Development of Design Standards for Public Transportation Services for the Transportation Handicapped in Large Urban Areas

JOHN C. FALCOCCHIO

This paper is concerned with the analysis of transportation variables from the viewpoint of the elderly and handicapped. The purpose of this analysis was to develop a set of functional design parameters that are responsive to the travel needs of transportation-handicapped persons. The transportation variables considered in this paper include walking distance, waiting time, service reliability, availability of seats in waiting areas and/or in the vehicle, safety, accessibility of vehicles and/or system, and fare. User interviews were obtained from a pool of riders of a specialized transportation service (Easyride) that operates in Manhattan's Lower East Side. Each measure of a transportation variable was rated by the interview sample by using a semantic scale, and tolerable (acceptable) levels for each variable were identified for each of six groups of age-handicap categories. The service design standards that emerge from this study recognize that the locomotive capabilities of elderly and handicapped persons differ according to the severity of handicap. These travel needs are identified for each level of transportation handicap considered and are quantified in terms of the suggested design guidelines.

Existing urban transportation services do not meet the special travel requirements of the elderly and physically disabled because these systems were designed and built according to standards that are adequate for the adult nonhandicapped population (1). As a result, many elderly and physically handicapped persons (i.e., wheelchair users and others who have severe mobility problems) tend to find these systems inaccessible, uncomfortable, or inconvenient to use. Many perceive these systems as not safe for travel because of fear of physical harm that might result from a fall or from personal assault by would-be muggers. Others find these systems too costly to use. Because of these conditions, the elderly and the handicapped suffer from a lack of personal mobility and are denied access to vital services and other opportunities.

This paper is based on a study (2) in which the transportation requirements of a group of elderly and handicapped travelers were analyzed. The service variables considered in the study included elements of travel comfort, convenience, safety, and cost. These service variables were measured for different age and handicap travel markets by using a semantic scale. The findings of these measurements serve as the basis for the identification of service design standards that are responsive in meeting the travel needs of the transportation-handicapped market groups considered.

BASIC COMPONENTS OF A TRANSPORTATION SERVICE

A transportation service may be viewed as consisting of three basic components: (a) the vehicle, (b) the operating system, and (c) the requirements imposed on the user. These three components of service must be considered jointly in the physical planning for service improvements, and their interaction must recognize the importance of user requirements that should be the determinants of design standards for accessible vehicles and accessible systems. (An "accessible vehicle" is one the traveler can enter, ride, and exit; an "accessible system" is one that permits the traveler to get to the vehicle from an origin or to a destination from the vehicle.)

The requirements of a handicapped user of a transportation service are highly dependent on the characteristics of the system and the vehicles used in the system. Vehicles may be of different designs, sizes, or shapes. However, their main features may be described according to whether they are accessible to wheelchair users and to those who have severe difficulties in climbing steps. System characteristics, on the other hand, vary significantly and the type of service provided will affect system accessibility. Transportation systems may be characterized in terms of routing (i.e., fixed, flexible, or fully independent of routing patterns), schedule (fixed, variable, or demand responsive), origin stop to destination stop (curb to curb, door to door, or through door to through door), etc. Each of these service patterns will impose different requirements on the potential user in terms of waiting time, walking time, seating, and climbing or descending steps or stairs, etc. It is clear then that transportation services useful to the transportation handicapped must be designed and operated to meet the capabilities of the handicapped.

These system-related user requirements may be expressed in terms of the following variables:

1. Convenience: (a) reliability, (b) waiting time, (c) transfers, (d) ease of getting on and off, (e) walking distance;
2. Comfort: (a) heating and ventilation, (b) noise, (c) sudden stops or turns, (d) having a seat;
3. Safety: (a) fear of falling, (b) fear of muggings; and
4. Cost: fare.

By using a sample of handicapped riders, it was possible to measure how each variable affects their ability to use a transportation service. [The sample-selection methodology and the characteristics of the interview sample are described elsewhere (2).] The sample consisted of users of a fully accessible paratransit service known as Easyride that is operated by the Vera Institute of Justice in the Lower East Side of Manhattan, New York City. For the purpose of this analysis the transportation handicapped (n = 126) have been classified into six travel-market groups:

1. EWC = elderly persons who use wheelchairs (n = 20)
2. ES = elderly persons who have severe difficulty in climbing steps (n = 31),
3. EM = elderly persons who have minor difficulty in climbing steps (n = 26),
4. NEWC = nonelderly persons who use wheelchairs (n = 25),
5. NES = nonelderly persons who have severe difficulty in climbing steps (n = 13), and
6. NEM = nonelderly persons who have minor difficulty in climbing steps (n = 11).

Handicap severity was self-assessed.

An additional sample (n = 24), designated TR839, of nonelderly nonhandicapped graduate students of the Polytechnic Institute of New York was inter-

Table 1. Weighting of comfort, convenience, safety, and cost variables.

Variable	EWC	NEWC	ES	NES	EM	NEM
Comfort						
Heating and ventilation	8.2	7.6	4.6	6.5	6.6	5.4
Noise	8.3	6.8	6.8	6.4	6.5	8.9
Sudden stops, turns, etc.	10.2	10.9	6.8	4.7	8.0	6.5
Having a seat	NA	NA	14.9	11.9	13.4	14.2
Convenience						
Reliability	12.7	11.7	9.9	9.5	8.5	9.4
Waiting time	10.7	10.5	9.1	9.5	8.7	9.2
Transfers	6.3	6.6	4.9	6.3	5.4	1.4
Ease of getting on and off	13.5	9.9	10.8	10.6	7.0	9.9
Walking distance	3.4[a]	5.1[a]	13.2	13.7	11.2	11.7
Safety						
Fear of falling	12.6	12.7	8.2	8.6	8.6	9.4
Fear of mugging	5.0	7.6	3.7	5.7	8.7	6.5
Cost						
Fare	9.1	10.6	7.1	7.6	7.4	7.6

[a]Distance covered by wheelchair. Most wheelchair users felt this variable is not important because they usually ride a door-to-door service.

viewed by using the same questionnaire that had been administered to the Easyride users. The purpose of this task was to compare the perceptions of the two groups in measuring the bus, subway, and taxi modes in terms of the travel comfort, convenience, safety, and cost variables.

The questionnaire used for the elderly and handicapped group was administered only to the users of the Easyride service. A user was defined as an individual who has taken at least one trip with Easyride. Questions were asked of Easyride users to determine their levels of satisfaction with the transportation variables enumerated above. This was done not only for the Easyride service but also for other forms of transportation available in the Lower East Side, such as buses, subways, taxis, and Ambulette vans (a medical-oriented transportation service that operates door to door). However, only those responses that were based on actual experience with a particular mode were recorded. Thus, for example, no evaluation of the subway mode was possible by the wheelchair users since this group cannot use the New York subway.

METHOD OF ANALYSIS

The responses obtained from the personal interviews were processed by computer by using the Statistical Package for the Social Sciences (SPSS), and the results of the analysis are summarized in graphic form below. A five-interval semantic scale was used to record responses.

FINDINGS

Reliability

Service reliability refers to that measure of service performance that relates to whether a trip can be made when needed by the user. If the service is unreliable, this means the passenger may arrive late at his or her destination, may not travel to where he or she would like to go, or may be forced to allot more time for travel than necessary by arriving early in order not to miss an appointment.

Reliability was valued as very important by the respondents. From Table 1 it may be seen that wheelchair users value it second to the fear of falling and the remaining groups value it third most important, below having a seat and walking distance.

One way of measuring the impact of service reliability is given in Figure 1. For each of the age-handicap classifications, the relationship between the length of delay and the impact of this delay on the average traveler is plotted. This is done for three typical trip purposes: medical trips, social visits, and shopping trips.

It may be seen that, in general, when lateness exceeds half an hour the service is perceived to be somewhat upsetting to extremely upsetting. There does not seem to be much difference in the effect of delay according to trip purpose. However, a delay experienced for medical-related trips seems to generate more concern.

Another trend that emerges from these relationships is that the effect of delay is perceived more negatively by those who have lower disability levels. This conclusion tends to be supported by the reaction pattern of those in the TR839 group, who perceive the effect of delay more critically than their elderly or handicapped counterparts.

Waiting Time

Waiting time is closely related to service reliability. In this discussion it is used to measure the effect of scheduled waiting time and is intended to measure a passenger's reaction to waiting, given that one knows the expected arrival time of the vehicle.

Figures 2 and 3 show the perceived impacts of waiting time for the sample groups. Those who have severe physical disabilities, as might be expected, have the greatest problem with having to wait while standing. Having to wait standing even for a few minutes upsets this group. For those who have minor difficulties, waits longer than 10 min present serious problems. When people are seated, however, waiting becomes a problem for waits longer than 20 min. The elderly seem to be more patient than the nonelderly, in general, but this pattern is not very pronounced. The importance of this attribute, as shown in Table 1, ranges from 8.7 to 10.7 and is very similar to the weight given to reliability.

Transfers

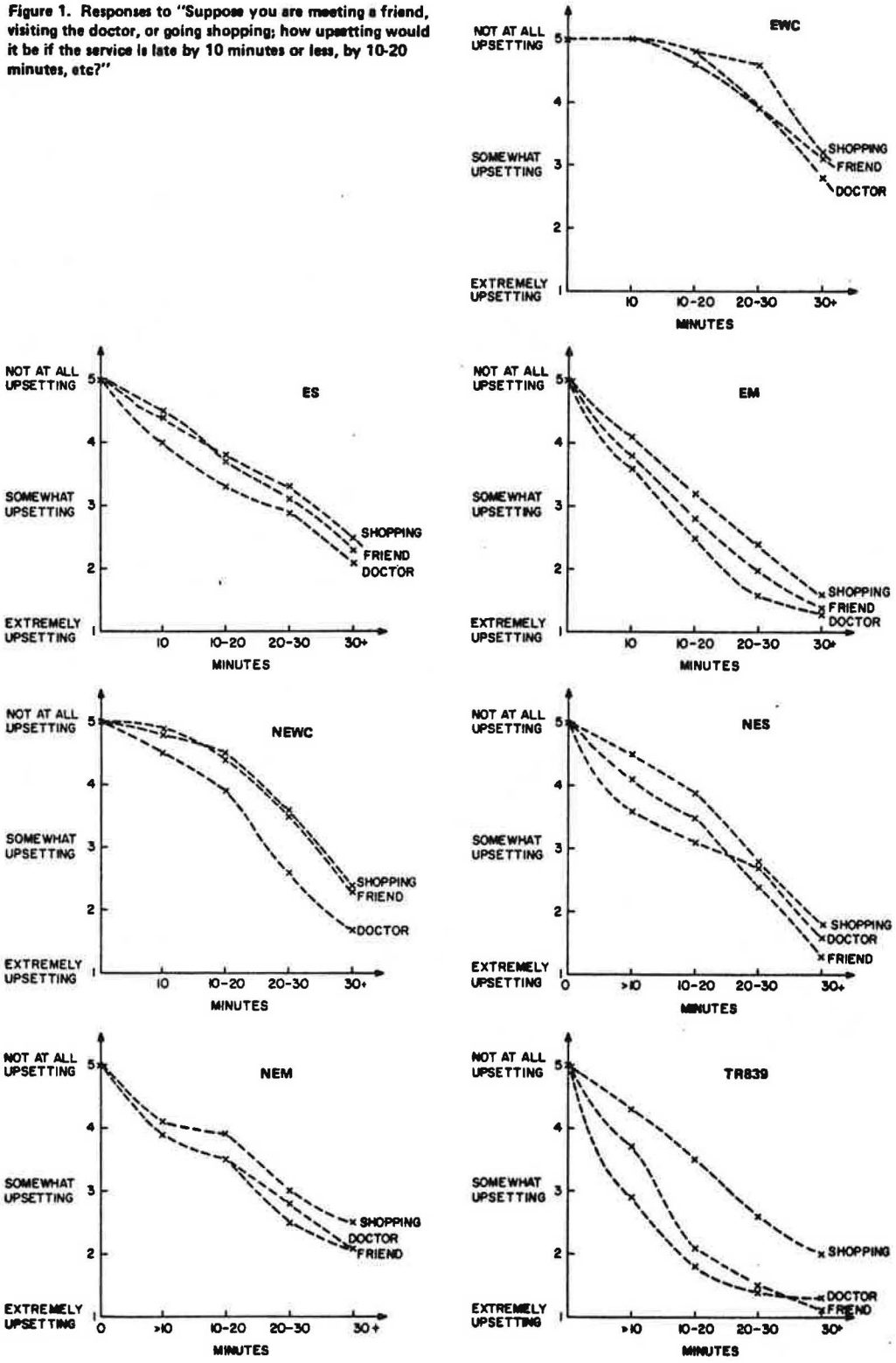
The act of transferring from one vehicle to another, as part of a trip, received a wide range of reactions. Figure 4 shows the results of the evaluations given by the sample to the need for transferring during travel. When one transfer is involved, the majority of the respondents indicated only a mild disapproval of the requirement. In this regard, it is necessary to note that the ratings do not necessarily follow what would be expected. For example, whereas it would be logical to expect that the level of dissatisfaction with the need for transferring would increase with increasing disability, this is not borne out by the data. Although it is difficult to explain the reasons for these apparent inconsistencies, one possible explanation may be with the fact that those who currently travel without having to transfer (i.e., wheelchair users) could not relate to this question. However, those with minor handicaps (i.e., EM), who are more likely to use different modes or vehicles in their daily travel, see the transfer requirement as more of a problem.

Getting On and Off, Up or Down

Vehicle accessibility and the problems experienced by the severely handicapped in getting on or off a vehicle are viewed as some of the most critical aspects of transportation service by the handicapped who are in a wheelchair or who have severe problems in climbing steps.

Figure 5 describes the kinds of problems

Figure 1. Responses to "Suppose you are meeting a friend, visiting the doctor, or going shopping; how upsetting would it be if the service is late by 10 minutes or less, by 10-20 minutes, etc?"



perceived in each mode and associated infrastructure (such as stairs or escalators). Easyride is viewed as the most easily accessible mode by all the respondents. The Ambulette accessibility is perceived as presenting some to little difficulty by the EWC and NEWC users and little or no difficulty by the ES users. Some of the wheelchair users have cited occasional difficulties in using Ambulette vehicles whose ramps were not wide enough to accommodate large wheelchairs.

The taxi and automobile tend to generate similar reactions from the EWC group; reactions range from some difficulty to great difficulty. In this connection, lack of sufficient space between the front and back seats was mentioned, as well as how the wheelchair is "just slammed down in the trunk" by the taxi driver. The problems with taxi and automobile accessibility by the ES and NES groups are similar and range between some difficulty and very little difficulty. The EM and NEM groups have

slightly fewer problems in getting in and out of taxis and automobiles.

The bus is not accessible to those in wheelchairs. Those who have severe problems (ES and NES) experience great difficulty in using the bus, and those in the EM and NEM groups find it somewhat difficult to get on or off. In this regard, several comments were made that the bus driver does not pull over to the curb at bus stops and that the driver frequently fails to activate the step-down mechanism of the "kneeling" buses.

The subway system was divided into three components: stairs, escalators, and the vehicle. Those in wheelchairs said that they cannot use the New York subway at all. Those who have severe problems in climbing steps (ES and NES) cite stairs, escalators, and vehicles as being too difficult or impossible to negotiate. Those who have minor difficulties seem to have very little problem with escalators but experience great difficulty with stairs. However, in this group only the elderly view vehicle access as presenting great difficulty; those who are not elderly seem to experience very little difficulty with the subway car.

Figure 2. Responses to "Does it bother you when you have to wait standing at a bus stop or terminal?"

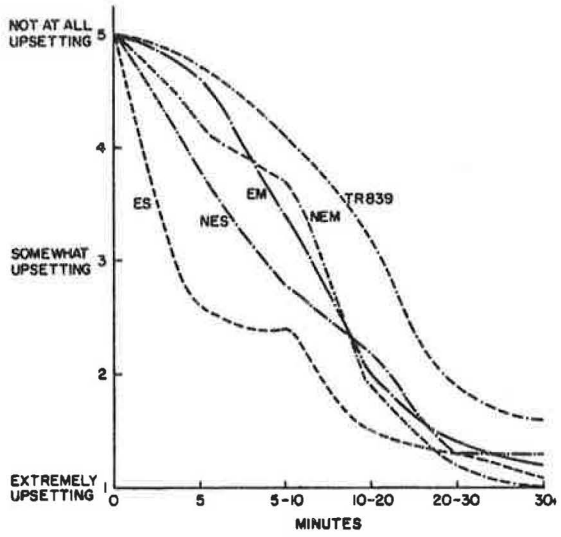
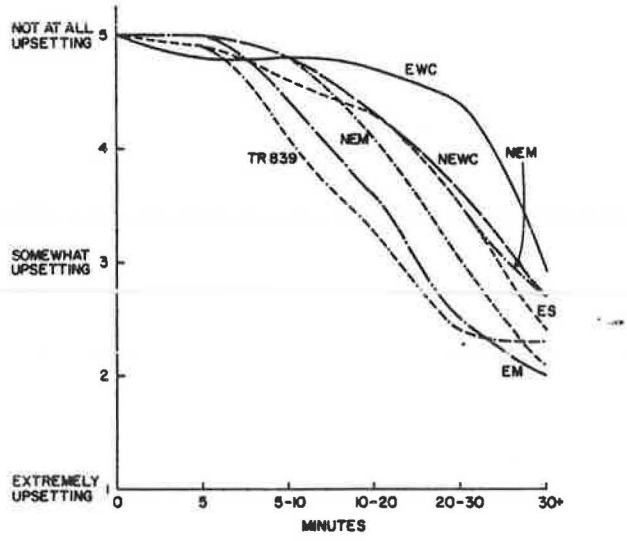


Figure 3. Responses to "Does it upset you when you have to wait sitting at a terminal or bus stop?"



Walking Distance

Figure 6 shows the range of problems experienced by the nonwheelchair sample about walking distance. It may be seen that the severely handicapped find walking one block or less (one city block is approximately 400 ft) somewhat to mildly upsetting; those who have minor difficulties find the need of walking one to three blocks somewhat to mildly upsetting. Thus, it appears that for system design purposes the service area of a fixed-route transit service is limited to half a block for those who have severe difficulties and to one and a half blocks for those who have minor difficulties.

As seen in Table 1, the importance of walking distance is at the top of the list, along with the need to have a seat in the vehicle.

In comparison, the TR839 group viewed walking distances of four to six blocks as mildly upsetting. This corresponds very closely to the quarter-mile

Figure 4. Responses to "Would you be upset if on a trip you have to transfer from one vehicle to another?"

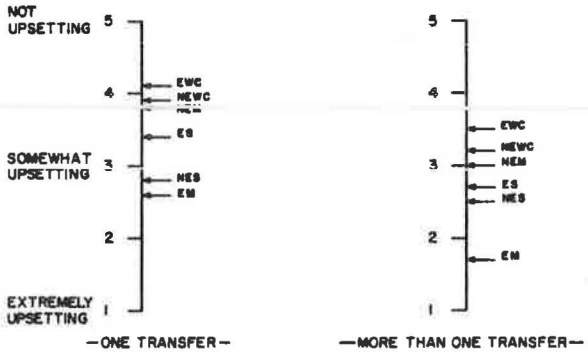
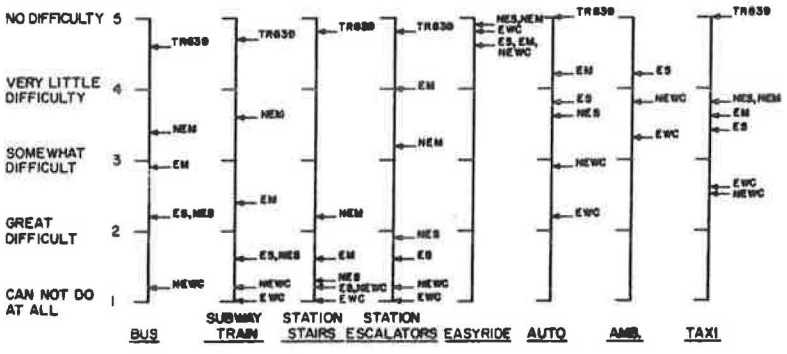


Figure 5. Responses to "With how much difficulty can you get on and off (up or down) each of the following vehicles?"



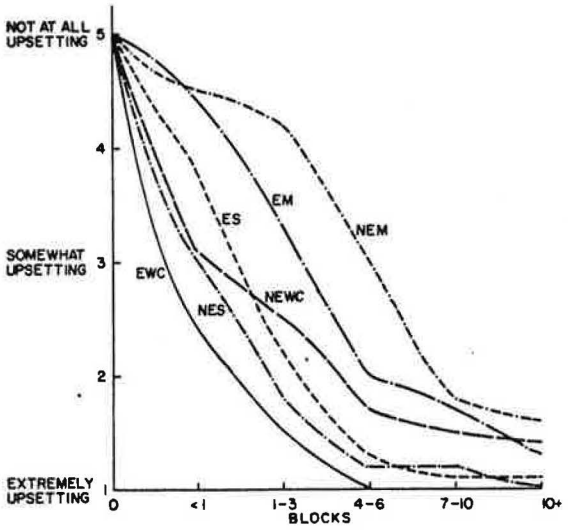
limit used to establish the walk-to-bus primary service area.

Heating and Ventilation

The comfort level for each mode of travel experienced by the respondents is shown in Figure 7. All users rated the Easyride service as providing an acceptable level of comfort. For the bus service and non-air-conditioned subway, the experience ranges between uncomfortable and sometimes uncomfortable. Taxi and automobile modes were found to provide acceptable levels of comfort.

It should be noted that the evaluation of these transportation services is based on the perception that users have of them. The mix of vehicles used in each service may vary so that, although the bus service uses air-conditioned vehicles, it appears that that mode's effectiveness in satisfying the ridership is not high. This may be a result of the rather frequent incidence of malfunctioning units.

Figure 6. Responses to "Would it be upsetting if you had to walk a block (1-3 blocks, etc.) in order to get to a bus stop, meet a taxi, etc.?"



Since the bus and subway are not accessible to wheelchair users, no evaluation of these modes was given by this group. However, for planning purposes, it may be assumed that wheelchair users would react similarly to heating and ventilation levels.

Noise

The responses given to noise are shown in Figure 8. Of all the transportation services considered, the non-air-conditioned subway generates the most negative response. The TR839 group shows the most severe objections to subway noise. The EM users do not seem to be bothered as much as the NEM users. A sense of general satisfaction is expressed with the air-conditioned subway cars, however. This is encouraging, since the New York City Transit Authority is proceeding to replace old vehicles with new air-conditioned ones.

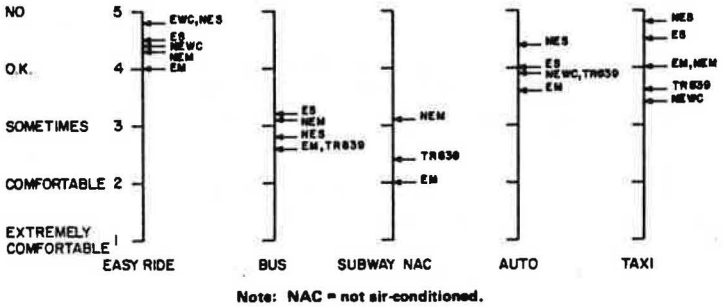
The importance given to the noise attribute is shown in Table 1, where it may be noted that the relative weights given to this item vary from 6.4 for the NES group to 8.9 for the NEM group.

In conclusion, it appears that vehicle noise is not perceived to be a serious problem by most of the respondents sampled, except for those who might use the IRT subway trains. Finally, it should be noted that reactions to noise do not seem to be dependent on either the age or the handicapped status of the traveler. It appears that this attribute is not seen as a problem by the average user and that any variation in responses is more a function of general opinions of the services than it is of actual performance as measured in the field.

Sudden Starts, Stops, and Turns

This attribute measures the operating features of the vehicles that result from driver performance under prevailing traffic conditions. Figures 9 and 10 show the ratings given by the users to each service. The bus service is perceived to have the highest levels of discomfort by the NES group and the taxi service by the NEWC group. These findings indicate a need for training drivers to avoid maneuvers that result in sudden stops, turns, etc. The weight given to this attribute ranges from 4.7

Figure 7. Responses to "When you ride a bus (subway, etc.), does the heat or lack of ventilation make you very uncomfortable, moderately uncomfortable?"



Note: NAC = not air-conditioned.

Figure 8. Responses to "Does noise make you uncomfortable when you ride a bus, taxi, etc.?"

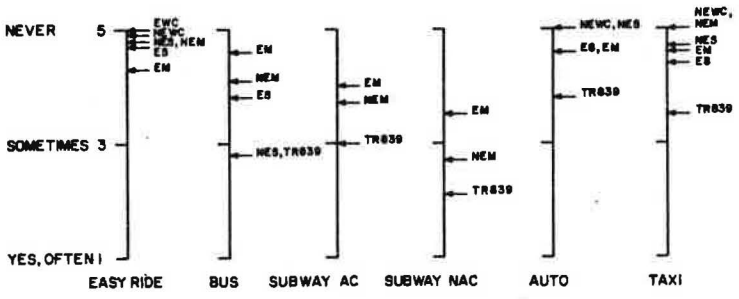


Figure 9. Responses to "Are sudden stops, starts, or turns uncomfortable to you when you ride seated?"

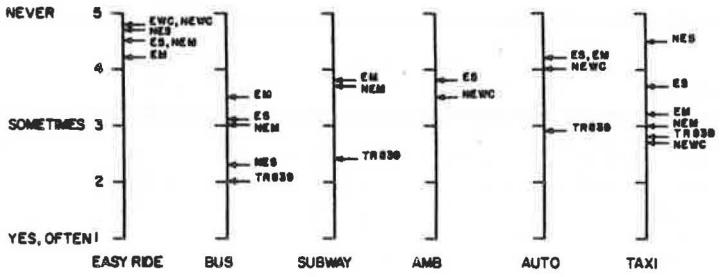


Figure 10. Responses to "Are sudden stops, starts, or turns uncomfortable to you when you ride standing?"

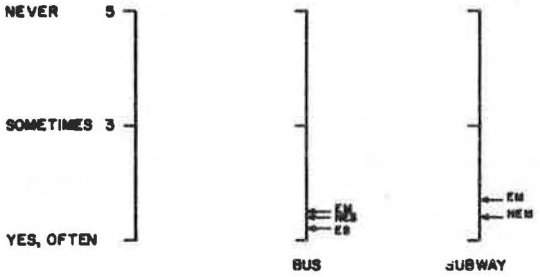


Figure 11. Responses to "(a) How important is it to you to have shelters at bus stops? (b) How important is it to you to have a seat while waiting for a bus?"

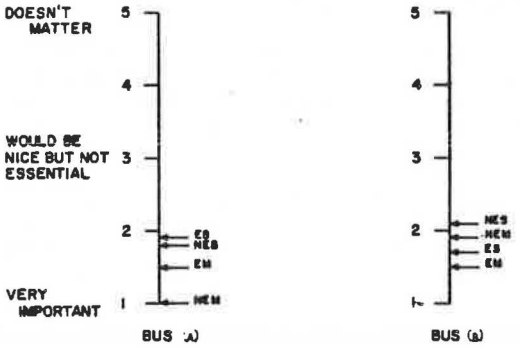


Figure 12. Responses to "How uncomfortable would it be for you to ride the bus, subway, or Easyride when you can get a seat?"

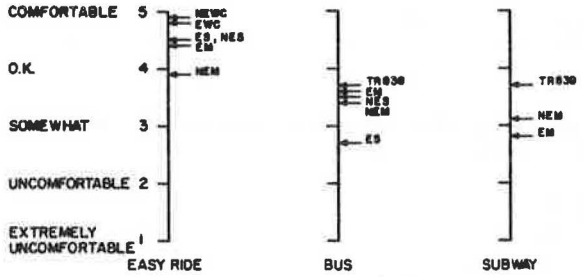
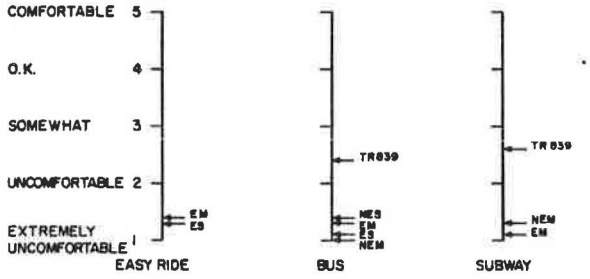


Figure 13. Responses to "How uncomfortable would it be for you to ride the bus, subway, Easyride, when no seats are available?"



for the NES group to 10.9 for the NEWC group.

The negative reactions of standees to the effect of sudden stops, turns, etc., are shown in Figure 10 for the bus and subway modes. These findings indicate that it is essential for the EM, NES, or ES rider to have a seat in the bus or subway. In the Lower East Side this is hardly possible during the rush hours.

In conclusion, it appears that there is a need to improve driver performance, especially for the taxi and bus modes.

Having a Seat

This attribute is very important for those who are not in wheelchairs. From Table 1, it may be seen that the ES, EM, and NEM groups view it as the most important of all attributes considered.

The availability of a seat was analyzed for different components of travel: while waiting for a vehicle, while riding on a vehicle, and as a function of time.

Seats at a Terminal

All of the Easyride respondents felt that it was very important to have a seat as well as a shelter at bus stops (Figure 11). In fact, it appears that the presence of a seat tends to offset the negative impact of waiting for a vehicle by significant amounts (Figures 2 and 3). The elderly and handicapped are more adversely affected by the lack of a seat than are those who are nonelderly and handicapped.

For purposes of comparison, it will be noted that there seems to be no need for a seat for those who are neither elderly nor handicapped (TR839 group) for periods of up to a 20-30 min wait. For waits longer than half an hour, seat availability becomes important (Figures 2 and 3).

Seats Available in the Vehicle

Figures 12 and 13 show that not having a seat while riding would be very uncomfortable for all of the handicapped groups (as well as for the TR839 group, but to a lesser extent). When a seat is available, however, the bus and subway services provide moderate levels of comfort (2.7-3.4 points out of a maximum of 5 points). Those who are elderly tend to experience the greatest discomfort during a bus or subway ride.

Safety

This variable was evaluated by the respondents for

Figure 14. Responses to "Are you afraid of falling or being in an accident when you use any of the above vehicles?"

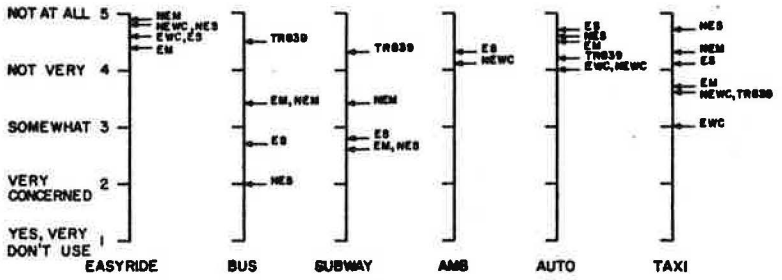


Figure 15. Responses to "Are you concerned about muggings or a holdup when you travel using any of the above vehicles?"

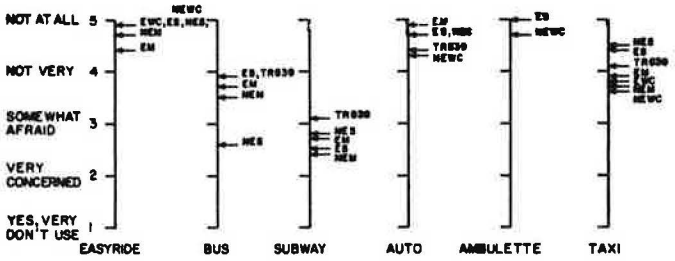
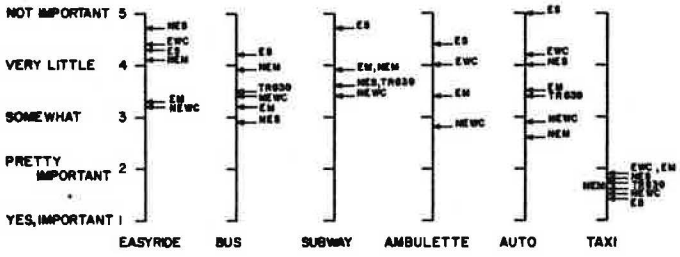


Figure 16. Responses to "Is travel cost important in deciding whether to use a bus, subway, taxi, etc.?"



two types of concerns: the fear of falling (or being in an accident) in using any of the services considered and the fear of being subjected to an act of personal assault during a trip.

Fear of Falling or Being in an Accident

This attribute is shown in Figure 14. The bus service is seen as unsafe by all groups. The typical responses range from very concerned (NES) to somewhat concerned (ES, EM, and NEM). Similar observations are made for subway service. For the taxi mode, only those who are elderly and in wheelchairs (EWC) are somewhat concerned about the fear of falling or being in an accident. Easyride, Ambulette, and the automobile are seen as the safest modes.

Fear of Muggings

Figure 15 shows that most people are in agreement in expressing fear of being assaulted during subway travel. Their responses vary from somewhat afraid to very concerned. Only the NES group expresses these same feelings for the bus service. The other groups think of the bus as providing a safer environment (responses range from not very concerned to somewhat afraid). Most people are not very concerned about personal safety during travel in a taxi and feel almost no fear when they travel by Easyride, Ambulette, or private car. It is interesting to note that the TR839 group does not exhibit significant differences from the elderly and handicapped sample for the subway, bus, taxi, and automobile modes.

Cost

The cost of traveling by any of the transportation services was assessed in terms of whether the amount paid influences the choice of mode or, presumably, making the trip at all.

It is not surprising to see in Figure 16 that all of the responses indicate that the taxi fare is an important element in a traveler's decision on whether to use that service. The responses for Easyride range from somewhat important to not important. It should be noted that the $0.30 round-trip fare charged to Easyride users cannot be burdensome in that it is not a mandatory fare. However, the $2.00 fare charged for work trips could be somewhat burdensome.

Although the use of Ambulette service is expensive (a minimum of $33.00 per round trip), reactions vary from very little to somewhat important because most, if not all, users are eligible for Medicaid and are therefore not charged for the service. However, Ambulette fees for non-Medicaid recipients and for trips other than for medical purposes are set at a rate much higher than $33.00 per round trip--even if the one-way distance is fairly short (i.e., 3-5 miles).

The $0.50 round-trip fare charged by the transit system is viewed with some to little concern in the decision to travel by bus or subway.

EMERGING SERVICE DESIGN STANDARDS

It has been shown that transportation services have varying levels of effectiveness in meeting the needs of the traveler who has a handicap. Of the service variables considered in describing the overall performance of a system, we have identified what the users can "endure" and what they cannot.

Transportation services have been analyzed by considering the joint coupling of the system's characteristics with the user's ability in coping with them. This was done for five types of transportation services: (a) door-to-door group-riding modes (Easyride and Ambulette), (b) door-to-door private mode (taxi that is phoned for), (c) quasi-door-to-door private mode (taxi that is hailed), (d) fixed-route transit bus, and (e) subway service. In addition, the mobility characteristics and variables for user's comfort, convenience, and safety have been examined for six types of age-handicap subgroups or travel submarkets. The results of these analyses were shown in the preceding sections.

The findings of these analyses are summarized in this section in the form of design parameters, suggested guidelines, or standards. Table 2 presents an emerging set of criteria that should be considered in the evaluation of an existing transportation

Table 2. Emerging transportation design standards for various age and handicap travel markets.

Service Characteristic	EWC	NEWC	ES	NES	EM	NEM	All Groups
Maximum walking distance (blocks)	0.5	1.5[a]	0.5	0.5	1.5	1.5	
Seating	NA	NA	Yes	Yes	Yes	Yes	
Transfers	NF	NF	NF	NF	1	1	
Maximum waiting time (min)							
Standing	NA	NA	1	3	10	10	
Seated							15
Accessibility							
Stairs							NF
Escalators	NF	NF	NF	NF	Yes	Yes	
Bus steps	NF	NF	NF	NF	Maybe	Yes	
Lift or ramp							Yes
Taxi step	NF	NF	Maybe	Maybe	Yes	Yes	
Reliability (late arrival) (min)	30	20	10	10	10	10	
Sudden stops in traffic							
Seated							Driver training required
Standing							NF
Noise (dBA)							70-80
Heating and ventilation							Air conditioning
Round-trip fare ($)							0.50
Shelters at stops							Yes

Note: NA = not applicable; NF = not feasible.

[a] Assumed upper limit for trips that do not involve negotiating curbs or similar obstacles.

service or in the planning for a proposed service improvement for the handicapped.

The service characteristics considered in Table 2 were found by the handicapped to be of critical importance while traveling. This, therefore, represents a set of necessary conditions that a particular service should meet in order to serve the travel needs of a particular travel submarket. These conditions, it should be noted, must be met simultaneously to satisfy the requirements of a transportation submarket. For example, having a fully accessible bus for NES travelers is not sufficient to assure that their mobility needs are met if they must wait standing more than 3 min for the bus, if they do not find a seat in the vehicle, or if they must travel a distance greater than one half block to or from the bus stop.

On close examination, this table suggests that not all transportation modes can be expected to effectively provide for the mobility needs of the severely handicapped, since operating characteristics such as fixed route, traffic delays, and loading conditions do not allow effective service even if the system had total vehicle accessibility.

What this table suggests is that those who are most severely handicapped require a transportation system that requires a minimum effort by the user (i.e., a door-to-door service). Full-accessibility buses, operating on a fixed route with a fixed schedule, do not meet this requirement. Yet wheelchair lifts on fixed-route buses have been mandated by the Urban Mass Transportation Administration for the purpose of transporting wheelchair-bound persons. This policy may not be in the best interest of the severely handicapped, and in particular of those in wheelchairs, if the trips have origins or destinations that are more than one block away from transit stops.

ACKNOWLEDGMENT

The study on which this paper is based was funded by the U.S. Department of Transportation's Research and Special Programs Administration, Office of University Research. I wish to express appreciation to Lee Wallerstein, the project monitor, who provided many valuable suggestions, reviews, and technical assistance in that study. I assume complete responsibility for the work, and any opinions expressed herein are not necessarily shared by the sponsoring agency.

REFERENCES

1. J. Falcocchio and others. Mobility of People and Goods in the Urban Environment: Mobility of the Handicapped and Elderly, Second Year Final Report. Polytechnic Institute of New York; U.S. Department of Transportation, DOT-TST-77-43, April 1977.
2. J. Falcocchio. A Methodology for Evaluating the Effectiveness of Transportation Improvements for the Elderly and Handicapped, Third Year Final Report. Polytechnic Institute of New York; U.S. Department of Transportation, DOT-OS-70084, Sept. 1978.