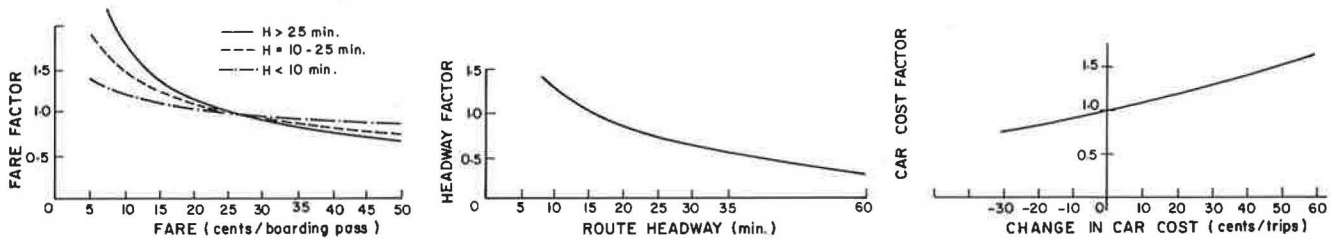
Figure 1. Proposals for fare, headway, and automobile cost factors.



4 and 5 indicate the degree of fit for the coefficients listed in Tables 1 and 2 respectively.

Figure 1 illustrates the demand-adjustment factors for fare, headway, and car cost to the CBD (generalized cost) of the model.

SUMMARY

The calibration results thus far have been promising for the two cities studied. The total route ridership is predicted with a standard deviation of about 12 percent, and the data confirm the basic model structure. Because of the large number of parameters to be estimated it has been necessary to do special field studies to validate some of them. These are currently under way.

The transferability of coefficients from one city to another is not directly possible. However, the adjustment factors (1.0, 0.5, and 1.66) required apply to the whole city. Preliminary indications are that these adjustments can be explained by general city character and climate.

The model, in controlling for differences in automobile ownership, population, access to route, headways, and such, shows considerable promise in comparing the performance of different routes and systems, and, when sufficient route data have been gathered to allow for a more confident estimate of the parameters, it should be very useful for the planning, design, and operation of urban bus routes.

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Mass Transit Guidelines Versus a Consumer Orientation in Public Transportation Systems

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This paper evaluates present and proposed mass transit guidelines that contain level-of-service criteria for public transportation. The limited scope of public transportation services that is typically contained within such guidelines is emphasized. The rationale presented supports the need for expansion of these guidelines to include the total range of public transportation alternatives and a consumer orientation. A review of the research concerning the attitudes of the ridership of transit systems illustrates the existing gap between the transit desired and that proposed in the guidelines. Areas for further research are also given, and a time frame for change in which public marketing of urban transportation systems is discussed and set in perspective is given.

The relatively recent shift from private to public transit operations and the ensuing local and state support in the form of capital and operating subsidies have caused perplexing problems for local governments. These governmental bodies traditionally have been involved with public support for such entities as police and fire protection and over the years have developed standards and appropriate cost-estimating procedures for those services. Capital and operating subsidies for public transit, however, are relatively new in many urban communities, and there are few standards and little knowledge about what should or should not be provided. Most gov-

ernment officials are seeking to develop standards and guidelines for public transit, the cost of which is consuming an ever-growing portion of their budgets.

The states (particularly those with bureaus of mass transit), rather than the local communities, have taken the lead in the development of guidelines for mass transit to ensure proper allocation of state-level funds for the support of local public transportation. Most notable are Pennsylvania (1), New York (2), and California: For example, Pennsylvania has had operating guidelines and standards for a statewide mass transportation assistance program since January 1973 (1).

Some individual transit authorities have also developed guidelines for service development. The most notable of these are the recent guidelines issued by the Massachusetts Bay Transportation Authority (3), Tri-Met of Portland (4), and the Denver Regional Transportation District (5). Officials in the U.S. Department of Transportation have also developed similar guidelines for public transportation (6).

LEVELS OF SERVICE

A common element of all of the guidelines mentioned above is the part entitled levels of service. This section typically lists the types of services to be offered, the frequency of such service in the form of headways, the availability of seating capacity, and special items (e.g., the density of the route network). It is also standard to include passenger-stop directives, passenger-shelter recommendations, and effective times for the trial of new service. These guidelines usually contain some directives pertaining to the marketing activity desired with respect to the provision of transit services. A few direct that if the minimum ridership levels are not achieved by the recommended level-of-service coverage, then the first alternative should be to analyze the marketing activity to determine whether the service offering is being correctly communicated to the potential markets.

An unfortunate and perhaps devastating aspect of these mass transit guidelines is the limited definition of public transportation-service offerings. That is, the level of service is assumed to be that of the traditional fixed-route, fixed-schedule transit system provided in the traditional manner of public ownership and operation. A few exceptions to this general rule are the provisions for special uses of the transit vehicle, in most cases the bus, for the downtown circulation system or for modification in a specialized program for elderly and handicapped individuals who cannot readily use the traditional system. However, federal law is mandating some form of change in traditional operating systems, and it is the threat of losing their operating subsidies that is making transit systems modify their fixed-route, fixed-schedule service to provide access for the handicapped and the indigent elderly.

A few systems such as the Denver Regional Transportation District are considering the use of paratransit options in the future. The Massachusetts Bay Transportation Authority does provide for the transfer of public transit operations to private operators when private operations appear to be more economical—of course with the provision of a protective labor clause that guarantees that no individual employee will be disadvantaged by such an operation. While it is encouraging to see such plans in a few operating systems, this should be set in the perspective that these are merely operational plans and are not yet implemented. Throughout the industry, the general rule is that many operational guidelines are aimed at maintaining a single service—the fixed-route, fixed-schedule transit system that has historically been unacceptable to the American consumer if the alternative of the private automobile was available.

The unfortunate aspect of these operational guidelines is that they may become the justification for the expenditure of funds for traditional transit systems in an environment of declining resources, and it is possible that urban areas that presently have funds to improve public transportation will find themselves building extensive fixed-route, fixed-schedule grid systems that are used only by captive riders who lack other alternatives. Another ironic note is that such guidelines can and are being used by larger urban areas in financial difficulty as the justification for cutting services that are not patronized by a sufficient number of individuals. In essence, plans for improvement and development in public transit are being used in many urban areas as a rationale for cutbacks in service. At the same time, the cost of this service is becoming continually greater to urban and rural taxpayers alike.

There is obvious need for a rethinking and subsequent revising of mass transit guidelines. Before public sentiment is completely eroded, there should be a reconsideration of the types of public transit services that truly meet consumer needs and an attempt to achieve the energy and pollution goals now being sought by federal, state, and local governments. The Mass Transportation Act of 1974 provided $12.9 billion for the improvement of public transportation over the ensuing 6 years. As the midpoint of this period approaches, those involved should recognize that in actuality little has been accomplished by the massive inputs of federal, state, and local moneys aimed at improving public transportation in urban areas. Major improvements have been made in rolling stock, physical facilities, and the wages of those involved in the provision of public transportation services; however, the output figures are dismally poor. There have been few increases in ridership, and this indicates a failure to decrease the emphasis on automobile traffic and to obtain the ensuing reduction in energy use and pollution. The time for action and change in direction is now.

REDEFINITION

The major point to be emphasized in this discussion of mass transit guidelines is the need for redefinition and expansion of the term level of service. The level of service provided should not be restricted to traditional transit and its variations in the form of express routes, route deviations, and such. Rather, the term should encompass all service offerings and combinations presently known to exist in the urban environment. This would include variations in the size of the bus, vans, taxis, and pools (either automobile, van, or bus operation). A complete range of service offerings would even include the jitney service.

The concept of levels of service should include all of the following:

1. Private automobile,
2. Rental automobile,
3. Car pool,
4. Van pool,
5. Taxi,
6. Jitney,
7. Subscription automobile or bus pool,
8. Charter,
9. Traditional tailored service (trippers)
10. Traditional route deviation,
11. Traditional express service,
12. Traditional transit,

13. Bicycle, and
14. Walking.

Fixed-route, fixed-schedule traditional transit service is only one of the services in this continuum. It is only by the recognition of this spectrum of service that there can be more understanding of the interaction of the levels of service provided by various alternatives and of the markets attracted by those levels of service. Only through an understanding of the attributes of ridership and of why individuals choose a particular mode will it be possible to develop standards for the appropriate level of service to be provided by a given service alternative and to communicate its availability and attractiveness to the potential user.

URBAN TRANSPORTATION MODE-CHOICE RESEARCH

Historically, transportation modal-choice research has been conducted by engineers. The typical origin-destination study counts the present traffic and determines the anticipated demand by using projection techniques. These techniques have worked well in planning for peak highway capacity, but they are inadequate for forecasting the expected demands of ridership choice by users of public transportation.

Many of these often simplistic mathematical models assume that individuals base modal decisions on strictly economic criteria. Typically, in this procedure, a mode-split analysis, based on specified performance characteristics of the transit system and selected socioeconomic characteristics of the trip mode, is used to forecast the aggregate demand for transit services. Unfortunately, the construction of such a theoretical model often uses a black box or unknown understanding of the specific mode choices made by consumers of public transportation alternatives.

More recently, consumer-attitude research developed from marketing research has been used to gain a deeper understanding of transportation mode choice in urban transportation. Analysis of this research by Mundy (7), Soloman, Soloman, and Sellien (8), Hille and Martin (9), and Lovelock (10) indicates that the significant variables in modal-choice behavior of urban consumers are safety, reliability, time savings, cost, convenience, and comfort. While the order of importance among these variables varies from study to study, they are consistently the ones that influence consumer behavior.

Although research in this area is recent, it is beginning to impact the planning for future transportation systems. For example, a recent article by Stein (11) concluded that "attitude surveys can be used to assess reactions to existing transportation facilities and improvements or to predict future travel behavior." An interesting review by Wachs (12) demonstrates the types of conclusions that can be reached through an analysis of consumer-attitude research. For example, consumers are extremely sensitive to urban transportation travel time. Travelers on the Shirley Highway Express Bus-on-Freeway System in Washington, D.C., have switched from their private automobiles in order to save time. Other amenities such as cost, lack of congestion, and comfort are secondary in importance. However, consistency and reliability of arrival time are more significant than total travel time.

More surprisingly, attitudinal research has shown that cost does not play the significant role in the choice of transportation mode that some have thought. The interpretation of such studies suggests that, in the relative range, cost is more dependent on the perceived level of service received. A poor service, no matter how inexpensive, will be perceived as being too expensive, and on the other hand, a transit service that meets the perceived expectations of the consumer can charge a premium without detracting from ridership interest. This concept is becoming well-known and understood by researchers in the area of urban transit, but appears to be incomprehensible to many transit operators and politicians.

In the comparison of attitudes toward public transit versus the private automobile, many of the alternatives among public transportation services have been completely neglected. But, in considering public transportation levels of service and alternatives, a complete range of the alternatives must be considered to gain a total appreciation of those options that may or may not be made available to urban consumers.

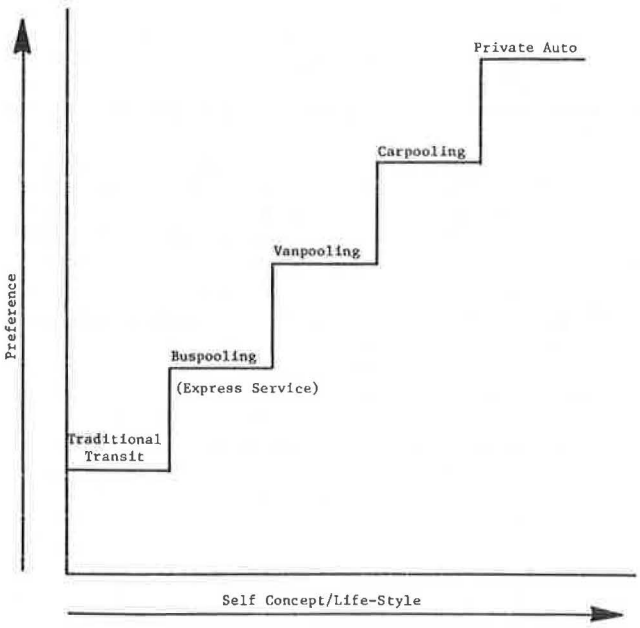
Consumer-related research indicates much about the urban traveler; however, there are many blank areas. For example, much is known about the user who is a transit captive. (This individual is readily accessible for answering opinion surveys while a captive on a public transit system.) The focus has only recently shifted to the noncaptive rider, the nonuser of public transit. Then, all too often, attempts are made to compare the attributes of the private automobile with the attributes of the public transit system and their respective levels of satisfaction. Such research is less than intelligently thought through and its results are, at best, inconclusive (13).

There is a broad spectrum of alternatives between the traditional fixed-route, fixed-schedule system and the private automobile. These alternatives should be considered, even though satisfaction data may or may not be appropriate in assessing true motives for modal-choice behavior. The conceptual differences of mode-choice behavior between these two alternatives are immense. For example, for many potential urban consumers of public transportation, choice of travel mode is not a simple continuum but a series of step functions. Figure 1 depicts the service alternatives and corresponding levels of service thought to be desired by most urban commuters. As one moves down from the private automobile, both consumer preferences and life-styles are threatened. It should be understood that requesting a change in personal travel mode is requesting a change in life-style, and perhaps in the personal perception of one's station in life.

Consumer researchers have a clear picture of the transit captive and what he or she desires from the public transit system: This is, of course, more direct service, shorter headways, more seating, and greater comfort. Also needed, however, are ridership profiles of the occasional rider. For example, what is the difficulty experienced by the occasional rider in attempting to use the traditional system? Is it readily accessible to that individual? What threshold levels of information are necessary to enable the casual rider to participate in the system? Through some very hard and expensive lessons, transit systems and authorities, bureaus of mass transit, and the federal government are beginning to realize that the nonpublic transit riders (those who have a true choice) cannot be persuaded to use a system that does not meet their personal needs by any amount of advertising. Many well-planned federal programs have failed to meet the consumer needs and to accomplish even the minimal goals and objectives set forth by Congress in appropriating vast sums of money for their purposes.

Demonstration projects and the appropriate testing of consumer attitudes toward them lead to a better understanding of the relationship between a service alternative, its level of service, and the markets attracted

Figure 1. Step function approach to urban transportation commuter mode-choice behavior.



by such service. As the attitudinal survey on the Shirley Highway Express Bus-on-Freeway System showed, time sensitivity is one of the most, if not the most, important variable in mode selection. This time concern reaches across all of the socioeconomic and demographic variables and affects a wide range of market potential. Much more experimentation, however, is needed with smaller vehicles, van pools, shared-ride taxis, and other similar systems. Only consumer attitudinal research on these demonstration systems will lead to a better understanding of the dynamics of the choice, which will make it possible to develop a comprehensive planning approach to public transportation offerings.

For example, in Knoxville, Tennessee, the current van-pool demonstration program is carrying as many riders as is the extensive express bus service. After legal, regulatory, and insurance problems were reduced as obstacles to private van operators, this new alternative to the automobile captured 1 percent of the consumer work-trip market in the first 6 months of its operation. (From a marketing or product penetration concept, 1 percent of the market in the initial 6-month period is an amazing success story.)

TIME FRAME FOR CHANGE

Life-styles, especially perceptions of one's own life-style, change very slowly. Individual mode choice for personal transportation will change gradually. To those who are seeking answers to problems of national energy shortages and urban pollution, the experience with revitalization improvements for traditional transit systems has been very disheartening. The one bright spot in accomplishing national goals has been the relatively enthusiastic acceptance of vans and van pools as acceptable alternatives to the private automobile.

As knowledge about urban transportation-service alternatives and the various levels of service within these alternatives increases, it is becoming apparent that new institutions or structures for providing public transportation services in urban areas are needed. The integration of traditional and paratransit services in a regulatory and organizational framework has been discussed elsewhere (14). However, merely diminishing regulatory and financial barriers and creating new organizations for providing public transportation will not by themselves bring about changes in consumer life-style with respect to mode-choice behavior.

At a minimum, a 5-year trial time will be needed to test many of the suggestions made as a result of consumer attitudinal research, and it will be the smaller and medium-sized communities that initially implement such changes and service offerings. Major changes in large metropolitan areas will come later, after comprehensive knowledge of the relationship between levels of service and the various markets attracted is developed.

However, certain kinds of cost-cutting measures can be very useful in large urban areas. The growth of contracted peak-hour commuter services such as Colonial Transit in the Washington, D.C., metropolitan area indicates a large potential commuter market willing to participate in express commuter services when they are offered. Colonial Transit began with a single vehicle a few years ago and is now a profitable multimillion dollar operation. In other urban areas this demand has become so strong that consumer groups have themselves formed bus pools to provide their own service.

It is significant that the specific problems of today are operational or management-oriented—they are not technological problems. These institutional and regulatory management problems can be solved with existing, well-understood techniques. Funds for and appreciation of consumer attitude research must be provided if these techniques are to be helpful in bringing about changes in urban public transportation. For the interim period at least, technology alone will not solve urban transportation problems, and funds currently directed toward research and development might better be spent in resolving regulatory and management problems. Technology and the development of transportation systems should not be forgotten in the long run, but in the very short run, more concern should be directed toward operationalizing what is becoming known and understood about urban transportation.

SUMMARY

This paper has reviewed existing mass transit guidelines and their emphasis on levels of service. It has attempted to show that a much broader definition of transit service alternatives (and the levels of service within these alternatives) is necessary to develop urban public transportation systems that meet consumer needs and desires. While there have been significant advances toward understanding urban transportation modal choice through consumer-attitude research, much yet needs to be done. Only by filling in the blanks about various transportation service alternatives and the reasons for their attractiveness to various target markets can one fully appreciate and comprehend the dynamics of the urban transportation mode-choice decision-making process. But such an understanding and a restructuring of the regulatory, financial, and institutional structures responsible for the development, implementation, and management of public transportation systems are required before the national goals of energy conservation, pollution control, and increased mobility for all citizens set forth by the federal government can be met. Much can be achieved through efficient, effective public transportation; however, it must also be recognized that in a free society mode-choice decisions are a right of the consumer. This freedom of choice is a constant challenge that requires continued change in service offerings, and it should be the concern of responsible planners and developers of public transportation that the

systems developed are those that are desired and acceptable.

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Bus Passenger Service-Time Distributions

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The characteristics of bus passenger service-time distributions are a necessary input for the transportation simulation models that are used to evaluate the operations of street transit systems. In this paper, distributions of passenger service times through bus doors (the rates at which passengers entered, passed through, and departed from the bus) are analyzed by photographic studies and simulated by an Erlang function. These mathematical expressions simulating the passenger rates of flow entering and departing from a bus are compared with the observed times; the differences are not significant at the 95 percent level. The results of this research can be used to analyze a series of bus transit-flow situations and may serve as guidelines in assisting the designer and operator in evaluating existing or proposed bus systems. Specific models could be developed to evaluate the effects of the method of fare collection on passenger queue lengths and average waiting time under different rates of passenger arrivals. The overall design of bus transit vehicles has been shown to affect passenger flows in relation to such items as fare collection and in the use of door(s) for boarding and alighting.

The characteristics of bus passenger service-time distributions are necessary for the evaluation of street transit systems by the use of simulation models. This paper analyzes photographic studies of passenger movements through bus doors and shows that an Erlang function can represent the service-time distributions in the simulation process.

The door of a street transit vehicle can be viewed as a single-server queueing model. Passengers arrive at a certain rate, pass through a service area, and depart at another rate. The rate of departure depends on how fast they pass through the service area. A simulation model that uses generalized arrival and departure rates for transit stations has been developed by Fausch (1).

Simulation models of the type developed by Fausch are tools that can be used to evaluate the operations of street transit systems. The information necessary for such a simulation includes data on the capacity of bus doors and on the arrival and service-time distributions of passengers. Under maximum capacity conditions, the alighting or boarding of passengers invariably occurs in a group. In other words, when a bus arrives at a stop, the passengers to board are already waiting and alighting passengers are waiting in the vehicle. The service-time distribution, however, is not the same for boarding and alighting passengers as it depends on factors that affect the interaction between passengers and