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16. Abstract

Two alternatives to meet the transportation needs of the Transportation Handicapped in Texas were evaluated. The two alternatives are accessible fixed-route buses and a separate specialized service. The accessible fixed-route bus alternative is the concept whereby existing fixed-route systems are made accessible by removing the barrier to entry through utilization of a device such as a wheelchair lift. The second alternative is the provision of a separate, specialized service. The specialized service is provided on a door-to-door basis as a demand-responsive operation. The two alternatives were evaluated on the basis of demand served, cost, and cost-effectiveness.

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COST-EFFECTIVENESS

OF

ACCESSIBLE BUSES IN TEXAS

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Technical Report 1061-1F

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Transportation of the Elderly and Handicapped

Sponsored by the

State Department of Highways and Public
Transportation in cooperation with the
Urban Mass Transportation Administration

Texas Transportation Institute
Texas A&M University
College Station, Texas 77843

September 1979

DISCLAIMER

This report was prepared by the Texas Transportation Institute for the Texas State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Urban Mass Transportation Administration.

The contents of the report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the sponsors. The report does not constitute a standard, specification, or regulation.

SUMMARY

The principal objective of this study is to evaluate two alternatives to meet the transportation needs of the Transportation Handicapped in Texas. The two alternatives are accessible fixed-route buses and a separate specialized service. The accessible fixed-route bus alternative is the concept whereby existing fixed-route systems are made accessible by removing the barrier to entry through utilization of a device such as a wheelchair lift. The second alternative is the provision of a separate, specialized service. The specialized service is provided on a door-to-door basis as a demand-responsive operation.

The two alternatives were evaluated on the basis of demand served, cost, and cost-effectiveness. Table S1 summarizes the results of the analysis.

Table S1: Summary of Demand, Cost, and Cost-Effectiveness for Two Alternative Approaches for Servicing the Transportation Handicapped in Texas

Alternative	15-Year Demand (passengers)	Total 15-Year Marginal Cost (1979 dollars)	Cost-Effectiveness ($/passenger)
Accessible Fixed-Route Buses	5,761,000	$ 97,276,000	$17.00
Separate Specialized Services	17,140,000	$160,441,000	$ 9.50

The impact on the state transportation fund for accessible fixed-route buses is $816,000 per year for the 15-year study period. The annual state cost for specialized service would be approximately $265,000. These are state share capital costs only which are 13 percent of total costs in current dollars.

Although the accessible fixed route alternative is presently mandated by the U.S. Department of Transportation, local jurisdications should be allowed the opportunity to select the specialized service alternative. The specialized service alternative, although more costly, is more cost-effective.

IMPLEMENTATION STATEMENT

The information presented in this report will enable local transit agencies as well as the State Department of Highways and Public Transportation to plan for the needs of the Transportation Handicapped. The information should aid in developing specific programs to meet those needs. The data presented will also aid localities in formulation of contingency plans to meet the federally mandated requirement that all fixed-route buses be accessible to the handicapped pending resolution of the rules which are now being litigated.

TABLE OF CONTENTS

I. INTRODUCTION

An issue that has been the subject of wide debate throughout the United States is "total accessibility." Total accessibility as used in this report concerns the recent mandate by the U. S. Department of Transportation (see 49CFR Part 27, Federal Register, Vol. 44, No. 106, Thursday, May 31, 1979) that all buses be accessible to the handicapped. This report evaluates the impact of that regulation on the transit industry in Texas relative to the alternative of providing "mobility" using an alternative service. Mobility as used in this report refers to the provision of a separate, specialized door-to-door service.

Background

In 1970, Section 16 was added to the Urban Mass Transportation Act of 1964, as amended, to require planning and design of mass transportation facilities to meet the special needs of the elderly and the handicapped. Section 16 states:

> It is hereby declared to be the national policy that elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services; that special efforts shall be made in the planning and design of mass transportation facilities and services so that the availability to elderly and handicapped persons of mass transportation which they can effectively utilize will be assured; and that all Federal programs offering assistance in the field of mass transportation (including the programs under this Act) should contain provisions implementing this policy (Public Law 91-453).

The broad national policy set forth in Section 16 does not specify how the special needs of the elderly and the handicapped are to be served. A debate ensued that has continued to the present. Proponents of accessibility have argued that the law requires all transit facilities and equipment to be totally accessible to the elderly and the handicapped, whereas others have

favored special services to meet the special mobility needs of the elderly and handicapped.

The history of Section 16 is long and complicated. The debate concerning Section 16 became largely a moot question in 1978 when it became clear that Section 504 of the Rehabilitation Act of 1973 would essentially take precedence. Section 504 provides:

> No otherwise qualified handicapped individual * * * shall, solely by reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance * * *.

On Thursday, May 31, 1979 (see Federal Register, Vol. 44, No. 106, pp. 31442 to 31483) the U. S. Department of Transportation issued its final rule for compliance of their programs with Section 504 of the Rehabilitation Act of 1973. The American Public Transportation Association has since filed suit opposing the regulations and continuing the debate.

Although the final rule spells out the definition of handicapped person in more detail than in previous definitions, it does not resolve the difficulty in specifying the target population. The definition states:

> "Handicapped person" means (1) any person who (a) has a physical or mental impairment that substantially limits one or more major life activities, (b) has a record of such an impairment, or (c) is regarded as having such an impairment. (2) As used in this definition, the phrase: (a) "Physical or mental impairment" means (i) any physiological disorder or condition, cosmetic disfigurement, or anatomical loss affecting one or more of the following body systems: neurological; musculoskeletal; special sense organs; respiratory, including speech organs; cardiovascular, reproductive; digestive; genito-urinary; hemic and lymphatic; skin; and endocrine; or (ii) any mental or psychological disorder, such as mental retardation, organic brain syndrome, emotional or mental illness, and specific learning disabilities. The term "physical or mental impairment" includes, but is not limited to, such diseases and conditions as orthopedic, visual, speech, and hearing impairments; cerebral palsy; epilepsy; muscular dystrophy; multiple sclerosis; cancer; heart disease; mental retardation; emotional illness; drug addiction; and alcoholism. (b) "Major life activities" means functions such as caring for one's self, performing manual tasks, walking, seeing, hearing, speaking, breathing, learning, and working.

> (c) "Has a record of such an impairment" means has a history of, or has been classified, or misclassified, as having a mental or physical impairment that substantially limits one or more major life activities. (d) "Is regarded as having an impairment" means: (1) Has a physical or mental impairment that does not substantially limit major life activities but that is treated by a recipient as constituting such a limitation; (2) Has a physical or mental impairment that substantially limits major life activity only as a result of the attitudes of others toward such an impairment; or (3) Has none of the impairments set forth in paragraph (1) of this definition, but is treated by a recipient as having such an impairment.

It is, however, unlikely that any definition can be broad enough not to exclude anyone yet be specific enough to easily determine program eligibility.

This study is timely in examining the cost-effectiveness of the program and estimating the impact in Texas. Perhaps it may add some quantitative perspective to the continuing debate. It is not likely, however, to resolve the conflict.

Objectives of the Study

The primary intent of the study is to evaluate the effect of requiring total accessibility, in comparison with a separate specialized service, on the transit industry in Texas. The accessible fixed-route bus alternative is the concept whereby existing fixed-route systems are made accessible by removing the barrier to entry by utilizing a device such as a lift. The second alternative is the provision of a separate specialized service. The specialized service is provided on a door-to-door basis. The following objectives are addressed in the study.

1. Estimate the capital cost of making the Texas transit fleet totally accessible.
2. Evaluate the effect of totally accessible vehicles on transit operating costs in Texas.

3. Estimate the demand for specialized transportation in Texas cities for those who cannot use a totally accessible transit bus in a regular route service.
4. Estimate the capital cost of specialized service to meet the demand in Texas cities.
5. Estimate the operating cost of specialized service to meet the travel demand of the Transportation Handicapped in Texas cities.
6. Assess the financial resources of State and local operators to meet the costs and estimate possible effects on existing service.

Organization of Report

The study findings are presented in the following order:

- Demand Estimation
- Cost
- Cost-Effectiveness
- Conclusions

Each section separately evaluates the two alternatives under consideration:

- Accessible Fixed-Route Buses
- Separate Specialized Service

II. DEMAND ESTIMATION FOR HANDICAPPED TRANSPORTATION

In order to evaluate the cost-effectiveness of the two alternatives for meeting the transportation needs of the handicapped, it is necessary to estimate the travel demand for the alternatives. There are at least two reasons for the need to estimate demand. One reason is that the demand for different types of service is likely to vary in response to the quality of the various alternatives. The other reason for estimating demand is that it is necessary to determine the demand in order to estimate the capital and operating costs. The following material presents the rationale, methods, and demand estimates for the two alternatives under consideration: accessible fixed-route service and a separate specialized service.

Handicapped Problems and Characteristics

Very little is known about the handicapped population. However, what data that do exist provide some insight into the Transportation Handicapped problem of making trips. Only some handicapped are presently capable of using the available transportation systems. Special features will be necessary to accommodate the rest of those who are still capable of being out on their own.

Due to inadequate transportation services, many handicapped and elderly individuals find it difficult to participate in some necessary activities. Former bus designs, with many physical barriers like high-rising steps and narrow doors, restricted the use of these vehicles by individuals with severe mobility impairments (e.g., wheelchair users). Table 1 presents the magnitude of the mobility problem among the chronically and physically handicapped.

In 1970, the handicapped median income was reported to be $2,500 as compared to $8,500 for the general population (1). Only one-third of the physically

Table 1: Percentage of Elderly and Handicapped Who Have a Difficulty with Basic Mobility

Actions	Chronically Handicapped[1]				Physically Handicapped[2]			
	No	WD[3]	Yes	Total	No	WD[3]	Yes	Total
Go more than one block	20%	30%	50%	100%	5%	5%	90%	100%
Go up and down stairs	35%	40%	25%	100%	5%	15%	80%	100%
Sit down/get up from bench	15%	30%	55%	100%	5%	5%	90%	100%
Go up and down inclines	20%	25%	55%	100%	0%	10%	90%	100%
Move in crowds	25%	25%	50%	100%	5%	5%	90%	100%
Manage cross walk signals	20%	15%	65%	100%	0%	5%	95%	100%
Hear a car horn	5%	15%	80%	100%	0%	5%	95%	100%
Wait standing up to 30 min.	50%	20%	30%	100%	10%	5%	85%	100%
Go up and down curbs	35%	35%	30%	100%	5%	10%	85%	100%

[1] People whose mobility is limited as the result of a chronic condition or impairment for more than three months.

[2] Those individuals who are not chronically handicapped, but do experience the cummulative disabilities generally associated with advanced age.

[3] With difficulty, i.e., able to perform the task but with difficulty.

Source: A Comprehensive Transportation Plan for the Elderly and the Handicapped. Linda King, et al, February, 1977 (1).

handicapped are employed according to 1970 National Census Data. A survey (2) in Seattle revealed that an additional 12% of the handicapped population would enter the job market if transportation was no longer a major problem.

Definition of Elderly and Handicapped

One of the major problems that arises when dealing with the definition of Transportation Handicapped is the determination of the different needs within the target population. Various study efforts (3, 4, 5) have approached this problem by categorizing the Transportation Handicapped according to the severity of mobility limitations, length of impairment, or medical conditions. The following section presents the different categories used by this study to define and estimate the Transportation Handicapped market.

Market Estimate

The process of market estimation is based on estimates of three categories of handicap. They are the chronic, acute, and institutionalized categories of the Transportation Handicapped. Separate estimates will be made for each category; but first, it is necessary to define the three groups.

Chronic and acute conditions are a means of separating the noninstitutionalized handicapped into two groups based on duration of the handicap. Acute conditions are expected to be temporary in nature and last less than three months. Chronic conditions generally last three months or more, although other specific conditions lasting less than three months but recurring frequently can be defined as chronic. The institutionalized population includes those in mental hospitals, homes for the aged, and other institutions.

Chronic Conditions

Two subcategories are used for persons with chronic conditions: 1) cannot use transit; and 2) use transit with difficulty. Persons in the homebound and wheelchair category are grouped in the cannot use transit subcategory. This group also includes those that need help (another person) and a portion of those who use other aids (other than wheelchairs). The remainder of those using special aids as well as those who have trouble getting around (but do not use other aids, nor need another to help, nor use a wheelchair nor is confined to house) are included in the second subcategory, use transit with difficulty.

The National Health Service (5) in the Limitations of Activity and Mobility report, provides information and incidence rates related to chronic conditions as shown in Table 2. Based on the 1972 National Health Service report, about 3.2% of the U.S. population have some chronic mobility limitations. This group can be subdivided into three different classifications;

a) Have trouble getting around, 1.3% of total population;

b) Needs help getting around, 1.0% of total population;

c) Confined to the house, 0.9% of total population.

Acute Conditions

Injuries can be assumed to be the most common acute conditions which might cause a transportation handicap. As a first order approximation, all those with fractures, dislocations, sprains and strains may be considered transportation handicapped. Overall incidence rates from National Health Survey data are 2.78 per thousand population. The only breakdown of these incidence rates available is 1.63 for those under 18, and 3.31 for those 18 years of age or older.

Table 2: Incidence of Mobility Limitations due to Chronic Conditions by Age, Region, and Mobility-Limitation Category: SMSAs (Noninstitutional)

Age and Region	Incidence of Mobility Limitation (Number of Mobility Limited/1000 Population)					
	Use Transit With Difficulty		Cannot Use Transit			
	Has Trouble	Uses Other Aids	Uses Other Aids	Needs Help	Uses Wheelchair	Confined to House
North East						
Under 18	0.90	0.15	0.08	0.45	0.23	0.45
18 to 64	8.44	1.46	0.84	1.31	1.31	5.48
65 & over	38.44	18.33	13.06	14.73	9.61	61.50
North Central						
Under 18	0.71	0.11	0.07	0.53	0.35	0.35
18 to 65	9.31	1.29	0.75	1.26	1.16	3.78
65 & over	44.77	20.84	14.85	16.33	10.89	38.11
South						
Under 18	0.26	0.10	0.06	0.78	0.47	0.94
18 to 64	12.96	1.91	1.10	1.76	1.67	7.11
65 & over	67.50	21.62	15.40	16.88	11.43	66.41
West						
Under 18	0.84	0.18	0.10	0.84	0.56	0.28
18 to 64	9.52	1.39	0.81	1.32	1.32	5.42
65 & over	40.90	20.12	14.33	16.15	10.76	40.90

Source: "Transportation Problems of the Transportation Handicapped" Vol.1, Crain and Associates, August 1976 (4).

Institutionalized Persons

Most of the information related to the institutionalized population is available through the Bureau of Census (6) reports. Some residents from a number of institutions, like mental hospitals, homes for the aged, chronic disease hospitals and other institutions, are transportation handicapped. However, for this study it is assumed that none of the institutionalized population will use public transportation, although an estimate of their numbers will be made in order to estimate the total Transportation Handicapped population.

Market Estimation Process

Using the above three categories, it is possible to estimate the Transportation Handicapped market. Input data consists of SMSA population by age group (6), institutional population by type of institution (6), incidence rates for chronic noninstitutional population (5) and incidence rates for acute conditions population (5). The process is defined below and summarized in Figure 1.

a) Compute noninstitutional population by age group by subtracting institutional population from noninstitutional population.

b) Apply incidence rate of the different mobility limitations categories for chronic conditions and acute conditions to the noninstitutional population. Table 2 (p. 9) presents the different mobility limitations categories for chronic conditions and their incidence within the urban population.

c) The mobility limitations categories for chronic conditions are then consolidated into the two Transportation Handicapped (T.H.) classifications, use transit with difficulty and cannot use transit*.

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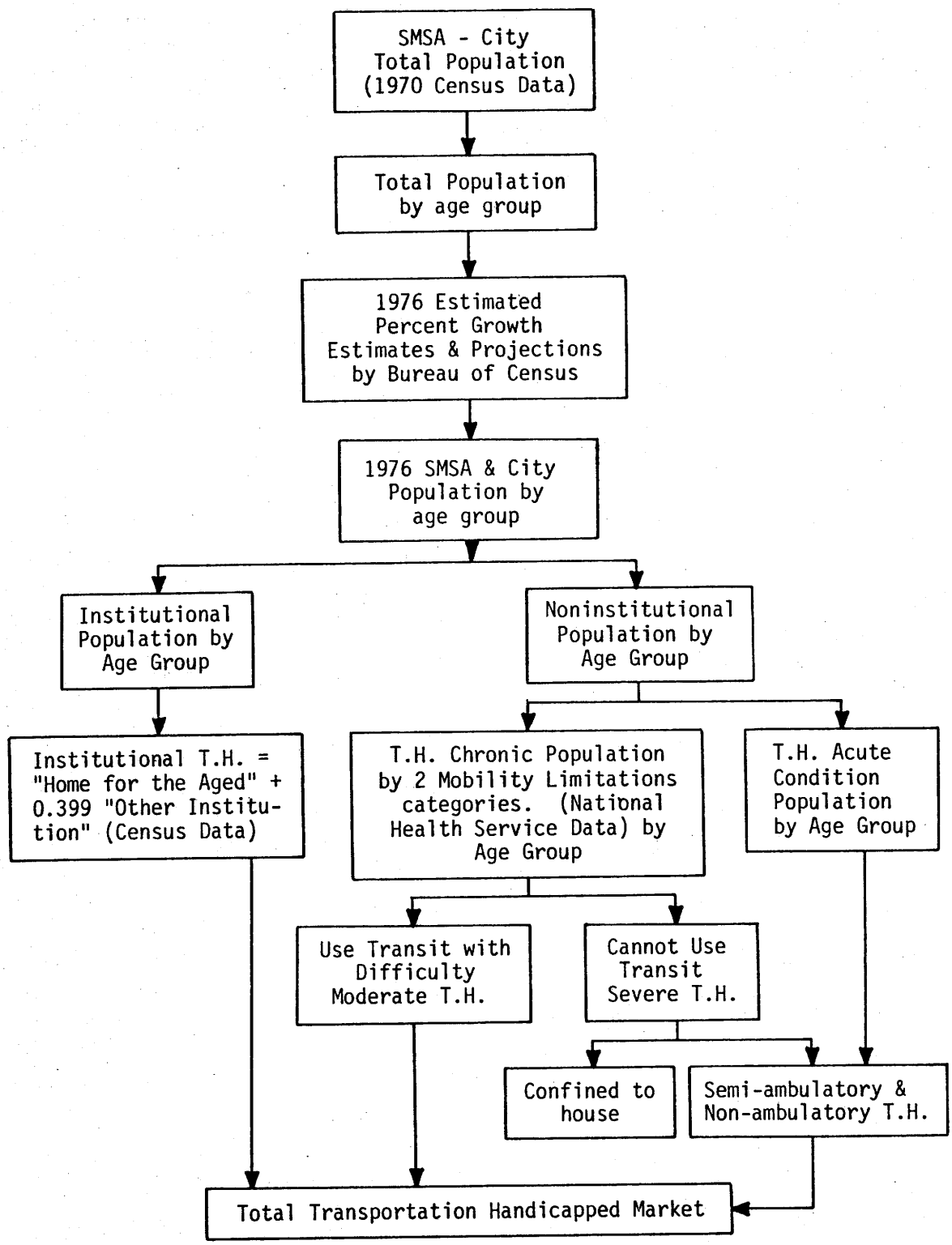
*Note: The homebound individuals will not be able to use any accessible public transportation since their critical condition would prevent them from riding independently or with an escort. For this reason this portion of the market would not be included for the estimation of the transportation handicapped population.

Figure 1: Market Estimation Procedure for Transportation Handicapped by Mobility



d) The acute condition population and "cannot use transit" chronic population are then consolidated to form the semi-ambulatory and non-ambulatory Transportation Handicapped population.

e) The institutional Transportation Handicapped population is approximated by obtaining the estimates for the "home for the aged" and "other institution" population from census data. Only 39.9% of the "other institution" population is considered to be transportation handicapped. Table 3 presents the percentage distribution of U. S. institutionalized population by age group and type of institution. Specific census data for each city would be used.

Table 3: Percentage Distribution of U. S. Institutionalized Population, by Age and Type of Institution

Age	Mental Hospital	Type of Institution	
		Home for the Aged	Other Institution
Under 18	4.40%	0.26%	28.00%
18 to 64	68.99	13.94	64.39
65 & over	26.61	85.80	7.61
TOTAL	100.00	100.00	100.00

Source: U.S. Bureau of the Census, Census of the Population: 1970, Detailed Characteristics (6).

"Transportation Problems of the Transportation Handicapped," Crain and Associates, August, 1976 (4).

f) The total Transportation Handicapped market is obtained by aggregating the "institutional" T.H., the "use transit with difficulty" chronic T.H., and the semi-ambulatory and non ambulatory T.H.

The validity of the preceding technique can be evaluated by comparing the results to a recently completed National Survey of Transportation Handicapped (7). The definition utilized by the National Survey of Transportation Handicapped to identify the transportation handicapped market is "any person which experienced general problems in the past 12 months such as visual, hearing, mechanical aids and perceived they have more difficulty in using public transportation than persons without their general problems and are not homebound.

Even though both market definitions are very similar there appears to be some difference when comparing the proportion of the Transportation Handicapped population over the total urban population. The estimates using the National Health Survey incidence rates yield a Transportation Handicapped population that is in the range of 2.5 - 4.0% of the urban population, while the National Survey estimates show 5%. This difference could be due to the fact that the incidence rates utilized by the National Health Survey are based on actual statistics in the Southern region of the U.S., categorized by age group and mobility limitations, whereas the National Survey figures represent the national trend for the overall Transportation Handicapped population.

For those purposes of this study the target market is the semi-ambulatory and nonambulatory exclusive of those confined at home. Those in institutions are assumed not to have the opportunity to use public transportation and/or have transportation provided by the institution. Those who can use transit, but do have handicaps are presumed to use transit presently if necessary or desirable and/or do not require a specialized service. Those confined to a house are assumed not to be able to use any public transportation service. Future reference to the target population will refer to the semi-ambulatory and nonambulatory Transportation Handicapped.

Travel Behavior of the Transportation Handicapped

There is little empirical data on travel behavior of the Transportation Handicapped that would provide a basis for forecasting their response to system modifications or installation of new equipment. Most of the available data relates to the evaluation of existing systems, and existing actual service demand characteristics. Latent demand or potential demand which has not been served by current modes due to barrier, economic or social inconveniences has been addressed by only a few studies (3, 7, 8, & 9).

Michaels and Weiler (3) used the results of their Chicago survey to predict the travel behavior of the Transportation Handicapped population in three different density areas, (urban, high-density suburban, and low-density suburban) within the city. The results indicated that trip frequency decreases with the increasing severity of mobility limitation, particularly in urban and high-density suburban. In the low-density suburban areas the trip frequency is the same for persons with either severe or moderate limitations. These differences in travel characteristics between the density classifications can be attributed to one of the following:

a) There are different needs for different density classes,

b) False correlation, or

c) The Transportation Handicapped that are more likely to make more needed (work, medical) trips may also be more likely to be less contained in their residential area choices.

According to the Michaels and Weiler report (3), the trip purpose survey results point out that the severe mobility category presents the highest percentage of work trips. One would expect that, as severity of mobility limitation increases, the percentage of "optional trips" (shopping and social)

decreases in favor of the necessary trips. Tables 4 and 5 show the distribution of trip purposes by mobility limitation and density.

Table 4: Trip Purpose versus Mobility Limitation Classification

Trip Purpose	Severe %	Moderate %	Little %
Recreation	21	22	19
Personal Business	7	7	8
Shopping	11	15	23
Social	27	33	32
Medical	7	7	6
Work	27	16	12
TOTAL	100%	100%	100%

Source: Reference (3).

Table 5: Trip Purpose versus Density Classification

Trip Purpose	Urban	High-Density Suburban	Low-Density Suburban
Recreation	18	20	21
Personal Business	8	7	16
Shopping	26	17	18
Social	30	37	30
Medical	8	3	3
Work	11	16	18
TOTAL	100%	100%	100%

Source: Reference (3).

A technique was developed by Michaels and Weiler (3) to determine the latent demand (travel desired by the users, but cannot be made due to economic, social or physical constraints) in order to measure the induced trips that could be attracted, with different changes in the accessibilities. Michaels

and Weiler defined latent travel demand as the difference between desired travel and the actual travel. The amount desired was reduced in order to eliminate factors other than transportation (economic, physical conditions). Table 6 shows the actual and desired trip rates developed in the study by mobility limitations, for each region.

Table 6: Actual and Desired Trips by Mobility for Each Region per Week

Mobility by Area	Actual Trips	Desired Trips	Ratio Actual/Desired
Urban Area			
Severe	2.8	5.1	.55
Moderate	3.1	5.7	.54
Little	4.6	6.9	.67
Suburban High-Density			
Severe	2.7	5.1	.53
Moderate	4.0	6.1	.65
Little	5.7	6.5	.88
Suburban Low-Density			
Severe	4.8	10.0	.48
Moderate	4.7	6.3	.75
Little	5.9	7.1	.83

Source: Reference (3).

The Michaels and Weiler report does not address the issue of which mode of transportation the Transportation Handicapped will use to fulfill their needs. For this reason, an alternative technique is necessary. Nevertheless, the

Michaels and Weiler data do provide some insight in the latent demand of the handicapped.

A recent study by the U. S. Department of Transportation entitled National Survey for the Transportation Handicapped (7) addressed the latent demand at a national level. The National Survey for the Transportation Handicapped defined latent demand for different transportation alternatives to the problem. The respondents to the survey were asked how many more trips they would take with each alternative. The four solution alternatives for which latent demand was determined are:

Alternative I - an accessible fixed-route system,

Alternative II - an accessible feeder to accessible fixed-route system,

Alternative III - a new door-to-door system, and,

Alternative IV - individual subsidies (taxi subsidies).

Of these four alternatives, only Alternative I and III are under consideration in this study.

In order to determine the potential users and the estimated additional trips a barrier sensitive potential estimate was performed. This estimate was based on those who expressed interest in the alternative concept by saying they would use the solution and who either are current users of the existing system or are non-users who would actually have their barriers removed as a result of the solution alternative.

Table 7 presents the latent demand trip estimate for the two alternatives. The barrier sensitive potential estimate for Alternative I is obtained by dividing the total number of additional trips (4.6 million/month) by the Transportation Handicapped population in mass transit areas (4.94 million). The estimate of 0.96 additional trips per month represents an increase of 3.2% over the total trips per Transportation Handicapped in mass transit areas per month

Table 7: Latent Travel Demand for the Two Solution Alternatives the Barrier Sensitive Potential Estimate

Estimation Criteria	Latent Demand in Trips Per Person Per Month	
	Alternative I Accessible Fixed Route (trips/month)	Alternative III Accessible Door-to-Door Service (trips/month)
Barrier Sensitive Potential	0.96	2.19

Source: Reference (7)

(29.6 trips/month). The Alternative III estimate is derived by dividing the additional number of trips using this mode (14.8 million trips/month) by the Transportation Handicapped population in urban areas (6.75 million). This yields an estimate of 2.19 additional trips/month, which represents an increase of 7.4% over the total trips per Transportation Handicapped in urban areas per month (29.5 trips/month). Table 8 presents the Latent Travel Demand estimates for the cities in Texas using the National Health Survey (6) incidence rates by mobility limitation category to estimate the Transportation Handicapped population and the latent travel demand generation rates from the National Survey of Transportation Handicapped People (7).

In projecting the level of demand for accessible fixed-route service it was evident that an adjustment in demand was required to account for the amount of public transit service provided. In other words, if minimal transit service is provided in a community, the latent demand potential is not likely to be achieved to the same degree as a community with a higher level of transit service. An adjustment factor was computed using a ratio of vehicle-hours of service divided by city population. Based on knowledge of the various systems, a ratio of 1.0

Table 8: Transportation Handicapped Market and Latent Demand Estimates for Texas Cities

City	Estimated City Population 1976	Non-Institutional		Institutional T. H.	Total Transportation Handicapped	Semi-Amb. & Non-Amb. T. H.	Total Fixed Route Latent Demand (pass/month)	1978 Reg.-Route Bus-Hours	Service Parameter Adjustment	Adjusted Fixed Route Latent Demand (pass/month)	Dial a Ride Latent Demand (pass/month)	Fixed Route Fare Revenue 1979 Dollars Per Year	Dial a Ride Fare Revenue 1979 Dollars Per Year
		Chronic	Acute										
Category A													
Dallas	941,758	20,057	2,554	4,468	27,079	7,445	7,147	934,230	0.992	7,090	16,305	17,016	39,132
Houston	1,483,915	29,196	3,985	5,281	38,462	10,955	10,517	1,268,208	0.885	9,307	23,991	22,332	57,578
San Antonio	747,418	16,025	2,000	3,462	21,487	5,980	5,741	915,808	1.000	5,741	13,096	6,888	15,715
Sub-total	3,173,091	65,278	8,539	13,211	87,028	24,380	23,405	3,118,246		22,138	53,392	46,236	112,425
Category B													
Austin	349,445	7,569	969	3,333	11,871	2,778	2,667	196,738	0.563	1,501	6,084	2,702	10,951
Corpus Christi	214,268	4,210	566	853	5,629	1,670	1,603	85,282	0.398	638	3,657	1,148	6,583
El Paso	381,377	7,129	1,001	681	8,811	2,717	2,608	434,432	1.000	2,608	5,950	5,477	12,495
Ft. Worth	438,842	9,557	1,192	2,420	13,169	3,539	3,397	229,538	0.523	1,777	7,750	4,265	18,600
Subtotal	1,383,932	28,465	3,728	7,287	39,480	10,704	10,275	945,990		6,524	23,441	13,592	48,629
Category C													
Abilene	103,452	2,641	285	1,430	4,356	951	913	19,576	0.189	173	2,083	208	2,450
Amarillo	135,897	3,043	379	645	4,067	1,111	1,067	47,770	0.366	390	2,433	702	4,379
Beaumont	130,432	2,879	353	703	3,935	1,011	971	52,728	0.404	392	2,214	706	3,985
Brownsville	67,164	1,439	173	306	1,918	544	522	35,998	0.531	277	1,191	499	2,143
Galveston	67,810	1,446	181	534	2,161	540	518	50,193	0.740	384	1,183	461	1,420
Laredo	78,347	1,633	203	211	2,047	619	594	79,651	1.000	594	1,356	1,247	2,848
Lubbock	165,987	3,364	450	938	4,752	1,039	997	71,307	0.430	429	2,275	1,030	5,460
San Angelo	69,417	1,782	191	366	2,339	649	623	18,570	0.268	167	1,421	200	1,705
Waco	100,396	2,797	279	1,255	4,331	1,010	970	37,257	0.371	360	2,212	864	5,309
Wichita Falls	98,771	2,561	273	642	3,476	928	891	20,635	0.209	186	2,032	446	4,879
Subtotal	1,017,673	23,585	2,767	7,030	33,382	8,402	8,066	435,685		3,352	18,400	6,363	34,578
State Total	5,574,696	117,328	15,034	27,528	159,890	43,486	41,746	4,499,921		32,014	95,233	66,191	195,632

Note: 1976 Estimates assume growth in non-institutional population proportional to growth in total population

Source: U.S. Bureau of Census (6)

was selected as a good level of service. Any system with a ratio of less than one had their latent demand reduced by the service ratio. Table 8 shows adjusted fixed-route handicapped demand which is the basis for further analysis of the accessible bus alternative. No adjustment was made to specialize service demand because the level of door-to-door service to be provided would be a function of the demand estimate.

III. COSTS

Two aspects of cost are considered for the two alternative systems. First, the capital cost requirements are determined for each alternative system. Second, the operating costs are also estimated for each alternative system.

Capital Costs

The capital costs are estimated based on the demand projected in the previous chapter. The costs are estimated for a fifteen-year period beginning in 1979. The fifteen-year period was selected since all vehicles are likely to be replaced during the evaluation period.

The procedure used to equate the various replacement program costs was to compute the present worth of the replacement program. The present worth technique results in the calculation of total cost in 1979 dollars. Three assumptions are required in the analysis.

First it is necessary to assume an interest rate by which to discount future expenditures. For this analysis a 10% interest rate was used. It should be noted that higher (NOT lower) interest rates make an analysis more conservative. A zero interest rate assumes a dollar in 1979 has the same value as a dollar in 1993. A 10% interest rate says a dollar in 1993 is equivalent to 26¢ in 1979.

The second assumption is that a vehicle depreciates proportionally to its age over its life and has no salvage value. Therefore, a 10-year old bus that originally cost $120,000 and has a 12-year life expectancy is assumed to be worth $20,000. This assumption is necessary to account for the terminal value of the fleet in 1993. The computation of a salvage value is also necessary if buses are replaced prematurely. Premature replacement is one alternative to obtain the required number (50% of peak-hour) of accessible buses by 1982 if

normal replacement would not meet the requirement. The other alternative is retrofitting buses with lifts.

The third assumption is the estimated replacement cost of buses during the 15-year period. Using American Public Transit Association data (10) for bus purchases from 1973 to 1978 it was determined that the average price increase was slightly in excess of 15%. Given the uncertain nature of future prices in general and bus prices in particular, it was assumed that the 15% annual price increase would be sustained. It should be noted that this price increase is partly due to changes in specifications. With virtual public ownership of all transit systems it is likely that specifications will continue to require additional and/or more expensive features.

Current (1979) bid prices in Texas were used to estimate the current large bus price at $106,250 without lifts and $117,250 with lifts. Small buses were assumed to be replaced with small diesel buses of transit-type construction. Costs were estimated at $90,000 without lifts and $100,000 with lifts. Vans without lifts were estimated at $10,000 and vans with lifts were estimated at $12,500. All costs were then increased 15% per year through 1993 except for vans. Vans were only expected to increase 10% per year. The cost of retrofitting a bus with a lift was estimated at $12,000.

Accessible Bus Alternative

The U. S. Department of Transportation Section 504 final rule requires accessible buses by 1982 or provision of an alternative service with an absolute 1989 deadline for accessible buses. To meet the accessible bus requirement it is only necessary that one-half the peak-hour fleet be equipped with lifts. However, the entire fleet will eventually be lift-equipped because all purchases (except vans) must include lifts.

For comparison purposes, the capital cost of a normal replacement program (i.e., replacement of worn-out buses) without lifts was calculated for the 15-year period ending in 1993. This period includes a complete replacement of the existing fleet. Table 9 summarizes the existing transit fleet in Texas and an estimated 15-year replacement program. The program was formulated using replacement dates specified by the transit system; if replacement dates were not provided, they were estimated. For estimation purposes, regular coaches were assigned a 12-year life, truck-chassis type buses were assigned an 8-year life, and vans a 4-year life.

For the purposes of this study, only 3 sizes of vehicles were considered. Large vehicles were those seating 40 or more, small vehicles had a capacity of 16 to 39, and vans had a capacity of 15 or less. Of course, these capacities are assuming no space loss for wheelchair positions. Lift-equipped vehicles would have appropriately less total capacity.

It should also be noted that the replacement program assumed existing peak-hour service plus a requirement of 10% spares. No replacement was programmed for excess equipment. No increase in service was programmed for any city.

Using the replacement schedule shown in Table 9, the capital cost of normal replacement for the 15-year period was calculated using costs for buses without lifts. Table 10 shows an example calculation for Fort Worth. Table 11 summarizes the capital costs for normal replacement in all 17 Texas transit systems.

In order to determine the cost of installing lifts on all new buses and also meeting the requirement that 50% of the total number of peak-hour buses be equipped with lifts by 1982, a second capital cost was calculated. If necessary, the replacement program was accelerated or existing buses were assumed to be retrofitted. The alternative selected was that which was least costly. For

Table 9: Existing Texas Transit Fleet and Estimated 15-Year Normal Replacement Program

Transit System	Vehicles Owned	Peak Hours Requirement	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Number of Accessible Buses Required by 1982	1982 Accessible Bus Deficit
Category A																			
Dallas	451L 6S	386	301L					50L			50L 6SA			50L	301L			193	None
Houston	583L 57S	362	255L 6SA	77L			14S	12S	25S		100L			151L	255L 6SA	77L		181	None
San Antonio	377L	300	189L	2L	18L			10S						121L	189L	2L	18L	150	None
Subtotal	1411L 63S	1,048																524	
Category B																			
Austin	71L 5S 5V	59		5VA				5VA			40L	5VA			23L	5VA	8L 5SA	30	30
Corpus Christi	23L 19S 9V	26	4V 14L			3V 2VA	4V			3V 2VA	4V	15L		3V 2VA	4V 14L			13	None
El Paso	109L	69												84L				35	35
Fort Worth	106L	90		23L					61L		20L					23L		45	22
Subtotal	309L 24S 14V	244																123	87
Category C																			
Abilene	12S	6	6S		2S										6S		2S	3	None
Amarillo	11L 26S	14				8S			4S		4S	10S						7	None
Beaumont	25L	13												15L				7	7
Brownsville	18S	12	7S	7S											7S	7S		6	None
Galveston	15L	11					3L	3L	3L	3L	3L							6	6
Laredo	22S	19		14S	8S											14S	8S	10	None
Lubbock	7L 34S	19		7L 9S	5S 1SA											7L 9S	5S 1SA	10	None
San Angelo	10S	5		6S												6S		3	None
Waco	16S 1V	14	2S		2S	12S 1VA					1VA				2S	1VA	2S	7	None
Wichita Falls	10S	4				3S				3S	2S							2	None
Subtotal	58L 148S 1V	117																61	13

Notes: L = Large (40 or more passengers) bus
S = Small (19 to 39 passengers) bus
V = Van

LA = Large Accessible Bus
SA = Small Accessible Bus
VA = Van Accessible

Table 10: Present Value (1979 Dollars) of 15 Year Capital Replacement Program for Ft. Worth Transit System Without Lifts

Year	Purchase	Cost	Retire	Salvage Value	PWIF i = 10%	1979 Cost
1979					1.00000	
1980	23L	2,810,324	23L	0	0.909091	2,554,840
1981					0.826446	
1982					0.751315	
1983					0.683013	
1984					0.620921	
1985	61L	14,991,543	61L	0	0.564474	8,462,336
1986					0.513158	
1987	20L	6,500,420	20L	0	0.466507	3,022,491
1988					0.424098	
1989					0.385543	
1990					0.350494	
1991					0.318631	
1992	23L	15,035,882	23L	0	0.289664	4,355,354
1993				-22,030,283	0.263331	-5,801,256
Total						12.603,705

Notes: L = Large Bus (40 or more passengers)

Table 11: Present Value (1979 Dollars) of 15-Year Replacement Program of Fixed-Route Buses With and Without Lifts

Transit System	Normal Replacement Program Capital Cost, (M dollars)	Replacement with 50% Accessible Buses by 1982 (M dollars)	Percentage Increase
Category A			
Dallas	64,722	71,359	10.3
Houston	80,771	89,078	10.3
San Antonio	42,512	47,757	12.3
Subtotal	188,005	208,194	10.7
Category B			
Austin	5,857	6,373	8.8
Corpus Christi	4,092	4,483	10.0
El Paso	6,353	7,326[1]	15.3
Ft. Worth	12,604	13,455	6.8
Subtotal	28,906	31,637	9.5
Category C			
Abilene	1,023	1,137	11.1
Amarillo	2,421	2,690	11.1
Beaumont	1,134	1,313[1]	15.8
Brownsville	1,810	2,011	11.1
Galveston	1,732	1,840	6.2
Laredo	2,478	2,754	11.1
Lubbock	2,687	2,966	10.4
San Angelo	725	805	11.0
Waco	1,699	1,872	10.2
Wichita Falls	734	860	11.1
Subtotal	16,443	18,248	11.0
State Total	233,354	258,079	10.6

Note: [1] Retrofit Alternative is less expensive.

two systems, El Paso and Beaumont, retrofitting would be least costly. Three systems, Austin, Fort Worth, and Galveston would have to accelerate their replacement program to meet the requirement at least cost. The other 12 systems would only have to change their specifications as part of normal replacement to meet the requirements. Table 12 shows an example calculation for Fort Worth, and Table 11 (see page 26) shows the cost of accessible buses for all 17 systems. As shown in Table 11, the normal replacement program would cost $233,394,000 in 1979 dollars. The accessible bus alternative would cost $258,079,000. The net effect is about a 10% increase in capital costs for accessible buses.

Specialized Service Alternative

The second alternative being costed in this section is a separate specialized service. This alternative is based on meeting the demand projected in Chapter II of this report. Table 13 shows the number of vehicles (including 10% spares) required and the estimated capital cost in 1979 dollars.

The capital program was formulated assuming half the required number of vans were purchased in 1980 and the other half (plus any odd number) were purchased in 1982. Vehicles were assumed to be replaced every four years through 1993.

Operating Cost

The second half of the cost analysis concerns operating costs. The following two subsections separately examine the operating costs for accessible fixed-route buses and separate specialized service.

Accessible Bus Alternative

There is little data and a wide difference of opinion concerning the marginal increase in costs to operate lift-equipped fixed-route buses. The final U. S. Department of Transportation rule implementing Section 504 of the

Table 12: Present Value (1979 Dollars) of 15 Year Capital Replacement Program for Ft. Worth Transit System With 50 Percent Accessible Buses

Year	Purchase	Cost	Retire	Salvage Value	PWIF i = 10%	1979 Cost
1979					1.00000	
1980	45LA	6,067,710	45L	336,463	0.909091	5,210,225
1981					0.826446	
1982					0.751315	
1983					0.683013	
1984					0.620921	
1985	39LA	10,577,034	39L	0	0.564474	5,970,461
1986					0.513158	
1987	20LA	7,173,400	20L	0	0.466507	3,346,441
1988					0.424098	
1989					0.385543	
1990					0.350494	
1991					0.318631	
1992	23LA	16,592,522	23L		0.289664	4,806,256
1993				-22,322,189	0.263331	-5,878,125
Total						13,455,258

Notes: L = Large Bus (40 or more passengers)

LA = Large Bus with wheelchair lift

Table 13: Capital Costs (1979 Dollars) for Specialized Service

Transit System	Number of Vans[1]	Total Capital Cost[2]
Category A		
Dallas	34	1,328,000
Houston	50	1,953,000
San Antonio	28	1,094,000
Subtotal	112	4,375,000
Category B		
Austin	11	424,000
Corpus Christi	7	268,000
El Paso	11	424,000
Ft. Worth	14	547,000
Subtotal	43	1,663,000
Category C		
Abilene	4	156,000
Amarillo	5	190,000
Beaumont	5	190,000
Brownsville	3	112,000
Galveston	3	112,000
Laredo	3	112,000
Lubbock	5	190,000
San Angelo	4	156,000
Waco	5	190,000
Wichita Falls	4	156,000
Subtotal	41	1,564,000
Statewide Total	196	7,602,000

[1]Includes 10% spares

[2]Figures have been rounded to the nearest thousand

Rehabilitation Act of 1973 (see 49CFR Part 27, Federal Register, Vol. 44, No. 106, Thursday, May 31, 1979, p. 31456) estimates the marginal increase in operating costs to average 1.3%. Texas Transportation Institute contacted numerous transit properties concerning experience with lift-equipped buses and could only identify 9 systems with any experience. Table 14 summarizes the operations of the 9 systems using lift-equipped buses.

Three areas have been identified as being impacted by using lift-equipped buses. The areas are: (1) increased maintenance directly attributable to the lift, (2) increased fuel utilization to operate the lift, and (3) increased costs due to the need to decrease schedule speed. Each of these areas will be examined.

The Denver Regional Transportation District's operating experience with 10 buses indicates one additional maintenance employee is required for every six buses. In addition, three additional staff members support the accessible service. According to the American Public Transit Association (APTA) 1976 Transit Operating Report (11), Denver operates 368 peak-hour buses utilizing a fleet of 395 vehicles. Total operating cost was $29,520,246 in 1976. Using APTA's 1978 Transit Labor Information Review (12), a top mechanic rate of $7.26 and fringe benefits of 23.5% yields an annual compensation of approximately $18,700 in 1976. The three additional staff members are ignored since maximum mechanic wages are likely to overestimate wage costs. Sixty-six additional mechanics would increase expenses $1,234,200 or 4.2%. This estimate is labor and benefits only for mechanics. Other costs are discussed subsequently.

San Diego Transit records for July 1, 1977 through April 30, 1978 indicate a lift maintenance cost of $350 per vehicle per month. Again these are maintenance only costs based on experience with 4 buses. On a per bus basis, the Denver costs were approximately $260 per bus. San Diego operated 257 peak-hour

Table 14: Operations Summary - Transit Companies with Lift Equipped Buses

City	Number of Lift Equ. Buses	Make	Boarding Time	Alighting Time	Additional Expenses	Comments
Topeka, Kansas 4/10/79	3	FMC	3-5 min.	3-5 min.	None	For E & H demand-responsive service. Little extra maintenance required. Only problem is electrical shock. Average number of repairs is 1 per month.
MARTA Atlantia, Georgia 4/10/79	13		3 min.		2 schedules 1 clerk 1 mechanic	Average lift breakdown is 1 per day. Operating on requests received from the E & H on a fixed-route basis.
Metro. Dade County Miami, Florida 4/12/79	8 operating	GM-Motor Home chassis retrofitted by Recreation/ Industries				Numerous front end breakdowns due to front axle overload. Inadequate alternator. Lift operates inadequately due to chains slipping off pullies. Transmission problems and oil leaks. Clutch problems.
Milwaukee County Transit System 4/5/79	100	Flexible with vapor travel light	3 min. planning figure	2 min. planning figure	Budgeted 5 employees at $75,000 per year.	Lifts have not been in use since they were received in June 1978. No additional schedule time planned. Will treat like other delays.
Regional Trans. District Denver, Colorado 4/6/79	10	Lifts - 70% dependable	3-5 min.	3-5 min.	1 maintanence employee per 6 buses. Additional training time to operators. 1 Dispatcher 1 Adm. Employee	Currently in mechanic familiarization and debugging mode on these lifts.
WMATA Washington, D.C. 4/8/79	150					These buses are still being tested on some routes.
San Diego, CA 4/10/79	4 scheduled daily. 3 operate 90% of the time		5 min. max. No impact on schedule	5 min. max. No impact on schedule	Operating Cost $351/month w/benefits 3.6% Additional fuel consumption	3 road calls/month. Headway on 2 routes are 60-80 min. work in coordination with San Diego Dial-a-ride service. Wheelchair usage is 162/11 months.
Intracity Transit Topeka, Kansas	3		3-5 min.	3-5 min.	None	Demand responsive service
Bi-State St. Louis, Missouri	157	Unknown	2½ min.	3½ min.	See text	Very low utilization by wheelchair passengers, probably due to inaccessibility to bus stops and severe winter. About 50% or 60% of the lift buses are inoperable on a given day.

Source: Mail Survey conducted by TTI to transit companies operating lift-equipped transit buses.

buses in 1976. Assuming 10% spares (since the 350 active buses exceed requirements) results in a total fleet requirement of 283. At $350 per vehicle, the total cost for the fleet would be $1,188,600, or 4.9% of the $24,221,123 total operating expense.

Experience in St. Louis with 157 buses is a $350 per month total cost with 42% of that cost attributable to lift maintenance. Peak hour service requires 730 buses or a total fleet requirement, assuming 10% spares, of 803. The total marginal increase in operating cost would be $3,066,000 or 7.0% of the $43,714,620 total operating cost.

It would, therefore, seem likely that operating costs for maintenance would not exceed 7% and would be more likely to be 5% or less as experience is gained maintaining lifts. For the purpose of this analysis, it is assumed that maintenance requirements will increase operating costs 5%.

The second area of concern is increased fuel costs. San Diego experienced a 3.6% increase in fuel consumption, or a $33,878 increase in 1976 costs. This is 0.1% of their total budget and does not appear to warrant further consideration. Increased fuel consumption is not considered in the analysis.

The third area of concern is the need to reduce operating speeds to accommodate handicapped riders. Table 14 (see page 31) indicates a range of boarding or alighting times of 3 to 5 minutes for handicapped service. For analysis purposes, a 4-minute boarding or alighting time was assumed. The following analysis will attempt to place an upper limit on the potential impact. Table 15 shows typical regular passenger service times on and off buses. For analysis purposes a 3-second service time is assumed for both boarding and alighting.

Table 16 indicates that projected demand will average 0.3% of existing ridership with most systems near the mean. Therefore, if 0.3% of riders require 240 seconds (4 minutes) while 99.7% require 3 seconds, average service

Table 15: Passenger Service Time On and Off Buses

Operations	Conditions	Time (Sec)
Unloading	Very little hand baggage and parcels; few transfers	1½-2½
	Moderate amount hand baggage or many transfers	2½-4
Loading	Single coin or token fare box	2-3
	Odd-penny cash fares	3-4
	Multiple-zone fares; prepurchased tickets and registration on bus	4-6
	Multiple-zone fares; cash, including registration on bus	6-8

Source: Highway Capacity Manual, Highway Research Board Special Report 87, 1965.

time is increased to 3.7 seconds, an increase of 23%. However, as shown in Table 17, passenger delay is only 17.9% of total trip time. Trip time, on the average, would increase to 22.1%, an increase of 4.2%.

To see how an average run might be impacted, it is useful to examine the average productivity of transit systems in Texas. Table 18 presents average speed and passengers per vehicle-hour for Texas transit systems. If the typical run is assumed to be an hour, the average number of handicapped rides is 24.78 x .003, or 0.07 per hour or 1 every 13.45 hours.

It, therefore, appears questionable whether additional time should be allocated to allow for handicapped riders at the projected low level of demand. Experience to date in at least one city, San Diego, has indicated no schedule problems resulting from delays in accommodating the handicapped. If schedules were adjusted, the amount of adjustment would be less than 5%. The impact of a 5% reduction in speed would be a less than 5% increase in cost.

Table 19 shows the estimated operating costs in Texas for 1979 by system. If operating costs are assumed to be increased 5% for increased maintenance of lifts, the increase in operating costs in Texas would be $5,163,000 in 1979

Table 16: Estimated Increase in Fixed-Route Handicapped Ridership with Accessible Buses

City	Fixed Route Regular Route 1978 Passenger (pass./yr.)	Estimated Fixed Route Semi- & Non-Amb. Ridership (pass./yr.)	Percent Increase In Demand Over 1978 (%)
Category A			
Dallas	25,557,634	85,080	0.3
Houston	32,913,708	111,684	0.3
San Antonio	23,417,021	68,892	0.3
Subtotal	81,888,363	265,656	0.3
Category B			
Austin	4,012,059	18,012	0.4
Corpus Christi	1,411,993	7,656	0.6
El Paso	8,226,670	31,296	0.4
Ft. Worth	4,282,548	21,324	0.5
Subtotal	17,933,270	78,288	0.4
Category C			
Abilene	205,036	2,076	1.0
Amarillo	558,148	4,680	0.8
Beaumont	964,293	4,704	0.5
Brownsville	801,146	3,324	0.4
Galveston	1,051,880	4,608	0.4
Laredo	2,659,324	7,128	0.3
Lubbock	2,202,972	5,148	0.2
San Angelo	220,601	2,004	0.9
Waco	458,050	4,320	0.9
Wichita Falls	213,926	2,232	1.0
Subtotal	9,335,376	40,224	0.4
State Total	109,157,009	356,216	0.3

Table 17: Classification of Passenger Delays

Factor Factor	Delay Time as Percent of Total Delay Time	Delay Time as Percent of Total Trip Time
Traffic Delays		
Traffic Signals	30.7	9.1
Stop Signs	1.9	0.6
Other Traffic Stops	7.2	2.1
Total	39.8	11.8
Passenger Stops	60.2	17.9
Total--All Delays	100.0	29.7

Source: "St. Louis Metropolitan Area Transportation Survey Report," W. C. Gilman & Company, Engineers, 1959.

dollars. If these costs are assumed to increase 10% annually over the 15-year study period, the present worth for the entire 15-year period is $77,445,000. These costs would be approximately doubled if it were necessary to reduce schedule speeds to accommodate handicapped riders.

Separate Specialized Service Alternative

The operating costs for the separate specialized service alternative are estimated assuming operating hours are the same as those for regular fixed-route service. This is a requirement of the Section 504 regulations. The cost of operating Saturday service was assumed to be 50% of normal weekday cost. Similarly, nighttime service and Sunday service were assumed to cost 25% of normal weekday service.

The operating costs for the specialized service were assumed to be the same as the operating cost per vehicle-hour for fixed-route service. These costs are shown in Table 19 (see page 37). The operating costs for specialized service are summarized in Table 20. The statewide total is $10,385,000 and represents an 11% increase over the estimated 1979 fixed-route (non-accessible) operating expenses of $98,025,000.

Table 18: 1978 Operating Statistics for Texas Transit Systems

City	Regular Route Passengers	Regular Route Veh.-Miles	Regular Route Veh.-Hours	Passengers / Veh.-Miles	Passengers / Veh.-Hours	Operating Speed Veh.-Miles / Veh.-Hours
Category A						
Dallas	25,557,634	13,061,397	934,230	1.96	27.36	13.98
Houston	32,913,708	16,583,188	1,268,208	1.98	25.96	13.08
San Antonio	23,417,021	12,380,166	915,808	1.89	25.56	13.52
Subtotal	81,888,363	42,024,751	3,118,246	1.95	26.26	13.47
Category B						
Austin	4,012,059	2,504,508	196,738	1.60	20.39	12.73
Corpus Christi	1,411,993	1,165,090	85,282	1.21	16.56	13.66
El Paso	8,226,670	3,973,097	434,432	2.07	18.94	9.15
Ft. Worth	4,282,548	2,908,379	229,538	1.47	18.66	12.23
Subtotal	17,933,270	10,551,074	945,990	1.70	18.96	11.15
Category C						
Abilene	205,036	308,941	20,678	0.66	9.92	14.94
Amarillo	558,148	696,744	49,770	0.80	11.21	14.00
Beaumont	964,293	556,175	52,728	1.73	18.29	10.54
Brownsville	801,146	442,487	35,998	1.81	22.26	12.29
Galveston	1,051,880	508,224	50,193	2.07	20.96	10.12
Laredo	2,659,324	733,075	79,651	3.63	33.39	9.20
Lubbock	2,202,972	960,059	71,307	2.29	30.89	13.51
San Angelo	220,601	265,884	18,570	0.83	11.88	14.32
Waco	458,050	472,560	37,257	0.97	16.80	12.68
Wichita Falls	213,926	289,745	20,635	0.74	10.37	14.04
Subtotal	9,335,376	5,233,894	436,787	1.78	21.37	11.97
State Total	109,157,009	57,809,719	4,501,023	1.93	24.25	12.84

Source: Texas State Department of Highways and Public Transportation
Preliminary Data

Table 19: Estimated 1979 Operating Costs for Texas Transit Systems

City	1978 Total Operating Expenses, $ ($)	1978 Reg. Route Veh.-Hours (Hours)	1978 Total Veh.-Miles (Miles)	1978 Regular Route Veh.-Miles (Miles)	Regular Route Operating Spd. Rt. Veh.-Miles / Rt. Veh.-Hrs. (MPH)	1978 Total Op. Exp. / Total Veh-Miles ($/Mile)[1]	Estimated 1978 Regular Route Operating Exp. / Veh.-Hr. ($/Hr.)[1]	Estimated 1979 Regular Route Operating Exp. / Veh.-Hr. ($/Hr.)[1]	Estimated 1979 Regular Route Operating Exp. ($)[2]	Estimated 1979 Regular Route Operating Exp. Increase ($)[2]
Category A										
Dallas	19,319,963	934,230	13,818,451	13,061,397	13.98	1.48	19.55	21.51	20,095,000	1,005,000
Houston	36,333,257	1,268,208	16,908,385	16,583,188	13.08	2.14	27.99	30.79	39,048,000	1,952,000
San Antonio	18,693,571	915,808	13,563,609	12,380,166	13.52	1.38	18.65	20.52	18,792,000	940,000
Subtotal & Weighted Avg.	74,346,791	3,118,246	44,290,445	42,024,751	13.48	1.68	22.65	24.92	77,935,000	3,897,000
Category B										
Austin	3,649,372	196,738	2,884,565	2,504,508	12.73	1.27	16.17	17.79	3,500,000	175,000
Corpus Christi	1,923,037	85,282	1,279,983	1,165,090	13.66	1.50	20.49	22.54	1,922,000	96,000
El Paso	4,064,834	434,432	3,983,601	3,973,097	9.15	1.02	9.33	10.26	4,457,000	223,000
Ft. Worth	4,134,836	229,538	3,089,734	2,908,379	12.23	1.34	16.39	18.03	4,139,000	207,000
Subtotal & Weighted Avg.	13,772,079	945,990	11,237,883	10,551,074	11.15	1.23	13.71	15.08	14,018,000	701,000
Category C										
Abilene	240,862	20,678	317,669	308,941	14.94	0.76	11.32	12.45	257,000	13,000
Amarillo	756,273	49,770	845,190	696,744	14.00	0.89	12.46	13.71	682,000	34,000
Beaumont	661,958	52,728	561,414	556,175	10.54	1.18	12.43	13.67	721,000	36,000
Brownsville	412,626	35,998	488,211	442,487	12.29	0.85	10.45	11.50	414,000	21,000
Galveston	647,196	50,193	533,370	508,224	10.12	1.21	12.25	13.48	677,000	34,000
Laredo	1,032,206	79,651	734,265	733,075	9.20	1.41	12.97	14.27	1,137,000	57,000
Lubbock	992,681	71,307	985,059	960,059	13.51	1.01	13.65	15.02	1,071,000	54,000
San Angelo	203,263	18,570	272,549	265,884	14.32	0.75	10.74	11.81	219,000	11,000
Waco	556,414	37,257	482,161	472,560	12.68	1.15	14.58	16.03	597,000	30,000
Wichita Falls	271,584	20,635	291,765	289,745	14.04	0.93	13.07	14.38	297,000	15,000
Subtotal & Weighted Avg.	5,775,063	436,787	5,511,653	5,233,894	11.98	1.05	12.58	13.84	6,072,000	305,000
State Total & Weighted Avg.	93,893,943	4,501,023	61,039,981	57,809,719	12.84	1.54	19.77	21.75	98,025,000	4,903,000

Notes: [1] Figures have been rounded to the nearest cent.
[2] Figures have been rounded to the nearest thousand.

Source: Texas State Department of Highways and Public Transportation, preliminary data

Table 20: Specialized Service Operating Costs (1979 Dollars) for Texas Transit Systems

City	Veh-Hrs. (Hrs.)	Operating Exp. Veh-Hrs. ($/hr.)[1]	1979 Total Operating Exp. ($)[2]	Number of Vehicles
Category A				
Dallas	92,116	21.51	1,981,000	34
Houston	133,719	30.79	4,117,000	50
San Antonio	74,287	20.52	1,524,000	28
Subtotal & Weighted Avg.	300,122	24.92	7,622,000	112
Category B				
Austin	24,174	17.79	430,000	11
Corpus Christi	15,214	22.54	343,000	7
El Paso	28,802	10.26	296,000	11
Ft. Worth	35,568	18.03	641,000	14
Subtotal & Weighted Avg.	103,758	15.08	1,710,000	43
Category C				
Abilene	6,960	12.45	87,000	4
Amarillo	10,440	13.71	143,000	5
Beaumont	9,280	13.67	127,000	5
Brownsville	5,072	11.50	58,000	3
Galveston	5,943	13.48	80,000	3
Laredo	5,680	14.27	81,000	3
Lubbock	10,440	15.02	157,000	5
San Angelo	4,640	11.81	55,000	4
Waco	9,280	16.03	149,000	5
Wichita Falls	8,038	14.38	116,000	4
Subtotal & Weighted Avg.	75,773	13.84	1,053,000	41
State Total & Weighted Avg.	479,653	21.75	10,385,000	196

Notes: [1]Figures have been rounded to the nearest cent.
[2]Figures have been rounded to the nearest thousand.

IV. COST-EFFECTIVENESS

The purpose of this chapter is to bring together all the cost, revenue, and ridership data in such a manner that decision makers can evaluate the two alternatives. First, however, it is appropriate to highlight the limitations of the data.

In general, we are dealing with alternatives and concepts for which very little empirical data exist. Until more data are available, however, the approach taken herein should meet any test of reasonableness. It should also be noted that some assumptions, consistently applied to both alternatives, will in most cases negate the lack of precision in some estimates. Overall, the approach taken is certainly less subjective than conclusions based on judgment alone.

The cost-effectiveness approach used is aimed at two aspects of providing handicapped service. Cost alone is often the means used in evaluating courses of action. It is clear that some people are only concerned with minimizing the cost of providing handicapped transportation. However, it seems rational that an expenditure of a small amount of money without any benefit is without serious merit.

The effectiveness aspect of the evaluation process is an attempt to answer the question of how well does the alternative meet the needs of the handicapped. The approach taken here is to assume that specialized service will be configured such that it is at least as convenient to use as fixed-route service. The largest obstacle in most existing systems to this requirement is the 24-hour call-in time. Convenience also assumes that service hours will parallel fixed-route service. Cost estimates for specialized service were made assuming a 24-hour call-in time was <u>not</u> required and that service hours were the same as for fixed-route service.

There are some areas of difference between the two services that were not addressed. The basic issue that no service can be equivalent to fixed-route accessibility is not addressed. If one agrees that fixed-route accessibility must be provided, the entire analysis is unnecessary.

Other attributes of an equivalent service are: travel time, travel cost, safety and security, and comfort. These issues are addressed as part of another study (12). For the purposes of this analysis it is assumed that the specialized service is at least as good as a fixed-route system in meeting the needs of the handicapped.

Having equated all other considerations, the primary measure of effectiveness is the number of passengers served. It follows that the most cost-effective system is the one with the least cost per passenger served. The most cost-effective system is not necessarily the least expensive alternative in total dollars.

The cost per passenger is determined from the previously calculated data by subtracting revenue from capital plus operating costs and dividing by passengers served. Costs are the total for the 15-year study period expressed in 1979 dollars. Revenues for both alternatives are based on no increases in ridership over the study period and are based on existing fixed-route fares as shown in Table 21.

The cost per passenger for accessible fixed-route service is shown in Table 22. The statewide average cost per passenger is estimated to be about $17.00. Costs are higher in the larger size cities and smaller in the medium and small size cities. Total net cost for the state is estimated to be $97,276,000.

Table 23 summarizes the cost per passenger for specialized service. The statewide average is about $9.50. Again, estimates are higher in large sized cities and lower in medium and small sized cities. Total cost for specialized

Table 21: Texas Transit System Fares

City	Base Fare Peak	Base Fare Non-Peak	Fare/Zone	No. of Zones	Transfer Charge	Elderly and Handicapped Base	Elderly and Handicapped Restrictions	Student Base	Fare Restriction	Other Special Fares	Survey Date
Category A											
Dallas	60¢	60¢	15¢	3	10¢	20¢	None	20¢	None	Park and Ride - 70¢	1/79, 6/79
Houston	40¢	40¢	10¢	3	Free	20¢	None	20¢	None	10¢ fare at CBD & children under 12 yrs. Max. # of zone charges is two.	2/79
San Antonio	25¢	25¢	5¢	3	Free	10¢	None	10¢	None	Zone fares are charged for outbound trips only.	2/79
Category B											
Austin	30¢	15¢	None	None	Free	15¢	--	15¢	None	Specialized (door-to-door) service for E & H. 50¢ per trip. 24 hour advanced reservation	11/78
Corpus Christi	35¢	35¢	10¢	3	Free	15¢	ID	20/$3.50	12 yrs. or High school ID	Children (5-11) & E & H zone fare = 5¢ Free zone charge for students, tokens 5/$1.50.	11/78
El Paso	35¢	35¢	10¢	2	Free	35¢/2	None	35¢/2	None	Park and Ride Express Service = 75¢	1/79
Ft. Worth	40¢	40¢	None	None	Free	20¢	None	40¢	None	Monthly Pass = $15.00, tokens = 10/ $3.75. Ride within CBD - free, children (5-11) = 20¢	11/78
Category C											
Abilene	25¢	25¢	None	None	None	10¢	None	15¢	None		6/79
Amarillo	40¢	40¢	None	None	10¢	15¢	ID	30¢	Student ID	Children (6-12) base fare - 30¢	2/79
Beaumont	30¢	30¢	None	None	5¢	15¢	None	10¢	None		11/78
Brownsville	35¢	35¢	None	None	None	15¢	None	15¢	None		3/79
Galveston	35¢	35¢	None	None	Free	10¢	ID	35¢/2	None	Tokens - 3/$1.00, ID good for 2 yrs.	
Laredo	25¢	25¢	None	None	10¢	10¢ off-peak	ID	10¢	None	E & H pay reg. fare during peak periods	6/79
Lubbock	40¢	40¢	None	None	Free	20¢	None	25¢	None	$3.50 passes/week	12/78
San Angelo	30¢	30¢	None	None	Free	10¢	None	20¢	None		11/78
Waco	40¢	40¢	None	None	5¢	20¢	None	20¢	None		1/79
Wichita Falls	45¢	45¢	10¢	2	5¢	20¢	None	20¢	None	E & H zone fare = 5¢	

Source: Texas Transportation Institute Mail Survey

Table 22: Fifteen-Year Accessible Fixed Route Cost per Passenger

City	Adjusted Fixed Route Demand (000 pass.)	Marginal Capital Cost (000 dollars)	Marginal Operating Cost (000 dollars)	Fare Revenue (000 dollars)	Net Cost (000 dollars)	Net Cost per Passenger (dollars)
Category A						
Dallas	1,276	6,637	15,075	255	21,457	16.82
Houston	1,675	8,307	29,280	335	37,252	22.24
San Antonio	1,033	5,245	14,100	103	19,242	18.63
Subtotal Weighted Avg.	3,984	20,189	58,455	693	77,951	19.57
Category B						
Austin	270	516	2,625	41	3,100	11.48
Corpus Christi	115	391	1,440	17	1,814	15.77
El Paso	469	973[1]	3,345	82	4,236	9.03
Ft. Worth	320	851	3,105	64	3,892	12.16
Subtotal Weighted Avg.	1,174	2,731	10,515	204	13,042	11.11
Category C						
Abilene	31	114	195	3	306	9.87
Amarillo	70	269	510	11	768	10.97
Beaumont	71	179[1]	540	11	708	9.97
Brownsville	50	201	315	8	508	10.16
Galveston	69	108	510	7	611	8.86
Laredo	107	276	855	19	1,112	10.39
Lubbock	77	279	810	15	1,074	13.95
San Angelo	30	80	165	3	242	8.07
Waco	65	173	450	13	610	9.38
Wichita Falls	33	126	225	7	344	10.42
Subtotal Weighted Avg.	603	1,805	4,575	97	6,283	10.41
State Total Weighted Avg.	5,761	24,725	73,545	994	97,276	16.89

Note: [1] Retrofit Alternative is less expensive.

Table 23: Fifteen Year Specialized Service Costs per Passenger

City	Demand (000 pass.)	Capital Cost (000 dollars)	Operating Cost (000 dollars)	Fare Revenue (000 dollars)	Net Cost (000 dollars)	Net Cost Per Passenger (Dollars)
Category A						
Dallas	2,935	1,328	29,715	587	31,456	10.38
Houston	4,318	1,953	61,755	864	62,844	14.55
San Antonio	2,357	1,094	22,860	234	23,720	10.06
Subtotal	9,610	4,375	114,330	1,685	117,020	
Weighted Avg.						12.18
Category B						
Austin	1,095	424	6,450	164	6,710	6.13
Corpus Christi	658	268	5,145	99	5,314	8.08
El Paso	1,071	424	4,440	187	4,677	4.37
Ft. Worth	1,395	547	9,615	279	9,883	7.08
Subtotal	4,219	1,663	25,650	729	26,584	
Weighted Avg.						6.30
Category C						
Abilene	375	156	1,305	37	1,424	3.80
Amarillo	438	190	2,145	66	2,269	5.18
Beaumont	398	190	1,905	60	2,035	5.11
Brownsville	214	112	870	32	950	4.44
Galveston	213	112	1,200	21	1,291	6.06
Laredo	244	112	1,215	43	1,284	5.26
Lubbock	410	190	2,355	82	2,463	6.01
San Angelo	256	156	825	26	955	3.73
Waco	398	190	2,235	80	2,345	5.89
Wichita Falls	366	156	1,740	73	1,823	4.98
Subtotal	3,112	1,564	15,795	520	16,839	
Weighted Avg.						5.41
State Total	17,141	7,602	155,775	2,934	160,443	
Weighted Avg.						9.36

Figures have been rounded to the nearest cent.

services, estimated at $160,443,000, is greater than for accessible fixed-route buses. The cost per passenger is less for specialized service because the projected demand is nearly 3 times greater than for accessible fixed-route service.

It is also informative to compare actual estimated expenditures versus available monies in the State Public Transportation Fund. It must be noted that these cost figures are different from the totals previously expressed in the economic analysis. The previous numbers were adjusted to 1979 dollars so that both alternatives could be compared. The following numbers are based on the estimated cost at the time of expenditure.

The 15-year estimated actual total capital expenditure for accessible buses is $1,114,716,000 which is $94,194,000 more than for normal replacement with non-accessible buses. The average annual marginal increase in state expenditures is $816,000 during the 15-year period. The 15-year estimated actual total capital expenditure for specialized service is $130,578,000 which translates into a $265,000 average annual state expenditure.

V. CONCLUSIONS

The study had as its principal objective an evaluation of two alternatives for meeting the transportation needs of the handicapped in Texas. The two alternatives evaluated were:

- Accessible fixed-route buses, and
- Separate specialized service.

In order to evaluate these two alternatives it was necessary to estimate:

- Demand,
- Cost, and
- Cost-Effectiveness.

Table 24 summarizes the results of the study.

If the goal is to provide the most cost-effective service, the separate-specialized service appears to be the better alternative in all Texas cities. However, budget considerations may make accessible fixed-route service the preferred alternative. It is, therefore, logical that local jurisdictions should have the option of choosing the particular system to meet their needs.

It does not appear that either alternative will have serious impact on the State Public Transportation Fund. The greatest impact is at the local level. This again suggests that some discretion at the local level appears warranted, even though present federal rules do NOT presently allow specialized service in place of accessible fixed-route buses.

Table 24: Statewide Cost-Effectiveness of Total Accessibility Alternatives

Alternative	Demand (passengers)	Total Marginal Cost (1979 dollars)	Cost-Effectiveness ($/passenger)
Accessible Fixed-Route Buses	5,761,000	97,276,000	$17.00
Separate Specialized Services	17,140,000	160,441,000	$ 9.50

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