

A MACROSCOPIC EXAMINATION OF THE
PROBLEMS OF AIRPORT ACCESS

by 6791

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INTRODUCTION

Surface transportation facilities which provide access to rapidly expanding airports are often inadequate to efficiently serve present and projected needs. The importance of air travel makes paramount the need to insure rapid and dependable access to the air terminal from various sections of an urban area.

The large investment of time, resources and capital needed to construct transportation facilities requires that these facilities be designed to accommodate long range needs. The designer is faced with the task of creating a transportation system that is fast, safe, efficient and compatible with both present and future urban form.

The purpose of this report is to examine the airport access problem as it has developed and attempt to identify alternatives to its solution. The airport access problem is viewed in a broad context in order to determine the general character of access difficulties being experienced throughout the United States.

The report briefly examines the effects that advances in aircraft technology and increasing air travel demands will have on the size and location of future airports. The assumption is made that although new developments in aviation technology may alter air travel patterns, air terminals will continue to grow in size and efficiency, creating a demand for much improved access conditions.

The problem analysis concentrates on the travel demands of airport users, the ability of various travel modes to satisfy travel demands and the

compatibility of various travel modes with present and future land use designs. Every attempt is made to view the airport access problem as it relates to basic goals and objectives established by a community as part of its comprehensive planning effort.

HISTORICAL DEVELOPMENTS

The airport access problem manifests itself through the increasing dissatisfaction of air passengers with the portion of an air trip that is spent on the ground. Air trip delays can be grouped into two categories, access delays and flight delays. Access delays are a function of ground conditions while flight delays are usually caused by congestion of the airways.

Access time includes all elements and functions, both inside and outside the airport, that are necessary for the air transport of persons and cargo except for the flight portion of the trip. For passenger trips, access time includes the time used in the selection of a trip mode, selection of a specific flight, making reservations and arrangements, choosing an access mode, walking, waiting for the access mode, parking at the airport if access was by private automobile, purchasing tickets, checking baggage, walking to loading area and finally waiting for boarding. At the destination similar activities are repeated, but in reverse order. The time spent in airport access involves considerable waiting because of peak demands at passenger service and customs facilities and because passengers typically schedule extra time to allow for possible delays. The unpredictability of delays results either in an over-estimation of required access time and an unplanned wait at the terminal or trip destination, or in an underestimation of required access time which results in a missed flight or a late arrival at the ultimate destination. The inability to efficiently plan total door-to-door travel time is a major factor in the increasing public dissatisfaction with air transportation in general and access conditions in particular.

The total air transportation system involves a delicate balance between the various components or subsystems of which it is composed. Four components that provide constraints on air transportation are the individual capacities of airways, airport technical facilities, terminal facilities and intracity transportation facilities (46). Airway capacities are a function of the type of aircraft, proximity of airports to one another, available communications and a general condition of airway congestion. Airport capacity is a function of physical improvements such as runways, taxiways and maintenance facilities. Terminal capacity is determined by the availability of parking, curb space for loading and unloading passengers, passenger service facilities and the traffic circulation system within the physical limits of the airport. Intracity transportation facilities include the network of streets and highways, bus and rail systems and at a few locations helicopter service to and from the airport. These components or subsystems are interrelated and inadequacies in any of the subsystems can affect the efficiency and potential capacity of the total air transportation system.

Problems of airport access are the result of deficiencies in terminal facilities and the intracity transportation network. This report will be limited to considerations that affect intracity travel to and from the airport. The selection of the intracity transportation portion of airport access is not to imply that the greatest problems and potential for improvement are found in this subsystem. The use of the term "airport access" will be used in the context of getting to and from the airport in full realization that this is only a part and perhaps not even the critical constraint of a given situation.

Airport access has been a traditional measure in the determination of airport adequacy. Since the early 1930's, the major criterion for judging the adequacy of an airport was the airport location in relation to the city

it served (25). During this period the distance from the airport to the city was measured as the ground distance utilizing the best highway routes from the airport administration building to the downtown post office. The post office was selected because it was always located in the downtown area and was also of major importance because of air mail delivery.

A survey of major airports conducted by the Civil Aeronautics Authority in 1939 revealed that among cities of over 100,000 population, 49 per cent of the airports were within six miles of the downtown area (25). All but seven per cent of the airports were within ten miles of the downtown post office.

Literature on airport engineering published in the early 1940's emphasized the necessity of a regional plan (40). The first criterion of an appropriate location was that the travel time between the airport and the business district be no more than 15 to 20 minutes. The exclusive mode of airport access during this period was highway travel.

An example of concern for compatibility of airport location with the regional planning efforts was an early recognition of the airport as an attraction for visitors whose only purpose was sightseeing and recreation. Early airport designs often included parks and other recreational facilities for use by the city population, but these items were added for somewhat selfish motives. The first reason was that development of parks and open space adjacent to the airport provided protection from the construction of obstacles to aviation. This protection was often achieved in the interest of recreation without forcing the expenditure of airport funds for the explicit purpose of controlling air rights in approach zones. The development of recreation facilities also attracted crowds that would allow the dual use of airport commercial facilities such as restaurants. Finally the traffic attracted to the airport vicinity for recreational purposes was a major factor

in the justification of improved roads serving the airport.

The need for improved airport access received more support during the period from the end of World War II until the early 1950's (5). During this period proponents for better access argued the need for freeways between business districts and airports. An example was the desire to build a freeway from Idlewild Airport to midtown New York and by so doing eliminate the delays caused by 58 traffic control signals along the then existing facility. To overcome the objections to building freeways to airports, it was argued that although airport user interests in freeways were substantial, the airport-city facility would be used by a far larger portion of the general population than that segment made up of airport users.

The demand for more freeways has continued to the present and as a result most airports are served by interstate highways and other urban freeways. The airport access problem however, is more acute today than at any time in the past partly because its solution has been impeded by several complicating factors (16).

One such factor has been the tremendous increase in the number of motor vehicles that must share the streets and highways of major cities. The acceptance of the automobile as the primary transportation mode for airport access as well as the majority of other trip purposes has caused peak hour traffic congestion that adversely affects airport access.

A second factor that complicates the airport access situation is the realization that airport access is only one aspect of the metropolitan transportation problem. Airport traffic is only a fraction of the traffic that goes past the airport to the suburbs. This is not surprising since many freeways in the vicinity of airports were originally justified by service provided for other than airport users. Airport access improvements constitute

only a part of the transportation improvements that are required in many urban areas. As a result, competition for available funds is great.

The number of governmental agencies that are involved in decisions affecting intracity transportation make coordination a necessary but complicated undertaking. These agencies which include federal, state, county, city, neighborhood and in some instances duly constituted authorities each have individual interests and requirements that must be satisfied.

Another factor influencing airport access is the fact that the larger airports can no longer be considered simply as important generators of traffic movements, but must be regarded as metropolitan concentrations of employment and urban activity. Airports have experienced phenomenal growth in passenger demands which have been accompanied by increases in employment and the number of visitors. Airports have become the focal point for new industrial sites, hotel and convention centers and other commercial ventures that accompany similar developments. Concentrations of employment and urban activity of this nature have generated large volumes of traffic causing overcrowding of facilities that must also serve as airport access facilities.

The changing technology and continued growth of air travel has caused many airport facilities to become inadequate and obsolete. The solution to this situation often involves a difficult choice between the expansion of existing facilities and the relocation of the airport. These decisions often involve political implications and after prolonged debate which can take several years, the problem is often resolved by a referendum of the voters. Conscientious development of access is not possible during the period when the future of an airport is in doubt.

A sixth complicating factor to an orderly solution of the airport access problem has been the inability of legislative bodies to accept projected air

travel demands (7). Growth projections have tended to be unbelievably high, but history has shown that the actual growth rates of airport usage have exceeded all projections. Even with a record of old predictions being far outstripped by actual developments it remains difficult for legislative bodies to accept present predictions when establishing priorities for capital improvements. The feeling that the upward trend surely cannot continue at its present pace still pervades official opinion.

The ability to meet the rising expectations of the traveling public is a difficult and elusive goal. Travelers have witnessed air travel time decreases and somehow expect that ground travel times should decrease proportionately. As a consequence the airport access problem becomes more serious even if actual conditions remain stable, simply because of changing attitudes.

Similar access problems exist at European airports, but with the exception of London, less emphasis is placed on the trip to and from the airport. Freeways are only now becoming commonplace and European travelers accustomed to narrow winding streets have not yet become as demanding as their United States counterparts. European airport access facilities are usually the responsibility of airport authorities and coordination for access improvements are greatly simplified. To date access problems have not received much emphasis mainly because the greatest delays experienced by European travelers occur within the terminal. European travelers are confronted with huge amounts of red tape and customs inspections which are not routine in the United States. The European opinion of improved access can be summarized by one official's comment when he asked, "What is to be gained by fast access roads and an efficient transportation system if a passenger is forced to spend half his travel time squeezing through the airport? We must place first things first(20)!"

Airport access is therefore seen as a very complex problem involving increasing expectations of the traveling public as well as other more specific interrelationships with other urban problems.

TRENDS IN AIR TRANSPORTATION DEMANDS

The requirements for access facilities are dependent on the scope and character of future aviation. Aviation remains an infant industry possessing great potential for discovery and innovation. The technological advancement and rapid public acceptance of air transportation have caused past efforts of prediction to be difficult and almost without exception inadequate. As a result airport facilities and supporting transportation systems have not been designed to accommodate the demands that have developed. If inadequate designs are to be avoided in the future, realistic estimates of the scope and character of future commercial aviation must be determined.

An often used rule of thumb that has been used to describe the growth of air transportation is that the magnitude of commercial aviation doubles every five years. This growth is indeed phenomenal. The Federal Aviation Administration forecasts the growth of air passenger traffic to be at a rate of over twice the rate for the rest of the national economy through 1981 (9). The number of domestic revenue passengers is expected to increase from 150.8 million passenger enplanements in 1969 to 460.0 million passenger enplanements in 1981 as shown in Fig. 1. This is an average increase of 9.7 per cent annually for the 12 year period. The increase in the past decade was from 56.6 million passenger enplanements in 1960 to 150.8 million passenger enplanements in 1969, or an annual increase of 11.5 per cent for a nine year period.

A great deal of caution must be exercised when utilizing long term trend information and forecasts because of significant year to year fluctuations.

Recent examples of cyclical behavior are the growth rates of passenger enplanements for the periods 1965 to 1968 and for 1969 and 1970. During the three years from 1965 to 1968, passenger enplanement increased at an average annual rate of 17.7 per cent, but during fiscal year 1969 the rate of increase was only 9.8 per cent. Although the data for fiscal year 1970 are not yet available the rate of increase is estimated to be only 3.3 per cent. The exceptionally rapid growth rate of the 1965-1968 period resulted from an unusually high rate of growth of the national economy, the war in Vietnam and a sharp decline in average passenger fares that occurred during this period. By mid 1969 the economy began to experience a general slowdown which has also been reflected in demand for air travel.

Fiscal Year	Revenue Passenger Enplanements (10 ⁶)		
	Domestic	International	Total
1960	56.6	-	-
1963	63.3	7.4	70.7
1964	74.4	8.6	83.0
1965	84.5	10.0	94.5
1966	102.2	11.7	113.9
1967	113.5	12.9	126.4
1968	137.5	15.1	152.6
1969	150.8	17.2	168.0
1970(est)	157.1	19.3	176.4
1971(est)	165.7	21.5	187.2
1972(est)	180.3	23.6	203.9
1973(est)	199.5	26.5	226.0
1974(est)	222.0	30.0	252.0
1975(est)	245.5	34.5	280.0
1980(est)	415.0	56.5	471.5
1981(est)	460.0	62.0	522.0

Figure 1. Scheduled passenger traffic of United States certificated route air carriers. (9)

Present projections indicate that a slowdown in passenger enplanements will continue through at least 1971 because of the combined effects of a lackluster national economy and the establishment of higher fares to cover greatly increased ticket taxes and operating losses being experienced by many major airlines. After 1971 it is expected that the long term increase in domestic enplanements will continue at a rate of approximately ten per cent per year through fiscal year 1981.

A disarming characteristic of trend analysis is the tendency to interpret a stable and perhaps slightly decreasing annual increase as an indication that the rapid increase in travel demands is approaching an end and that the problems related to these demands will be more easily contained. In actuality however, the base on which growth must develop may have reached such a magnitude that even a small per cent increase is large in an absolute sense. For example a ten per cent increase in domestic enplanement in 1960 would have resulted in 5.7 million new passengers. A similar increase could be achieved in 1970 with an increase of only 3.6 per cent.

The Federal Aviation Administration also issues long range forecasts of aviation demands at major air transportation hubs. A hub is described as the general geographic area surrounding a major city and includes all airports that serve the area. For example, the New York air transportation hub includes J.F. Kennedy International, LaGuardia, Newark and eleven smaller airports serving the area immediately surrounding New York City. Forecasts for individual hubs roughly parallel the travel demand increases expected to occur nationally. Figure 2 summarizes forecasts for the seven largest United States air transportation hubs. Also included is the forecast for Kansas City which ranks 17th in size. The forecasts indicate that the demand at major hubs is expected to triple during the next decade. The comprehension

of a threefold increase in the already prodigious demand that exists in New York City or Chicago challenges the imagination. Even more dramatic is the fact that in the relatively short period of a decade there will exist six United States cities with air transportation demands approximately equal to the present demands found in the New York area. By 1980 the New York City air transportation hub will serve approximately the total demand presently being served by the six largest air transportation hubs.

Transportation Hub	Base Year 1965	Forecast of Enplaned Passengers (10 ⁶)		
		1970	1975	1980
Atlanta	3.4	6.9	11.9	20.0
Chicago	8.7	16.0	27.4	46.2
Dallas	2.6	5.0	8.6	14.8
Kansas City	1.2	2.2	3.8	6.4
Los Angeles	6.1	11.0	18.8	31.8
New York	11.6	21.1	36.2	61.0
San Francisco	4.1	7.7	13.2	22.3
Washington, D.C.	4.3	8.0	13.8	23.5

Figure 2. Forecast of enplaned passengers on scheduled airlines at major air transportation hubs through 1980. (8)

The phenomenal growth of air transportation has been the result of successful marketing of the short travel times, improved travel environment and the competitive costs of air transportation (25). Salesmen involved in early efforts to promote air travel were instructed to emphasize the ability of air transport to travel long distances in short periods of time and still maintain reliable schedules. A great deal of effort was spent to dispel the public's association of danger with flying which had been perpetrated by the early barnstorming flying exhibitions. The fear of commercial flight has been overcome to a large degree by persons who make business trips, but

reminders of flight hazards are still found in many air terminals in the form of life insurance vendors.

Business travel by commercial aviation is now so commonplace that the airline industry has taken it for granted and is concentrating its marketing efforts on personal and recreational travel. Promotion campaigns encourage vacations in distant lands, encourage wives to accompany their husbands on business trips and use special youth fares to initiate young adults into the "jet set". Present trends of increasing affluence, shorter work weeks, longer vacations and earlier retirement all point to a population that is willing and able to use air transportation for purposes other than business travel. The growing acceptance of air travel is evidenced by the fact that in 1967 there were 440 air trips taken for every 1,000 persons in the United States (6). This figure is expected to increase to 2,200 trips per 1,000 population by 1990. The development of the market potential for air travel during an extended period of world peace and affluence could result in travel demands that exceed all present predictions just as predictions have been exceeded throughout the history of air transportation.

DEVELOPING TRAVEL TECHNOLOGIES

Demand for air transportation is a function of individual preferences, the perception of travel costs and the availability of acceptable substitutes for air transportation. Since the end of World War II commercial aviation has benefited from increasing desires for travel amenities, the relative decline in the cost of air travel made possible by larger aircraft and from the decline in transportation service provided by competitive travel modes. The information presented in Fig. 3 indicates that the rapid increase in the demand for air travel occurred during a period when domestic travel by public carrier actually declined by 25 per cent. These gains which were accomplished at the expense of bus and rail ridership now include the majority of long distance trips by public carrier. Proposed improvements of rail passenger service and greater bus utilization of new improved freeways will provide a real substitute for short haul air travel. Recent government action regarding rail transportation may be an early indication of improved rail service such as that now available on a limited basis between New York City and Washington, D.C. As bus and rail transportation begin to show potential for greater public acceptance there are indications that air transportation is beginning to suffer growing pains.

Present day airports are growing in disfavor with nearly every segment of society. Air travelers are finding the terminal facilities congested, parking lots full and access difficult. Pilots and airport authorities complain of approach restrictions, inadequate runways and outdated control procedures. Urban residents are adamant concerning aircraft noise, air

pollution and alleged ecological damage. A proposal to improve a given situation usually meets with resistance from an opposing segment of the population.

Year	Intercity Passenger Volumes (10 ⁶)						
	Air		Bus		Rail		Total
	Number	%	Number	%	Number	%	
1950	17.5	3	338.5	60	209.1	37	565.1
1955	38.2	8	237.8	52	183.6	40	459.6
1960	56.6	16	187.7	51	122.7	33	367.0
1965	84.5	22	193.4	50	106.3	28	384.2
1967	113.5	27	204.0	49	98.1	24	415.6

Figure 3. Domestic intercity passenger volumes by mode of travel for selected years between 1950 and 1967. (9, 46)

A popular solution to the problems facing the air transportation industry is the construction of an enormous centralized regional airport located a long distance from the central business district of the metropolitan area. This approach to the problem improves flight conditions and minimizes effects on the urban environment, but greatly complicates airport access. Even at locations where modern facilities have been constructed to provide airport access, travelers must traverse longer distances and still contend with urban congestion during a significant portion of the intra-urban trip. The increased access times become especially significant for short haul air transportation.

Airport accessibility with its increasing costs in time, inconvenience, and money relates directly to the total cost of air transportation. The inevitable result of increased costs is the loss of a number of passengers to other transportation modes. The relative attractiveness of alternate methods of intercity travel increases as the difficulty of airport access

increases.

A study relating airport accessibility to passenger generation in the Buffalo, New York area indicated that the generation of air passengers per one thousand population is greatest within the 15 mile radius of the airport (13). The generation rate in the area located 15 to 25 miles from the airport was only 62 per cent of the inner 15 mile radius. The area from 25 to 35 miles from the airport had a passenger generation rate only 25 per cent of the rate within the central area.

Other studies have resulted in similar findings and tend to discount the effects of certain segments of the population, such as agriculture, which makes infrequent use of air transportation. Data from 21 California airports indicated that air passenger generation rates in the band from 0 to 10 miles was greater than in the band between 10 and 20 miles, although urban population was greater in the second band in 7 of the 21 airport locations (13). Studies have shown that a steep decrease in air passenger generation per 1,000 population occurs as access distance from the airport increases. A ten mile increase in the distance from an airport appears to result in approximately a forty per cent change in generation rate. Data compiled in New York City indicates that as access time is increased from 1/2 hour to 1 1/2 hour approximately fifty per cent of potential passengers are lost to air transportation.

At first glance nearness to an airport does not appear to be a legitimate causal relationship concerning the need for air travel. Nearness to an airport however, does lower the costs of access and may influence persons to use air transportation. Of greater impact however, may be the tendency of persons and businesses that make frequent use of air transportation to locate near airports.

Persons surveyed concerning the effects that increased access distances to airports would have on the frequency of their personal air travel usually discount the effect as negligible. When questioned further however, business managers usually indicate higher costs and lost time would result in a more critical evaluation of trip purpose and possibly result in fewer trips of longer duration and a greater use of the telephone.

The problems associated with conventional air transportation coupled with the realization that the operational limits and capacities of many airports are below projected levels of demand indicate that the development of substitutes for conventional air transportation may be required. An new system should avoid the airways, airports and access facilities already overcrowded by the demands of air transportation. Any new system would have to be competitive with existing systems and ideally require a relatively small investment in new facilities. A new system would necessarily involve the establishment of a useable network as the initial stage of development.

The development of short take off and landing aircraft (STOL) and vertical take off and landing aircraft (VTOL) is an advancement of aviation technology that has the potential to provide service that parallels existing systems. Proponents of developing systems estimate the future of VTOL aircraft to be far beyond what could be considered as airport access transportation (34). The beginning of commercial VTOL travel will build on the existing commercial and military experience with helicopters. Early versions of VTOL aircraft will undoubtedly be large helicopters capable of linking city pairs up to 250 miles apart operating from small decentralized air terminals and thereby eliminating the present concept of airport access. Description of more sophisticated VTOL vehicles stagger the imagination. For example Jack Dymant, chief engineer for Air Canada has stated that

by the year 2000 all airplanes will be wingless, wheelless, lifting bodies. He predicts the existence of a 1,000 passenger, 1 million pound nuclear powered transport by 1990 (14). These predictions may indicate a too rapid rate of development and in some quarters may even receive the label of science fiction. Predictions such as these are about as believable as the statement that the United States would safely land men on the moon by 1970 must have sounded the day before the successful Soviet launching of Sputnik I.

The Vertol Division of Boeing Company predicts that if VTOL vehicles can be introduced to short haul flights of up to 250 miles in New York City by 1975 that VTOL transportation would account for 27 per cent of the projected air movements for 1985 (34). This traffic could be diverted from existing airports greatly relieving congestion.

The development of high speed rail service also has potential to serve as an acceptable substitute for air transportation for short distance intercity travel. European and Japanese experience with rail transportation has proven that dependable rapid rail transportation is possible.

An indication of the public's acceptance of rail transportation can be found in the experience gained with the New York City to Washington, D.C. Metroliner. In 1968 it was predicted that increased service provided by the "Turbo Train" and "Metroliner" between New York City and Washington, D.C. would increase travel demand by 10 per cent. Within the first six months of operation, the demand actually increased by 73 per cent (28). Service was inaugurated with three round trips daily and increased to six round trips daily in December 1969 with consideration being given to the provision of hourly service at some future date.

These gains in ridership are even more remarkable when viewed in the context in which they occurred. First of all it must be realized that although

the rolling stock and roadbed were of modern design, the equipment must be described as belonging to the first generation of rapid rail technology and has great potential for improvement. In addition the procedures of obtaining tickets, reservations and travel information can only be described as poor. A conscientious effort of marketing and the provision of modern ticketing and passenger handling procedures would have easily exceeded the limited capacity of presently available facilities.

The potential of rail transportation is recognized by the aviation industry as evidenced by a statement of George W. James, Vice President of Economics and Finance of the Air Transport Association of America in which he stated that "... while he expects long distance rail travel to be practically extinct by 1980 with Airlines handling 85 per cent of intercity carrier travel, the next decade will see a new and growing role for the new breed short distance trains such as the New York City to Washington, D.C. Metroliner. These trains will serve the 100 to 300 mile journeys through heavily populated corridors." (3).

Various planning commissions are beginning to recognize the future diversion of passengers from conventional commercial flights to alternate means of travel. A study of air travel demand in the Washington, D.C. - Baltimore Region for the period 1970 - 1990, sponsored by the Metropolitan Washington Council of Governments has estimated that diverted passengers would range close to ten per cent of total commercial air passengers by 1990 (6). The study expresses the opinion that alternate modes of travel such as vertical or short take-off and landing (V/STOL) aircraft operating from advantageously located sites and new high speed trains both require a great deal of technological development, but that such developments are very likely to occur by 1980. If both V/STOL aircraft and high speed trains are

providing reliable service, it is estimated nearly three and one-half million passengers per year could be diverted from traditional aviation by 1980. This number is projected to increase to nearly seven million in 1985 and over eleven million by 1990.

The predicted diversion of ten per cent of all air passengers in the Washington, D.C. area is of great significance to travelers and transportation in general, but will not unduly alter the foreseeable future of conventional air transportation. The ten per cent diversion by 1990 represents only a small part of the anticipated annual growth rate of the air transportation industry. The diverted travel would primarily involve short haul trips which have not been known for their profitability to the air transportation industry.

Of greater significance to the airport access problem is the realization that even with the development of alternate travel modes, the absolute size of conventional airports and the existing travel demands at these airports can be expected to increase. The massive land areas that have been accumulated for airport purposes will continue to attract large volumes of travelers regardless of the aviation technology being utilized within their boundaries.

Therefore, the development of airport access can take place with the assumption that although the new developments mentioned previously may alter air travel patterns, air terminals will increase in size and efficiency, creating a demand for much improved ground access facilities.

TRAVEL DEMANDS OF AIRPORT USERS

The solution of the airport access problem requires a thorough knowledge of the scope and character of the intra-urban travel demands of airport users. An analysis of the character of access trips must include the magnitude, spatial distribution and peaking characteristics of travel requirements.

Past efforts to determine travel characteristics have included various adaptations of origin and destination surveys. Information sought during these surveys traditionally includes the location of the local origin and destination, the mode of ground travel, time of travel and trip purpose. The collected data describes the extent, peaking characteristics and spatial distribution of airport related travel. Many surveys also request information about the traveler concerning the nature of his employment, family income, frequency of air travel, education level, sex, baggage information and more detailed information concerning the trip purposes. The socio-economic data are being used to determine causal relationships which will enable the construction of mathematical models to aid in forecasting future conditions.

The logistics of conducting an airport origin and destination survey at a major airport are involved and expensive. Initial preparation involves a survey of all activities at the airport in order to design a sampling procedure that will provide unbiased and representative responses. Advance preparation also includes the design and printing of questionnaires, hiring and training of survey personnel and the selection of a survey period that is representative of normal conditions.

The actual interview of airport users can be conducted in various situations. One method is a roadside interview of all traffic going to and from the airport. The roadside interview technique does not allow a detailed survey because drivers become uncooperative if delayed for more than about one minute. Data obtained are usually limited to the origin and destination, number of persons in the vehicle, trip purpose and time of interview. When employing the roadside interview technique provisions must also be made to survey persons using other transit facilities such as buses, rail transit and helicopters that provide airport service.

A second origin and destination survey technique is to conduct interviews within the airport terminal. Interviews are usually limited to air passengers and are conducted in the vicinity of loading and unloading facilities. Considerable difficulty is often encountered in attempts to conduct a survey amid the confusion and excitement that exists prior to boarding or while locating baggage.

A common survey technique involves the distribution of survey material while in flight with the completion of questionnaires being supervised by the flight hostess. This procedure requires the cooperation of all airlines using the airport and involves difficult coordination. Airlines usually agree to help conduct a survey provided the survey does not interfere with normal flight routines. The short travel times of modern aircraft often do not allow adequate time to provide the amenities of personal attention, meals and cocktails demanded by air travelers, much less allow time to conduct surveys.

The increasing dissatisfaction of air travelers with what are often considered to be disproportionate access travel times has resulted in increased numbers of airport access studies. A great number of surveys that are

motivated by dissatisfaction with airport access are designed primarily to study the travel demands of air travelers and largely ignore the travel demands of other airport users.

When considering the airport as a trip generator, it must be realized that air passengers constitute only a portion of the travel to and from airports. A meaningful analysis of travel patterns in the vicinity of airports must include the travel needs of all persons that utilize airport access facilities. The airport population is comprised of four groups, namely; air travelers, airport employees, visitors and persons that conduct business at the airport.

The significance of airport employment of traffic generation is demonstrated by the employment of over 37,000 employees at J.F. Kennedy International Airport; 6,000 employees at LaGuardia Airport and 5,900 employees at Newark Airport in New York City during 1966 (26). Similar figures show 37,350 persons employed at Heathrow Airport in London in 1966 (44). The impact of a major maintenance facility on total employment is demonstrated at the new Kansas City International Airport where Trans World Airlines operates a gigantic overhaul base which will serve TWA and other airlines. The 1969 employment at this single facility was 5,100 and this number is expected to increase after the airport becomes fully operational (37).

The number of visitors, defined to include well wishers and greeters of air passengers as well as persons using the airport facilities for leisure activity, constitute a larger percentage of the airport population than is commonly believed. Studies at New York City airports have indicated that sightseers are about equal in number to air passengers (26). As many as 11,500 persons have visited J.F. Kennedy Airport on Sundays for strictly

sightseeing purposes such as observing aircraft operations. The number of visitors has been found to vary between individual airports, but their presence always results in significant demands being placed on ground access facilities.

A fourth category of airport users includes various "service" personnel who are often grouped in a category of "other" for lack of a better definition. This group includes salesmen, vendors, deliverymen, repairmen and others who are not employed at the airport, but work there as part of their work routine. A study of various United States airports indicated that this group accounts for 3 to 7 per cent of the trips attracted to airports (46).

Figure 4 shows the estimated total airport populations on an average day in 1966-1967 as determined by a survey of access conditions of major United States airports conducted by the American Society of Civil Engineers Committee on Transportation To and From Airports (42). The airports surveyed included the 4 largest airports, 7 of the top 10 largest airports and 9 of the largest 15 airports in the nation at the time of the survey. The population groupings for this survey were similar to those previously defined except that persons on airport business previously described as "service" personnel were included in the visitor category.

The airport passenger category included persons enplaning and deplaning as well as transfers and through passengers. There is considerable variation in the per cent of through and transfer passengers found at various airports with this group accounting for 10 to 30 per cent of the total passenger populations.

At first glance the employee populations shown in Fig. 4 appear to be extremely low. For example employees at Kennedy International are shown to number 23,000 while it was previously reported that over 37,000 persons were

employed at the facility during the same period. Employee counts on a typical day indicate daily airport employee population to be considerably lower than total employment due to flight crew rotations, shifts, length of work week, vacations and sick leave. Completely independent findings in a survey at Heathrow Airport in London indicated that on the day of survey a total of 37,350 persons were employed at the airport, but only 23,750 reported to work (44). These figures are in amazingly close agreement with the data from Kennedy International.

Airport	Passengers	Employees	Visitors	Total
Atlanta	29,600	12,000	36,700	78,300
Chicago-O'Hare	50,000	16,000	25,000	91,000
Kansas City	6,700	1,100	1,500	9,300
Los Angeles	42,000	33,000	43,700	118,700
Miami	22,000	5,000	3,000	30,000
J.F. Kennedy	46,800	23,000	22,800	92,600
LaGuardia	17,200	3,300	4,000	24,500
Newark	14,000	3,300	4,200	21,500
Seattle	10,000	4,000	4,700	18,700
Wash,D.C.-Nat'l	26,000	13,100	26,000	65,100
Total	264,300	113,800	171,600	549,700
Per Cent	48%	21%	31%	100%

Figure 4. Estimated average day airport population (1966-67). (42)

Although the passenger category varies between airports, it includes 47 per cent of the combined populations of the airports shown. The passengers at individual airports range from 36 to 73 per cent of total populations. Daily airport access trips by various categories of the population however, are not proportional to their relative populations. Employees and visitors can be assumed to make two daily trips while enplaning and deplaning passengers make only one trip. Transfer and through passengers

do not contribute to access trip demands.

Using the total population data in Fig. 4 and the criteria that employees and visitors make two daily trips, enplaning and deplaning passengers make one trip daily and through passengers make no trips reveals the importance of persons other than air passengers in total trip demand. Admittedly, there is considerable variation in the per cent of transfer passengers that are encountered at the various airports, but for the sake of illustration an assumption of 15 per cent would be on the low side. In this example, air passengers, employees and visitors account for 28, 29 and 43 per cent of daily access trips, respectively.

The contribution of air passengers to total person trips shown in the above example agrees closely with survey information obtained at various airports. Port Of New York Authority data for 1967 indicates that airline passengers accounted for 27 per cent of average daily one way person trips at Kennedy International Airport (47). Similar data for San Francisco International Airport indicates that 33 per cent of 1967 weekday person trips were made by air passengers (47).

It can be concluded that airports daily attract large populations creating large access travel demands. The magnitude of these demands coupled with the realization that projected increases in air travel will cause similar increases in ground travel are indications of the severity of the airport access problem. The relative contribution of the various segments of an airport's population to the total travel demand illustrates the importance of not limiting an analysis of travel patterns to those associated with air passengers.

A complicating factor to the solution of airport access difficulties is the wide geographical distribution of origins and destinations of airport

trips. A map of desire lines from almost any airport indicates trip ends distributed throughout the metropolitan area. One distinguishing factor is the number of trip ends that are located within six miles of the airport. This factor can be attributed to the tendency of industry and businesses which frequently use air transportation to locate near an airport in order to minimize the costs and inconveniences of airport access.

A second item common to airport travel desires is the tendency for the central business district to be the major single origin or destination of access travel. The increasing public dissatisfaction with airport-CBD travel has resulted in emphasis being placed on this portion of the total problem.

An airport travel study conducted in San Francisco during 1967 indicated that only 9 per cent of outbound person trips were to the CBD (32). Data obtained during 1965 by the Indianapolis Regional Transportation and Development Study also indicated that 9 per cent of traffic bound for the airport originated in the CBD (32). From this and other similar data it can be concluded that the central business district accounts for only a small percentage of airport associated travel demands.

A survey by the American Society of Civil Engineers concerning airport access indicated that airline passengers, employees and airport visitors were responsible for approximately 50, 15 and 35 per cent of airport-CBD travel respectively (42). These percentages should not be accepted without caution. Generalizations of this nature may not be appropriate because of the great differences between cities and the difficulty of identifying the boundaries of each central business district. In New York City, for example The CBD is often defined as Manhattan Island which includes a very large area of commercial, industrial, institutional as well as very high density

residential land use. The central business district of other cities typically involve smaller land areas and certainly do not include the residential population that is found in Manhattan.

Central business districts do not account for a majority of airport access trips even when consideration is limited to access travel of air passengers. Central business districts of different cities generate varying percentages of air passenger airport access travel. Figure 5 indicates that the per cent of air passenger origins in the CBD range from 15 to 55 per cent for the selected airports. It should be realized that although the CBD is considered to be the origin or destination, it is not a single location. In reality the data describe many separated trip ends that accumulate within a large, hard-to-delineate section of the urban environment.

Airport	Per cent of Air Passenger Origins in CBD
O'Hare, Chicago	33
J.F. Kennedy, New York	47
San Francisco	20
National, Wash, D.C.	42
Newark, New York	38
LaGuardia, New York	55
Philadelphia	15
Cleveland	28
Pittsburg	25

Figure 5. Per cent of total air passenger origins in the central business districts. (47)

A third characteristic of airport associated travel involves the seasonal, daily and hourly variation in travel demands. The weekday hourly variations in volume are the most pronounced and closely approximate the peaking characteristics of other urban travel demands. As a result, airport traffic must contend with the inefficiencies inherent in peaked travel demands at the

time of day when competition for access facilities by other urban traffic is greatest.

Modern airports are major employment sites and work travel patterns are similar to the travel patterns at other employment centers within the metropolitan area. The majority of work trips occur between 7 and 9 A.M. and 4 to 6 P.M. Airports with major maintenance facilities which operate on three shift twenty-four hour schedules also experience a minor peak at midnight when the shifts change. Airports with a high percentage of clerical and office employment must contend with very high morning and evening peaks (45).

Travel patterns of air passengers do not exhibit the extreme peaking characteristics typical of work trips. The vast majority of air travel at major airports occurs between 8:00 A.M. and 10:00 P.M. with the percentage of travel within the peak hour ranging from 7 to 11 per cent. The combination of increased air travel and airway congestion has tended to distribute air traffic demands throughout the day causing a reduction in peaking. The introduction of new large aircraft in the 1970's can be expected to again increase peak hour demands (32).

A fourth characteristic of airport associated travel is the popularity of the private automobile as compared to public transportation modes that may be available. The dependence on the private automobile and highway transportation for airport access is a finding common to all airport access studies. The variations between cities are primarily a function of the relative importance of the airport facility as an employment center.

A 1967 survey at the San Francisco International Airport determined that 86 per cent of the 67,000 daily person trips departing the airport used the private automobile as their mode of travel (32). Figure 6 indicates the

great dependence on the private auto for airport access at San Francisco Airport. Air passengers were the only trip purpose category that made a significant number of trips by an alternate mode. The 18 per cent of the business, social and others category that utilized alternate travel modes included 1,185 truck trips. It is important to realize that even the public modes, with the exception of helicopter travel, are totally dependent on highway facilities.

Trip Purpose	TRAVEL MODE					
	Auto		Bus		Helicopter, Truck Taxi, Limousine Other	
	Number	%	Number	%	Number	%
Air Travel	15,487	72	2,610	12	3,308	16
Serve Passenger	18,403	99	133	1	40	0
Employees	17,950	91	198	1	1,492	8
Business, Social	5,856	81	102	1	1,291	18
Total	57,696	86	3,043	5	6,131	9

Figure 6. Mode of departing weekday trips at San Francisco Airport with relation to trip purpose in 1967. (32)

The modal choice of air passengers in New York City during 1967, is shown in Fig. 7. Although the dependence on the private automobile is not as great as in San Francisco, the combination of private automobile and taxi still account for 64 to 85 per cent of air passenger access trips. Modal choice information limited to domestic travel for a similar period shown an even greater dependence on automobile travel. Although marked differences exist between modal choice usage at the three airports, comparisons with 1956 data indicate an increase of auto-taxi usage, especially by domestic air passengers (12). Helicopter patronage has also increased

because this is a new service that did not exist at the time of earlier surveys.

ACCESS MODE	AIRPORT		
	J.F. Kennedy	LaGuardia	Newark
Airport Bus or Limousine	20 %	12 %	25 %
Helicopter	2 %	-	1 %
Commercial	-	-	10 %
Subway-Bus	3 %	3 %	-
Private Auto	46 %	38 %	54 %
Taxi	29 %	47 %	10 %

Figure 7. 1967 Summary of mode of airline passenger travel to New York City airports. (32)

Air travelers that are residents of the urban area in which the airport is located can be assumed to have greater access to a private automobile than non-residents. The differences in modal choice of resident and nonresident air passengers shown in Fig. 8 indicate that the use of private auto by residents is approximately 2 to 3 times that of nonresidents. The lack of automobile availability however, is partially compensated for by the use of rental automobiles by nonresidents. The use of a combination of private automobile, rented automobile and taxi in the cities of Dallas, St. Louis and Atlanta ranges from 94 to 97 per cent for residents and from 73 to 81 per cent for nonresidents. These figures again illustrate the predominance of the automobile as the principle mode of airport access.

Travel mode is also affected by the land use at the origin or destination of an access trip. Experience has shown that travelers from residential land use areas depend almost exclusively on private automobiles for access while travelers from commercial and business areas make greater use of

available public modes of transportation. The information in Fig. 9 describes the modal choice of air passengers traveling between CBD's and ten major airports. It is seen that automobiles, taxis and other highway modes account for the majority of access travel even in the CBD. The high usage of taxis at the San Diego Airport can be attributed to the close (2 miles) proximity of the CBD to the airport.

Access Mode	AIRPORT					
	Dallas		St. Louis		Atlanta	
	Resident 48%	Non.Res. 52%	Resident 49%	Non.Res. 56%	Resident 35%	Non.Res. 65%
Priv.Auto	92	48	79	33	87	30
Rented Auto	-	18	1	21	-	14
Taxi	5	15	15	20	7	29
Limousine	2	12	3	16	5	15
Other	.5	6	1	8	.5	10
No Response	.5	1	1	2	.5	2

Figure 8. Access modes as a percentage of originating air passenger trips made by residents and nonresidents of selected metropolitan areas. (31)

Airport	Private Auto	Rental Car	Taxis	Subway- Bus Transfer	Public Bus	Airport Bus or Limousine	Heli- copter
Atlanta	70	13	10	-	1	6	-
Chicago-O'Hare	18	6	36	-	-	40	-
Denver	44	5	35	-	1	15	-
Los Angeles	40	14	15	-	1	30	-
New York-Kennedy	22	-	44	3	-	30	1
New York-LaGuardia	16	-	65	3	-	16	-
New York-Newark	13	-	9	-	13	64	1
San Diego	10	10	80	-	10	-	-
Seattle-Tacoma	27	-	15	-	1	54	3
Wash,D.C.-Nat'l	12	3	64	-	2	19	-

Figure.9 Modal choice of access travel by air passengers between airports and central business districts expressed as a percentage. (42)

The dependence on the automobile as the primary access mode is not limited to the United States. A survey conducted at Heathrow Airport during 1966, revealed private transportation, which was defined to include taxis, accounted for 60 per cent of nontransfer passengers on business trips and from 45 to 55 per cent of nontransfer passengers on pleasure trips (44). In addition, approximately 76 per cent of employee trips were by private modes even though only two-thirds of the employees were from car owning households. Smaller surveys conducted at Heathrow have indicated that the percentage of persons using private modes of transportation has been rather stable with a slight shift to private modes. This trend indicates that although the slight shift to private transportation is not dramatic, it will proceed at least as rapidly as increases in employment.

The origin and destination survey technique has permitted an analysis of travel demands that exist at a particular airport and the comparison of travel patterns at different airports. Comparisons have shown that each airport has its individual characteristics depending on the size, geographic location and function of the facility as well as the character of the surrounding environment. The similarities between travel patterns at various airports overshadow their differences.

Similarities in travel patterns include the contributions of persons other than air travelers to the total traffic, the wide geographic distribution of trip ends, peaks in traffic volumes which correspond to work shift scheduling and peaking of air travel, and the dependence of airport access travel on highways and the private automobile. The dependence on highway travel exists for all trip purposes and geographic distributions of person trips.

The characteristics of airport associated ground travel, although

common to most airports, should not be used as exclusive criteria in the design of future transportation systems. The origin and destination method of data collection and analysis has several shortcomings which could adversely affect planning activities.

In the first place, the collection and especially the combination of survey data for different cities, periods of time, and surrounding environments cannot be made without statistical bias. Various studies utilize different techniques and in varying degrees are subjected to nonresponse bias, sampling variability and the influence of unplanned events such as airline strikes. The absence of continuing or at least periodic surveys makes it difficult to even identify trends of travel characteristics at the same airport. This is not to say that the data available are not sufficient to describe the general patterns that exist, but that the data should not be used for exacting comparisons and projections.

A second danger in using survey data is the tendency to extend past and present behavior into the future without a full investigation of the desirability of such an action. Projections by extrapolation tend to lock in solutions prior to an understanding of the whole problem. In the area of airport access, it would be very easy to hypothesize that since air travelers have made little or no use of rail transit in the past or at the present that it would not be in the public interest to invest in future rail systems. If a similar approach had been taken fifty years ago, the aviation industry would not exist today.

Designers of future transportation systems must place emphasis on trip purpose, spatial distribution of trip ends and the time distribution of travel. The existing mode of travel is important only as an indication of the needs and desires of the traveling public and as a point of reference

from which future travel modes must evolve.

ACCESS TRAVEL MODES

The severity of the airport access problem can be expected to increase along with foreseeable advances in aviation technology and the rapidly increasing demands for intercity travel. Immediate solutions of access problems will utilize new developments in existing modes of intracity transportation which include automobiles, buses, limousines, trains and helicopters. New technological developments of vertical and short take off and landing aircraft (V/STOL), tube trains, multimodal containers, small automated cars, hovercraft and other air cushion vehicles, and dial-a-bus systems are likely to be used sometime in the future.

The increasing traffic congestion along airport approaches and the increasing demand for parking space in close proximity to airport terminal buildings are indications of the unacceptability of simple projections of present trends. These worsening conditions prompted the Federal Aviation Administration's Eastern Regional Director to remark that, "It will be absolutely impossible to continue the luxury of 1.2 passengers per surface vehicle entering an airport. Future access to air terminals will be possible only by some kind of public transit vehicle." (4). The extent and timetable for the required replacement of private transportation with public transportation systems is open to debate, but the need for improvement of existing systems cannot be questioned.

The admitted need for improvements in access conditions has spurred the development of varied access systems. Proponents of rapid rail transit, monorails, helicopters, highways, air cushion vehicles and other systems are

often in competition with each other, each claiming the best solution to the problem. With the exception of highway modes, proposed systems are generally lacking in experience with airport access service. Limited experience with new modes has been gained in demonstration projects financed with federal mass transit research grants.

Access systems can be grouped into general categories of highway vehicles, rail oriented vehicles and vehicles that operate without fixed facilities. The characteristics of these broadly classified groups will be discussed without attempting modal comparison.

Highway Oriented Modes — The wide geographic distribution of trip ends can only be served by a wide-spread transportation network reaching into every part of an urban area. The network of streets and highways is the only existing system that fulfills this requirement. The present network of freeways, highways and streets literally enables door to door transportation between any two locations within a metropolitan area.

The existence of an extensive highway network combined with the popularity of the automobile has resulted in traffic congestion along roads serving airport facilities as well as along highways throughout much of the urban area. The trend of urbanization and the movement to the suburbs have increased the dependence on the automobile to such an extent that in many instances the automobile is the only travel mode available for urban transportation. Admittedly it can be argued that present urban structure is the result and not the cause of automobile usage, but debates to determine whether the chicken or the egg came first are not important at this point in history. Of real importance however, is the realization that congestion along many routes has become so severe that the dependability of highway travel is in question.

Congestion not only affects travel by private automobile, but also hinders transportation by rented automobiles, taxis, limousines and buses.

The reduction of traffic congestion while travel demands are increasing can be accomplished by the addition of new facilities and by increasing the efficiency of existing facilities. The addition of new facilities could be accomplished by the construction of more highways or other transportation modes which will be discussed later.

At many airports considerable gains can still be achieved by the addition of new highway facilities. The provision of additional interchanges to facilitate the separation of employee and air passenger traffic could have profound effects on peak hour congestion at many airports. Projected increases in air freight will require major revisions in existing circulation patterns in order to efficiently serve the increasing number of trucks that will be attracted to cargo terminals. It is reasonable to assume that efforts to improve circulation patterns by constructing new facilities will continue in the future as they have in the past. Experience has shown however, that the reduction in traffic congestion resulting from the construction of new facilities is often a short-lived condition negated by the attraction of additional development and travel demands along the new facility.

There are several constraints that may preclude the solution of traffic problems by the construction of more and larger highway facilities. A partial listing of these constraints includes the high costs of construction, the undesirability of relocating large numbers of persons, housing shortages, damage to neighborhoods, various environmental considerations and the political unfeasibility of unlimited freeway construction.

Improved airport access achieved through a reduction in congestion could also be accomplished by improving the efficiency of existing freeways.

Traditional traffic engineering methods have concentrated on increasing the number of vehicles per hour that a facility can safely accommodate. New ideas and techniques still in embryonic stages, are beginning to recognize that the movement of persons is a more important criterion in judging the efficiency of a facility than is the movement of vehicles. In theory there is great potential for reducing traffic congestion by increasing the number of persons per vehicle. For example, if the average number of persons per automobile could be increased from the present 1.4 persons per vehicle to 3 persons per vehicle, the effect would be greater than the doubling of existing facilities. One traffic lane handling 1800 vehicles per hour with 1.4 persons per vehicle carries 2,520 persons per hour. The same lane can handle 800 buses per hour with 50 passengers per bus or 40,000 persons per hour, a 1500 per cent improvement.

One method of providing more efficient bus transit service and thereby making bus transit service more attractive to the urban traveler is to preempt a freeway lane currently devoted to mixed traffic which is composed primarily of private automobiles. Exclusive bus operations on an uncongested lane of a freeway would eliminate delays due to congestion along the major portion of an urban trip. Exclusive bus lanes would require the development of new traffic control procedures to insure efficient operations at the entrance and exits of the special bus lanes. A deterrent to the implementation of exclusive bus lanes is the public's reaction to the "wasted capacity" that would exist. For example only 54 (fifty passenger) buses are required to handle the same amount of passengers handled by 1800 automobiles averaging 1.5 passengers per vehicle. This traffic volume, although providing equal service, does not approach full utilization of a freeway lane. This condition however, does provide an incentive for automobile passengers to use public

bus transportation.

To overcome public objections to "wasted capacity" of bus lanes, provisions could be made to allow other multipassenger vehicles to use the bus lane until such time as bus usage required full use of the facility. Multipassenger vehicles would include limousines, mini-buses and even car pools with a set minimum number of passengers. An incentive for users of private automobiles to switch to public bus transportation would exist as long as the requirements for using bus lanes were stringent enough to insure an uncrowded rapid flow of traffic.

The preferential treatment of multipassenger vehicles has potential throughout the metropolitan area. The designation of certain streets or freeway lanes for the exclusive use of multipassenger vehicles and the development of traffic signal actuation systems that recognize the passenger carrying ability of a vehicle would greatly improve the travel characteristics of highway oriented public transportation. These improvements coupled with other obviously necessary improvements in bus scheduling and travel comforts could conceivably induce persons to use multipassenger vehicles thereby lessening general urban congestion.

The concept of providing preferential treatment for buses can benefit airport access systems in two ways. First of all since many of the delays encountered in travel to and from airports occur at scattered locations throughout the urban areas, any improvement in urban travel resulting from lessened congestion is also of specific benefit to airport users. A more obvious benefit involves the greatly improved and more predictable travel times between the airport and central business district that are possible when buses do not encounter traffic delays.

One proposal for solving the airport access problem at the new Kansas

City International Airport recognizes the potential of transit freeways (38). As a first step to the construction of an area wide transit system it is proposed to construct an exclusive bus highway from the CBD to the airport. Initial priorities would involve the purchase of all right of way and the stage construction of the bus highway beginning in the downtown area where the present effects of congestion are the greatest. This plan would insure the preservation of future transit corridors, develop community experience and acceptability of public transit and be the first segment of a area wide facility. The initial dependence on buses would not preclude switching to twenty first century systems as they evolve.

Projections for the year 1990 indicate that Kansas City International Airport will serve approximately 47,000 passengers daily of which approximately 12,000 will have origins or destinations in the CBD(38). Even when assuming a 10 per cent peak hour accumulation of air passengers and assuming that all air passengers traveling to or from the CBD will utilize bus transit (very improbable), the demand for airport-CBD service could be satisfied by only 30 (forty passenger) busloads during the peak hour. It is obvious that only a small percentage of the transit freeway capacity would be utilized by air passengers. The extra capacity would be utilized by buses providing service for employees commuting to work either in the CBD or in the airport vicinity.

The vehicle recommended for air passenger service is a highway type bus designed for comfort. Amenities planned include comfortable seats, climate control, stereophonic music, stock market news service and a dependable trip time of approximately 15 minutes. The commuter buses would be regular transit type buses, but with the capability of operating at speeds of 50 to 60 miles per hour. These buses would operate from "park and ride" and "kiss and ride" facilities located along the transit freeway.

It has been shown that highway oriented travel modes have the unique ability of providing airport access service to all parts of an urban area by utilizing the existing network of highways and streets. Highway oriented public transportation facilities have the potential of providing much improved service from the airport to the CBD and other areas of concentrated demand, provided the problems of congestion can be eliminated. The effects of congestion can be reduced by preferential treatment of buses on existing highways and the construction of special bus routes. An investment in right of way and pavement does not preclude conversion from highway type vehicles to more sophisticated transportation systems at some future date.

Rail Oriented Modes — According to a 1967 survey, rail service between airports and downtown areas existed in only seven locations in the world (22). These locations were: Boston, Berlin, Brussels, Johannesburg, London-Gatwick, Stockholm and two in Tokyo. Only the facilities at Brussels and London-Gatwick were patronized to a significant extent by airline travelers. Since 1967 rail facilities have also been extended to the Cleveland Airport. The airport-city rail link in Brussels is operated by the Belgian National Railway and is used by less than one-half of the air passengers. During recent years the facility has operated at an annual deficit (22). The London-Gatwick service has been the most successful with 60 to 75 per cent of the air passengers utilizing it for their trip to London. The success of the London-Gatwick rail service is attributed to the location of the air terminal directly on a heavily traveled commuter railroad, the lack of competitive bus service, the long distance for taxi service, and the congested roads between the airport and CBD which results in considerable time savings by rail. The service provides rapid trains with only 15 minute headways. Even though a

high percentage of the air passengers use this facility, the vast majority of riders are daily commuters.

The rail airport service in Boston has attracted very few air passengers or airport employees to its total ridership. The major weakness of the service includes the necessity to transfer to a bus for the final mile of the trip to the air terminal. In addition the airport is located only four miles from the CBD and as a consequence rail service cannot provide significant savings in time or money.

The only United States experience with rapid rail airport access has been gained from the 1968 extension of the Cleveland Transit System to Hopkins Airport. The Cleveland Transit System is a municipally owned operation that provides bus and rail transit throughout the Cleveland Metropolitan Area. The rail system was opened in 1955 and is the newest such system in the United States. With the 1968 airport extension, the system includes slightly over 19 miles of track.

The rail system is primarily a commuter route operating from "park and ride" and "kiss and ride" facilities. The new airport extension however, does enable transit service from the airport which is the western terminal of the rail system to any of 16 stops along the rail facility's 19 mile length. The 12 mile trip from the airport to the Cleveland Union Terminal which is the downtown transportation center, takes approximately 22 minutes (17). By comparison, rush hour travel by automobile on the recently completed freeway takes about 30 minutes. Time savings are greater for persons traveling past the downtown area to the eastern suburbs. Service is provided at 10 to 12 minute intervals with less frequent service during late evening hours. The fleet of rail cars includes 88 cars purchased between 1954 and 1958 with a seating capacity of 52 persons and 20 eighty-passenger, air

conditioned cars purchased in 1967 in anticipation of the airport extension. The new vehicles provide baggage facilities for the convenience of air passengers.

Cleveland took advantage of a unique situation and was able to provide rail service to the airport by constructing only a 4 mile extension of the then existing facility. Considerable publicity has been given to the airport access implications of the Cleveland Rail Transit, but it must be realized that this system is primarily a general purpose commuter facility operating nine free parking lots for transit users (18).

The Cleveland Hopkins Airport Access Study analyzed the impact of the rapid rail transit extension to Hopkins Airport. The study included a survey of airport users before rapid rail service was begun and a second survey after one year of operation. As shown in Fig. 10, it was determined that only 14.5 per cent of all air passengers originating or terminating their trips at Hopkins Airport used rail transit. The low acceptance is due in part to the poor area coverage offered by rail transit. Air passenger utilization of rail transit was greater in areas directly served by the rail system. For example, 26.3 per cent of the air passengers with origins or destinations in the rapid rail service area and 35.7 per cent of the air passengers going to or from the CBD chose rail transit as their access mode.

Of greater interest is the land use that exists at the local origin or destination of trips made by air passengers that used rail transit. Figure 11 indicates that the majority of air passenger utilizing rail transit have origins or destinations at private residences. This findings is contrary to intuitive judgement that a rail transit system would primarily be used between the airport and central business district. The Cleveland study however, indicated that only one-fourth of the air passengers using rail

transit begin or end their trip in the CBD. The limited desire of air passengers to travel to the CBD illustrates the relative unimportance of providing exclusive airport-CBD transit facilities.

TRAVEL MODE	LOCAL ORIGIN OR DESTINATION		
	Rail Transit Service Area	CBD	Total Area
Private Auto	45.2	17.1	56.8
Rented Auto	6.6	7.1	10.2
Taxi	10.7	17.6	8.5
Airport Bus-Limousine	8.7	20.3	7.1
Rail Transit	26.3	35.7	14.5
Other	2.5	2.2	2.9

Figure 10. Air passenger's mode of travel to and from Hopkins Airport, Cleveland, Ohio after opening of rail transit service expressed as a percentage of origin or destination classification. (17)

LAND USE	AIR PASSENGERS UTILIZING RAIL TRANSIT		
	Resident	Non-Resident	Total
Residence	79.0	25.2	54.9
Motel/Hotel	0.9	36.6	16.8
School	0.9	6.0	3.3
Place of Employment	13.0	2.4	8.3
Other Business Place	3.3	25.9	13.2
Other	2.9	3.9	3.5

Figure 11. Local origin and destination land use of air passengers using rail transit from Hopkins Airport, Cleveland, Ohio. (17)

Monorail systems are often mentioned in proposals to alleviate airport access problems. These systems, although dependent on new technologies, have many of the same limitations that plague conventional rail systems. Monorail trains must operate over fixed routes, require the acquisition of expensive right of way, require the construction of elaborate fixed facilities and finally do not possess the flexibility necessary to adjust to urban changes. Monorail systems are incompatible with existing trackage and terminal facilities and consequently cannot be used to extend a metropolitan service as was possible in Cleveland with traditional rail facilities. A major obstacle to the development of monorail facilities is the dependence on new and evolving technology and the requirement for unique designs for each new installation. As a result it is not possible to take advantage of the benefits of mass production and standardization that are possible with conventional rail designs.

A monorail system was opened for service between Tokyo and Tokyo International Airport in 1964. To date this facility has experienced limited success with a ridership of only 15 per cent of its 80,000 passenger per day capacity (22). One reason for the limited usage is that the running speed is only 37 mph which is less than the design objective. Difficulties of this nature can be expected in early prototypes of new technologies.

The failure of the Tokyo monorail to live up to expectations can also be attributed to several factors not related to technology (4). First of all the downtown terminal is poorly located requiring additional efforts to reach ultimate destinations. The terminal location at the airport also requires inconvenient transfers in getting to and from check-in facilities. In addition the fare is \$1.00 as compared to \$.10 on the area wide rail system. It is often less expensive to hire a taxi for the trip to the airport than it

is to take the monorail and a short taxi ride within the CBD. The monorail which is an almost exclusive CBD-Airport facility is not able to function as a part of the Tokyo rapid rail transit and consequently is totally dependent on CBD-Airport passengers which account for less than 30 per cent of all air travelers. A final reason for the lack of success of the monorail system is the competition of a parallel expressway. The Tokyo experience with monorails demonstrates that monorail systems have the disadvantages of conventional rail systems in addition to a few of their own.

A unique proposal for the solution of New York City's airport access problem involves a hybrid rail/highway vehicle. The vehicle is a highway bus modified with hydraulically controlled steel wheels that can be used for rail operations (19). The proposal involves the utilization of presently unused Long Island Railway trackage in the downtown area in an attempt to escape urban congestion. As the vehicles leaves the congested area the wheels are retracted and the vehicle functions as a highway vehicle. This proposal has advantages only in unique instances where unused existing tracks could be utilized to avoid congestion. Major problems of this concept include the comfort and noise levels of the vehicle, scheduling of operations in railroad yards and very complex labor union jurisdictional disputes involving vehicle operators. The inability of normally equipped buses to use the route would limit the operational flexibility of a metropolitan area bus company.

In general, rail transportation systems have the ability to move large numbers of persons from one point to another while maintaining reliable schedules. The high cost of right of way, permanent facilities, rolling stock and operating expenses require a large patronage if passenger revenues are expected to finance transit operations. Even the largest airports do

not generate sufficient travel demands over any one link to place substantial demands on a high capacity system. The Director of Planning and Development for the Port of New York Authority estimates that the peak hour passenger travel from Manhattan to Kennedy International in 1975 could be handled by only 70 buses. This demand in itself could not justify the construction of an exclusive Airport-CBD rail facility.

Air and Water Access Modes — One approach to the airport access problem is to avoid the congestion and high construction costs associated with ground transportation and develop alternate travel modes that utilize presently uncrowded waterways and airways. The rapidly developing technologies of vertical or short take off and landing aircraft (V/STOL) and air cushion vehicles (ACV's) have only opened the door to future possibilities involving these travel modes.

The major advantage inherent in water or air-borne modes of transportation is the ability to operate without expensive physical improvements along the traveled route. Independence from fixed facilities allows a flexibility in route selection not available to other transportation modes.

The V/STOL aircraft likely to be used in the immediate future will be improved versions of existing helicopters. Helicopters have the ability to operate from limited landing areas and do not require the construction of extensive facilities. As a consequence helicopters are capable of providing service to a number of locations within an urban area with a relatively small investment in permanent physical facilities. The relatively small investment required for permanent facilities would enable a city to construct helicopter terminals and continue the concept of operating private vehicles from public facilities as is done at airports and on highways. The limited investment

however, may even permit private operation of terminal facilities similar to the operation from the roof of the Pan American Building in New York City.

The speed inherent in helicopter operations enables fast and dependable service from scattered locations within an urban area to airport terminals located at some distances from the CBD. Rapid travel is becoming increasingly important because of recent trends toward locating centralized regional airports long distances from established central business districts. Although helicopters are not a recent invention, VTOL technology is still in its early stages of development. Existing technological limitations that affect the dependability of VTOL aircraft for airport access use are the problems of perfecting instrumentation for low level urban flying and the problems involved in developing sufficient lifting power on hot days. Research efforts in VTOL development show great promise for developing lifting capacity far in excess of the requirements for intra-urban travel. In addition it is not unreasonable to expect advancements in navigational aids that will enable safe low altitude all weather urban navigation.

Present models of commercial passenger helicopters have relatively high direct operating costs. For example Los Angeles Airways' experience with 28-passenger Sikorsky S-61 helicopters indicate costs to be about \$.075 per seat mile (29). There is every indication that future larger VTOL aircraft will bring about reductions in costs per seat mile similar to those that occurred in fixed wing aviation as larger aircraft were developed.

The major deterrent to large scale intra-urban helicopter service is the growing public opposition to noise. Organized opposition to noise pollution is increasing as a result of a growing public awareness of the environment and research efforts investigating the effects of noise on human beings. The end result of public opposition is the regulation of helicopter operations

to the extent that helicopters are limited to set routes and hours of operations. Social and environmental considerations could easily preclude the development of the full potential of VTOL travel.

Helicopter access service is presently available at several major airports. Helicopter fares at the New York and Seattle airports are shown in Fig. 12 and are seen to range from about twice the taxi fare at LaGuardia Airport to less than the taxi fare at Newark Airport (42). The peak hour travel time from Manhattan to Kennedy Airport by helicopter is 8 minutes as compared to one hour by taxi. Caution must be exercised when comparing the travel times and costs of helicopter and taxi access travel because helicopter costs do not include the time and expense of travel to the heliport and taxi costs do not include the customary tip expected by the driver. These hidden costs tend to be compensatory. In addition several airlines subsidize the cost of helicopter access in which case the cost to the passenger is only \$5.00.

AIRPORT	Distance to CBD (miles)	Peak Hour Speed (MPH)		Peak Hour Travel Time Minutes		Fare \$	
		Heli- copter	Taxi	Heli- copter	Taxi	Heli- copter	Taxi
Kennedy-N.Y.	16	120	16	8	60	10.50	6.00
LaGuardia-N.Y.	7	70	11	6	40	7.35	3.50
Newark-N.Y.	13	130	26	6	30	10.50	11.85
Seattle-Tacoma	12	144	29	5	25	8.00	7.00

Figure 12. Comparison of helicopter and taxi travel times, average speeds, and fares for peak hour conditions at selected airports. (42)

With the expenditure of \$11.50 for helicopter access in New York City and a similar expenditure for helicopter service in London, it is possible to save nearly two hours in a trip from downtown New York to downtown London. This savings is equivalent to the time expected to be saved by the introduction of the SST (23). This example illustrates the potential improvement in total travel times that can be achieved by improved VTOL access.

Los Angeles Airways provides access service for approximately 2 per cent of Los Angeles International Airports' air passengers with a fleet of 28-passenger Sikorsky S-61 helicopters (29). Los Angeles Airways' President M. Belinn expects future helicopter operations to reach 20 per cent of the market by the construction of ten strategically placed "Skyports". A "Skyport" is a transportation center which provides satellite terminal facilities, parking and public intraurban transportation. Transportation centers could very easily provide restaurants, shops and other facilities as traffic increases. Skyports served by future versions of VTOL aircraft will not be limited to airport access responsibilities but will have the potential to become transportation centers serving the entire metropolitan area.

Vehicles that can operate on bodies of water also have the ability to provide transportation service without large investments in permanent facilities. Air cushion vehicles (ACV's) have been promoted as a means to utilize existing waterways to provide urban transportation. ACV's can operate as amphibious craft kept slightly above the water surface by a discharge of air directed downward. ACV's can theoretically operate over land or water without elaborate facilities such as rails or highways, but present experience has been limited primarily to water routes with minimum amounts of land travel. Operations on land have encountered high "skirt"

maintenance costs and problems caused by sand and dust being ingested into the engines.

A demonstration project to study the potential of ACV's to provide access to the Oakland and San Francisco Airports was conducted by the Port of Oakland in 1965-66. The demonstration included service between downtown Oakland and the San Francisco International Airport and Between downtown San Francisco and the Oakland International Airport. Fares, scheduling and promotional efforts were integrated with an existing helicopter service providing similar connections.

The infancy of the state of development of ACV's was evidenced by the lack of a United States manufactured ACV suitable for a test of this magnitude. The vehicles chosen for the test were two 14 passenger SR.N5 ACV's manufactured by Westland Aircraft, Ltd, England. These craft were modified by Textron Corporation's Aerosystems Company and renamed Sk-5 ACV's (30). The craft were all metal, 23 ft. wide, 38 ft. 9 in. long, with a gross weight of 15,000 lbs. and were powered by a General Electric turbine engine. The craft was capable of 70 mph and could travel a 17 per cent gradient from a stop position.

The Oakland demonstration was designed to evaluate the operational feasibility of utilizing ACV's for scheduled service over water, the economic feasibility of such operations as based on direct operating costs, and the passenger acceptance of vehicles in terms of their predominant comfort characteristics. Trial operations were controlled by Coast Guard regulations limiting operations to daylight hours and to speeds not in excess of 50 knots. In addition passenger operations were suspended when winds exceeded 25 knots, waves were over 3 feet and visibility was less than 1000 yards.

Test results indicated cancellations due to weather conditions were

more frequent than can be considered satisfactory. During June and July cancellations rates due to weather were approximately 20 per cent. These cancellation rates must be viewed as limitations of the test vehicle and not the ACV principle. The introduction of larger and heavier craft with improved navigation and radar systems would eliminate weather cancellations except for the most severe conditions. Trip cancellations due to mechanical difficulties were also more frequent than could be tolerated for extended operations. The necessity of obtaining replacement parts from England contributed to long periods of down time. A major reason for mechanical problems was the construction of the vehicle from essentially off-the-shelf hardware which was originally designed for other uses. It is expected that greater reliability would result if components were designed specifically for ACV use. Special design of components could be warranted only if a large demand for ACV's could be foreseen. During the test it was discovered that the ACV could not be operated indiscriminately over land because of problems associated with the ingestion of dirt and sand particles into the engine. The dust problems were remedied by paving a sand approach and by sprinkling water on a dirt approach (30). These minimum precautions proved satisfactory, but did point out the requirement of taxiways for ACV's operated on land.

Passenger acceptance of the vehicles' characteristics which included rocking motion, vibration, noise and crowded seating conditions was favorable. It is difficult to determine the effect that novelty and "sense of excitement" contributed to the passengers initial reaction. European experience with ACV's has shown that service with new and larger craft is commercially feasible in areas adjacent to large bodies of water. An official of Textron Corporation's Bell AeroSystems Company estimates improved service at a reduced cost as new and larger ACV's are introduced (15).

Problems inherent in ACV operations include the dependence on waterways for the major portion of travel, the necessity to provide some sort of taxiway for overland travel, high operating costs and general inexperience with this travel mode. Proponents of extensive ACV operations can expect to meet strong public opposition to the disrupting effects of rapid vehicles on the general "peace and tranquility" associated with environmental and recreational aspects of bodies of water. The many problems associated with ACV operations, not the least of which is the dependence on waterways, make it unlikely that ACV's will become generally accepted as airport access vehicles.

LAND USE CONSIDERATIONS OF AIRPORT ACCESS

Historically transportation has played a dominant role in determining the location and structure of urban areas. Early United States cities were located along the seacoast and at junctions of major rivers because of easy access to water transportation. As rail transportation developed, inland cities located at points with access to railroads exhibited very rapid growth. Similarly as a national network of highways developed, urban location and form were directly affected. The full impact of air transportation on the location and form of urban development has not yet been experienced. If history can be considered an indicator of the future, there is no reason to expect air transportation to have a lesser impact on urban form than those exerted by past transportation technologies.

The problems inherent to airport access are directly related to the evolution of land use patterns of an urban region. A very broad view of urban structure is necessary in order to develop an appreciation of the interdependence of land use and airport-associated intra-urban travel. Consideration must be given to all areas within an urban region not just to a limited area such as the central business district. In planning for the general welfare of an urban region, conscientious efforts must be made to avoid maximizing the efficiency of a subsystem (such as the airline industry or a political entity) to the potential detriment of the entire urban region. These broad objectives cannot be achieved without examining the land use potential of the entire region.

This chapter will examine several relationships of urban land use and

airport development as they relate to the airport access problem. These relationships involve current trends of urbanization, decentralization of urban areas, the selection of airport locations, airports functioning as centers of economic activity and direct relationships between land use and intra-urban modes.

Effects of Urbanization and Suburbanization — The underlying cause of a myriad of urban problems, including transportation inadequacies, is the concentration of the majority of the population on a small proportion of the available land area. The migration of rural population to urban areas and the natural growth of urban populations has concentrated a wide spectrum of problems in a few metropolitan areas. If present trends continue unabated, the year 2000 will find 208 million people crowded into large cities with 3 per cent of the nation's land area, another 45 million in smaller cities with 1 per cent of the land area and the remaining 57 million persons living in rural areas with 96 per cent of the land (43). Problems involving travel congestion are directly related to the rapid urbanization of society.

General trends toward urbanization are accompanied by the decline of the relative importance of central business districts. The move to the suburbs by industry and population has created a loosely bound urban form typically described as suburban sprawl. There is no reason to believe that trends toward urban decentralization will end.

The spatial distribution of decentralized land use patterns greatly complicate the problems of intra-urban transportation. The most obvious effect on airport access involves the greatly increased travel distances between the airport and other areas within the urban region. Unfortunately, the move to the suburbs is led by the same affluent part of society that

constitutes a major portion of the demand for air travel. As a consequence the proportion of air travelers with origins and destinations outside the central city can be expected to increase.

The large amount of land required for suburban, low density, land use patterns has caused suburban development to extend long distances from the central business district into the countryside. As a result new airports have been forced to locate long distances from the populations they serve.

The Airport Location — The growing demands for air travel and the evolution of jumbo aircraft have resulted in requirements for huge centralized airports. Existing facilities at many major airports are inadequate to meet projected demands without extensive expansion. Unfortunately other land use has been allowed to develop around the airport in a manner that makes further expansion impossible. The only alternative is to construct a new airport similar to what has been done at Dallas, Kansas City, Dulles Airport serving the District of Columbia and several other locations.

Although the importance of airport service to a community is almost universally recognized, the urban planner is faced with conflicting demands concerning airport location. Airline passengers desire air transportation to be easily accessible and as near their origin or destination as possible. At the same time communities want the airport to be located as far away as possible in order to eliminate the effects of noise and air pollution.

Organized opposition to airports has developed in such major cities as London, Tokyo, Frankfurt, Miami, Los Angeles, New Orleans, San Francisco and generally in any city immediately following announcements of proposed airport improvements (33). Major opposition has been focused on noise and alleged environmental damage to urbanized as well as undeveloped areas. Opposition to noise

can be expected to increase as air freight volumes increase because cargo flights will utilize night scheduling in order to avoid daytime congestion and attempt to maximize the efficiency of aircraft and airport facilities. Studies have shown that night time operations that interfere with television reception and sleep are more obnoxious to the public than daytime operations (21). The difficulty of selecting an airport location can be appreciated when it is realized that Dulles Airport (Wash., D.C.) and Dallas Airport required 10,000 and 20,000 acres of land respectively for the construction of airport facilities. Land requirements of this magnitude dictate the avoidance of urbanized areas. Urbanization in the New York City general area, for example, is so extensive that some areas 40 and 50 miles distant from the CBD are too densely populated to be suitable for airport development (33). To make matters even worse the large areas of relatively flat land required for airports are usually developed early. At the same time areas surrounding existing airports are so heavily urbanized that there exists little possibility for expansion of existing facilities. It seems reasonable therefore, to assume that future airports serving jumbo and supersonic aircraft will be located well beyond existing suburban development and 30 to 50 or more miles from existing central business districts. It becomes obvious that land use considerations and limitations greatly influence the severity of the airport access problem.

The historical trend toward the development of larger, more centralized airports designed to serve new and larger aircraft may be nearing an end. The ever increasing problems of airport deficiencies, air space congestion, competition with incompatible land uses and the disadvantages of locating airports long distances from population centers may require a new concept of airport service (24). It is becoming apparent that centralized airports

cannot continue to serve the varied and continually increasing demands for airport facilities to serve airline passengers, business and private aircraft, greatly expanded cargo service, air taxi and helicopter operations. As a result two separate, but related trends in airport planning and design are emerging.

The first trend involves the decentralization of airport terminal activities in an attempt to relieve the ground congestion and access problems that exist in the immediate airport vicinity (36). Figure 13 is a rough illustration of the remote terminal concept. In the remote terminal concept aircraft service facilities remain centralized, but parking lots and passenger service are provided at strategic locations throughout the metropolitan area. These remote terminals become transportation centers providing air, bus and rail transportation service. Transportation centers can vary in size, but as a minimum must provide short and long term parking, perform all the required passenger service functions and provide a direct means of access to the central airport. Although Fig. 13 indicates air, bus and rail connections between the central airport and all remote terminals, it is unlikely that all three modes would be provided at each location.

Remote terminals could be ideally located in large regional shopping centers. Mutual benefits could be derived from the construction of additional transportation facilities and the concentration of large numbers of air travelers. The concentration of airport travel desires in a few regional centers would greatly simplify the task of providing public transportation to different parts of a metropolitan area. Air travelers would still be required to use private automobiles, taxis and other travel modes for travel to and from the remote terminal. The benefits of the remote terminal concept cannot be realized without imaginative and compatible land use planning.

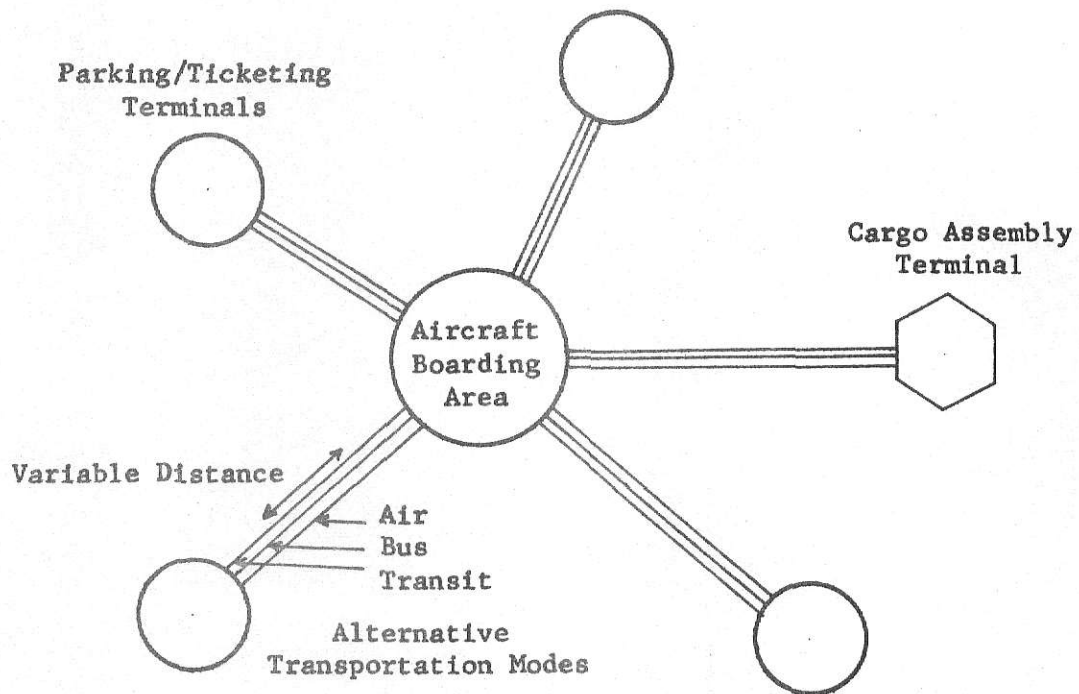


Figure 13. Remote Terminal Concept. (36)

A second trend of airport design that directly affects both land use and airport access is the use of specialized "satellite" airports to serve a regional area. It is becoming generally recognized that huge centralized airports increase airport access problems, are not compatible with private and business aircraft, have not been designed to handle projected cargo demands and drastically alter land use patterns. Satellite airports should be designed as a network serving an entire region rather than a single metropolitan area. Specialized satellite airports may be the only feasible way to provide diversified air service to the linear cities that are developing along population corridors. As the cities in a given population

corridor merge into a single urbanized area, associations with traditional political entities become meaningless. For example, as the area between Washington, D.C. and Baltimore, Md. develops, it becomes unimportant that Friendship Airport has traditionally been considered as the Baltimore Airport. Of real significance however, is that an airport system capable of serving the populations of the many surrounding cities is able to function and expand in a manner that will satisfy future demands. These long range needs can only be attained through land use planning.

Figure 14 is an idealized schematic of a network of satellite airports. The distances between the many air terminals range from a few miles to over one hundred miles. The scattered terminals would reduce access travel for VTOL and short range flights, but would greatly increase travel distances for long range and international air travel.

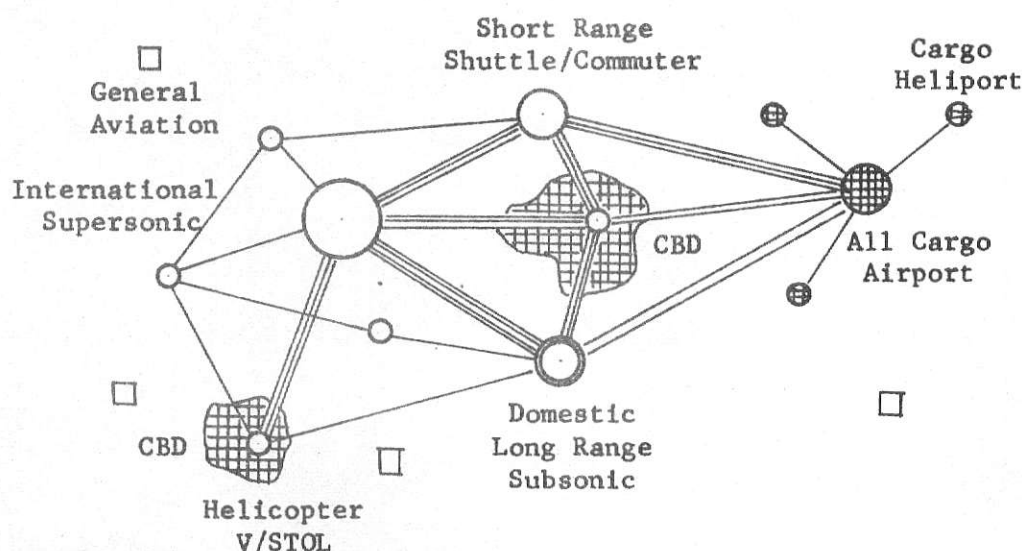


Figure 14. Future complex of specialized satellite airports. (36)

Both the remote terminal concept and satellite airport concept attempt to minimize the dependence of an urban area on a single airport location for all its air transportation requirements. As a consequence focal points for urban development are located at transportation centers dispersed throughout the area rather than being concentrated in the CBD and at the airport. The development of this land use pattern would require a network of access facilities serving the entire region rather than isolated point to point facilities.

Airports as Centers of Economic Activity — Airports have traditionally been viewed as transportation facilities and not as major centers of economic development. As hinted at previously however, population centers have historically formed around transportation interfaces and predictably, airports are rapidly becoming centers of economic activity not unlike central business districts. The attraction of industrial, commercial and residential development to the airport periphery results in highway congestion far beyond that generated by the airport itself. The construction of additional transportation facilities temporarily reduces congestion but simultaneously attracts additional development, further compounding the access problem. In all probability, peripheral developments will continue to expand until they become the nucleus of future centers of economic activity.

A study of the impact of airports on the market value of real estate has shown that airports greatly increase property values. The industrial land values in the vicinity of the San Francisco International Airport increased 1200 per cent during the ten year period from 1950-1960 (35). The value of land immediately surrounding the J.F. Kennedy International Airport similarly increased as a result of activities attracted to the airport. In

Chicago, the Centrex Industrial District immediately west of O'Hare International Airport is one of the most actively developing industrial sections in the entire metropolitan area. Since the opening of O'Hare Airport between 5000 and 5500 motel hotel rooms have been constructed near the airport (11). This is three to four times the amount of hotel development that occurred in the CBD during the same period. In addition over 3.6 million square feet of general office space has been constructed within 15 minutes travel time of the airport. Over forty per cent of this office space is owned by firms using the word "O'Hare" in their names (11). Even though airports are generally considered to be incompatible with residential land use, very high density multifamily residential development has occurred in close proximity to the airport. These dwellings are occupied by employees of the airport activities and the industrial business and commercial activities located nearby. The airport vicinity has all the facilities and services that are available in rather sizeable communities and continues to experience very rapid growth.

Rapid development of the areas surrounding modern airports can be attributed to the following factors (35).

1. The availability of air transportation including commercial, air cargo and private aviation attracts industries with a requirement for air transportation services.
2. Utilities installed to serve the airport can be easily adapted to serve nearby industrial facilities.
3. Open land beyond urbanized area provides the required space for modern horizontal industrial buildings. Low buildings are not incompatible with airport operations.
4. Flat terrain needed for airport development is also ideal for large scale industrial site development.
5. High capacity highway access provided for the airport also

provides direct access to nearby industrial facilities providing great inducement for industry.

6. Industrial and commercial development tends to attract more development. These agglomerative forces are caused by the interdependence between industries, labor, and infrastructure that is inherent in modern society.

The establishment of new population centers located some distance from present urban centers greatly complicates the problem of airport access. One approach available to the urban planner is to use the airport as a focal point for the design of "new towns" whose economy is based on industrial and commercial activities with a large demand for airport services. The access problem would be "solved" by the gradual relocation of activities with significant demands for airport services. On the surface this approach may appear to show a blatant disregard for existing urban development, but on closer examination it is seen to be only an expression of historical developments that occur immediately after the introduction of a new transportation technology. Furthermore this approach is only an expression of events already occurring without the guidance of a land use plan that fully recognizes the complexities of urban growth. The problem at new airports is not if relocation and new development will occur, but if they can be accomplished in a manner that will insure land use and transportation efficiencies. An acknowledgement that the airport-ground transportation interface is a predominant factor influencing the location and form of future urban centers would permit deliberate and timely planning of future developments.

Land Use and Transport Modes — The private automobile is used for 96 per cent of all daily passenger trips in urban areas and is also the primary

travel mode utilized for airport access (41). The popularity and widespread ownership of private automobiles have permitted land use patterns to change from dense developments along fixed transportation routes to a wide spread, low density suburban development structured totally around a network of streets and highways. Urban planners have designed neighborhoods with a complex system of local and collector streets intended to discourage travel through residential areas. The resulting maze of streets serving low population densities virtually prohibits door to door intra-urban transportation by any mode other than the private automobile. The popularity and dependence on the automobile is a self-fulfilled prophecy because land use was designed to take maximum advantage of the extreme mobility afforded in automobile travel. It is virtual certainty therefore, that the automobile will continue to be used by employees, airport visitors and air passengers with origins or destinations in low density residential land use areas.

The ability of rail systems to rapidly transport large numbers of passengers is of little value unless land use patterns can insure the existence of a large demand. Experience has shown that at least one of three conditions must exist if rail systems can be expected to attract significant ridership (41). The first condition is that the central city or primary service area must have a high population density of at least 14,000 to 20,000 persons per square mile. A second condition is the existence of a strong central business district with employment exceeding 100,000 persons, a minimum of 50 million square feet of floor space and daily CBD destinations of 300,000 persons per square mile. Finally rail transit may be successful if serving a single corridor with over 70,000 daily person trips bound for the CBD or other single destination by all modes. These extreme conditions do not exist in many central business districts much less at airport developments.

The construction of new rail facilities involves many of the same disruptions encountered in the construction of new highways. The separation of neighborhoods, increases in the noise level and the concentration of transit riders would all have a pronounced effect on existing land use.

Although bus systems are not compatible with low density suburban developments, they do not require the high densities needed to support rail transit. The ability of buses to use existing streets and highways minimizes the impact of a new bus system on a community. It is conceivable that concentrations of apartment complexes combined with park and ride facilities would support bus service for daily commuters to the airport. It is unlikely however, that significant concentrations of air traveler origins and destinations would result from these actions.

Helicopter service is not compatible with many existing land use patterns because of the noise level associated with present aircraft. As a result commercial helicopter operations are generally restricted in the use of urban airspace in a manner that limits the potential of helicopter intra-urban travel. The future of intracity air transportation is dependent on the establishment of land use patterns that designate the location of heliports and corridors in which VTOL aircraft can operate without disturbing residential areas, hospitals, schools and other land use areas sensitive to noise. The success of VTOL operations is as dependent on land use plans and air rights zoning as it is on aircraft technology and passenger demands.

The most serious problem facing public modes of transportation is the lack of an efficient collector system capable of serving low density land use. When consideration is limited to air passengers, the problem becomes even more severe with the central business district being the only location with significant concentrations of air passengers. Furthermore the term

"CBD" is often used indiscriminately to describe the downtown area and brings to mind a stereotyped image of a compact area containing the economic heart of a city. In reality however, the geographic area represented by the term CBD involves an extensive grouping of different land uses not capable of being conveniently served by one transit terminal. The traveler is required to use a taxi or other means of conveyance to get from the transit terminal to his ultimate destination. The time gained by using rapid transit for travel to and from the airport can easily be lost while engaged in transferring from one mode of travel to another. The downtown terminal location of the Tokyo monorail system mentioned previously is an example of a downtown terminal considered to be at least partially responsible for the less than expected use of the airport-CBD monorail system. The difficulty of locating a new transit route and terminal within an established CBD in a manner that maximizes passenger convenience and minimizes adverse community effects cannot be over emphasized.

PROBLEM ANALYSIS

An attempt has been made to present information concerning the airport access problem as it is usually understood. The problem can be briefly stated as the inability of urban transportation systems to meet the rising expectations of air travelers with regard to the travel time and reliability of travel to and from airports. Much of the literature implies that the solution to the airport access problem is a simple matter of choosing between the latest developments in urban transportation hardware thereby providing access facilities adapted to the travel demands of a particular airport. There is no question that man possesses the ability to design, build and operate transportation facilities ranging from conventional highway, rail and helicopter modes to exotic high speed vehicles powered by linear induction motors and vacuum tubes. If man can build and operate spacecraft and lunar vehicles, he is also capable of developing urban transportation systems that can only be described as present day science fiction.

The solution to the airport access problem however, is not limited to problems of technology. The limited resources that are available for urban services and capital improvements make it imperative that all available resources are used in the best possible manner. The resulting competition for funds by such diverse needs as health, education, recreation, transportation and utilities requires the establishment of a system of priorities. When faced with a myraid of urban needs it is very likely that urban governments will not consider airport access as critical as the overall urban transportation problem or even as important as other social needs. The complex

interrelationships of the many urban problems, not the least of which is a shortage of funds, require that airport access be considered as only a part of the total requirement for improved urban transportation.

The analysis of airport access must begin with the identification of basic community goals and the role that transportation must play in the achievement of these goals. Transportation problems and requirements for transportation improvements should be identified and described as simply as possible. It is not possible to identify and maximize the benefits of a program of improvement unless the problem areas as well as the desired objectives are specified. A fundamental question that must be answered is, "Does the airport access problem exist because the community requires better air transportation or because airport traffic comprises an especially significant part of the urban transportation problem?"

Airport associated travel in large urban areas is without exception only a small fraction of the total urban travel. In most instances airport traffic is even a minor portion of travel that occurs within the major travel corridor serving the airport and central business district. Since the airport is only one of several major traffic generators located in an urban area it is apparent that even a total and immediate solution to the airport access problem would not have a major impact on the total urban transportation problem. The impact on urban transportation is especially insignificant if the airport access "solution" is oriented toward serving the approximately ten per cent of airport associated trips that are made by air passengers with origins or destinations in the CBD (10). The minimal effects of an airport access solution on urban transportation would indicate that greater benefits could be achieved by other approaches to the problems of urban transportation.

In the event the airport access problem is defined as a need for better air transportation, the need for improved access can be considered somewhat differently than general urban transportation requirements. When defined in this manner airport access is clearly a subsystem of air transportation and must be analyzed as such. The objective of air transportation is to provide safe, dependable and rapid transportation from a given location in one city to a location in a second city. There should not be major concern over what portion of the total trip is spent airborne, in the terminal or in local travel, as long as the overall trip time is reasonable. It may be possible to achieve greater improvements in air transportation by improving access conditions than by seeking further reductions in air travel times through the development of faster and more sophisticated aircraft. The reduction of access time is therefore, a means by which the primary goal of improved air transportation can be achieved.

Reduction in access times can be achieved by any of a combination of alternate approaches to the problem. The first involves the elimination of delays that occur in terminal activities such as parking, securing tickets, checking and claiming baggage and in the long walks often encountered in boarding aircraft. This report does not explore the various efficiencies that could be achieved by improvements in terminal design and procedures involving passenger services except to acknowledge that substantial improvements are possible. The concept of remote terminals mentioned previously is only one of many innovations involving passenger handling procedures that has the potential of greatly reducing congestion and the accompanying delays without necessarily reducing actual access travel times. An interesting feature of the improved terminal services alternate is that all passengers stand to benefit from any improvement as compared to a limited number of

passengers that can take advantage of specialized transit improvements such as a rail link to the CBD or helicopter service to selected locations.

A second alternate to reduced access travel times is the provision of new rapid access facilities. These facilities could be any one or a combination of the travel modes previously discussed. Although the provision of new access facilities is considered as one alternate, it involves making a selection of one of many subalternates. Basically the decision to construct additional facilities involves the identification and evaluation of the benefits and disbenefits to air passengers and society in general. Every effort must be made to quantify the benefits of real savings in time and the value of increased service. Similarly the negative effects on land use and the environment as well as the monetary costs of construction and operation must be evaluated and quantified. The effects should be evaluated in accordance with the basic goals of the community and not according to a secondary criterion such as the ability to collect sufficient revenue to be self sustaining.

Limited mention will be made concerning the advantages and/or disadvantages of the various technologies of intra-urban travel. The reluctance to become deeply involved in discussions involving technology is based in part on the belief that the greatest benefits can be derived by concentrating on the objectives of transportation rather than on a particular method by which the objective may be achieved. The application of technology without a good view of goals is to have "solutions looking for problems" (1). A second reason for not considering particular travel modes to be more applicable than others is that unique situations require individual solutions. A personal bias to a particular mode could prove to be a detriment to the evaluation of

a given situation. A third reason to avoid a discussion about technologies is that a process of evaluating the benefits and costs to society of a large number of alternative solutions will in itself lead to a supportable decision regarding the most desirable alternate. This procedure will insure a solution based on the goals and evaluation criteria established by a particular community.

A third alternate to reduced travel times and more reliable access is to concentrate on an area-wide urban transportation system with the realization that improvements in area wide transportation will also benefit airport associated travel. This approach may be the only way to achieve improved service to a significant portion of the geographically dispersed travel demands characteristic of airport associated travel. The establishment of priorities to capital improvements involving transportation could be accomplished in a manner that would benefit airport travel as well as general area wide transportation. For example the construction of an airport-CBD public transportation link (rail or bus) as the initial or early phase of a regional network would certainly benefit airport access. A heavily traveled airport-CBD corridor could very possibly be an ideal location in which to inaugurate new transit service.

The position of the federal government to date has been to consider airport access as only one of the ingredients in the total metropolitan transportation problem (2). The rationale behind this position is to encourage the construction of systems that will serve every key point within a community with airports naturally being one of the most important points. The congestion problems on roadways to and around airports are considered to belong to the communities involved and federal participation toward their correction is limited to existing federal programs for urban and transportation

improvements. All improvements must be in accordance with a comprehensive, cooperative and continuing planning effort for the entire metropolitan area. These requirements insure that improvements are constructed in accordance with community objectives and that the airport facilities will be convenient to the community as a whole and not just to the downtown area. Special consideration can be given to projects involving research and development of modernized transit systems that also have potential for improving access travel. Research and development projects have been funded for projects directly involving airport access in the San Francisco-Oakland ACV experiment, New York City helicopter service and the Cleveland Airport rapid rail extension. The basic reason for the expenditure of federal funds in these projects is to obtain experience with new technologies and not the solution of a particular access problem.

A fourth alternate to the airport access problem that must be considered, is the null or do nothing alternate. The oversight of this option can lead to the automatic construction of facilities to meet future "extrapolated" demands and what can be called the "make larger syndrome" (1). An analysis based on community goals rather than on the satisfaction of demands derived from extensions of past trends may indicate that the public interest would best be served by altering existing trends. A first step in this direction may well be the refusal to provide additional facilities.

The null solution, although rarely recognized as such, exists whenever there is competition for limited resources. Competition for funds insures that consideration is given to projects which the community believes will yield greater benefits. An example of a community decision imposing the null solution was the defeat of a general obligation bond issue for an airport access facility by the voters of Kansas City, Missouri. Kansas City voters

however, have since approved an increase in income taxes to be used for city services such as the hiring of more police and firemen and the provision of improved garbage collection. This example illustrates the fallacy of considering transportation problems separate from total community objectives.

Uncertainty regarding the expansion or relocation of airports is also responsible for decisions not to improve access facilities. The "wait and see" attitude concerning access improvement is in actuality the null solution being imposed until other more pressing problems involving airport location and land use are resolved.

In addition to decisions regarding the definition of the airport access problem and the evaluation of alternates to its solution there are two primary issues which must be resolved (1). The first is a decision regarding who is or should be responsible for airport access. The second issue that must be resolved involves the responsibility for financing access improvements.

The resolution of these questions again must begin with the community statement of goals and objectives. If for instance, it has been decided that airport access is a significant part of the total urban transportation problem causing congestion and delays of intracity travel, it is logical to conclude that benefits from improvements would accrue to the entire population. In this instance, where the basic goal of improvement of airport access is directed to the general improvement of urban transportation, it is logical to place responsibility for construction and financing upon the governmental agencies responsible for the transportation system. The priorities for specific projects would be established along with other needed transportation improvements of the community.

A more common situation is for airport access to be an insignificant part of the total urban transportation problem. The requirement for improved

access is predicated on the desire to improve air transportation. At this point it must be realized that the goal of improved air transportation in itself is not sufficient to warrant the investment of public funds. The requirement to consider the basic urban objectives when considering all improvements cannot be over estimated. This argument is presented much more capably by Britton Harris in the following quotation:

"Transportation is one of many ways that society uses to achieve its purposes. I will not discuss goals for transportation since transportation should have only one objective: namely, to assist society in the achievement of its most basic ends. The minute we begin to discuss transportation goals of efficiency, speed and so on, independently of the over riding needs of society or responsive only to a part of these needs, we are in danger of suboptimization. This can lead to aborting society's efforts to attain its own objectives." (39)

Therefore, it must be decided if air transportation provides sufficient economic and social benefits to a community to justify the expenditure of public funds for its improvement. Unless the dependence of a community upon air transportation is extremely obvious it may not be politically feasible to spend public funds for airport access facilities designed primarily for air passengers. This situation becomes even more acute when considering expensive high level of service facilities such as an airport-CBD rapid rail system which can serve only a small percentage of the widely dispersed air passenger travel demands. It is difficult to obtain broad public support for the construction of facilities to serve air passengers of which 75 per cent have annual family incomes over \$10,000 and 50 per cent have family incomes over \$15,000 while corresponding percentages are about 22 per cent and 6 per cent respectively for the public in general (48). In addition air passengers engaged in business trips are usually reimbursed separately for

travel expenses. Public attitudes toward specialized airport services as they relate to the financial problem of the modern city can require the re-evaluation of stated urban goals. This feedback is a necessary part of the planning process.

The determination of responsibility for financing airport access projects justified by economic benefits to a community is further complicated when consideration is given to traditional local, state and federal matching fund formulas. The project as viewed on a local scale may provide economic benefits by the attraction of businesses and the establishment of hotels, tourist facilities and other economic activities. When viewed from the federal viewpoint, benefits of this nature that accrue to a community are often achieved at the expense of a different community. From the viewpoint of the national economy as a whole, it is not proper to consider these transferred benefits when evaluating benefit-cost relationships unless there are underlying reasons for encouraging economic growth in a particular area. The development of Appalachia, assistance for economically depressed cities and the establishment of new towns in an effort to alter existing trends of urbanization are examples of social goals that may justify such action. It is doubtful that the best interests of the public are served when federal funds are used to finance projects that could be described as "Chamber of Commerce" type competition between communities for new industry and other commercial enterprise.

The air transportation industry is also a candidate for financial responsibility for the maintenance of the air transportation system which includes airport access as one of its subsystems. From the industry viewpoint such action may be justified whenever investments in access systems have the potential to yield benefits equal to those realized from investments

in new aircraft technologies or passenger handling facilities. The air transportation industry operating under a profit motive is unencumbered by many of the political and social issues faced by governing bodies when establishing priorities. As a result the justification of a project may be easier from the viewpoint of private industry than from local, state or federal governmental positions. The above reasoning is not to imply that industry profits could be realized by investments in airport access under present conditions, but only to recognize that improvements in airport access do benefit the air transportation industry. It is reasonable therefore, to place some responsibility for airport access upon the air transportation industry.

The development of the intracity helicopter service for air passengers mentioned previously is a unique opportunity for the air transport industry to provide technology and financial investment toward the solution of the access problem. There are several reasons why air transportation industry investment in helicopter access service appears to be a natural course to follow. In the first place the airport access problem is often considered to involve only delays encountered by air passengers. Helicopter service designed for air travelers could provide a valuable service for the "customers" of the air transportation industry. Helicopter access service could be provided at an additional cost that is only a small fraction of the total cost of a medium to long-distance air trip. This additional cost could be paid for directly by the passengers using the service or it could be hidden in the price of first class air fare along with the cost of movies, meals, cocktails and other personal services presently provided by airlines. An airline providing "free" access service may be able to achieve a profitable competitive edge over other airlines.

The modernistic character of helicopter access should be readily accepted by air travelers already accustomed to vehicles with rapid acceleration, noise and other aircraft characteristics. Travelers accustomed to the speed and dynamic nature of air transportation may be psychologically more willing to board a helicopter than a bus or subway. It seems a logical step for airlines to attempt to improve total trip quality by investing in access facilities especially if there is an existing demand for a potentially marketable service.

Another reason for air transport industry involvement in helicopter access is the potential of VTOL aircraft. There is no reason to doubt that access experience with VTOL aircraft will enable improvements in VTOL technology to the extent that VTOL aircraft will become the principal mode of commercial travel for trips less than 300 to 500 miles in length. By participating in early access developments, the air transportation industry would be in an ideal position to take advantage of evolving trends toward VTOL air travel for short to medium-distance transportation. The potential market for short to medium distance air travel is many times larger than the total existing market for air travel.

The determination of financial responsibility for airport access improvements has been shown to be a complex problem involving non-quantifiable relationships between various levels of government and private industry. The decisions of private industry and the various levels of government to invest in improved access facilities are based on completely different objectives and evaluation criteria. As a result it is not possible to derive a cost sharing formula with application to other than individual situations.

It has been shown that the solution to the airport access problem involves many alternatives involving technology, problem approaches and

responsibility for financing. It is not possible to approach the problem from the viewpoint of a single interest group because of existing interrelationships between internal airport circulation, external airport circulation and urban transportation networks. The importance of coordinating the efforts of airport authorities, the air transport industry, metropolitan planning bodies, state highway departments, urban mass transportation agencies and other affected agencies cannot be over emphasized.

SUMMARY AND RECOMMENDATIONS

Airport access has been shown to be an elusive problem involving rapidly increasing demands for air travel, geographically distributed trip ends, urban congestion, various trends in land use patterns and continually increasing expectations of air travelers. In addition the situation is complicated by the interrelationships of the many social, economic and environmental problems that exist in metropolitan areas. The establishment of priorities for public and private investment toward the alleviation of existing problems has been shown to be dependent on the objectives of a particular interest group. The established priorities may be in conflict with the viewpoints of other equally concerned and legitimate interests. The conflicts and competition for available resources between the many existing needs such as health, education, transportation, etc. makes it imperative that every decision is based on a broad comprehensive approach to the total urban situation.

Conclusions and recommendations concerning airport access improvements can be made only with the understanding that such recommendations are general in nature and that the situation at any particular location must be evaluated on its individual merits. The access problem is seen to be so imbedded in the form and structure of urban society that it would be foolhardy to propose specific modes, routes and transportation technology as a real and lasting solution. A proposal must also have the support of the general public if it is to have any chance of success. It is the conclusion of the writer that the solution to airport access problems should concentrate on the

following items:

1. The establishment of transportation objectives by which to achieve the community goals established in the comprehensive planning process.
2. The establishment of alternate intercity short haul transportation systems to reduce the dependence on conventional air transportation.
3. The establishment of land use patterns that are compatible with transportation systems.
4. The establishment of an intra-urban transportation network rather than a specialized airport - downtown link.
5. The establishment of remote terminal facilities with VTOL service provided by private investment.

Establishment of Transportation Objectives — The establishment of transportation objectives by which to achieve community goals involves the establishment of specifications for a transportation system. These specifications must include a quantification of required travel, level of service, need for modal choice, tolerable environmental effects and consideration of existing systems. Decisions regarding transportation needs must be based on the social and economic requirements of the community and not on desires to optimize a particular transportation subsystem. It must be realized that except in rare instances, transportation is not an end in itself, but only the movement of persons or goods to allow other social and economic activities.

The identification of transportation needs must be an integral part of the comprehensive planning activity of an urban area. Of specific importance is the determination of the role of air transportation in the achievement of community goals. The determination of a specific level of service for

airport access would include a comparison of the benefits that accrue at various levels of service in an attempt to find a realistic and economical solution.

The major reason for placing emphasis on the establishment of transportation objectives is to insure that airport access is considered within the context of the metropolitan plan. A program of this scope is greatly affected by almost every decision made in the planning process. Conversely the total plan is affected by decisions regarding airport access. The re-evaluation and feedback involved in the appraisal of economic and social benefits that accrue from improved airport access is a difficult but necessary beginning for a responsibly planned facility.

Alternate Modes of Intercity Transportation — There is a tendency to inflate the importance of air transportation to an urban economy by considering air transportation to be synonymous with rapid transportation to the exclusion of other travel modes. In actuality modern rail facilities have the potential to equal CBD to CBD travel times of air transportation for relatively short trips such as between New York City and Boston or Washington, D.C. In addition express buses operating on freeways with preferential treatment are capable of providing sufficiently rapid service to satisfy a significant percentage of today's air passengers. The development of direct intercity VTOL service from CBD locations is still another means by which dependence on existing centralized airports could be reduced.

The establishment of alternate modes of intercity short-haul transportation with high levels of service would provide needed transportation capacity without further aggravating existing airport congestion. The change in air travel demands that could result from the establishment of alternate

methods of travel would, in effect, extend the useful life of airports and airport access facilities thereby delaying or eliminating the requirement for new airports located great distances from an urban area.

The following somewhat facetious example illustrates the fallacy of the insistence on increased conventional air service in the Northeast Corridor area of the United States. Conventional air service between New York City and Washington, D.C. involves 24.8 and 14.3 miles of access travel to Dulles International and Kennedy International Airports respectively. The access distance involves over 17 per cent of the most difficult portion of the total trip, but does not contribute to the actual intercity trip. After completing the access trip, the traveler must enter the air terminal, check his luggage, board a "boarding lounge", board his aircraft, leave the aircraft, walk, get his luggage, and transfer to another travel mode for the access trip to the CBD. In the absence of alternate intercity travel modes, the traveler is willing to confront this regimentation and somehow still believe he has received a high level of service. Alternates to conventional air travel could be a 1 to 1 1/2 hour trip by modern rail service, a 1/2 to 1 hour trip by VTOL aircraft or even a 3 hour trip by bus. A side benefit of providing alternate travel modes in heavily populated corridors would be the ability to provide similar service to Baltimore, Wilmington, Philadelphia and other cities within the corridor with a relatively small investment in additional rails, bus lanes or heliports. This illustration is also applicable to other population corridors in the United States.

The establishment of alternate intercity travel modes with high levels of service would allow travelers a real choice in transportation, thereby reducing the dependence on air travel and the associated problems of airport access. Traditional fixed wing aircraft would be relegated to medium and

long distance travel, a job to which they are ideally suited. The construction of additional intercity transportation systems would extend the useful life of existing airports, reduce the requirements for access facilities and most important provide improved service to intercity travelers.

Compatible Land Use Patterns — The establishment of land use patterns that are compatible with transportation systems is an essential ingredient in any attempt to provide efficient airport access. An initial land use consideration involves the location of new airports. The relative location of an airport to the population that it serves is the greatest single factor that determines the magnitude of the access problem. When locating a new airport a trade off must be made between the cheaper land, the lessened impact on the urban environment, and the difficult access inherent in locating at a distance from a city; and the expensive land, noise and easier access that a more "urban" site would allow. It is not possible to choose only the advantages of each alternate. The friction of distance inherent to a land use plan can be the binding constraint that determines the practical level of service capable of being provided by an access system.

A second land use consideration is the compatability of urban form with specific modes of access. The spatial distribution found in suburban low density areas does not lend itself to rapid and efficient public transport. The establishment of transportation corridors that are coordinated with strips of high population densities would permit long range investment in transportation facilities. Linear development along transportation corridors may be the only way to take advantage of the futuristic travel modes being developed. The designation of a transportation corridor should not be labeled as a railway or a highway, but as a strip of land reserved for use

by evolving modes of transportation. A transportation corridor could conceivably begin as dedicated land, then be used as a highway location, be later improved to freeway standards with rail facilities in the median and ultimately be used as the location for twenty-first century modes.

A third land use consideration involves the establishment of strategically located hubs of economic activity that could also serve as heliports for helicopter access at the present time and as terminals for future VTOL intercity transportation. In addition to land use design this undertaking should include the reservation of air rights in certain zones and corridors for the purpose of transportation. These actions would prohibit the indiscriminant location of incompatible land uses such as schools, hospitals, residences and other noise sensitive developments. The failure to establish air corridors can only result in over flights of noise sensitive areas and the resulting adverse public opinion. There is no question that organized public opposition could greatly affect the future operation of VTOL aircraft and thereby simultaneously affect the airport access problem. These conflicts should be avoided to the maximum extent possible.

A fourth land use consideration is the establishment of land use controls in the vicinity of new airports. The fragmented nature of county, state and city enforcement of land-use zoning that exists in the undeveloped areas usually chosen for new airports is often contradictory and usually ineffective over a long period. The failure to provide for residential, business and commercial developments in the vicinity of airports results in these activities being located in an unplanned manner that is detrimental to airport associated travel.

Significant long range solutions to airport access problems are not possible without a coordinated effort to insure compatibility between land

use patterns and transportation systems. The establishment of compatible land use must be a major part of any effort to improve airport associated intra-urban travel.

Establishment of Urban Transportation Network — It is recommended that efforts to improve airport access be directed to the establishment of an area wide transportation network rather than to the construction of specialized airport-CBD links. The spatial distribution of trips to and from the airport clearly indicates that a single route between the airport and downtown could serve only one-third of the air passengers and only about ten per cent of airport associated travel. In addition there is no indication that the majority of even this small percentage would be attracted to a new facility. There is evidence, such as the Tokyo Monorail experience, that new specialized facilities do not live up to their expectations.

The continuing decentralization of urban areas, the rising proportion of air passengers traveling for personal reasons, the increasing tendency for business trips to begin and end at home rather than from a business office and the mushrooming of the size of urban areas all point to the decrease in relative importance of any one location as a concentration of air travelers. Of particular importance is the realization that the air transport industry has captured almost the full potential of business travel and may face serious competition from electronic means of conducting business such as video-phone, instant document transmission and instantly available video tape replayable in television consoles. At the same time the potential market for personal and leisure time travel has scarcely been touched. The early retirements, longer vacations and growing affluence of society can only result in increased leisure time travel, further reducing the

significance of city centers as the major single location of trip ends.

There is no reason to believe that the change from linear travel patterns to network patterns will end.

The consideration of airport access as only a part of the urban transportation problem does not diminish the importance of finding a solution to the airport access problem. The airport, which is among the major traffic generators in an urban area is a logical location from which to begin stage construction of an urban transit network. The construction of an extensive urban wide system would justify much greater research and development costs than would a limited special purpose facility. In addition the value of an area wide system increases with time because of network expansion while the value of a specialized system usually declines with the passage of time because of obsolescence and competition.

A network approach to the improvement of urban transportation has the advantage of having greater public support than efforts to build specialized systems for the benefit of small segments of the population. As a result the concentration on an urban wide network is generally considered to benefit the general public, greatly simplifying decisions regarding the financial responsibility of the various levels of government and private industry.

Much of the existing literature on airport access ignores the network approach and concentrates on the merits of a particular point to point line haul system capable of transporting large numbers of passengers. The literature is especially oriented to a wide assortment of monorails and conventional rail systems stressing high levels of service. Almost without exception, these articles neglect to mention the peaking character of airport travel, problems of funding, the advantages inherent in the mass production of standardized items and other basic elements of the access problem.

The hardware being proposed for specialized systems is unique and requires extensive research, original design and special fabrication without any assurance that projects of similar design will ever be constructed to take advantage of the large investment in the development of prototypes. It is the opinion of the writer that the principal benefits that have accrued from the fragmented approach to the airport access problem are in the form of technological developments and research findings rather than improved transportation.

Remote Terminal Concept of Handling Passengers — Important gains toward the solution of airport access problems can be achieved by changes in passenger collection and handling procedures. The establishment of air passenger terminals in transportation centers strategically located within a metropolitan area would simplify access travel from many areas served by a large "regional" airport. Remote terminals could also be established in communities located well beyond the boundaries of a metropolitan area. The remote terminal concept is dependent on highly reliable rapid transportation between passenger terminals and aircraft boarding areas.

The means by which to transport passengers between terminals and aircraft boarding areas can best be developed through coordinated efforts involving public and private investment. The recommended course of action involves the construction of terminal facilities with public funds with the understanding that the airline industry would provide public helicopter service between the airport and remote terminals. The public expenditure for remote terminal facilities would reduce airport congestion, but perhaps more important, would allow the creation of transportation centers which if combined with regional shopping centers could become focal points for future

land use designs. Private investment by commercial airlines would allow industry concentration on the pressing problem of air passenger dissatisfaction with airport access in a manner that would also allow a gradual transition from conventional aviation to VTOL operations.

The concept of remote terminals mentioned above can also be implemented on a much smaller scale by locating passenger service facilities in parking lots connected to the main terminal by some sort of transportation. The mode of transport could range anywhere from buses to small Disneyland-type monorails. This system, more accurately described as intra-airport transportation, has the potential of reducing congestion in the area immediately surrounding the air terminal.

Conclusion — The problem of airport access must be considered as it relates to basic community goals and objectives. The optimization of a transportation subsystem should only be attempted in an effort to achieve the needs of society. The expenditure of resources to improve a particular transportation subsystem, such as air transportation and airport access, is not justified if the same expenditure in an alternate transportation system, such as a modern intercity rail system, would yield greater benefits.

The gravity of the airport access problem must be evaluated on real needs such as the requirement to be able to travel from the suburbs of Los Angeles to the suburbs of New York in a given period of time. Demands for improvement simply because more than 50 per cent of the total trip time is spent on the ground are based only on emotional factors which may not be an accurate reflection of real needs.

The recommendations that have been offered for the improvement of airport access are fundamental in nature because a lasting and real solution

to the problem cannot be achieved in any other manner. The application of technology without the overriding direction of a comprehensive plan can only lead to fragmented and often conflicting solutions. The development of new transport technologies has been relegated to a lesser position simply because the problems of urban planning, transportation finance and political direction are much more ominous. There is no question that our national wealth and industrial powers are more than adequate to create new transportation systems for all United States cities provided that public commitment and financial support are available. Consequently the real barriers to innovation are not technical, but involve the entire spectrum of what is loosely termed "the urban crisis".

The airport access problem as well as the myriad of urban problems that currently exist would properly be approached in the following manner as stated by General Gavin (26).

"First, we must make sure that the solution we are applying to a given aspect of our domestic revolution actually will solve the problems; we must understand the revolutionary situation we are in and make certain our responses fit this new situation. The crisis is too immense and time too precious for us to prescribe once again yesterday's medicine for today's ills.

Second, the response we make must be of a size appropriate to the emergency. No strategy however correct, is going to work if applied in a small way. Challenge and response must be of the same order of magnitude."

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A MACROSCOPIC EXAMINATION OF THE
PROBLEMS OF AIRPORT ACCESS

by

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The purpose of this report was to examine the much publicized problem of airport access as it relates to required improvements in intercity and intracity transportation. The examination was conducted in a broad context in order to determine the character of access difficulties being experienced throughout the United States.

The airport access problem was found to be directly related to the rapidly increasing popularity of air travel. Projected increases in the number of air travelers and the use of jumbo aircraft will place great demands on existing facilities that are already experiencing inefficiencies caused by congestion.

Although the airport access problem manifests itself through the dissatisfaction of air passengers with travel to and from airports, it was determined that air passengers constitute less than one-third of the person trips to and from airports. Airport employees and visitors are involved in the majority of access travel and constitute an especially significant portion of rush hour concentrations of travel demands. The diverse composition of airport associated travel precludes solutions to the airport access problem that concentrate solely on the problems of air travelers.

A major factor complicating the airport access problem was determined to be the wide geographic distribution of trip ends. The only significant concentration of air passenger trip ends was found to exist in the central business district, but even this location accounted for only a small portion of the total origins and destinations. Existing travel patterns greatly limit the potential benefits of providing a high capacity line haul system between the airport and the central business district.

The difficulty of airport access was found to be greatly influenced by several characteristics of developing land use patterns. The interrelationships of airport access and land use involve trends of urbanization, decentralization of urban areas, the selection of airport locations, airports becoming centers of economic activity, and the compatibility of land use and urban travel modes.

As a result of the examination of airport access problems that exist at various airports, it was concluded that efforts to improve airport access should concentrate on the following items:

1. The establishment of transportation objectives by which to achieve the community goals established in the comprehensive planning process.
2. The establishment of alternate intercity short haul transportation to reduce the dependence on conventional air transportation.
3. The establishment of land use patterns that are compatible with transportation systems.
4. The establishment of an urban transportation network rather than a specialized airport - downtown link.
5. The establishment of remote terminal facilities with VTOL service provided by private investment.

It was concluded that a real and lasting solution to airport access problems is not as dependent on the development of new transportation technologies as it is on the resolution of problems involving urban planning, transportation finance and political direction. The real barriers to innovation are not technical, but involve the entire spectrum of what is loosely termed "the urban crisis".