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| 16. Abstract This research was designed to explore ways to improve the integration of air transportation with multimodal ground transportation and to ensure improved passenger mobility between airports and major population centers in cities. Statistical information and data used in this research effort comprise secondary data which were obtained from large airports and governmental agencies; and primary data which were obtained through direct field surveys. Field surveys were conducted at Houston Intercontinental (IAH), William P. Hobby (HOU), Dallas/Fort Worth (DFW), and New Orleans (MSY) airports. The methodology used in conducting this project involved: (1) an extensive literature review and descriptive analysis of existing ground transportation services at large airports and (2) the gathering of information and data on the profile of airport patrons and the propensity of airport patrons to utilize mass transit systems to access large airports. Careful analysis of all findings from this research effort revealed serious ground transportation problems at large airports primarily caused by vehicle congestion. The research report concluded with recommended solutions to the foci of ground transportation problems at large airports; namely, vehicular congestion on roadways and terminal curbs. | | | | | |
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SOUTHWEST REGION UNIVERSITY TRANSPORTATION CENTER

**ENHANCED INTEGRATION OF MULTIMODAL
GROUND TRANSPORTATION WITH AIR
TRANSPORTATION AT SELECTED MAJOR AIR
CARRIER AIRPORTS**

by

Isaac Richmond Nettey

Center For Transportation Training and Research
Texas Southern University
3100 Cleburne Avenue
Houston, Texas 77004
January 1995

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PREFACE

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To the Glory of God; my parents, Ebenezer and Ruby Nettey and my young son, Nevin Brandon Nettey, that he may grow to know the elegant power of the written word.

del Gratia

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Abstract

This research was designed to explore ways to improve the integration of air transportation with multimodal ground transportation and to ensure improved passenger mobility between airports and major population centers in cities. Statistical information and data used in this research effort comprise secondary data which were obtained from large airports and governmental agencies; and primary data which were obtained through direct field surveys. Field surveys were conducted at Houston Intercontinental (IAH), William P. Hobby (HOU), Dallas/Fort Worth, and New Orleans (MSY) airports. The methodology used in conducting this project involved: (1) an extensive literature review and descriptive analysis of existing ground transportation services at large airports and (2) the gathering of information and data on the profile of airport patrons and the propensity of airport patrons to utilize mass transit systems to access large airports. Careful analysis of all findings from this research effort revealed serious ground transportation problems at large airports primarily caused by vehicle congestion. The research report concluded with recommended solutions to the foci of ground transportation problems at large airports; namely, vehicular congestion on roadways and terminal curbs.

EXECUTIVE SUMMARY

Over the last two decades, rapid growth of air transportation service at large airports has created the need for improved integration of air transportation with multimodal ground transportation. Rapid growth of air transportation service has also created the need to ensure efficient passenger mobility between airports and major population centers in cities. Ground transportation at large airports is dominated by private transportation in privately owned automobiles. Overwhelming dominance by this mode of ground transportation poses several problems, including the following:

- (1) Increased congestion of vehicular traffic on ingress and egress infrastructure within the airport terminal complex.
- (2) Obstructed flow of vehicular traffic by cars in search of highly cherished parking spaces in proximity to the passenger terminal buildings.

Each of the stated problems is worsened by the increase in demand for transportation during peak travel periods when transportation delays are least tolerable and most economically wasteful as well. Progress in air transportation has occurred primarily in aircraft design, operation and function. Airport access has enjoyed limited improvement. Ground access needs of airport patrons overwhelm the capacity of existing ingress and egress facilities at most large airports.

The current levels of mass transit services in existence at the 23 largest airports in the U.S. are inadequate. Even worse, there are no meaningful plans or projects in progress to improve ground transportation at any of the said airports that indicate imminent change in the existing modes of transportation. Structural changes in the existing ingress and egress at an airport can only resolve the stated problems partially if the modes of ground transportation are not reoriented in the direction of fewer vehicles with high occupancy.

This research project was developed to identify ground transportation problems and the viability of enhancing the integration of multimodal ground transportation with air transportation at large airports. To gather primary data, field surveys were conducted at Houston Intercontinental Airport (IAH), Dallas/Fort Worth International Airport (DFW), William P. Hobby Airport (HOU), and New Orleans International Airport (MSY). Since operations and patronage of these airports bear considerable similarity to operations and patronage of the 23 largest U.S. airports, the results of this research effort could be carefully reviewed, possibly revised and adopted at those other airports.

The thrust of this research project involved a trifocal approach to find feasible strategies that would further integrate intermodal transportation at large airports. The project therefore consisted of:

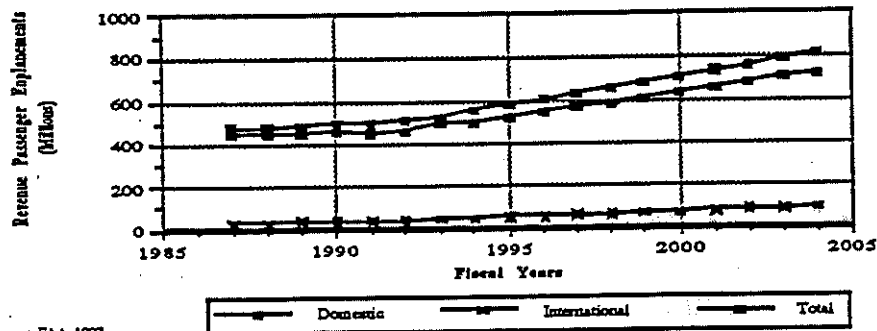
- (1) An extensive literature review and descriptive analysis of existing ground transportation services at large airports. Modes of ground transportation analyzed included private vehicles, mass transit systems, Automated Guideway Transit Systems (AGTS), automobile rental and taxicab services
- (2) The gathering of information and data on the profile of airport patrons and the propensity of airport patrons to utilize mass transit systems, to access large airports. Secondary data employed in this research effort were obtained from large airports in the U.S. and overseas which have significant mass transit service. The solicited airports which furnished secondary data were Washington National Airport (DCA), Boston Logan International Airport (BOS), Cleveland Hopkins International Airport (CLE) and Hartsfield Atlanta International Airport (ATL) in the U.S.; and London Heathrow Airport Limited (LHR), Aeroporti di Roma (Fumicino Airport-FCO) and Aeroport de Geneve-Cointrin (GVA) overseas.

- (3) A proposal of possible solutions to ground transportation problems and recommendation of mechanisms to enhance integration of different modes of ground transportation at large airports.

Analyses of the information, primary and secondary data utilized in this research effort revealed the following:

1. There is an upward trend in the number of passenger enplanements and aircraft operations in the U.S. The upward trend in passenger enplanements and aircraft operations indicated in Figure ES-1 implies that demands placed on airport access facilities will enjoy a comparable increase.

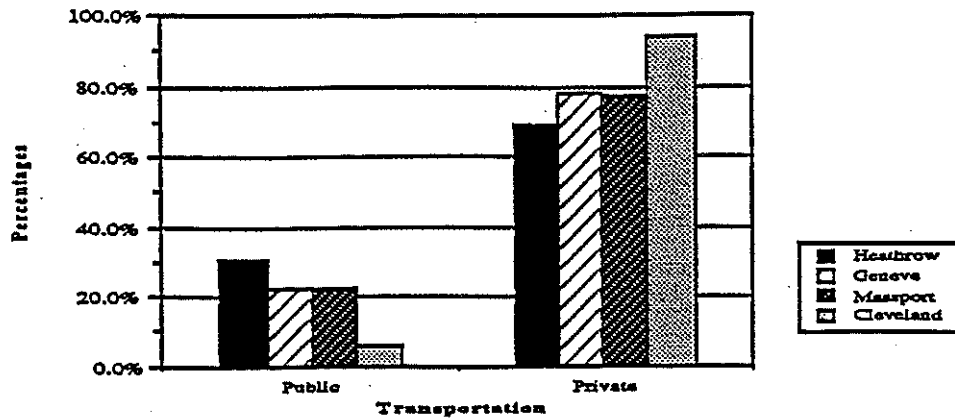
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United States Commercial Air Carriers and Regional/Commuters Total Scheduled Passenger Traffic



Source: FAA, 1993

2. Use of mass transit to access large airports appears to be higher at overseas airports than at U.S. airports. Figure ES-2 is a graphical representation of the different levels of mass transit usage at two airports in the U.S. (BOS and CLE) contrasted with two airports overseas (LHR and GVA).

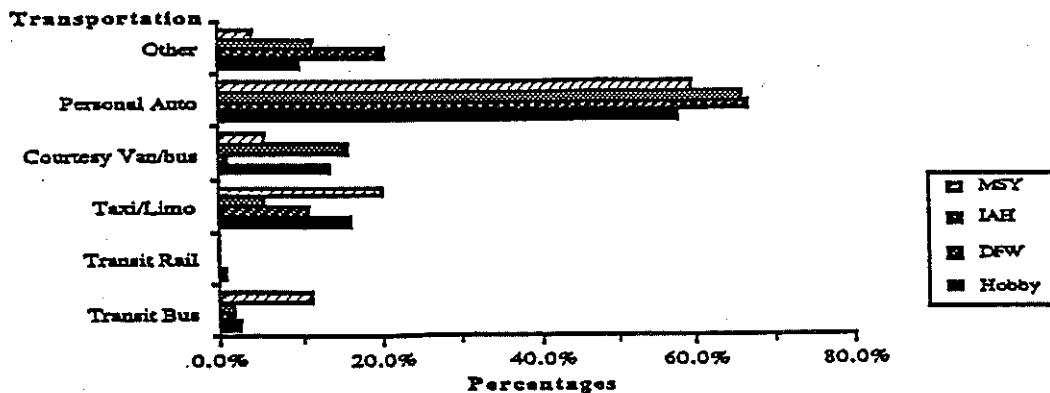
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Airport Public Transportation Versus Private Vehicles at Selected Airports



Source: Nenny, CTR-TSU, 1993

- Mode of transportation used is the most powerful predictor of which airport patrons are most likely to use mass transit systems to access large airports. Airport patrons who use personal automobiles to access the surveyed airports were the most likely to use mass transit. The overwhelming preference of this group of airport patrons for mass transit is graphically portrayed in Figure ES-3.

Figure ES-3
Airport Patrons Who Would Use Mass Transit Versus The Mode of Transportation Normally Used While Travelling



Source: Nenny, CTR-TSU, 1993

4. Educational level attained by airport patrons appeared to be a strong determining factor of the propensity to use mass transit to access the airports surveyed.
5. The main culprit of ground transportation and accessibility problems at large airports is vehicular congestion.

The totality of findings in this research project revealed that even though there is no ground transportation crisis at the nation's largest airports, there are serious transportation and ground access problems which could evolve into a crisis if no remedial steps are promptly taken. The nexus of the present ground transportation and access problem at airports are, roadway congestion and curbside congestion at the terminals. Solutions to these problems lie in fundamental design changes to properly channel vehicular traffic, the use of mass transit systems to ease vehicular congestion and standardized signage to ensure efficacious flow of traffic.

Chapter I

Project Introduction

A. Introduction

In the Department of Transportation's (USDOT) Strategic Plan, published in January 1994, Secretary Federico Pena reported the existence of 4 million miles of highways and roads, 170,000 miles of railroad routes and 11,000 rail miles of rapid transit in the United States. Additionally there are over 17,000 airports, heliports, seaports and seaplane bases around the nation.

Using these facilities are, over 144 million registered automobiles, 46 million trucks, over 70,000 buses, 1,000 trolleys, 5,000 commuter rail cars, and over 298,000 civil registered aircraft in the United States (Pena). Transportation industries represent 17 percent, or about \$ 1 trillion , of Gross Domestic Product (GDP) and transportation capital stock in the U.S. is valued at \$ 2.4 trillion dollars (Pena). These remarkable statistics place the U.S. in the forefront of transportation on the global stage.

The ultimate purpose of this massive public and private investment in transportation is to "strengthen America by bringing people and communities closer together, spurring trade and commerce to meet the new demands of a global economy, revitalize manufacturing and maintain national security" (Pena p.2). The challenge posed by this mammoth system lies primarily in the need to improve its efficiency so as to ensure that it continues to serve the public and enhance the quality of life in an environment characterized by rapid technological changes. The need to improve the efficiency of the national transportation system is demonstrated by the disturbing fact that "twenty three large airports experience at least 20,000 hours of airline flight delays each year" (Pena, 4).

A major flaw in the national transportation system is **excessive fragmentation** and **poor integration** of the **different modes of transportation**. This flaw constitutes a major impediment to improving efficiency in the entire transportation system. A more obvious and stark transportation problem is the worsening condition of vehicular congestion. It is in recognition of the severity of these problems and challenges that secretary Pena listed the need to "tie America together through an effective intermodal transportation system" as the first item on the USDOT's list of seven strategic goals (Pena).

B. Project Background

Through technological advances that have enhanced safety and the aeronautical integrity of air transportation, airports have evolved into a major component of the nation's industrial sector. In that role, airports constitute a vital integral part of the transportation network within the U.S., and in most technologically advanced nations throughout the world.

Partly because of the highly technical nature of aviation, progress and development within aviation have been predominantly aeronautical - more efficient aircraft engines, more powerful aircraft engines, longer runways for larger aircraft, larger terminal buildings to handle larger aircraft and increased passenger traffic, higher resolution radar equipment, global navigation systems mounted on platforms in Earth's orbit, etc.

The tremendous technological and operational progress experienced by aviation since the dawn of powered flight in 1903 has significantly boosted its popularity among the traveling public. Consequently, "airports have become the terminal of choice among travelers in the U.S. whose trip lengths exceed 200 miles" (Wells, 55)

"Airports are clearly places for people, over a billion a year in the United States alone" (Weinstein and Madrigal, 18). The yearly billion patrons comprise airline passengers, meeters and greeters who visit airports to meet or send off passengers, and airport and airline employees. Of the three groups,

passengers constitute the primary group responsible for generating demand for and patronage of an airport's services. The number of airline passengers in the U.S. steadily increased to 487 million in 1993 (Chris Chimes, Air Transport Association, Washington, D.C.).

With the phenomenal growth in the number of airport customers-from practically zero to 1 billion a year in less than a century- problems have arisen at airports, especially large airports. Since the primary operational focus of airports is the facilitation of air transportation, its aeronautically related problems receive considerable attention. Unfortunately, non-aeronautical problems, which are tangential to the provision of safe and efficient air transportation services, receive minimal attention.

One of the perplexing problems facing airports in recent years, particularly large, and to a lesser extent, medium hubs, is the "volume and severity of landside management problems" (Street, 43). The situation is worsening in many cases, 'and more and more taxicabs, airport shuttles, hotel and motel courtesy vans and rent-a-car company buses compete with private automobiles for finite curb space" (Street, 43). J. Spencer Dickinson, Deputy Executive Vice President of the American Association of Airport Executives (AAAE), contends that "it is a challenge a lot of airports are faced with in terms of providing efficient transportation facilities for the traveling public with increasing demand for frontage space" (Street, 43)

Of critical importance to sustained growth of airport service is research into airport ground transportation problems and the proposal of viable solutions to resolve the identified problems. Of even greater importance to the sustained growth of airport service is the critical evaluation of all proposed solutions and systematic implementation of each viable proposed solution.

Ground transportation problems at airports are not limited to large airports in the United States. Indeed they are global and present at most large airports in industrially advanced countries. For instance, "at Tokyo's Narita Airport, traffic jams as well as congestion at car parks are proverbial" (Mama, 39). Whereas the problem of ground transportation at large airports is

persistent and global, efforts to resolve it are not. Decreasing attention directed towards resolving ground transportation problems in the vicinity of large airports is worsening an undesirable trend in which airport customers spend as much time on the ground negotiating their automobiles to the airport terminal as they do onboard flights to their destination airports. Obviously, such an undesirable trend could be fatal to further patronage of existing major hub airports.

With the rapid growth of air transportation service at large airports over the last two decades, the need for integrating air transportation with multimodal ground transportation, to ensure efficiency of passenger mobility between airports and major business centers in cities, has become more acute. The proximity of large airports to major commercial and business centers makes efficient mass transportation a crucial ingredient in the overall effort to maximize their economic benefits. Efficient and relatively inexpensive multimodal ground transportation has the additional benefit of maximizing the use of existing infrastructure at each of the four airports.

Ground transportation at large airports is dominated by private transportation in privately owned automobiles. Overwhelming dominance by this mode of ground transportation poses several major problems, including the following:

1. Increased congestion of vehicular traffic on ingress and egress infrastructure within the airport terminal complex.
2. Difficulty in securing parking spaces for vehicles in close proximity to the passenger terminal building. Most airport customers, especially airline passengers, cherish parking space in close proximity to terminal buildings for two primary reasons
 - a) Timely access to the terminal building and departure or arrival gate areas
 - b) Less difficulty in carrying luggage from parked vehicles to the terminal. Difficulty in securing parking spaces naturally

prolongs the search for available parking space. The continuous roving of cars in search of parking spaces not only squanders valuable time but creates a vehicular "spillover" from parking lots. "Spillover" exacerbates vehicular congestion on airport terminal roads.

Each of the stated problems is worsened by the increase in demand for transportation during peak travel periods. Unfortunately, peak travel periods are also the periods when transportation delays are least tolerable and most economically wasteful, as well.

From recently published reports of surveys conducted since 1989 on the socioeconomic characteristics of customers at 55 airports, Weinstein and Madrigal reported that:

1. Most travelers at airports are male.
2. Among "business travelers, 75% are well educated males at an average age of 42 and household income of \$65,000" (Weinstein and Madrigal, 19).
3. "60% of leisure travelers are well educated females with an average household income \$56,000 and an average age of 43" (Weinstein and Madrigal p. 19).

These characteristics of business and leisure travelers suggest that "they are demanding" (Weinstein and Madrigal, 19) and intolerant of delays.

Whereas early emphasis has been placed on the impact of delays on passengers, it is worthwhile to mention that convenient access to airports will encourage greater patronage by other persons served by an airport. These patrons spend an average of 65 minutes at an airport during each visit (Weinstein and Madrigal). With convenient airport access, patronage by meeters and greeters is likely to enjoy an increase. The average length of visits to large airports may increase as well. If meeters and greeters spend less time in traffic and arrive at the airport less stressed, expenditure on concessionaire products may be commensurately high.

The present levels of mass transit services in existence at the 23 largest airports is inadequate. Worse still, there are no meaningful plans or projects in progress to improve ground transportation at any of those airports that indicate imminent change in the existing modes of transportation. Structural changes in the existing ingress and egress at an airport can only resolve the stated problems partially if the modes of ground transportation are not reoriented in the direction of fewer vehicles with higher occupancy.

C. Research Objective

This research project sought to identify ground transportation problems and the viability of enhancing the integration of multimodal ground transportation with air transportation at large airports. To gather primary data, field surveys were conducted at Houston Intercontinental Airport (IAH), Dallas Fort Worth International Airport (DFW), William P. Hobby Airport (HOU), and New Orleans International Airport (MSY). Since operations and patronage of these airports bear considerable similarity to operations and patronage of the 23 largest U. S. airports, the results of this research effort could be carefully reviewed, possibly revised, and adopted at those other airports.

The thrust of this research project involved a trifocal approach to explore feasible strategies to further integrate intermodal transportation at large airports. The project therefore involved:

1. An extensive literature review and descriptive analyses of existing ground transportation services at large airports. The literature review and descriptive analyses of existing ground transportation services at large airports are presented in Chapters II and III of this report.
2. The gathering of information and data on the profile of airport patrons and the propensity of airport patrons to utilize mass transit systems, to access large airports. The information gathering process involved the collection of primary data through field

surveys at IAH, HOU, DFW, and MSY, as well as secondary data from the Federal Aviation Administration (FAA). Additional information was obtained from other large airport facilities in the U.S. and abroad that have considerably more mass transit services available for their patrons. The summation of this information and data are presented in Chapter IV and the appendices.

3. Proposal of possible solutions to ground transportation problems and recommendation of mechanisms to enhance integration of different modes of ground transportation at large airports. The third component of the research project is presented in Chapter V.

Chapter II

Primary Modes of Ground Transportation at Large Airports (Part I)

Large airports which enjoy air transportation services by the major air carriers are generally accessible by several modes of ground transportation. Whereas the multiplicity of transportation modes varies considerably between airports and different regional areas, there appears to be a semblance of uniformity. This uniformity is manifested by the availability of at least one or more of 5 major ground transportation modes at every large airport.

The five major modes of ground transportation present at large airports comprise

1. Private Vehicles
2. Mass Transit Service
3. Automated Guideway Transit Systems (AGTS)
4. Automobile Rental
5. Taxicab Services

The enumerated modes of transportation may be for private services or commercial purposes. With the exception of private vehicles, the remaining four modes of ground transportation are invariably used for commercial purposes.

A. Private Vehicles

Discussion on private vehicle usage at large airports fell under four subcategories in this report. The four subcategories are vehicular traffic, vehicular access, airport roadway signage, and airport parking.

1. Vehicular Traffic

As a matter of historical record and regular practice, private vehicles are clearly the overwhelming favorite among the different modes of transportation used by patrons of large airports in the U.S. Existing statistical data indicate

that most large airports generate 0.9 to 1.3 vehicles for every originating and terminating passenger (Whitlock, Mandle, and La Magne). A ground transportation system survey by Wilbur Smith and Associates at Miami International Airport (MIA), Denver Stapleton International Airport (DEN), and the American Airlines terminals at John F. Kennedy (JFK) and Los Angeles International Airports (LAX) indicated that low occupancy travel modes have a minimum of 75 percent of the air passenger traffic (Brothers).

By 1990, private vehicles accounted for approximately 85 percent of the ground transportation activity at DFW, the second busiest airport in the world (Cooke). This high percentage leaves a remainder of 15 percent of ground transportation activity to be shared by "share ride prearranged limousines", taxicabs, large buses, rental cars, and courtesy vans (Cooke, 11). At an airport with over 50 million patrons each year, these percentages translate into fairly large numbers of private vehicles.

The percentage of private vehicles used to access large airports is generally high at large airports whose profile consists of the following characteristics:

1. Location in major metropolitan areas with poorly developed mass transit systems or limited mass transit service.
2. Location in major metropolitan areas with highly decentralized patterns of residential and commercial development. Such decentralized patterns of development results in diverse trip origins from home and work sites to the airport.

Both Houston and Dallas fit the above profile quite well and therefore have considerably high percentages of ground transportation activity being accounted for by private vehicles. Traffic surveys conducted by Lemus Engineering Corporation at IAH in March 1989 showed 33,400 private vehicles exiting the airport each day over the 12 hour period between 7 A.M. and 7 P.M. (Peat Marwick). This figure translated into 71.4 percent of the total vehicular traffic on IAH's egress facilities during the stated time period.

The percentage of private vehicles would be expected to be higher during the other 12 hours of the day (7 p.m. - 7 a.m.) when the frequency of commercial ground transportation service diminishes disproportionately.

2. Vehicular Access

Access to large airports by private vehicles is provided by airport ingress and egress infrastructure and facilitated by roadway signage. The use of large numbers of private vehicles by airport patrons creates problems related to the convenient accessibility of airports. The primary manifestation of airport access problems is in the form of vehicular congestion on airport roadways and at terminal curb spaces. In this research report, **curbs** or **curb spaces** represent the interface between the airport roadway system and passenger terminal buildings.

To cope with the large volume of vehicular traffic, most large airports build limited access roadways, freeways and expressways to ensure rapid transfer of airport patrons between the airport terminal complex and urban areas (Whitlock, Mandle, and La Magne). Unfortunately, airport access facilities also serve urban travel requirements due to the inevitable encroachment of urban development around large airports (Whitlock, Mandle, and La Magne). In addition to vehicular traffic destined for the airport terminal, airport roadways must also contend with vehicles that use its roadways for through travel. Tragically, peak hour airport traffic characteristically overlaps with peak hour urban traffic, thus worsening congestion and delay on airport access roads (Whitlock, Mandle, and La Magne). Peak hour periods are the times when urban traffic is least desirable on airport roadways.

On John F. Kennedy Boulevard, the main North South artery into IAH, "through traffic surges to 26% and 20% of total traffic during the morning and evening peak hour periods, respectively" (Turner, Collie & Braden, Inc., II-9). With the anticipated growth of suburban population around large airports, it would be logically sound to anticipate a corresponding increase in through airport traffic.

Traffic distribution of private vehicles destined for large airports falls into five primary groups (Hart, 117):

1. Those going to the curbs and then to close-in parking lots
2. Those going to the curbs and then to remote parking facilities
3. Those going directly to close-in parking lots
4. Those going directly to remote parking facilities
5. Those that stop to drop people off at the curb and do not park

After a study of ground transportation systems at over two dozen airports, Wilbur Smith and Associates reported that actual loading and unloading time is fairly constant for the following modes of transportation: cars 0.6 to 1.3 minutes; and buses 0.8 to 1.5 minutes. The length of time vehicles remain parked at curbs, however, varies between 2.4 to 4.3 minutes for cars and 1.6 to 3.5 minutes for buses (Brothers). From these statistics, cars (private vehicles) are clearly the less efficient users of curb space and buses the more efficient.

Difference between types of passengers is another major factor that determines the demand for curb space. International passengers normally require more curb space because of additional luggage and accompanying meeters and greeters (welcome or send-off parties) who also require curb space. Business travelers in contrast require minimal use of curb space and are normally accompanied by no meeters and greeters.

The manageable factors that govern convenient access to large airport roadways and curbs include (Cooke, 41):

1. Physical plant design
2. Level of control over vehicle operators
3. Degree of incentives and sanctions that can be applied

“Good ground transportation systems are designed into terminals on the front end, not as an afterthought” (Cooke, 41). To remain a positive factor in ensuring convenient ground access, well designed transportation systems and terminals must be supported by well enforced vehicular traffic control policies.

Properly enforced vehicular traffic control policies have proved to be an effective mechanism for easing vehicular congestion at curbs and on terminal roadways. Dwell time at curbs varies directly with strictness of enforcement (Brothers). The most common problem related to vehicular traffic control policies is the incremental development of rules and regulations governing ground transportation at large airports.

Rules and regulations developed in an incremental fashion are rarely comprehensive and difficult to enforce effectively. It is generally difficult to enforce policies when the drivers for whom the policies are designed are either unaware of them or do not comprehend them. The employment of court room facilities in the nearby city of Grapevine to assess fines or inflict punishment for moving violations has not significantly impacted airport patrons' driving habits or preference for accessing DFW in private vehicles.

Rigid curbside enforcement and impartial use of tow away rules have served effectively in preventing certain abuses of curbside parking privileges at most large airports. They have failed, however, to completely resolve curbside grid lock and severe congestion on terminal roadways during peak travel periods when most airlines have closely scheduled arrivals and departures on wide bodied aircraft. Wide bodied aircraft generally accentuate the effect of peaks by significantly increasing the number of passengers who need to use curb space and other ground access facilities at about the same time.

The success of off-site passenger processing at Victoria Station in London and St. Gallens in Zurich have proved off-site processing to be a viable tool to minimize curbside gridlock at peak travel times. Security concerns have severely limited the use of off-site passenger processing, however. Security concerns affecting aviation have primarily stemmed from conflicts and political tensions in the Middle East, and the subsequent targeting of aviation as a vehicle for expressing political goals through acts of terrorism and sabotage.

Access fees are also employed by large airports to ensure efficient use of roadways and curbside facilities by airport patrons. Access fees can constitute a mechanism for recovering the cost of providing airport access

facilities and ancillary infrastructure. Access fees accomplish both goals effectively when they are structured to reflect direct use of airport facilities and infrastructure.

In using access fees to regulate the use of airport access facilities, it is generally best to levy access fees on commercial vehicles as well as private vehicles. Automated Vehicle Identification (AVI) Systems that keep track of vehicles equipped with transponders in the vicinity of passengers terminals have become a very reliable tool for determining the number of trips made by commercial vehicles at large airports. Access fees at airports with AVI systems could be effectively based on the number of trips commercial vehicles make. Access fees for private vehicles could be based on such mechanical properties as wheel base or gross weight.

Large airports that have made *bona fide* efforts to promote transportation modes to decrease vehicular congestion generally experience a decline in the use of private vehicles. Between 1984 and 1987, Massport experienced a "9% decrease (55% to 46%) in the use of private vehicles for parking or passenger drop off" at BOS (Clippinger and Taft, 4). Over the same period, "the use of high occupancy vehicular modes of transportation-buses, airport limousines, and subways-to access Logan International Airport increased from 15% of all passengers to 22%" (Clippinger and Taft, 4).

3. Airport Roadway Signage

Signage on the ingress and egress to and from large airport facilities accomplish two primary functions. These functions comprise providing direction and orientation for airport patrons driving private, commercial, service, and utility vehicles on airport roads (Hart). Orientation involves airport patrons' perception of their location or position relative to their surroundings while accessing or departing from the airport terminal complex and its constituent facilities. Effective signage enables airport patrons to experience a seemingly effortless sequence of logical decisions in a timely fashion while traveling on airport roads.

Poor signage makes a significant contribution towards disorientation and delayed orientation at large airports. Both disorientation and delayed orientation suffered by patrons of large airports are normally caused by transition in surroundings, scale, or mode of transportation, and the physical layout of the airport terminal complex. Each transition in surroundings, scale, or mode of transportation invariably constitutes a decision point. The level of complexity inherent in the design of the airport terminal complex directly correlates with the multiplicity or frequency of decision points encountered by airport patrons while using the airport's roadway system.

From a functional perspective, an ideally designed airport terminal complex and signage system generally enable airport patrons to enjoy a seemingly effortless sequence of logical decisions with respect to direction while on the airport's premises. Under such ideal circumstances, directional signs support orientation. And airport patrons are able to make quick decisions easily, at minimal frequency, about their direction of travel. Efforts made by large airports to ensure that their patrons enjoy the benefits of ideal signage include the minimization or complete elimination of multiple directions and instructions appearing at the same time on roadway signage.

4. Airport Parking

There are three main types of vehicular parking at most large airports:

1. Short-term metered parking
2. Short-term hourly parking
3. Long-term parking

Short-term metered parking generally occurs next to curbs or islands in very close proximity to the passenger terminal building. Short-term metered parking rarely lasts for more than two hours. Short-term hourly parking may be available in lots separated by no more than a terminal road from the passenger terminal building. Vehicular parking in short-term parking lots may extend up to about 10 hours. Long-term parking is normally available at lots located between terminal buildings or more frequently, at spacious perimeter lots that are remote from the passenger terminal building. Airport patrons who use long-term parking generally park for more than 10 hours or for several days.

Short-term metered parking has the highest rates, and long-term parking has the lowest. Short term hourly parking rates are intermediate and may fall between the rates for the other two areas. Susan E. Clippinger and Alex Taft contend that curb areas never function well if they are used as short term parking by people meeting arriving passengers. "Short term parking must *therefore* be moved off the curb into a lot" (Clippinger and Taft, 15). Airport patrons who use short term parking generally park parallel or perpendicular to the curb, adjacent to a parking meter. Long term parking lots tend to use nose-in herring bone parking configurations that may enable vehicle operators to pull in and out of parking spaces with greater ease.

Generally "50% - 60% of cars in short term parking (*hourly and metered*) remain parked for less than 2 hours" (Hart, 116). Surveys have demonstrated that "short term, close-in parking requires 15% - 30% of the total parking area for 70% - 80% of all users. In contrast, long term remote parking lots require 75% - 89% of the total parking area for only 15% - 30% of all users" (Hart, 116).

The obviously high turnover rate (three to five times) of cars in short-term parking is primarily responsible for the disparity in volume of cars and size of parking areas between long and short term parking (Hart). The use of discriminatory pricing to force long-term parking into perimeter parking lots is responsible for the high turnover of cars in short-term parking.

In addition to facilitating the transfer of passengers, luggage, and other travel-related transactions at airports, parking also represents the source of considerable income for airports. At most large airports, including the four where surveys were conducted for this project, parking is a leading source of revenue, sometimes the source of most revenue when compounded with access fees. In spite of the EPA mandate that imposed limits of 10,215 parking spaces, Boston Logan International Airport generated revenues of \$33.8 million in 1987 from parking (Clippinger and Taft).

B. Mass Transit Service

"Mass transit service may be in the form of local service with frequent stops, express service with limited stops, peak period service, shuttle services, and feeder services" (Armstrong-Wright, 3). The two main types of mass transit service available at large airports are bus transit and rail transit.

1. Bus Transit

Bus transit is clearly the oldest and most common mode of mass transit service available at airports. Airport Bus Transit Service may be used for accessing the airport or for bridging extensive distances between different facilities at the airport. Airport Bus Transit Service may therefore involve transporting passengers from the terminal to aircraft for hard stand boarding, moving airport patrons between terminals, shuttle services for airport employees, or for accessing remote vehicular parking lots.

Transit buses and vans may carry a combination of standing and sitting passengers numbering between 10 to 80. Bus transit services to large airports primarily have sitting passengers. Standing passengers, if any, may normally be found on local service transit systems with routes to the airport.

Bus Transit Services to airports may operate in mixed traffic, reserved lanes, or segregated busways. Bus transit operations in mixed traffic is the most common and least expensive of the three to establish. Reserved lanes are relatively inexpensive because they can be used by general vehicular traffic during nonpeak periods. Table II-1 is a quantitative representation of the cost of service per passenger for the three modes of bus transit operations.

Table II-1. Bus Transit Total Costs (Capital Operating Cost in \$)

| <u>Right of Way</u> | <u>*Cost Per Passenger</u> |
|---------------------|----------------------------|
| Mixed traffic | 0.02 - 0.05 |
| Reserved lanes | 0.02 - 0.05 |
| Segregated busways | 0.05 - 0.08 |

*Trolleybus transit systems cost approximately 20% more

Source: World Bank, Technical Paper Number 52. Washington, DC., 1986.

"The journey speed and output of buses can be greatly enhanced by bus priority measures, in particular, reserved bus lanes" (Armstrong-Wright, 5). High Occupancy Vehicle (HOV) lanes or exclusive busways in which bus routes are separated by medians or barriers with grade separation, or priority at intersections, considerably expedite the movement of airport patrons using mass transit systems.

The Houston Department of Aviation has skillfully employed the use of grade separation to expedite the flow of inbound traffic on John F. Kennedy Boulevard into IAH and the Flyover Entrance Ramp on Broadway Boulevard into HOU. Dulles International Airport (IAD) has designated a multilane road for the exclusive use of its commercial ground transportation and HOV traffic. The skillful use of grade separation or priority measures at the said airports has improved the efficiency of the existing road system by increasing the average journey speed of all vehicles and the total volume of traffic. It is worthwhile to note that in all 3 cases, efficient use of airport ingress and egress facilities has been accomplished without changing the prevalent modes of ground transportation.

2. Rail Transit Services

Rail services at airports are essentially track bound transit systems that may be generally classified as either:

1. Fixed guideway transit systems, or
2. Automated guideway transit systems (AGTS)

Fixed guideway transit systems primarily serve as rail systems that provide access to the airport under the guidance of an operator. Automated guideway transit systems normally provide programmed interterminal shuttle services or other transportation services for airport personnel **within** the airport terminal complex.

a). Fixed Guideway Systems

Fixed guideway systems that provide transportation services to airports consist of light rail and rapid rail systems. **Light rail transit systems (LRT)** are electrically powered rail systems with the following characteristics:

1. Passengers usually board from the road surface or from low platforms
2. Rail cars operate in single units or in short trains at slow to moderate speeds on trackways which may be shared with other traffic and may have sections of exclusive rights of way (Armstrong-Wright , 11)

Unlike light rail transit service at urban centers, light rail transit service to airports seldom suffer from disruption by other traffic at junctions. Light rail transit systems that service airport routes generally have an elevated or underground right-of-way at junctions.

Rapid rail transit systems (RRT) operate on elevated trackways or in underground tunnels (subways, tube, etc.) at high speeds and frequencies that make exclusive rights-of-way indispensable. At such high speeds, "RRT systems provide the highest transit capacity currently available" (Armstrong-Wright , 17).

The comparably high speeds, high frequency of service and enormous transit capacity offered by rapid rail transit makes it one of the most promising modes of mass transit service for accessing large airports served by major air carriers. Under conditions of extreme crush loading, six-car trains of the Osaka Metro regularly carry 1,750 passengers, while eight-car trains on the Hong Kong Metro carry 3,000 passengers (Armstrong-Wright, 17). On occasions of free ridership, such as Independence Day 1985, ridership on Metro in Washington, DC., reached astronomical levels of 1,700 passengers in a train of six cars after the conclusion of the fireworks display at the Smithsonian Mall. Even though such levels of transit capacity cannot be maintained on a regular basis in the U.S. due to cultural preferences and other social factors, the aforementioned passenger loads are a clear demonstration of the considerable transit capacity offered by rapid rail.

RRT systems, which operate on elevated tracks or in underground tunnels, involve substantial capital costs and considerably high operating costs.

Table II-2. Rapid Rail Capital Costs (Millions of \$)

| Item | Elevated Tracks | Underground Tunnels |
|-----------------------------------|-----------------|---------------------|
| Support structure/tunnel per mile | 32 - 64 | 96 - 144 |
| Tracks / mile | 1.6 - 2.4 | 1.6 - 2.4 |
| Signals/ mile | 1.6 - 8.0 | 1.9 - 8.0 |
| Power | 1.6 - 4.8 | 1.6 - 2.4 |
| Stations (each) | 3.2 - 8.0 | 8 - 32 |
| Depots (each) | | 10 - 40 |
| Workshops (each) | | 15 - 50 |
| Rail Car (each) | 1 | 1 |

Source: World Bank. Technical Paper Number 52. Washington, DC., 1986.

The capital costs associated with the various components of an RRT System indicated in Table II-2 suggest that the total cost of an underground Rapid Rail System spanning 20 miles with 25 stations, 400 cars, 2 depots, and 2 workshops would cost about \$3.8 billion, or an average cost of \$192 million per mile. Because of the high capital costs associated with RRT Systems, municipal governments invariably rely on debenture securities, which introduce additional costs in the form of interest payments and finance charges.

To recoup the capital investment in RRT systems, it is practically imperative to maximize patronage and revenue by integrating rapid rail service into the public transit system through reshaping bus networks to provide effective feeder service to, and from, rail stations. Since reshaping bus networks involves no serious changes to existing facilities, bus transit lends itself very well to serving as a feeder service for RRT systems. Buses also have the additional advantage of having access to multi-point destinations in scattered suburban areas as well as clusters of stations in urban centers.

Connections to power transmission systems and the need to realign tracks severely constrain the feasibility of tramways and trolleys to serve as feeder services for Rapid Rail transit systems. Failure to successfully integrate Rapid Rail Transit systems into public transit systems or other modes of transportation, including air transportation at large airports, severely impacts patronage of RRT service and causes a significant loss of potential ridership.

Tragically, the absence of a seamless transition between RRT service at airports with considerable passenger traffic and significant potential ridership is very common. The location of Washington METRO's airport station a couple of blocks from the main passenger terminal at National Airport renders RRT an impractical means of accessing National Airport for a significant percentage of its patrons.

Maximum patronage cannot be attained by an RRT system whose route network is primarily restricted to affluent sectors of its market or a system whose fare structure is discriminatory. "A fare structure is discriminatory against low income persons when it imposes a cost which exceeds 10% of the income of more than 15% of the population" (Armstrong-Wright, 25).

The possibility of maximum patronage is significantly enhanced when passenger convenience is facilitated by seamless transition between RRT service and other modes of transportation. It is only rational to expect that mass transit systems around airports would continue to become better integrated with other modes of transportation systems within the airport terminal complex.

Chapter III

Primary Modes of Ground Transportation at Large Airports

(Part II)

Chapter III is made up of descriptive analyses of the last three of the five modes of transportation listed at the beginning of the previous chapter. The remaining three modes of ground transportation comprise automated guideway transit systems, automobile rental and taxicab services

A. Automated Guideway Transit Systems (AGTS)

Technically, Automated Guideway Transit Systems (AGTS) comprise all mechanized vehicular systems used for horizontal and vertical movement of people and goods. Such a broad definition encompasses elevators, automated conveyor systems for luggage, escalators, moving walkways, and trackbound transit systems. However, the thrust of this research effort is restricted to the integration of multimodal transportation systems utilized in the **horizontal movement** of airport patrons. This report therefore addresses AGTS utilized primarily for the horizontal, not vertical, movement of airport patrons over extensive distances within the airport terminal complex.

At large airports serving major air carriers, the volume of origination and destination passengers constitutes a major factor in determining distances between passenger handling facilities. High traffic volumes require large facilities which entail considerable distances between passenger handling facilities. Increased distances between airport facilities entail more time and trouble for airport patrons (Mueller). Generally, "walking distances of 800' to 1,000' have gradually become accepted and can be used as a planning objective" (Hart, 33) in designing passenger handling facilities and connecting infrastructure which impact patrons of large airports.

At present, most large airports employ certain modes of AGTS to alleviate difficulties in passenger movement over short distances within the airport passenger terminal. Such modes of AGTS include moving walkways and

escalators, or elevators, where airport patrons would have to traverse distances whose gradients exceed 15 percent (Mueller). Over longer distances within the airport terminal complex, large airports typically use interterminal automated trains and other shuttle transportation services to facilitate convenient passenger movement.

Interterminal trains have been used to expedite the movement of airport patrons at several large airports serving major airlines in the U.S. for over two decades. Airports with such service include Atlanta Hartsfield International Airport (ATL), IAH, DFW, Orlando International Airport (ORL), Seattle Tacoma International Airport (SEA), and McCarran International Airport (LAS) in Vegas.

With the exception of the AGTS at ATL and DFW, AGTS at the other airports have relatively simple route networks without branches (Mueller). DFW introduced the first AGTS with a complex route network utilizing numerous switches and multiuse vehicles capable of leaving the guideway and traveling on roadways and apron areas under steering (Mueller).

The anticipated multiple uses of DFW's AGTS included the transportation of mail, luggage, and trash during off-peak periods in special utility vehicles. Airline schedule changes and the consequent restrictions imposed by passenger demand for transportation, as well as the malfunction of an incinerator, eliminated these other uses. As is the case at other airports, DFW's AGTS is therefore used primarily for the movement of passengers between terminals.

Tragically, AGTS at the aforementioned airports seldom connect directly with any intracity mass transit rail service. ATL may be the only airport whose AGTS directly interfaces with an urban fixed guideway mass transit system, MARTA (Metropolitan Atlanta Rapid Transit Authority).

In conformity with the norm at most airports equipped with AGTS, the primary beneficiaries of IAH's AGTS are passengers in transit who need to make interline transfers. With respect to interline transfers, it is recommended that "the frequency, size and speed of the AGTS are selected so that a total

journey time from the deplaning point to the boarding point of another aircraft, including..walking distances, does not exceed 20 minutes" (Mueller, 58). IAH's AGTS is also used by passengers to access parking areas located between terminals. Ridership of IAH's AGTS may be increased by eventually extending its route structure to serve long-term parking lots in perimeter areas and the airport station of the proposed Texas High Speed rail when it is completed.

The decision to extend IAH's AGTS to the said passenger facilities must include very careful cost analyses to ensure such service is comprehensively cost effective. The average operating cost (7.1 cents per place per 1000 feet) of IAH's AGTS is among the lowest in the industry (Mueller). In addition, it may be worthwhile to indicate that while the total capital cost of airport AGTS varies considerably (\$2 million - \$170+ million), they all share a general average cost breakdown as follows (Mueller):

| | |
|-------------------------------------|------|
| Guideway/tracks | 26% |
| Stations | 11% |
| Maintenance and support services | 5% |
| Power and utilities | 7% |
| Vehicles | 19% |
| Command, control and communications | 13% |
| Engineering and project management | 19 % |

In addition to financial concerns about extending AGTS service to parking areas, such service should also be structured to ensure that "the total journey time from the vehicular parking area to check-in counters, including the average walking distances, does not exceed 15 minutes" (Mueller, 59).

Critical to AGTS ridership at large airports is the quality of the interface between airport AGTS and other modes of transportation used to access airports. For AGTS to enjoy excellent ridership by effectively interfacing with other transportation modes of transportation within the airport terminal complex, they must generally satisfy the following conditions:

1. Reliable service without interruptions during peak periods
2. Short waiting times
3. Comprehensible directional information
4. Boarding without steps

The need for comprehensible directional information is critical, because at the point of interface between two different modes of transportation, all first-time users face orientation difficulties or problems. The degree to which airport patrons have had previous experience with similar transportation modes dictates the extent to which they would encounter difficulties at the point of interface between two different transportation modes. A comprehensive system of directions with simplified details on changing transportation modes alleviates some of the difficulties encountered at the point of interface.

Close integration of different transportation modes, which minimizes physical separation between the different modes at the point of interface, is very critical to passengers. The appeal of both AGTS and urban mass transit systems serving large airports decreases as the separation increases at the point of interface, especially for passengers who need to carry their luggage (Mueller). Problems related to passenger orientation and movement of luggage are significantly reduced or virtually eliminated when the terminus of one mode of transportation is in very close proximity to the origination point of another transportation mode at the point of interface within the airport terminal complex.

B. Automobile Rental Services

Car rental services at large airports generally fall into two categories in terms of their location with respect to the airport terminal complex. The two categories are made up of on-airport rental car agencies and off-airport rental car agencies. Both categories rely on origination and destination passenger traffic as the primary source of business. Such traffic is predominantly made up of origination and destination passengers who do not reside in the cities served by the large airports they travel in and out of.

Airport rental car agencies operate on a contractual basis with the airport authorities they draw their passengers from. With a few exceptions, most on-airport rental car agencies are subjected to higher contractual surcharges or privilege fees than off-airport rental car agencies. "Privilege fees are fees charged an operator or company for the privilege of doing business on the airport and for the business benefits the company enjoys as a result of the presence of the entire airport and access to its passengers" (Peat Marwick, 28).

The difference in surcharges and privilege fees levied upon both categories of airport rental car agencies have been the subject of considerable litigation over the last decade and half. Surcharges or privilege fees levied on airport rental car agencies are usually in the form of a percentage of gross receipts. "The amount of these fees should reflect the relative business benefits and privileges enjoyed by competing ground transportation operations" (Peat Marwick, 28). In addition, rental car agencies may either pay a blanket fee for operating a fleet of courtesy vehicles or a license fee for each courtesy vehicle used to transport customers between the passenger terminal and rental car lot. Surcharges and privilege fees are still evolving and being shaped by judicial rulings resulting from legal contests between airport authorities and primarily, off-airport rental car agencies.

Rental car agencies provide a critical service to airport patrons, especially to business travelers, and more recently, to tourists and vacationers visiting resort towns. In 1988, Peat Marwick reported in a terminal survey at ORL that 69 percent of airport passengers using commercial ground transportation at ORL used the services of car rental agencies. These rented cars were used to access the plethora of amusement and vacation attractions near Orlando, including Disney World and MGM and Universal Studios.

The ease of personal transportation facilitated by rental car agencies for vacationers, tourists, and conventioners made a major contribution to the phenomenal increase in the number of passengers at ORL from about 6 million to 16 million between 1981 and 1990 (Cooke).

At large airports such as LAX, where rental car agencies have over 20,000 vehicles rented out at any given time, the number of customers who need to be shuttled to and from passenger terminals is significant (Davidson). Unfortunately, the shuttling of rental car customers in courtesy vans and buses between terminals and rental lots contributes to vehicular traffic on the ingress and egress of large airports. Worse still, rental car agency courtesy vans and buses exacerbate the dismal competition for limited curb space at passenger terminals. This condition is at its worst at airports that do not segregate commercial ground transportation from private vehicles or other modes of ground transportation. Most large airports, including the four where field surveys were conducted for this research project, segregate commercial ground transportation traffic by restricting commercial vehicles, including rental agency courtesy vans, to designated curb spaces at assigned terminal entrances and exits.

Additional steps being taken by rental car agencies to reduce vehicular congestion on terminal roads include the replacement of larger courtesy buses with smaller courtesy vans. Even though large courtesy buses offer more comfortable space for customers and serve as excellent "mobile billboards" for advertising rental car agencies, they can create considerable congestion within the confined areas around terminal exits and entrances.

Airports with car rental lots in close proximity to each other have resorted to using a common courtesy bus for all their customers. This innovative approach to providing courtesy shuttle service for rental car agency customers proved to be quite successful in reducing congestion on airport terminal roads and saving courtesy van fees for rental agencies during a year's experiment at DFW. The main drawbacks during the DFW experiment involved the inability of the common use courtesy van drivers to forward rental information on express customers so that their paperwork could be ready when they arrived at their respective rental lots (Street). Minneapolis-St. Paul International Airport (MSP) employed common use courtesy transportation for all its rental car agency customers in summer 1989. Unfortunately, "it met considerable resistance from the rent-a-car operators who prefer to have their own identified mode of transportation for passengers" (Street , 45).

A few large airports, including St. Louis Lambert International Airport (STL), have rental car agencies in multilevel parking facilities within walking distance from the passenger terminal. The location of rental lots in such close proximity to passenger terminals eliminates the need for courtesy vans and its associated problems. However, failure to properly route rented cars in and out of the airport may contribute to vehicular congestion on terminal roadways. Therefore, the location of rental lots in close proximity to passenger terminals may not be practical for large airports with sizable car rental activity, such as ORL and LAX.

C. Taxicab Service

Among large airports without mass transit service, taxicabs are the most frequently used mode of demand service commercial ground transportation (Cooke). Taxicab service is therefore of considerable importance in the transportation of patrons to and from airports serving major air carriers. At DFW, "virtually 100% of the demand service is required to travel via taxicabs. Other commercial ground transportation services such as limos, buses, and courtesy cars are limited to prearranged pickups" (Cooke, 10)

Over the last three decades, taxicab service at large airports has generally evolved from a monolithic single-provider system into a myriad of service providers operating under different contracts that tend to vary from one large airport to another. Taxicab operations are generally regarded as a service for the benefit of passengers as opposed to a source of revenue for airports. Privilege fees and surcharges levied on taxicabs at most large airports are therefore nominal in nature. Such fees may be assessed per trip or in the form of a periodic license fee. Taxicab surcharges and privilege fees are often designed to control and regulate taxicab operations at large airports in major metropolitan cities. The revenue accrued from the nominal surcharges and privilege fees paid by taxicabs are normally used to defray the cost of administering and regulating taxicab services at large airports.

At the time of its opening, IAH had a 20-year exclusive contract for taxicab service with the Greater Houston Transportation Company, a.k.a. Yellow Cab. "Under the exclusive contract *which expired on January 30, 1990*, all taxicab services at IAH were provided by Yellow Cab or its subcontractors" (Peat Marwick, 3). "Taxicabs at Houston Hobby Airport however operated under an open access system" (Peat Marwick, 3). Upon expiration, the 20 year contract was not renewed because service at IAH had matured enough to ensure regular supply of taxicab service without an exclusive contract.

The paramount philosophy that governs the relationship between most large airports and taxicab operators revolves around two main objectives:

1. To ensure that the business needs of taxicab operators remain subservient to the service needs of airport patrons (Cooke, 41). This is primarily because taxicab operators fulfill an ambassadorial role before most first-time travelers to any city. Airports therefore attempt to ensure that taxicab services are "characterized by clean, attractive and well serviced vehicles operated by honest, courteous and properly attired employees" (Cooke, 41).
2. To ensure that the supply of taxicabs constantly meets the demand for taxicab service by airport patrons. To accomplish this objective, some large airports designate sizable pieces of precious real estate within the terminal area for taxicabs to wait till dispatched to pick up passengers. The use of 'hold' or 'staging areas' for controlling taxicab traffic to terminal curbs enjoys considerable support in certain large airports including BOS and IAH (Cooke).

Unfortunately, taxicab hold areas may serve as an irksome bottleneck that erode the cordiality of taxicab operators and adversely impact the level of courtesy extended to airport patrons by drivers. The erosion of cordiality tends to be most serious when anxious taxicab operators become exasperated with long waits under unfavorable weather conditions of extreme heat or cold.

During peak travel periods when demand for commercial ground transportation is high, delays may develop between the time a taxicab leaves the hold area after it is dispatched and the time it arrives at the terminal's curb. Under such circumstances, it is best to establish the hold areas in reasonably close proximity to the terminal. Establishing hold areas in reasonably close proximity to passenger terminal buildings normally expedites the delivery of taxicab service and ensures less waiting time for passengers and shorter turn aroundtime for taxicabs.

CHAPTER IV

Research Findings

Statistical information and data used in this research effort comprised previously gathered **secondary data** which were obtained from airports and governmental agencies and **primary data** which were obtained through direct field surveys conducted as part of this research effort. This chapter is a summation of selected statistical information and data gathered for this research effort, as well as the analyses of such information and data. Statistical information and data gathered for this research effort that do not constitute part of this chapter are presented in the appendices for reference purposes.

A. Secondary Data

Secondary data employed in this research effort comprised historical records of annual enplanement over the last 10 years, projected enplanement over the next 5 or 10 years, number of airport patrons over the last 10 years and the number of patrons projected over the next 5 to 10 years, the number or percentage of airport patrons who used mass transit systems (rail/subway/metro/tube or bus/coach/airport express/ airport limo) to access the airport over the last 10 years and the number of patrons projected to access the airport via mass transit over the next 5 to 10 years.

Airport patrons consist of all persons who patronize the airport. Persons patronizing the airport are airline passengers, visitors to the airport, and employees who work at the airport.

Requests for secondary data were sent by letter to large U.S. and overseas airports with significant mass transit services. These U.S. airports were solicited for information:

1. Metropolitan Washington Airport Authority (National Airport- DCA)
2. Massachusetts Port Authority (Boston Logan International Airport- BOS)
3. Cleveland Hopkins International Airport (CLE)
4. Hartsfield Atlanta International Airport (ATL)

These overseas airports received similar requests for information:

1. New Tokyo International Airport, Narita (NRT)
2. Aeroporti di Roma (Fumicino Airport- FCO)
3. London Heathrow Airport Limited (Heathrow Airport- LHR)
4. Aeroport de Geneve-Cointrin (Geneva Airport- GVA)

In response to the requests, the following U.S. airports sent the information and data indicated below:

1. Metropolitan Washington Airport Authority
 - a) Washington National Airport
 Breakdown of airport patrons/users
 80% Passengers
 15% Meeters and greeters
 5% Employees
 - b) Annual passenger enplanement

| | | |
|-----|-----------------------------|-----------|
| (1) | Washington National Airport | 1941-1992 |
| (2) | Washington Dulles Airport | 1962-1992 |
 - c) Projected Passenger Enplanement

| | | |
|-----|-----------------------------|-----------|
| (1) | Washington National Airport | 1993-2001 |
| (2) | Washington Dulles Airport | 1993-2001 |
 - d) Annual Compounded Growth rate

| | | |
|-----|-----------------------------|-------|
| (1) | Washington National Airport | 1.9 % |
| (2) | Washington Dulles Airport | 4.0% |

- e). Enplanement by market share of all carriers
 - (1) Washington National FY1988 - FY1992
 - (2) Washington Dulles Airport FY1988 - FY1992
- f) Answers to questions 3, 4, 5 and 6 were not yet available. Studies were nearing completion.

2. Massachusetts Port Authority-Boston Logan International Airport

- a) Ridership percentages on mass transit systems

| | |
|--------------------------|------|
| Subway (rail transit) | 7.5% |
| Scheduled Bus | 8.9% |
| Unscheduled Bus and Limo | 6.2% |

3. Cleveland Hopkins International Airport

- a) Total passenger traffic
1958 - 92

- b) Projected passenger enplanement (*Total passenger traffic*)

| | | |
|------|-------------|-----------------------|
| 1995 | 5.3 million | <i>(10.6 million)</i> |
| 2000 | 6.1 million | <i>(12.2 million)</i> |
| 2010 | 8.3 million | <i>(16.6 million)</i> |

- c) Total Aircraft Operations Projected to Increase by Approximately 25% between 1989 - 2010

| | |
|------|---------|
| 1989 | 256,537 |
| 1995 | 274,800 |
| 2000 | 285,600 |
| 2010 | 322,200 |

- d) Rapid transit (only form of public transportation serving CLE)
Annual boarding approximately 250,000
Annual boarding expected to exceed 500,000 within the next 10 years in view of plans to rehabilitate, relocate, and extend airport rapid transit line

4. Hartsfield Atlanta International Airport
 - a) Past and projected total number of domestic passenger enplanement and deplanement
1981 - 2002
 - b) Past and projected total number of international passenger enplanement and deplanement
1981 - 2002
 - c) Past and projected total number of domestic aircraft operations
1981 - 2002
 - d) Past and projected total number of International Aircraft Operations
1981 - 2002
 - e) Past and projected weight of cargo
1981 - 2002
 - f) Past and projected weight of mail
1981 - 2002
 - g) Graphical representation of average rail entries at the airport station for weekdays, Saturdays, and Sundays
1989 - 1990

Large airports overseas from which statistical information and data were solicited sent in the following information and data:

1. New Tokyo International Airport - Narita, Narita-Shi, Chiba 80
No response
2. Aeroporti di Roma - Fumicino Airport
 - a) Total traffic: Outbound and inbound passengers
1983 - 92
 - b) Total projected traffic for outbound and inbound passengers

| <u>Year</u> | <u>Passenger Projection</u> |
|-------------|-----------------------------|
| 1995 | 23,620,000 |
| 2000 | 31,100,000 |
| 2005 | 40,180,000 |

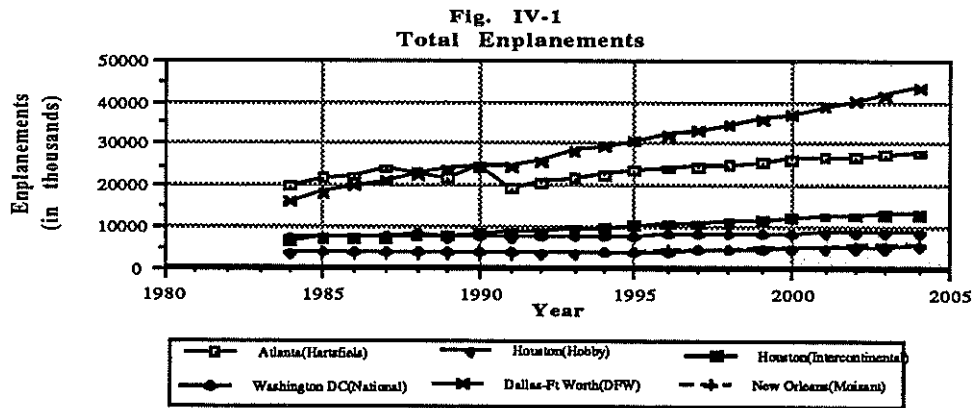
3. London Heathrow Airport, Ltd.
 - a) Historical passenger and air traffic miles
1965 - 1992
 - b) Projected passenger and air traffic miles
1993 - 2001
 - c) Operational information including
Top 10 Airlines according to passengers carried in June
1993
 - d) Percentage of passengers who travel by the following mass
transit systems:

| | |
|-----------|-----|
| Bus/coach | 12% |
| Rail/tube | 19% |

4. Aeroport de Geneve - Cointrin
 - a) Global passenger traffic at Geneva Airport from
1983 - 92
 - b) Annual average growth of passenger traffic
est. 2 - 3%
 - c) Approximately 106,000 visitors enter the airport each year
 - d) Same number anticipated in the future
 - e) Based on 1992 survey:
 - 22% of visitors use public transportation
 - 78% use private vehicles

f) Same expected for the future.

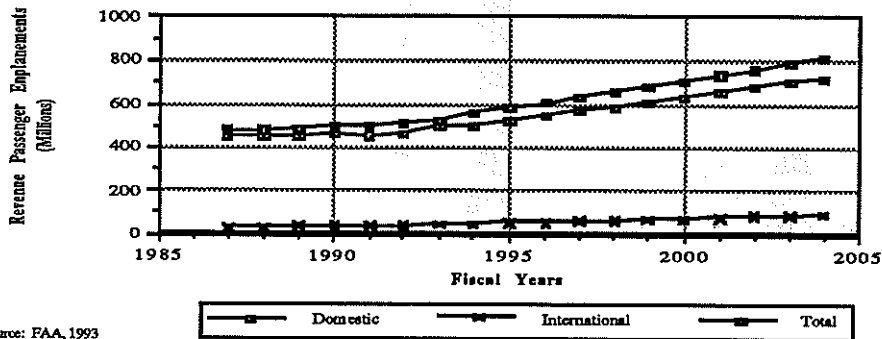
Additional information and statistical data were obtained from the Office of Aviation Policy, Plans and Management Analyses of the Federal Aviation Administration on enplanement and aircraft operations at ATL, DCA, DFW, IAH, MSY and HOU. The said data consisted of historical and projected operations between 1976 and 2005. The statistical data on passenger enplanement (1984 and 2004) for the six airports are graphically presented in Figure IV-1.



All historical and projected enplanement figures suggest steady long-term growth in passenger traffic at reasonable rates of growth throughout the rest of the decade and the first few years of the next century at the six airports. The projected compound growth rates vary from about 1.9 percent to a robust 6 percent per annum. Since these airports are fairly representative of large airports in the U.S., they indicate a favorable trend of steady growth in passenger traffic at the nation's busiest airports, barring any unforeseen catastrophes such as open warfare between nations. Figures IV-2 and IV-3

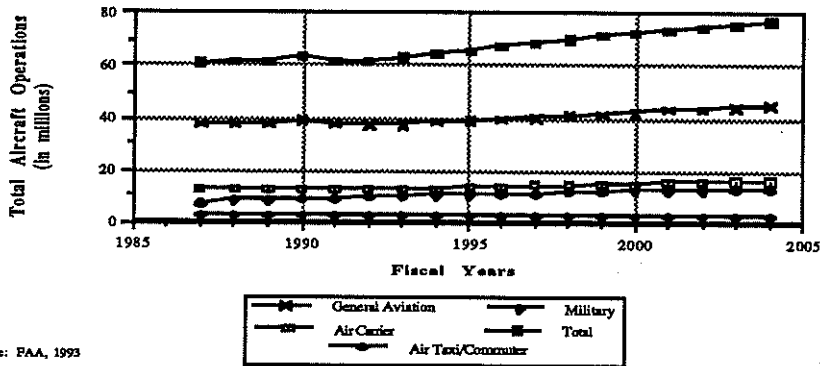
represent national growth trends in passenger traffic and aircraft operations at airports with air traffic control towers. Steady growth in passenger traffic would generate a commensurate increase in the number of airport patrons. An increase in the number of airport patrons would increase demand on airport ground transportation infrastructure.

Fig. IV-2
United States Commercial Air Carriers and Regional/Commuters Total Scheduled Passenger Traffic



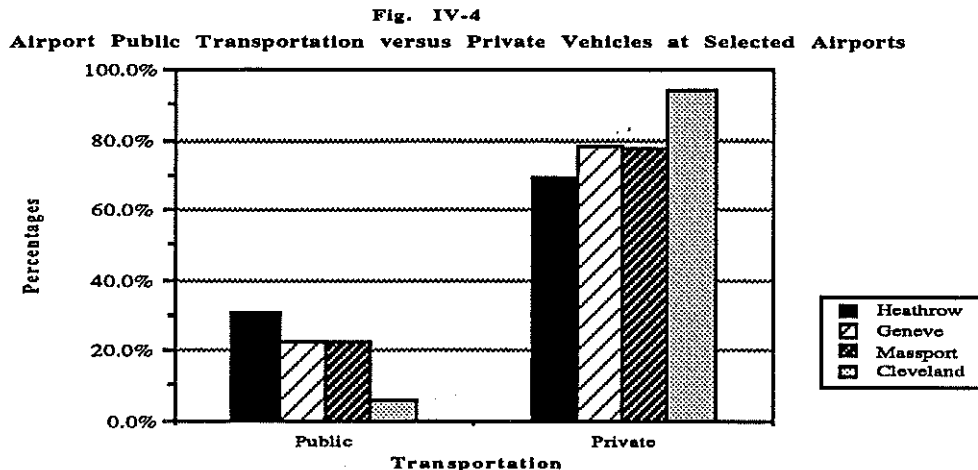
Source: FAA, 1993

Fig. IV-3
Total Aircraft Operations at Airports with FAA Traffic Control Service



Source: FAA, 1993

Four airports furnished secondary data on the use of mass transit services to access their airports. Two of the four airports (BOS and CLE) were in the U.S., and the other two were overseas (LHR and GVA). Information on mass transit usage at all four airports is presented in Figure IV-4.



London Heathrow Airport has the highest percentage of passengers (31 percent) who use mass transit systems to access the airport. The 31 percent at LHR consists of 12 percent who use buses or coach and 19 percent who use British Rail or the London Underground's tube train service. CLE has 5.6 percent of its passengers using Rapid Rail Transit to access the airport. Whereas 5.6 percent at CLE appears low, it translates into 250,000 passengers each year. That statistic implies 250,000 fewer passengers on airport roadways each year or about 6,850 fewer passengers on airport roads each day. With anticipated rehabilitation, relocation, and extension of the airport rapid transit line at CLE, patronage of rapid rail is expected to increase to 500,000 within 10 years. That represents a fairly sizable shift in passenger demand for ground transportation from roadway infrastructure to mass transit rail.

B. Primary Data

Primary data for this research project were obtained through field surveys of patrons at IAH, HOU, DFW, and MSY. All surveys were conducted by a single research assistant to minimize cost and ensure uniformity of statistically random samples of patrons at all four airports. The target number of surveys for each of the four airports was 200 odd.

Survey instruments that were never or were only partially completed by airport patrons who no longer wished to participate in the survey were discarded. Each patron who participated was given a clipboard with a questionnaire (see appendices) and a pencil. Patrons who opted to use their own pens did so. There was no requirement for questionnaires to be filled out in lead. A total of 784 survey instruments were completed at the four airports on the dates indicated below in Table IV-1.

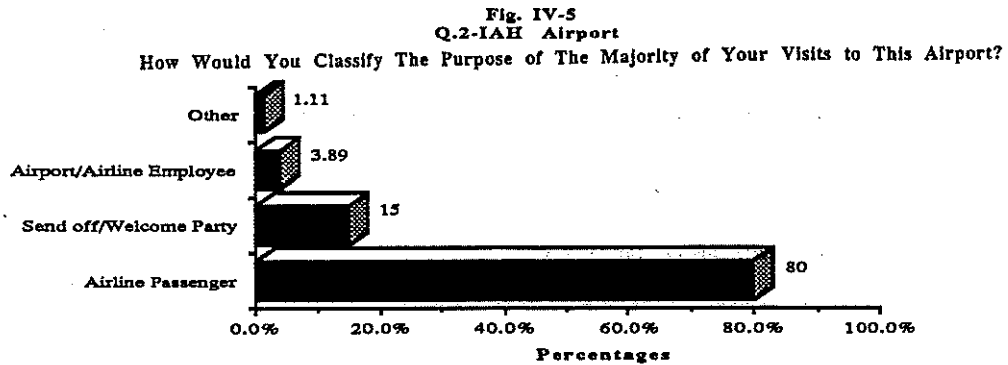
Table IV-1. Airport Field Survey Schedule

| <u>Airport</u> | <u>Survey dates</u> | <u>Number of surveys completed</u> |
|----------------|----------------------|------------------------------------|
| IAH | August 05 - 06, 1993 | 180 |
| HOU | August 10 - 11, 1993 | 214 |
| DFW | August 27 - 29, 1993 | 171 |
| MSY | August 12 - 13, 1993 | 219 |

Enough questionnaires could not be completed during the first attempt at MSY on August 12 - 13, 1993. An additional attempt was made on August 19 - 20, 1993, during which enough questionnaires were successfully completed.

Questions 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, and 14 were definitional. They solicited parametric information on the profile of airport patrons in the areas of vocation, frequency, and purpose of travel, exposure to mass transit service at airports, formal education, and household income. Questions 10, 11, and 12 were designed to determine if airport patrons would use mass transit services if they were available at the four airports. They also sought to determine the key

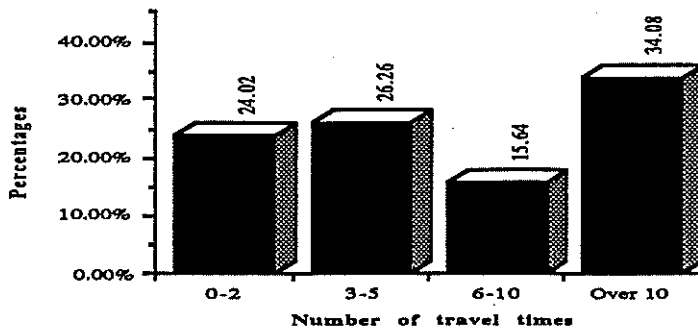
As indicated in Figure IV-5, 80 percent of the patrons surveyed at IAH were Airline Passengers, 15 percent were meeters and greeters, and 3.89 percent were employees at the airport.



Source: Noney, CTR-TSU, 1993

The statistical breakdown of airport patrons at IAH is comparable with similar statistics from other large airports including DCA. Of the 180 patrons successfully surveyed at IAH, a majority of 34.08 percent (see Figure IV-6) had traveled over 10 times by air in the previous year.

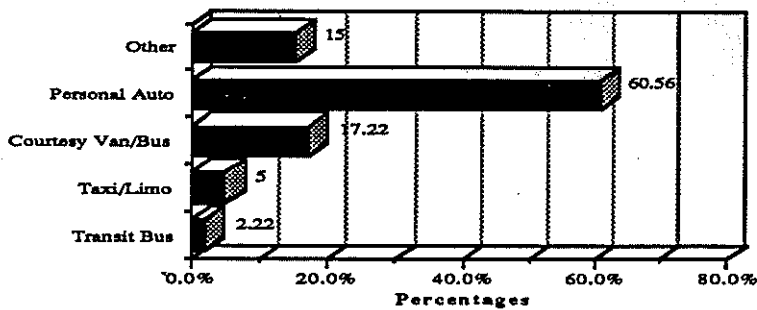
Fig. IV-6
Q.3-IAH Airport
How Often Did You Travel By Air Last Year?



Source: Netey, CTIR-TSU, 1993

Of the airport patrons surveyed at IAH, 60.56% stated they normally use personal automobiles to access the airport and only 2.22 percent normally use transit buses to access the airport. The distribution of transportation modes used to access the airport are presented in Figure IV-7.

Fig. IV-7
Q.6-IAH Airport
What Mode of Transportation Do You Normally Use To Access This Airport?

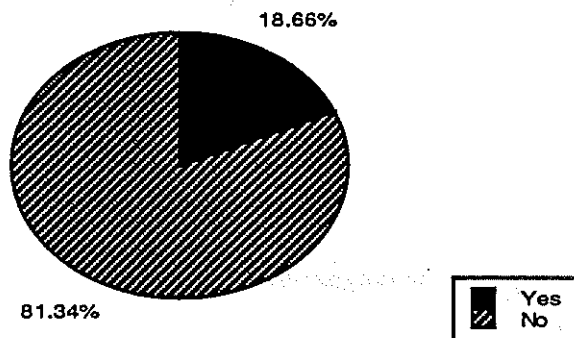


Source: Netey, CTIR-TSU, 1993

Slightly over half (50.31 percent) of all patrons surveyed at IAH ranked depot location as the most significant factor that would affect their decision to use a mass transit system at IAH to access residential or business districts. Depot location appeared to be the most critical factor in deciding whether the airport patrons surveyed at all four airports would use mass transit services to access business and residential districts from the airports. An overwhelming percentage of the patrons surveyed at IAH stated they would use a mass transit system to access residential or business districts. As indicated in Figure IV-8, only 18.66 percent of the patrons surveyed at IAH responded in the negative about using mass transit to access business and residential districts from IAH.

Fig IV-8
Q.10-IAH Airport

**If Available, Would You Use A Mass Transit System At This Airport
To Access Residential or Business Districts Within This City?**



Source: Netzev, CTR-TSU, 1993

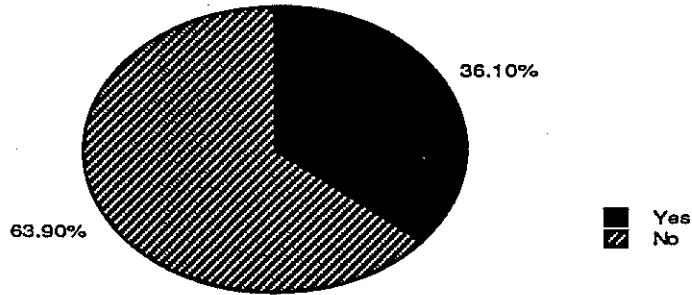
Of the 214 airport patrons who were surveyed at HOU, 58.29 percent used personal automobiles to access the airport on the day of the survey and slightly over 60 percent normally use personal automobiles to access HOU. The local bus transit service in Houston (METRO) has four routes to Hobby Airport. Of the four routes, one is a circulator that connects the other routes to the airport, two are local service routes, and the fourth is a crosstown service route.

In spite of the availability of these four bus transit service routes to HOU, 63.9 percent of the patrons surveyed responded they had never used the mass transit system while traveling to or from HOU (Fig. IV-9a). However, 62.07 percent of the patrons surveyed at HOU stated they would use a mass transit system to access residential and business districts within the city if it were available (Fig. IV-9b). Clearly, patrons of HOU are either not aware of the availability of bus transit service or they may not consider the existing METRO bus service as a mass transit system they could rely on to access business and residential districts of the city. This is a salient point.

When large airports in the U.S. receive bus transit service as part of local service, the ridership tends to consist primarily of airport employees. This tendency warrants further investigation and research. It may involve factors that are external to the scope of this research project.

Fig. IV-9a
Q.9-HOU Airport

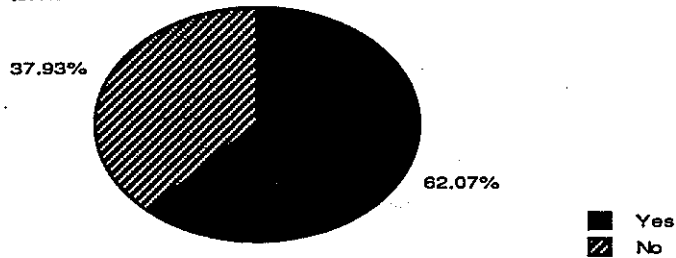
Have You Ever Used The Mass Transit System While Travelling To or From This Airport?



Source: Noney, CTR-TSU, 1993

Fig. IV-9b
Q.10-HOU Airport

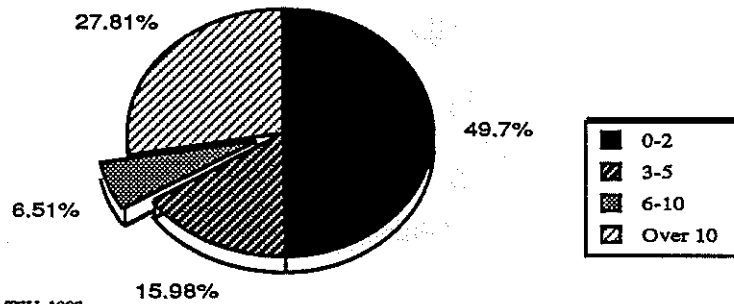
If Available, Would You Use A Mass Transit System At This Airport To Access Residential or Business Districts Within The City?



Source: Noney, CTR-TSU, 1993

Of the 171 airport patrons who fully completed surveys at DFW, nearly half (49.7 percent) indicated they had taken two or fewer business trips by air last year. A slight majority (50.3 percent) of the surveyed patrons at DFW indicated they had taken three or more business trips by air last year.

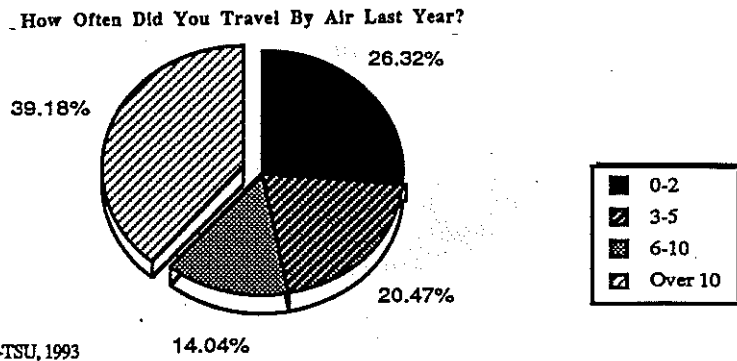
Fig. IV-10
Q.4-DFW Airport
PERCENTAGE OF BUSINESS TRIPS TAKEN BY AIR LAST YEAR
 Last Year, How Many Of Your Travels By Air Were For Business Purposes?



Sources: Nettey, CTR-TSU, 1993

Of the percentage that took three or more business trips by air last year, a majority (27.81 percent) had taken over ten business trips by air last year. Without the classification of business as the purpose of air travel, the percentage of surveyed DFW patrons who traveled over ten times by air last year increased from 27.81 percent to 39.18 percent.

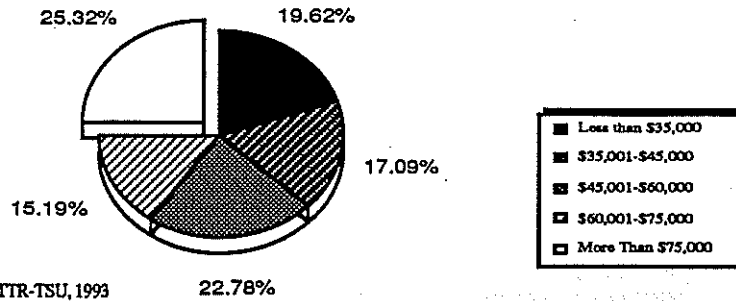
Fig. IV-11
 Q.3-DFW Airport
 FREQUENCY OF AIR TRAVEL IN THE PREVIOUS YEAR



Among the four classes of air travel frequency, (0 - 2, 3 - 5, 6 - 10, over 10 times), the largest group of air travelers surveyed at DFW traveled over 10 times last year.

It is quite clear from these statistics that most of the patrons surveyed at DFW are frequent fliers who travel quite often by air. As persons who travel by air quite often, DFW's patrons can be expected to be sophisticated persons who fit the profile of airport patrons presented in Chapter 1 by the Weinstein and Madrigal survey. The majority of DFW's patrons surveyed are college graduates (about 80 percent) and a respectable percentage of about 35 percent have received graduate education. With these impressive qualifications, it is not surprising that the household income bracket to which most DFW patrons belong (25.32 percent) is the \$ 75,000+ a year income bracket.

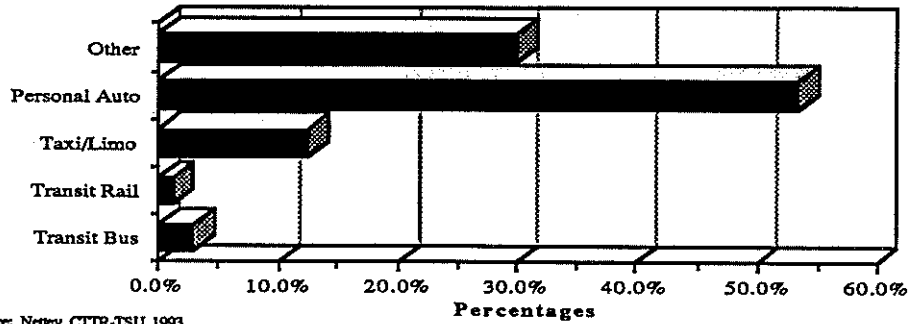
Fig. IV-12
Q.13-DFW Airport
Household Income Bracket
 What Was Your Household Income Last Year?



Most of the patrons surveyed at DFW (about 55 percent) normally use personal automobiles to access DFW. Among the patrons surveyed, 72.67 percent stated they would use a mass transit system at DFW to access business or residential districts if such a system were available. Nearly 80 percent of the DFW patrons surveyed indicated that the most critical factor that would affect their decision to use a mass transit system is depot location.

Of the 219 airport patrons surveyed at MSY, 74.65 percent were airline passengers, 19.82 percent were meeters and greeters, and 5.07 percent were airport/airline employees. An overwhelming majority of 80.28 percent visited or traveled through MSY less than six times last year. Of these percentages, nearly 65 percent normally use personal automobiles to access MSY. It is worthwhile to note the distinction between the percentage of patrons surveyed at MSY and DFW who used "other" mode of transportation to access the two different airports.

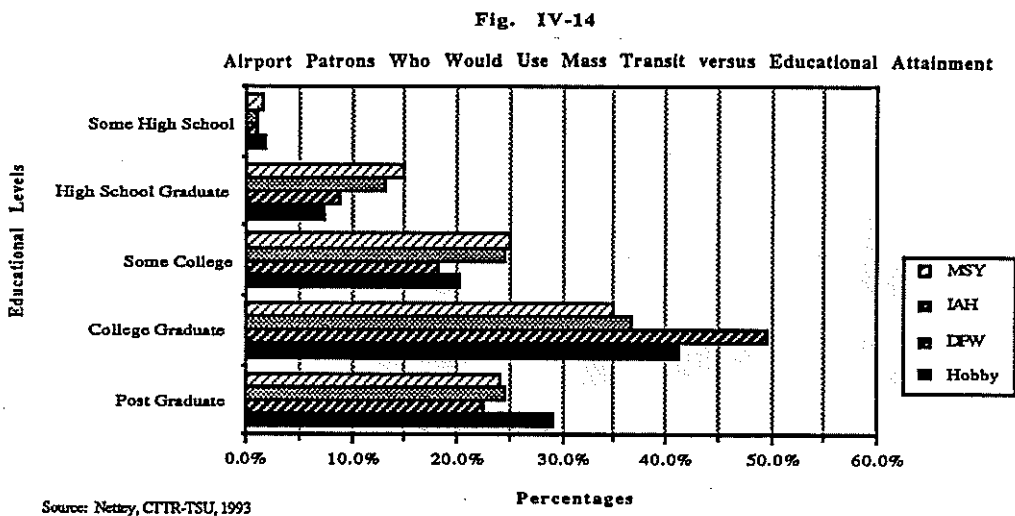
Fig.IV-13
Q.5-DFW Airport
Mode of transportation used to access the airport.
What Mode of Transportation Did You Use To Access The Airport Today?



Source: Netey, CTR-TSU, 1993

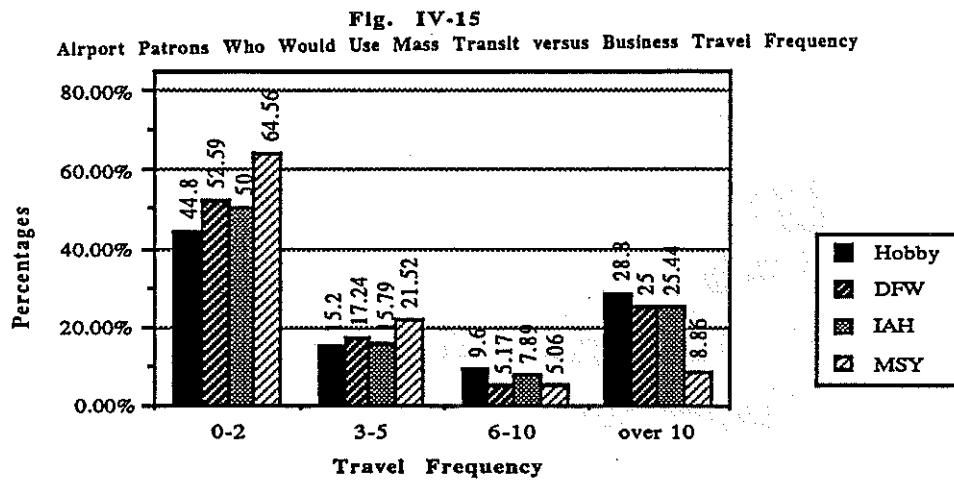
At MSY, this percentage was less than 5 percent compared with about 30 percent at DFW. The stark difference between the two airports may be accounted for by the fact that DFW has a much larger percentage of connecting passengers who fly into the airport to make interline transfers or intraline connections. Unlike origination and destination passengers, connecting passengers do not normally use ground transportation to access the airport.

When the level of formal education received was used as a predictor of who would use mass transit at the four airports, it became clear that college graduates are most likely to do so. Among the four airports, patrons surveyed at DFW who are college graduates had the highest percentage.



Strangely however, patrons who had not completed high school were the least likely to use mass transit at the four airports. From the results of this survey, it can be safely deduced that airport patrons with very low levels of formal education are the least likely customers of mass transit service at airports. Educational level appears to be a determining factor in the propensity to use mass transit among airport patrons.

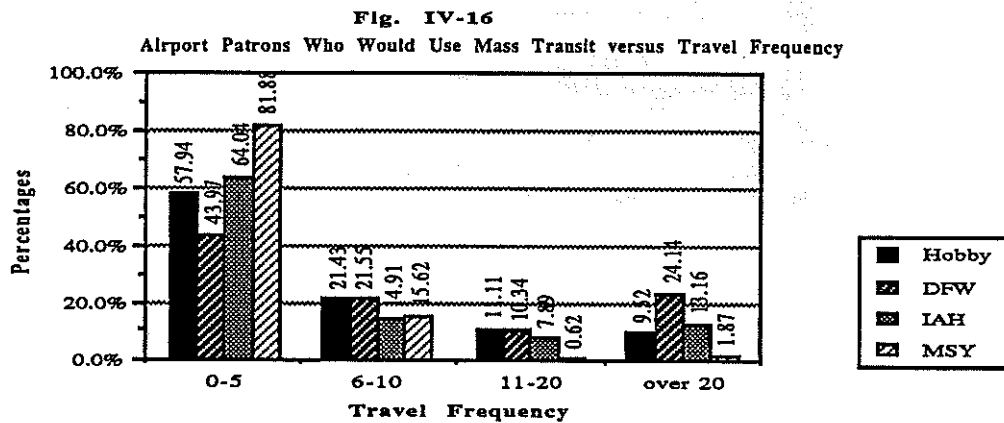
In using the frequency of business travel to predict who would use mass transit service at the four airports, it is clear that airport patrons at either end of the business travel frequency spectrum (0 - 2 times and over 10 times) are more likely to use mass transit.



Source: Netey, CTIR-TSU, 1993

Those who took two or fewer business trips comprise the highest percentage of patrons who would use mass transit. As indicated in Figure IV-15, MSY patrons who made two or fewer trips are the highest percentage of patrons (64.56 percent) who would use mass transit.

The survey instrument classified frequency of air travel by airport patrons last year into four main groups, namely, 0 - 5, 6 - 10, 11 - 20 and over 20 times. Of the four groups, patrons who traveled 5 times or fewer were the highest percentage of patrons who indicated that they would use mass transit service to access business or residential districts if available.

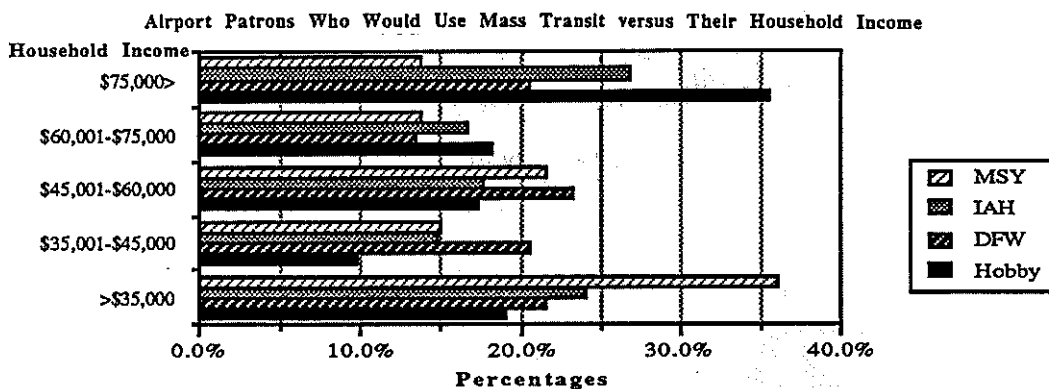


Source: Nettey, CTR-TSU, 1993

Airport patrons at MSY topped this group with a polled statistic of 80 percent and DFW patrons had the lowest percentage at 40 percent.

Household income, when taken as a composite entity at the four airports does not appear to be a major factor in determining the percentage of patrons who would use mass transit. Graphical representation of household income and the percentage of airport patrons who would use mass transit in Figure IV-17 shows a bipolar distribution that peaks at household incomes of below \$ 35,000 and households with incomes above \$ 75,000.

Fig. IV-17

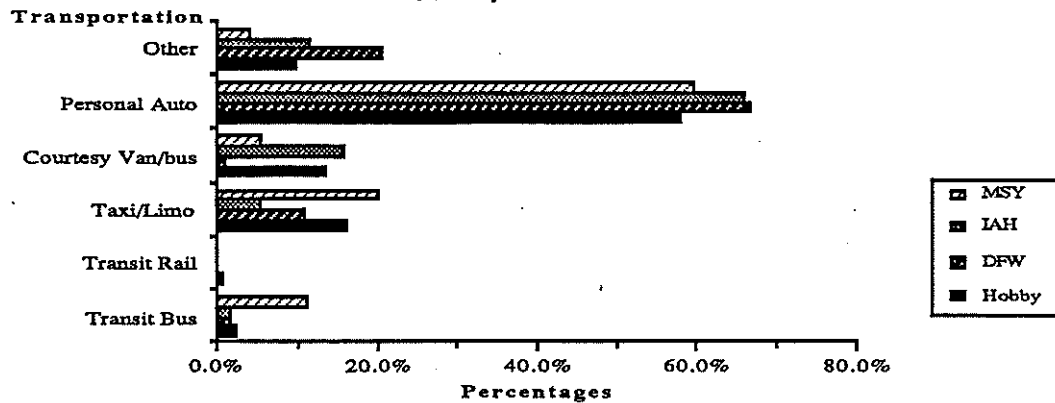


Of the five cross-tabulated distributions that sought to depict the correlation between patrons who would use mass transit and the five variables (formal education, frequency of business travel, frequency of travel, household income, and mode of ground transportation normally used), mode of ground transportation normally used is the most obvious predictor of which patrons are most likely to use mass transit systems.

The graphical representation of this correlation, depicted in Figure IV-18, clearly shows that airport patrons who use personal automobiles are the highest percentage of patrons who would use mass transit service to access business and residential districts if available.

Fig.IV-18

Airport Patrons Who Would Use Mass Transit versus The Mode Of Transportation Normally Used While Travelling



Source: Netney, CITR-TSU, 1993

The percentages are equally high at each of the four airports where patrons were surveyed. These high percentages forebode well for mass transit usage at the four airports. Airport patrons who use personal automobiles to access large airports represent a potentially rich source of patrons for mass transit service.

The indication that among the patrons surveyed, most who use personal automobiles to access large airports would use mass transit services, makes a very strong argument for the establishment of viable mass transit services at these airports that cannot be ignored.

Chapter V

Recommended Solutions

After careful analyses of all findings from this research effort, it is clear that there is no ground transportation crisis at the nation's large airports. It is however obvious that there are serious ground transportation problems at large airports. These ground transportation problems have the unmistakable potential of evolving into a crisis at the current rate of growth of air transportation at large airports. It is therefore prudent, indeed imperative, that remedial steps are taken in a preemptive fashion, to halt the undesirable evolution of ground transportation problems into a crisis at the nation's large airports.

A. Terminal Curbside Congestion

Ground transportation and accessibility problems at large airports take several forms. The main culprit however, is vehicular congestion. Prolonged inaction to resolve landside vehicular congestion problems at airports may result in violation of EPA Clean Air Act mandates. Such "violations may invariably trigger rules and possible penalties designed to reduce vehicular exhaust emissions" (Clippinger and Taft, 1). As previously stated in Chapter II, the EPA imposed a limit of 10,215 vehicles for airport parking at BOS because of vehicular congestion and its allied problems.

The primary solution to airport congestion related problems does not lie in regulatory measures. It lies in fundamental design changes to properly channel vehicular traffic and prevent congestion under normal operational conditions (Clippinger and Taft). Terminal curbs are the indisputable nexus of vehicular congestion in the airport terminal complex. The nodality of vehicular congestion at terminal curbs makes curbs the focus of strategies designed to relieve vehicular congestion in the airport terminal complex.

To relieve vehicular congestion in the airport terminal complex, large airports should employ the use of multiple curbs and traffic lanes in the vicinity of passenger terminal building entrances and exits. The multiple curbs and lanes should be designed to:

1. Segregate **curb traffic** from **through traffic**. To ensure that through traffic does not interfere with terminal curb traffic, it is necessary to dedicate no fewer than two lanes for through traffic at busy terminal entrances and exits. A single lane for through traffic is susceptible to being inadvertently blocked by a confused or desperate driver during peak hours.

Two factors determine the number of traffic lanes required in front of passenger terminal buildings to ensure expeditious vehicular flow. The two factors are:

- a) Average numbers of vehicle stops at the curb
- b) Volume of through and bypass traffic

Both values could be determined through manual and automated traffic counts of stops at the curb and volume of through / bypass traffic, respectively.

2. Segregate arrival traffic from departure traffic. "Surveys show that dwell times for arrival passenger traffic is higher than dwell times for departure passenger traffic because baggage loading from curb to car takes longer than baggage off loading from car to curb" (Hart, 112). Arrival curbs must therefore be designed to be 20 percent - 30 percent longer than departure curbs.

Airports with passenger operations in the millions, such as the four airports where surveys were conducted for this project, tend to segregate arrival and departure traffic by levels. Obviously segregation by levels can only be employed as a solution at airports with multilevel terminal structures.

3. International passengers travel with more luggage and well wishers than domestic passengers, so their needs for curb space exceed the needs of domestic passengers. Terminal buildings designated for international flights must not only have more curb space, their location must also ensure that vehicular congestion in front of International Terminal buildings does not create a bottleneck for the entire airport.

4. Regulation of access to curbs based on vehicular function. Because commercial vehicles have higher occupancy than private automobiles, they have slightly longer dwell times than private automobiles. In recognition of varying dwell times, it is necessary to segregate private vehicles from commercial vehicles before they enter the terminal road system. Successful segregation of commercial vehicle traffic from private automobile traffic would ensure maximum utilization of curb spaces by minimizing waste. The terminal roadway segregation system must direct high occupancy commercial vehicles to close-in curbs at the terminal and private automobiles to island curb platforms.

In addition to employing "design oriented" solutions to ensure efficient curb usage, firm enforcement of airport traffic rules also serves as an effective secondary tool to decrease vehicular congestion on terminal roadways. Where enforcement is practical and reasonable, overtime fees should be established to minimize excessive waiting at curbs or circulation on terminal roadways. Vehicles which exceed an allowed time for passenger pick-up should be subjected to overtime fees. Time allowed for passenger pick-up must reasonably reflect dwell times for passenger pick-up at different times of the day. 'Assessed overtime fees should be designed to recover the cost of enforcement' (Peat Marwick, 26).

Off-site processing of departure passengers and their luggage has the potential to significantly ease vehicular congestion on terminal roadways by reducing demand for curb spaces at the passenger terminal. Where security concerns do not prohibit off-site processing, the following steps must be

included in the regular procedure for processing passenger luggage:

1. Checked-in luggage must be x-rayed and examined by workers other than off-site personnel.
2. No unaccompanied luggage must ever be allowed on board aircraft.

B. Airport Roadway Congestion

Successful implementation of the aforementioned solutions to curbside congestion can only serve as a partial solution to the ground transportation problem at airports. At best, they are a temporary solution. Efficient use of curbs cannot prevent problems caused by vehicular traffic levels that exceed the capacity of an airport's roadway system. In the absence of a transition from low occupancy vehicles to high occupancy vehicles, every large airport would eventually reach the saturation point of its ground transportation infrastructure.

Long-term solutions to ground transportation problems consist of strategies designed to ensure efficient use of an airport's ingress and egress system. Efficient use of airport roadways decrease passenger pressure on terminal curbs. The efficiency of an airport's ground transportation infrastructure is increased if the number of vehicles on the roadways decreases without a comparable decrease in the number of airport patrons.

Strategies to increase the efficiency of an airport's roadway system include:

a. Mass Transit Service

Among the different modes of transportation available at large airports, mass transit offers the potential to eliminate vehicular congestion by reducing the number of airport vehicles without reducing the number of airport patrons. Field surveys conducted as part of this research effort among patrons of IAH, HOU, DFW, and MSY indicate that most airport patrons would use mass transit to access business and residential areas from the airport, if available.

The percentage of airport patrons who answered yes and no to question 10 (If available, would you use a mass transit system at this airport to access residential or business districts within this city?) are presented in Table V-1.

Table V-1. Percentage of Airport Patrons Who Would Use Mass Transit if Available

| Response | IAH | HOU | DFW | MSY |
|----------|-------|-------|-------|-------|
| Yes | 81.34 | 62.07 | 72.67 | 75.47 |
| No | 18.66 | 27.33 | 24.53 | 37.93 |

Source: Nettey, CTR-TSU

It is in the interest of all large airports that anticipate any growth in passenger traffic to develop mass transit systems for the expeditious movement of patrons. Airports that anticipate modest growth in the number of origination and destination passengers may develop or encourage the use of bus transit systems. Bus transit service may be developed to access such airports from "Park and Ride" lots at peripheral locations of the airport, suburban areas, and transit depots in commercial or business centers.

Rail transit service is most suitable for airports with large volumes of origination and destination passengers. Rail transit offers the capacity and frequency of service that makes it ideal for airports with large numbers of origination and destination traffic. Where trip origins of airport patrons are too dispersed, private automobiles must be consolidated in suburban lots from which rail transit service would connect patrons with the airport.

Airports that establish new mass transit services or already enjoy mass transit service must improve the transition between all modes of transportation serving airport patrons within the airport terminal complex. Improvement of ground transportation access through effective integration of multimodal ground transportation could increase the size of markets served by airports. Wider markets and increased patronage of an airport's service normally cause an increase in airport revenue.

b. Signage and Information

Whereas commercial air transportation services between large airports enjoy considerable levels of standardization, ground transportation signage and information seldom enjoy a comparable level of standardization among different airports. Efficaciously provided information on fares, schedules, and directions are indispensable to the operation of a viable intermodal transportation system. Next to design of airport roadway infrastructure, signage and the dispensation of information is of paramount interest to airport patrons who would use mass transit systems to access an airport. Airport informational signs must be simple and direct, requiring minimal time for processing.

Large airports around the nation need to use a single set of standards for airport signage and symbology. This set of standards should govern both the text and display of signage in all areas of the airport terminal complex. A single standard of airport signage and symbology would considerably diminish problems related to direction and orientation suffered by airport patrons.

Minimization of direction and orientation problems would enable airport patrons to move easily within the airport terminal complex. Standardization of signage would also make a significant contribution towards effective integration of multimodal ground transportation at large airports serving major air carriers.

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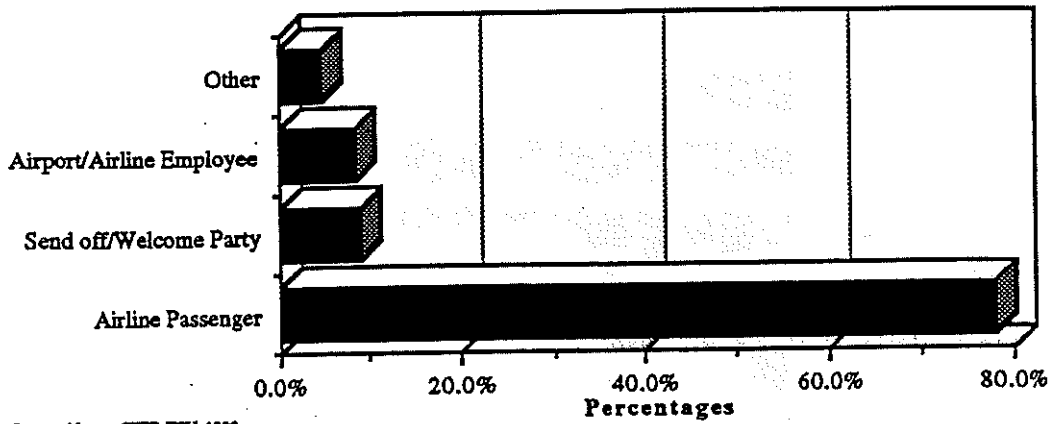
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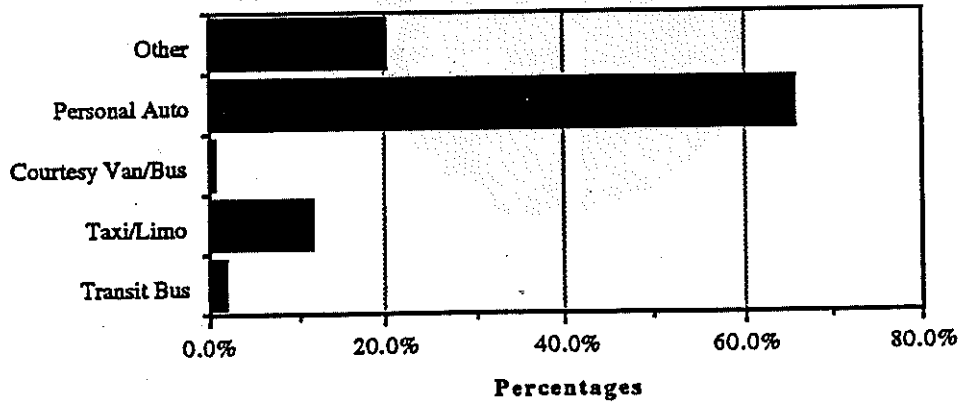
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Appendices

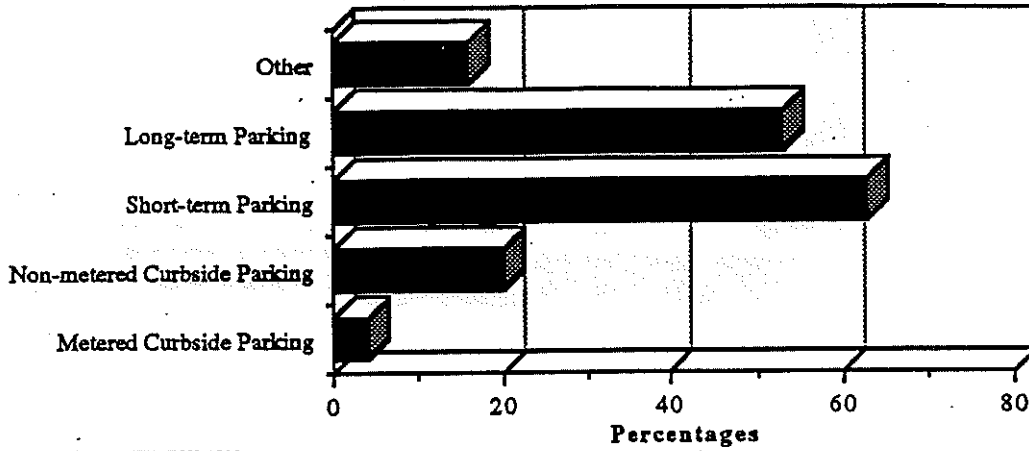
Q.2-DFW Airport
How Would You Classify the Purpose of the Majority of Your Visits to the Airport?



Q.6-DFW Airport
What Mode of Transportation Do You Normally Use to Access This Airport?

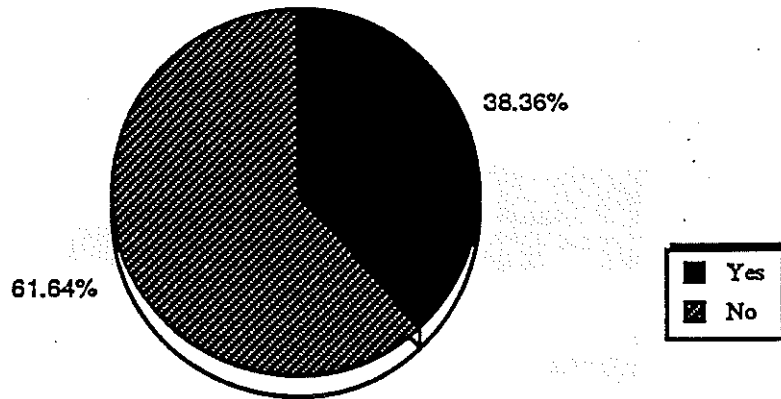


Q.7-DFW Airport
What Type of Airport Parking Do You Normally Use?



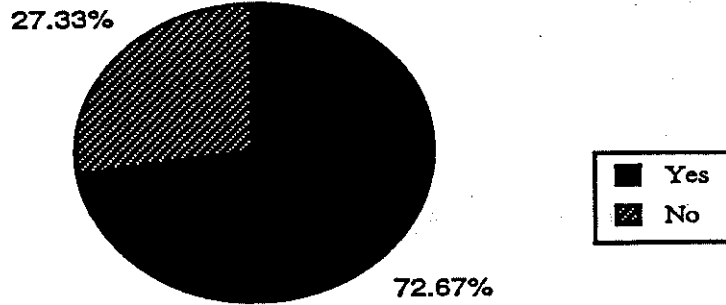
Source: Netley, CTR-TSU, 1993

Q.9-DFW Airport
Have You Ever Used The Mass Transit System While Travelling To or From This Airport?



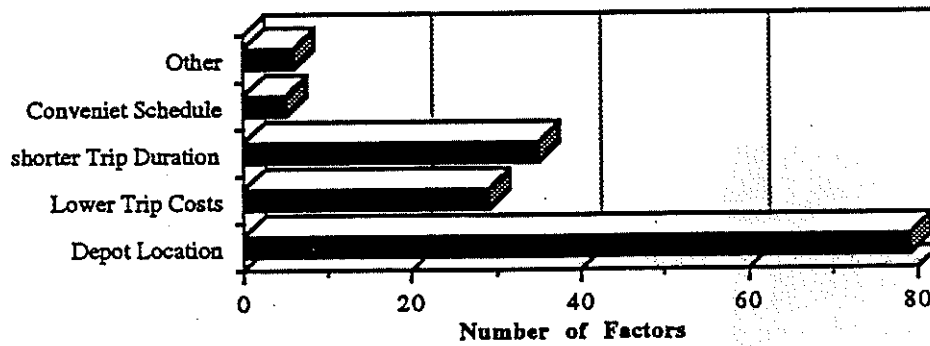
Source: Netley, CTR-TSU, 1993

Q.10-DFW Airport
If Available, Would You Use A Mass Transit
System At This Airport To Access Residential
or Business Districts Within This City?



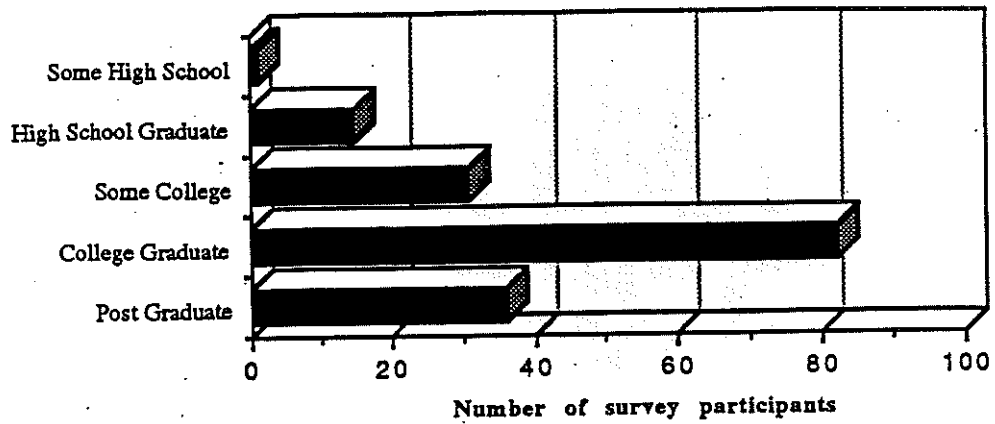
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Q.11-DFW Airport
Indicate the Factors Which Would Significantly Affect
Your Decision To Use A Mass Transit System, (Versus
Other Modes of Transportation) at This Airport?



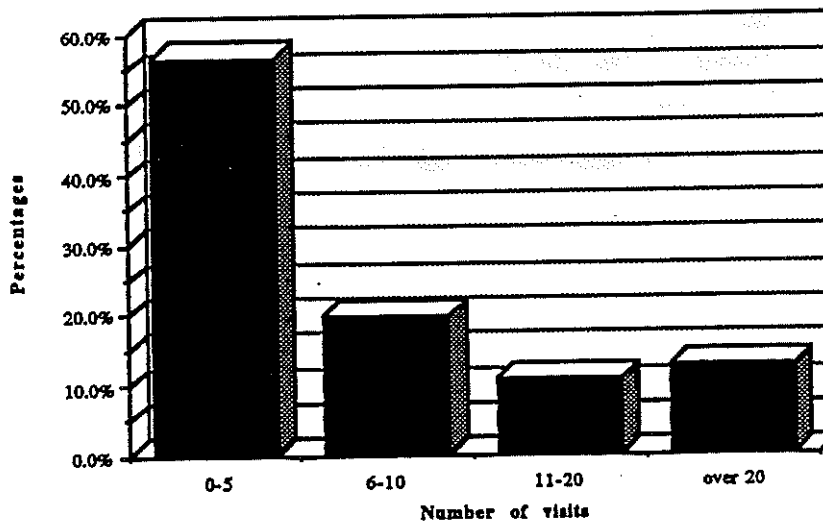
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Q.14-DFW Airport
What is The Highest Level of Formal Education You Have Received?



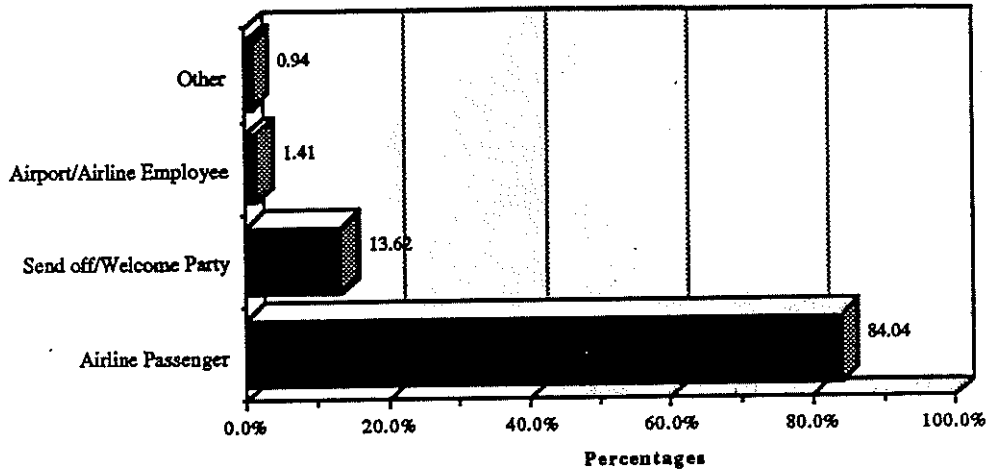
Source: Nalley, CITR-TSU, 1993

Q.1-HOU Airport
How Many Times Did You Visit or Travel Through This Airport Last Year?



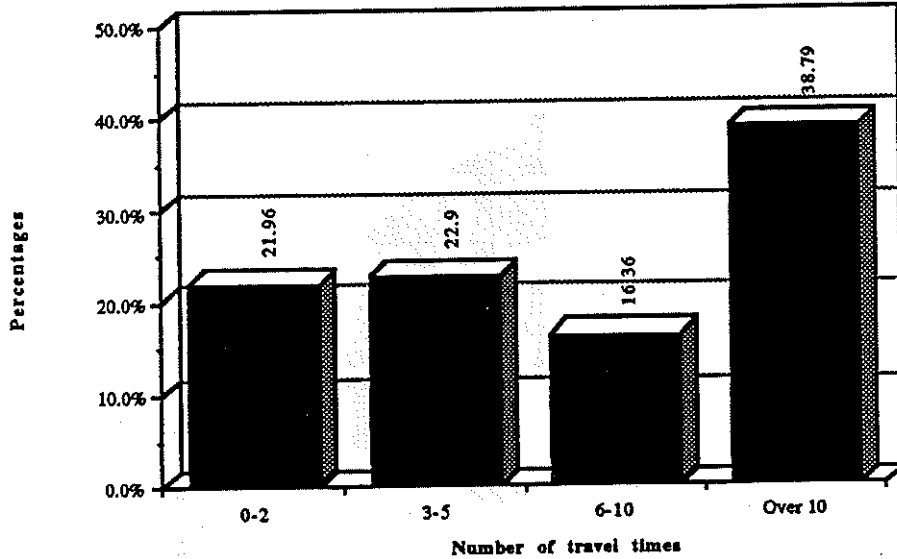
Source: CITR, Texas Southern University, 1993

Q.2-HOU Airport
How Would You Classify The Purpose of The Majority of Your Visits To This Airport?



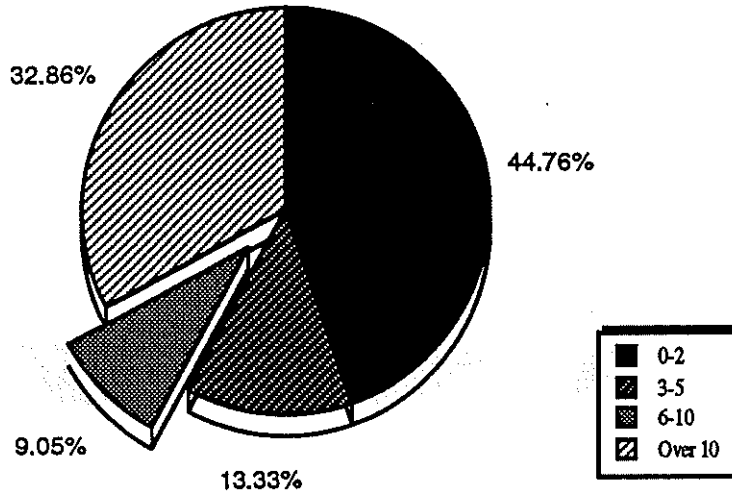
Source: CTTR, Texas Southern University, 1993

Q.3-HOU Airport
How Often Did You Travel By Air Last Year?



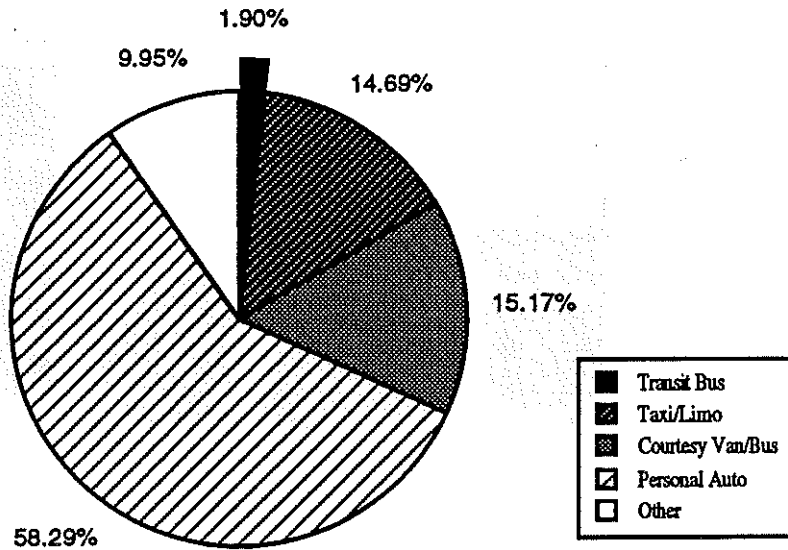
Source: CTTR, Texas Southern University, 1993

Q.4-HOU Airport
Last Year, How Many of Your Travels By Air Were For Business Purposes?



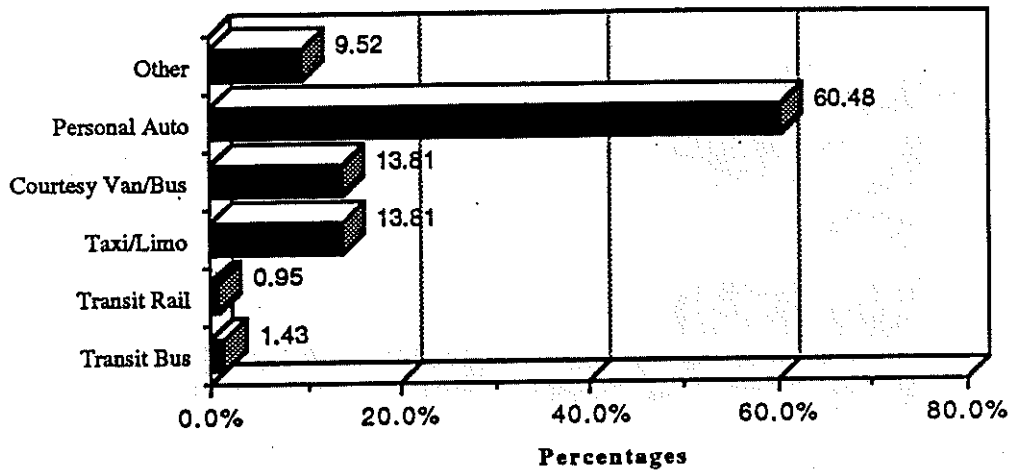
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Q.5-HOU Airport
What Mode of Transportation Did You Use To Access The Airport Today?



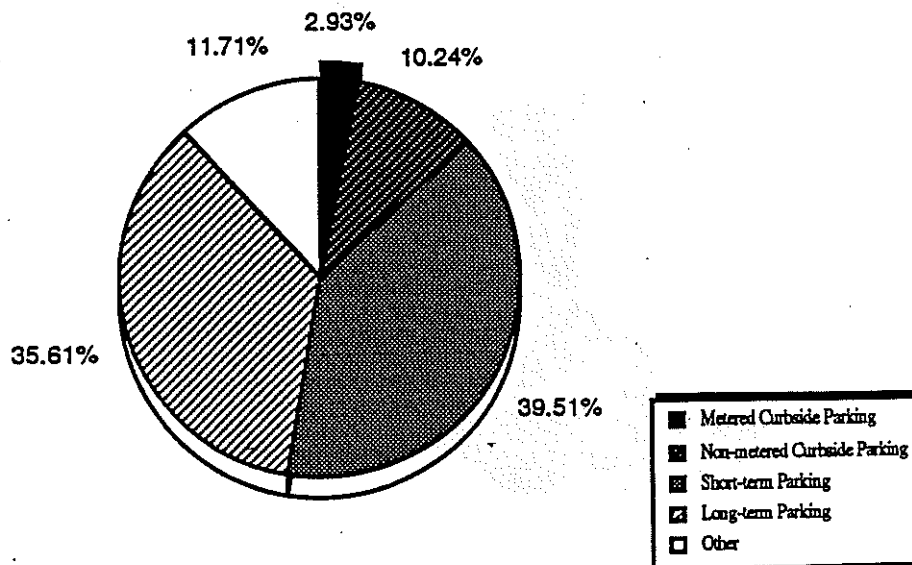
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Q.6-HOU Airport
What Mode of Transportation Do You Normally Use to Access This Airport?



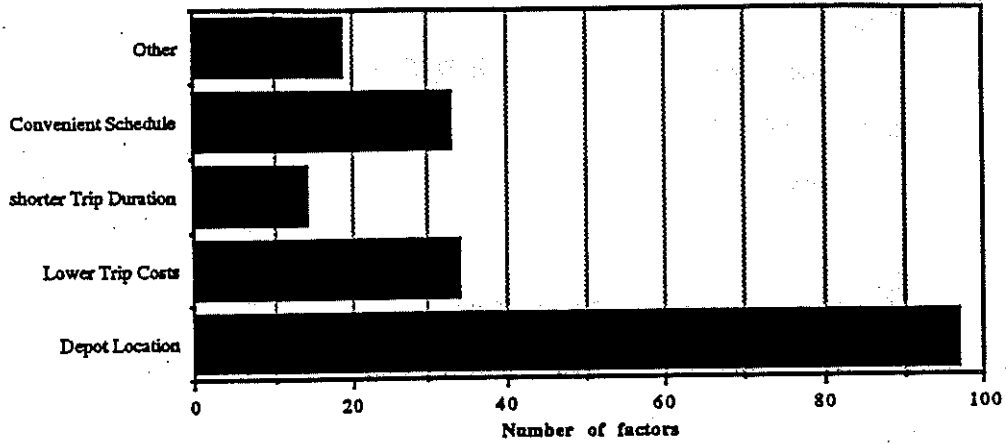
Source: Nettey, CITR-TSU, 1993

Q.7-HOU Airport
What Type of Airport Parking Do You Normally Use?



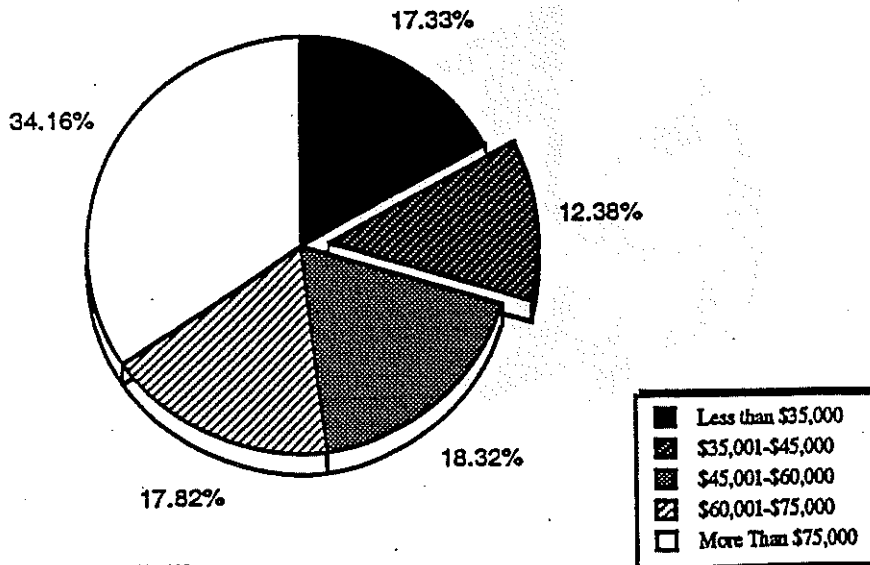
Source: Nettey, CITR-TSU, 1993

Q.11-HOU Airport
Indicate the Factors Which Would Significantly Affect Your Decision
To Use Mass Transit System, (Versus Other Modes of Transportation) At This
Airport?



Source: CTR, Texas Southern University, 1993

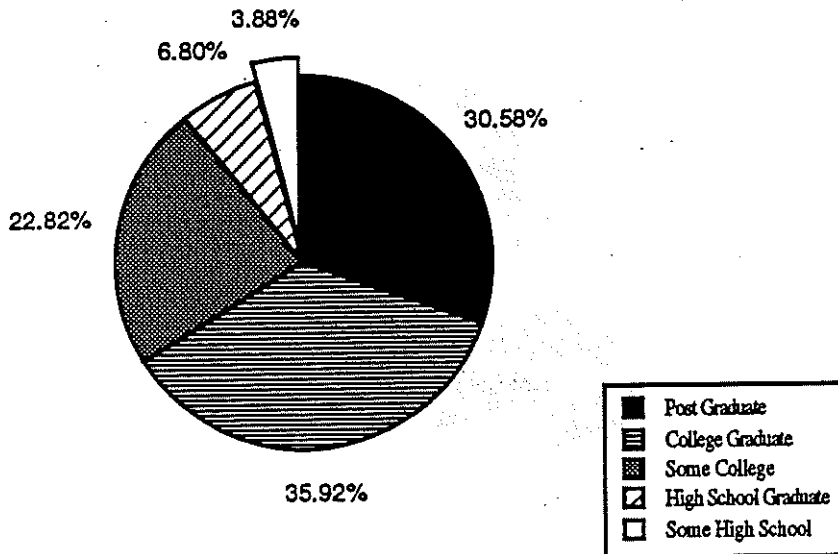
Q.13-HOU Airport
What Was Your Income Last Year?



Source: Netey, CTR-TSU, 1993

Q.14-HOU Airport

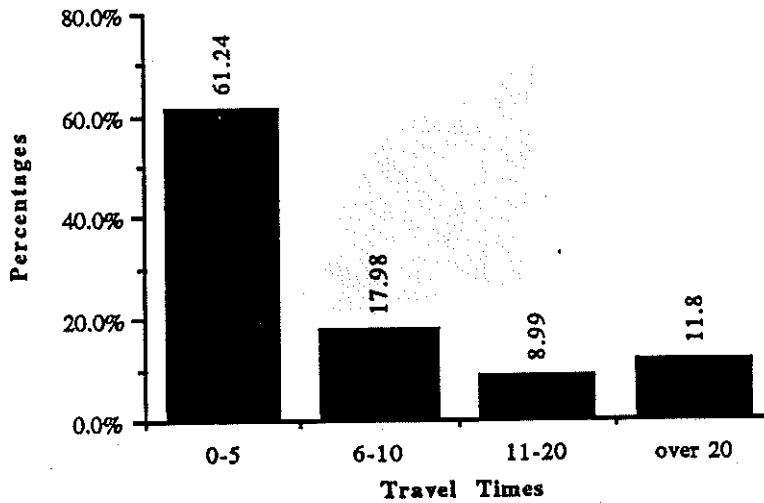
What Is The Highest Level of Formal Education You Have Received?



Source: Netley, CTR-TSU, 1993

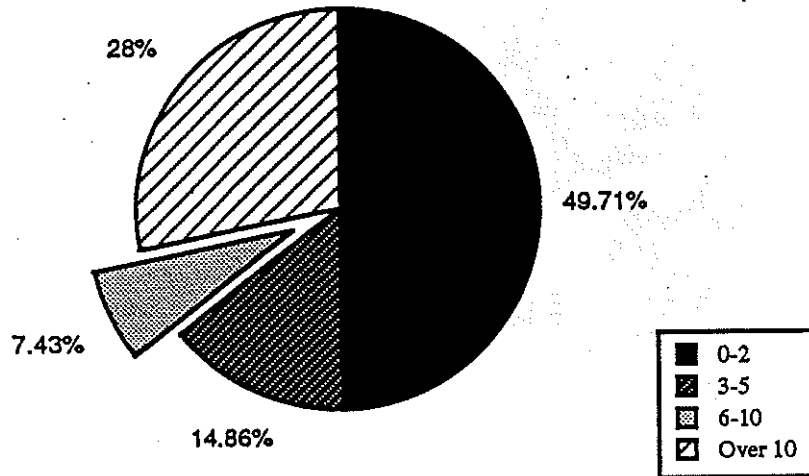
Q.1-IAH Airport

How Many Times Did You Visit or Travel Through This Airport Last Year?



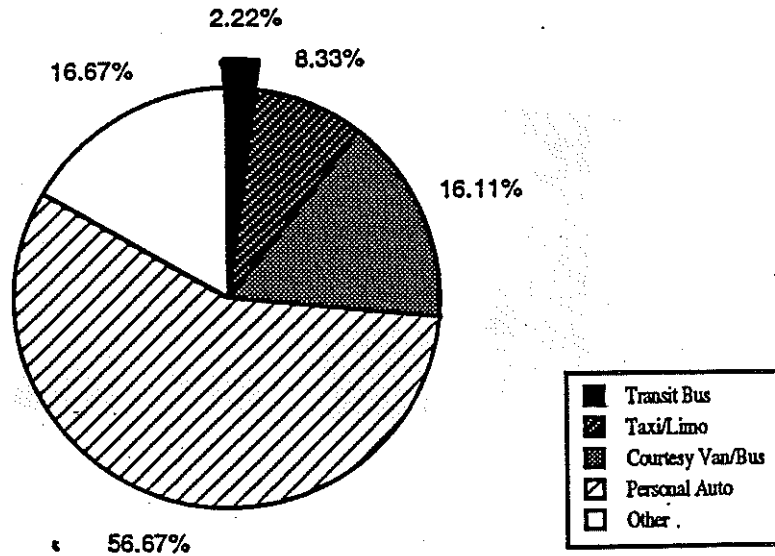
Source: Netley, CTR-TSU, 1993

Q.4-IAH Airport
Last Year, How Many of Your Travels By Air Were for Business Purposes?



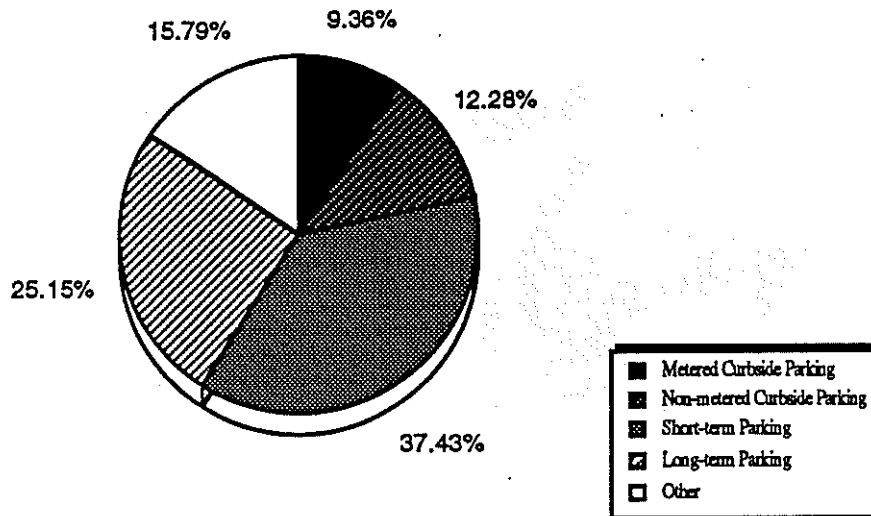
Source: Nettey, CTR-TSU, 1993

Q.5-IAH Airport
What Mode of Transportation Did You Use to Access the Airport Today?



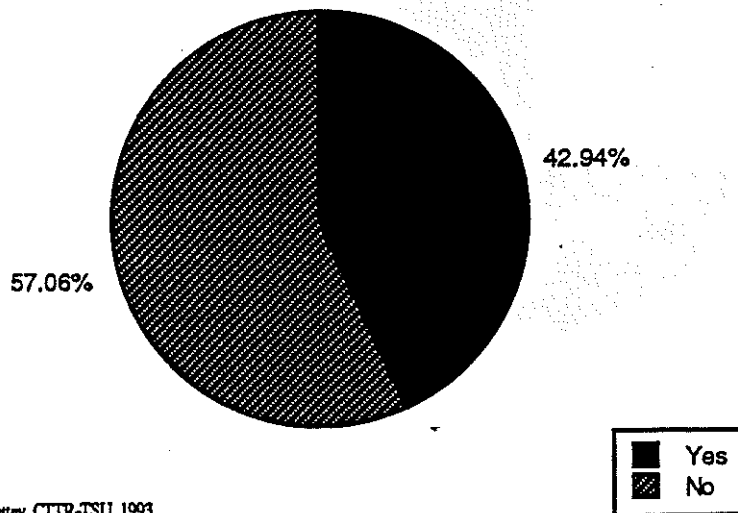
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Q.7-IAH Airport
What Type of Airport Parking Do You Normally Use?



Source: Netey, CTR-TSU, 1993

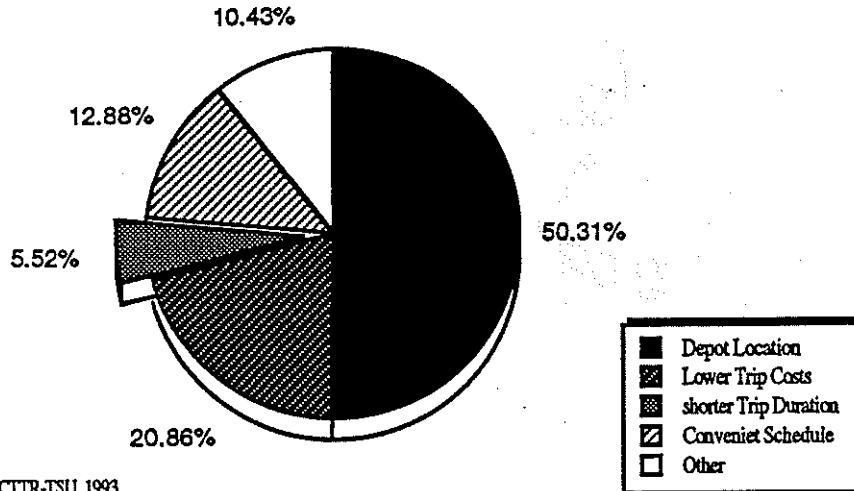
Q.9-DFW Airport
Have You Ever Used the Mass Transit System While Travelling To or From This Airport?



Source: Netey, CTR-TSU, 1993

Q.11-IAH Airport

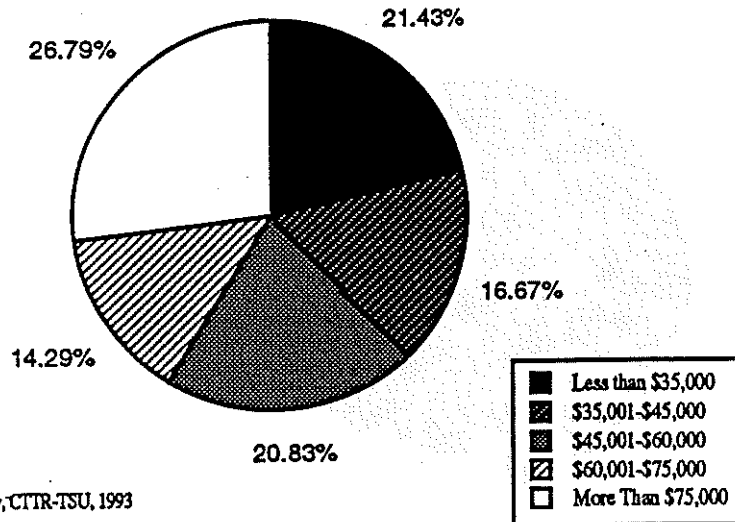
Indicate the Factors Which Would Significantly Affect Your Decision to Use A Mass Transit System, (Versus Other Modes of Transportation) at This Airport?



Source: Netzey, CTR-TSU, 1993

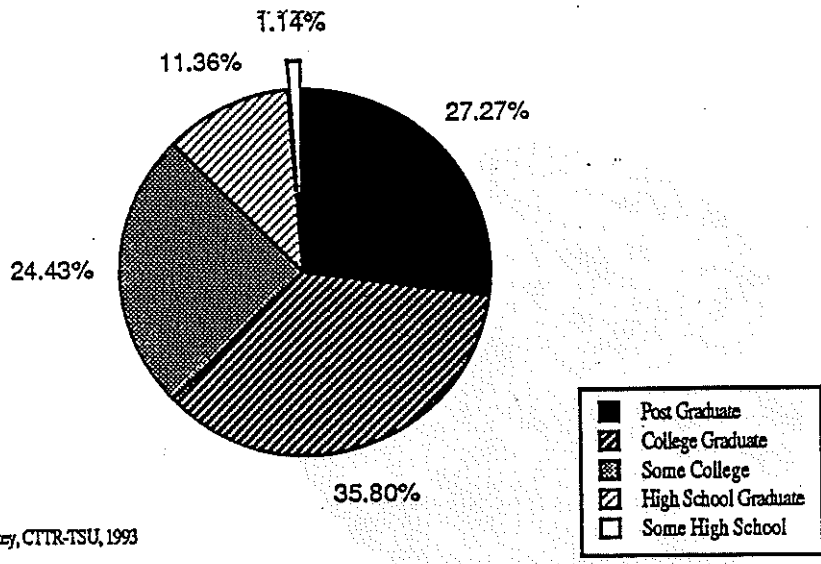
Q.13-IAH Airport

What Was Your Household Income Last Year?



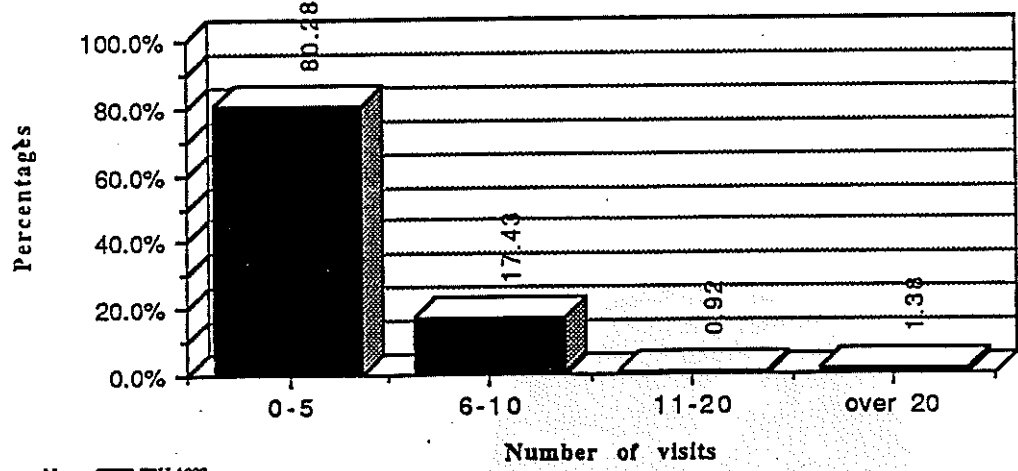
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Q.14-IAH Airport
What is the Highest Level of Formal Education You Have Received?



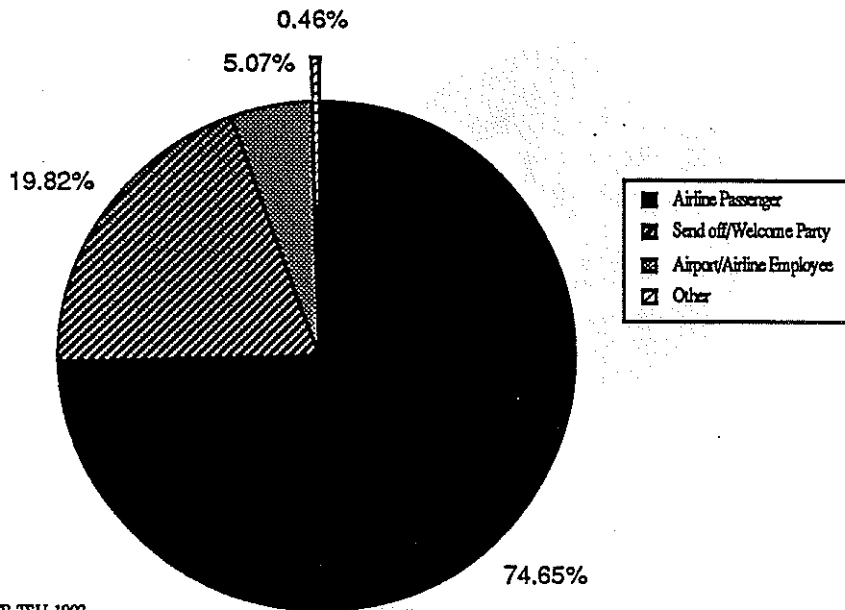
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Q.1-MSY Airport
How Many Times Did You Visit or Travel Through This Airport Last Year?



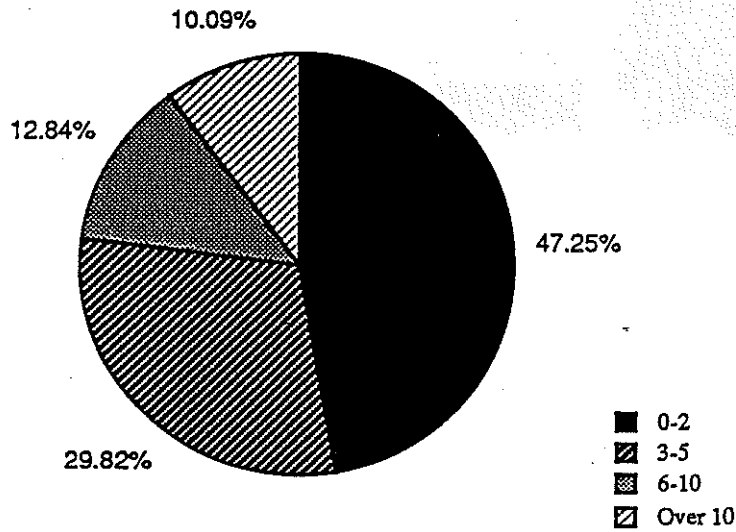
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Q.2-MSY Airport
How Would You Classify The Purpose of
The Majority of Your Visits to This Airport?



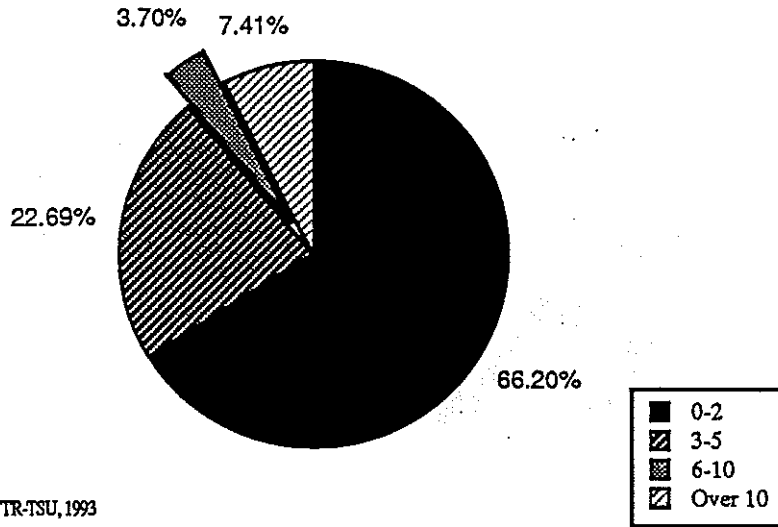
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Q.3-MSY Airport
How Often Did You Travel By Air Last Year?



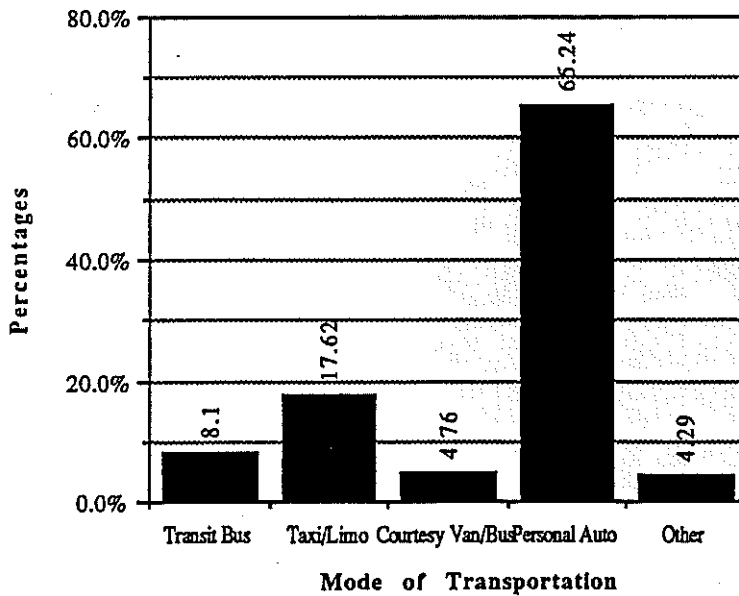
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Q.4-MSY Airport
Last Year, How Many of Your Travels By Air Were for Business Purposes?



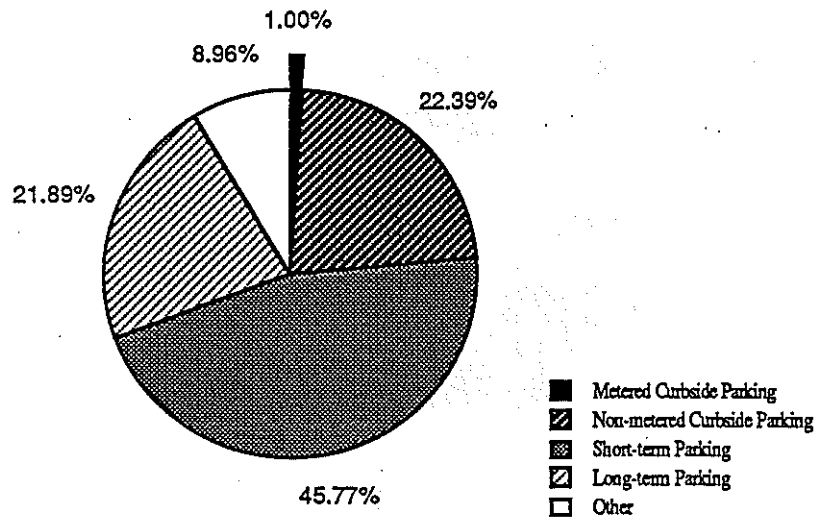
Source: Nettey, CTTR-TSU, 1993

Q.6-MSY Airport
What Mode of Transportation Did You Normally Use To Access This Airport?



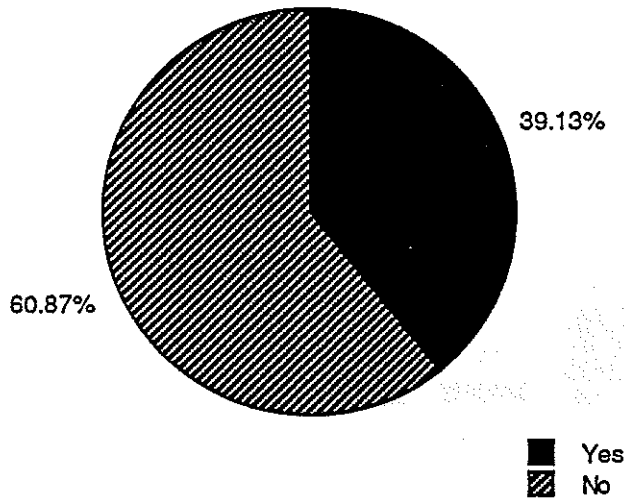
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Q.7-MSY Airport
What Type of Airport Parking Do You Normally Use?



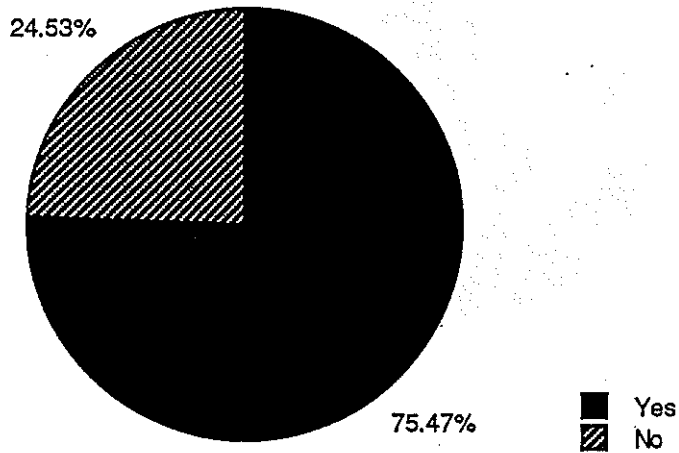
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Q.9-MSY Airport
Have You Ever Used The Mass Transit System While Travelling To or From This Airport?



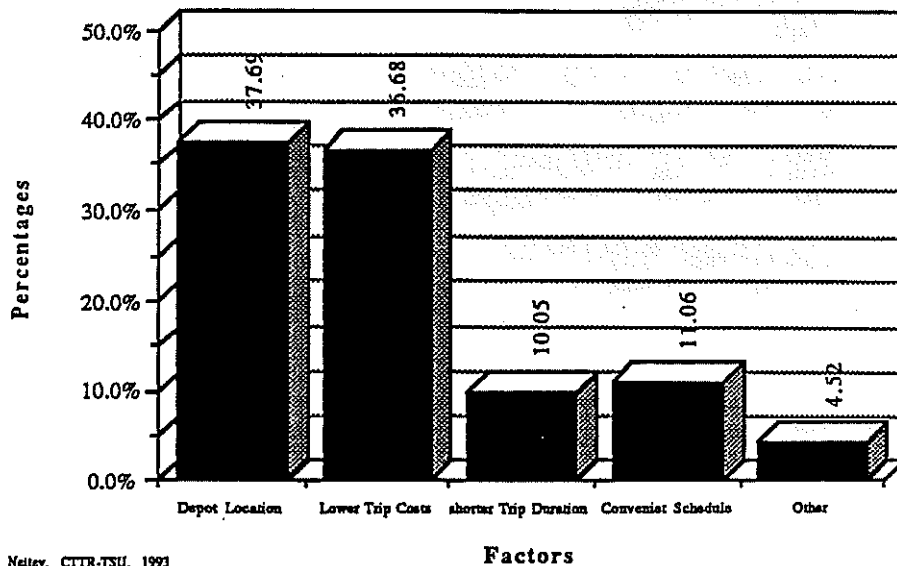
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Q.10-MSY Airport
If Available, Would You Use A Mass Transit System At This Airport
To Access Residential or Business Districts Within This City?



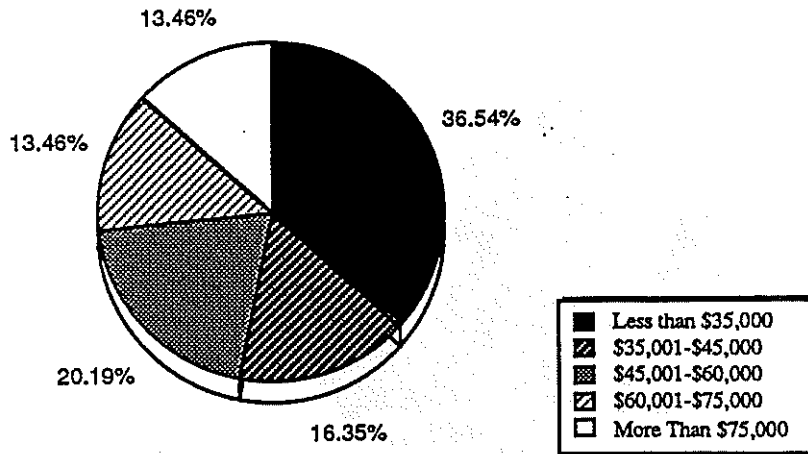
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Q.11-MSY Airport
Indicate The Factors Which Would Significantly Affect Your Decision To Use A
Mass Transit System, (Versus Other Modes of Transportation) at This Airport?



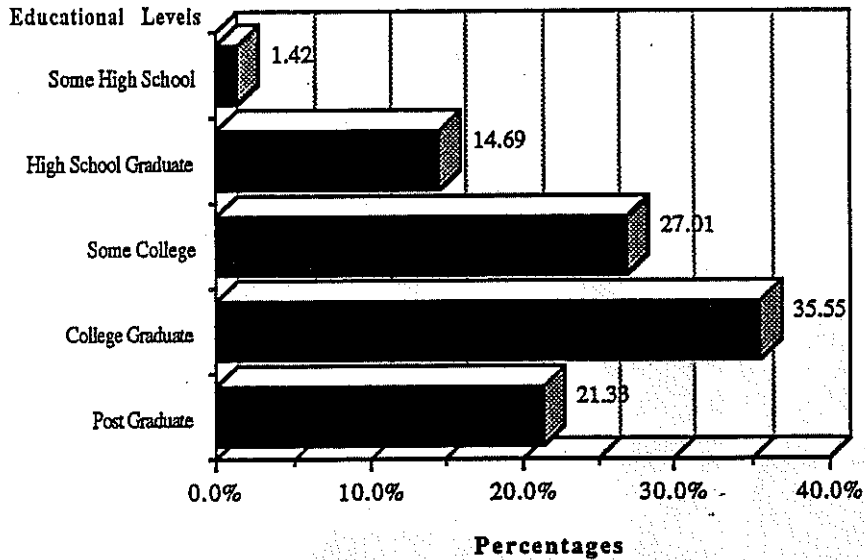
Source: Nettey, CTR-TSU, 1993

Q.13-MSY Airport
What Was Your Household Income Last Year?



Source: Nenny, CTR-TSU, 1993

Q.14-MSY Airport
What Is The Highest Level of Formal Education You Have Received?



Source: Nenny, CTR-TSU, 1993