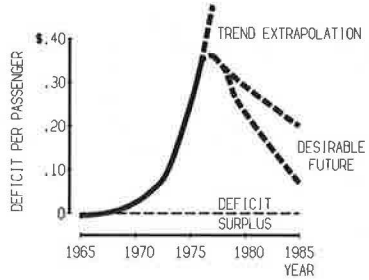


Figure 2. Potential of integrated regional transit.

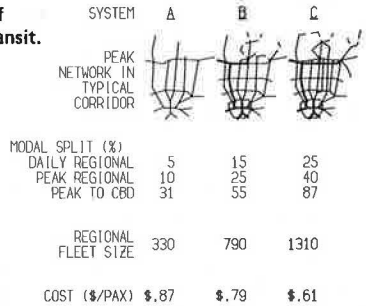


Figure 3. Incremental evolution of integrated transit.

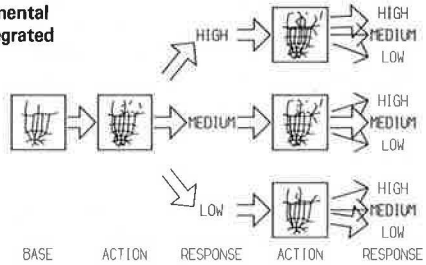
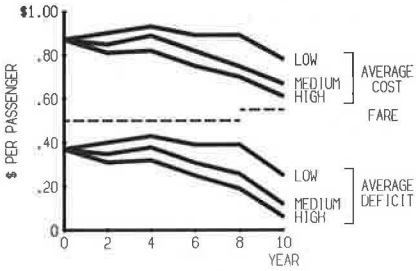


Figure 4. Average costs and deficits of flat fare policy.



By the end of period, the total deficit in all paths has returned to earlier levels, even though more areas are being served by transit.

Alternative fare policies can also reasonably be assumed. For example, the increase in average trip length that accompanies increases in regional modal split, the increased use of flexible and hybrid modes that can offer doorstep service, and the increase in frequency of service and direct routes in the fixed-route system could justify a 50 percent increase in average fare over the 10-year period. The average cost, fare, and resulting deficits of this fare policy are shown in Figure 6. In contrast to the flat-fare case (Figure 4), a per-passenger surplus is achieved by the end of the 10-year strategy under high and moderate ridership responses, and even with a low response, transit operations almost break even.

The total daily deficits that result from the increased fare policy are shown in Figure 7 (distance and service-based fare). The per-passenger surpluses (Figure 6) translate into large total surpluses by the end of the 10-year period if the ridership response is at least moderate, which is an appealing prospect.

Figure 7 also shows the deficit that results from a less stringent fare policy. If average fare increases are due only to increased trip length, and the increases range from 30 to 40 percent of those assumed with the distance and service-based fare policy, this policy will yield a break-even transit operation at the end of 10 years if the response is high and a 60 percent reduction in the daily deficit if the response is moderate.

SUMMARY OF RESULTS

The key financial implications of the 10-year expansion strategy are summarized below.

	10-Year Program Deficit ($)		Tenth-Year Deficit	
Response	Total	Seed Funding	Annual ($)	Per Passenger (¢)
Do nothing	180 000 000	0	18 000 000	39.9
Low	197 000 000	17 000 000	14 000 000	20.8
Medium	217 000 000	37 000 000	9 500 000	7.6
High	252 500 000	72 500 000	3 000 000	1.3

The first row shows the results (in constant 1975 dollars) of not doing anything: 10 years of $18 million deficits. The remainder shows the strategy results for each of the three ridership response levels. The difference between the improvement program and the do-nothing deficits represents the required seed funding, or the cost of the program. What the cost has bought in terms of reduced deficits is shown by the tenth-year annual deficit column. For example, if the high ridership response is achieved, then the annual deficit can be cut from $18 million to $3 million with a 10-year investment of $72.5 million. This saving of $15 million/year allows the investment to pay for itself in less than 5 years. Similarly, the medium and low ridership responses require investments that pay for themselves in 4⅓ years and 4¼ years respectively. Therefore, when a 10-year improvement program can be tailored to the ridership response that it generates, its cost can be recovered in about 15 years (5 years after its conclusion). The other benefits of an expanded, integrated regional transit system—improved service to users, decreased roadway congestion, decreased energy consumption and air pollution, and efficient use of existing roadway capacity—are substantial bonuses of the improvement program (7).

IMPLEMENTING THE STRATEGY

Despite the clear benefits, the implementation of the improvement strategy will not be simple. While some of the components are in operation in some places, such as the Shirley Highway (Washington, D.C.) and Market Street (Philadelphia) bus lanes, or are being demonstrated as part of the service and methods program, such as the Knoxville transportation-brokerage system and the Rochester dial-a-ride system, the complete package has not been assembled anywhere. The Minneapolis-St. Paul region is currently undertaking the group 0 components in anticipation of such an attempt, and in Ann Arbor and Rochester transfers between paratransit and line-haul services have been coordinated.

The improvement strategy uses flexible services for pump priming, i.e., for attracting additional patronage

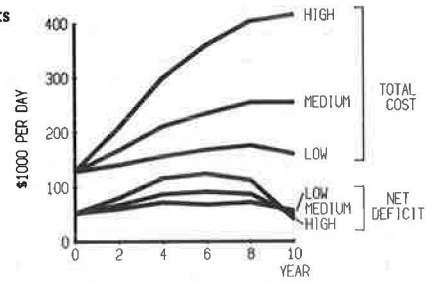


Figure 5. Daily costs and deficits of flat fare policy.

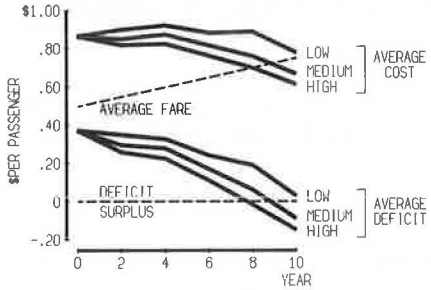


Figure 6. Average costs and deficits of distance and service-based fare policy.

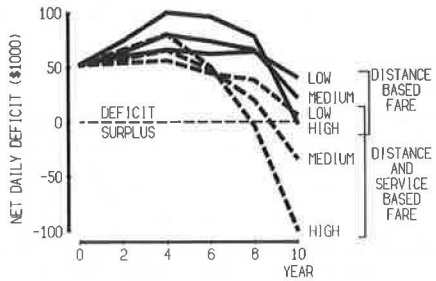


Figure 7. Daily deficits of increasing fare policies.

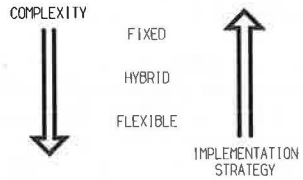


Figure 8. Implementation dilemma.

(9). As ridership grows, the system gradually shifts to more structured operations (e.g., fixed-route and point deviation) in which faster and more frequent service can be offered at lower cost (7). Unfortunately, the flexible services are the most difficult to operate effectively and reliably. This dilemma, posed in Figure 8, indicates that comprehensive transit-improvement strategies should not rely heavily on flexible services until more is learned about their successful operation. Meanwhile, less complex services such as subscription and route deviation might be used as pump primers.

Experience in Ann Arbor, Michigan, suggests that there can be more compelling criteria than mere economic efficiency when making transit operating decisions. Doorstep services, for example, which are very attractive to particular market segments, may have to be retained beyond their theoretically useful life in response to political pressures. But offered as an optional service with a premium fare, they could provide the public with a broader choice of service, which is itself a desirable social goal.

Having described some potential barriers to implementing a major transit improvement strategy, some indication of success is in order. As part of a response to declining ridership, the transit authority in Rochester, New York, implemented a free downtown zone and reduced off-peak fares. Not only did the ridership increase, but the reductions in the peak fleet requirements resulted in a significantly reduced operating deficit.

CONCLUSIONS

This study has shown that goals of expanded and improved transit service and of reduced operating deficits can both be accomplished, and that integrated regional transit is a viable candidate for achieving these goals and the corequisite ridership response. The rich variety of service options provided by this concept helps to create a travel marketplace that should allocate both public and private resources more efficiently than is done in current transportation systems. Together with increased transit coverage, these options could foster the public support needed to undertake necessary institutional changes.

Furthermore, an incremental strategy can be designed for implementing integrated regional transit. The flexibility inherent in this approach is very comforting for, with careful monitoring, large investments in risk capital or seed money (in the form of increased deficits during the 10-year implementation period) are required only when commensurately large payoffs prove feasible. This is the benefit of the incremental approach, which allows goals and actions to be adjusted on the basis of experience. Thus, even with a low ridership response, a slight deficit reduction can be produced, allowing the seed money to be recovered by the fifteenth year following strategy implementation.

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Abridgment

Bus Transit Route Demand Model

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There have been transit-demonstration grants over the past 12 years in almost every city in America. While the general results of these demonstrations are evident in increased ridership and the improved public image of transit, the particular results necessary for further detailed improvements in the system have not been available because there is no accepted model of bus ridership that can be used for data collection to document the findings and results of transit demonstrations.

The need for a detailed model for transit ridership is clearly documented (1). In the day-to-day operation of bus companies there is no way to estimate the ridership effects of changes in headways, route extensions, fare increases, crowding on buses, increased central business district (CBD) parking rates, changes in the cost of gasoline, and so forth. While rules of thumb, such as the 30 percent shrinkage factor for fare increases, can be used, there is no method for correlating and combining the observed effects of other, more recent, fare changes into these rules.

For example, the city of Atlanta (2) purchased the privately owned Atlanta Transit System in March 1972. Over the next year or so they (a) lowered the fare to 15 cents, (b) purchased 490 new buses, (c) improved headways, (d) expanded service periods, (e) extended lines, and (f) created five new lines. The result was an overall 30.2 percent increase in transit ridership by June 1973. A study of systemwide rider characteristics was made to identify new and old riders and their characteristics. However, no individual route information is available, and, without such a breakdown, it is impossible to identify the effect that each of the six separate improvements had on transit ridership (2).

The story is similar for many cities. With new sources of funds and public ownership, there have been new routes, new buses, new hours, and more passengers. Austin, Texas, since 1972, has increased the number of route-kilometers by 77 percent and reduced off-peak fares to 15 cents. Ridership has increased from 300 000 to 500 000/month, but again there is little or no information to identify the effects of each change or of the further changes that should be made to fine tune the system.

THE PROPOSED MODEL

The aim of the model is the prediction of the effects of fare changes, route relocations, headway changes, and such on either an existing or a proposed bus route. The model should be applicable on a single-route basis so that systemwide models would not be required every time a new route extension was being considered. Moreover, the data requirements should be normally available to the operator of the transit property. The model was envisaged as an operations or short-term planning model rather than as a long-term one.

The model is based on the fact that transit ridership is related directly to the existence of both population and employment within good access times of the route. It includes land use variables in a product form (population times employment) similar to the gravity model. Access time is considered for two distances, 150 and 300 m (500 and 1000 ft). The population is divided into two groups: non-automobile-owning and automobile-owning households. The effects of fares, headways, and such are determined by multiplicative factors that modify an average forecast of ridership in a demand-elasticity type of adjustment.

To make the model useful for operations planning, the demand is separated into peak and off-peak time periods, and, to exploit the predominant characteristics of transit ridership, boarding and alighting passengers and the direction of movement (whether inbound or outbound from the CBD) are considered separately.

The general form of the model is then

$$\text{Demand} = (\text{population} \times \text{employment}) \times \text{demand-adjustment factors} \quad (1)$$

where

demand = (on or off) (inbound or outbound) (by time period),
population = (for automobile or non-automobile-owning household) (for 150 or 300 meters),