TRANSIT IN THE U.S. AND TEXAS: PAST, PRESENT, AND FUTURE

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TABLE OF CONTENTS

ABSTRACT

This report presents the results of a study of transit systems in the U. S. and Texas. Historical data are analyzed to identify the factors contributing to the decline of transit. The role of transit today is contrasted to its role of fifty years ago. Present and future needs for transit in Texas are identified. Characteristics of rail-rapid-transit and bus-rapid-transit systems are compared and their applicability to Texas cities evaluated.

Key Words: Transit, public transportation, mass transportation, urban transportation, rail-rapid-transit, bus-rapid-transit.

SUMMARY

Transit ridership in the nation reached a peak of about 23 billion passengers in 1947 and it has declined to less than 7 billion in 1971. However, the decline in transit usage did not begin in 1947. When increases in urban population and increases in trips made by urban residents are considered it becomes obvious that transit usage in America has been declining for more than fifty years. In 1915, about 3 out of every 4 urban trips were made via transit. Today, fewer than one in 20 urban trips are served by transit. Obviously, the role of transit has changed from being the primary form of urban transportation fifty years ago to serving specialized travel needs today.

The decline of transit has been attributed to various factors including the following: increasing fares, deteriorating service, increasing incomes, increasing automobile ownership, and decreasing population densities. However, an evaluation of the data indicates that the decline of transit may have been due to the following:

(1) a desire for lower density housing,

(2) availability of the automobile, and

(3) rising personal income.

These factors combined to create an urban form and associated lifestyle in which transit cannot be the primary mode of transportation. Nevertheless, transit systems can serve some very important roles in the total urban transportation system of today.

The current and future role of transit systems in Texas cities might be divided into the following relatively distinct areas:

(1) Public Transportation - providing general mobility for those persons who do not have access to private transportation;

(2) Mass Transportation - providing for the rapid movement of masses of people in brief periods of time along major travel corridors; and

(3) Internal Circulation - providing effective circulation of persons within areas of highly concentrated activities.

Most transit systems in Texas are currently serving as public transportation - providing a modest level of mobility to those persons who do not have an automobile available. Several Texas cities currently have a need for mass transportation and internal circulation systems, and these needs will increase in the future.

Increasing levels of downtown development in some Texas cities are creating an increasing need for mass transportation, but the low density residential development characteristic of these cities makes it extremely difficult to design a mass transportation system which can function effectively and efficiently. Hence, an understanding of the characteristics and capabilities of various modes of mass transportation is essential for proper planning.

New rail-rapid-transit systems are being constructed or considered in several cities around the nation, and similar systems have been proposed for Texas cities as the appropriate solution for their mass transportation problems. However, considering the relative costs of systems, urban forms of Texas cities, and the type of mass transportation service needed, it appears that bus-rapid-transit systems would be more applicable for Texas cities.

Texas contains some thirty major urbanized areas in which about three-fourths of the state's population lives. Each of these urbanized areas has some transit needs. The purpose of this report is to present data and information which will help to place transit in its proper perspective. A recognition of the role that transit plays in the urban transportation system is essential to the formulation of effective programs for transit in Texas.

IMPLEMENTATION STATEMENT

Public and mass transportation operations have, in the past, been considered to be entirely the responsibility of the various cities. Consequently, the federal and state governments paid little heed to the mounting problems facing transit operators until many of them were forced to cease operations. Cities were faced with the choice of doing without any form of transit service or assuming the entire burden themselves.

More recently, the federal government and many state governments have recognized the magnitude of the problem, and have begun to work with the cities in seeking solutions. The State of Texas has taken several actions during the past three years intended to promote the development of sound public and mass transportation systems throughout the State. All indications point to a need for the State of Texas to assume an increasingly active role in the transit area.

Unfortunately, many of the state and federal efforts aimed at rejuvinating the transit industry have been less than successful. Some of these efforts were poorly conceived because of an apparent lack of recognition of the role that transit plays in the urban transportation systems of today and the relationship between urban form and transportation systems. The role of transit has changed drastically during the past fifty years, and it cannot return to its former role in cities with the urban form typical today.

The purpose of this report is to identify the role of transit in Texas and to discuss some of the transit technology available today. Hopefully, the information presented herein will be useful in helping the cities and the State to formulate effective programs of public and mass transportation.

OVERVIEW OF THE U. S. TRANSIT INDUSTRY

A brief overview of trends and conditions in the transit industry nationwide can prove helpful in evaluating the transit industry in Texas. The following paragraphs present a brief summary of historical trends and current conditions, as well as a discussion of the reasons for the decline of transit usage in America.

Historical Trends

Despite the fact that the urban population of the U. S. has more than tripled in the past fifty years, transit ridership has dropped to less than half of what it was fifty years ago. Many reasons have been offered to explain this downward trend in transit ridership including the following: decreasing population densities, deteriorating transit service, increasing incomes, and increasing automobile ownership. Whatever the reason or reasons for its decline, it is obvious that transit's role in the total urban transportation function has changed drastically during the past fifty years. Perhaps a brief look at the history of transit in the U. S. can help explain this change.

For centuries, urban dwellers had to walk or use animal-drawn transportation to get around in their city. This did not pose too great a problem because there were no reasons for cities to get so large that these modes of transportation could not serve them adequately. Then, during the 1800's, the industrial revolution resulted in strong economic forces attracting people to rapidly growing cities. Since there was still no mechanized form of urban transportation, new urban residents had to crowd into the same land area that could be served by non-mechanized transportation – resulting in some extremely high population densities.

Then in the late 1880's, the electric streetcar appeared on the urban scene (1)*. It greatly increased the mobility of the urban resident and permitted the cities to expand outward along the new streetcar lines (2). The streetcar rapidly became the primary form of urban transportation. Indeed, the early streetcar lines were so successful that a tidal wave of streetcar line construction occurred in the early 1900's. Inevitably, some imprudent investments were made.

By 1917, some 30,000 miles of streetcar lines were in operation — approximately one mile of line for every 1500 urban residents (3). Almost 10 percent of this mileage had been abandoned by the time that streetcar ridership had reached its peak in 1923. Nevertheless, the streetcar was the dominant mode of urban transportation fifty years ago. It provided a level of service never known before by achieving average overall speeds of 10-15 miles per hour (including stops). Such speeds were 2 to 3 times faster than those attainable with a horse-drawn tram. Due to the increased speed provided by the streetcar, people could live 5 or 6 miles away from their jobs and still get to work in the same time that they had once spent walking.

A few cities, however, were already so densely populated that their downtown streets did not have sufficient capacity to adequately serve pedestrians, wagons, and streetcars. Therefore, systems were designed and constructed which enabled electric-powered rail cars to operate in subways and on elevated structures. Since these vehicles did not have to contend with other types of traffic, they were able to achieve overall operating speeds of 20 to 25 miles per hour — appreciably faster

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*Number in parenthesis denotes reference listed at end of the report.

than any other form of urban transportation then available. This new form of urban transportation was appropriately labeled "rail-rapid-transit".

New York City had several elevated transit lines in operation in the 1890's, and they opened their first subway system in 1904 (4). A second subway system was opened prior to 1920 and another was built in the late 1920's. These three systems were acquired by the city in 1940 and are now operated as one system. New York City's combined rail-rapid-transit (RRT) system including some 237 miles of lines with 476 stations is one of the largest RRT systems in the world (5).

Boston opened the first subway line in America in 1897. Chicago's rail-rapid-transit system consisted of all elevated lines from 1897 until 1943 when the first subway portion was opened (6). Philadelphia opened its first line in 1908 with subsequent additions in 1922, 1928, and 1936 (5)(7).

These four cities (New York, Philadelphia, Boston, and Chicago) have had rail-rapid-transit operations since the early 1900's. Some additions were made to these systems during the 1920's, but there were no significant changes in RRT systems nationwide from then until after World War II. Cleveland entered the ranks of cities served by RRT when they opened a short line in 1955 and extended it to the airport in 1968. Boston and Philadelphia made some extensions to their systems during the late 1960's and now new systems are being built in other cities. San Francisco-Oakland opened the first portion of their new system in 1972; Washington, D. C. is constructing an RRT system; and Atlanta and Baltimore are finalizing designs (5)(8).

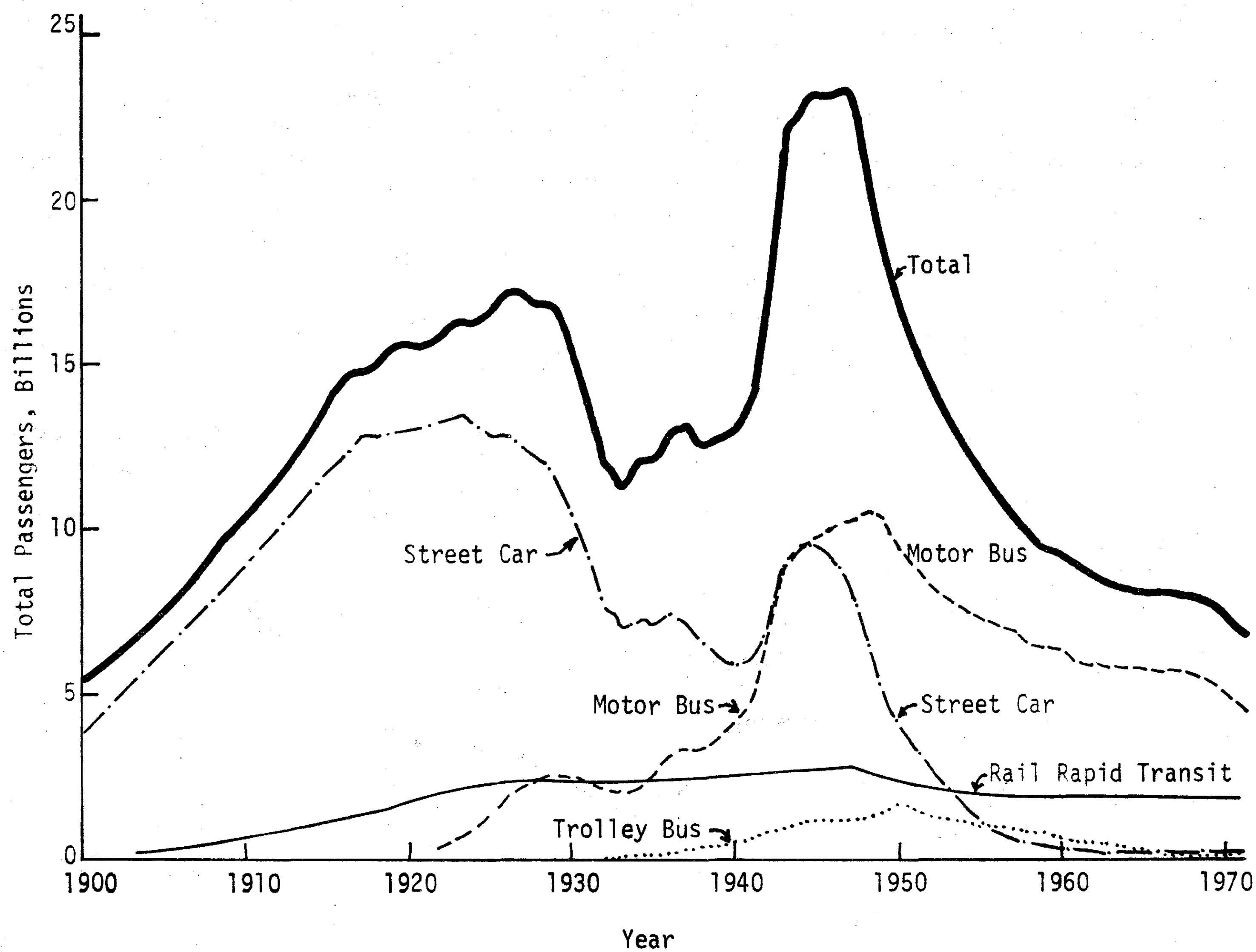
The changing nature of the transit industry during the last fifty years is indicated by the data presented in Figures 1, 2, 3, and 4. Total transit ridership (see Figure 1) peaked in 1926 and then began to decline. It reached a temporary low in 1933 and began increasing slowly until the advent of World War II. Ridership dropped precipitously after 1947, almost leveled out in the mid-1960's, and has been dropping rapidly since 1968 (3)(9)(10)(11)(12).

The changing complexion of the transit industry over the years is indicated by the number of vehicles used by each mode as shown in Figure 2 (1)(3)(9)(10)(11)(12). Streetcars were the dominant mode of transit prior to World War II, and motor buses have been the dominant mode since then. Streetcar ridership reached an all time high of 13.5 billion annual passengers in 1923 and has been declining ever since except for a brief recovery during World War II. The streetcar had become almost extinct by 1955. Motor buses were just appearing on the scene in 1920, but because of their greater flexibility, which enabled them to serve a more dispersed clientele, they rapidly supplanted streetcars.

Trolley buses (electrically-powered, rubber-tired vehicles) were also used to replace streetcars on some lines from 1935 till 1950. However, trolley buses never did become very popular, and they, too, are now virtually extinct.

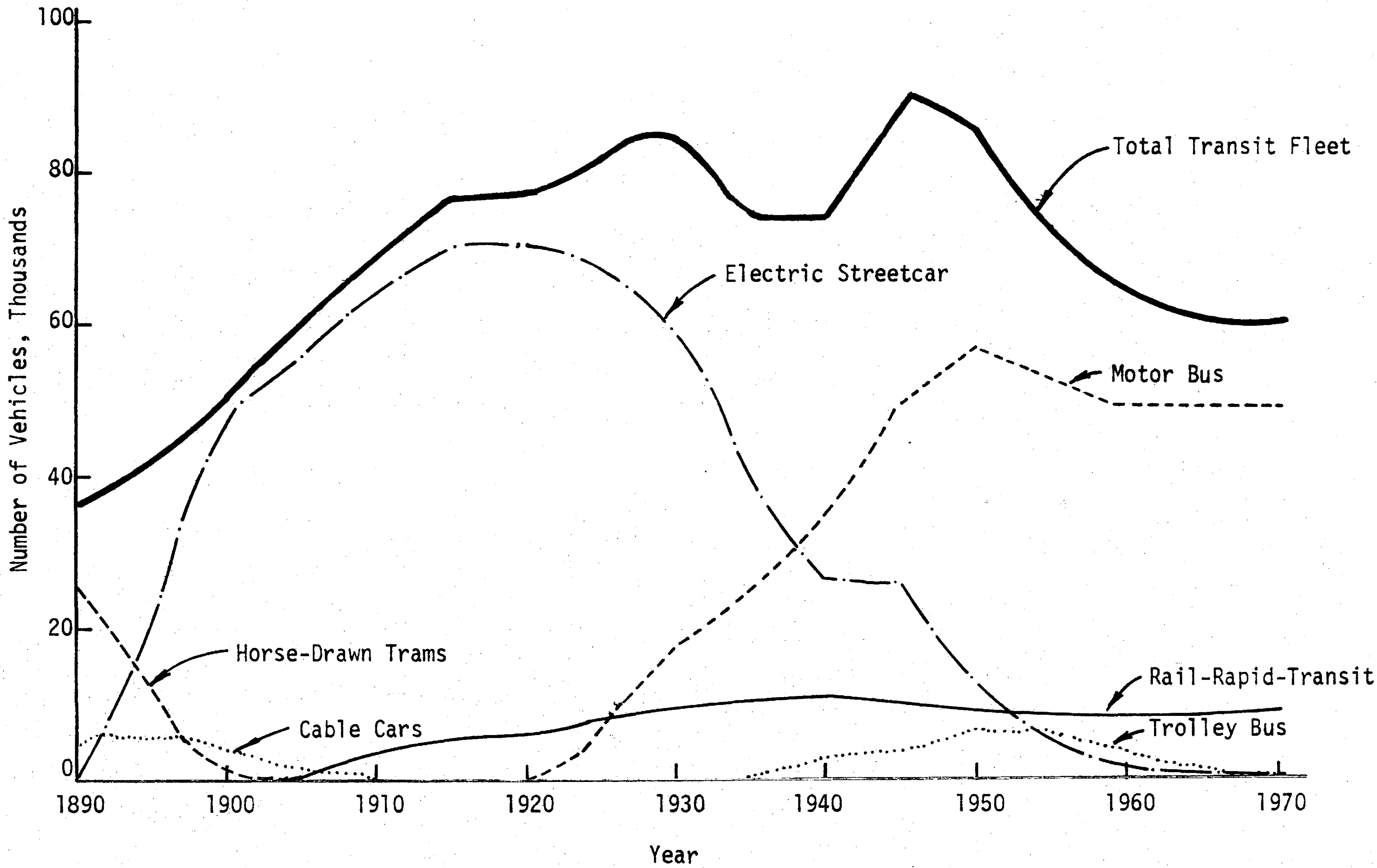
Rail-rapid-transit ridership has remained relatively constant over the last fifty years. By virtue of the decline in ridership on other modes, RRT's share of the total transit market has increased from 12.5 percent in 1922 to 26 percent in 1971. However, RRT ridership has also declined about 5 percent per year in the past two years despite recent additions to the systems (12).

FIGURE 1
TRANSIT RIDERSHIP TRENDS IN THE U.S.A.



Sources: Street Railway Journal (1900-1908)
Electric Railway Journal (1908-1930)
Census of Transportation (1902-1927)
Dewees, Decline of American Street Railways (1922-1950)
ATA, Transit Fact Book (1935-1970)

FIGURE 2
TRENDS IN THE TRANSIT VEHICLE FLEET



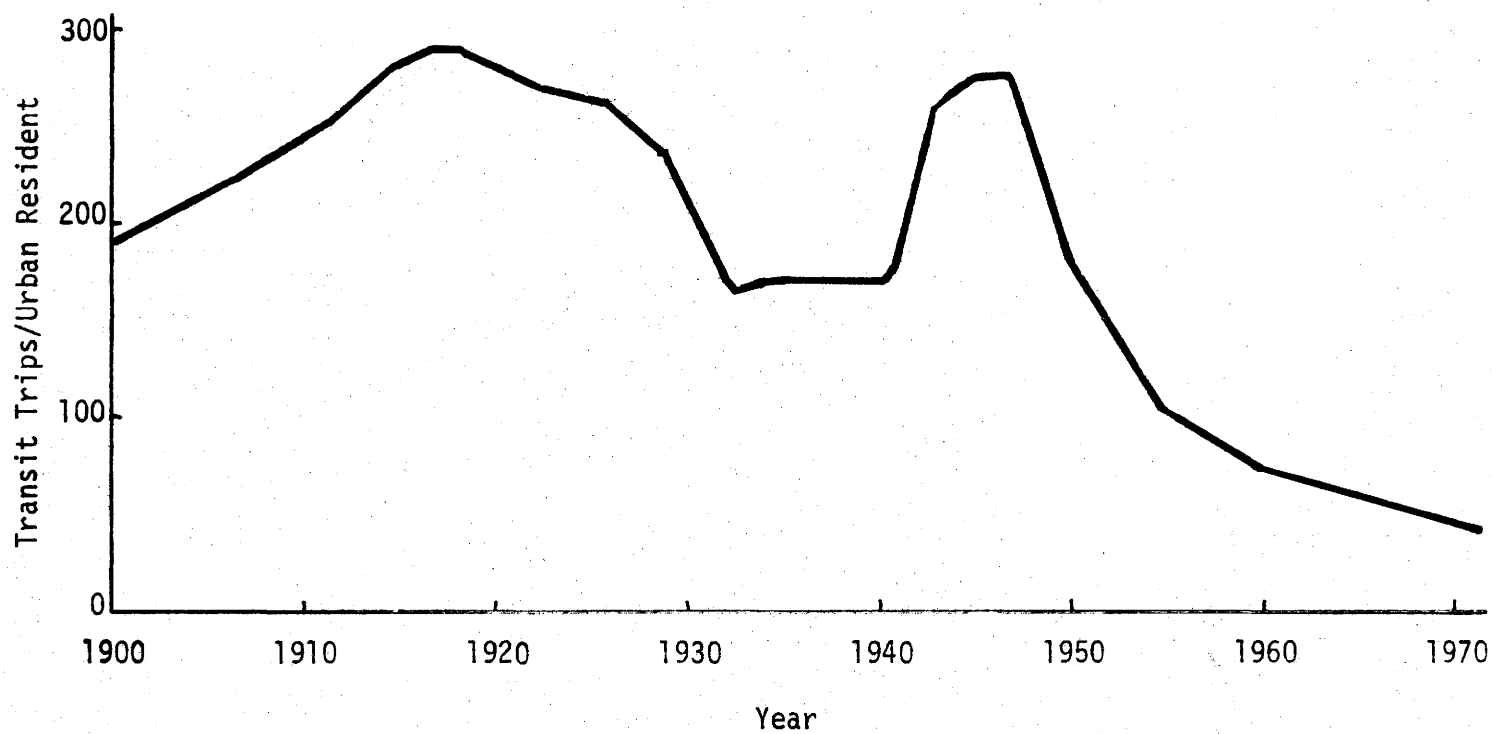
Sources: Crosby, A Resume of the Electric Street Railway (1890-1900)
Street Railway Journal (1900-1908)
Census of Transporation (1902-1927)
Electric Railway Journal (1909-1930)
ATA, Transit Fact Book (1935-1970)

Total transit ridership values over the past fifty years, as shown in Figure 1, do not reflect the extent of change in transit usage. During this fifty year period, the urban population was increasing from about 50 million to 150 million (13). Thus, even though the total ridership reached a peak during World War II, the average number of transit trips made by urban residents each year was about the same during World War II as it was during the 1920's (see Figure 3).

Numerous urban transportation studies conducted in various cities since World War II have shown that the total number of daily trips made by an average resident has been increasing rapidly. Hence, the degree of reliance upon transit by urban residents has changed drastically over the past fifty years. The trend, shown in Figure 4, has been downward since 1915 — except for the slight recurrance during World War II. In 1915, approximately three out of every four urban trips were made on transit. Today, fewer than five percent of all urban trips are served by transit. Obviously the role of transit has changed from being the primary form of urban transportation to one of serving limited specialized needs.

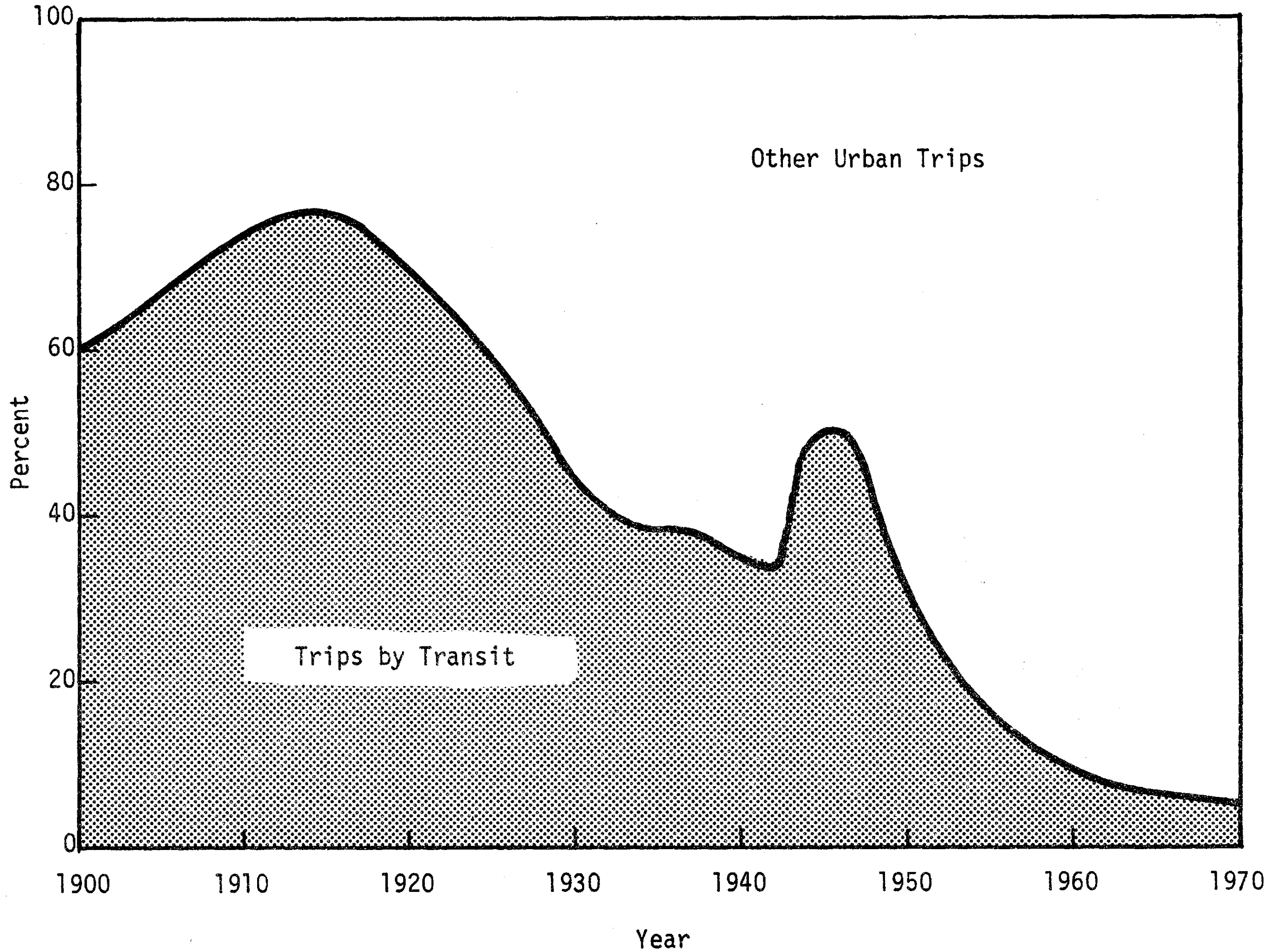
The long-term trend toward decreased dependence upon transit by urban residents has precipitated related problems for the transit industry. Despite frequent fare increases, revenue has not increased as rapidly as operating expenses (see Figure 5) (3)(9)(10)(11)(12). Consequently, the transit industry, as a whole, has sustained rapidly increasing deficits in recent years. The total dificit for 1971 is estimated to exceed $400 million (about $2 per person in the U. S.). The $75 million deficit incurred by the MBTA in 1971 amounts to $30 per resident of the Boston Metropolitan area served by MBTA (14).

FIGURE 3
TRENDS IN THE AVERAGE NUMBER OF TRANSIT TRIPS
MADE BY URBAN RESIDENTS EACH YEAR



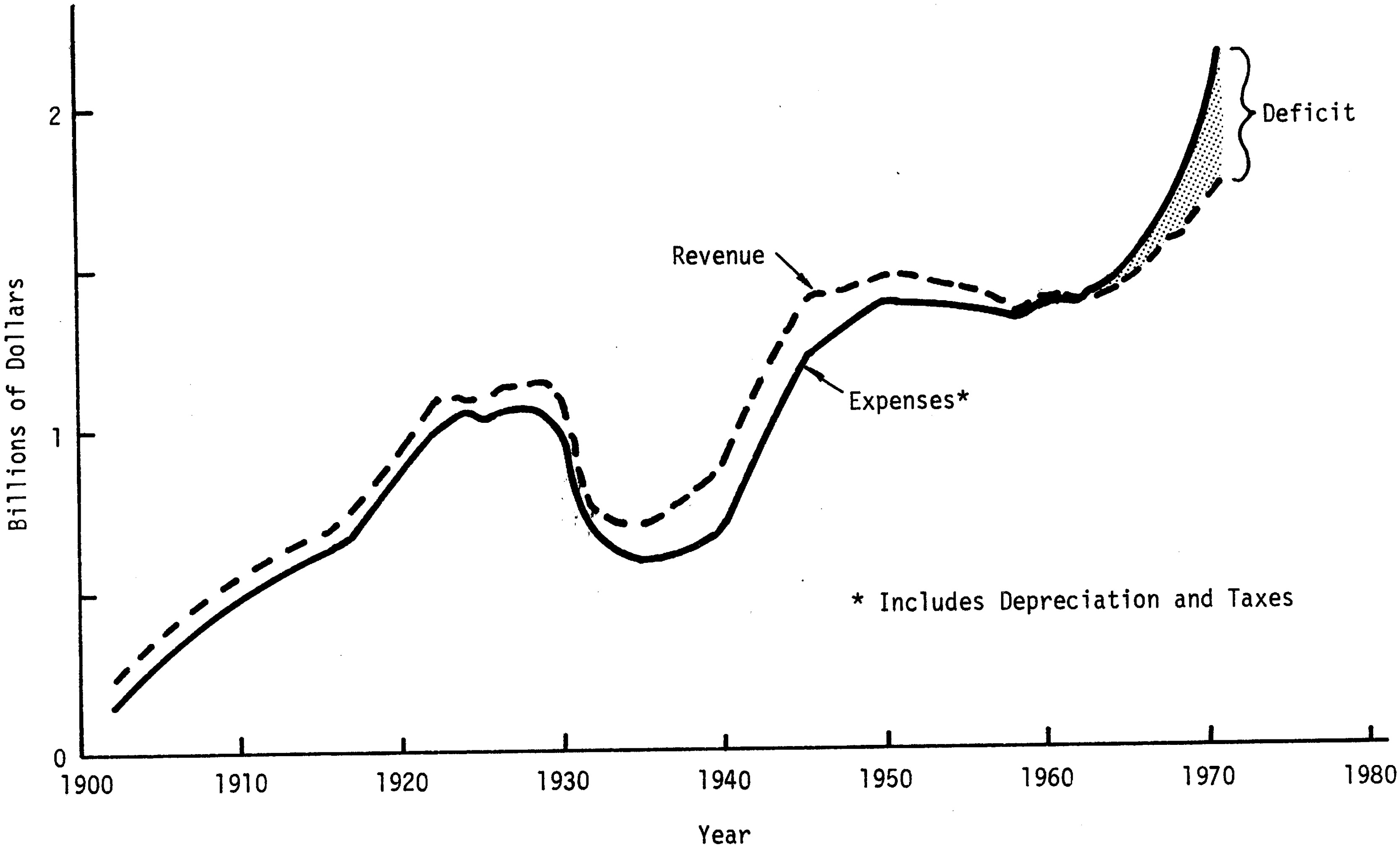
Sources: Transit Ridership - Same as for Figure 1
Urban Population - Bureau of Census

FIGURE 4
TRANSIT TRIPS AS A PERCENTAGE
OF ESTIMATED TOTAL URBAN TRIPS



Note: See Appendix A for supporting calculations

FIGURE 5
OPERATING CONDITIONS OF U. S. TRANSIT INDUSTRY



Sources: Street Railway Journal (1900-1908)
Electric Railway Journal (1909-1930)
Census of Transportation (1902-1927)
ATA, Transit Fact Book (1935-1970)

Fifty years ago, virtually every transit system in the nation was owned and operated by private enterprize. Many of these privately owned systems have either ceased operations entirely or have been taken over by public agencies. The composition of the transit industry in 1971 is indicated in Figure 6. Although only 14% of the systems are publicly owned, these public systems operate 68% of the vehicles, carry 84% of the passengers, generate 83% of the revenue, and employ 85% of the manpower (12). Obviously, only the smaller bus systems are operated by private enterprize and most of these are in severe financial trouble. In fact, the bus company in Houston (which operates some 378 buses) is one of the largest privately owned transit systems remaining in the nation.

Reasons for the Decline of Transit

Many people have tried to explain the reasons for the rapid decline of transit in America. The following factors are most frequently cited as the major contributors:

(1) Increasing fares,

(2) Deteriorating service,

(3) Increasing incomes,

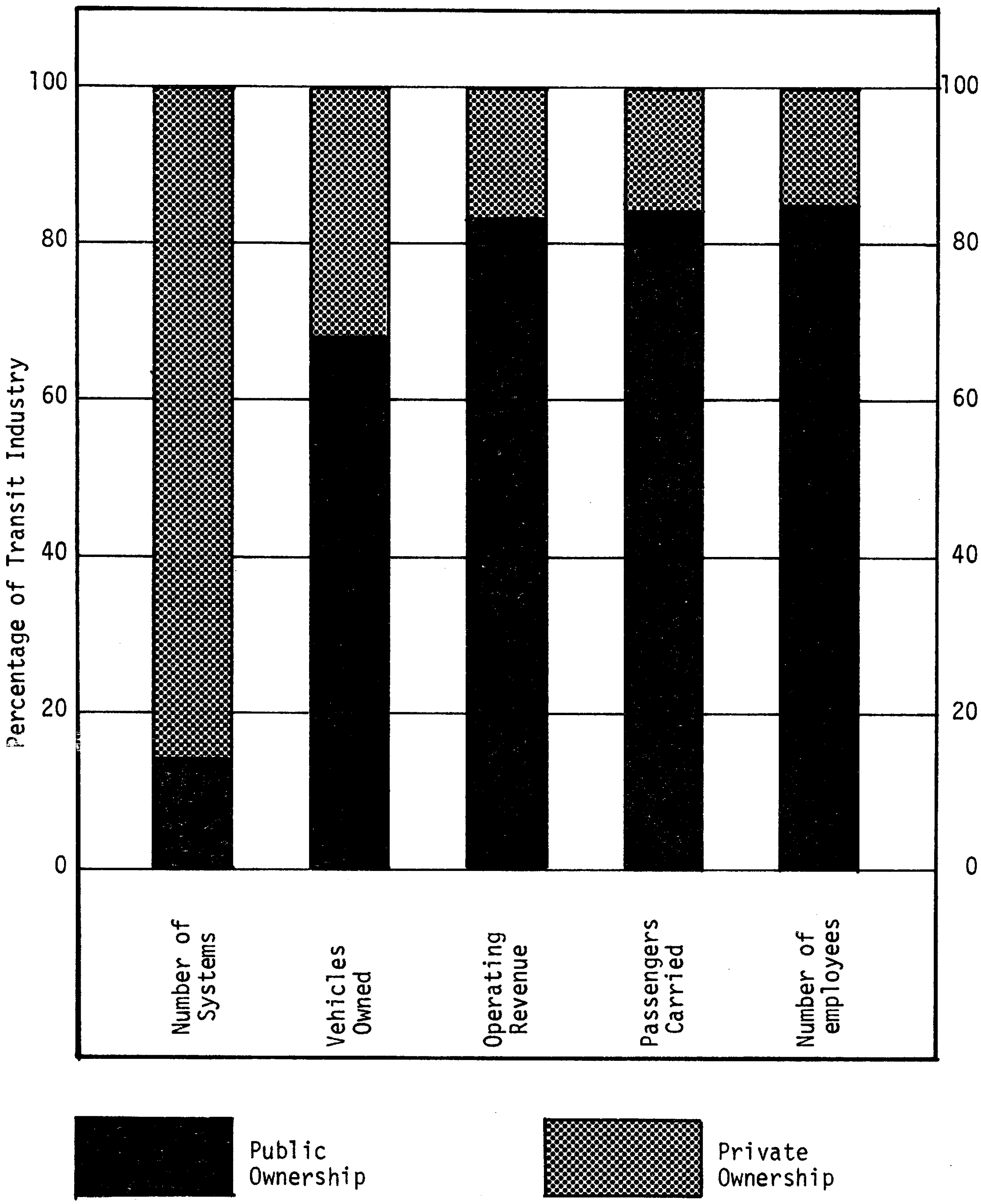
(4) Increasing automobile ownership, and

(5) Decreasing population densities.

Data pertaining to these factors are presented in Figure 7, 8, 9, and 10.

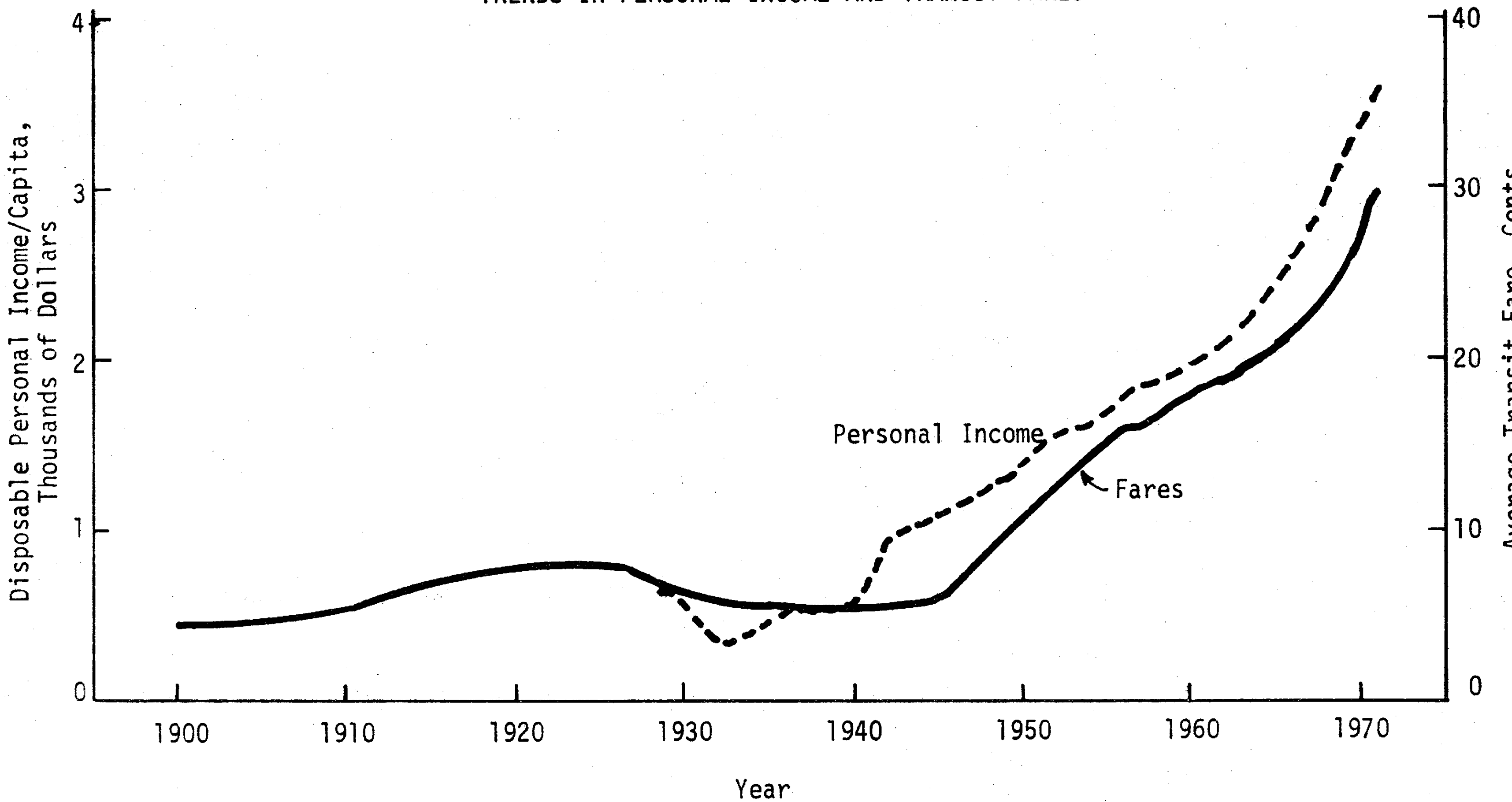
Transit fares have increased steadily since 1945 – the period of most rapid decline in ridership (see Figure 7). However, the disposable personal income per capita has increased even faster than transit fares. Even with the higher fares of today, the cost to the individual to make an urban trip via transit is usually less than the cost of driving

FIGURE 6
COMPOSITION OF TRANSIT INDUSTRY - 1971



Source: ATA, Transit Fact Book

FIGURE 7
TRENDS IN PERSONAL INCOME AND TRANSIT FARES



Sources: Transit Fares - Street Railway Journal (1900-1908)
Electric Railway Journal (1908-1930)
Census of Transportation (1902-1927)
ATA, Transit Fact Book (1935-1970)

Personal Income - Economic Report of the President, 1972 an automobile. So it seems dubious that increased fares have been a strong contributing factor in the decline of transit (9)(10)(11)(12)(15).

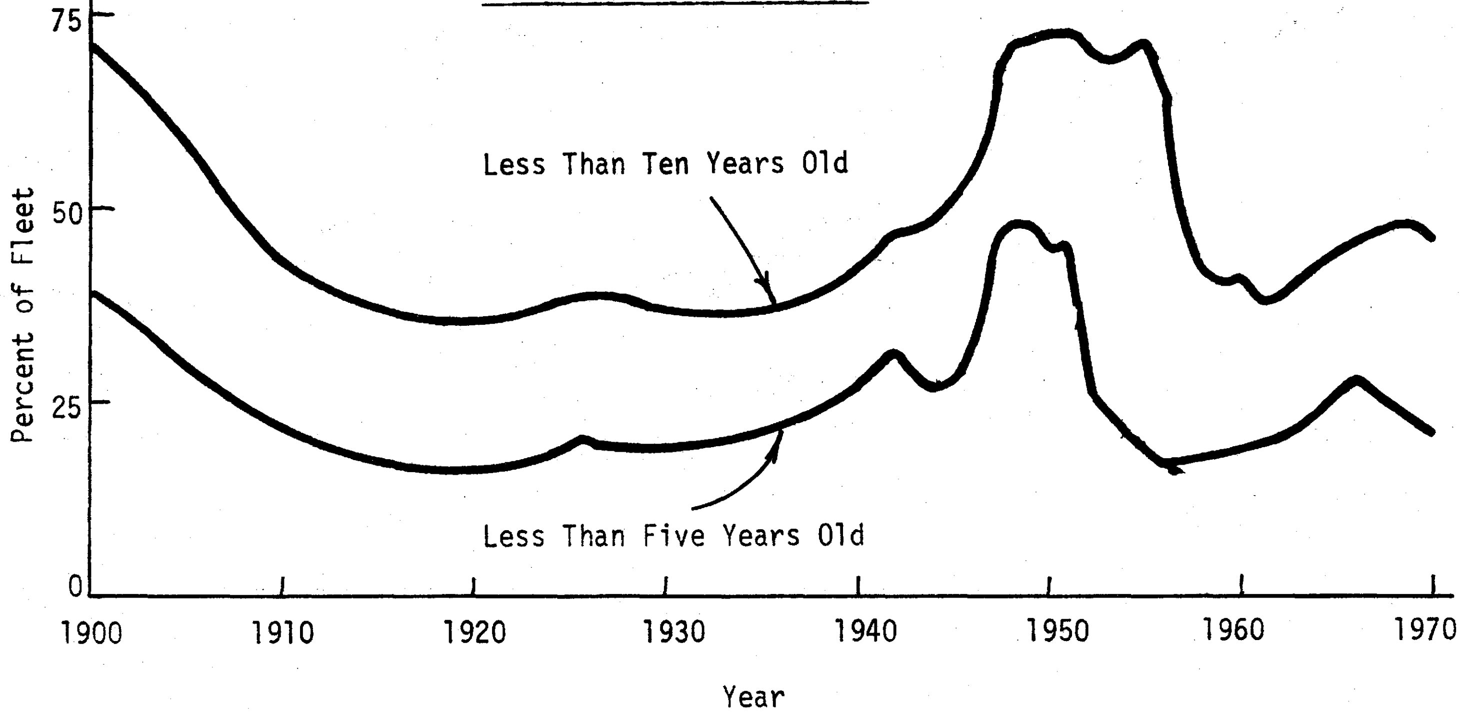
Trends for two of the primary measures of the "level-of-service" provided by the transit industry, the age of transit vehicles being used and the number of vehicle-miles of service provided, are presented in Figure 8. These curves show that shortly after World War II, while ridership was declining most rapidly, transit vehicles in the fleet were newer than at any time since the turn of the century. Also, the rate of decrease in vehicle-miles of service has been much slower than the decline in ridership (1)(9)(10)(11)(12). Thus, it appears that any deterioration in transit service has been more of a result of declining ridership rather than a causative factor.

Average personal income in the U. S. has increased steadily since the mid-1930's; however, this factor alone would not have caused a decline in transit usage unless transit is what economists refer to as an "inferior good." Any item — such as beans or potatoes — which people tend to buy less of as their income increases is an "inferior good." Results of most economic studies of transit patronage do indeed indicate that transit is an "inferior good."

As their incomes increased, Americans began satisfying their mobility needs with private transportation (the automobile) rather than using more transit. Automobile ownership has increased in parallel with the growth of population (see Figure 9) (13)(16). However, availability of automobiles has increased drastically over this time period -- from one auto for every 13 persons in 1920 to one auto for every 2.3 persons in 1970. Certainly, this increased availability of automobiles has contributed to the decline in transit usage, but there must be some

FIGURE 8
MEASURES OF "LEVEL-OF-SERVICE" FOR TRANSIT

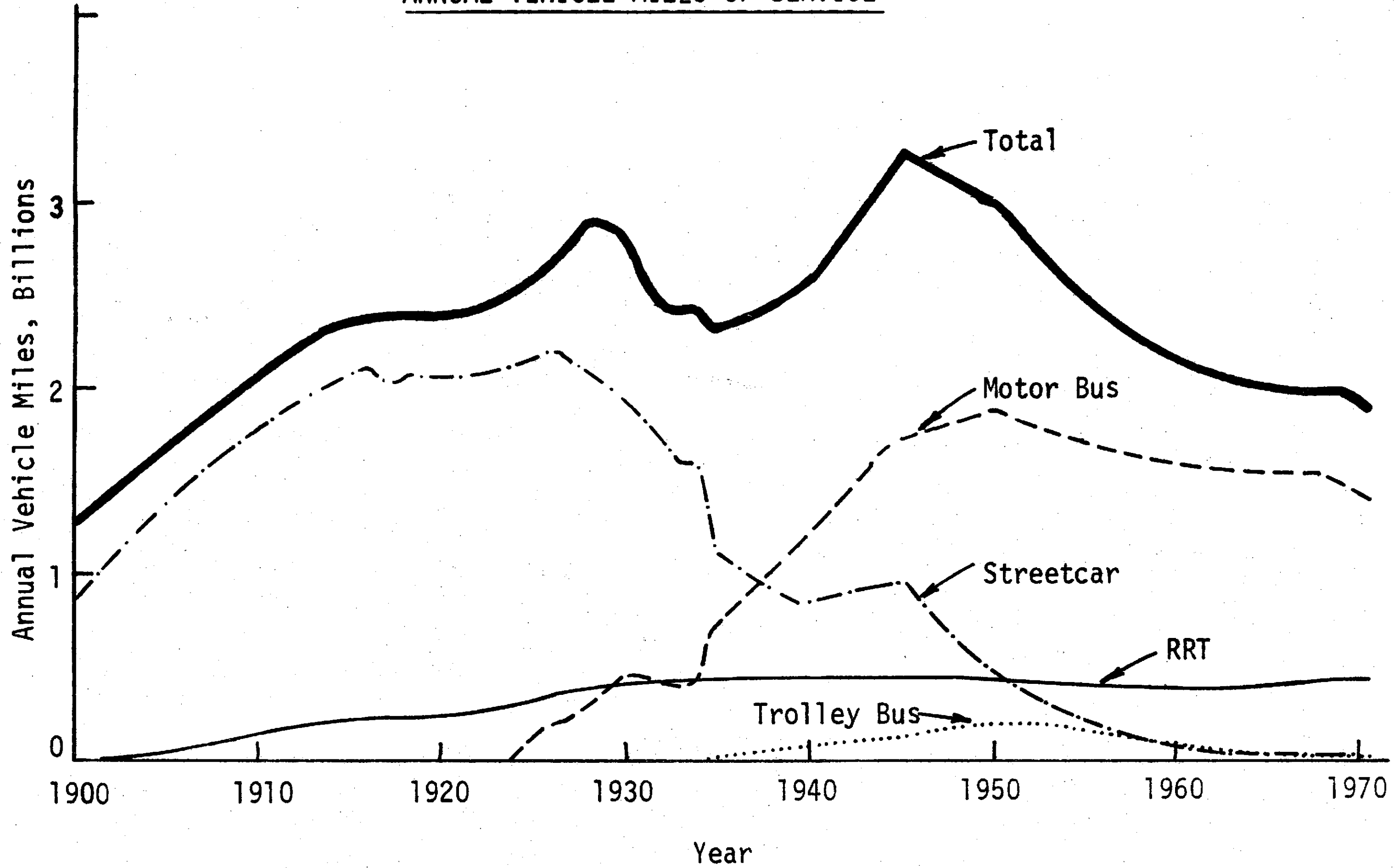
FIGURE 8A
AGE OF VEHICLES IN FLEET



Sources: Street Railway Journal (1900-1908)
Electric Railway Journal (1909-1930)
Census of Transporation (1902-1927)
ATA, Transit Fact Book (1935-1970)

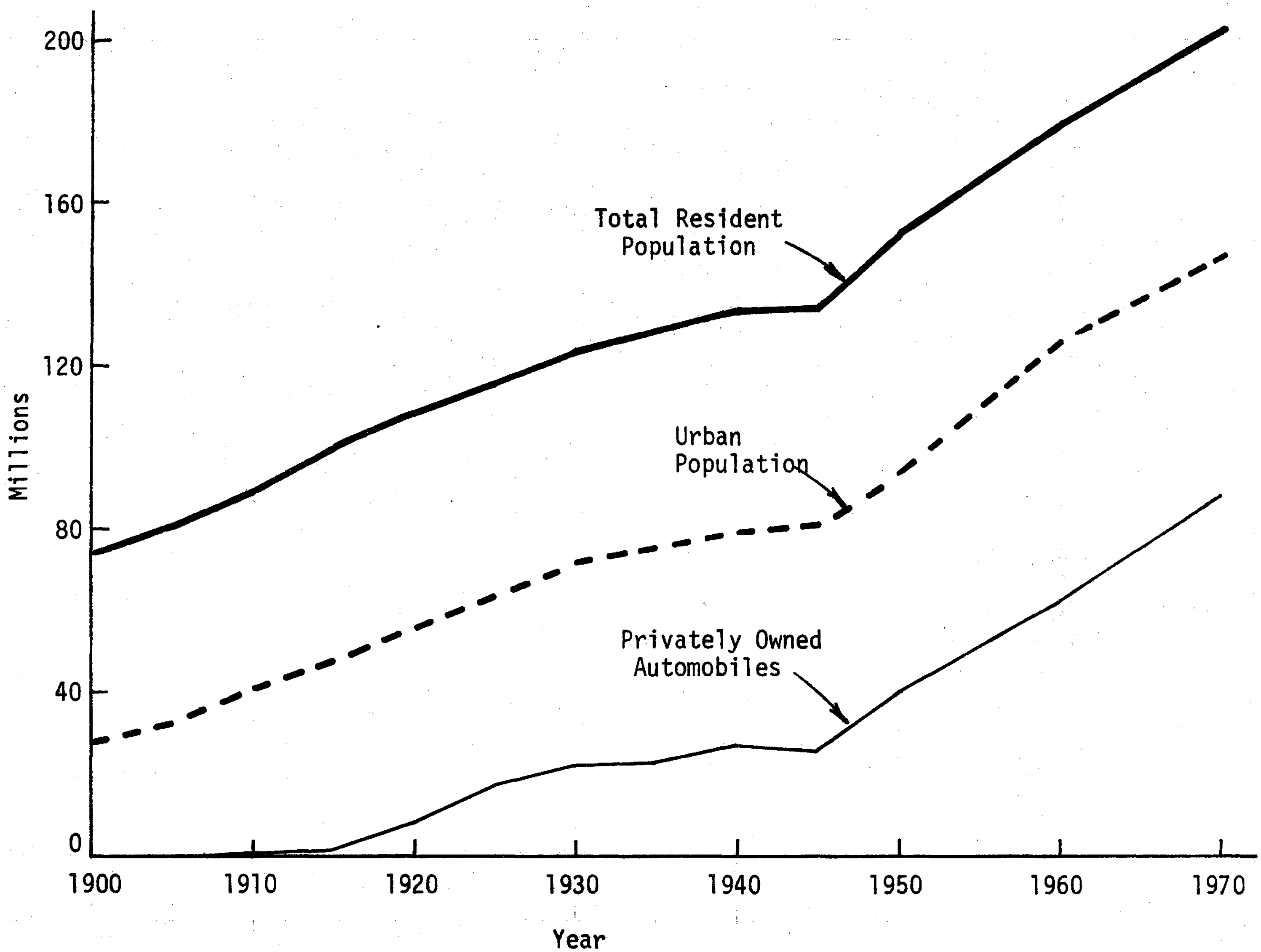
FIGURE 8B

ANNUAL VEHICLE-MILES OF SERVICE



Sources: Street Railway Journal (1900-1908)
Electric Railway Journal (1909-1930)
Census of Transportation (1902-1927)
ATA, Transit Fact Book (1935-1970)

FIGURE 9
TRENDS IN POPULATION AND AUTOMOBILE OWNERSHIP
IN THE U.S.A.



Sources: Bureau of Census, Statistical Abstract of the United States 1971
Department of Transportation, Highway Statistics 1970

reasons why Americans so overwhelmingly prefer this more expensive mode of urban transportation. The key to this question may be more related to desired life-styles than to transportation services per se.

The electric streetcar was a resounding success because it offered a more desirable option in living conditions (lower population densities) as well as improved transportation services. The motor bus supplanted the streetcar because it could serve a more dispersed population — it did not offer a higher level of transportation service. The automobile, like the streetcar, has been accepted so eagerly because it offers a higher level of transportation service and it permits the achievement of even lower population densities.

Americans have traditionally exhibited a strong desire for low density housing — primarily single family dwelling units. They have yielded this preference only when strong economic forces and current transportation technology dictated higher densities. As soon as the technology was available and they could afford to do so, they exercised this preference by moving to less crowded conditions. During the last fifty years, except for temporary pauses during the depression and World War II, urban population densities have been trending downward toward the density corresponding to single-family housing (see Figure 10 for examples of population densities) (13).

In 1907, for example, the residential population density of Manhattan Island was 115,000 persons per square mile (17). By 1970, it had dropped to 67,000 persons per square mile (13). The average population density for all U. S. central cities was only 7800 persons per square mile in 1950, and it had dropped to 5800 by 1960 (38). Meanwhile, suburbs were developing at densities of 2000 to 4000 persons per square mile.

FIGURE 10 - EXAMPLES OF RESIDENTIAL POPULATION DENSITIES

Characteristic Housing Type	Population Density, Persons/Sq. Mile	Example City
		Manhattan Island-1910
	100,000	Manhattan Island-1950
Crowded Tenement Buildings		Manhattan Island-1970
	50,000	Brooklyn-1940
Modern High-Rise Apartment Buildings		New York City-1970 (5 Boroughs)
	20,000	Boston-1950
Row-Houses	15,000	San Francisco, Chicago, Philadelphia } 1970
		Boston-1970
Garden Apartments	10,000	Miami-1970 Cleveland-1970
Duplexes		Los Angelos-1970
Single-Family Houses on Small Lots	5,000	Oakland-1970
		San Antonio-1970
	3,000	Dallas & Houston-1970
Single-Family Houses on Large Lots	2,000	Ft. Worth-1970
	1,000	

Sources: Bureau of Census, Statistical Abstract of the United States 1972, and Electric Railway Journal, Vol. XXXV, No. 23, p. 982.

The flexible transportation capabilities of the private automobile made these lower population densities possible; however, without a rising personal income, Americans could not have exercised their preference for low density housing so readily. European cities have just begun to experience the same trends during the last 10-15 years. In Hong Kong, the residents are still living at population densities far in excess of anything ever known in America.

Thus, it appears that the real factors behind the decline of transit usage in America were:

(1) a desire for lower density housing,

(2) availability of the automobile, and

(3) rising personal income.

These factors have combined to create a lifestyle in which transit can never return to its role of being the primary mode of urban transportation. This is not to say, however, that there is no longer a need for transit to serve specialized transportation needs of urban America today.

THE ROLE OF TRANSIT

Fifty five years ago, approximately three-fourths of all urban trips* were made via transit. Today, less than five percent of urban travel is served by transit. Obviously, the role of transit has changed during this time span. The current and future role of transit systems in American cities might be divided into the following relatively distinct areas:

1. Public Transportation
2. Mass Transportation, and
3. Circulation Within Concentrated Developments.

The following sections discuss the needs and objectives of each of these areas as well as various forms of transportation which might be used to serve these needs.**

Public Transportation

Americans have developed an entire way of life based upon the mobility provided by the automobile. Commercial establishments, such as supermarkets, depend upon this mobility to provide sufficiently large market areas for high-volume, low mark-up operation. Recreational and entertainment facilities provided on a regional basis offer a broader variety of services than can be offered on a neighborhood basis. Residential location no longer needs to be closely tied to place of employment — resulting in a much broader choice of housing services and other amenities than previously available to the urban dweller.

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*Other than walking trips.
**This section is extracted from Reference 18.

The quality of life in America has been vastly improved because of increased mobility, but in the process of change, individual mobility has become a necessity rather than a luxury. Those persons who, for any reason, do not have access to private transportation are severely disadvantaged unless some degree of mobility can be provided by public transportation.

A surprisingly large segment of the nation's population is unable to provide for their own transportation. In fact, less than half of the population are licensed drivers. This means that the other half must depend either upon other individuals or a public transportation system for their mobility. Trends in transit ridership indicate that most non-drivers currently depend upon other individuals for transportation. The question that must be answered is whether or not it is socially desirable that all non-drivers should be forced to be dependent upon some other individual for transportation. If not, then some form of public transportation must be provided.

The objective of public transportation is to provide a level of mobility within an urban area which is consistent with the goals and standards established by the community. Public transportation systems can never provide a level of service (flexibility, availability, convenience, speed, etc.) comparable to private transportation, but they should provide the following:

(1) service to all parts of the community,

(2) reasonably frequent service to most areas, and

(3) fares consistent with the service provided and the segment of population served.

A public transportation service is aimed at the non-driver segment of the population. Potential users come primarily from persons who are:

(1) too young or too old to drive,

(2) physically or mentally handicapped,

(3) economically disadvantaged,

(4) suspended drivers, or

(5) tourists and travelers.

As such, public transportation systems serve a social need within the community.

When a community decides to provide a public transportation system, the citizens should recognize that revenue from user charges will probably not be sufficient to cover the cost of operation. Depending upon the level of service provided, the operating deficit can be quite substantial. Since public transportation serves a social need, some financial support from the general tax fund may be justified.

Public transportation service may take one of several forms depending upon the needs of the community. It may be a regularly scheduled bus service or it could be a "Dial-a-Bus" type operation. In some cases, where there are only a few people who use the service, some form of subsidized taxi service may be a better alternative.

Mass Transportation

There are definite economic advantages to concentrating certain business activities within a relatively small area of land, typically the Central Business District (CBD) or "downtown" area, and there are advantages to using common business hours. However, the resulting travel demands of masses of people converging on one area within short periods of time overtaxes the transportation system resulting in severe congestion.

The objective of mass transportation is to provide for the rapid movement of masses of people in order to serve peak travel requirements within major travel corridors. Mass transportation serves an economic need rather than the social need served by public transportation. A mass transportation system is justified only if it can provide a level of service consistent with user needs while requiring a smaller total expenditure of resources and time than that required for alternative forms of transportation.

Mass transportation systems are most effectively used to serve high-volume movements between fixed points of concentrated activity and along high-density corridors. Thus, it has been used effectively in north-eastern cities with high-density residential areas. Southwestern cities, however, have developed at relatively low residential densities (2000-4000 persons/sq. mile) even though many of them experience extremely high daytime densities in the CBD (in excess of 100,000 persons/sq. mile). These high daytime densities in the CBD create a need for mass transportation, but the low residential densities pose severe problems for serving the commuter demands with mass transportation. Hence, careful planning is needed in selecting an appropriate mass transportation system for these cities.

Existing rail-rapid-transit and bus transit represent the two extremes of available types of mass transportation (fixed way vs flexible). Rail-rapid-transit systems operate on their own fixed way so that they do not have to contend with congestion caused by other traffic.

However, their service area is permanently limited to the range of their fixed way. Buses, on the other hand, can operate on city streets and freeways with a great deal of flexibility in service areas and routes, but they must contend with automobile traffic.

Circulation Within Concentrated Developments

Areas of highly concentrated activities such as CBD's, airports, and large universities need an effective internal circulation system in order for them to function as a single development. Walking is the traditional mode of circulation within such areas; however, when these developments grow too large, the pedestrian mode can no longer adequately serve their circulation needs.

Although residential population densities in urban America have been decreasing for many years, the daytime population densities in many downtown areas have been increasing rapidly in recent years. For instance, the resident population density of Manhattan Island decreased from about 90,000 persons/sq. mile in 1950 to about 67,000 persons/sq. mile in 1970 (13), but the daily influx of office workers has increased fast enough to keep the total daytime population density above 300,000 persons/sq. mile during this period (19). Indeed, the extensive subway system on Manhattan Island now serves more as an internal circulation system for one huge CBD than it does as a mass transportation system (bringing commuters in).

Daytime concentrations of people in many downtown areas have increased to the point that their pedestrian circulation systems are inadequate. Thus, there is an increasing need for some type of people-mover transit system to supplement the pedestrian mode in the total circulation system serving these areas.

Many forms of people-movers have been proposed recently including horizontal elevators, moving sidewalks, monorail trains, personal-rapid-transit (PRT) systems, and rubber-tired trams. All of these concepts are aimed at filling the gap between conventional transit systems and walking. They operate at speeds of 5 to 15 miles per hour, and most of them use remote power sources so that service can be provided directly into buildings through a network of passageways without encountering engine exhaust problems.

TRANSIT IN TEXAS

Historical Perspective

At first glance, it might appear that transit service in Texas cities followed the trends observed nationwide. However, there was one very significant difference between cities in Texas and the major cities of the nation which set the national trends. Texas cities did not grow large enough to necessitate high-density residential development before transit systems evolved. Therefore, transit service helped city residents in Texas retain, rather than obtain, low-density housing.

A horse-drawn (or mule-drawn) tram system was installed in Dallas in 1871 when the city's population was less than 4,000 persons. Electric streetcars came to Dallas in 1891 when the population was less than 40,000 (20). San Antonio, the largest city in Texas at the time, began mule-drawn tram service in 1874 with a population of 15,000 and began streetcar service in 1890 with a population of less than 40,000 people (21).

Despite the relatively low population densities, streetcar service was very popular in Texas cities in the early 1900's. At one time, virtually every city in Texas with a population of 5,000 persons or more - and some which were even smaller - had streetcar service. However, because of the marginally low population densities, the motor bus rapidly replaced the streetcar in most Texas cities during the 1920's and early 1930's. San Antonio ceased streetcar operation in 1933, but Dallas continued to operate some streetcars until 1956.

Population growth of major cities in Texas during the last 100 years

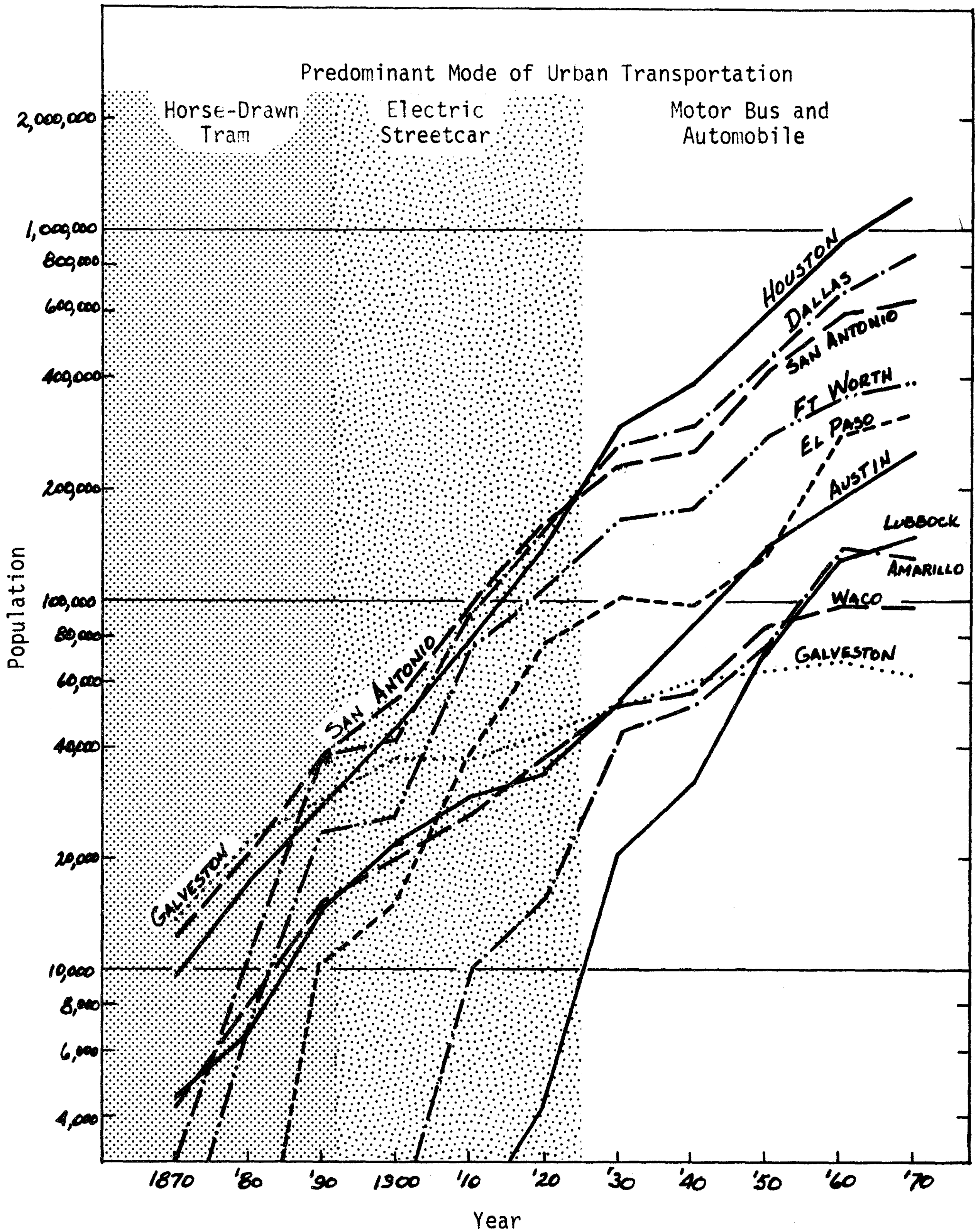
(1870-1970) is shown in Figure 11 (22). The dominant mode of urban transportation during each time period is also noted on the figure. Throughout this period of urban growth, the average population density of Texas cities remained in the 2,000-5,000 persons per square mile range - a density commensurate with single-family houses. New transportation technology (streetcar, motorbus, and automobile) came along in time to permit Texas cities to continue to grow in population without sacrificing single-family houses. Also, the nature of urban development in Texas facilitated the transition to automobiles as the primary mode of urban transportation.

Recent Trends

The demise of privately owned transit companies in Texas is almost complete. In 1954, all 37 cities shown on Figure 12 were served by privately owned transit companies. Today, private companies are providing transit service in only eight cities, eleven cities have taken over the transit system and continued to operate it, and transit service has ceased altogether in other Texas cities (23). Several of the remaining privately owned transit companies have already announced that they will be forced to stop operations in the very near future unless the city agrees to take over the system or subsidize its operation.

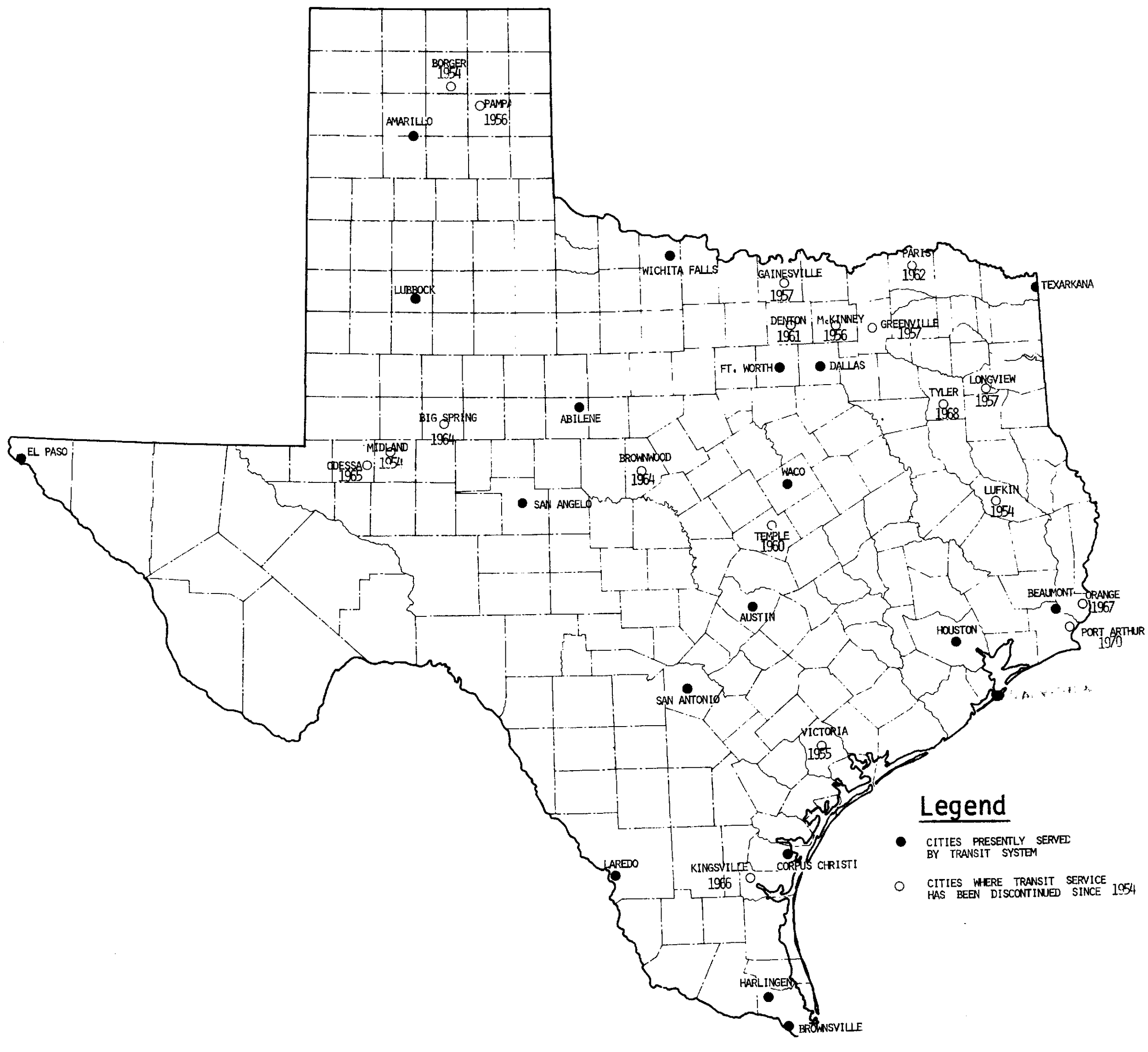
Transit ridership in Texas has declined at about the same rate as the national average. Recent ridership trends for those cities which still have transit service are shown in Figure 13 (24). Of course, when ridership figures for those cities which have ceased operation are

FIGURE 11
POPULATION GROWTH OF TEXAS CITIES



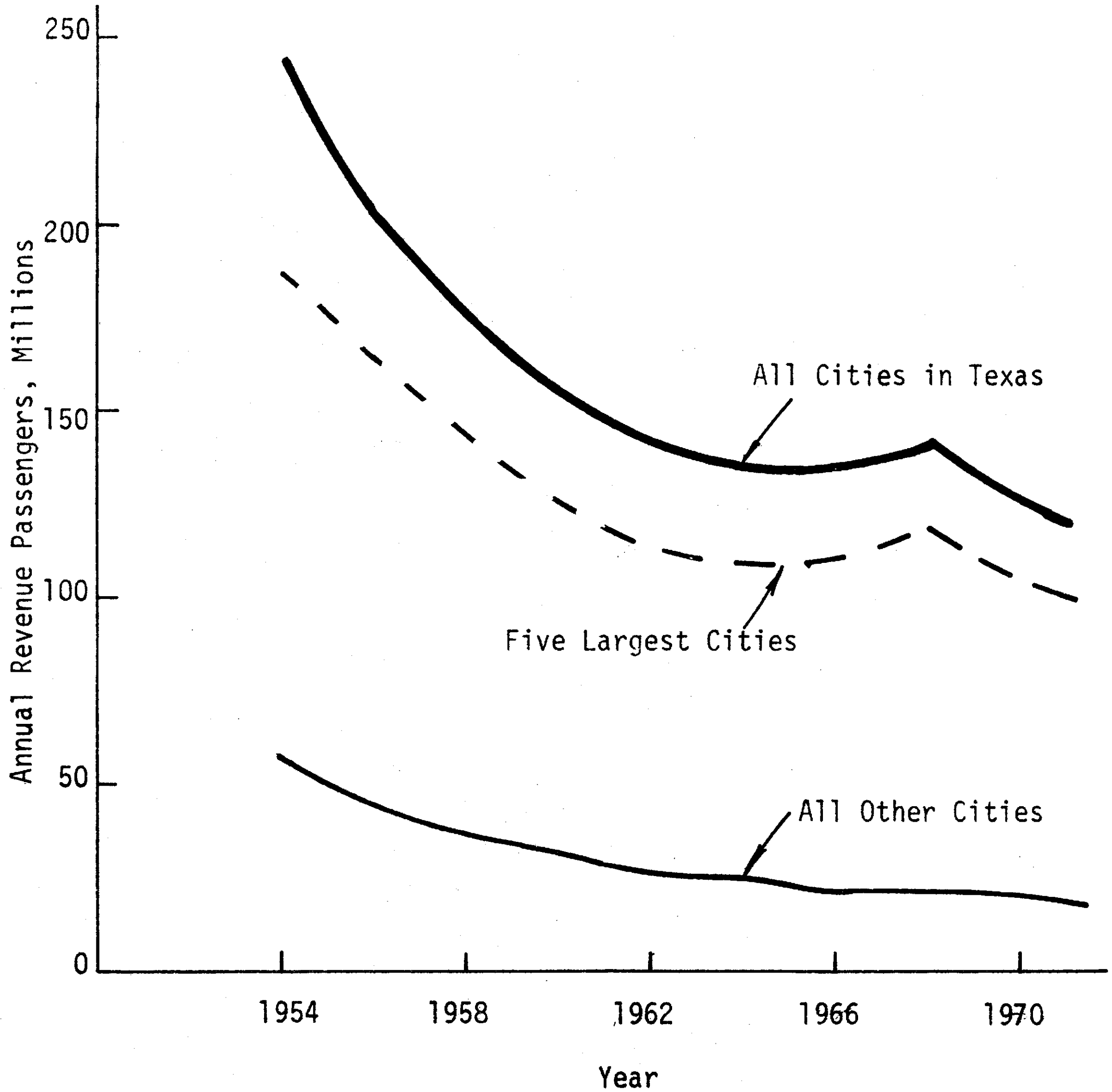
Source: Texas Almanac

FIGURE 12
CITIES WITH CURRENT OR RECENT
TRANSIT SERVICE



Source: American Transit Association

FIGURE 13
TRANSIT RIDERSHIP TRENDS IN TEXAS CITIES



Source: Texas Highway Department

included, total ridership for the State has declined even faster than indicated by Figure 13. The five largest cities managed to reverse the ridership trend temporarily during the mid-1960's, but their ridership is dropping rapidly once again.

Nature of Transit Today

The relatively minor role that transit plays in total urban travel in Texas is reflected in the data presented in Table 1 (25). In most cities, trips made via transit constitute no more than five percent of the total urban trips. When only those trips going to or through the CBD are considered, the percentage made via transit is higher. However, these figures are somewhat misleading since most transit routes pass through the CBD so that bus passengers usually have to go through the CBD even though their ultimate destination is somewhere else.

Some interesting data concerning characteristics of bus riders in Texas are presented in Table 2 (21) (26) (27) (28). The following generalizations are indicated by these data:

1. Most bus riders are daily users coming from families with relatively low incomes who do not own a car.
2. Very few people ride the bus if they have a car available for that particular trip.
3. Very few bus passengers are from the categories of the "very young and very old" — most of them are between 17 and 65 years old.
4. The primary purpose for bus trips is to travel to or from work.

TABLE 1
PERCENTAGE OF URBAN TRIPS MADE BY TRANSIT

CITY	YEAR OF SURVEY	PERCENT OF TOTAL URBAN TRIPS*	PERCENT OF TRIPS* TO CBD
Abilene	1965	1	1
Amarillo	1964	1	2
Austin	1962	4	5
Beaumont	1963	4***	9
Brownsville	1970	5	8
Corpus Christi	1963	8	5
Dallas	1964	3***	15
El Paso	1958	9	21
	1970	7	18
Fort Worth	1964	3***	6
Galveston	1964	4	27
Harlingen	1965	6	2
Houston	1960	4	20
Laredo	1964	9	11
Lubbock	1964	1	5
Port Arthur**	1963	4***	3
San Angelo	1964	2	2
San Antonio	1969	5	19
Texarkana	1965	3	3
Wichita Falls	1964	1	2

* Excludes walking trips and school bus passengers.

** No longer operates transit service.

*** Denotes percentage characteristic of entire study area.

Sources of Data: Texas Highway Department, Urban Transportation Studies for Cities Listed

TABLE 2
CHARACTERISTICS OF BUS RIDERS IN TEXAS

CHARACTERISTICS	HOUSTON	SAN ANTONIO	WACO	WICHITA FALLS
Riders per day, thousands	67	75	1.6	1.6
% Daily Users	75	76	69	69
Family Income Levels:				
% Less than $ 3000	32	32	--	--
% Less than $ 4000	--	--	50	53
% Less than $ 6000	67	71	90	82
% Riders from families who do not own a car	45	44	54	56
% Riders with no car available for that trip.	80	84	89	--
Sex of Rider:				
Male, %	28	29	30	27
Female, %	72	71	70	73
Age of Riders:				
% Under 16 Years Old	3	6	--	12
% 17 - 65 Years Old	92	88	--	73
% Over 65 Years Old	5	6	--	15
Purpose for Trip:				
Work, %	61	49	63	46
Shopping, %	4	9	11	12
School, %	10	23	10	15
Other, %	25	19	16	27

Sources of Data: Transit Studies for Cities Listed

Data contained in Tables 1 and 2 indicate that transit systems in Texas are serving as public transportation systems. A modest level of mobility is being provided for a relatively small segment of the population who do not have access to private transportation. Thus, a very important social need is being served. In the larger cities, the bus systems are also providing a limited amount of mass transportation service.

Future Needs for Transit Service

Texans depend heavily upon the automobile for mobility, but a portion of the population still does not have access to an automobile. Thus, it appears that the need for public transportation service will continue to exist for many years in most cities. However, if personal incomes continue to increase faster than the cost of living, the portion of population needing public transportation will probably decline in the future.

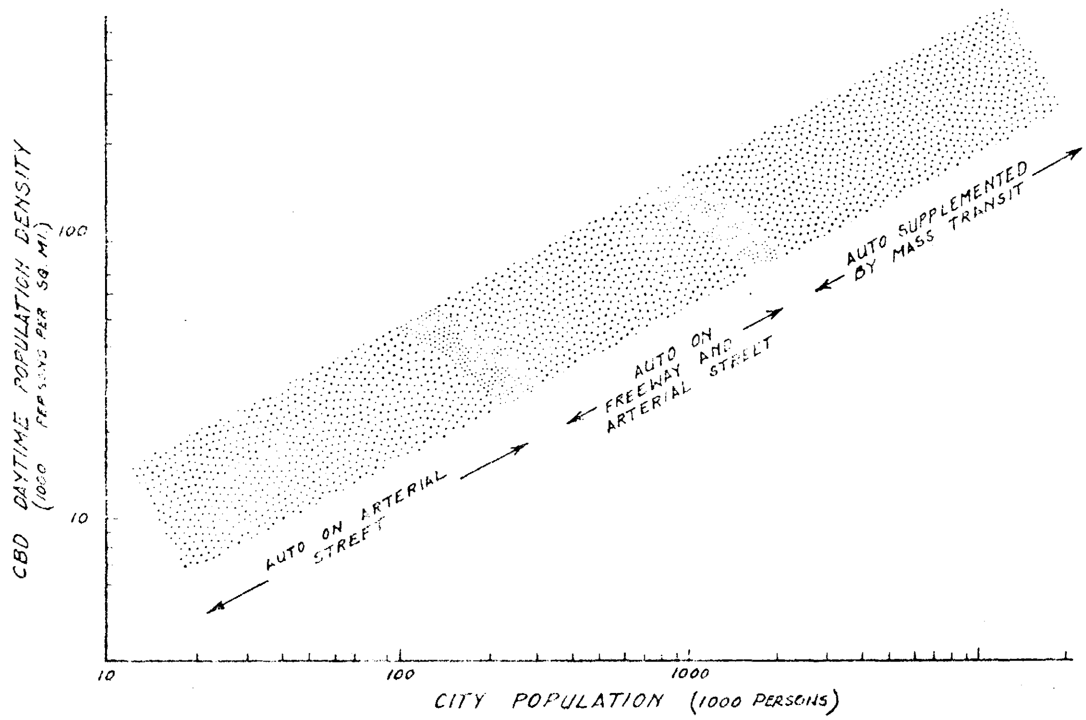
A decline in the need for public transportation is not lamentable - it is desirable. If every person could have sufficient access to private transportation to satisfy his mobility needs, there would be no demand for public transportation. Then each person could enjoy the benefits of our mobile life-style. Unfortunately, there will always remain a small segment of the population who cannot provide for their own mobility because of physical disabilities or legal restrictions if not for economic reasons. However, as the demand for public transportation decreases, the nature of the service provided might change.

Conventional scheduled local bus operations, the type of service presently used for public transportation in Texas, are a relatively expensive way to provide mobility for a small number of persons. A demand-responsive type of public transportation service can provide a higher level of service to a few persons at a lower total cost. No one method of providing public transportation will be best for every community, but virtually every sizeable community will have a need for some form of public transportation.

The need for some form of mass transportation is rapidly increasing in a few of the larger cities in Texas. Because the Central Business District (CBD) or "downtown" area has historically been the area with the greatest level of development within the city, it is the largest traffic generator. The nature of activities within the CBD have changed during the last 20 years from primarily shopping to primarily office activities. Even though many CBD's experienced a lull in development during this transition period, some have continued to develop at a rapid rate (particularly Houston and Dallas). Traffic problems associated with so many people converging on such a small area in short periods of time are enormous.

Recent studies of transportation problems associated with the CBD have identified some theoretical relationships between city size, intensity of CBD development, and transportation systems needed to support certain levels of development (29). These theoretical relationships, which assume an ideal system of streets and freeways, are depicted graphically in Figure 14. Based upon these analyses, the level of development in the Houston and Dallas CBD's has already exceeded that which can be supported by automobiles alone under current operating conditions. Thus, some supplemental mass transportation is needed now, and additional development in these CBD's will necessitate a higher level of dependence on mass transportation. Also, some form of people-mover system will be needed to supplement the pedestrian circulation system if these CBD's continue to develop.

FIGURE 14
RELATIONSHIP BETWEEN CITY SIZE, CBD DEVELOPMENT, AND TRANSPORTATION SYSTEMS



Source: TTI, Coastal Zone Transportation Study

MODES OF MASS TRANSPORTATION

Increasing levels of downtown development in some Texas cities are creating an increasing need for mass transportation, but the dispersed nature of residential development in those cities makes it extremely difficult to design a mass transportation system which can function effectively. None of the traditional modes of mass transportation appear to be applicable to this type of urban development. Hence, an understanding of the characteristics and capabilities of various modes of mass transportation is essential for proper planning.

Rail-Rapid-Transit

Rail-Rapid-Transit (RRT) systems operate within urban areas on rail lines constructed on exclusive rights-of-way (whether below ground, above ground, or at grade) so that they do not have to contend with other forms of traffic. Most RRT systems use vehicles that are powered by direct current with electrical pickup from a third rail. Older RRT systems have stations located about every half-mile along the route which is all within the highly developed portion of the city. Some of the newer lines use station spacings of one to two miles, and they extend out into the suburbs surrounding the high-density development. Hence, some of the distinction between RRT systems and commuter rail systems is becoming blurred.

Systems which use conventional streetcars as rolling stock are generally not considered as RRT systems even when they operate on grade-separated facilities. Some experts refer to such systems as light-rapid-transit (LRT). Most of the streetcar lines still in operation in the

United States — in Newark, Shaker Heights (Cleveland), Philadelphia, and Boston — could be classified as LRT systems since they do not operate in streets with automobiles, trucks, and buses. In comparison with other modes of urban transportation, the differences between LRT and RRT systems seem relatively minor; nevertheless, data concerning light-rapid-transit operations are normally included with other street-car operations rather than with rail-rapid-transit operations. Hence, the data presented here are for RRT systems only.

The first RRT systems in the United States were opened at about the turn of the century. They achieved average operating speeds in excess of 20 mph — appreciably faster than any other forms of urban transportation at that time — so they were appropriately named "rail-rapid-transit". Numerous technical improvements have been achieved in RRT vehicles over the years to improve their efficiency, safety, and the quality of ride. However, none of these advancements have resulted in a significant increase in operating speeds for those RRT systems with stations located about every half-mile along the route.

Some pertinent data concerning all existing RRT systems in North America are presented in Table 3 (5). The average speeds shown are from the most recent available reports on operations for each system. These data show the strong correlation between station-spacing and average speed. Even the newer systems have not been able to achieve higher speeds when they have closely spaced stations (Toronoto, Montreal, and Mexico City). However, systems with stations spaced at about one-mile intervals (Cleveland and PATCO) achieve speeds over 30 mph. The Bay Area Rapid Transit (BART) system hopes to be able to achieve speeds of 45 mph with stations spaced about 2 miles apart.

TABLE 3
RAIL-RAPID-TRANSIT SYSTEMS IN NORTH AMERICA

City/System	Route Length (Miles)	Miles Under-Ground	Number of Stations	Average Speed Including Stops (MPH)	Year Major Portion of System Completed	1970 Population Density of Central City (Persons Per Square Mile)
New York City:						
NYCTA	237	137	476	20 - 22	1904,'22, '29	26,343
PATH (Newark-NYC)	14	N/A	13	—	1908,'62	16,273 - 26,343
Chicago: CTA	89	10	~125	23	1897,1943,'69	15,126
Philadelphia:						
SEPTA	30	19	52	17 - 20	1908	15,164
PATCO (Lindenwold)	14	2	12	38	1969	-
Boston: MBTA	23	12	44	16 - 22	1906	13,936
Cleveland: CTS	19	0	18	30	1955, 1968	9,893
San Francisco/Oakland BART	75	23	38	45*	1973	15,764/6,771
Montreal	16	16	26	20 - 23	1966	23,525**
Toronto	21	~21	45	18 - 20	1954,'68,'70	-
Mexico City	26	22	49	20	1970	-

* Predicted Operating speed for BART
** 1956 Population Density for Montreal

Sources: Jane's All the World's Railway and U. S. Census - 1970

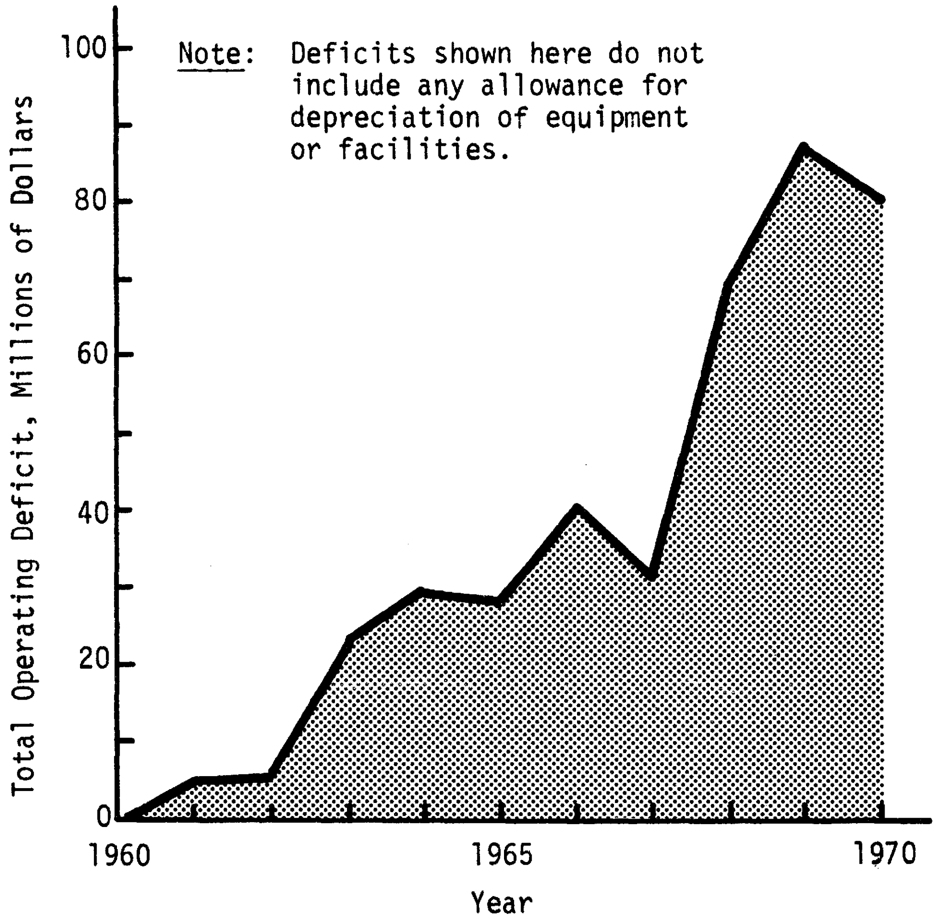
Of course, speed is not the only consideration for selecting a station-spacing plan for a new RRT system. The population density of the service area and the way that riders are expected to get to and from the station are primary considerations. The older RRT systems were built to serve areas which had already developed at very high population densities (greater than 25,000 persons/square mile) compared to modern urban development (less than 5000 persons/square mile). Thus, when the stations were located at half-mile intervals, enough people lived within a quarter-mile distance from a station to support the system with walk-in traffic.

Today, however, the public's level of reliance on transit and the population densities of cities have declined so much that no RRT system can rely entirely upon walk-in traffic. Even on the Toronto system, with its half-mile station spacing and relatively high population density, more than 80 percent of the RRT passengers get to the station by bus or streetcar rather than by walking (30). Hence, some of the newer RRT systems (Cleveland, PATCO, and BART) have spread out their stations, built large parking lots near the station, and established a network of feeder buses to bring passengers to the stations.

During the decade of the 1960's, additions and improvements to RRT systems in the U. S. resulted in a 5 percent increase in route-miles, a 6 percent increase in number of vehicles, and a 15 percent increase in vehicle-miles of service (5)(31). Yet, total ridership on RRT systems decreased by more than 7 percent between 1960 and 1970 (12). Operating costs increased more rapidly than revenues so that the total net annual deficit for all RRT systems in the U. S. increased dramatically (see Figure 15) (31). In 1970, for the first time, every RRT system in the nation incurred a significant operating deficit (see Table 4).

FIGURE 15

GROWING OPERATING DEFICITS FOR RRT SYSTEMS IN U.S.



Source: Institute for Defense Analysis

TABLE 4

GROSS OPERATING PROFIT (DEFICIT) OF RAIL RAPID TRANSIT PROPERTIES, 1960 THROUGH 1970

(Thousands of Dollars)

Property	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
New York City											
NYCTA	(1,232)	(6,653)	(9,608)	(22,936)	(28,984)	(24,487)	(36,578)	(29,509)	(64,966)	(80,213)	(56,569)
PATH	156	186	(821)	(2,021)	(3,149)	(5,019)	(5,137)	(5,657)	(6,308)	(6,195)	(6,840)
Chicago: CTA	(108)	(571)	365	10	(77)	(989)	(1,160)	104	569	1,104	(5,257)
Boston: MBTA	(892)	(324)	1,774	1,217	1,057	472	212	1,352	(235)	(2,049)	(10,200)
Cleveland: CTS	326	344	154	(135)	(323)	(277)	(435)	(310)	(384)	(545)	(1,128)
Philadelphia											
SEPTA	1,173	1,960	1,241	1,032	1,766	2,049	2,089	1,800	1,655	1,705	(323)
PATCO (Lindenwold)										(832)	(147)
Total for U. S. Systems	(577)	(5,158)	(5,895)	(22,842)	(29,633)	(28,251)	(41,009)	(32,220)	(69,669)	(87,025)	(80,464)

Note: These figures do not include any allowance for depreciation of facilites or equipment.

Source: Institute for Defense Analyses, Economic Characteristics for the Urban Public Transportation Industry.

Despite the obvious problems facing existing RRT systems in the U.S., several new systems are now being built and numerous others are being proposed as the ulimate solution of the urban transporation problem. Part of the popular support for rail-rapid-transit is based upon misleading information that frequently appears in the literature. First, rail-rapid-transit is often presented as something new, but it is really more than 70 years old. Second, the term "rapid" in the title is misleading when the speeds are compared to urban transportation of today. (Both of these points have been covered in the preceeding discussion.) Finally, the capacity values quoted for RRT are misleading.

Capacities of 60,000 persons/hour are quoted for a single line of RRT and compared to observed utilization for a freeway lane of 2250 persons/hour in automobiles or 5000 persons/hour in buses. Data presented in Table 5 show that hourly capacities of 60,000 or more have actually been measured on some RRT lines — but only with at least two-thirds of the passengers standing (32). None of those systems listed provide as many as 20,000 seats/hour. Designers of the BART system expect it to be able to provide a capacity of 28,800 seats/hour across the bay — a significant increase in seating capacity over existing RRT systems. The relative capacities of various types of urban transportation systems are compared in Table 6 on the basis of seats per hour (29).

TABLE 5
RAIL RAPID TRANSIT - OBSERVED PEAK HOUR VOLUMES

Location	Trains Per Hour	Headway (Seconds)	Actual Passenger Load	Seating Capacity			% Seated
				Per Car	Per Train	Total	
NEW YORK	32	112	61,400	60	600	19,200	31
NEW YORK	31	116	44,510	40	360	11,160	25
NEW YORK	30	120	62,030	60	600	18,000	29
TORONTO	28	128	35,166	62	496	13,888	39
CHICAGO	25	144	10,376	49	294	7,350	71
NEW YORK	24	150	36,770	40	360	8,640	23
CLEVELAND	20	180	6,211	53	318	6,360	100

SOURCE: Capacity and Limitations of Urban Transportation Modes, Institute of Traffic Engineers (1965).

TABLE 6
CAPACITIES OF URBAN TRANSPORTATION MODES

Mode	Flow Rate, Units/Hour/Lane	Seats Per Vehicle	Capacity Seats/hour
Automobile on Freeway	2000 autos	5 per auto	10,000
Bus-Freeway	200 buses, 1600 autos 500 buses, 1000 autos	50 per bus 5 per auto	18,000 30,000
Exclusive Busway	1250 buses	50 per bus	62,500
Skybus	40 ten-car trains	35 per car	14,000
Rail Rapid Transit	40 ten-car trains	75 per car	30,000

Source: TTI, Coastal Zone Transportation Study

Some pertinent design characteristics and costs of newer RRT systems are presented in Table 7. As might be expected, systems with a higher percentage of underground routes and with closer station spacing cost more per mile. Another important cost factor is the availability of an existing right-of-way. The Cleveland and PATCO (Lindenwold Line) systems were constructed on existing railroad rights-of-way primarily at grade, and they generally utilize the most "Spartan" design approaches possible. Hence, the cost-per-mile for these two systems is considerably lower than for other systems.

Another factor worth noting is the trend for rapidly escalating costs. For example, when BART was first approved in 1962, the estimated cost per mile was less than $10 million. The final cost for BART was slightly more than $19 million per mile. Three years ago the official estimated cost-per-mile for the Washington, D.C. system was $25 million instead of the present $30 million, and most observers expect it to go even higher before

TABLE 7
CHARACTERISTICS AND COSTS
OF NEWER RRT SYSTEMS

System	Miles of Route			No. of Sta-tions	System Cost		Year Com-pleted (or Expected
	Total System	Under-ground	Ele-vated		Total Cost Millions	Cost/Mile Millions	
Montreal (Original System)	15.5	N/A	N/A	26	214	14	1966
Toronto (Recent Extensions)	20	16	0	28	380	19	1966-1974
Cleveland*: CTS (Airport Extension)	4	0	0	3	18	4.6	1968
Philadelphia: PATCO* (Lindenwold Line)	14.5	2	1	13	95	6.5	1969
San Francisco/ Oakland: BART	75	23	25	38	1,400	19	1973
Washington, D.C.: METRO	98	47	N/A	86	3,000	30	1979
Atlanta: MARTA	50	9	16	37	1,200	24	1980

* Systems Constructed on Existing Rail Right-of-way.

Sources: Jane's All the Worlds Railways ATA, Passenger Transport the system is completed. Atlanta is still in the design phase for their system, so their estimated costs are also likely to increase in the future.

Bus-Rapid-Transit

Bus-Rapid-Transit (BRT) systems offer advantages of both RRT and local bus transit modes. BRT has the flexibility of operating on existing streets for collection and distribution of passengers. However, the essential element of a BRT system is a provision for unhindered line-haul operation on that portion of the route leading to or from the area of concentrated development. This freedom of movement on the line-haul portion might be assured by one of the following means:

1. exclusive busways;
2. reserved lanes; or
3. mixed flow on freeways equipped with traffic surveillance and control.

BRT systems can also utilize terminals and parking lots in much the same manner as RRT systems. However, the same bus can be used for collection and distribution as well as line-haul operations so that passengers do not have to transfer at the terminal.

Although the concept of "express" bus routes is not new, the exclusive use of prime highway facilities by buses is a recent innovation. Current demonstration projects on the Shirley Highway leading to Washington, D.C. and the Lincoln Tunnel leading to New York City have shown encouraging results. Several other cities around the nation are now experimenting with reserved lanes for buses (see Table 8)(33).

The primary disadvantage of the exclusive busway approach is the cost of providing a fixed-way for buses only. This drastically increases the

TABLE 8 - SELECTED BUS-PRIORITY PROJECTS

Name of project	Location	Nature of project	Length	Date implemented	Results	Cost
			Miles			*Millions of dollars*
Shirley Highway	Northern Va. to Washington, D.C. (I-95)	Exclusive bus lane during peak	9	Sept. 1969	Reductions in bus travel times of up to 30 minutes. Ridership during 4 a.m. and p.m. peak hours 20,000 passengers, or more than twice level before project.	7.4 (construction 2.8; bus garages, maintenance and related services 4.6)
Blue Streak	Seattle (I-5)	Reversible bus-priority ramps		Sept. 1970	Ridership increased 35 percent during first month of operation, steadily since then. 70 percent of new passengers formerly commuted by auto.	1.29 (70 buses, park and ride lot, operating costs)
I-495 approach to Lincoln Tunnel	New Jersey	Exclusive bus lane during peak	2.5	Dec. 1970	Average bus flow 485, average passenger flow 21,000, 8-9 a.m.; 8-second bus headways during peak bus travel-time savings of 15 minutes; faster speeds for automobiles.	0.65 total project cost (including 0.134 for bus access roadway) plus 0.200 annual operating cost
Southeast Expressway	Boston	Exclusive bus lane	9	May 1971	Reductions in bus travel times of 14 minutes in a.m. peak, 4 minutes in p.m. During first 2 months, a.m. peak bus ridership increased 25 percent.	0.038 capital
Bay Bridge toll lanes	San Francisco-Oakland Bay Bridge	Exclusive lane for buses and carpools	0.5	Apr. 1970 (buses) Dec. 1971 (carpools)	Buses save 5-15 minutes during a.m. peak.	No additional costs, but some lost in toll revenue.
Reserved transit lanes	Washington, D.C.	Transit lanes established in direction of peak flow		1962 1966 1971	Increased traffic volumes in some routes; reduced bus travel time up to 23 percent on one route.	
Reserved transit lanes	Newark, N.J.	Bus priority and peak bus lanes	0.9	1971	All traffic moving more smoothly bus travel times reduced 20-25 percent.	

Source: U.S. DOT, 1972 National Transportation Report

average cost per passenger mile in corridors that do not have a large passenger demand. In order to minimize this cost, some people have proposed reserving lanes on existing freeways for buses; however, there are severe operational problems associated with reserved freeway lanes.

The Bus-Freeway system is a variation of the Bus-Rapid-Transit concept in which buses operate on a freeway in mixed flow with automobiles, but the traffic entering the freeway is metered to prevent congestion on the freeway. By giving priority to the entry of buses, the number of persons traveling on the freeway can be increased even though the number of vehicles is reduced. The cost of freeway surveillance and control is much less than the cost of an exclusive busway, and automobiles can utilize all remaining freeway capacity. Thus, the Bus-Freeway concept is highly suited for serving corridors with light to moderate transit passenger demands (34).

Studies of potential transit demands in Texas cities have revealed no existing corridors leading to the CBD with potential peak-hour transit demands of more than 15,000 passengers per hour, and most corridors have maximum peak-hour demands of only 5,000-10,000 passengers per hour (34)(35). Obviously, some major redevelopment would have to occur within Texas cities before any corridor would have sufficient demand to need the capacity of either an RRT line or an exclusive busway. Indeed, if enough people could be attracted to them, buses operating on existing radial freeways leading to downtown Dallas and downtown Houston can deliver more people to the CBD than would be required if the total land areas within the inner freeway loops were developed with 100-story buildings*.

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*See Appendix B

The cost of installing surveillance and control equipment (needed to implement bus-freeway concept) on existing freeways is estimated to vary from $50,000 to $100,000 per mile. Annual costs of operating these control systems are about $15,000 to $20,000 per mile. Thus, even if the total cost of the freeway surveillance and control system were charged to the transit operation (even though automobile traffic on the freeway would also benefit), the cost of a bus-freeway system is very low in comparison to fixed-way modes (34).

If, for example, a bus-freeway system were built to be as nearly comparable to a BART-type rail-rapid-transit system as possible, the total cost would be approximately as shown below.

Route:	75 miles of Freeway S & C at $100,000/mile =	$ 7.5 million
Stations:	38 stations at $2 million/station =	76.0 million
Vehicles:	375 buses at $50,000 each =	18.8 million
	Total Initial Cost =	$102.3 million

Of course, these costs assume that all of the cost of surveillance and control equipment is assigned to the transit system and that none of the cost of the existing freeway is borne by the transit. The 375 buses shown provide the same number of seats (at 50 seats/bus) as do the 250 vehicles (with 75 seats/vehicle) bought initially for BART. Thus, for comparable systems, the cost comparison is:

Bus-Freeway System	$ 102 million
Rail-Rapid-Transit System (BART-type)	1,400 million.

Summation

The need for some form of mass transportation to supplement the automobile-based urban transportation system is increasing in several Texas cities. Yet, none of the modes of mass transportation are directly applicable to low-density urban development characteristic of Texas cities. Careful planning and sound judgement will be required in developing mass transportation systems to effectively and efficiently serve these cities.

New rail-rapid-transit systems are currently being constructed or considered in several cities around the nation, and similar systems have been proposed for Texas cities. Considering the relative costs of systems, urban forms of Texas cities, and the type of mass transportation service needed, it appears that bus-rapid-transit systems would be more applicable for Texas cities. Certainly, they should be given serious consideration during the planning phase.

APPENDIX A
CALCULATION OF TRENDS IN THE PERCENTAGE OF URBAN TRIPS MADE VIA TRANSIT

Origin-destination surveys performed as a part of urban transportation studies conducted in numerous cities since World War II have revealed a trend toward increased travel on the part of urban residents (25). An increased propensity to make trips was also noted by urban transportation experts during the first half of this century (9)(10)(11). Based upon these data, scarce though it is prior to 1950, the number of annual urban trips per resident was estimated as shown in Table 11. The values were then divided into the number of annual transit trips per resident (total transit ridership/urban population) to obtain the percentage of urban trips made via transit.

TABLE 11
TRANSIT TRIPS AS A PERCENTAGE OF TOTAL URBAN TRIPS

Year	Estimated Number of Annual Urban Trips/ Person	Number of Annual Transit Trips/Person	Percentage Made by Transit
1900	310	190	61%
1905	320	215	67%
1910	340	250	74%
1915	370	280	76%
1920	400	280	70%
1925	450	265	59%
1930	500	220	44%
1935	450	170	38%
1940	500	170	34%
1945	550	275	50%
1950	600	190	32%
1955	700	105	15%
1960	800	75	9.4%
1965	900	60	6.7%
1970	1100	50	4.5%

APPENDIX B

CBD DEVELOPMENT WHICH COULD BE SUPPORTED BY BUS-RAPID-TRANSIT

- Land area inside inner freeway loop ∿ 1.5 sq. mi.
  (either Houston or Dallas)

- Assume entire area developed with 100-story buildings

- Calculations

Maximum CBD accumulation	∿	1,000,000 persons
Peak-hour arrivals	∿	400,000 persons
Number of buses required	∿	8,000 buses
Number of freeway lanes	∿	8 lanes
Number of CBD street lanes	∿	20 lanes

- Conclusion

  Existing street and freeway capacity is sufficient to support this level of CBD development - - - if enough people could be persuaded to ride buses.

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