

Anticipated Attitudinal Responses to Dual-Mode Transit Systems and Their Effects on Mode Choice

Martin Wachs, School of Architecture and Urban Planning, University of California, Los Angeles

Based on the review of a large number of attitude surveys and based on behavioral responses to recent transit innovations, several conclusions are reached regarding likely perceptual responses to dual-mode transit and their effects on mode choice. Studies indicate that travel time variance or reliability among modes is more important than small time savings and that the portion of travel time spent in walking, waiting, and transferring is more important than time spent moving. Thus, dual-mode systems appear to have the potential to be relatively attractive to travelers. Although total travel cost appears to be less important to mode choice than travel time, parking costs associated with automobile travel can strongly influence the competitive position of dual-mode systems. Among comfort and amenity features, seat assurance and air conditioning outweigh other factors in the minds of most riders, and automatic control is rarely perceived as a safety hazard. Experience with express bus operations on freeways, treated in this paper as a prototype of dual-mode systems, indicates that riders attracted to that service are drawn largely from among former automobile users, thus indicating the potential market for dual-mode systems.

Any new movement system that might be implemented in an urban area must be evaluated in terms of its relation to a society that is structured to a significant degree by the automobile. Because it met certain needs for movement in an efficient and attractive way, the automobile has been one of the basic forces shaping our cities, ordering our activities, patterning our relations, and determining our attitudes toward virtually every aspect of our personal lives. Thus, we cannot anticipate attitudinal responses to new transport systems outside of that context. Any new approach to the provision of mobility, including potential dual-mode systems, must be viewed as a step in an evolutionary process that has largely been shaped by the automobile and that has effects going far beyond movement alone.

There are two basic reasons for looking beyond automobile-dominated transportation systems for the future mobility of our society. Ironically, both of these reasons stem from the success of the automobile itself.

The first is that the response of society to the automobile has produced what Hardin has called a "tragedy of the commons" (1). Although the automobile has provided many of us individually with tremendous freedom and opportunity at fairly low personal cost, our massive response to and dependence on it have provided us with great collective costs that we are beginning to refuse to tolerate. Congested roadways, polluted air, accidental death and injuries, and depleted natural resource reserves are among the common costs that we pay for the private advantages we gain from mobility provided by automobiles. This condition may be interpreted as setting forth an important ground rule for the evaluation of new technological approaches to the provision of urban transportation service. Because the automobile has ordered our living patterns and attitudes in certain ways and has done so at relatively low personal cost, we can anticipate that new transportation systems will be at-

tractive to potential users only if they perform as well as the automobile system in the eyes of the members of the public who do have a choice between modes. A dual-mode system that is generally less attractive than the automobile in terms of cost, travel time, door-to-door convenience, reliability, and psychological impacts should not be viewed as even having the potential to replace the automobile as the primary movement system. Such a dual-mode transit system must be viewed explicitly as a supplement to the automobile system for particular populations in particular locations for particular types of trips and times of day. As a society, of course, we might choose to make dual-mode transit equivalent in attractiveness to the automobile by decreasing the attractiveness of the automobile as well as by trying to design a dual-mode transit system that is equal in attractiveness to the automobile system.

The second major reason for our search for new transportation systems relates to the fact that the automobile, because of its attractiveness, has become such a basic ingredient of twentieth century life that a minority who do not have access to automobiles are severely disadvantaged. The old, the young, the poor, and the handicapped have become dependent on others who have automobiles, or they must endure poor public transportation service precisely because the automobile has reduced the demand for and the provision of high-quality public transportation service. We look to new transportation systems in large part to provide improved mobility to those who are now disadvantaged by lack of access to an automobile, and we must evaluate dual-mode systems in terms of the potential contribution they can make to the mobility of those having limited accessibility to an automobile-dominated system (2).

The two major reasons for considering new transportation systems are intimately related. Certainly, we can provide mobility to those who are currently without

access to the automobile only through an extensive and flexible system that reaches areas of relatively low manifest travel demand and that does so at reasonable cost. Recent experience with dial-a-ride and similar systems indicates that it is costly to deliver high-quality service to the mobility dependent through a transit subsystem that is independent of the system that provides peak-hour commuter service (3). On the other hand, a public system that proves to be an attractive alternative to the automobile could, by virtue of the demand for it, offer more extensive service in response to high levels of demand and thereby also offer increased mobility to those who are currently without adequate mobility. Of course, the proponents of many new technological approaches to the provision of transit service hope that their systems will provide service that is attractive enough to lure automobile travelers out of their automobiles for at least a specific set of trips and a specific pattern of origins and destinations, and that perhaps their systems will be used in combination with policies aimed at reducing the attractiveness of the automobile.

ROLE OF ATTITUDINAL AND BEHAVIORAL STUDIES OF PREFERENCE FOR MODAL CHARACTERISTICS

In this paper the results of several attitudinal studies are compared with measured responses to a few innovative transit operations in order to reach tentative conclusions about likely responses to dual-mode transit operations. In this comparison, attention is also given to particular policy variables, such as downtown parking charges, that influence the relative attractiveness of the automobile. The impact on traveler attitudes and choices of variables such as travel time, reliability, convenience, comfort, safety, cost, and amenity is reviewed. An attempt is made to interpret the importance of such variables. Conclusions are based on preferences stated in attitudinal studies and on preferences revealed in user responses to new transit innovations throughout the country. These attitudinal and behavioral responses are interpreted in terms of their potential impact on dual-mode transit systems.

Because the relative attractiveness of dual-mode systems in comparison with existing automobile and transit systems will prove to be critical in determining the success or failure of dual-mode innovations, we must attempt to estimate the likely attractiveness of such systems to potential users and to design them in such a way as to increase their relative competitiveness. This task is difficult, for we do not fully understand the psychological mechanisms that underlie the attractiveness of the automobile or the mechanisms that result in modal-choice decisions. Yet, a sufficient number of attitudinal studies have been conducted that significant patterns of similarity exist from one setting to another. These enable us to generalize regarding traveler attitudes toward transportation modes. Although we cannot be certain that conclusions of attitude surveys will be accurate predictors of modal-choice behavior, especially with respect to transit systems that do not exist, we can compare generalizations drawn from repeated findings in attitudinal studies with measured responses to new transit services and operations, such as exclusive-lane express bus operations, dial-a-ride services, new rail transit, and park-and-ride service. If behavior patterns do seem consistent with the conclusions of attitudinal studies, we may increase our confidence in judgments made on the basis of such attitudinal studies.

The contribution of attitudinal studies and of user

perceptions to the evaluation of modal quality and modal-choice behavior has been minimized recently because of the feeling that attitudes toward the quality of alternative modes are not significant in the prediction of choice making by travelers. To a certain extent, this position may be supported by recent empirical work. For example, Hartgen (4) fitted 50 binary modal-choice models to data for a sample of 471 urban travelers. He found that situational factors, such as automobile ownership and socioeconomic status, accounted for 80 to 90 percent of the variance in modal choice and that attitudinal variables measuring preferences for particular modal characteristics explained only 10 to 20 percent of the variance in modal choice. Although such findings do serve to emphasize the difficulty associated with the determination of attitudinal and perceptual information that is useful in policy making, they do not lead to the conclusion that attitudinal variables are unimportant. This is so for at least three reasons.

1. Most existing models, including those employed by Hartgen, do not adequately account for causal linkages that might exist between situational variables and attitudes. For example, automobile ownership—a situational variable that explains a great deal of variance in modal choice—might be high among travelers whose income permits multiple automobile ownership precisely because of their attitudes toward the relative quality of transit systems versus the automobile. Similarly, locational choices may be made on the basis of perceptions of the quality of available transportation modes.

2. Models such as those examined by Hartgen may be fitted to data for travelers who are in situations in which little choice exists and in which attitudes are not fully operative in the modal-choice decision. Thus, automobile owners in areas of low transit service might have positive attitudes toward high-quality transit service, but the absence of such service does not allow these attitudes to influence their choice. Similarly, low-income persons without automobiles might choose the transit mode based on their "situational" variables precisely because they do not have the option to exercise their preferences for the automobile mode. Thus, examination of perceptions and attitudes seems especially important in the consideration of new transit modes that will result in changes in the situational variables, which, it is hoped, will help to make travelers more able to act in accordance with their attitudes and preferences.

3. Although behavioral choices and situational variables can be directly observed, attitudes must generally be measured through survey instruments and therefore depend on our ability to appropriately elicit dimensions of preference. Our ability to do so is still quite imperfect and might result in a lowering of statistical explanation, but the study of response patterns in a variety of situations can heighten our understanding of preferences to the point at which they may be used in the formulation of policy even without high levels of statistical fit in particular modal-choice applications. In part, this is the reason I have tried to focus on common attitude dimensions that emerged in many studies and to compare them with observed behavior in situations in which new transit choices were provided.

NATURE OF POTENTIAL DUAL-MODE TRANSIT SYSTEMS

Because dual-mode transit is still a developmental concept, it may be viewed as having the potential to range over a wide array of performance properties. Thus, to anticipate attitudinal responses to dual-mode systems requires that a working definition of dual-mode systems

be specified as a basis for comparison. In the following analysis, dual-mode systems are assumed to be those that are capable of fully automatic, or driverless, operation on specific guideways; manual, or driver-controlled, systems are those that operate on conventional streets. The dual-mode vehicle has been conceptualized as varying from a small private capsule similar to an automobile (5) to a large vehicle similar in nature to a conventional bus (6). Dual-mode systems will likely first be applied in situations in which public transportation vehicles are used and might later be extended to include private vehicles. For this reason, in the remainder of this paper, principal attention will be given to a public transit concept of dual-mode systems in which a vehicle operates under driver control for its collection and distribution activities and operates under automatic control for the line-haul portion of the trip. In carrying out their collection and distribution functions, dual-mode vehicles can be envisioned as serving fixed schedules and routes or flexible routes that are demand actuated. Smaller vehicles (say, as many as 20 seats) would probably be used to service routes on which collection and distribution are demand actuated, while larger vehicles (say, as many as 50 seats) would be used to provide service where collection and distribution are provided along fixed routes. In many ways, existing express bus operations on exclusive freeway lanes constitute an important prototype of dual-mode transit systems. When such buses operate as local collectors and downtown distributors, they are similar to the dual-mode proposals that involve fixed-route collection and distribution, except that the vehicle is under manual control during the line-haul portion. When such buses operate from centralized outlying bus terminals that are augmented by park-and-ride lots, they might be viewed as early prototypes of dual-mode systems that include demand-actuated collection and distribution service. In such cases the automobile takes the place of the demand-actuated collection system. For these reasons, special attention will be given to reviewing ridership response patterns and attitudinal responses to service variables of express buses on freeways to anticipate later responses to dual-mode systems.

ATTITUDES TOWARD TRAVEL TIME AND TRAVEL TIME RELIABILITY

In a recent survey, Wallin and Wright found that most transportation planning agencies use total travel time as the most frequent predictor variable in estimating the demand for alternative modes of travel (7). Therefore, in estimates of the likely impact of dual-mode transit systems, total travel time from origin to destination for the dual-mode system and its competitors, especially the automobile, would likely be considered most important in modeling the response to a dual-mode innovation. Indeed, one study to estimate the potential of dual-mode transit in Milwaukee did employ the ratio of travel time via dual-mode transit to travel time via automobiles as the principal predictor variable in estimates of modal choice (6), although this ratio was modified to incorporate other factors such as seat assurance.

Studies of traveler attitudes and perceptions, however, indicate that measures of total elapsed travel time are an oversimplification of the psychological mechanisms that travelers use in their considerations of travel time. Rather, attitudinal studies show repeatedly that perceptions of the importance of travel time depend on travel time reliability as well as on elapsed travel time alone. Arriving on time at an in-

tended destination was often seen as more important than the minimization of elapsed travel time in work and non-work trips (8,9), although travel time reliability (or arrival time variance) did not appear among the 13 most important variables used in estimating modal choice through modeling (7).

Attitudinal surveys conducted among riders of the Shirley Highway express bus revealed that, among express bus riders who had previously commuted by automobile, travel time savings were the most frequently cited reason for switching to the bus (in comparison with other factors such as cost, congestion, and comfort). However, when they rated the attributes of the bus service that were of great importance to them, 90 percent of the bus users cited reliable schedules and only 29 percent cited a 5-min saving in travel time (multiple responses were permitted by the survey instrument) (10). Thus, we may conclude that, although elapsed travel time is important in modal-choice decisions, reliability in arrival time has a greater importance to travelers than is reflected in current predictive models.

Dual-mode technology is intended to improve travel time reliability for the line-haul portion of the trip by eliminating travel time variances due to congestion and bottlenecks and simultaneously to permit line-haul travel at higher speeds. This technology, therefore, has the potential for eliciting favorable user responses on this important dimension of attitude. However, developmental efforts will have to ensure that delays and unreliability are not inherent parts of the system at the point at which vehicles are switched from manual to automatic control or caused by breakdowns in control during the line-haul portion of the trip. The important conclusion from the attitudinal literature is that reliability of travel time is of significant importance when compared to elapsed travel time as a measure of system performance. This should be considered as important among evaluation criteria for dual-mode technology and should be incorporated in efforts to model responses to dual-mode systems. Since reliability is of great importance to travelers and of great significance to the design concept of dual-mode transit, it should not be overlooked in demand analyses even though most existing modal-choice models do not incorporate this variable.

ATTITUDES TOWARD RELATIVE COMPONENTS OF TRAVEL TIME

Studies of traveler perceptions and attitudes indicate that the concept of travel time is considerably more complex in the mind of the traveler than is represented by the travel time ratios commonly used in modal-choice forecasting. In addition to consistently finding that reliability or variance in travel time is an important component of attitude toward transportation modes, surveys also reveal that time spent in waiting, walking, transferring modes, or parking a vehicle is consistently viewed by travelers as more onerous than time spent in moving in a vehicle during a line-haul portion of a trip. Because the automobile is superior to most existing transit modes with respect to the minimization of out-of-vehicle and terminal times and because dual-mode technology seems to hold promise for significant improvement over current transit modes on this dimension, efforts should apparently be made to incorporate these findings in the estimation of demand for dual-mode systems and in the development of dual-mode technology.

In spite of the fact that data used in most modal-choice models are often too highly aggregated to allow the consideration of separate components of travel time, some studies do provide estimates of orders of magnitude in the perceived differences among trip time ele-

ments. In Leeds, England, Quarmby derived an economic value of walking time that was between two and three times the value placed on time spent in actually riding (11). In Chicago, Lisco found that commuters would pay approximately 2.8 times as much money to avoid walking time than they would pay to avoid riding time (12). The Regional Plan Association of New York deduced a perceptual weight for walking time of 3.2 times the perception of riding time (13); and, within the Port Authority Bus Terminal in New York, passengers appeared to weight walking time about twice as heavily as they weighted riding time (14). Although the foregoing evidence is drawn from studies in which actual behavior of travelers was monitored and interpreted, attitudinal studies yield similar results. A survey of travelers in Washington, D.C., found that 84 percent of the respondents stated among criteria for a new transportation system that it should be designed so that the "place to get off is no more than 5 minutes from the destination." This was the most commonly cited criterion for the design of a new system among more than 2000 respondents (15, Vol. 1).

Similarly, there seems to be ample evidence that travelers perceive waiting and transfer time as much more onerous than time spent in riding. For example, in considering 33 attributes of both work and nonwork trips, Nash and Hille found that "avoidance of a wait of more than 5 minutes" was the single attribute that yielded the greatest perceived difference between the automobile and the public transportation modes in studies conducted in Philadelphia and Baltimore and that attitudes toward public transit modes were quite unfavorable relative to the automobile (8). Another survey in Washington, D.C., showed that 30 percent of the 2000 commuters interviewed objected to having to transfer at all and that 51 percent of the commuters objected to specific transferring policies that reflected the situation that governed their everyday trip making (15, Vol. 2). Studies in Paris, France, show that passengers weight the waiting and transferring time components of a trip approximately three times as heavily as they do riding time (14).

Recently, Brown constructed a modal-choice model that included attitudinal variables within a discriminant function for predicting modal choices for system configurations that did not exist in Vancouver, British Columbia. He found that, for park-and-ride service, the time spent in parking an automobile and waiting for the bus was a significant variable in accounting for the variance in modal choice. He concluded, for example, that, if walk time from vehicle to bus ramp were kept to about 2 min and if transit headways were reduced to about 4 min (compared with existing headways approaching 20 min), the inconvenience of such a transfer operation would cease to be a significant barrier to the attraction of riders from their automobiles. These figures, of course, constitute high levels of service compared with that of most current transit operations (16).

In response to the kinds of findings reviewed above, Watson proposed the use of a measure called the "journey unit" in considering the effects of out-of-vehicle time on modal choice. A journey unit is one step in a complete trip and might consist of a walking unit, a waiting unit, a transferring unit, or a riding unit. Because a transit trip on current modes typically includes a larger number of journey units than an automobile trip, Watson believes that this simple measure could add to the explanatory power of modal-choice models (17). Using reconstructed information on journey unit differences between automobile and transit trips, Stopher applied this concept to sets of data for London and for Skokie, Illinois (18). He found that the inclusion of this

measure did significantly improve the explanatory power of a logit modal-choice model and that the addition of the new measure did not significantly decrease the significance of the coefficients of the travel time and travel cost variables in the models. Thus, the conclusion may be reached that the treatment of transfer, waiting, and walking time as perceptual choice elements that are independent of gross travel time measures—a treatment suggested by the attitudinal research cited above—does hold promise for the improvement of modal-choice modeling.

Dual-mode transit systems probably offer the greatest attractiveness to riders through their potential for minimizing the inconvenience of transfers between the collection and the line-haul portions of the trip and between the line-haul and the distribution portions of the trip. Survey research shows that this is one dimension in which travelers perceive the automobile as being clearly superior to existing public transit modes. The potential success of dual-mode technology will undoubtedly depend to a great extent on the degree to which it can be made relatively attractive in comparison with the automobile in this key dimension. Development and demonstration projects involving dual-mode systems should certainly concentrate on the ability of the technology to minimize transfer, wait, and access times.

ATTITUDES TOWARD TRAVEL COSTS

Many studies of attitudes toward transportation system alternatives and many studies of traveler behavior have resulted in the conclusion that the monetary costs of travel via various modes do not constitute as salient a factor in modal-choice decisions as some of the other variables that have already been cited. In a recent study, for example, Wallin and Wright flatly conclude that "cost does not play a major role in the choice of a transportation mode" (7). Thus, although cost emerges as an independent dimension of traveler attitudes in many factor analyses of the attributes of travel choices, it rarely receives high ratings as a critical determinant of specific choices (19). Part of the explanation for this type of conclusion lies in the finding by other researchers that as many as 75 percent of automobile drivers had never actually estimated the cost of their trips by automobile (20).

Further investigation of the influence of travel cost on choices made by travelers indicates, however, that these generalizations might not be operative with respect to all population groups and that attitudes toward costs must be considered in terms of more fully developed choice situations than are usually included in most attitude surveys. For example, surveys of elderly travelers indicate that cost is of great significance in their travel choices and that they frequently do alter their travel patterns to take advantage of reduced fares during off-peak hours (21). Although the elderly constitute only 10 percent of the total population and are often underrepresented in travel attitude surveys, the finding that their attitudes toward travel costs are at variance with the attitudes of larger populations indicates the importance of considering the specific characteristics of a proposed service area before generalizing about the importance of this variable.

Other findings indicate that, in specific choice situations that may be relevant to the planning and evaluation of dual-mode systems, travel cost cannot simply be discounted as having relatively low importance to travelers. For example, reference was made earlier to the potential for viewing express bus operations as being in some ways prototypes of dual-mode service. The Shirley Highway express bus operation does yield some impor-

tant data about the influence of costs on traveler decisions, and these data tend to contradict the above statements about the low importance of travel costs. A survey of both automobile users and express bus users in the Shirley Highway corridor indicates that, although the express bus captured nearly 40 percent of the target trips for this service and travel time and schedule reliability are major reasons for the switch of former drivers to the bus service, 56 percent of those still using their automobiles reported that they were provided free parking at their work locations and 90 percent of the automobile users reported that they paid less than \$1/day for automobile parking. The significance of this statement is underlined when compared with the result that the most common reason cited by travelers who tried the bus but switched back to their automobiles was that the bus was expensive. Since fares for this service are generally less than \$1 and since the median income of both automobile users and bus users was more than \$15 000/year, the cost of parking in relation to the fare does appear to be a significant element of the modal decision in the Shirley corridor (10, ch. 4).

In the previously cited efforts to build a modal-split model based on attitudinal data, Brown also found that parking cost was a significant variable in affecting a modal choice for trips to downtown Vancouver. He stated that, for the sample of commuters for which he calibrated his model, "the parking charge needed, by itself, to effect a 50 percent shift to bus transit would increase from an average of about \$0.55 per day to about \$1.00 per day." He was comparing the use of the automobile to the use of a transit system incorporating a park-and-ride lot (16). Of course, recent proposals of the U.S. Environmental Protection Agency for parking surcharges reflect an underlying assumption that some elements of cost are important in traveler modal-choice decisions as well.

Thus, although travelers tend to rate the importance of travel cost low when responding to generalized attitudinal inquiries, their behavior might indicate that such questions are not sufficient to fully elicit their views toward costs. The finding that most automobile drivers do not even attempt to estimate their actual costs, plus an obviously important response to parking costs in the two studies cited above, indicates that daily out-of-pocket parking costs may receive psychological weights much greater than other elements of automobile cost that are not paid out as part of a specific trip.

The implication for dual-mode transit planning would be clear, especially if further research were to substantiate this view. Although dual-mode systems have the potential to approach the automobile along certain dimensions of perceived transportation quality, cities contemplating the institution of dual-mode systems might be well advised to consider such systems in combination with policies that discourage free parking or that impose a parking surtax. If cost is to be either a deterrent to the use of dual-mode systems or an element of the attractiveness of those systems, fares should be considered in relation to parking costs rather than total automobile transportation costs.

ATTITUDES TOWARD COMFORT AND AMENITY LEVELS

When characteristics of transportation service such as vehicle comfort and amenity features such as seat configurations, carpeting, ride quality, and availability of diversions (e.g., capability to listen to the radio) are considered, results of attitudinal surveys in which respondents were asked to consider generalized or idealized transportation systems and surveys of users of

particular systems have shown similar results. In general, provided that basic physiological needs are met through the avoidance of excessive vibration, noise, odor, or jerk, physical luxury of a vehicle or the presence of a wide range of amenities appears to be less important to the traveler's decision process than other variables already cited. A few dimensions of amenity do, however, appear to be of much greater importance than others and should thus be given special attention.

Although in one study by Nash and Hille travelers cited protection from weather when waiting for a vehicle, availability of package and baggage space, and the ability to listen to the radio as being major contributors to the difference between their levels of satisfaction between automobiles and existing transit vehicles, they rated such variables as being less important to modal choice than travel time reliability, cost, and avoidance of waiting for both work and nonwork trips (8). The conclusion is that, although commuters recognized the inherent advantages of the automobile, those advantages were not critical to the choice made between modes, but were seen rather as extra bonuses associated with the availability of an automobile. In a review of a number of attitudinal studies of transit modes, Navin came to a similar conclusion (21).

Although the broad concepts of comfort and amenity are generally less important to traveler modal-choice decisions than the other dimensions of service cited earlier, a few specific elements of comfort and amenity do seem to be more important to the choice process than other elements of comfort and amenity. The extent to which a seat is assured to passengers and the presence or absence of air conditioning were consistently rated as more important than other elements of comfort and amenity. In studies cited by Navin, seat assurance emerged in many studies as only slightly less important than travel time reliability and often as important, in modal-choice decision situations, as cost differences between modes (21). An interview study of nearly 200 persons who were riding specifically designed "new-feature" buses in service on Shirley Highway routes showed that 90 percent of the respondents rated schedule reliability as having a significant impact on their modal choice and rated no feature in the comfort or amenity category as being nearly as important. From among about a dozen features that were incorporated in the new-feature bus, only air conditioning (cited as important by 71 percent of the respondents) and seat assurance (cited by 62 percent of the respondents) were considered significant in the decision that had been made to ride the buses. Other features, including improved leg room, larger windows, carpeting, and absence of advertising, were all significantly less important than other travel service variables, including fares, travel time, and schedule reliability (22).

The significant conclusion to be reached regarding the development of dual-mode systems is that commuter reactions have consistently shown that to provide luxurious interiors and plush environments is not necessary to attract riders. Meeting basic physiological requirements, providing high probability of seat availability, and incorporating temperature control are the most critical aspects of comfort and amenity that should be addressed in vehicle design. Additional items of amenity, such as space for packages, might be incorporated in the design to enhance the attractiveness of the vehicles, but such features do not seem most critical in attracting patrons out of their automobiles.

ATTITUDES TOWARD SAFETY AND IMPLICATIONS FOR AUTOMATIC CONTROL OF VEHICLES

The concern of the traveler for physical safety during a trip may be considered as a passive or threshold dimension of attitude in the modal-choice decision. The traveler seems to assume that the journey will be safe, and the probability of being involved in an accident or of becoming the victim of a crime is not explicitly considered as part of the choice mechanism. However, when explicitly queried about the importance of safety, travelers give this factor an extremely high rating of importance (23). Because most travelers experience a low probability of bodily harm in a typical journey, they do not make the importance of this factor explicit in considering alternative travel modes. Should danger become apparent to travelers, however, the importance of personal safety might well become the dominant factor in modal choice. Recently, for example, a crime wave on particular bus routes in Los Angeles brought about a dramatic but temporary decline in ridership.

Since dual-mode systems employ automatic vehicle control during the line-haul portion of the trip, an important issue might be the extent to which travelers' passive assumptions of safe conditions might be affected by their knowledge that a vehicle is under automatic control. Few studies have addressed this specific issue, but those that have done so show that commuters do not display any particular fear of automatic control features. In one survey in Washington, D.C., 93 percent of the respondents stated that automatic control would not be a barrier to their riding (15). Reactions to automated train service in New York City indicated that the public had little fear of automatic train operation on the Forty-second Street shuttle (24). In most services operated under automatic or semiautomatic control, an operator has been present during automatic operation, and this will likely be true of initial dual-mode operations. Therefore, based on limited evidence, automatic control will likely not be a barrier to traveler choice unless significant safety problems arise. If such problems do arise, their impact on ridership could be significant.

DEPENDENCE OF ATTITUDES ON SOCIOECONOMIC, DEMOGRAPHIC, AND SITUATIONAL VARIABLES AND IMPLICATIONS FOR DUAL-MODE TRANSIT

Previous sections of this paper have contained an impressionistic assessment of a wide range of findings from many studies of transportation attitudes and behavior. The intent was to generalize from many studies to reduce a large body of data to some tentative conclusions useful in policy analysis. To this point, the generalizations about attitudes and behavior have not been categorized by socioeconomic groups or by demographic characteristics. I have chosen to present conclusions in this manner because the important dimensions of attitude that have been cited seem to be generally true across lines that might be drawn on the basis of sex, age, income, education, and residential location. Even though some studies have found it possible to form distinct perceptual groups that differ from one another in terms of demographics, these differences do not obscure the general findings already presented.

Socioeconomic and demographic variables such as automobile ownership, income, occupational status, and age are significant variables in forecasting modal choice. Usually, upper incomes, higher educational levels, and higher automobile ownership rates are as-

sociated with higher probabilities that travelers will select for a work trip. Since, as stated earlier, dual-mode service can only be significant if it can compete successfully with the automobile, it is important to determine whether it can attract persons who do have a choice: those with higher incomes, greater educational levels, and higher occupational status. This will depend to a great extent on whether the modal-choice models reflect true attitudinal differences with demographic differences, or merely situational differences. Interestingly enough, Assael and McMillan found in a national survey that people who exhibited a propensity to select the automobile in choice situations (upper-income professional males) were not significantly less favorably disposed toward transit modes than toward the automobile (25). The poor rated transit and automobile service as of equal quality, but they favored more investment in transit. The rich rated the automobile as being of superior quality, but favored greater investments in transit. Middle-income groups and men more than women favored the automobile as a superior mode and the one that should receive the greatest investment and improvement. The extent to which these attitudinal differences reflect basic differences in perception versus actual experience with systems of different performance qualities is a subject that can be debated. However, situational factors do appear to influence attitudes quite significantly, and the relations between attitudes and demographic variables are thus influenced more by the intervention of actual travel experience and service levels than by the inherent differences in attitude as a function of demographics. Support for this position comes from the well-known work of Nash and Hille, who stated (8):

Generally, the most satisfied people were the middle-class suburbanites living fairly close to the CBD. They, of course, are the ones who possess one or more autos and find it most feasible and satisfying to use them for both (work and non-work) trip purposes. Surprisingly, the low-income group living closest to the CBD was generally more satisfied than people living in the remote suburbs. Apparently, they have adjusted to a lack of auto in many cases and probably keep their trips short and to a minimum. The people farthest from the CBD were least satisfied, probably because their very location made traveling difficult and onerous. They tended to be relatively dissatisfied with all modes for most factors.

Following the same line of reasoning, one might argue that the greater importance placed by women than by men on dimensions of comfort and amenity such as having room for parcels and strollers on transit vehicles reflects the fact that women travel more often than men do for shopping purposes and travel more often with their children. Similarly, the importance placed on lower fares by the elderly reflects their more limited income circumstances.

If the dimensions of attitude toward modal choice are strong enough to transcend socioeconomic and demographic group differences and if differences in current modal choices reflect situational constraints and opportunities, then transit systems that are similar to the automobile on attitudinal dimensions that have been described above can induce travelers to leave their automobiles. Preliminary evidence available from ridership surveys of premium transit service unequivocally supports this view.

In the Shirley Highway corridor, for example, those choosing to use express buses for their work trips have done so because of high levels of schedule reliability, favorable travel times in comparison with the automobile, and convenient access to the buses without significant waiting and transfer times. Interview studies showed that 82 percent of those using the buses in this corridor had an automobile available for the trip, but nearly half of the users of conventional bus service in the corridor

had no automobile available. Three-fourths of the Shirley Highway bus riders who used park-and-ride service and 56 percent of those who walked to the bus had incomes of more than \$15 000. In addition, 60 percent of the Shirley Highway bus riders were male while 45 percent of the conventional bus riders in the corridor were male. In summary, in terms of socio-economic and demographic factors, those choosing to use the premium buses on freeways were more like the typical automobile commuter than like the typical bus commuter. Of course, as mentioned earlier, the availability of free or low-cost parking at the work site did appear to be one significant deterrent to use of the premium bus service (10, ch. 4).

Preliminary results from the San Bernardino express busway experiment appear to be similar to those from the Shirley Highway. Here, 35 percent of prebusway transit users in the corridor were male, but exactly half of the premium service users were male. About 80 percent of the users of the new service come from households owning one or more automobiles, and 48 percent previously used automobiles rather than buses for the same trip for which they now use the busway. Significantly, 80 percent of the busway users and only 46 percent of the users of prebusway transit service had incomes of more than \$10 000/year (26).

To the extent to which expressway bus operations constitute a prototype of future dual-mode operations, these results are most encouraging. They indicate that the conclusions reached earlier about attitudes toward transit are correct. Given favorable performance on the dimensions of attitude cited above, such service can attract riders from among the social and demographic groups that have traditionally been considered automobile users.

CONCLUSIONS AND IMPLICATIONS FOR DUAL-MODE DEVELOPMENT

The review of many studies of traveler attitudes indicates that some generalizations are possible with regard to the impact of modal-service characteristics on the attraction of users.

1. In considering travel time differences among modes, one must recognize that travel time reliability or variance is probably of greater importance than elapsed time in influencing favorable attitudes toward a mode.
2. That portion of travel time that is devoted to waiting, walking, transferring, or generally out of vehicle is perceived as being significantly more onerous to travelers than time spent moving in the vehicles.
3. Although total travel cost is probably less important than elements of travel time, the availability of free or low-cost parking appears to significantly influence the perceived relative cost of alternative travel modes.
4. Among many possible elements constituting comfort and amenity, those that appear to influence modal choice most significantly are seat assurance and air conditioning.
5. Automatic control of vehicles is probably not perceived as a safety hazard by most potential users of dual-mode transit systems.
6. Differences among social and demographic groups in attitudinal responses to alternative transit modes probably reflect differences in experiences and levels of service they receive under current transportation system configurations.
7. Experience with premium express bus operations on exclusive lanes indicates that travelers attracted to such service are demographically and attitudinally quite

similar to automobile users. The implication of this preliminary finding is that high-quality transit service can compete successfully with the automobile.

I began this paper by asserting that there were two basic reasons for pursuing advanced public transit technology in a society as dominated by the automobile as ours.

1. Transit improvements should be extended to those who do not currently have adequate mobility because of their lack of access to automobiles.
2. We seek to mitigate the negative effects of the externalities that we commonly share as costs of the personal mobility we gain from the automobile.

Clearly, the extension of basic mobility to those who lack accessibility to automobiles can be achieved to a much greater extent and with simple existing transit technology. The key question is whether demand for conventional transit service can be made great enough to help in defraying the costs of delivering such service to the mobility limited. The automobile is relatively so attractive to those who have a choice that it might be too expensive to deliver conventional transit service only to those who are currently transit dependent. If new systems can simultaneously attract many of those currently using automobiles and provide service to the mobility dependent, they will be socially and financially more desirable than the current mix of private and public transportation.

I have demonstrated that those who currently use automobiles can be attracted to high-quality transit modes. Existing bus technology has already been shown to have the capability of attracting former automobile users when it satisfies the perceptual needs of travelers who do have a choice. The critical question that must be answered, therefore, as dual-mode systems are considered in the next decade, is, Can dual-mode systems significantly outperform existing transit systems at a developmental cost that is low enough to make the investment worthwhile? If the answer is no, we might better use our resources to provide higher quality transit service with existing technology and to extend transit service to meet the needs of the mobility limited. If the answer is yes, dual-mode development should probably be pursued. Special attention should be given to the dimensions of user response outlined in this paper, and further attention should be focused on the contribution that such developments can make to the needs of the mobility limited.

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